Aalto University
School of Science

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# Decision-making in virtual teams: Role of interaction and technology

Master's Thesis

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Instructor: Dr. Marko Hakonen

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Abstract

Advances in technology have over the last two decades supported the development of virtual teams, constituted of geographically distributed members collaborating through technology. Virtual teams are formed to perform complex tasks, and successful decision-making is crucial for their performance. Despite the popularity of virtual teams, little is known about the nature of decision-making in them. There is a need to study this subject in more detail, and take into account the effects of the newest technologies.

In this thesis I have chosen to investigate the decision-making process in virtual teams, aiming at discovering critical factors for success and failure. Earlier theories on decision-making in co-located teams are applied to test their validity for a virtual setting. I have also studied how technology specific features affect the decision-making process in order to shed light to what the role of technology is in virtual team decision-making.

I studied 21 teams of three persons each, collaborating on a decision-making task in a laboratory setting. A web conferencing tool was used by half of the groups and a virtual environment by rest of the groups. The sessions were recorded and transcribed for enabling qualitative analysis of team discussions and interaction with technology.

My findings supported the applicability of general decision-making theories for virtual teams. Especially, vigilant decision-making theory gained support from the findings. Factors, such as shared understanding, thorough discussion before decision, high amount of valuable information shared, much questioning, and reevaluation were found to be important for successful decisions. Unsuccessful teams, on the other hand, had reverse tendencies and made major wrong assumptions that led to poor decisions. High questioning and reevaluation could save a group that were about to make mistakes. Moreover, specific technology capabilities influenced slightly the virtual team decision-making. The web conferencing tool showed to have some advantages over the virtual environment in this specific task. Specifically, the virtual environment contained some pitfalls due to ease of use and a high possibility of individual and unprocessed decisions.



Keywords: Virtual teams, decision-making, interaction, collaboration technologies

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Sammandrag

Teknikens utveckling har under de senaste två decennierna stött utvecklingen av virtuella team, bestående av geografiskt utspridda medlemmar som samarbetar med hjälp av teknik. Virtuella team bildas för att utföra komplexa arbetsuppgifter och lyckade beslut är avgörande för deras prestanda. Trots deras popularitet, vet man lite om beslutfattandes karaktär i virtuella team. Det finns ett behov av att studera detta ämne mer ingående och beakta effekterna av den senaste tekniken.

I detta diplomarbete har jag valt att utforska beslutfattningsprocessen i virtuella team med syftet att upptäcka kritiska faktorer för lyckade och misslyckade beslut. Tidigare teorier om beslutsfattande i samlokaliserade team används för att testa deras giltighet i virtuella miljöer. Jag har också forskat i hur teknikspecifika särdrag påverkar beslutsprocessen för att belysa teknikens roll i virtuella teams beslutsfattande.

Jag undersökte 21 team, bestående av tre personer, som utförde en uppgift som involverade beslutsfattning. Testen utfördes i en laboratoriemiljö. Hälften av teamen använde sig av ett webbkonferens verktyg och hälften använde sig av en virtuell miljö.

Forskningsresultatet stödde antagandet att man kan tillämpa allmänna teorier om beslutsfattande i virtuella miljöer. Speciellt teorin ”vigilant decision-making” fick stöd från resultatet. Faktorer såsom gemensam förståelse, grundlig diskussion innan beslutsfattande, stor mängd värdefull information delad, mycket ifrågasättande och omvärdering visade sig vara viktiga för lyckade beslut. Team som misslyckade hade å andra sidan omvända tendenser och gjorde store felaktiga antaganden som ledde till misslyckade beslut. Mycket ifrågasättning och omvärdering kunde rädda grupper som var på väg att göra ett misstag. Dessutom inverkade specifika tekniska funktioner på beslutsfattandet i virtuella miljöer. Webbkonferens verktyget visade sig ha en del fördelar i jämförelse med den virtuella miljön i denna specifika uppgift. Uttryckligen, den virtuella miljön innehöll ett antal fallgropar som berodde på programmets användarvänlighet i samband med möjligheten till individuella och obearbetade beslut.



Nyckelord: Virtuella team, beslutsfattande, interaktion, samarbetsteknologier

## Acknowledgements

Writing this master thesis has given me valuable insights about where I am today and where I would like to be in the future. This work is the most meaningful that I have done during my studies since it has open up a new world to me. I have become more and more fascinated and curious about work psychology and especially virtual work. Despite my technology based study orientation, I am not one of the most technical persons in the world. Now I see, that it is not necessarily a problem.

I am grateful for getting this opportunity to write my thesis under guidance of my supervisor Prof. Matti Vartiainen. He has given me valuable help and shared his experience with me. I am especially pleased since I got to work with genuine and helpful people at the Virtual and Mobile Work Research unit – vmWork at BIT Research Centre at Aalto University School of Science. I would like to thank the vmWork team for all useful help they have given me and for sharing their experiences with me. It has been a blast.

One person that above all deserves my greatest gratitude is my instructor Dr Marko Hakonen. As I once twittered during my thesis work "luckily there are people such as @mhakon that can bring order to my mind suffering a confused moment!" He has really helped me with the procedure and also made me realize that there is no need to hurry, things will turn out the way they should when you have faith in what you are doing. He has also reminded me about the amplitude of my work and helped me to distinguish between a masters´ thesis and a doctoral dissertation which in fact has helped me to stay on track.

I would also like to thank my partner Mathias because he is the person that supports me through everything in life. He has accepted my absence during some hectic times when school and work took up all my time. My mom and dad should also receive my greatest gratitude for all the support they have given me.

Emma Nordbäck, Espoo 14.11.2011

## Contents

# 1. Introduction

As organizations have become more global and the need to rapidly respond to changes has increased, geographically distributed work has turned into a common way of doing work. Advances in technology have over the last two decades supported the development of virtual teams (VTs), composed of geographically distributed members collaborating through technology. A possibility to quickly create VTs with members having the best expertise and knowledge for a certain task has brought competitive advantage to organizations. It is possible to respond to agile market changes, without expensive and time consuming business trips. (Martins, Gilson, & Maynard, 2004)

With these new possibilities come challenges as well. Organizations are facing difficulties in coping with and managing the dispersion of work. VTs are formed of people best suited for a task, so expectations on performance are consequently high. However, researchers (e.g., Olson & Olson, 2000) argue that "distance matters" and there might be severe obstacles in coordinating group efforts in VTs. Despite the nature of the task, a virtual team should reach some sort of agreement in the end through decision-making. Studies on decision-making in VTs have mainly concentrated on text-based communication and particularly on decision outcomes (Martins et al., 2004). There is a need to assess the actual decision-making process and take into account the newest possibilities of technologies. The rapid development of 3D virtual environments (VEs) during the last decade has brought virtual work up to a whole new level with possibilities for collaboration almost like in face-to-face (FTF) settings. The effects that these environments have on team decision-making have, however, merely been hinted at (Schouten, van den Hooff, Feldberg, 2010).

The norms and characteristics of co-located teams have to be reconsidered in this virtual setup. Can commonly accepted theories about decision-making in groups be applied to VTs as well? Why do some teams make outstanding decisions while other

teams reach disastrous decisions? VTs face new challenges due to the nature of collaboration, and decision-making in VTs is a crucial topic to be investigated more.

## 1.1 Background

This study has been conducted in cooperation with the research group "Virtual and mobile work" (vmWork) at BIT Research Centre at Aalto University School of Science. It is a part of an ongoing research program named ProViWo (Professional Collaboration and Productivity in Virtual Worlds) funded by Tekes. This research project studies how virtual worlds can be used in professional, work related collaboration and to enhance productivity in globally distributed teams. The experiments in this study were conducted at iLab which is a usability and interaction laboratory at Aalto University.

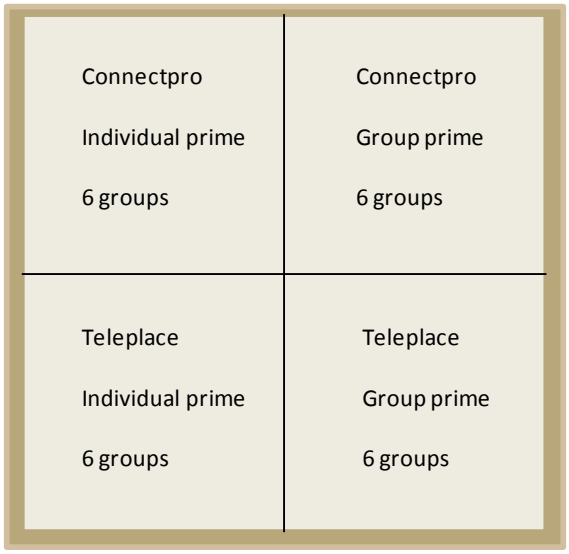



**Figure 1. Four experimental settings in our study**

The experimental design of this study followed a 2x2 structure with groups of three students in each category. Half of the groups used a web-conferencing tool with text, audio and video (Connectpro), while the other half of the groups used a virtual environment with avatars (Teleplace). Additionally, these halves were divided into 2 more clusters that were primed with different orientation tasks before the actual test. (Figure 1)

Originally we had two competing hypotheses in this study. First, based on media richness theory (Daft & Lengel, 1986), we supposed that the virtual environment, Teleplace, would lead to better results because it provided a richer media. Secondly, based on social identification and self-categorization theories (Haslam, 2001) we supposed that the teams that were primed with a group orientation task would reach better results than the individually primed groups. On the contrary, initial statistical

analyses of all groups revealed that technology did not matter and that individual prime resulted in better decisions than group prime. This led me to question what actually caused success or failure in these groups and what characterized their decision-making. With this aim at hand, I decided to do a qualitative analysis on enablers and hindrances of group decision-making process.

The fact that groups often fail to perform according to expectations have led researchers to investigate what issues contribute to effective group decision-making. A lot of research has been conducted in co-located teams collaborating FTF, and there are well established theories in this field. Ever since new technologies have emerged as collaborating tools, researchers have tried to compare and find differences between co-located teams and VTs collaborating through computer-mediated technologies. Recently researchers have begun to shift away from comparing the two working conditions to concentrate fully on virtual work. This study continues in this field and will concentrate merely on VTs collaborating through computer-mediated tools.

## 1.2 The scope of this study

The scope of this study is on decision-making in virtual teams. My study was originally not aimed at studying this subject but the initial surprising findings from the experiments led me to question what actually contributed to successful decisions in VTs. Furthermore, how the technologies supported the team decision-making process raised as a question with no clear answer. Literature review revealed that decision-making in VTs still is an understudied area. There is thus a need for more research.

In this study I shall focus on different aspects of the decision-making process in VTs, collaborating through computer-mediated collaboration tools on a decision-making task. The study was conducted in a laboratory setting (Figure 1). Originally, 24 teams participated but three have been excluded due to technical difficulties or missing participants. The analysis is thus based on 21 teams.

## 1.3 Research questions

The aim of this thesis is to examine group decision-making process in virtual teams. Different aspects of the VTs interaction processes will be studied and different factors of the decision-making process are kept in focus. By studying the decision-making process in detail I seek to find answers to the following research questions.

**RQ1. What are critical factors for successful decision-making in virtual teams?**

The objective is to investigate if there are any crucial factors that make a VT decision-making successful. Are there acts at the group level and critical member contributions that contribute to successful decisions?

**RQ2. What factors contribute to decision-making failure in virtual teams?**

The objective is to investigate if there are any factors that lead to poor VT decision-making. Are there critical group level acts and critical member contributions that contribute to decision failure?

**RQ3. What is the role of technology in decision-making in virtual teams?**

This research question is seeking to find out how different technologies and media capabilities affect the decision-making process of VTs. Are there any benefits or drawback of the technologies used in decision-making tasks?

## 1.4 Structure

This chapter presents the framework of this thesis. It presents the background, research questions and the scope of this study. Next chapter will present the theoretical background to create an understanding of decision-making in teams. It will highlight different aspects of team decision-making and present findings concerning VTs. It will additionally present main decision-making theories that lay the ground for the empirical research. Chapter 3 will present the methods used in this study and explain the conducted experiment in detail. After that the results are presented in chapter 4. The results are divided into 2 sections, one concerning the factors of successful and poor decision-making and one highlighting the role of

technology in VT decision-making. Finally, I will discuss the results in detail in chapter 5 and relate them to theories presented in chapter 2. Based on the findings I will discuss the limitations of this study and make suggestions for future research.

# 2. Theoretical background

Computer-mediated communication (CMC) is necessary in a large part of organizations today due to globalization and the nature of work. People have to cooperate within VTs tackling with difficulties as well as advantages that FTF collaboration lacks. Even though CMC differs from FTF communication it is still communication between people, and many phenomena in co-located teams have been found to be rather similar in VTs (Martins et al., 2004). This chapter will present different aspects of group processes and primarily of decision-making. First, VTs are described in more detail to get a picture about the nature of their work and the context of my study. After that group processes will be presented which will lead us into the core subject: theories and models of decision-making in VTs.

## 2.1 Virtual teams

Technology has brought new dimensions to team work and has helped organizations to cope with the rapidly changing global market. It is no longer a must for a team to be located at the same office or to communicate synchronically. Instead, VTs relying on CMC are becoming commonplace in organizations. VTs can be created spontaneously and can consist of people best suited for the task, independent of their geographical location (e.g., Lipnack & Stamps, 1999; Gibson & Cohen, 2003). Members can enter the team when their expertise is needed and leave when the task is completed (Nijstad, 2009). Moreover, travelling costs can be decreased with the use of VTs (Martins et al., 2004)

There is no universal definition of a VT and the definitions have been discussed widely during past two decades. Researchers are shifting away from the earlier viewpoint of VTs as something opposite to traditional teams collaborating FTF and are instead focusing on the *degree of virtuality* of the team. (Griffith & Neal, 2001; Martins et al., 2004; Hertel, Geister, & Konradt, 2005) Yet there is an ongoing debate on what affects the degree of virtuality. However, it is rather commonly agreed that a team that merely collaborates through technology is more virtual than a team that occasionally meets FTF, and a team that is dispersed over multiple

countries is more virtual than a team located in the same city (Gibson & Cohen, 2003).

Below I present two definitions of a VT:

- "VTs are groups of geographically and/or organizationally dispersed coworkers that are assembled using a combination of telecommunications and information technologies to accomplish an organizational task." (Townsend, DeMarie, & Hendrickson, 1998, p. 18)
- "VTs are teams whose members use technology to varying degrees in working across locational, temporal, and relational boundaries to accomplish an interdependent task."(Martins et al., 2004, p. 808)

Townsend and his colleagues were the first to define a VT and at the time a VT was assumed to be completely computer-mediated, opposite to a conventional team communicating FTF. Recent definitions (e.g., Martins et al., 2004) stress that VTs first of all should be considered as teams and that *virtuality* is a characteristic of the team. I argue that the latter definition is better because it considers virtuality more as a continuum than as an absolute state. VTs are though much more complex than co-located teams and further research on issues regarding VTs is necessary in order to understand how to manage them effectively (Powell, Piccoli & Ives, 2004)

In this study, a VT refers to a team of dispersed members, collaborating through technology, for a common goal. This definition is used throughout this thesis. Dispersion in this study was artificially achieved in a laboratory setting so that the members were not geographically dispersed in reality.

VTs provide great opportunities to the ways of organizing work. However, there is another side of the coin as well including several challenges (Hertel et al., 2005; Martins et al., 2004). Problems usually arise from lack of a "common ground", development of trust, coordination and control issues, and management of the team (Nijstad, 2009). Establishing and implementing VTs without addressing the challenges of virtual work may lead to unnecessary failures (Powell et al., 2004). I

will not go into detail in every challenge but in chapter 2.5.1 I will highlight some problems concerning decision-making in VTs.

## 2.2 A framework of studying groups

Groups can be considered as an entity that is build up of smaller parts, i.e. members. A group is thereby a multilevel system that can be studied both at individual level and at group level. (Nijstad, 2009) A group's success depends on the members' capabilities and the group's capability to put together different skills and collaborate effectively for a common goal. There is no guarantee for a group to succeed even though it is composed of people with the right skills for the task. Instead, group performance is a result of the activities at the group level (Nijstad, 2009). In this chapter, I will present the input-process-output framework for studying groups. This leads us to the core subject of this thesis, decision making.

### 2.2.1 Input-process-output model

The input-process-output (IPO) model was originally presented by Hackman and Morris in 1975 and it is the most common framework for studying teams. The theory states that team inputs are converted into team output through interaction processes. (Hackman & Morris, 1975) According to IPO the two primary reasons why teams fail are poor inputs or faulty processes. Even though the members´ capabilities are ideal for a specific task the team can still fail due to inefficient or faulty processes (Steiner, 1972). Steiner stated that a team's actual performance is equal to its potential performance minus losses that stem from poor processes. The potential performance of a team is determined by the team input which broadly means member resources in combination with task requirements. Effective interaction processes are consequently vital for team success.

In reality, teamwork is not as linear or static as the IPO model implies. A team´s interaction processes might also change due to the outcomes of the team. (Driskell, Sales & Radtke, 2003) A team is seldom isolated from its surroundings and environmental factors, usually called moderators, are also influencing team

processes (Martins et al., 2004). According to Kozlowski and Klein (2000) the team context is highly influencing team output. They see team context as a combination of top-down organizational constrains, such as technology, structure, leadership, and culture, and bottom-up phenomena that arise within the interaction among the team members.

Figure 2 presents a more detailed IPO model of virtual team functioning and is based on of Martins et al.´s (2004) and Powell et al.´s (2004) frameworks.

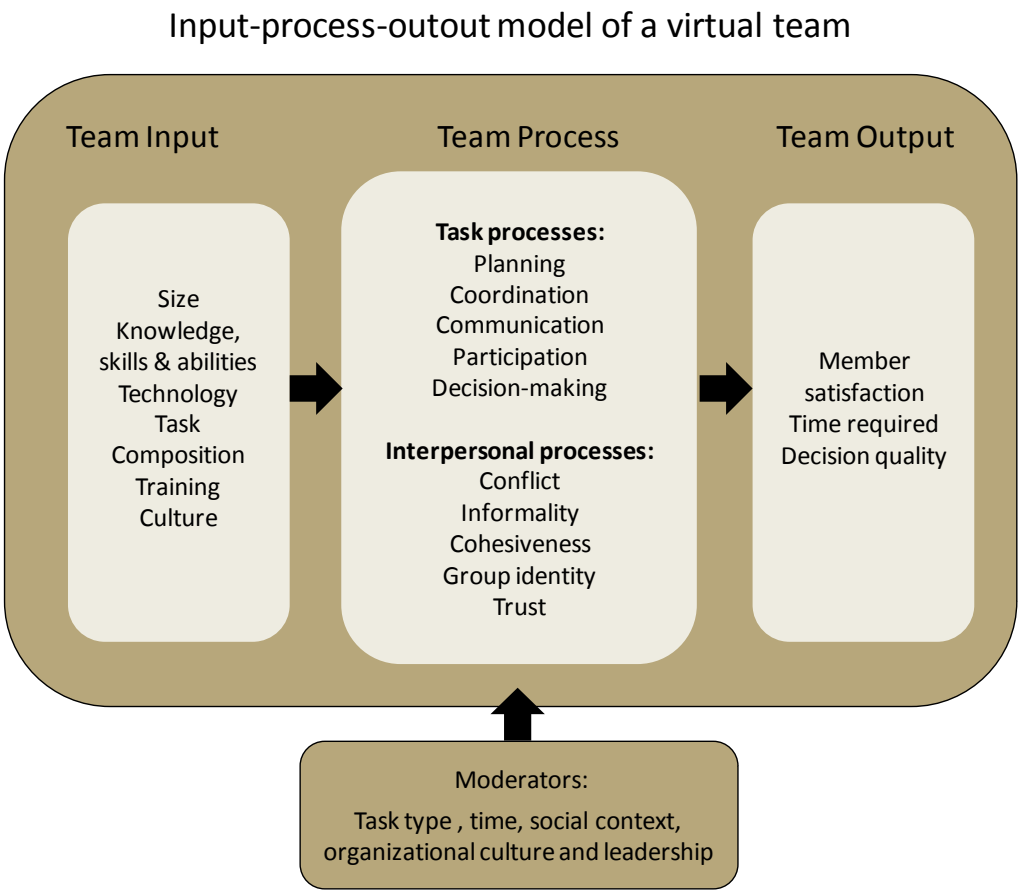



**Figure 2. The IPO framework of studying virtual teams (Martins et al., 2004; Powell et al., 2004)**

### Team input

The team input presents the starting conditions of a team and is composed of human and material resources. The inputs presented in Figure 2 are: team size, member knowledge, skills and abilities (KSAs), technology, task, composition, training and culture (Hackman & Morris, 1975; Martins et al., 2004). In a VT, the type of technology used (Daft & Lengel, 1986) and the members´ technical expertise is critical for the team´s success (Kaywort & Leidner, 2000). I will return to the technology topic later and present the technologies used in this study.

The group members bring their individual characteristics such as KSAs as well as motives, emotions and personalities to the group (Nijstad, 2009). When working on a common task group members interact and contribute to the goal. The different contributions may differ in size and importance and may influence other group members. In VTs it might be more difficult to establish a shared goal and members might have different intentions and motives (Blackburn, Furst & Rosen, 2003).

### Team processes

Team processes can be divided into task and interpersonal processes (Figure 2). Task processes include planning, coordination, communication, decision-making and participation. I added decision-making as one of the task processes in teams since it cannot be included in the other task processes and since it is central for this thesis. On the other hand, many task processes such as coordination, communication and participation are relevant in studying decision-making and can be considered as parts of the decision-making process. They will all be discussed in more detail later in this work.

Although this thesis will focus on decision-making in VTs and thus I shall mainly consider task processes, interpersonal process are influencing decision-making as well. Conflict, informality, cohesiveness, group identity and trust are examples of interpersonal processes (Figure 2). Social influence is a fundamental to all kind of group processes and especially to decision-making (Nijstad, 2009). People with high

status, usually leaders, tend to influence group members more than members with lower status (Nijstad, 2009). Group members also differ on how much they speak during a conversation. People who talk more tend to be more influential (Bales, 1953). Cohesiveness is one of the most influential aspects of teamwork but has been showed to be diminished in VTs (e.g., Straus, 1997). The development of trust has also been proven to be harder to develop in VTs, yet it is crucial for successful completion of VT tasks (Jarvenpaa & Leidner, 1999; Sarker, Lau & Sahay, 2001).

Besides team input and team process, so called moderators are also influencing team performance. Task type, time, social context, organizational culture and leadership are examples of moderators of VT performance. (Martins et al. 2004) It is not easy to determine which task type is best suited for virtual work. Some researchers have found that in negotiation and intellective tasks FTF-teams outperform CMC-teams, when again no differences in decision-making tasks were found (e.g., Hollingshead, McGrath, O'Connor, 1993). These differences where faded over time, which indicates that time is crucial moderator as well. Social context has also showed to influence performance in VTs. Cooperation and communication openness, for instance, improves virtual team performance (Zack & McKenney, 1995). How organizational culture and leadership affect virtual teams are still subjects that need more investigation (Martins et al., 2004).

### Output

As presented in Figure 2, team outcome can be measured in member satisfaction, time required and decision quality. This is a small piece of team performance and the picture is becoming more complex when it comes to VTs. It is a challenge to make an exact definition of what constitutes an effective or successful group. Although many definitions have been proposed over the years (Jex, 2002), the most comprehensive definition has been proposed by Hackman (1987) in conjunction with his normative model of group effectiveness. According to Hackman´s definition, group effectiveness is a combination of the following factors to the extent that:

1) The group produces something that is judged to be acceptable.

2) The group interact in such a way that the members can work together in the future.

3) The group members show a reasonably high level of satisfaction.

On the basis of this definition, group effectiveness is not possible to measure exactly and effectiveness depends on the judge. It has furthermore been suggested that other aspects like organizational learning, organizational memory and knowledge management should be added to the measures of VT effectiveness (Furst, Blackburn & Rosen, 1999).

Several studies have tried to find out whether VTs or traditional teams outperform each other. The results have been mixed with some studies suggesting that VTs are better (e.g., Sharda, Barr & McDonnell, 1988), whereas other found that traditional teams were most effective (e.g., McDonough, Kahn & Barczak, 2001). The majority of studies found no difference between the two types (e.g., Burke & Aytes, 1998). Furthermore, most researchers have not found differences in decision quality (e.g., Cappel & Windsor, 2000). VTs are here to stay and the collaboration technology should match the team task and context as well as social relations (Andriessen, 2003). Instead of comparing success of VTs and co-located teams, I suggest that more studies should concentrate on revealing the best practices for VTs and concentrate on what tasks and goals they can be utilized for and how technology can support their work.

## 2.3 Group decision-making

Groups that work together for a common goal should, despite the nature of the task, reach some sort of agreement in order to achieve their goal. Decision-making is therefore one of the most critical tasks in group work and is not only influenced by members' expertise and skills. During past four decades researchers have found many conditions under which groups make better decisions than individuals. Groups have more resources and knowledge to benefit from and will eventually make a

better decision than individuals working alone. (e.g., Vroom & Yetton, 1973; Jensen & Chilberg, 1991; Nijstad, 2009) Group members usually represent different perspectives and approaches to problems, so they can find blind spots and shortcomings in other´s thinking (Jensen & Chilberg, 1991). Despite this, many argue that the range of skills and knowledge group members possess are not being used to its full potential (e.g., Gruenfeld & Hollingshead, 1993). Group performance depends on the interaction among group members and poor decisions are made when they have problems with communication and decision-making process. (Janis & Mann, 1977; McGrath, 1984; Jensen & Chilberg 1991)

Many researchers argue that the quality of the interaction among group members is the most important determinant of success in group decision-making (Hackman & Morris, 1975; Gouran & Hirokawa, 1983). The fact that decision-making groups often fail despite talented members has led many small-group researchers to investigate what the critical factors in successful group decisions are (Hirokawa & Rost, 1992). This thesis is continuing in this field of research, but in a virtual setting.

Nijstad (2009) notes on group decision-making: "Group decisions are made in order to reach consensus and ensure that everyone's opinion is heard, and that (most) group members agree with the decision" (p. 123). People are often more willing to accept a decision when they had opportunity to contribute to the result. Consensus-building is therefore essential in group decision-making. However, too strong cohesiveness might make members wanting to satisfy primarily the consensus-function, instead of focusing on reaching the best result (Janis, 1972). If conformity pressures are too high, it is likely that the group makes poor decisions (Bernard, Hock-Hai & Kwok-Kee, 1995).

One important feature of high-quality decision-making is the frequent expression and management of conflict. If the group agrees upon every suggestion, ideas will for certainty remain untested. (Jensen & Chilberg, 1991; Jehn & Mannix, 2001) Another prerequisite of successful decision-making is information sharing, which is the primary process by which team members share their knowledge (Bunderson &

Sutcliffe, 2002; Jehn & Shah, 1997). Stasser and Titus (1985) investigated groups' information sharing and argue that group members do not contribute with their whole information storage to a group decision. This will lead to losses in information, and the decision will in the worst case be based on only a small piece of the available information. The more information is shared in the group the more likely it is that the decision is successful (Winquist & Larson, 1998). Additionally, performance is enhanced when the members share unique information (Mesmer-Magnus & DeChurch, 2009). Unfortunately, groups tend to spend more time discussing on commonly known information than unique information and decision quality is deteriorated (Dennis, 1996; Stasser & Titus 1985).

The group decision-making process in which individual resources are combined is critical in carrying out a successful group decision. Next, I will present some characteristics of a group decision-making process.

### 2.3.1 Stages of group decision-making process

When the United States launched the *Challenger* space shuttle in 1986, there was significant evidence available to the decision makers indicating on a high risk for explosion (Kruglanski, 1986). That information was ignored and downplayed and information was restrained at each successive level of the decision-making process (Gouran, Hirokawa & Martz, 1986). The disaster of the *Challenger* is an evident example of how a faulty decision-making process can lead to disastrous outcomes. It has been stated that groupthink was the cause of this decision-making fiasco (Janis, 1982). I will explain the groupthink phenomena more in chapter 2.4.1.

In a group decision-making process members go through different stages which all contribute to the success of their decision. The stages presented in Figure 3 are not universal by any means and groups may skip some phase or add another to the picture as well. The different stages in the decision-making process have to be coordinated inside the group. As the task gets more complex, the coordination of the different steps in the decision-making process becomes more important (Boos & Sassenberg, 2009)

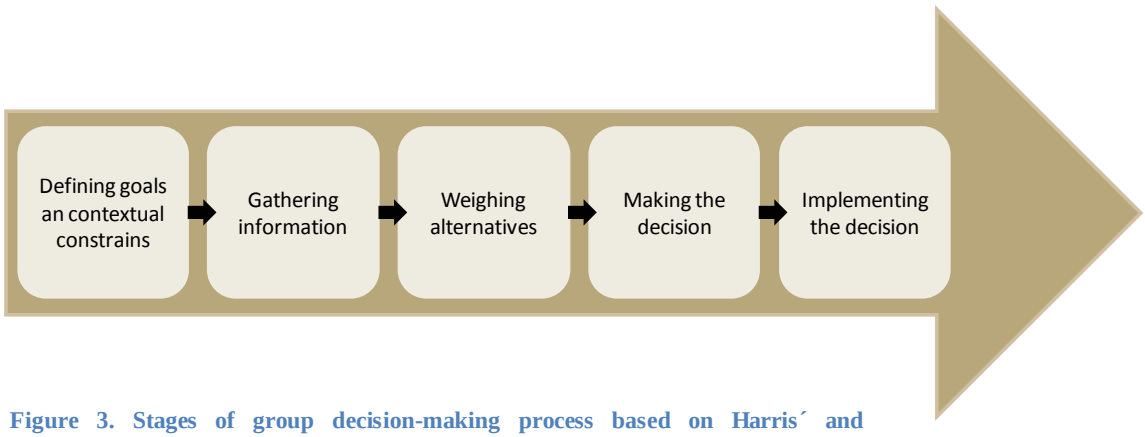



**Figure 3. Stages of group decision-making process based on Harris´ and Sherblom´s model (1998)**

The first step in the decision-making process is to define the goals to achieve and criteria for the evaluation of success. "If we don´t know where we want to go, and if we don´t know what to expect when we get there, it doesn´t really matter how much effort we put into making our decision" (Harris & Sherblom, 1998, p. 139). Therefore, it is important that the team reaches a mutual understanding of the task in the beginning. Contextual constrains are an inevitable element of the decision-making process and both external and internal constrains have to be considered. External constrains are, for example time, resources, energy and knowledge while internal constrains are those that are intrinsic to the problem like causes, limitations, implementation, physical location or technical issues. (Harris & Sherblom, 1998) The Challenger disaster is an example where external constrains such as timely launch was so prominent that other important constrains where overlooked.

The next stage in the decision-making process is to gather information. In Harris´ and Sherblom´s (1998) model, this was not a distinct phase but I chose to lift it up due to its importance for decision-making. Before weighting alternatives important information should be distributed over the whole team. The acts of gathering information and weighting alternatives might be restricted by time, resources, knowledge and energy (Harris & Sherblom, 1998). When different alternative solutions have been surveyed, it is time to evaluate each solution and its consequences. A solution can have many hidden impacts that only can be found when thoroughly investigating it.

After surveying different alternative solutions it is time to reach a decision. As the number of alternatives increases, and perhaps becomes more complex, the decision-making becomes harder. Decision-making is dynamic by many means and the team members´ own preferences and motives are also influencing the decision-making (Hackman & Morris, 1975). Last but not least, the decision has to be implemented. Even an ideal decision may fall short if it is implemented poorly. Usually a decision is being evaluated after this stage but evaluation should in fact occur throughout the decision-making process in order to successfully and effectively reach high-quality decisions (Harris & Sherblom, 1998). It is of significant importance to investigate the whole decision-making process, not just parts of it, in order to understand what contributes to successful and poor decisions.

## 2.4 Models of decision-making

In this chapter, I will highlight central models of team decision-making that seek to explain failures and successes and provide frameworks of studying decision-making. These models were central for this thesis when the coding scheme for the mapping of decision-making in this study was developed.

### 2.4.1 Groupthink

Groupthink refers to "a mode of thinking that people engage in when they are deeply involved in a cohesive ingroup, when members' strivings for unanimity override their motivation to realistically appraise alternative courses of action" (Janis, 1972, p. 9). With the groupthink theory, Janis explains how strong concurrence seeking can lead to poor decision making. The groupthink theory strives to explain why a group of competent people sometimes make extremely poor decisions (e.g., Bay of Pigs invasion, The Cuban Missile Crises, Challenger). Groupthink arises when people strive to maintain group harmony and consensus so much that they lose focus on the task itself with all its dimensions.

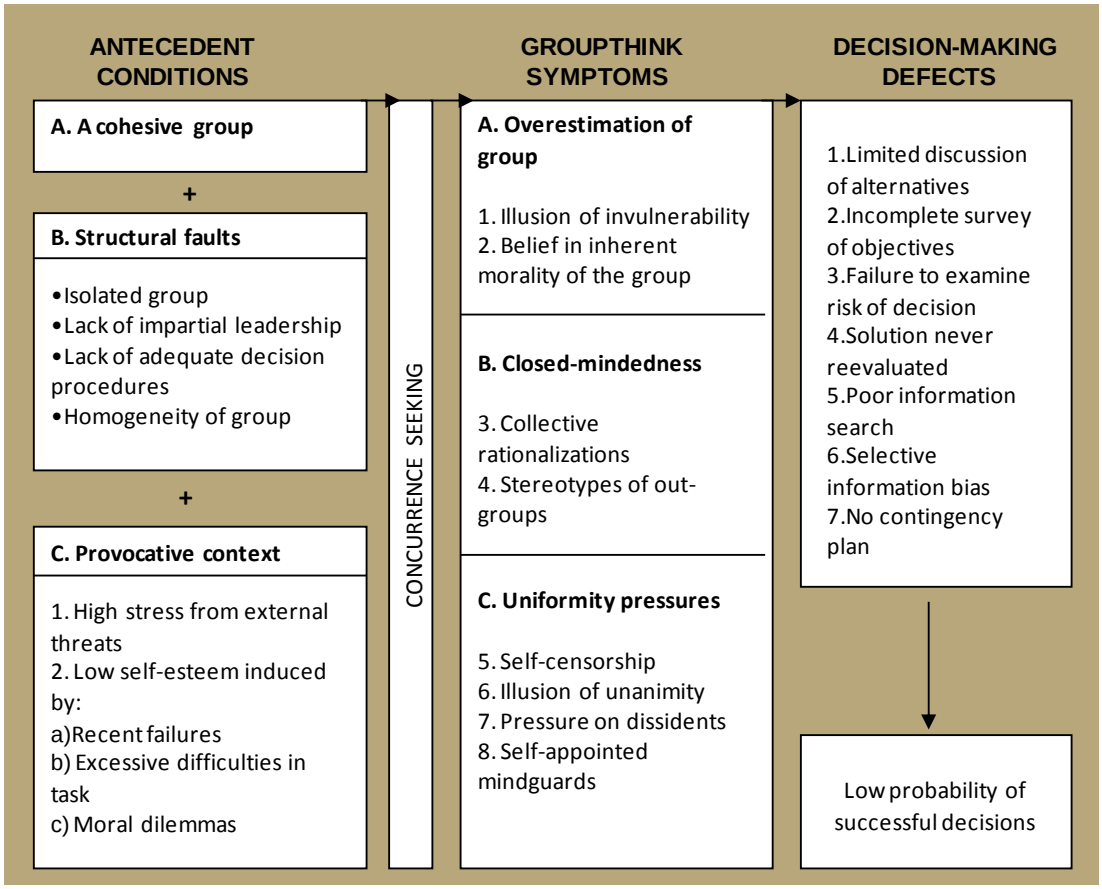



**Figure 4. Theoretical analysis of Janis´ groupthink framework (Janis, 1982, p. 244)**

Figure 4 presents the framework for the groupthink theory. As can be seen there are different categories that will raise the probability of poor decisions. Antecedent conditions are grouped into three clusters where the first represents a highly cohesive group. The second concerns structural faults such as isolation, lack of impartial leader, lack of adequate procedures and homogeneity. The final cluster is external and internal stressors causing a high level of stress. These antecedent conditions can result in excessive concurrence seeking within the group and cause groupthink.

Janis identified eight main symptoms of groupthink: (a) an illusion of invulnerability, (b) an illusion of morality, (c) rationalization, (d) stereotyping, (e) self-censorship, (f) an illusion of unanimity, (g) direct pressure on dissidents, and (h) reliance upon self-appointed mindguards. By facilitating the development of shared illusions and related norms, these symptoms are used by groups to maintain esprit de

corps during difficult times. The price paid to maintain group cohesiveness, however, is a decline in mental efficiency, reality testing, moral judgment, and ultimately it leads to a decline in the quality of decision-making (Whyte, 1989).

When groupthink is present in a team, different decision-making defects will arise and increase the likelihood of a decision to be unsuccessful. Different decision defects are: limited discussion of alternatives, incomplete survey of objectives, failure to examine risk of decision, the original solution is never reevaluated, poor information search, selective information bias, and lack of contingency plan. These defects are to a large extent opposites of vigilant decision-making that is presented in chapter 2.4.2.

Despite the wide acceptance of Janis´ groupthink theory, there are researchers that have started to question its accuracy and empirical reliability (e.g., Fuller & Aldag, 1998; Turner & Pratkanis, 1998; Baron, 2005). Fuller and Aldag argue that groupthink has become a symbol of bad group decision-making and that faulty decisions too easily are explained with signs of groupthink. In an earlier review of groupthink literature (Aldag & Fuller, 1993) they state that most support for groupthink comes from retrospective case studies on decision fiascos rather than studies on the decision-making processes, comparing good vs. bad decisions. Moreover, no empirical study has found support for the full groupthink model (Fuller & Aldag, 1998; Baron, 2005). To my knowledge, groupthink has not been studied in the context of VTs. Janis did not consider important variables in group work such as group norms, the nature of the task, the degree of leader power, and stage of group development. Fuller and Aldag (1998) suggest that researchers should question whether they are aiming at advancing group decision-making in their research or merely aiming at finding support for the groupthink phenomenon.

### 2.4.2 Vigilant vs. hypervigilant decision-making

Janis and Mann (1977) developed a decision-making model that distinguishes between an ideal pattern of successful decision-making (vigilant) and a corresponding pattern of extremely poor decision-making behavior (hypervigilant).

The vigilant decision-making pattern highlights the importance of careful and thorough information processing in the decision-making process. Some specific communication behaviors have been pointed out to characterize a vigilant decision-making which most likely lead to high-quality decisions. According to this view, an effective group:

- thoroughly investigate a broad range of alternative actions,
- carefully contemplates negative and positive consequences of each action,
- questions members' propositions to find hidden or faulty assumptions,
- searches intensively for new information to base evaluation on,
- takes new information into account, not only information supporting earlier assumptions,
- bases decisions on accurate and reasonable premises,
- reevaluates all the alternatives before affirming a final decision, and
- makes a detailed implementation plan for the final decision (Janis & Mann, 1977).

If the group meets the criteria above, it is said to have a vigilant information processing. When the task is becoming more ambiguous, involving complex choices, a high degree of vigilant information processing will raise the probability of successful decisions to occur. Meeting each criterion more adequately will lower the probability for gross miscalculations. (e.g., Janis & Mann, 1977; Jensen & Chilberg, 1991) The fewer criteria met, the higher the likelihood of the group to undergo unanticipated setbacks and to reach poor decisions (Janis & Mann, 1977).

As an opposite of vigilant decision-making, Janis and Mann (1977) identified hypervigilant decision-making patterns. A state of hypervigilance may occur when the decision-makers are under high stress due to unexpected threat or time pressure. Hypervigilant decision-making results in impulsive and disorganized decision-making. A hypervigilant decision-making pattern, in contrast to vigilant patterns, is characterized by:

- limited consideration of alternatives,

- nonsystematic and selective information search,
- rapid evaluation of information, and
- rapid selection of solution without reexamination (Janis & Mann, 1977).

These criteria are rather similar to defects identified in the groupthink model (Janis, 1972). Thus, this theory can be seen as an operationalization of key aspects of groupthink defects.

A group with more vigilant decision-making patterns has proven to reach better decisions than a group with less critical thinking (Janis & Mann, 1977; Keinan, 1987; Jensen & Chilberg, 1991; Baradell & Klein, 1997). According to Janis and Mann (1977) a hypervigilant decision making pattern could occasionally be adaptive to save time and effort but is mainly seen as deviation from the ideal vigilant decision-making patterns. On the contrary, researchers have also found evidence that contradicts with the theory that vigilant decision-making is the best approach to solving tasks and these researches stresses the impact of task demands (Klein, 1996; Johnston, Driskell & Salas, 1997). A hypervigilant decision-making strategy may be more approapriate for naturalistic tasks which Johnston and his colleagues define as "one in which decisions are made under time pressure, data are ambiguous or conflicting, the consequences of error or poor performance are costly, and decision-makers are familiar with the task" (Johnston et al., 1997, p. 620). Klein noted (1996) that a vigilant approach might be inappropriate when time is severely limited, the people possess expert knowledge and can decide what information is relevant for the task or when the data is ambiguous and hard to evaluate from all angles. Based on these assumptions, no conclusion about whether a vigilant or hypervigilant approach in decision-making is better can be drawn. Competences, task demands and different restrictions are all highly influencing the decision-making process.

### 2.4.3 The functional perspective of group decision-making

The functional perspective has emerged during the last three decades and is commonly used in studies of group performance. It is built upon the work of Bales (1950, 1953), Janis (1972, 1982) and Janis and Mann (1977) among others. Hence,

it is an elaboration of groupthink and vigilant decision-making. According to the functional perspective, the interaction and communication between members plays an essential role for a group to fulfill necessary requirements of their tasks, which in turn affect the group's chances of making successful decisions. Defective group interaction will most likely result in poor decision-making and inadequate fulfillment of task requirements. (e.g., Hackman & Morris, 1975; Gouran & Hirokawa, 2003) A cornerstone of the functional perspective is that "effective group decision-making is contingent on interactions´ contributing to the satisfaction of critical task requirements" (Orlitzky & Hirokawa, 2001, p. 314).

When studying team decision-making, one have to take into account communication and interaction among members. Effective communication is crucial when the task is complex and requires thorough processing of information (Shaw, 1964; Gouran & Hirokawa, 1983). A complex task is characterized to have unclear goals, several goal-path mechanics, low goal-path clarity and different obstacles on the way (Hirokawa, 1990). Communication allows members to combine their knowledge and skills and reach a successful decision that would have been difficult or even impossible for the members to achieve alone (Hirokawa, 1990; Hayes, 1997). In simple tasks, however, input variables such as members´ expertise tend to be more important than process variables such as communication and interaction (Hirokawa, 1990)

According to the functional theory, effective group decision making is most likely to occur when group members:

1. a) Show a correct understanding of the task,
   b) determine the minimal criteria any decision must possess,
   c) identify relevant and realistic set of alternative solutions,
   d) examine carefully the alternative solutions in relationship to defined, criteria and
   e) select the alternative that analysis reveals to be most likely to meet desired criteria.

2. Employ appropriate ways for overcoming cognitive, affiliative, and egocentric constraints that are hindering fulfillment of task requirements.
3. Review the process by which the group reaches a decision and, if necessary, reconsider the final decision. (Gouran & Hirokawa, 1996)

These aspects indicate that the group members´ interactions are crucial for team decision-making performance. The importance of amount of alternative solutions is, however, disputed. Results from a meta-analysis conducted by Orlitzky and Hirokawa (2001) indicate that the amount of alternative solutions is not related to decision-making effectiveness. Time spent on brainstorming ideas is not crucial; instead careful evaluation of the alternatives is more important (Orlitzky & Hirokawa, 2001). Even though a wide range of alternative solutions is of great use in decision-making it is important to emphasize the importance of thoroughness. The solutions will not speak for themselves so the group must evaluate the alternative solutions and critically test ideas, arguments and proposals in order to reach a decision to represent the group's best effort (Jensen & Chilberg, 1991). Furthermore, studies like Hirokawa´s study (1983) and Graham and colleague's study (1997) provide evidence showing that the amount of alternative solutions generated is not crucial for successful decisions, but rather the quality and effort put into those decisions (Graham, Papa & McPherson, 1997).

The second aspect, constrains consists of cognitive ones that is members´ feelings of pressure due to limited time or information. Affiliative constrains occurs when a member pursues to maintain relationships in the group more than achieving high performance. Egocentric constrains arise when members strive to favor themselves more than the group, e.g. by dominating. Any of these three constrains may result in shortcuts in the decision-making process which leads to poor fulfillment of the task requirements. The last aspect about reviewing the process is stated to be important because members are not always able to assess all dynamics of the task, and problems may pass by unnoticed. By taking a new look at the decision-making process and the derived alternatives, the group may reflect on what have been done

and make changes if something new is discovered, even though this might require starting over. (Gouran & Hirokawa, 2003)

## 2.5 Decision-making in virtual teams

### 2.5.1 The role of technology in virtual team decision making

Research on decision-making processes in VTs is still in its infancy. Until recently, most studies have focused on text- and audio-based technologies when it comes to virtual work (Martins et al., 2004; Schouten et al., 2010). The findings of VT performance in the area of decision-making are mixed. Several researchers have found no differences in decision quality between virtual and co-located teams (e.g., Cappel & Windsor, 2000; Straus & McGrath, 1994), while others have found that co-located teams outperform VTs (e.g., Andres, 2002; McDonough et al., 2001). At the same time, researchers have found evidence proving that VTs performed better than teams collaborating FTF. These findings indicate that VTs make more effective decisions (Schmidt, Montoya-Weiss & Massey, 2001), generate better ideas (Valacich, George, Nunamaker & Vogel, 1994) and more ideas (Chidambaram & Boström, 1993). One constraint of virtual work that a wide range of researchers have found is that it takes longer time to reach a decision (e.g., Archer, 1990; Galegher & Kraut, 1994).

Studies on decision-making performance in VTs have mainly focused on decision outcomes. The decision-making process in VTs, on the other hand, has to my knowledge received little attention in research. Especially 3D virtual environments (VEs) are still an area of much speculation and uncertainty in the context of VTs (e.g., Sivunen & Hakonen, 2011). VEs can be defined as communication systems in which multiple users share the same three-dimensional digital space and obtain information, navigate, manipulate objects and interact with each other via avatars (Sallnas, 2005; Yee & Bailenson, 2007). An avatar is a person´s digital self-representation in a graphic 3D from (Yee & Bailenson, 2007). In VTs, technology is central for communication and collaboration. It is thereby important to understand

the effects it has on teamwork and team performance (Montoya, Massey & Lockwood, 2011).

Media richness theory (MRT) (Daft & Lengel, 1986) states that a richer media allow more information cues and feedback and is therefore better suited for communicating ambiguous information and making complex decisions in teams. Technologies with higher ability to transfer rich information (e.g. visual, social, non-verbal and feedback-cues) are referred to as richer media (Daft, Lengel, & Trevino, 1987). The less the social cues are filtered out, the richer the media. The media richness can be measured on the medium´s potential to allow multiple channels, immediacy of feedback, natural language and personal focus on the medium. FTF communication is ranked as the richest media and is best suited for complex and ambiguous tasks while CMC is less rich and is more appropriate for fairly routine and unequivocal tasks. Inconsistent findings of the media richness theory have given rise to less technology deterministic theories as well (Axtell, Fleck & Turner, 2004). For example, Social Information Processing theory (SIP) is an adaptation theory, and represents so-called cues-left-in perspective, stating that social cues are possible to convey through technology but they only take longer time to come into effect (Walther, 1992).

As noted earlier, one challenge that VTs have to face is the development of a "common ground" (Nijstad, 2009). Problems and miscommunication may occur when team members lack *mutual knowledge*: knowledge that the team members share in common and know they share (Krauss & Fussell, 1990) In VTs it is harder to establish mutual knowledge and people may assume that other team members automatically share mutual knowledge due to their professional status or organizational membership (Cramton, 2001).

Despite the dispute on how well CMC can meet the quality of FTF communication, virtual collaboration tools have brought several advantages to teamwork that are not present in FTF conditions. Some advantages mentioned in literature are:

- lower probability of production blocking and evaluation fear,

- easier access to people with relevant information and right expertise for a problem,
- possibility to record and save communication and decisions,
- less inhibition due to social norms and group pressures (Ensher, Heun & Blanchard, 2003; Straus, 1997).

VTs enable people with best expertise for a certain task to work together, despite their physical or organizational location. This indicates for a possibility of very successful and competent decisions in VTs. The fact that production blocking can be decreased is also bridging for a more effective information and idea sharing which possibly contributes to better decisions.

It has been stated that CMC should favor group decision-making because the medium strips away the social inefficiencies that arises from FTF communication (Johansen, Vallee & Collins 1978; Pinsonneault & Heppel, 1998; Rice 1984). It is in order here to notice that these findings hold for earlier forms of CMC but is not so straightforward with newer technologies. VEs are rich communication media in which teamwork can be more sophisticated than with earlier forms of CMC (Montoya et al., 2011). How VTs will interact and reach decisions in VEs is still a subject in need of further investigation (Montoya et al., 2011).

It has been argued that CMC differs from FTF communication in terms of status and power (e.g., Dubrovsky, Kiesler & Sethna, 1991; McGuire, Kiesler & Siegel, 1987; Weisband, 1992). These researchers suggest that CMC decreases status and power differences and thus enhances equality in group decision-making. It has been found that CMC lowers some social inhibitions and barriers to communicate. Generally people participate more in group discussion and influence final decisions more equally in CMC groups (e.g., George, Easton, Nunamaker & Northcraft, 1990). One explanation to this effect is that CMC usually lacks social context cues or social information about members (Sproull & Kiesler, 1986, 1991). Later studies have not supported the status-equality effect of CMC (Weisband Schneider & Connolly, 1995; Postmes, Spears & Lea, 1998). Weisband and her colleagues (1995) found

that high-status members dominated group discussions in both CMC and FTF group when again Postmes and his colleagues found (1998) that social boundaries can be enhanced in CMC setting. CMC do not automatically make social differences to disappear. Once people are aware of each other's statuses they act accordingly with their labels independent of the communication type.

Studies have also shown that the possibility of being anonymous foster a more equal participation. Anonymity might reduce unwanted social influences that group work usually brings with it and lead to an open exchange of ideas. (e.g., Pinsonneault & Heppel, 1998) If this is the outcome of anonymity, the group is more likely to produce free-spoken, independent and novel decisions (Constant, Sproull & Kiesler, 1996). On the other hand, it has been prompted that anonymity might reduce the positive effects of group constraints and thus lead to group polarization and extreme decision-making (Kiesler, Siegel & McGuire 1984).

While some evidence suggests that computer-mediated collaboration can reduce social influences, it has also been found that it can foster the development of a strong group identity. According to "The Social Identity Model of Depersonalization Effects" (SIDE) anonymity has different effects depending on identity salience. (Lea & Spears, 1992) When a group identity is salient the group norms will influence on how group members communicate and behave. In turn, when member´s personal identity is salient in anonymous interaction, group norms are overshadowed by individual choices (Lea & Spears, 1992). Group norms, however, may have either positive or negative effects on decision-making. The SIDE theory might be one explanation to the controversy that CMC sometimes seems to wipe out social constrains and be more task-oriented while other times it seems to be more normative and relationship directed (Lea, Spears & Rogers, 2003).

The visibility of members work activity is high in co-located teams. Team members can easily judge how much effort other team members put into the task (Davison, Bélanger & Ahuja, 2006). VTs do not have the same information available but the emergence of VEs is bringing a valuable aspect to the picture. VEs enable team

members to identify others and track their positions in the virtual space (Benford et al., 1997). A study of team collaboration and decision making in VEs has found that avatar-based interaction fosters a higher level of consensus, satisfaction, and cohesion among group members than traditional text-based CMC (Schouten et al., 2010). VEs seem to foster immersion, a feeling of being enveloped and deeply engaged in the VE (Schuemie, Van der Straaten, Krijn & Van der Mast, 2001), which makes it possible for people to work together in richer ways than with traditional communication technologies (Montoya et al., 2010). Avatar gaze, for example, indicates the direction in which a person is looking and other nonverbal communication in VEs are also essential acts of human interaction (Monoyea et al. 2010). VEs are the nearest that VT work can get to co-located teamwork today.

### 2.5.2 The media synchronicity theory

Media richness theory (MRT) (Daft & Lengel, 1986) presented above is one of the most widely used media theories. It has been stated that a richer media is better suited for ambiguous tasks. However, empirical tests of MRT applied in CMC have been mixed (see Dennis, Fuller & Valacich 2008 for examples), and MRT might not be appropriate to measure how well the media is suited for virtual work. With the invasion of VEs, the approach might change because the quality of the media cannot longer be measured only based on media richness. I argue that CMC has unexploited potential, especially since the quality of the media is developing rapidly and people are becoming more and more used to this type of communication.

As a response to MRT, Dennis and Valacich (1999) developed the *media synchronicity theory* (MST). According to MST, decision-making and other tasks requiring team collaboration can be divided into two communication processes: transmission of new information, *conveyance*, and discussion of preprocessed information, *convergence* (Dennis et al., 2008). These two processes require different media capabilities, and it is too broad to state that a media matches the overall task. In Figure 5, different media capabilities and their explanations are listed.

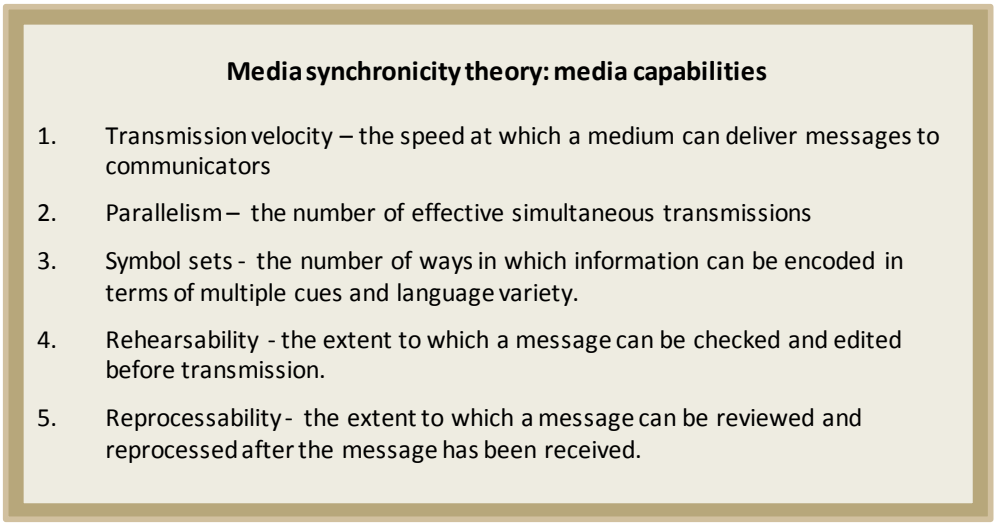



**Figure 5. Different media capabilities proposed by media synchronicity theory (Dennis et al., 2008)**

The media capabilities suggested by MST are not far from the ones proposed by Daft and Lengel (1986) in MRT, but the considerable difference is the role of these capabilities. As noted above, MST suggests that different media capabilities support different stages of the decision-making process. MRT, on the other hand, suggests that different media capabilities are together contributing to the richness of the media and thus the appropriateness of the media for the overall task.

When teams are making decisions, it is important that team members transmit important information they possess to other team members who in turn, have to process this information. At this conveyance phase the media should support effective transmission of information and enable individual processing of the information. (Dennis et al., 2008) Media that enables greater reprocessability, rehearsability and a high degree of parallelism, are more appropriate for conveyance processes.

Convergence is "the discussion of preprocessed information about each individual´s interpretation of a situation, not the information itself" (Dennis et al., 2008, p. 580). At the convergence phase a shared understanding of the task and others viewpoints should be reached. A shared understanding is considered to be vital for successful decision-making performance (e.g., Van Ginkel & Van Knippenberg, 2008). When a medium supports convergence, it is said to allow synchronicity. A medium allows

synchronicity when it has a high velocity rate and symbol sets supporting the ongoing task (Zigurs & Buckland, 1998) and simultaneously a lower degree of parallelism, rehearsability and reprocessability. In a recent study, it has been found that decision-making teams reached a higher level of shared understanding in 3D VEs than in text-based CMC (Schouten et al., 2010). The same study also found that a shared understanding is a critical prerequisite for successful decision-making in VTs.

## 2.6 Studying decision-making and the role of technology in this thesis

In Chapter 2 I presented a framework of analyzing VT decision-making, starting from the input-process-output framework. Then, I explained decision-making in traditional teams and central theories in this field. Finally, I concentrated on decision-making in VTs and the role of technology.

For the methodology used in this study, however, the decision-making and media theories presented have been most influential. Central theories of group decision-making are the groupthink theory (Janis, 1972), the vigilant decision-making theory (Janis & Mann, 1977) and the functional perspective (Gouran & Hirokawa, 1996) and I used them as a foundation to the analysis of decision-making in this thesis. I derived several criteria of team decision-making from these theories in order to get a strong theoretical ground for analysis. In the next chapter, I will explain in more detail how these theories have affected the decision-making coding scheme that I developed. I will also present the additional models that affected the methodology and describe the analyzing process.

In addition to decision-making theories, I examined CMC and other technologies in order to get a picture of how the media affects VT decision-making. Moreover, I discussed Media richness theory (MRT; Daft & Lengel, 1986) and Media synchronicity theory (MST; Dennis & Valachic, 1999). Those were the main bases for analyzing the role of technology in VT decision-making. Especially media synchronicity theory influenced my methodology, since it distinguishes between

different stages in the decision-making process and not merely the richness of the media, as the media richness theory suggests.

# 3. Data and methods

In this section the experiment and the methods used in this study are described in more detail. This study is a theory driven qualitative analysis of decision-making process in VTs. The analysis was aimed at discovering critical factors of failure and success in the teams´ decision-making process and studying what technical features affects the decision-making in VTs.

## 3.1 Experiment

### 3.1.1 Design

As noted in chapter 1.1 this study was based on an experiment with students in groups of three persons each. Half of the groups used a web-conferencing tool with text, audio and video (Connectpro), while the other half of the groups used a virtual environment with avatars (Teleplace). Additionally, these halves were divided into two more groups that were primed with different orientation tasks before the actual test. These two priming tasks were done in order to activate the benefits of individual work vs. group work (see page 40). The division into these four subjects can be seen in Figure 1 (page 9).

The experiments on which this study was based on were conducted at iLab which is a usability and interaction laboratory at Aalto University. The laboratory enables synthetically dispersion of team members without having the team members dispersed geographically (Figure 6). All communication was computer-mediated and the members had barely met FTF before the experiment.

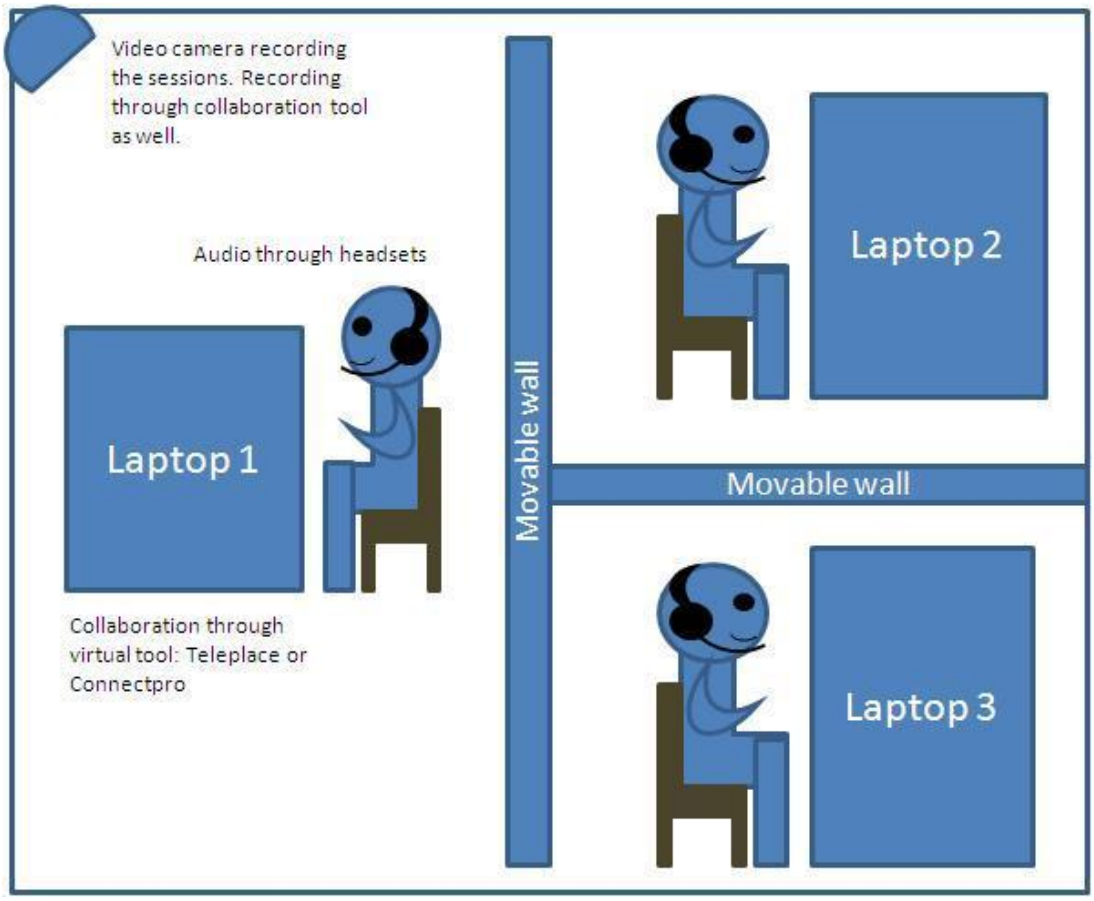



**Figure 6. Experimental setup in this study**

### 3.1.2 Data collection

The experiment constituted of a training session, a short initial survey, a priming task, the actual decision-making task and a last survey session. In the training session, the team members rehearsed the use of the collaboration tool and were trained in using its important functionalities (Figure 7).


**Figure 7. Training session in Teleplace**

After this session they filled out an initial questionnaire about first use impressions, and were primed to the two conditions. This priming task was done in order to influence the people´s Active-Self concept (Wheeler, DeMarree & Petty, 2007). According to this view, the Active-Self concept influences people's motivational and behavioral representations, which guide their behavior. In our study, half of the groups were primed with an individual priming task, which we assumed would lead to a more individual Active-Self. Here the team members wrote a short story about the benefits of individual work in user-centered product development. The other half of the teams were in contrast primed with a group priming task in order to turn on a more group oriented Actual-Self. Here the team members individually wrote a short story about the benefits of teamwork in user-centered product development. After the priming task they went on to the main task of the experiment where the persons had to solve a classic group communication and decision making exercise called "Survival on the moon" (Wilderdom, 2011). The team had 20 minutes to solve the task. These sessions were automatically recorded in order to enable further analysis and coding. In Teleplace the recording mode was chosen to be a so called "birds view" (see Figure 10) in Connectpro the recording captured the shared screen view in real time (see Figure 9). After the teams had completed the task, they filled out a

last questionnaire about their use experiences. The whole task description can be found as an appendix (Appendix 1) but the questionnaires are omitted because they were not used for the analysis in this study.

### 3.1.3 Participants

The participants in this study were 63 undergraduate students at Aalto University School of Science. Participation in the experiment was a subtask of a user-centered product development course. The students formed groups of three persons each, and we sought to form groups of people that had not worked together before. Due to practical reasons students were able to register to any group they wished. The survey revealed that 56% of the students had not done any work together before, while the rest had done little (34%) or much (10%) work together.

Furthermore, all students did not show up for the experiment so three groups did not qualify for the analysis of this thesis. The original amount of 24 groups (72 people) was thus decreased to 21 groups (63 people) that have been used in the analysis in this study.

The participants were spread over an age range of 19-30 years old. The average age of the participants was 22,5 years old. 70 % of the participants were men. 90 % of the participants had no experience with the technologies that were used in the experiment.

Figure 8 demonstrates the division of those 21 teams that qualified for the data analysis.

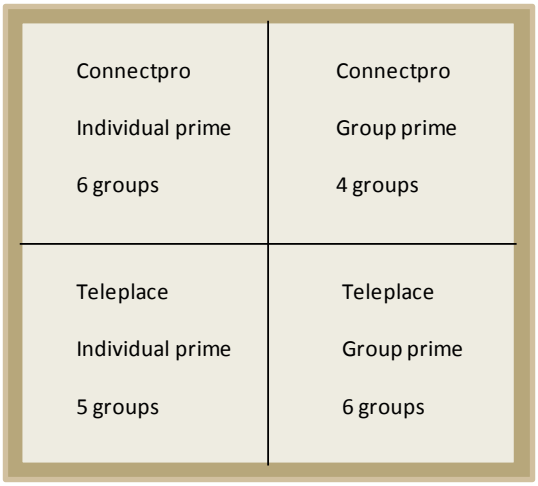



**Figure 8. The 2x2 experimental design of our study with 21 teams**

### 3.1.4 Task and its performance metrics

The task that the groups had to perform was a classic group communication and decision making exercise, called "Survival of the moon" (Wilderdom, 2011). The task was to rate a list of different items in order of importance together in the group. The scenario was a crew that was returning to the mother ship on the sunlit side of the moon after carrying out a 72-hour exploration trip. The crew crash-landed about 300 kilometers from the mother ship and had to return to it in order to survive. With this goal in mind the group had to arrange a list of 15 items according to how important they were for getting the crew back to the mother ship. The whole task description can be found as an appendix (Appendix 1).

According to the inventors of this task people tend to get intensely engaged because their survival is at stake in the task and the decisions are not easy to make. The team performance is measured by error points. There is a specific order of the items that is right, rated by NASA experts. If a team arranges the items exactly in this order it would receive 0 points. Consequently, the less points a team receives, the more successful it is. For each item, the number of points that teams score differs from the NASA ranking is marked and added up to the total points. The lower the total, the better the team´s score. Plus or minus differences are disregarded. According to the NASA ranking the team success can be categorized as follows:

0-25 points = excellent
26-32 points = good
33-45 points = average
46-55 points = fair
56 -70 points = poor
71-112 points = very poor

Measuring the teams´ success based on scores is an outcome-oriented approach. A process-oriented approach might be more suitable for real work tasks (Harris & Sherblom, 1998). According to Fisher (1980) researchers should study and compare communication behavior in groups with high-quality decisions to groups with lower-quality decisions in order to improve group decision making. This study sought answers to both high- and low-quality decisions. It does not start from the

outputs, i.e. the NASA ranking points; instead it investigated the decision-making process in detail and last, put the findings in relation to the scores that the teams were ranked with.

### 3.1.5 Technology used

Two established collaboration technologies, Connectpro and Teleplace, were used in our experiment. Half of the teams used Connectpro and the other half Teleplace. Connectpro is a web conferencing software tool enabling text, audio and video. (Adobe Connect 8, 2011). The structure of Connectpro is presented in Figure 9.

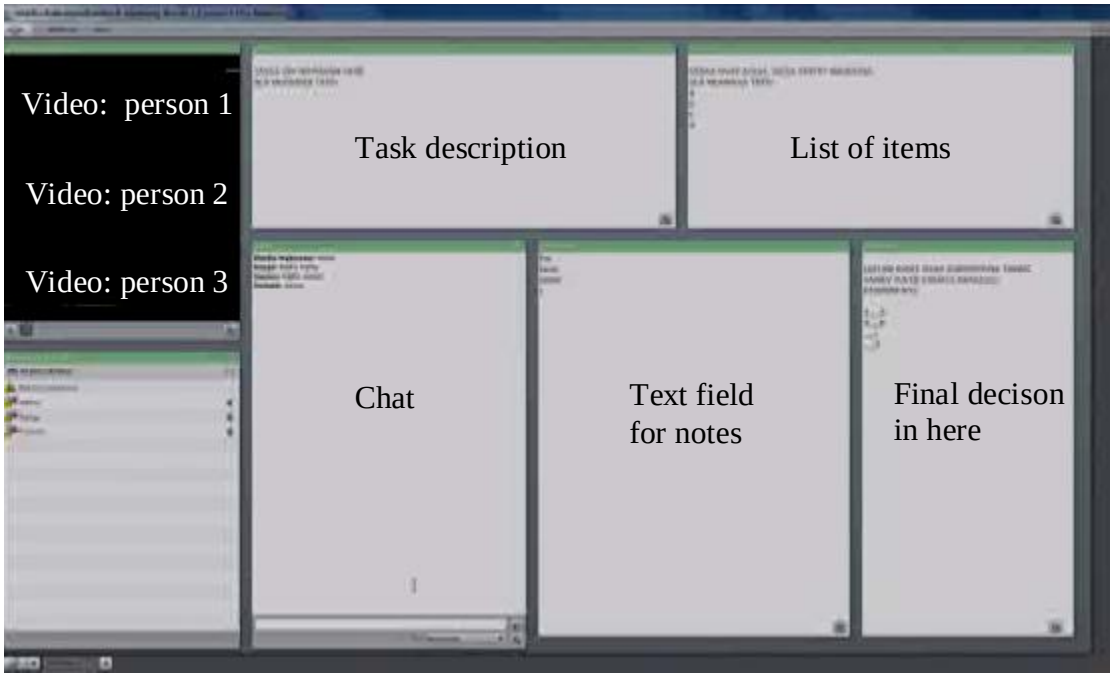



**Figure 9. The view of different functions in Connectpro**

The specific divisions of the text fields used in this experiment were: task description, a list of the items to arrange, a chat window, a text field for notes and a window where the items should be numbered in order of importance in the end (Figure 9).

Like Connectpro, Teleplace is an online collaboration tool (Teleplace, 2011) but apart from Connectpro, Teleplace is a 3D virtual environment with avatars representing the team members (Figure 10). An avatar is a digital character that

represents a person's identity in a virtual environment (Conway, 2007) and whose actions are controlled by a person in real time. In addition, Teleplace supports text, audio and video and was assumed to be a richer media than Connectpro.

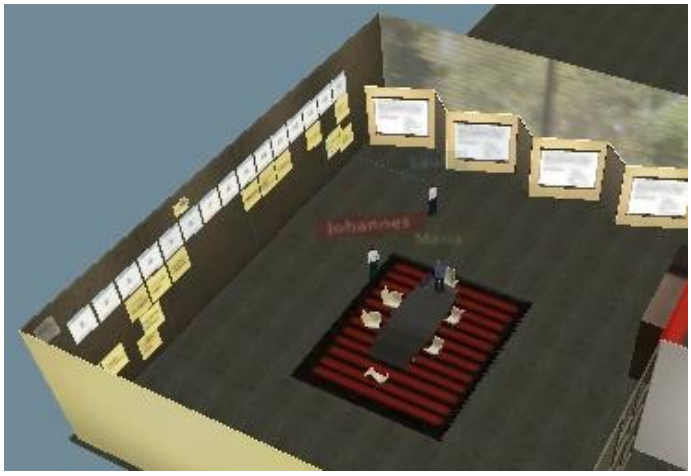



**Figure 10. The Teleplace work room, seen from "birds view"**

In this study, we did not use videos in Teleplace which might have put the two media in a more equal position. The work room that was used in Teleplace is presented in Figure 10. The four boards to the right presented the task description while the patches on the wall to the left presented the items that the team had to arrange in order of importance. Figure 10 illustrates how the members implemented their decision by moving patches on the wall under the numbers 1-15. A "laser pointer" appears when a person is editing some content, e.g. moves a patch. Visibility of other members' activity is high in Teleplace.

## 3.2 Qualitative data analysis

The original hypotheses were that the virtual environment, Teleplace, would lead to better results than Connectpro and that the group primed groups would perform better than the individual primed groups was not supported. The initial analysis revealed that the results contrasted the original hypothesis. This led me to question what actually caused success or failure in the groups and what characterized their

decision-making. With these questions in mind, I decided to conduct a qualitative analysis on enablers and hindrances of group decision-making process.

As noted before, a potential way of evaluating the success of decision-making is to compare the decision-making procedure that led to bad decisions to a successful decision-making procedure. (Fisher, 1980; Harris & Sherblom, 1998) This is difficult to assess quantitatively (Harris & Sherblom, 1998) and a better approach would be to do a qualitative analysis. A qualitative analysis is appropriate for gaining a deeper understanding of the process behind a phenomenon (Corbin & Strauss, 2008). The survey that the participants filled out after they had completed the moon task was not included in the analysis of decision-making because it did not provide relevant material for the research questions.

All the experiment sessions were recorded to enable transcription of them. Both the spoken and written discussion was transcribed by me. The different persons were distinguished based on different colors. Analysis of discussion was crucial since the groups had to discuss in order to arrive at group decisions. The results about technology specific features of the decision-making process in these virtual teams were obtained by observation of the video tapes. For the analysis of the decision-making process, a coding scheme was developed to suit this study. I will next present this coding scheme and explain how it was built.

### 3.2.1 Background of coding scheme

The coding scheme that was used for mapping the teams´ decision-making in this study (see Appendix 2) was derived from the decision-making theories presented in the previous chapter in combination with the Interaction Process Analysis (IPA) scheme (Bales, 1950) and the Argument coding scheme (Meyers, Seibold & Brashers, 1991). IPA is widely used in studies about group interaction and consists of 12 different communicative acts which can be tracked in group interaction. The Argument coding scheme is another coding scheme that goes deeper into the discussion and especially argumentation. Moreover, these two models fitted well to the set-up of this study and enabled a more detail analysis of team interaction and

communication. The decision-making theories included were the groupthink theory, the vigilant decision climate, and the functional perspective.

#### 3.2.1.1 Influences from decision-making theories

The groupthink theory, the functional perspective and the vigilant decision-making theory presented in chapter 2, all influenced the construction of the coding scheme. The theories were not included as such but rather processed to suit this study. Some aspects of these theories were not relevant for this study and were therefore left out.

The groupthink theory was included because several of the antecedent conditions that can result in groupthink were present in the groups. The nature of the survival task could have enhanced cohesiveness. Moreover, the groups may have suffered from structural faults such as isolation, lack of impartial leadership and possibly the lack of adequate decision-procedures. Furthermore, the time restriction of 20 minutes raised the level of external stress. All these antecedent conditions can result in strong concurrence seeking, groupthink symptoms and decision-making defects. I was most of all interested in investigating whether the decision-making defects proposed by Janis (1982) were found in the groups in this study. Therefore codes that concerned discussion of alternatives, survey of objectives, evaluation and reevaluation of decision and information search were included.

Some years after Janis presented his groupthink theory he and his colleague Mann (1977) listed specific communication behaviors that characterized a vigilant decision-making climate. This is a central basis of the coding scheme in this study and it can be argued that the more of these vigilant characteristics are found in a group the more likely the group is to reach high quality decisions. Codes that were included from this theory were concerning: the evaluation of positive and negative consequences of alternatives, the questioning of members' propositions, the information search climate, what decisions are based on, and reevaluation of decisions.

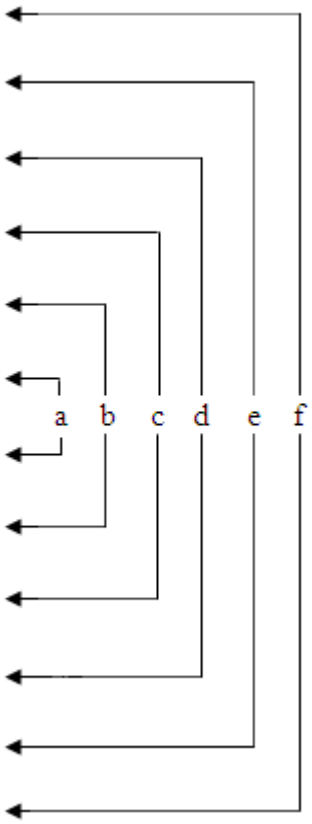
The functional perspective, which differs from the vigilant decision-making theory, e.g. on the importance of task requirements, has also been highly integrated to the coding scheme. Codes providing information about the groups understanding of the task, identifying of alternative solutions, evaluation of the solutions, reevaluation and reconsidering final decision, and making possible changes to the final result were included in the coding scheme. The determination of minimal criteria any decision must possess was left out because it is not central to the task in my study. Moreover, overcoming of cognitive, affiliative, and egocentric constraints were also left out because this study did not focus on the people's feelings about the situation nor socio-emotional aspects of the decision-making.

#### 3.2.1.2 Interaction Process Analysis

Bales (1953) proposed that a group working on a common task has to manage orientation, evaluation and control. Orientation is the first stage where the group creates an understanding about the task and acquires relevant information. Here it is important to exchange ideas and thoughts that in the next step are evaluated. The evaluation stage will most likely result in a group decision. Depending on the stressfulness of the situation the group members might start to exert control over each other in order to reach a decision successfully.

Based on these assumptions about group interaction Bales (1950) has developed the IPA coding scheme for analyzing group interaction (Figure 11). This scheme breaks down group interaction into smaller series of acts that can be observed and coded.

| | |
|---|---|
| 1. | *Shows solidarity*, raises other´s status, gives help, reward |
| 2. | *Shows tension release*, jokes, laughs, shows satisfaction |
| 3. | *Agrees*, shows passive acceptance, understands, concurs, complies |
| 4. | *Gives suggestion*, direction, implying autonomy from other |
| 5. | *Gives opinion*, evaluation, analysis, expresses feeling, wish |
| 6. | *Gives orientation*, information, repeats, clarifies, confirms |
| 7. | *Asks for orientation*, information, repetition, confirmation |
| 8. | *Asks for opinion*, evaluation, analysis, expression of feeling |
| 9. | *Asks for suggestion*, direction, possible way of action |
| 10. | *Disagrees*, shows passive rejection, formality, withholds help |
| 11. | *Shows tension*, asks for help, withdraws out of field |
| 12. | Shows antagonism, deflates other´s status, defends or asserts self |




A sub-classification of system problems to which each pair of categories is most relevant

a. Problems of orientation
b. Problems of evaluation
c. Problems of control
d. Problems of decision
e. Problems of tension-management
f. Problems of integration

**Figure 11. The Interaction Process Analysis (IPA) coding scheme (Bales, 1950)**

Based on these categories, it is possible to create an interaction profile of the group as a whole. These profiles might be used for finding similar patterns among successful and less successful groups. A specific research hypothesis can also be tested, e.g. by looking at a particular variable in group process and see how it is related to group success (Brown, 1988).

In this study, the categories a, b, c and d were almost entirely integrated in the coding scheme. The categories e and f are only partly included because they stresses socio-emotional issues more than task related issues and this study focuses on task related aspects of the decision-making process. The aim with integrating IPA into

the coding scheme was to find what types of communicational acts relevant for decision-making process in VTs.

#### 3.2.1.3 Argument Coding Scheme

Interpersonal influence processes is significantly influencing group decision-making and patterns of argument are central in the role of communication (Seibold, Meyers & Sunwolf, 1996). Researchers have studied how the nature of argumentation affects decision-making and how it characterizes effective and ineffective groups (see Meyers et al., 1991 for examples). Different coding schemes have been developed for empirical research on argumentation (e.g., Canary, Brossmann & Siebold, 1987; Meyers et al., 1991). According to Meyers´ and colleague´s (1991) revised coding scheme, arguments can be divided into categories such as: arguables, reinforces, promptors, delimiters and nonarguables (Meyers et al., 1991). A simplified version of the coding scheme is presented below.

ARGUMENT CODING SCHEME

ARGUABLES:
Statements of fact or opinion and possibly call for support or conference
Elaborations of statements, providing evidence, reasons or other support
Amplifications, explanations/expansions of statements in order to establish relevance of the argument

REINFORCES:
Agreement with another statement and possibly followed by elaboration or amplification

PROMPTORS:
Disagreement of another statement and possibly followed by explanation

DELIMITORS:
Statements that provide context for arguable or provides a common ground

NONARGUABLES:
Non-argument related statements for orientation
Unrelated statements to the task. (Meyers et al., 1991)

In Meyers and colleague's study (1991), it was found that assertions, elaborations and agreement statements were most frequently used in decision-making groups. In

a study with computer-mediated teams, it was found that arguments supporting decision proposals were more common than arguments showing disagreement (Lemus, Seibold, Flanagin & Metzger, 2004). Many studies in FTF settings have shown similar results (e.g., Meyers et al., 1991, Canary, Brossmann & Siebold, 1987). This may, however, be problematic if it leads to failures in questioning other members' statements for hidden spots and defects. Too high consensus may lead to groupthink and poor choices (Janis, 1972).

Statements of a fact or an opinion are more convincing and easier for other members to evaluate when they provide evidence for them. Take, for example, a statement like "oxygen tank is the most important item to bring to the moon" and a more elaborated like "oxygen tanks is the most important item to bring to the moon (conclusion) because a human cannot survive without oxygen (premise)". The second statement is easier for members of the decision-making group to consider and base their decisions on (Jensen & Chilberg, 1991). Recognizing fallacies in arguments is another useful skill in groups and requires much critical thinking. It is most likely easier to find gaps in other people's logic than it is to produce flawless arguments of our own (Jensen & Chilberg, 1991).

This argument coding scheme has influenced the coding scheme in this study highly. Most of these communicational acts are relevant to decision-making in VTs. By digging deeper into argument acts I strived to find out how and what kind of statements were shared and how members received and acted upon statements.

### 3.2.2 Coding scheme in this study

The transcribed recordings were coded in a qualitative data analysis program, Atlas.ti. The coding scheme used, was constructed to enable a detailed mapping of the decision-making process at both individual level acts as well as group level acts. The idea was to use a bottom up strategy, by first mapping the groups' interaction at individual level and then move on to larger entities. By doing so I strived to get a picture of the group decision-making process at a broader level, without forgetting the smaller communicational acts that also are important in decision-making in

teams. Next, I will first present the individual level scheme and then explain how the picture of the whole groups´ decision-making was emerged during the coding process. The different colors used in the transcribed text distinguish the different persons in the group so that it is possible to track who speaks and when.

#### 3.2.2.1 Analysis of individual level

The whole individual level coding scheme can be found as an appendix (Appendix 2) but I will present some main categories with examples to get a picture of the types of questions used. The main questions that the coding categories were built upon are presented in Figure 12. The first category for coding concerned whether the members showed a correct understanding of the task and whether they managed to set up a clear procedure how to carry out the task and delegated tasks inside the group.

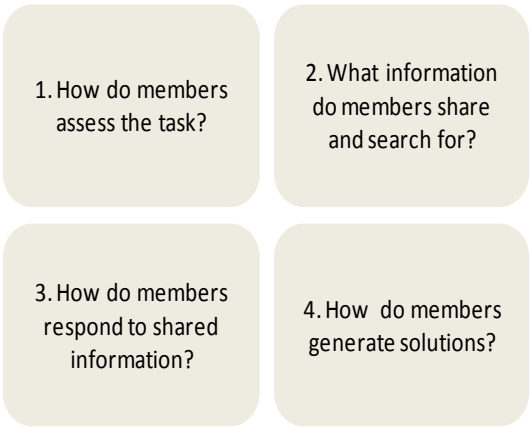



**Figure 12. Main categories that build up the coding scheme**

One example from the first category is:

a. *A group member manages to set up a shared goal to the group in the beginning of the task*
   i. *And show a correct understanding of the problem*
   ii. *But does not understand the problem correct*
b. *A group member does not manage to set up a shared goal in the beginning of the task.*

From these statements I constructed code names for Atlas.ti such as *Sharegoal_right* and *Sharegoal_wrong* and I coded all sentences matching this code. In some cases, one sentence could be presented by several codes, and was thus given several codes. Figure 13 illustrates a simple example on how sentences were coded. The sentence

"I think that the task is to walk all the way to the mother ship" have been coded as Sharegoal_right, and "Yes I agree" and "Ok" are both coded as Agreement_simple.

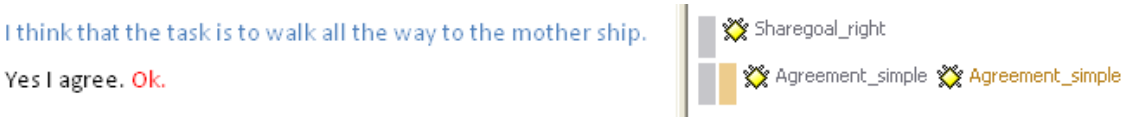



**Figure 13. Illustrative example of how sentences are coded in Atlas.ti**

The second area of the categories concerned information sharing. The nature of the information, the nature of suggested solutions as well as different aspects of orientation were mapped. An example from this category is:

*INFORMATION SHARING:*

a. *A member gives a valuable statement which is a fact or opinion*
    i. *With an explanation*
    ii. *Without any explanation*
b. *A member gives an inaccurate statement or opinion*
    iii. *With an explanation*
    iv. *Without any explanation*
c. *A member gives an irrelevant statement for the group's decision-making (tangents, side issues, self-talk, jokes )*

From these statements I again named codes for Atlas.ti such as *shareinfo_valuable_explanation*, *shareinfo_valuable_noexplanation*, *shareinfo_inaccurate_explanation*, and so on.

Another aspect this category mapped was information search. In this category, members´ requests for information, solution suggestions, evaluation on ideas and help with orientation were coded. An example from this category is:

*SOLUTION SUGGESTION:*
*A member asks for solution suggestions / solution directions.*

The third category dealt with responses that team members gave to other member's statements and suggestions. The coding scheme distinguished between simple agreement and agreements with elaborations or evidence and correspondingly for disagreement. Evaluation, defense and clarification of information were coded separately. An example of a category regarding responses is shown below.

*AGREEMENT/ + ELABORATION*

*a. A member gives a simple agreement on a statement*

*b. A member gives an agreement on a statement*

*i. With an explanation (evidence, reason, other support) in the right direction.*

*ii. With an explanation (evidence, reason, other support) in the wrong direction.*

Fourth, acts concerning generation and evaluation of solutions were mapped. Here the aim was to evaluate, how decisions were made. Codes were built on how preliminary decisions were made, how decisions were reevaluated, were fallacies recognized, was important information overlooked, and did the members agree upon their final solution. One example of this category is:

*PRELIMINARY DECISION:*

*A member makes a preliminary decision*

*a. Without any/or little discussion*

*b. After discussion*

#### 3.2.2.2 Analysis on group level

The transcribed recordings that were coded in Atlas.ti were also used for analysis on group level. An example of how the group discussion was coded in Atlas.ti according to the coding scheme is presented in Figure 14. The codes to the right are individual level codes except from the first two G_EVALUATION+ and G_DECISION+ that present group level codes. G_EVALUATION+ means that the group carried out a good evaluation with thorough discussion together in the group and G_DECISION+ means that the group reached a good decision in the end of the evaluation.

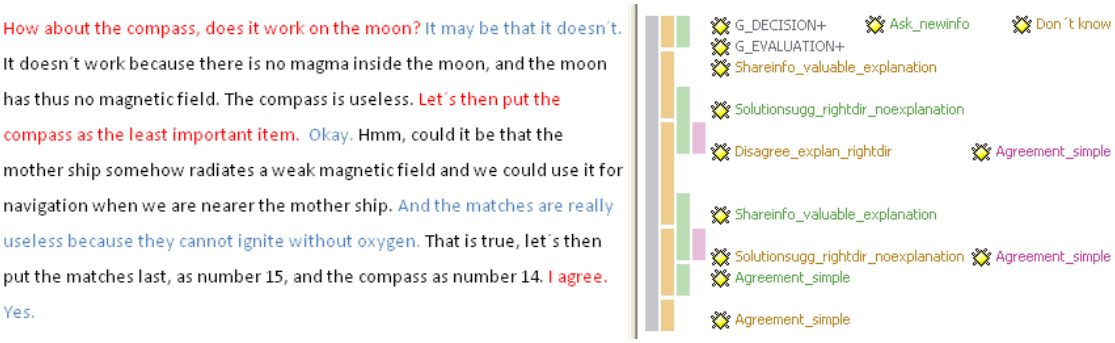



**Figure 14. An example of the coding procedure in Atlas.ti**

After every group had been coded with individual level codes I started to categorize larger entities similarly as the example presented above. Unlike the individual level coding procedure, the group level codes were not given to single sentences, but rather to discussion episodes that included several sentences. I looked at these discussion episodes and mapped the central characteristics of them. The codes that were derived at this stage described discussion episodes over one subject (e.g. about compass in Figure 14 above) and represented group level acts. The group level codes derived during the coding process were not directly based on background theories. Instead, these codes were derived by thoroughly analysis of the discussions, looking at the meaning of the conversation in combination with all the member level codes given to the sentences in the discussion.

The discussion in Figure 14 includes several members´ opinions, questions, valuable information sharing and responses about the same subject. In the end of the discussion the group reaches a successful decision. The discussion in Figure 14 is thus characterized by a good evaluation leading to a successful decision and coded by group level codes such as G_EVALUATION+ and G_DECISION+. These two codes together, describe an act at group level.

For another example, the two codes G_SOLUTION_BRAINSTORMING- (the group discussed shortly about a possible solution) and G_DECISION-_UNPROCESSED (the group makes a rapid, faulty decision) were given to the discussion below.

*"I think that the compass is really important because we can navigate with is. Yes that is probably better than the stellar map. I agree, let´s put it as number four."*

This discussion could not be coded with the same codes as the discussion presented in Figure 14 because this discussion was no thorough enough to be characterized as an evaluation and the decision was not discussed at all, but rather rapidly made, which explains the second code G_DECISION-_UNPROCESSED. The code G_SOLUTION_BRAINSTORMING- means that the group discussion was rather brief and incomplete, and in this case, built up of faulty assumptions.

By finding these group level categories the aim was to raise the abstraction level of the coding in order to disclose the upper level structure of the group's entire decision-making process. In each group, I looked at the group-level codes and constructed patterns that described the behavior best. After that I compared the group patterns and named the final success and failure factors of decision-making. The fact that the VTs, in which the decision-making process consisted mainly of success factors were incidentally those that gained low group scores (low number of error points) in the task. That is, the scores did not dictate the coding and analysis.

## 3.3 Analyzing technology observations

In addition to coding the prescribed group discussions at individual and group level in Atlas.ti, I analyzed the video recordings. This was done in order to get a picture of the role of technology in VT decision-making, and in order to find out how different media features and capabilities affected the decision-making process. At this stage, possible differences between Connectpro and Teleplace were tracked. This part of the analysis was less theory driven, although both MRT (Daft & Lengel, 1986) and MST (Dennis & Valachic, 1999) influenced this analysis of the recorded content.

At first, I analyzed to what extent the two technologies (Connectpro and Teleplace) supported the media capabilities mentioned in MRT and MST. The result from this part is presented in chapter 5.1.5 of this thesis (Figure 20). The main part of the analysis of technology observations, however, consisted of tracking the actions of

team members and their use of technology in decision-making process. When I analyzed the observations of the recorded content of the groups´ interaction, I had some particular questions in mind that guided the analysis. I sought to answer the following questions:

1. How the teams utilized the different features of the technology in their decision-making process? In Connectpro, I looked at how they used audio, video, different text fields, and the chat in their decision-making. In Teleplace, I looked at how they used audio, chat, avatars, and moved the patches during their decision-making.
2. How the media supported parallel acts of the team members and how this affected team decision-making? For example, I observed how the possibility of simultaneous moving of patches in Teleplace groups affected the decision-making procedure and its result. In Connectpro groups, on the other hand, I looked at how the lower possibility of parallel acts affected the decision-making procedure and subsequent decision. Here, my observations were partly based on MRT.
3. What the sequences of actions were in the team leading to their final decision? I wanted to find out if there were any differences in decision-making procedure between a web conferencing tool and a virtual environment.
4. Did any particular roles emerge in the groups? Did anyone take the role as a leader or for instance as a secretary? I also looked at the team members' contributions and whether they participated equally or with varying effort.

# 4. Results

In this section, the results from the analysis of collected data are presented. The results were reached with the coding scheme developed for this study and by analysis of video tapes. The main findings answered the two first research questions in this study, highlighting critical factors in successful decision-making as well as the nature of unsuccessful decision-making. I will present some examples from the group discussions that illustrate some aspects of the decision-making process. Since the groups used Finnish as their spoken language, I have translated the quotations into English. I will also present some special features of the decision-making procedure in Connectpro and Teleplace and highlight some differences between the two technologies in chapter 4.2 and answer the research question 3 there.

## 4.1 Critical factors in successful and poor group decision-making process

This chapter will go through critical factors of successful and unsuccessful group decision-making processes. The groups in this study were categorized in three different degrees of success, based on the points they received (Table 1).

**Table 1. Division of the groups into different level of success**

| Successful groups | Moderate groups | Unsuccessful groups |
|---|---|---|
| 18 – 26 points | 30 – 32 points | 38 – 47 points |
| G1 - G7 | G8 - G12 | G13 - G21 |

As can be seen in Table 1, seven groups received points between 18 and 26 and were categorized as successful, five groups 30-32 points and were categorized as moderate and nine groups received 38-47 points and were categorized as unsuccessful. It is noticeable here that none of the teams were poor according to the NASA ranking. This may be due to the fact that all groups were comprised of students in engineering and thus had knowledge in natural sciences which probably helped them in the "moon task".

Initially, I will present the central factors that were found in the decision-making processes in general. After that I will highlight which of these were prominent in successful groups and finally which were prominent in unsuccessful groups.

### 4.1.1 Group level characteristics

As I analyzed the group level codes in Atlas.ti, I found the following categories that described the overall picture of a specific group's decision-making. These categories presented different aspects of the decision-making process at a more abstract level than the single codes used throughout the group analysis. Factors in class A constitute valuable elements of decision-making, while categories in class B describe less wanted behavior (Table 2).

**Table 2. Division of factors into good and poor factors in team decision-making**

| Element | Class A: valuable elements of decision-mak | Class B: poor elements of decision-makin |
|---|---|---|
| 1 | Correct understanding of the task | Wrong understanding of the task |
| 2 | Thorough discussion before decision | Many unprocessed decisions |
| 3 | High amount of valuable information shared | High amount of incorrect information shar |
| 4 | Much questioning | Little questioning |
| 5 | Reevaluation | No reevaluation |
| 6 | No major wrong assumptions | Major wrong assumptions |

The first category assesses the aspect of understanding of the task. Groups understood the task right (1A) or wrong (1B). The second category describes the nature of discussion in the group. Some groups were characterized to have thorough discussions before making decisions (2A) while other seemed to rush into decisions and make many unprocessed decisions (2B). Category 3 concerns information sharing and shows three different kinds of information sharing that were tracked. These were high amount of information shared of either valuable (3A) or incorrect (3B) information. The forth category assesses the questioning climate in the groups. Groups were found to question much (4A) or little (4B) or somewhere in between, which is not lifted up to an own class. The fifth category that was found concerned the last part of the groups' decision-making process. Some groups reevaluated their

decisions in the end (5A) while others skipped this phase (5B). The last factor that was found to affect the decision quality highly was whether the group made some major wrong assumptions (6B) or not (6A). These wrong assumptions or misjudgments about some information were highly impairing the decision quality and was thus highlighted as an own factor.

### 4.1.2 Characteristics of successful group decision-making

Out of twenty-one groups I found seven groups (G1-G7) that performed significantly better than the other groups and five groups (G8-12) that performed moderately well. The different factors that characterized their decision-making process are depicted in Table 3 and Table 4. The categories 1A/B – 6A/B are the same that were presented in Table 2 in previous chapter. The technology used by each group is marked to tables 3 to 5 with acronyms CP (Connectpro) and TP (Teleplace).

**Table 3. Central factors in successful team decision-making (n = 7)**

| G 1 | G 2 | G 3 | G 4 | G 5 | G 6 | G 7 |
|---|---|---|---|---|---|---|
| 1A | 1A | 1A | 1A | 1A | 1A | 1A |
| 2A | 2A&2B | 2A | 2A | 2A | 2A | 2B |
| 3A | 3A | 3A | 3A | 3A | 3A | 3A |
| 4A | 4A | 4A | 4B | 4B | 4B | 4A |
| 5A | 5A | 5A | 5A | 5A | 5A | 5A |
| 6A | 6A | 6B | 6B | 6B | 6A | 6A |
| CP | CP | CP | CP | CP | TP | TP |

1A. Correct understanding of the task
1B. Wrong understanding of the task

2A. Thorough discussion before decision
2B. Many unprocessed decisions

3A. High information sharing (valuable)
3B. High information sharing (incorrect)

4A. Much questioning
4B. Little questioning

5A. Reevaluation
5B. No reevaluation

6A. No major wrong assumptions
6B. Major wrong assumptions

**Table 4. Central factors in moderate team decision-making (n = 5)**

| G 8 | G 9 | G 10 | G 11 | G 12 |
|---|---|---|---|---|
| 1A | 1A | 1A | 1A | 1A |
| 2A&2B | 2A | 2B | 2A | 2A&2B |
| | 3A&3B | | 3A&3B | |
| 4A | 4B | 4A | | 4A |
| 5B | 5A | 5A | 5A | 5A |
| 6A | 6B | 6B | 6B | 6A |
| CP | TP | TP | TP | TP |

### 1A: Correct understanding of the task

A first convincing factor that was found in all successful decision-making teams was that they showed a correct understanding of what they had to achieve. Six of seven groups discussed the goal at some point in the decision-making process, and thus created a shared understanding of the task.

*"So we have to walk 300 km to the mother ship? Yes. Apparently".*

In this simple conversation above, all three members took part and knew what to keep in mind when making decisions. It is striking that all successful groups contained this factor (1A). Also all the five groups (G 8 – G 12) that classified in the moderate successful cluster, showed a correct understanding of the task. I argue that this is a fundamental aspect of successful decision-making.

### 2A: Thorough discussion before decision

The second factor that was found in most successful groups was that they thoroughly discussed items before making a decision. Depending on the virtual tool used this was carried out in slightly different ways. In Teleplace, verbal communication was the dominant way of discussion. Merely one out of all eleven Teleplace groups used writing (chat) as a help to memorize discussed matters. In Connectpro, writing played a significant more central role in discussion. Six out of the seven successful groups used the reflection area for visualizing their decisions and to write notes about the different targets that had to be arranged in order of

importance. Group 7 did not classify into this category and discussed issues very shortly and made many rapid decisions. Group 2 was categorized by both 2A and 2B, since they additionally to thorough discussion before decisions also made many unprocessed decisions.

**3A: High amount of valuable information shared**

All successful groups were categorized by a high information sharing climate. The information was furthermore of valuable kind such as:

> *"The stellar map is very important so that we can navigate to the mothership."*
>
> *"Oxygen tanks are the most important item to bring with us, because there is no oxygen on the moon and a human cannot survive a minute without it."*
>
> *"A box of matches is useless, because they do not ignite without oxygen."*
>
> *"The compass does not work because the moon has no magnetic field."*

These examples of information are bringing valuable help for the decision-makers, in comparison to statements such as "*The compass is useless*". If someone is unaware of the lack of magnetic field on the moon it would be difficult to rank this statement. In worst case the group would agree upon it without questioning further.

High information sharing of valuable facts is a core feature of successful decision-making process. Without sharing valuable facts, it is difficult for the team to derive high quality decisions. Then the decision-making process would rely more on speculation and the level of uncertainty would increase.

**4A: Much questioning**

Four out of the seven successful groups were categorized to have a high questioning climate. They questioned other members statements and suggestions and did not simply agree upon every suggestion. One example of how a discussion in one of these groups looked like is presented below:

*"What about the Solar-powered FM receiver-transmitter? It can be quite important, or wait a minute, it doesn´t work on the moon. I was also thinking that maybe the frequency is wrong on the moon. I mean it doesn´t work at all in space. Okay. Why doesn´t it work? I think that the FM could have some affect on the signal. Radio broadcasts and satellites are working fine so what is different here? FM is a modulation method and should not affect the waves. And waves are proceeding in empty space as well. Then the FM receiver-transmitter is very important so we can contact the mother ship. I agree, let´s put it next! Yes."*

This example illustrates a group with high questioning. The member that questioned why the FM receiver-transmitter does not work started a discussion with much valuable information. Without this questioning act, the group may have reached a poor decision. This example also illustrates a possible discussion that classifies the factor thorough discussion before decision (2A).

Three out of the seven successful groups did not question much and were instead characterized by a climate of much simple agreement. In the five groups (G 8 – G 12) that classified in the moderate successful cluster, three groups were characterized by high questioning and one by low questioning. It seems like a high level of questioning is a good feature of a good decision-making process but it is not a requirement. High questioning increases the possibility to find fallacies in other members' statements, but does not in itself lead to high quality decisions.

**5A: Reevaluation**

Reevaluation was the third factor that was found in all successful groups. This was in some of the groups only a short stage where they quickly went through the items order and agreed upon their final solution. In other groups though, the reevaluation were more thorough and did contribute to their success. Below, an example of a good reevaluation is presented.

*"Is this order now ok? Let´s go through it one more time. Okay, so first oxygen because we cannot survive a minute without it, then water, then the stellar map*

*for navigation...and last the pistols because there are no enemies on the moon. Hey wait a minute, why did we put the compass as number 10 when it doesn´t work? Good question, it should actually be the least important item, number 15. Yes, we still have time to make changes so let´s put it there. Sure! Yes. So how is the order now?...”*

The group, whose reevaluation is presented above, recognized some major defects in their solution and did some important changes in the end. For this group reevaluation saved them from some mistakes that they were about to make.

Four out of the five medium successful groups carried out a thorough reevaluation in the end before reaching a final decision. I argue that this was one thing that saved these groups from making poor decisions. Reevaluation gives the group the opportunity to go through their decision one last time and find defects in their decision.

**6A: No major wrong assumptions**

Three out of the seven successful groups made some major wrong assumptions about the task that deteriorated their performance. Two of these groups made the assumption that they were at the dark side of the moon and thus it was very cold, while this were not the case. The task was very ambiguous in this aspect, and it was not straightforward to decide whether the team was on the dark or the sunny side of the moon. Actually, 12 out of all the 21 teams made this same assumption which led to significantly poorer results.

#### 4.1.2.1 A perfect decision-making group

The group that performed best of all groups (G 1) received 18 points and was characterized by using all factors of successful decision-making:

**1A: Correct understanding of the task**
**2A: Thorough discussion before decision**
**3A: High amount of valuable information shared**
**4A: Much questioning**
**5A: Reevaluation**

**6A: No major wrong assumptions**

First of all, they assessed the task correctly and discussed things thoroughly before making decisions. They also shared much valuable information and questioned each other's statements. In the end, they reevaluated their decisions, but did not find it necessary to change anything anymore. A typical discussion in the group is presented below.

*"What is the most important item? I consider water to be the most important, without it we would die if we have to walk for 5 days. That is true, but I also think that oxygen is vital for survival. Yes, without oxygen we would die in a minute, should we put it first? Absolutely! Yes. "*

Here one can notice how disagreement followed by valuable facts resulted in a flawless decision. Thorough evaluation is an important factor of high quality decision-making process.

#### 4.1.2.2 Conclusions on successful groups

One conclusion that holds for every successful group is that their decision-making process is constituted mostly of factors in class A, describing the valuable factors of team decision-making. Every successful team had 4 - 6 factors in class A and only 0 - 2 factors in class B, describing the detrimental factors of team decision-making. It is noticeable here that the group that performed best was characterized by having all six factors in class A. The moderate groups had correspondingly 3 – 5 factors in class A, and 1 - 3 factors in class B. Their decision-making was also built up of mostly valuable factors, but the distinction was not as clear as for the most successful groups. The only conclusion about these groups that can be drawn is that they all understood the task right and that reevaluation in the end saved most of these groups from ending up in the unsuccessful cluster.

I argue that a couple of deficient factors in a group´s decision-making process do not lead to failure provided that the majority of the factors are in class A. A right understanding of the task, a high amount of valuable information shared and a

reevaluation in the end was found in all seven successful groups. A right understanding of the task is laying the right conditions for the decision-makers and is thus one of the most important factors in a successful decision-making process. High sharing of valuable information is also vital for groups to make accurate decisions, without uncertainty and speculation. Last, reevaluation can save a group from letting defective decisions pass through. Thorough discussion before decision and high questioning, which were found in most successful groups, can help the group to discover shortcomings and fosters a higher information sharing climate.

### 4.1.3 Characteristics of unsuccessful group decision-making

Out of twenty-one groups, nine groups failed in many aspects of their decision-making process. The different factors that characterize their decision-making process are shown in Table 5. The categories are the same that were presented in Table 2 in chapter 4.1.1.

**Table 5. Central factors in unsuccessful team decision-making process (n = 9)**

| G 13 | G 14 | G 15 | G 16 | G 17 | G 18 | G 19 | G 20 | G 21 |
|---|---|---|---|---|---|---|---|---|
| 1A | 1B | 1B | 1A | 1A | 1A&1B | 1A | 1A | 1B |
| 2B | 2A | 2A | 2A&2B | 2B | 2A&2B | 2B | 2A&2B | 2B |
| | 3B | 3B | 3B | 3A&3B | | | | 3B |
| 4B | 4B | 4B | 4B | | 4B | 4B | 4A | 4A |
| 5A | 5B | 5A | 5A | 5B | 5B | 5A | 5B | 5B |
| 6B | 6B | 6B | 6B | 6B | 6B | 6B | 6B | 6B |
| CP | CP | CP | CP | TP | TP | TP | TP | TP |

1A. Correct understanding of the task
1B. Wrong understanding of the task

2A. Thorough discussion before decision
2B. Many unprocessed decisions

3A. High information sharing (valuable)
3B. High information sharing (incorrect)

4A. Much questioning
4B. Little questioning

5A. Reevaluation
5B. No reevaluation

6A. No major wrong assumptions
6B. Major wrong assumptions

**1B: Wrong understanding of the task**

Also in the unsuccessful groups, the majority of the groups understood the task correctly. Correct understanding of the task did not lead these groups to successful

decisions but I argue that it is a requirement for successful team decision-making. Three teams understood the task wrong and decided to wait for the mother ship to come and get them instead of walking to the mother ship. These three teams performed worst of all which indicates that a wrong understanding of the task was most likely to result in major failure. One team that did not even discuss about the goal had no common ground to base decisions on.

**2B: Many unprocessed decisions**

Seven out of nine unsuccessful groups made many unprocessed decisions. They had very short discussions and seemed sometimes to rush into decisions. Three of these groups did occasionally discuss and think through things in more detail and were, therefore, categorized by both codes: thorough discussion before decision (2A) and unprocessed decisions (2B). Some examples of common decisions in these groups are presented below:

> *"What should we put as number three? Water. Okay. "*
>
> *"Okay, maybe we should put the matches last. Ok, as number 15. Yes."*
>
> *"The first aid kit is quite important, yes here…" (a person making an individual decision)*

The examples are illustrating the nature of unprocessed decisions. The last example shows the worst case scenario of team decision-making, namely a member making an individual decision. As an opposite to thorough discussion before decisions, this decision-making climate is more risky and exposed to inaccuracies passing easily by.

The majority of the groups that were classified to make many unprocessed decisions used Teleplace as their collaboration tool. In chapter 4.2, I will present some findings related to the technology and provide possible reasons for this finding.

**3B: High amount of incorrect information shared**

A high information sharing climate does not lead to successful decisions, if the information is incorrect. Five out of nine unsuccessful groups shared much incorrect information, one group shared very little information, while three groups were categorized somewhere in the middle. If the group furthermore was characterized by little questioning things got even worse. Then the group most likely approved the faulty information and based decisions on inaccurate premises. An example of incorrect information sharing is presented below.

> *"I argue that the compass is important, because we can use it for navigation. That is true. It is probably one of the most important items. Then I was thinking that if we attach the oxygen tanks on the self-inflating life raft and ignite it with the matches we get a jet engine and can move faster forward. That sounds like a really good idea, and it should actually work..."*

Here the members did not possess much knowledge about the moon and thus went on to make a disastrous decisions. Valuable knowledge is vital for successful decision-making.

**4B: Little questioning**

As noted above little questioning in the group might result in poor decisions if based on incorrect facts. Six out of nine unsuccessful groups showed a climate of little questioning and much simple agreement. Two groups questioned more while one group was categorized somewhere in the middle. I do not argue that low questioning automatically leads to poor decisions but I argue that questioning can help a group to overcome pitfalls in their decision-making.

Overall, I was surprised over how little questioning occurred in the groups in this study. Only seven out of 21 groups questioned the suggestions thoroughly.

**5B: No reevaluation**

Five out of nine unsuccessful groups did not reevaluate their solutions at all. They made decisions and simply agreed upon their final decision in the end. Some examples of how these groups ended their decision-making process are presented below.

> *"...then last the signal flares as number 11? Yes. Great, are we then ready? Yes. I agree."*

> *"Okay so that was the last one. Let´s get going then! Yes, it is probably unnecessary to make any changes. Haha yes."*

> *"Yes the compass is then next to the matches. Okay, I guess that´s it. Yes. Yes. What now, do we hang around here the rest of the time if we are already finished?"*

In these groups, there was not much thought about the correctness of their final decision. They seemed to rush into a final conclusion. Four out of the nine unsuccessful teams however, did reevaluate their decision in the end. All of these groups made some changes due to their reevaluation which lead to improvements in their results just like it did for the four moderately successful groups. This reinforces my notion that reevaluation leads to improvements in decision-making quality and increases the probability of successful decisions.

**6B: Major wrong assumptions**

The first factor that was found in all unsuccessful groups was that they made some major wrong assumptions. Wrong assumptions resulted in poor decisions since they were based on wrong premises. It is striking that all these groups at least made the same wrong assumption about the temperature on the moon. The following two examples highlight this.

> *"I think that it is very cold on the moon, at least during night time. Yes, the portable heating-unit is a must to carry with us."*

*"Since we are on the dark side of the moon the heating unit is very important, probably one among the most important items. Yes, I would say that it is even more important than water because what would we do with water if it freezes"*

All unsuccessful groups considered it to be very cold on the moon and made a misjudgment about the importance of the heating unit. The task was a bit ambiguous and it was difficult to know this for sure whether the space crew had landed on the dark or on the sunny side of the moon. The purpose with this task in this study, however, was not to reach excellent performance in every team, rather to gain much valuable information about team decision-making process.

#### 4.1.3.1 The weakest performing decision-making group

The group that performed weakest of all groups (G 14) received 47 points and was characterized by:

**1B: Wrong understanding of the task**
**2A: Thorough discussion before decision**
**3B: High amount of incorrect information shared**
**4B: Little questioning**
**5B: No reevaluation**
**6B: Wrong assumptions**

First of all, the group did start off with a wrong goal in mind. Second, the group discussed thoroughly information before making discussions but that information was of incorrect type and some wrong assumptions contributed to even worse outcomes. Furthermore the group members did not question other members´ statements and the discussions were more like the example below:

*"Okay, so we decide to stay here and wait for the mother ship to come and get us, but are we on the dark or the sunny side of the moon? Because if we are on the dark side it is seriously cold. The border is not so sharp. So we can assume that we are on the sunny side. At least enough on the sunny side. Yes. Yes at least so much that we are not completely on the dark side. But cold, it is for sure there. It is anyway cold there yes. That is true … Let's place the heating unit before the water. Sounds good. Agree."*

Here they were starting with the wrong goal and made a significant wrong assumption. The members were not questioning much, rather they agreed upon the proposals. In the end of the group decision-making, they did not reevaluate their decision and shortcomings were never found.

#### 4.1.3.2 Conclusions of unsuccessful groups

One conclusion that holds for every unsuccessful group is that their decision-making process is constituted mostly of factors in the class B, which constituted poor factors in team decision-making. They had all 3 - 5 factors in class B, and 1 - 3 factors in class A (valuable factors of team decision-making). The group that performed weakest was characterized by 5 Bs and 1 A. I argue that a majority of defective factors in a group´s decision-making process will most likely result in faulty decisions. However, I did not found any other factors than wrong assumptions (6B) in all unsuccessful groups. The rest of the factors were distributed unequally among the groups. Some conclusions can still be drawn on the unsuccessful groups. A wrong understanding of the task will certainly lead to failure since the group will base its decisions on inaccurate premises. High information sharing of wrong information also results in faulty decisions if the group fails to question the truth of these statements and find the defects. Thorough discussion before decisions will not save unsuccessful groups from making poor decisions if the discussion circulates around wrong assumptions and faulty information. High questioning and reevaluation raise the probability of a group to find defects in their decision. According to the results, these factors were rare in unsuccessful groups and resulted in many defects to pass undiscovered.

### 4.1.4 Breaking down decision-making factors into smaller acts

All the successful groups, except of one were characterized to have thorough discussions before a decision. This interaction pattern can be broken down into smaller acts. Good solution brainstorming and good evaluations were found in all these groups. Some groups did some poor evaluations and solution suggestions as

well, but mainly good evaluations. An example of a good evaluation procedure is presented below.

Member 1: Asks for solution suggestion
Member 2: Gives a solution suggestion in the right direction that calls for support
Member 3: Gives a solution suggestion in the wrong direction
Member 2: Disagrees, shares valuable information
Member 3: Agrees
Member 1: Agrees, makes a preliminary decision.

The different paths were many, and this example above illustrates only the nature of a good evaluation. Other commonly communicational acts that usually constituted a good evaluation were: questioning of new information or asking for more information about some statement, evaluation of an idea, solution suggestion with explanations and recognition of fallacies in others´ thoughts. If comparing this to rapid decisions the difference is remarkable. An example of a rapid decision is presented below.

Member 1: Gives a solution suggestion in the wrong direction with no explanation
Member 2: Agrees
Member 1: Agrees, makes a preliminary decision.

Unfortunately, these kind of decisions were common especially in groups with little questioning. Overall, simple agreement was extremely common in the groups while disagreement was very uncommon. Disagreement was as common in successful as in unsuccessful groups and the same holds for agreement. No significant difference can be drawn between successful or unsuccessful groups based on the amount of agreements vs. disagreements. The results further indicate that the way of discussing and evaluating things influenced the decision quality more than any individual's contribution per se. This became even more prominent when I analyzed the information sharing acts at individual level. Even though members in successful groups on average shared more valuable than incorrect information there were also several groups that did the opposite. Some unsuccessful groups had very competent members that shared much valuable information with the right explanation. Still these groups failed somehow even though they had much valuable information available to them. It is therefore impossible to understand group decision-making

process without considering group level acts where the individual statements are put into a broader perspective. Thus, I did not found any evident individual level attributes of neither successful nor unsuccessful group decision-making.

### 4.1.5 Participation and roles

17 groups out of 21 were characterized by equal member participation. In the other four groups, two persons mainly affected the decisions. Merely in one of these groups, two persons were good friends and left the third member out of the discussion. In the other 3 groups with unequal participation, the third member did not contribute to the decisions nearly at all, maybe because of shyness or laziness. The reason can only be speculated based on the collected data and remains unanswered.

I was astonished how little roles emerged in the groups. Some differences were found based on the technology use that I will explain in the next chapter. No conclusion based on roles can be drawn except from the one that division of tasks in the groups was extremely rare. No conclusion on decision-outcomes can be drawn based on different roles in the groups. I had assumed that dominant characters would be more prominent, but this was not the case. Based on these findings it seems that equal participation is usual in VT decision-making.

## 4.2 The role of technology in VT decision-making

There were no major differences in performance between groups that collaborated through Connectpro and groups that collaborated through Teleplace. On average, Connectpro groups performed better than Teleplace group but the difference was small (1,4 points; statistically not significant). This was found by comparing average points of Connectpro and Teleplace groups, after the exclusion of three of the original 24 groups (see chapter 1.1 and 3.1.3). In the decision-making process, however, some differences were tracked. I will next highlight how the decision-making process was executed in the two programs.

### 4.2.1 Features of decision-making in Connectpro

Connectpro facilitated text-based communication without removing the opportunity for audio based communication. In fact, all Connectpro groups except of one, used speech as their primary form of communication. The text field were also used much and seemed to play an important role in visualizing ideas and facts to the group. Eight out of the ten Connectpro groups used the text fields as a tool when reaching decisions.

An example of how the decision-making procedure was progressed in Connectpro is presented in Figure 15. The same procedure was found in most of these groups.

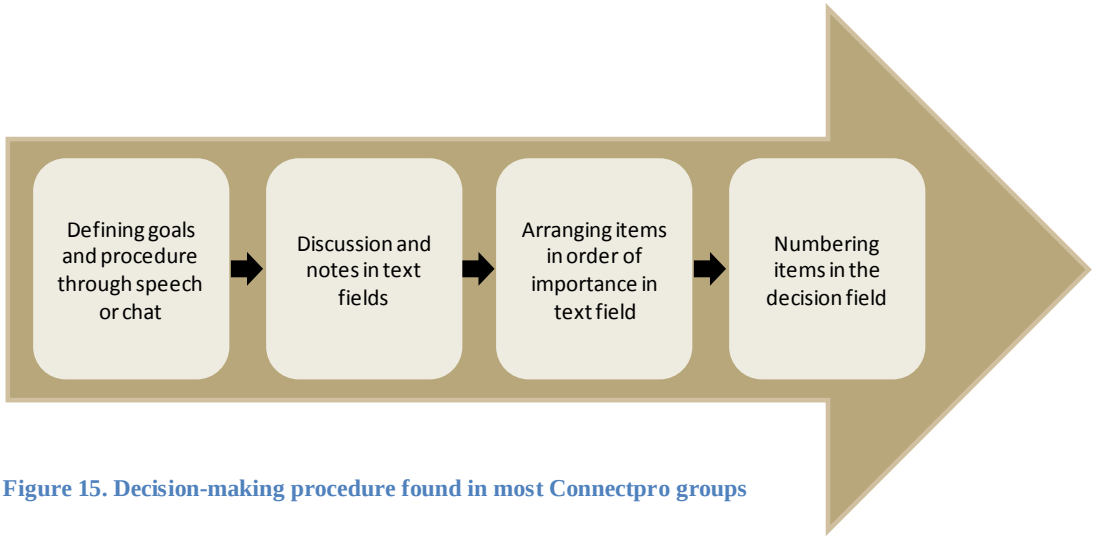



**Figure 15. Decision-making procedure found in most Connectpro groups**

The groups usually started by defining goals to achieve and the procedure, i.e. how to carry out their decision. Then they started to discuss about the different items and decide a preliminary order for them. Six out of ten groups made notes about the different items to memorize and visualize discussed information. Four out of these groups ordered the items into clusters of different importance before starting to number the items. The rest four groups started to number the items without writing any notes about them. The last act was to number the items in the result field. The majority of groups numbered the items in another field first before moving on to making a final decision in the result field.

The performance of these groups did not differ on the basis of the chosen procedure. I thus argue that the nature of the groups´ discussion, goal and information sharing were affecting the decision quality more than the technical features of Connectpro.

### 4.2.2 Features of decision-making in Teleplace

Teleplace enabled both text-based and audio based communication. Despite this, barely one group took advantage of the chat or writing notes in their decision-making process. The rest of the groups used only verbal communication and physical moving of patches on the wall. It should be noted here that the patches on the wall were meant to be moved into right positions and this was thus a central procedure in the decision-making process.

An example of how the decision-making procedure was progressed in Teleplace is presented in Figure 16. The same procedure was found in most of these groups.

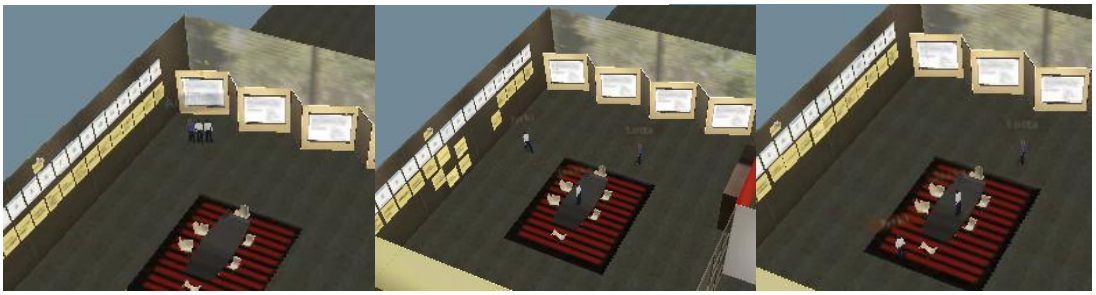


**Figure 16. Decision-making procedure found in most Teleplace groups**

First of all, the group went and read the task instructions. In the majority of the groups, the members chose to read the instructions from the same board standing side by side. At the board, the groups defined the goal and possibly a procedure of how to carry out the task.

At the second stage, the groups arranged the patches on the wall in order of importance. Ten out of eleven groups started the arrangement from most important to less important. At some stage, they changed the focus and arranged items from the least important to more important. Last they arranged the middle area. Five out

of eleven groups moved the patches mostly together in the group while discussing reasons for the decisions. The rest six groups, on the other hand, did much individual moves of the patches. In these six groups, I found a defect that I will hereinafter refer to as the *Teleplace defect (TD)*. Out of these six groups four were categorized in the unsuccessful cluster of teams, one among the moderately successful teams and one in the successful cluster of teams. Groups that suffered from the TD tended to make rapid decisions, often just filling the free slots, and forgot to discuss through all items. This seems to stem from the ease of arrangement of the patches in combination to a high level of parallelism. It was so easy to move the patches that the groups sometimes did some impulsive or even irrational decisions. It was furthermore possible for the members to make decisions simultaneously, which sometimes left reasoning and information sharing short. In Figure 17, it is demonstrated how one group did a switch of two items leaving three items in the middle unconsidered. The group in question wanted to move item E before item A in the order of importance. They did not think that item A was less important than items B, C and D, but still these items were now in a misplaced position. The same defect was not found in Connectpro. I argue that the TD stems from a high degree of parallelism in combination with the ease of use of the program for this specific task.

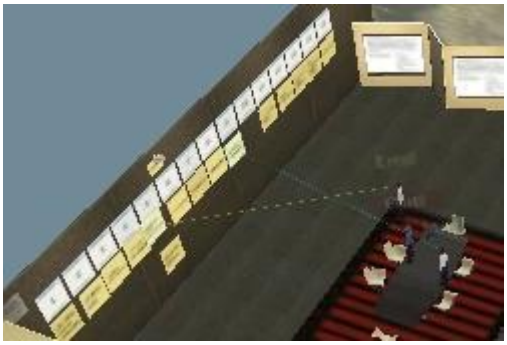


**Figure 17. One possible scenario of the TD**

TD was demonstrated in individual and thus poorly processed decisions. A high level of individualism seems to have had a negative effect on the group's performance. I suggest that individual processing of information still can be beneficial in the beginning of group decision-making if the end of the process turns into group discussion. Now the groups' individual arrangements caused information to go unprocessed. The ease of use of the program in combination to a high level of parallelism caused the TD in six groups, which affected these groups decision quality negatively.

### 4.2.3 Connectpro vs. Teleplace

Since there were only minor differences in performance between groups that collaborated through Connectpro and groups collaborated through Teleplace, I cannot clearly state that any of the two tools is more appropriate for VT decision-making. On average, Connectpro groups performed slightly better than Teleplace (1,4 points) and I will next highlight some of the differences.

Both Connectpro and Teleplace support effective transmission of information and enable individual processing of information. In Connectpro groups, information sharing and processing was deeper in the aspect that also writing, in addition to speech, was used for visualizing and processing of information. The team members had all information available in front of them all of the time. In Connectpro, eight out of ten groups had one member to make notes while the other two groups had no division of tasks. In all groups, except of one, this division emerged naturally without any discussion about it. Connectpro does not support simultaneous typing in the same window so it was natural to have one person to do all notes. Some groups were surprised over this shortcoming.

In Teleplace, on the other hand, the possibilities of information sharing were not used to its full potential. Teleplace enables writing (chat and note patches), but merely one team used this possibility. In Teleplace, any clear roles were not emerged, like the secretary role in Connectpro. One reason might have been that simultaneous working with the patches was possible. Merely one group in Teleplace announced one person to read the task description board, while two persons moved the patches. Individual decision-making occurred more frequently in Teleplace than in Connectpro. In several teams, it was found that team members did individual arrangements of the patches and even individual decisions which other team members did not notice straight away. The same phenomenon was not tracked in Connectpro. In successful decision-making, it is however important to reach a shared understanding. Here, I argue that Connectpro was better suited since the members shared the same window view all the time and individual decisions could not be made unnoticed. I though argue that both Connectpro and Teleplace are

suitable tools for decision-making in virtual teams, but it seems like Teleplace has more pitfalls, at least in the task used in this study.

# 5. Discussion and conclusions

This thesis explored decision-making in virtual teams. Different factors of the decision-making process were found through the analysis of 21 VTs of three persons each, collaborating on a common task. These factors were associated with different levels of team performance, and differences between successful and poor decision-making were tracked. Furthermore, some technology specific features were found in the decision-making process of VTs.

In this chapter, the results from this study are discussed and compared to earlier findings on decision-making in traditional and VTs that were presented in chapter 2. In addition, I will evaluate the study and provide some suggestions for future research topics.

## 5.1 Responses to research questions and major findings of the study

This study revealed that group interaction highly affects the quality of the decision-making. The first research question in this study sought answers to what factors are critical for successful decision-making in VTs. The valuable factors found in successful groups are presented in a process model (Figure 18; see also table 2 in chapter 4.1.1). The model presents the key phases that were found in most of the successful VTs decision-making process.

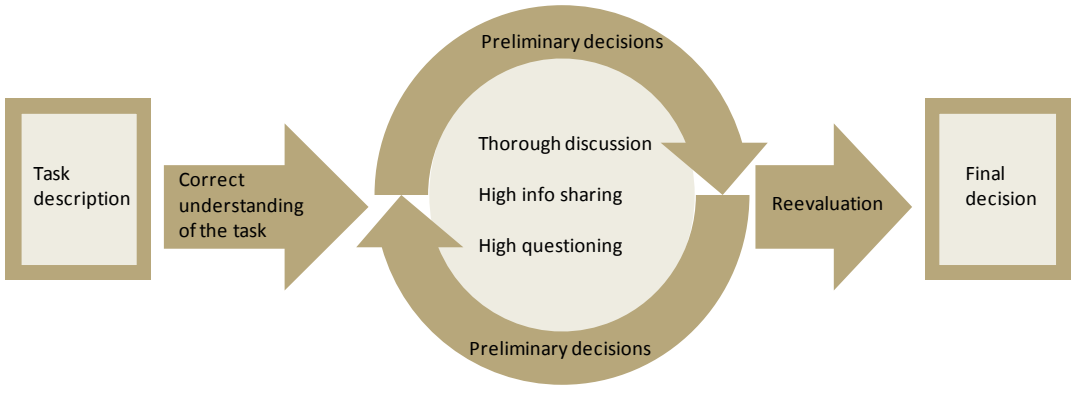



**Figure 18. The VT decision-making as a process**

Correspondingly, the second research question sought answers to what contribute to decision-making failure in VTs. The factors found in unsuccessful groups, were reverse to those found in successful VTs. The third research question assessed how the technological features affect the decision-making process in VTs. The findings to this question are discussed in chapter 5.1.5

The process model illustrates the fact that decision-making was not linear. Instead, it was an iterative process even though in the results chapter I have presented only the central factors for success and failure. The non-linearity was also due to the type of task which actually constituted of 15 smaller decisions (the order of importance of 15 items).

The first crucial factor for success was a correct understanding of the task. Groups that succeeded in carrying out a thorough discussion, constituted of valuable information sharing, were likely to reach high quality decisions. Moreover, if the group questioned statements and decision proposals and made a reevaluation in the end, the group was able to find shortcomings, and thus reach better decisions. Groups that failed in their decision-making had defects in their communication and interaction. They did more rapid decisions and failed to carry out thorough discussions with relevant information. Unsuccessful groups often shared much incorrect information, did rapid decisions and forgot to reevaluate their decision in the end. All unsuccessful groups did some major wrong assumption and thus, even if they managed to carry out a thorough discussion, the discussion was based on wrong premises. High questioning and reevaluation proved to be valuable factors even in groups which had many poor decision-making factors, saving them from mistakes they were about to make.

### 5.1.1 The importance of vigilance

Literature review showed that there are many relevant theories on what constitutes an ideal team decision-making process. The vigilant decision-making model was an attempt to define ideal patterns that would increase the likelihood of successful decisions and correspondingly hypervigilant patterns for poor decisions (Janis &

Mann, 1977). The results of this study supported the core assumption in vigilant decision-making that careful and thorough information processing in the decision-making process leads to better results. Figure 19 shows the matches and mismatches between the factors found in successful groups in this study in relation to the vigilant decision-making theory.

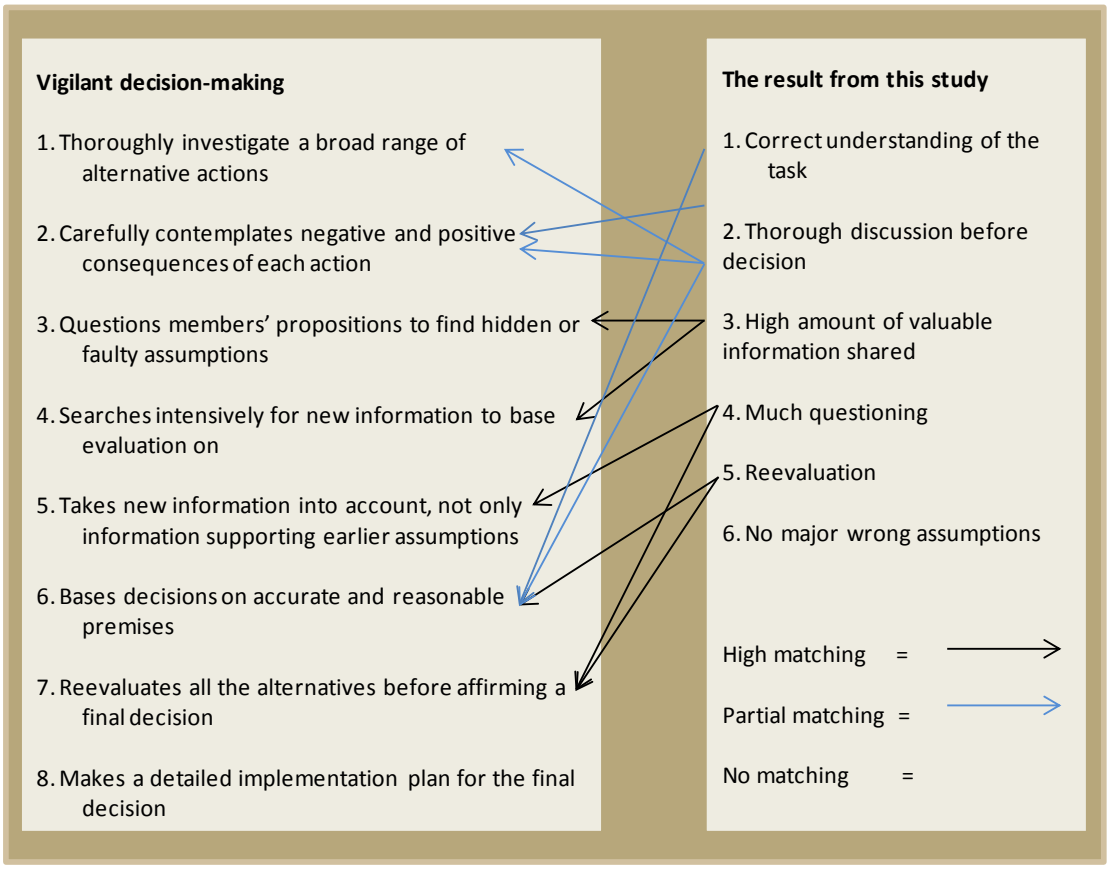



**Figure 19. The matches between the elements of vigilant decision-making theory (Janis & Mann, 1977) and the results of successful decision-making in this study**

As can be seen in Figure 19, many factors found in this study are highly or partially supporting the vigilant decision-making model. Janis and Mann (1977) did not put much emphasis on the first phase of decision-making namely assessment of the task. This study suggests that a correct understanding of the task is crucial for successful decision-making and should be emphasized. This factor is partially similar to the sixth factor in Janis´ and Mann´s theory (1977) and is laying the ground for accurate and reasonable premises. If the task is understood wrongly, there is no way that

accurate and reasonable premises in evaluation can save the group. On this respect, the results from this study support the functional perspective of group decision-making (Gouran & Hirokawa, 1996) which states a correct understanding of the task as the first aspect of successful decision-making. I argue that this is even more important in virtual teams than in co-located teams since a lack of "common ground" and "mutual knowledge" is more prominent in virtual teams (Nijstad, 2009; Cramton, 2001).

Thorough discussion before decision was found in most successful groups and is partially similar to the second criterion (careful contemplation of negative and positive consequences of each action) of vigilant decision-making (Figure 19). The nature of the task was not requiring that every item was examined based on both negative and positive consequences but yet careful evaluation was highly related to success. I argue that positive and negative contemplation are more important in political decisions and tasks where the decisions can result in fatal consequences. The quality of the discussion was more important than the quantity of solution suggestions. This is in line with the findings of Orlitzky and Hirokawa (2001) who suggested that the amount of alternatives is least related to decision-making effectiveness. Additional studies (e.g., Graham et al., 1997; Hirokawa, 1983) are also emphasizing the importance on thoroughness, stating the quality and effort put into the decisions is crucial.

All successful VTs of this study shared high amount of valuable information. This factor is partially related to the first (thoroughly investigation of a broad range of alternative actions), second (careful contemplation of negative and positive consequences of each action) and sixth (bases decisions on accurate and reasonable premises) criteria of vigilant decision-making (Figure 19). High sharing of valuable information provided the members with more accurate facts to evaluate and to base decisions on. It opened up new possible solutions and thus contributed to a wider range of alternatives to be considered. In one group, for example, a group had ranked the FM receiver-transmitter as unimportant until one member explained that radio waves can proceed in space and do not need oxygen. This opened up a new

possibility for the group and another member realized that they could use the FM receiver-transmitter to contact the mother ship, and thus ranked the item as more important. High amount of valuable information shared was according to the results of this study one of the most important things in VT decision-making. This supports the findings of Winquist and Larson (1998), stating that the group is more likely to succeed the more information they share, although this study additionally emphasizes the importance of the correctness of the information. One team that shared information merely through text shared very little of it and ended up at poorly processed decisions based on insufficient amount of information. As noted before, mutual knowledge can be challenging in virtual teams (Cramton, 2001) and a high sharing of information contributes to a higher degree of mutual knowledge.

Much questioning is highly matching with the third factor (questioning of members' propositions to find hidden or faulty assumptions) and the fourth factor (intensively search for new information to base evaluation on) of vigilant decision-making (Figure 19). Even though high questioning was not found in every successful group, it was a significant factor in preventing teams with several defects in their decision-making from failing. Many teams would have performed worse without this factor. This finding supports the vigilant decision-making: teams with high questioning searched intensively for information and questioned other members´ statements. I argue that if group members question a lot, the probability of reaching high quality decisions is increased. Like Jensen and Chilberg stated (1991), it is easier to find gaps in other people's logic than it is to produce flawless arguments of our own. This indicates that some incorrect statements and suggestions of members will not necessary result in poor decisions, provided that the group is able to think critically.

Reevaluation was found in all successful groups of this study. This was highly matching with the fifth (taking new information into account, not only information supporting earlier assumptions) and the seventh (reevaluation of all the alternatives before affirming a final decision) factors of vigilant decision-making (Figure 19). This factor gives also support to the functional perspective of successful decision-making (Gouran & Hirokawa, 1996). Groups that reevaluated their decisions in the

end or during the decision-making process tended to recognize some major defects in their solution and did some important changes despite lack of support for earlier assumptions. I argue that this factor saved several groups from mistakes that they were about to make and contributed to success. In Teleplace, this was found to be extremely important for teams suffering from the Teleplace defect (see page 75). Since most of these teams carried out individual decisions at some point it was possible that a member detected a wrong placement of an object during the reevaluation in the end. This indicates that reevaluation is even more important in virtual teams, in which it can be difficult to keep track of other members´ activities. The fact that the TP defect was found in the 3D VE was rather surprising since these working environments are argued to support tracking of others activities (Benford et al., 1997).

The sixth success factor of VT decision-making of this study, that is the absence of major wrong assumptions, is highly related to the sixth criterion of vigilant decision-making (bases decisions on accurate and reasonable premises; Figure 19). This factor is dichotomous. In other words, it exists or it does not exist, and it cannot be described as a process unlike other factors. Rather, it was included as an opposite to major wrong assumptions that were salient in every unsuccessful group to show how gross misjudgments can have a severe negative effect on group decision-making.

The last factor in vigilant decision-making model concerning implementation was not considered here since it was irrelevant to this study. The VT members never had a chance to make any implementation plans.

Even though the factors that were prominent in successful groups in this study did not cover all the aspects of the vigilant decision-making theory there are strong connections to it. The factors found in this study, all matched with the vigilant factors at some degree and clearly raised the probability of successful decisions to occur. The groups that performed poorly used only few of the decision-making criteria outlined in the vigilant decision-making model. Despite this, I disagree with Janis and Mann that hypervigilant decision-making patterns would result in

extremely poor decisions. The hypervilant stategy is not as thorough as the vigilant strategy but I agree with Klein (1996) and Driskel et al. (1997) that a hypervigilant strategy, under certain task conditions, can be a more optimal way of carrying out decisions. These special conditions of hypervigilant strategy are time pressure, ambiguous or conflicting data, costly consequences of errors or poor decisions and familiarity with the task. The team task in this study was ambiguous and had to be solved in a limited time, which might indicate that hypervigilant decision-making could be a better strategy. However, the team members were unfamiliar with the task and the results from this study revealed that this can be a sufficient requirement for a vigilant approach being more appropriate. More studies on organizational tasks with people possessing different working skills are needed to evaluate what decision-making strategy is best suited for VTs. I argue that the decision-making process is highly dependent on moderators of VTs like task type, time, social context, organizational culture and leadership (Martins et al., 2004) and the process needs to be studied alongside with these moderators. Real life VTs are seldom isolated from their surroundings and can most likely search for more information or help from their environment if needed.

### 5.1.2 The potential importance of organizational context

The functional perspective emphasizes the importance of appropriate communication and interaction between members in fulfillment of task requirements (Gouran & Hirokawa, 1996). The findings of this study support this perspective because the nature of communication played an important role for the success and failure in these VTs. One proof for this was that the way of discussing and evaluating things influenced the decision quality more than any individual´s contribution *per se*. The competent members that shared valuable information did not necessary lead the group to successful decisions. I therefore argue that effective communication at the group level is vital in successful team decision-making.

Despite the fact that this study gave support to some aspects of the functional perspective, the similarities are less apparent than with the vigilant decision-making

model. The importance of the first phase, understanding of the task and the last phase, reevaluation, are highly supported by this study but the process in between is differing on one relevant aspect; the importance of criteria. The functional perspective emphasizes the importance of the context of the task, and successful decision-making includes elaboration of decisions to meet desired criteria (Gouran & Hirokawa, 1996). In organizational contexts several criteria have to be met and these criteria can be different for those involved and affected. Some members may work for economic profit or promotion, others for acceptance and belonging with team members and others for honor or fame. A team is surrounded by a specific work environment and culture and the desired criteria that their decisions have to meet are often very complex. I thus argue that the functional approach of decision-making complements the vigilant decision-making approach by taking the organizational context into account. This study did not take these kinds of contextual factors into account since the teams were ad hoc, with no work history, and had no intention of further collaboration. They did not establish any criteria in their decision-making and I was rather surprised over how most of the groups assessed the task in a somewhat disorganized way. The members' motivation was probably not very high due to the fragmentary situation and it is likely that some groups´ did not care about the result as much as others did. On the other hand, this experiment can be seen as a rather realistic scenario for VTs that on short notice have been formed of people with no common work history and are supposed to solve a highly complex and ambiguous task in short time. For these situations, the results from this study provide valuable guidelines.

### 5.1.3 Breaking down communication into smaller acts

Although I agree with the importance of communication, I did not found any result indicating that any particular communicational acts were most important for successful decision-making. Active discussion which involved the whole group tended to result in successful decisions while a more passive communication climate raised the probability of failure. This is in line with research proposing patterns of argument to be central in communication and decision-making (e.g., Seibold et al.,

1996; Meyers et al., 1991). A conclusion of this study is that the more valuable insights the group encounter during their decision-making path, the more likely the end result is successful. A group that simply agrees on anything is more likely to let errors pass by unnoticed. Unfortunately, the most interesting finding about specific communication or argumentation factors was the fact that simple agreement was extremely common and that disagreement on the other hand was rare. The high frequency of agreement is, however, consistent with the results of Lemus´ and his colleagues (2004).

Problems with coordination and control have been stated to be common in VTs (Nijstad, 2009). I did not find any major problems with this in the virtual teams in this study, at least not any impact on their decision quality. Some members spoke simultaneously so that information was lost but then members repeated their message. I believe that coordination and control can be more problematic in real-work situations where the execution of the task is less straightforward than it was in this experiment. Furthermore, equal member participation was found in 17 out of 21 groups, and hardly any delegation or self-emerging roles were found. This might have lead to a freer exchange of ideas and more novel decisions, found in several studies (e.g., Pinsonneault & Heppel, 1998; Constant et al., 1996).

### 5.1.4 Poor performance was not due to groupthink

Although several antecedent conditions of groupthink (Janis, 1972) might have been present in the VTs of this study and the high level of simple agreements raises the question whether groupthink was present, there are no clear evidence supporting the groupthink model. It is problematic to study groupthink in a laboratory setting, within a short time interval, when groupthink it is assumed to develop over a longer period (Janis, 1982). Furthermore it is difficult to evoke and control the antecedent conditions that are a core foundation of the phenomenon (Janis, 1982). This study found very little evidence for groupthink symptoms which indicates that despite several parts such as antecedent conditions, strong concurrence seeking due to time limit and decision-making defects, of the groupthink framework (see page 24) are

present. The results from this study reveal how defective decision-making factors are resulting in poor outcomes, but are not providing support for the groupthink theory. Instead, I argue that poor fulfillment of valuable decision-making factors can be due to the severe time limit, a lack of motivation among members due to the fragmentary context and poor skills in collaboration. I agree with Fuller and Aldag (1998) that poor decision-making too easily is explained with signs of groupthink. I argue that researchers should assess the decision-making process from a broader perspective concentrating on the interaction and communication among team members in action.

### 5.1.5 The influence of technology

This study revealed both advantages and problems related to the use of virtual environments in team decision-making. Identifying these can help VTs in carrying out successful decisions and in minimizing the negative effects of technology as well as in taking advantage of its possibilities.

The findings from this study contradicted with our original hypothesis that teams using the "richer media" Teleplace would perform better than teams using Connectpro (Daft & Lengel, 1986). On the contrary, teams using Connectpro performed slightly better. The difference was, however, small and no clear conclusion of which program is better suited for team decision-making can be drawn. Both technologies supported communication through speech and typing. Connectpro had videos available but I have no evidence on how the groups used this as a help in their communication. We did not use videos in Teleplace, but on the other hand seeing the other avatars provided rich information about other members´ activities. Based on media richness it is therefore difficult to define which of the two technologies is richer and thus better suited for team decision-making. Both technologies are highly supporting the four media capabilities of the MRT (Figure 20). Moreover, it is problematic to evaluate the technologies suitability based on the MRT since it argues a certain media to be best suited for a complete task. Instead I suggest that the media´s suitability can better be evaluated based on the media

synchronicity view which points out that that certain media capabilities are necessary at different stages of the decision-making process (Dennis & Valacich, 1999) and not for the overall task.

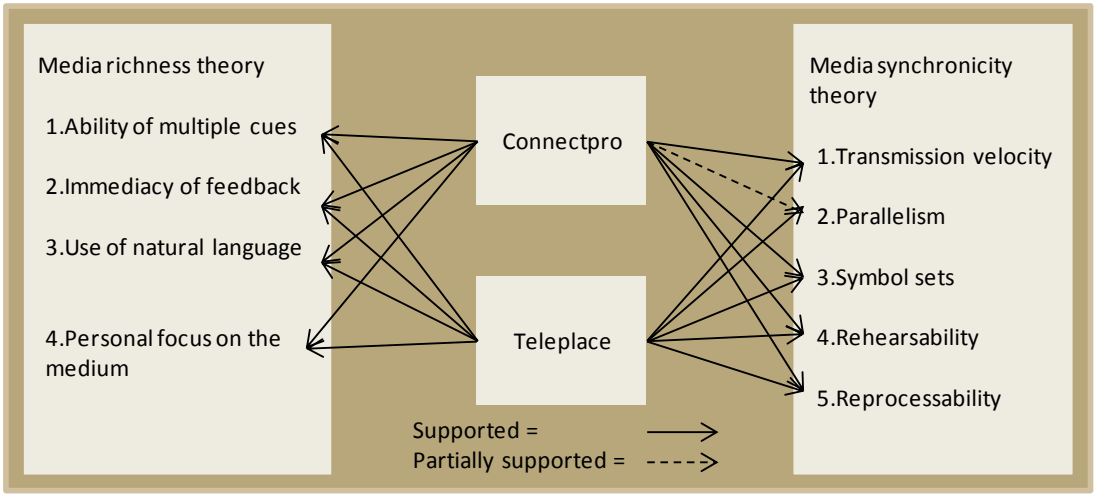



**Figure 20. Support of different media capabilities in the media richness theory (Daft & Lengel, 1986) and media synchronicity theory (Dennis et al., 2008)**

In Figure 20, it is seen that nearly all media capabilities are supported in both Connectpro and Teleplace. Parallelism, however, is only partially supported in Connectpro. This could be seen as a drawback of the medium but I argue that this was one of the reasons that Connectpro groups performed better. I agree with Dennis and Valacich (1999) that different phases in decision-making require different media capabilities. According to Dennis and his colleagues (2008) the convergence phase constitutes of discussion of preprocessed information and should result in a shared understanding. At this stage, the medium should support a high velocity rate and appropriate symbol sets for the task (Zigurs & Buckland, 1998) and simultaneously a lower degree of parallelism, rehearsability and reprocessability. A high degree of parallelism in addition to ease of use of Teleplace resulted in the Teleplace defect in six groups. This was demonstrated in many individual moves of patches, rapid decisions, often in free slots, and a lower degree of group discussion. Even though parallelism is valuable in the beginning of a decision-making process to share much information, it is problematic if the decision-making will not at some point turn into a collective discussion as suggested

in MST. In Connectpro, the members shared the same window all the time, and could not make individual decisions unnoticed. The team members had the information available in front of them all the time

The conveyance phase (transmission of new information) should support effective transmission of information and enable individual processing of information (Dennis et al., 2008). At this phase, I argue that both technologies are supporting the necessary media capabilities related to this, even though Teleplace supports a higher level of parallelism. Surprisingly, Teleplace was not used to its full potential and information sharing was more thorough in Connectpro, where discussion was realized through both speech and writing. I argue that the development of VEs, like Teleplace, should concentrate on creating better ways for sharing information so that the group could better manage the information flow and reach a mutual understanding. In this aspect, it seems that Connectpro is better than Teleplace according to the results from this study. It has been stated that the more information that is shared in the group the more likely it is for the decision to be successful (Winquist & Larson, 1998). On the same time, however, it has been stated that the quality and effort put into the decisions are important for success (Graham, Papa & McPherson, 1997). I argue that a high amount of information shared can be valuable for the group decision-making only if the information becomes mutual and processed by the whole group. In addition, the quality of the information is crucial, which have been shown in this study.

To compare the level of visibility between Connectpro and Teleplace is not straightforward. In Connectpro, the video offered facial cues but, on the other hand, no evidence on a specific person´s activity by looking at the video stream could be traced. Teleplace, on the other hand, offered cues on the team members' positions and actions based on the movements of the avatar. However, my results on TD suggested that the avatar-based interaction did not bring advantages over the more traditional collaboration tool with text and audio. This is not fully in accordance with the results from Schouten and his colleagues´ study (2010), noting that VE suits better for decision-making than text-based CMC-tools. A significant difference

between their study (Schouten et al., 2010) and this study is that in this study the CMC-tool (i.e. Connectpro) enabled audio and video in addition to text. These studies were therefore not comparable and I suggest that VEs should be compared to CMC-tools supporting both audio and text, before stronger conclusions are made.

## 5.2 Evaluation of the study and future research

This study was a theory-driven qualitative analysis of decision-making process in virtual teams. The analysis was aimed at discovering critical factors of failure and success in the VTs´ decision-making process and studying what technical features are affecting the decision-making in these teams. Both the spoken and written discussion was transcribed and coded with a decision-making coding scheme developed for this study. The results about technology specific features of the decision-making process in these virtual teams were obtained by observation of the video recordings. Overall, I think that this was a successful way of capturing the whole decision-making process in virtual teams.

The findings from this study support the applicability of general decision-making theories also in a virtual context. Particularly, the vigilant decision-making theory, gained much support in this study. The functional perspective was also applicable, but showed that a more specific context is needed in order to better study its correctness in virtual teams. By integrating the interaction process analysis (Bales, 1950) and the argument coding scheme (Meyers et al., 1991) into this study I managed to use a bottom up strategy to find out group level acts, derived from the individual level codes. This proved to be a valuable method.

By observing the groups behavior through the video tapes it was possible to capture the technology specific features of decision-making in VTs. Additionally, the media synchronicity theory proved to be fruitful in assessing the implications of the two technologies used. Interestingly, the VE (Teleplace) was found to have some drawbacks in supporting group decision-making, but on the whole both technologies enabled high quality VT decision-making.

The number of groups in this study proved to be sufficient for finding similar factors and processes from many groups. According to qualitative analysis literature (Coffey & Atkinson, 1996), no great emphasis is put on the amount of participants in qualitative analysis, compared to quantitative analysis. Instead the thoroughness of the analysis is important and it is desirable that the data is explored from many perspectives. I consider this study to fulfill these requirements since the coding procedure was made at both individual and group level and was furthermore complemented with observation of the actual activities in the decision-making process.

Measuring decision quality is not straightforward in means of what constitutes a good vs. a bad decision. In most real-world tasks, decision quality cannot be measured on an absolute ground like in the NASA task. A decision proven to lead to great results in the short run may turn out to be a complete fiasco in the long run and vice versa (Hirokawa et al., 2003). A decision that is good from some angle may be terrible from other perspectives. Take for example a decision that satisfy the leaders of an organizational team and brings ideal profit for the company but lead to poor satisfaction and motivation among subordinates. Can that be regarded as a successful decision? A process-oriented approach might be more suitable for real work tasks (Harris & Sherblom, 1998). According to Fisher (1980) researchers should study and compare communication behavior in groups with high-quality decisions to groups with lower-quality decisions in order to improve group decision-making. This study sought answers to both high- and low-quality decisions. It did not start from the outputs; instead it investigated the decision-making process in detail and last, put the findings in relation to the scores that the teams achieved. By doing this the group outcomes did not affect the perceived decision-making process.

One limitation of this study is that it studied VTs in a laboratory setting with lack of work context. The VTs were ad hoc teams gathered for this experimental setting with no common work history and no intention for future work. The short time of this study did not allow any real work situations and long term team development, so processes evolving over time were not possible to investigate. Further, the teams

were collaborating over virtual environments and were synthetically dispersed, but they were still situated in the same room. This was a restraint of this study that might have had an effect of the perceived virtuality. However, I argue that this had little, if any, impact on the teams' decision-making process, since the team members had no communication prior to the experiment.

The assigned (NASA) task was suitable for laboratory experiments but may not be the kind of task that occurs in a real organization. The VT was also isolated from the outside world, which does not usually apply for real VTs. Intervening factors, like social context, organizational culture, task type and time are in fact influencing the team through the members´ own motives and through the groups´, the leaders´ and the organizations´ expectations. I thus argue that more studies that are made in the work context are needed in order to reach valuable findings about decision-making in VTs. Furthermore, these kinds of studies could provide valuable insights about different stages in the decision-making process.

This study concentrated on qualitative analysis of the decision-making process. Within the limits of this work, no quantitative generalizations have been drawn. All codes are still available and it is possible to quantify them. Continuing my work by statistical analysis would contribute to the validity of the results presented here.

Although the rapid growth of interest in virtual organizations and a growing emphasis on self-managing VTs, relatively little is known about the communication dynamics and decision-making processes in virtual teams (Schouten et al., 2010; Scott & D´Urso, 2003). Most studies have focused on text- and data based technologies, leaving VEs relatively unexplored, and furthermore concentrated more on decision-making outputs than processes (Martins et al., 2004; Schouten et al., 2010) This study was process oriented but, as suggested in previous chapter, more studies in this field, investigating real-work teams in context are needed.

In this study, vigilant decision-making climate proved to lead to better decisions than hypervigilant climate. It would be interesting to see how decision-making in a "real" VT comprised of people with expert knowledge in their work tasks would tackle a

work related problem in an agile working environment in which rapid changes are commonplace. A concrete way would be to apply the same or a similar coding scheme to a real organizational setting with a VT collaborating on a task where a decision has to be reached during the meeting or over several meetings. One example could be a meeting in a global company, which would also inform us on how cultural aspects impact the decision-making. Another possibility would be to examine the decision-making process in a project carried out fully in a VE. The results from this kind of studies could then be compared to the results from this study in order to evaluate the importance of context and different intervening factors. I argue that the context and seriousness of the situation is difficult to achieve in laboratory settings were the results hardly matter to decision-makers.

Furthermore, it would be important to get a picture over how much decision-making defects are due to faulty decision-making processes and how much are due to faulty input. This study did not take members knowledge, skills and abilities into account and I can therefore not exclude the possibility that the input also played an important role. It would be important to get all group members engaged in the whole decision-making process, especially during the convergence phase (see page 35). Therefore, more studies on how technology could enhance collaboration especially in the convergence phase of decision-making are needed. It would be extremely important to identify the different phases in decision-making process and find out how technology best could support these different phases.

Moreover, further information on what specific tasks and purposes virtual environments are best suited for is needed. Becoming more aware of enablers and hindrances of VEs is vital for successful implementation of them. According to this study, the VE did not bring any concrete benefits for team decision-making. Nevertheless, I argue that this is still an area of much unused potential.

## 5.3 Conclusions

Despite some limitations, the results of this study provided valuable insights of decision-making in virtual teams. The virtual tools used were both rather well suited

for team decision-making and did not hinder the groups from carrying out successful decisions. Teleplace contained some pitfalls due to ease of use in combination with high parallelism, which enabled individual and unprocessed decisions. Mostly, however, poor performance originated from poor decision-making processes. Factors such as shared understanding, thorough discussion before decisions, sharing lots of valuable information, much questioning, reevaluation, and sticking to correct assumptions, were found to result in good decision-making. Moreover, high questioning and reevaluation could save a group from fatal mistakes whereas wrong understanding of task lead always to failure. Many group decision-making theories developed for traditional settings proved their applicability to virtual teams as well. However, further studies are needed in order to validate my findings and to increase our knowledge on decisions-making in real-life virtual teams.

## References


Andres, H. P. (2002). A comparison of face-to-face and virtual software development teams. *Team Performance Management*, 8(1/2), 39–48.

Andriessen, J. H. E. (2003) *Working with groupware. Understanding and evaluating collaboration technology*. London: Springer Verlag

Archer, N. P. (1990). A Comparison of Computer Conferences with Face-to-face Meetings for Small Group Business Decisions. *Behaviour & Information Technology*, 9(4), 307-317.

Axtell, C. M., Fleck, S. J., & Turner, N. (2004). Virtual teams: Collaborating across distance. In C. Cooper & I. Robertson (Eds.), *International review of industrial and organizational psychology* (pp. 205–248). Chichester: John Wiley & Sons

Bales, R. F. (1950). A set of categories for the analysis of small group interaction. American Sociological Review, 15, 257-263.

Bales, R. F. (1953). The equilibrium problem in small groups. In T. Parsons, R. F. Bales, & E. A. Shils (Eds.), *Working papers in the theory of action* (pp. 111-161). New York, NY: Free Press.

Baron, Robert S. (2005) So Right It's Wrong: Groupthink and the Ubiquitous Nature of Polarized Group Decision Making. *Advances in Experimental Social Psychology*, 37, 219–253

Benford, S., Bowers, J., Fahlen, L. E., Greenhalgh, C., & Snowdon, D. (1997). Embodiments, avatars, clones and agents for multi-user, multi-sensory virtual worlds. *Multimedia Systems*, 5(2), 93–104.

Bernard C. Y. Tan, Hock-Hai Teo and Kwok-Kee Wei. (1995). Promoting consensus in small decision making groups. *Information & Management*, 28(4), 251-259

Blackburn, R., Furst, S. A., & Rosen, B. (2003). Building a winning virtual team: KSA's, selections, training, and evaluation. In C. B. Gibson & S. G. Cohen (Eds.), *Virtual teams that work: Creating conditions for virtual team effectiveness*. San Francisco: Jossey-Bass.

Boos, M., & Kolbe, M. (2009). Facilitating Group Decision-Making: Facilitator's Subjective Theories on Group Coordination, *Forum: Qualitative Social Research Sozial Forschung*, 10 (1)

Brown, R. (1988). *Group processes: Dynamics within and between groups* (1st ed.). Oxford: Blackwell.

Bunderson, J. S., & Sutcliffe, K. M. (2002). Comparing alternative conceptualizations of functional diversity in management teams: Process and performance effects. *Academy of Management Journal*, 45(5), 875–893.

Burk, K. and Aytes, K., (1998). A longitudinal analysis of the effects of media richness on cohesion development and process satisfaction in computer-supported workgroups. *Proceedings of the Thirty-First Hawaii International Conference on Systems Sciences*, 1, 135-144 .

Canary, D. J., Brossmann, B. G., & Seibold, D. R. (1987) Argument structures in decision-making groups. *Southern Speech Communication Journal*, 53(1), 18-37.

Cappel, J. J., & Windsor, J. C. (2000). Ethical decision making: A comparison of computer-supported and face-to-face group. *Journal of Business Ethics*, 28(2), 95–107.

Chidambaram, L. and Bostrom, R. (1993). Evolution of Group Performance Over Time: A Repeated Measures Study of GDSS Effects. *Journal of Organizational Computing*, 3(4), 443-469.

Coffey, A. & Atkinson, P. (1996). *Making sense of qualitative data: Complementary research strategies*. London: Sage.

Constant, D., Sproull, L., & Kiesler, S. (1996). The kindness of strangers: The Usefulness of Electronic Weak Ties for Technical Advice. *Organization Science*, 7(2), 119-135.

Conway, C. (2007). Professor avatar. *Inside Higher Ed*. Retrieved from http://www.insidehighered.com/views/2007/10/16/conway/

Cramton, C. (2001). The Mutual Knowledge Problem and its Consequences for Dispersed Collaboration. *Organization Science,* 12(3), 346-371.

Daft, R., & Lengl, R. H. (1986). Organizational information requirements, media richness and structural design. *Management Science*, 32(5), 554-571.

Daft, R. L., Lengel, R. H. and Trevino L.K. (1987). Message Equivocality, Media Selection and Manager Performance: Implications for Information Systems. MIS Quarterly, 11,355-366.

Davison, R., Bélanger, F., Ahuja, M., & Watson-Manheim M. B. (2006). *Information Technology & People*. Bradford, GBR. Emerald Group Publishing Ltd.

Dennis, A.R., Fuller, R.M. and Valacich, J.S. (2008). "Media, Tasks and Communication Processes: A Theory of Media Synchronicity," *MIS Quarterly*, 32(3), 575-600.

Dennis, A. R., & Valacich, J. S. (1999). Rethinking Media Richness: Towards a Theory of Media Synchronicity. In R. Sprague (Ed.), Proceedings of the 32nd Hawaii International Conference on System Sciences (pp. 1-10). Los Alamitos, CA.

Dennis, A. R. (1996). Information exchange and use in small group decision making. *Small Group Research*. 27(4), 532-549

Driskel, J. E., Sales, E., Radtke, P. H. (2003). Virtual teams: Effects of Technological Mediation on Team Performance. *Group Dynamics: Theory, Research and Practice*. 7(4), 297-323.

Dubrovsky, V. J., Kiesler, S., & Sethna, B. N. (1991). The equalization phenomenon: Status effects in computer-mediated and face-to-face decision making groups. *Human-Computer Interaction*, 6(2), 119-146.

Ensher, E., Heun, C., & Blanchard, A. (2003). Online mentoring and computer-mediated communication: New directions in research. *Journal of Vocational Behavior*, 63(2), 264–28

Fisher, B. A. (1980). *Small Group Decision Making* (2nd ed). New-York: McGraw-Hill

Fuller, S. R., & Aldag, R. J. (1998). Organizational tonypandy: Lessons from a quartercentury of the groupthink phenomenon. *Organizational Behavior and Human Decision Processes*, 73(2/3), 163-184

Furst, S. A., Blackburn, R. S., & Rosen, B. (1999). Virtual team effectiveness: A proposed research agenda. *Information Systems Journal*, 9(4), 249-269.

Galegher, J. and Kraut, R.E. (1994). Computer-mediated Communication for Intellectual Teamwork: An Experiment in Group Writing. *Information Systems Research*, 5(2), 110-138.

George, J. F., Easton, G. K., Nunamaker, J. F., & Northcraft, G. (1990). A study of collaborative group work with and without computer-based support. *Information Systems Research*, 1(4), 394-415.

Gibson, C. B., & Cohen, S. G. (2003). *Virtual teams that work: Creating conditions for virtual team effectiveness.* San Francisco: Jossey-Bass.

Gouran, D. S., & Hirokawa, R., Y. (1983). The role of communication in decision-making groups: A functional perspective. In M. S. Mander (Ed.), *Communications in transition* (pp. 168-185) New York: Praeger.

Gouran, D. S., & Hirokawa, R., Y. & Martz, A. E. (1986). A critical analysis of factors related to decisional processes involved in the Challenger disaster. *Central States Speech Journal*, 37, 119-135.

Gouran, D. S., & Hirokawa, R. Y. (2003). Effective decision making and problem solving in groups: A functional perspective. In R. Y. Hirokawa, R. S. Cathcart, L. A. Samovar, & L. D. Henman (Eds.), *Small group communication* (8th ed., pp. 27-38). Los Angeles: Roxbury Publishing Company

Graham, E. E., Papa, M. J., McPherson, M. B. (1997). An applied test of the functional communication perspective of small group decision-making. *The Southern Communication Journal*, 62(4), 269-279

Griffith, T. L., and Neale, M. A. (2001) Information processing in traditional, hybrid, and virtual teams: From nascent knowledge to transactive memory. *Research in Organizational Behavior*, 23, 379-421.

Gruenfeld, D.H., & Hollingshead, A.B. (1993). Sociocognition in work groups: the evolution of group integrative complexity and its relation to task performance. *Small group research,* 24(3), 383-405.

Hackman, J. R. and C. G. Morris, 1975. Group tasks, group interaction process and group performance effectiveness: A review and proposed integration. In L. Berkowitz (Ed.), *Advances in experimental social psychology*. (pp. 47-99). New York: Academic Press.

Hackman, J. R. (1987). The design of work teams. In J. Lorsch (Ed.), *Handbook of organizational behavior* (pp. 315-342). Englewood Cliffs, NJ: Prentice-Hall.

Hakonen, M., & Sivunen, A. (2011). Review of Virtual Environment Studies on Social and Group Phenomena. *Small Group Research*, 42(4), 405-457

Harris, T.E. & Sherblom, J.C. (1998). *Small group and team communication*. Needham Heights: Allyn & bacon.

Hayes, N. (1997). *Team Management*. Thomson Business Press, London.

Hertel, G., Geister, S., & Konradt, U. (2005). Managing virtual teams: A review of current empirical research. *Human Resource Management Review,* 15(1), 69-95.

Hirokawa, R. Y. (1983). Group communication and problem-solving effectiveness II: An investigation of procedural functions. *Western Journal of speech Communication*, 47, 59-74

Hirokawa, R. Y. (1985). Discussion procedures and decision-making performance: A test of a functional perspective. *Human Communication Research*, 12, 203-224

Hirokawa, R. Y. (1988). Group communication and decision-making performance: A continued test of the functional perspective. *Human Communication Research*, 14, 487-515

Hirokawa, R. Y. (1990). The role of communication in group decisionmaking efficacy. *Small Group Research*, 21, 190 –204

Hirokawa, R. Y., & Rost, K., M. (1992). Effective Group Decision Making in Organizations. Field Test of the Vigilant Interaction Theory. *Management Communication Quarterly*, 5(3), 267-288.

Hirokawa, R. Y., Cathcart, R. S., Samovar, L. A., Henman, L. D. (2003). *Small Group Communication. Theory & Practice (An Anthology)* (8th ed.). Los Angeles. California. Roxbury Publishing Company.

Hollingshead, A. B., McGrath, J. E., & O'Connor, K. M. (1993). Group task performance and communication technology: A longitudinal study of computer-mediated versus face-to-face work groups. *Small Group Research*, 24(3), 307–333.

Janis, I. L. (1972), *Victims of Groupthink*. Boston: Houghton Mifflin.

Janis, I. L. (1982). *Groupthink: Psychological studies of policy decisions and fiascos*. Boston: Houghton Mifflin.

Janis, J. I., & Mann, L. (1977). *Decision making: A psychological analysis of conflict, choice, and commitment.* New York: Free Press.

Jarvenpaa, S. L., Leidner, D. E. (1999). Communication and trust in virtual teams. *Organizational Science*, 10(6), 791-815.

Jehn, K. A., & Shah, P. P. (1997). Interpersonal relationship and task performance. An examination of mediating processes in friendship and acquaintance groups. *Journal of Personality and Social Psychology*, 72(4), 775–790.

Jehn, K. A., & Mannix, E. A. (2001). The dynamic nature of conflict: A longitudinal study of intragroup conflict and group performance. *Academy of Management Journal*, 44(2), 238–251.

Jensen, A. D., & Chilberg, J. C. (1991). *Small Group Communication: Theory and application*. Belmont, California. Wadsworth Publishing Co.

Johansen, R., Vallee, J., & Collins, K. (1978). Learning the limits of teleconferencing: Design of a teleconference tutorial. In M. C. J. Elton, W. A. Lucas, & D. W. Conrath (Eds.), *Evaluating new telecommunication systems* (pp. 385-398). New York: Plenum.

Johnston, J. H., Driskell, J. E., & Salas, E. 1997. Vigilant and hypervigilant decision making. *Journal of Applied Psychology*, 82(4), 614-622.

Kayworth, T., & Leidner, D. (2000). The global virtual manager: A prescription for success. *European Management Journal*, 18(2), 183–194.

Kiesler, S., Siegel, J., & McGuire, T. W. (1984). Social psychological aspects of computer-mediated communication. American Psychologist, 39(10), 1123-1134.

Kozlowski, S. W. J., & Klein, K. J. (2000). A multilevel approach to theory and research in organizations: Contextual, temporal, and emergent processes. In K. J. Klein & S. W. J. Kozlowski (Eds.), *Multilevel theory, research, and methods in organizations: Foundations, extensions, and new directions* (pp. 3-90). San Francisco, CA: Jossey-Bass.

Krauss, R. P., Fussell, S. (1990. Mutual knowledge and communicative effectiveness. In J. Galengher, R. Kraut, & C. Egido (Eds.) *Intellectual Teamwork: Social and Technological Foundations of Cooperative Work* (pp.111-146.). Hillsdale, NJ: Lawrence Erlbaum,

Kruglanski, A. W. (1986). Freezethink and the Challenger. *Psychology Today*, 20(8), 48-49.

Lipnack, J., Stamps, J. (1999). Virtual teams: The new way to work. *Strategy & Leadership*, 27, 14-18

Lea, M., Spears, R. (1992). Paralinguistic and social perception in computer-mediated communication. *Journal of Organizational Computing*, 2(3/4), 321-341

Lea, M., Spears, R., Rogers, P.(2003) Social Processes in Electronic Teamwork. The central issue of identity. In: S. A. Haslam, D. van Knippenberg, M. J. Platow, & N. Ellemers (Eds.). *Social identity at work: Developing theory for organizational practice*. (pp. 99-116). New York: Psychology Press.

Lemus, D., Seibold, D., Flanagin, A., & Metzger, M. (2004). Argument and decision-making in computer-mediated groups. *Journal of Communication*, 54(2), 302–320

Martins, L. L., Gilson, L. L., and Maynard, M. T. (2004). Virtual Teams: What do we Know and Where do we Go From Here? *Journal of Management*, 30(6), 805-835.

McDonough, E., Kahn, K., Barczak, G. (2001). An investigation of the Use of Global, Virtual, and Collocated New Product Development Teams. *The Journal of Product Innovation Management*, 18(2), 110-120.

McGrath, J. E. (1984). *Groups: Interaction and Performance*. Englewood Cliffs, NJ: Prentice-Hall.

McGuire, T. W., Kiesler, S., & Siegel, J. (1987). Group and computer-mediated discussion effects in risk decision making. *Journal of Personality and Social Psychology*, 52(5), 917-930.

Mesmer-Magnus, J., & DeChurch, L. (2009). Information sharing and team performance. A meta-analysis. Journal of Applied Psychology, 94(2), 535–546.

Meyers, R. A., Seibold, D. R., Brashers, D. (1991). Argument in Initial Group Decision-Making Discussions: Refinement of a Coding Scheme and a Descriptive Quantitative Analysis. *Western Journal of Speech Communication*, 55, 47-68

Montoya, M. M, Massey, A. P., Lockwood, N. S. (2011). 3D Collaborative Virtual Environments: Exploring the Link between Collaborative Behaviors and Team Performance. *Decision Sciences*. 42(2), 451–476

Nijstad, B. A. (2009). *Group performance.* New York: Psychology Press

Olson, G. M., & Olson, J. S. (2000). Distance matters. *Human-Computer Interaction*, 15, 139-179.

Orlitzky, M., & Hirokawa, R. Y. (2001). To err is human, to correct is divine: A meta-analysis of research testing the functional theory of group decision-making effectiveness. *Small Group Research*, 32(3), 313–341.

Pinsonneault, A., & Heppel, N. (1998). Anonymity in group support systems research: A bew conceptualization, measure, and contingency framework. *Journal of Management Information Systems*, 14(3), 89-108.

Postmes, T., Spears, R., Lea, M. (1998). Breaching or Building Social Boundaries? SIDE-Effects of Computer-Mediated Communication. *Communication Research*, 25(6), 689-715

Powell, A., Piccoli, G., & Ives, B. (2004). Virtual Teams: A Review of Current Literature and Directions for Future Research. *Database for Advances in Information Systems*, 35(1), 6-36

Rice, R. E. (1984). *The new media: Communication, research and technology*. Beverly Hills, CA: Sage.

Sallnäs, E.-L. (2005). Effects of communication mode on social presence, virtual presence, and performance in collaborative virtual environments. *Presence*, 14(4), 434-449.

Sarker, S., Lau, F., and Sahay, S. (2001). Using an Adapted Grounded Theory Approach for Inductive Theory Building About Virtual Team Development. *Database for Advances in Information Systems*, 32(1), 38-56

Schouten, A. P., van den hoof, B., & Feldberg, F. (2010) Real decisions in virtual worlds: team collaboration and decision making in 3D virtual worlds. ICIS 2010 Proceedings, 18.

Schuemie, M. J., Van der Straaten, P., Krijn, M., and Van der Mast, C. A. P. G. (2001). Research on Presence in Virtual Reality: A survey. *Cyberpsychology and Behavior*, 4(2),183-201.

Seibold, D. R., Meyers, R. A., & Sunwolf. (1996). Communication and influence in group decision making. In R. Y. Hirokawa & M. S. Poole (Eds.), *Communication and group decision-making* (2nd ed) (pp. 242-268). Newbury Park, CA: Sage.

Sharda, R. Barr, S.H., and McDonnell, J.C. (1988). Decision Support System Effectiveness: A Review and an Empirical Test. *Management Science*, 34(2), 139-157

Shaw, M. E. (1964). Communication Networks. In L. Berkowitz (Ed.) *Advances in experimental social psychology* (pp. 111-147). New York: Academic Press.

Sproull, L., & Kiesler, S. (1986). Reducing social context cues: Electronic mail in organizational communication. *Management Science*, 32(11), 1492-1512.

Sproull, L., & Kiesler, S. (1991). *Connections: New ways of working in the networked organization*. Cambridge, MA: MIT Press

Stasser, G., & Titus, W. (1985). Pooling of unshared information in group decision making: Biased information sampling during discussion. *Journal of Personality and Social Psychology*, *48*(6), 1467.

Steiner, I.D. (1972). *Group Process and Productivity*. New York: Academic.

Straus, S. G., & McGrath, J. E. (1994). Does the medium matter: The interaction of task type and technology on group performance and member reactions. *Journal of Applied Psychology*, 79, 87–97.

Straus, S. G. (1997). Technology, group process, and group outcomes: Testing the connections in computer-mediated and face-to-face groups. *Human–Computer Interaction*, 12(3), 227–266

Townsend, A., DeMarie, S. and Hendrickson, A. (1998). Virtual Teams: Technology and the Workplace of the Future. *Academy of Management Executive*, 2(3), 17-29.

Van Ginkel, W. and Van Knippenberg, D. (2008). Group Information Elaboration and Group Decision Making: The Role of Shared Task Representations. *Organizational Behavior and Human Decision Processes*, 105(1), 82-97.

Vroom, V., & Yetton, P. (1973*). Leadership and decision making*. Pittsburgh, PA: University of Pittsburgh Press.

Walther, J. B. (1992). Interpersonal effects in computer-mediated interaction – a relational perspective. *Communication Research*, 19(1), 52-90.

Weisband, S. P. (1992). Group discussion and first advocacy effects in computer-mediated and face-to-face decision-making groups. *Organizational Behavior and Human Decision Processes*, 53, 352-380.

Weisband, S. P., Schneider, S. K., Connolly, T. (1995). Computer-Mediated Communication and Social Information: Status Salience and Status Differences. *Academy of Management Journal*, 38(4), 1124-1151.

Wheeler, S. C., DeMarree, K. G.,& Petty, R., E. (2007). Understanding the role of the self in prime-to-behavior effects: The active-self account. *Personality and Social Psychology Review*, 11, 234–261.

Whyte, G. (1989). Groupthink reconsidered. *Academy of Management Review*, 14(1), 40–56.

Winquist, J. R., & Larson Jr, J. R. (1998). Information pooling: When it impacts group decision making. *Journal of Personality and Social Psychology*, *74*(2), 371

Yee, N., & Bailenson, J. N. (2007). *Human Communication Research*, 33, 271-290.

Zack, M. H., & McKenney, J. L. (1995). Social context and interaction in ongoing computer-supported management groups. *Organization Science*, 6(4), 394–422.

Zigurs, I., and Buckland, B. K. (1998). A Theory of Task Technology Fit and Group Support Systems Effectiveness. *MIS Quarterly*, 12(4), 313-334.

## Other references

www.wilderdom.com, retrieved 30 Mars, 2011

www.teleplace.com, retrieved 4 April, 2011

www.adobe.com, retrieved 4 April, 2011

www.vmwork.net, retrieved 2 May, 2011

## Appendix 1: NASA Exercise: Survival on the Moon

You are a member of a space crew originally scheduled to rendezvous with a mother ship on the lighted surface of the moon. However, due to mechanical difficulties, your ship was forced to land at a spot some 200 miles from the rendezvous point. During reentry and landing, much of the equipment aboard was damaged and, since survival depends on reaching the mother ship, the most critical items available must be chosen for the 200-mile trip. Below are listed the 15 items left intact and undamaged after landing. Your task is to rank order them in terms of their importance for your crew in allowing them to reach the rendezvous point. Place the number 1 by the most important item, the number 2 by the second most important, and so on through number 15 for the least important.

You have 20 minutes to complete the task in your group.

Your Ranking
_____ Box of matches
_____ Food concentrate
_____ 50 feet of nylon rope
_____ Parachute silk
_____ Portable heating unit
_____ Two .45 caliber pistols
_____ One case of dehydrated milk
_____ Two 100 lb. tanks of oxygen
_____ Stellar map
_____ Self-inflating life raft
_____ Magnetic compass
_____ 20 liters of water
_____ Signal flares
_____ First aid kit, including injection needle
_____ Solar-powered FM receiver-transmitter

## Appendix 2: Coding Scheme – Individual level

This coding scheme was derived from group decision-making theories, such as the groupthink theory (Janis, 1982), the vigilant decision-making theory (Janis & Mann, 1977) and the functional perspective (Gouran and Hirokawa, 1996) in combination with the interaction process analysis (IPA) scheme (Bales, 1950) and the argument coding scheme (Meyers, Seibold & Brashers, 1991).

### PROBLEM IDENTIFICATION AND ASSESSMENT /INITIATION

1. A. A group member manages to set up a shared goal to the group in the beginning of the task
    a. And show a correct understanding of the problem
    b. But does not understand the problem correct

    B. A group does not manage to set up a shared goal in the beginning of the task.

2. A. A group member manages to set up a clear procedure how to carry out the task/implement the solution.
    B. A group member does not manage to set up a clear procedure how to carry out the task/implement the solution.

3. A group member manages to delegate clear tasks for each group member.

### INFORMATION EXCHANGE

### A) INFORMATION SHARING

4. INFORMATION SHARING:
    a. A member gives a valuable statement which is a fact or opinion
        i. With an explanation
        ii. Without any explanation
    b. A member gives an inaccurate statement or opinion
        i. With an explanation
        ii. Without any explanation
    c. A member gives an irrelevant statement for the group's decision-making (tangents, side issues, self-talk, jokes )

5. SOLUTION SUGGESTION
    a. A member gives a statement/solution suggestion/solution direction (that call for support, action or discussion about it) in the right direction
        i. With an explanation in the right direction
        ii. With an explanation in the wrong direction
        iii. Without any explanation
    b. A member gives a statement/ solution suggestion/ solution direction (that call for support, action or discussion about it) in the wrong direction
        i. With an explanation in the right direction
        ii. With an explanation in the wrong direction
        iii. Without an explanation

6. ORIENTATION:
    a. A member gives orientation about the task or what is to be done next.
    b. A member speaks out loud about available information in the task description.
    c. A member repeat, clarify, confirm some information to the group

## B ) RESPONSES TO INFORMATION SHARED

7. AGREEMENT/ + ELABORATION
    a. A member gives a simple agreement on a statement
    b. A member gives an agreement on a statement
        i. With an explanation (evidence, reason, other support) in the right direction.
        ii. With an explanation (evidence, reason, other support) in the wrong direction.

8. DISAGREEMENT/ + ELABORATION
    a. A member gives a simple disagreement on a statement
    b. A member gives a disagreement on a statement
        i. With an explanation (evidence, reason, other support) in the right direction.
        ii. With an explanation (evidence, reason, other support) in the wrong direction.

9. DOES NOT KNOW
   A member gives a response indicating on poor knowledge on a certain subject of discussion.
10. EVALUATION
    A member evaluate or analyze an idea, express feeling or opinion.
    a. *And manage to look at both negative and positive aspects of the idea*

11. DEFENCE: Statements that defend statements met with disagreement.

12. CLARIFICATION OF AN STATEMENT: Statements that explain or expound on other statements in order to establish the relevance of the argument through inference

13. INTERRUPTION:
    a. A member interrupts another member while speaking so information is lost.
    b. A member stop to think midstream
    c. A member mumble (information gets lost)

## INFORMATION SEARCH /QUESTIONING

14. INFORMATION SEARCH:
    a. A group member asks for entirely new information
    b. A group member asks for more information about some statement.
    c. A group member asks for explanations. (Why like that? But does that work on the moon? e.g.)

15. SOLUTION SUGGESTION:
    A member asks for solution suggestions / solution directions.

16. ASKS FOR EVALUATION
    A member asks for opinion, evaluation or analysis on ideas

17. ORIENTATION:
    a. A member asks for orientation about what is to be done next.

b. A member asks the group (a member) to repeat, clarify, confirm some information
c. A member asks for status about others actions or understanding of a topic.

## GENERATION AND EVALUATION OF SOLUTION

18. PRELIMINARY DECISION:
    A member makes a preliminary decision
    a. Without any/or little discussion
    b. After discussion

19. OVERLOOKS INFORMATION
    A member overlooks some shared information and drops it out without giving any feedback.

20. RECONSIDERING: A member reconsiders rejected ideas.

21. RECOGNIZE FALLACIES: A member recognizes fallacies in others' solutions.

22. REEVALUATION
    In the end, a member goes through/reevaluates their answer.
    a. If something has changed his/her opinion, the member suggests changes to their answer.

23. AGREEMENT ON FINAL DECISION
    a. A member agrees with the final decision.
    b. A member does not agree with the final decision.