Computer-mediated Group Interaction and Innovativeness

Investigating the effects of communication properties, cognitive style, and idea generation attitudes on innovative thinking processes

by

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- Abstract -

Strong abilities to innovate by use of communication technologies are often appraised as a source of competitive advantage in the information economy, and research concerning the facilitating role of technology regarding organizational innovation is therefore required. In this dissertation the focus is directed at the relationship between electronically mediated communication and innovative thinking. The impacts of computer-mediated communication on specific thinking processes in group-based problem solving are addressed, and hypotheses concerning the effects of different aspects of the communication environment (the degree of synchronicity, parallelism, and identification) on manifestations of innovative thinking processes (divergent focus and convergent focus) are proposed. The moderating roles of the group members' attitudes toward idea generation (preference for ideation and preference for evaluation) and their cognitive styles (explorative and assimilative) are also discussed and hypothesized on.

Experiments involving a total of 95 graduate and undergraduate students were conducted in order to test the hypotheses. The results revealed few overall differences between the chosen communication properties in their influence on innovative thinking processes. However, effects of synchronicity on convergent focus were found, indicating that low synchronous interaction may enhance the evaluative processes in group-based problem solving. Further, when the subjects' attitudes toward idea generation and cognitive styles were included as moderators, some interesting findings appeared. Most notable is the important role of preference for evaluation in low synchronous interaction. It was observed that low synchronicity positively influences convergent focus for participants with low preferences for evaluation. It was also found that divergent focus increases with increasing explorative cognitive styles in interaction with low identification of group members' contributions, while the opposite relationship was found when the level of identification was high. The most important practical implications that can be drawn from the study relate to the overall conclusion that the same collaborative tools (configurations) should not be used in all phases of the problem solving process. That is, group facilitators have to consider both personal and technological factors in order to configure the communication environment that best supports the objectives of the work that is to be carried out.

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Part I

- Introduction -

In the first part of the dissertation, I introduce the issues underlying the importance of the research focus. Thereafter, the research question I try to answer is put forth, and the expected contribution of the research is described. The introductory section is ended with an outline and brief description of the various parts of the dissertation.

1   Introduction

It is becoming widely recognized that the transition to a knowledge society and a global information economy will be the most important social and economic changes of the next decade. Characteristics of this economy - international competition, fragmented and demanding markets, and diverse and rapidly changing technologies - are placing intense pressure on companies to adopt flexible approaches to development of products and services, shorten innovation processes (Kessler, 1996), and speed up time to market (Iansiti & MacCormack, 1997). Superior performance in product/service development and innovation is therefore believed to be one of the main sources of competitive advantage in the modern market place.

Another characteristic of the information economy is the growing importance of technology-based communication and interaction. Qualities of communication media like the Internet render possible a simultaneous exchange of rich and detailed information among a large number of people and organizations (Evans & Wurster, 1997), and information technology is therefore increasingly being used to support collaborative work in a variety of organizational settings. Software that facilitates computer-mediated communication allows members of collaborative teams to jointly generate ideas, make decisions, and solve problems. The available collaborative tools speed communication by providing features such as text chat, instant messaging, joint document editing, and real-time online collaboration, and "virtual teamwork" has therefore become a viable form for work in modern organizations (Martins et al., 2004).

1.1   Research question and positioning

In this business environment, characterized by a widespread use of electronic communication facilities and a constant need for innovation, it is not just the information or the technology *per se* that commands strategic attention. Rather, the environmental, technological, organizational, and human conditions that allow for successful utilization of the technology regarding facilitation of innovation processes are of equal or greater importance. Based on this acknowledgement, this study will focus on how qualities or properties of electronic communication media may impact on individuals' innovative thinking in group-based problem solving, and the following research question will be tried answered:

Do electronic communication media influence innovative thinking processes? If yes: How?

Many studies in the computer-mediated communication (CMC) literature focus on differences between various "communication modes" (e.g. face-to-face and dispersed computer-mediated interaction), without digging deeper into the underlying qualities of the modes (see e.g. Fjermestad, 2004 for a review). However, in order to generate new knowledge on desirable use of ICT in groups, it is important to investigate how the distinctive characteristics of different CMC settings impact on relevant individual and organizational factors. I will therefore not adopt a "mode perspective" in this study, but rather put emphasis on variables that all mediated and non-mediated communication processes can be described and evaluated by, which will vary in strength depending on the context in which the interaction occurs (e.g. how electronic interaction tools are configured). There are many theories that have been developed in this research stream, and accordingly there are many theoretical concepts describing underlying features of communication modes. Theories like Media Richness Theory (Daft & Lengel, 1986), Media Synchronicity Theory (Dennis & Valacich, 1999) and Burgoon et al.'s (2000a; 2000b) interactivity model all make efforts in describing the constituent parts of mediated communication. Based on existing theoretical contributions, a part of the dissertation will be devoted to a discussion of properties that can be used to describe and evaluate mediated communication processes, with a particular focus on properties I find to be of special importance for individuals in group-based problem solving processes.

In studies occupied with group-based CMC and Group Support Systems, the outcome factors are generally efficiency measures (e.g. decision time, number of decision cycles), effectiveness measures (e.g. decision quality, decision confidence), satisfaction measures (e.g. participation, influence, confidence), consensus (e.g. decision agreement, commitment), and usability measures (willingness to work together again, system utilization) (Fjermestad & Hiltz, 1999). Further, in studies focusing on the relationship between use of ICT in group interaction and innovation, the dependent (innovation) variables investigated are often products or artifacts resulting from the group processes. Variables commonly used in this research domain are for example the number and/or quality of the ideas generated (e.g. Connolly et al., 1990; Gallupe et al., 1992). Accordingly, little emphasis has been put on how

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communication properties influence the *innovation processes* which lead to better or more desirable scores on the outcome variables. This research applies such a process perspective, and focuses on innovative thinking processes for each individual in a group-based problem solving situation. Moreover, literature focusing on problem solving in groups has shown that individual factors like cognitive style and attitudes toward idea generation may account for variability in both processes and outcomes of problem solving sessions, and these variables are therefore included as moderators in the study.

The conceptual model of the dissertation can on this basis be depicted as follows:
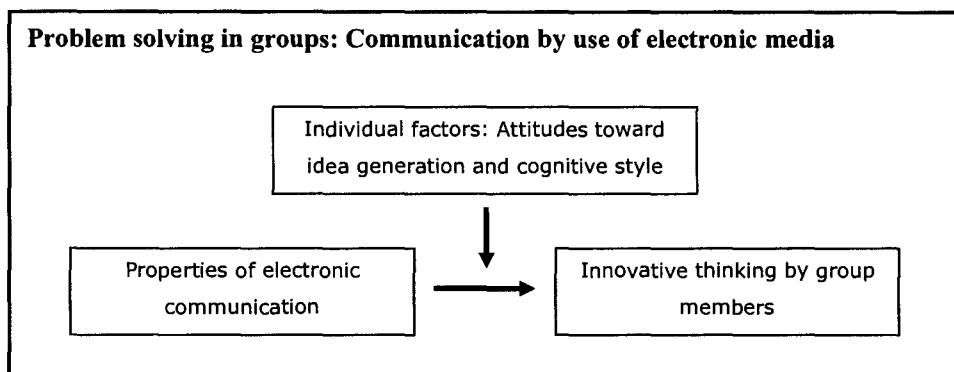
Figure 1.1: Conceptual model

1.2   Contribution

The role of modern information and communication technologies in stimulating and managing innovation in organizations is becoming more important for every day that goes by. This is clearly evident when observing large companies such as Nortel, Shell, and Proctor and Gamble initiating "idea factories" in which teams interact by use of Internet-technology, with the goal of generating ideas that can change existing business paradigms (Stepanek, 1999). In order to be successful in generating innovative ideas, it is not sufficient to focus only on the technological features that enable group interaction, but also the individuals that constitute the groups, and how they perform in these rather novel settings, must be focused. In other words, the most vital resources necessary for generating the desired ideas are individuals' abilities to be creative. This is *possessories of individuals*, and may be influenced by the way interaction with others is effectuated. The role of ICT in group/team work focusing on idea generation

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must therefore be to support the individuals' innovative thinking in the best possible ways, which again accentuate the importance of knowledge of the relationship between communication media qualities and individuals' innovative thinking.

The relevance of this research focus can be attributed to two main factors. First and foremost, the research may increase our understanding of both the virtues and shortcoming of electronic media for group interaction when it comes to the individual group members' thinking processes, and how important a well-considered selection of communication media is for the outcome wee seek. This, again, is relevant as convergence and integration of information and communication technologies result in an increase in organizational members' opportunities for interaction along different types of communication channels. This integrated media environment will influence and, to some extent, shape human interaction, which necessitates a deliberate selection of communication media based on both their positive and negative qualities with reference to the tasks that are to be accomplished and the purpose of the interaction. The second factor that makes this research highly relevant is related to the increasing importance of innovation in the information economy. Along with, and partially as a consequence of, the increasing use of ICT, we experience a need for a stronger focus on customization and differentiation of products and services. The number of factors that competitive organizations have to optimize is rising, and the knowledge needed for any economic activity has become highly specialized. Putting things to the extremes, organizations' speed and quality of innovation processes are basically matters of death or survival in the information economy. How, then, can information technologies be used to facilitate innovative thinking? Providing an answer to this question will be the managerial contribution of this research.

1.3   Outline of the dissertation

The dissertation is organized as follows: In part II, I present and discuss the theoretical constructs that are used to build the research model. This literature review is divided into three chapters: In chapter 2, called *innovative thinking*, I discuss the different processes involved in effective idea generation and problem solving, and how different thinking processes are manifested in language. In chapter 3, *individual differences: attitudes and cognitive style*, I present and discuss how individuals' attitudes toward idea generation and cognitive styles might affect the components of the idea generation processes that were

presented in chapter 2. The final chapter of part II (chapter 4), is called *communication media: capabilities*, and here I present a categorization of various media capabilities with reference to the degree to which the media support and enable various affordances/properties that characterize all communication situations. In this discussion, the affordances that I find most important for the innovative thinking processes presented in chapter 2 are defined.

In part III, I first present the conceptual model, where I delineate the relationships between the constructs that are discussed in the literature review. More specifically, I illustrate how affordances supported (to a certain degree) by various communication media may impact on manifestations of innovative thinking processes. I also point out my assumption of the moderating effects of individuals' attitudes toward idea generation and cognitive styles on these relationships. Second, hypotheses regarding the main effects of affordances on innovative thinking processes, and the moderating effects of individual differences, are put forth.

Part IV concerns the methodological approach of the research. More specifically, in chapter 6 (*method*), I describe the research design applied, and discuss how the affordances (independent variables) were manipulated. I further present how measures of both dependent and independent variables were developed. The last chapter of this part, *results and analysis* (chapter 7), consists of a presentation of the results of the statistical tests that were effectuated in order to test the hypotheses proposed in chapter 5.

In the fifth and last part of the dissertation, I first discuss the results of the empirical research, and present potential explanations for the findings (chapter 8). Thereafter (in chapter 9), I discuss theoretical, methodological, and practical implications, limitations of the study, and the dissertation is ended with some suggestions for future research.

Part II

- Literature Review -

In this part, I describe the theoretical platform of the research. I start by clarifying my perspective on innovative thinking in chapter 2. This includes a discussion of both cognitive and social aspects involved in the process, and the chapter is ended by describing the concepts that I use in the conceptual model. Chapter 3 deals with individual differences that are important when it comes to innovative thinking, and in chapter 4 I discuss qualities of communication media that are relevant for group collaboration aiming at producing innovative ideas. Similar to chapter 2, the last two chapters in this part also end with a selection and definition of the constructs (individual differences in chapter 3 and communication media affordances in chapter 4) that I use in the research model.

2   Innovative thinking

In this chapter I discuss the process of innovative thinking in the context of idea generation in a problem solving situation. I start by defining relevant concepts like thinking, innovation, and idea generation, and further discuss what kinds of cognitive processes that are involved in the idea generation phase of problem solving activities. The last part of the chapter concerns manifestations of these cognitive processes in language, and the chapter is ended with a description of two different concepts that I find important for the purposes of this research and which will be used as dependent variables in the study.

2.1   Introduction

The field of innovation is very diverse; innovation research has emanated from many academic disciplines including management, psychology, economics, and sociology, among others. Within these and other disciplines, researchers tend to conceptualize innovation in different ways (Read, 2000). One of the initial difficulties in innovation research is therefore to define exactly what innovation is. Authors have made distinctions between studies of the "diffusion" and "adoption" of innovations, as well as between studies of "innovating" and "innovativeness" (Damanpour, 1991). One central point of contention in this respect is whether innovation is a process or an outcome.

For the purpose of this study, innovation is understood as a process of creating or modifying an idea and developing it to produce products, services, processes, structures, or policies that are new to the organization (Zhuang, 1995; Nohria & Gulati, 1996; Read, 2000). The stages or phases in the innovation process are conceived to encompass the generation, development, and implementation of new ideas and behaviors (Blazevic & Lievens, 2002). This conceptualization of innovation is highly related to *organizational creativity*. Woodman et al. (1993) define organizational creativity as "the creation of a valuable, useful new product, service, idea, procedure, or process by individuals working together in a complex social system" (p. 293). They frame the definition of organizational creativity as a subset of the broader domain of innovation. That is, even though much innovation involves creativity, innovation can also include the adaptation of preexisting products or processes created outside of the organization.

2.2   Innovative thinking in idea generation

This study will focus on the idea generation phase. Both innovation and organizational creativity are initiated with idea generation, but based on the distinction between these concepts outlined above, the process of idea generation can be viewed as slightly broader for innovation than for creativity. "Creative idea generation" includes finding solutions (ideas, products, processes, etc.) that are new to the market, while "innovative idea generation" involves finding solutions that are new to the adopting unit. In this understanding of the concepts, all creative ideas are innovative, but an innovative idea is not necessarily creative. In spite of this difference, I perceive the idea-generating process to be relatively similar in both innovative and creative processes, and I will therefore not distinguish creative idea generation from innovative idea generation. In general, the goal of idea generation is to create a pool of candidate ideas for further evaluation, and ultimately, implementation.

Successful idea generation is related to certain thinking processes. The concept of *thinking* is often construed as "an umbrella term for a range of *processes* associated with *"high-level" cognition*, such as reasoning, categorization, and judgment and decision making" (Holyoak & Spellman, 1993: p. 266. My italics). In a problem solving situation, the first process that needs to be initiated is a search for alternatives. That means that the decision makers or problem solvers have to collect information that is relevant to the problem, and which may contribute to, or are necessary for, a successful change. After the search for alternatives, the decision makers need to select one specific solution that they find most appropriate for the task they face.

There exists little controversy regarding the importance of these two "opposite" phases to be present in idea generation activities; in other words, successful completion of idea generation entails a combination of *divergent* and *convergent* thinking. The following discussion of cognitive processes involved in idea generation will therefore be based on the distinction between divergence and convergence.

2.2.1   The roles of divergent and convergent thinking in idea generation

The distinction between divergence and convergence is, among other things, used in describing different thinking procedures necessary for successful problem solving. Ever since

Alex Osborn launched the modern wave of creative thinking in business with his 1942 book, *How to Think Up*[1], effective creative problem solving techniques emphasize divergent, impractical thinking before developing a practical solution. Thus, in a problem solving context, exercising divergent thinking involves starting with a specific problem and generating various options and perspectives on the problem. Convergent thinking follows the divergent process, and acts to narrow down the options available to obtain a number of "satisfying" solutions to the problem (see figure 2.1).
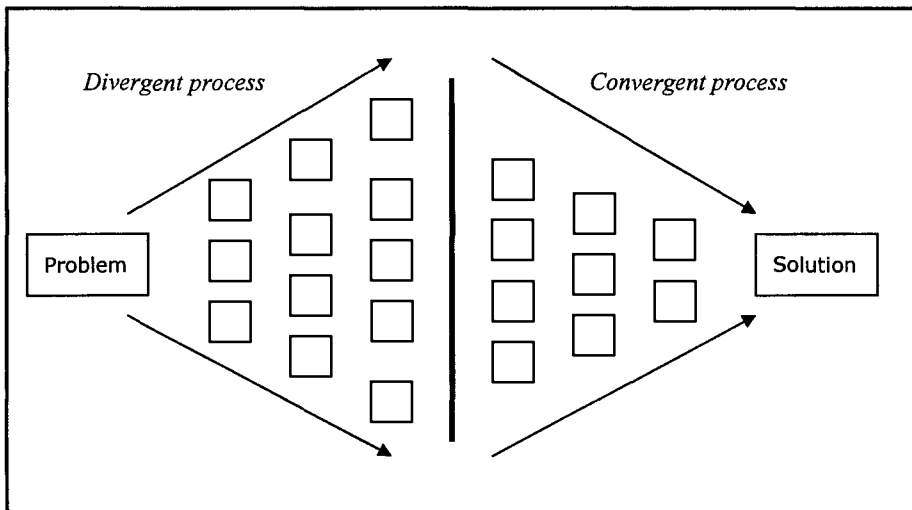
Figure 2.1: Divergent and convergent thinking

In this context, divergence involves branching behavior that explores and expands in different directions, and divergent thinking and behavior thus refer to going off in new directions rather than thinking solely on one solution, and deriving a variety of ideas from given information. The goal of divergence is to generate many different ideas about a topic in a short period of time. It involves breaking a topic down into its various component parts in order to gain insight about the various aspects of the topic. Divergence typically occurs in a spontaneous, free-flowing manner, such that the ideas are generated in a random, unorganized fashion. Following divergent thinking, the ideas and information will be organized using convergent

[1] Alex F. Osborn, (1942): *How to Think Up*. McGraw-Hill, New York.

thinking; i.e., putting the various ideas back together in some organized, structured way. Convergence is an integrating and narrowing process that focuses on testing and exploiting a given direction. It reduces the dimensions or complexity of a system, and thus refers to finding an appropriate or "correct" solution to a stated problem.

Based on the discussion above, my understanding of the idea generation concept can be expressed as follows: "Idea generation is a process that consists of both divergent and convergent thinking with the objective of creating the best possible idea or solution to a problem". In this process, it may be reasonable to consciously separate divergent thinking from convergent thinking as people cannot simultaneously be creative and critical when generating innovative and practical solutions. Hence, some authors advocate the deliberate distinction between "idea-producing" (divergent) and "idea-selection" (convergent) thinking processes. Within this general approach, two schools of thought have appeared. One school allows for the use of judgmental and convergent thinking during idea production (e.g. Simon et al., 1962), while the other one expressly prohibits any such thinking during idea production. Belonging to the latter school of thought, Basadur et al. (1982) identified a sequenced two-step thinking process called "ideation-evaluation". They defined "ideation" as the production of ideas without evaluation, and "evaluation" as the application of judgment to the ideas produced.

Basadur et al. (1982) argue that the deliberate separation between ideation and evaluation is important. One of the reasons for making a clear distinction between these processes, and start with a pure divergent process, is related to the need for the problem solvers to detach from existing ways of doing things. That is, people may hold back ideas they think are stupid or silly, and by this using divergent and convergent thinking interchangeably or even at the same time. Similarly, the problem with accepting ideas that make sense right away is that the *reason* they make sense up front is that they are based on what the problem solvers already know from the past. In these situations, the productivity or effectiveness will at best be improved marginally. To create significant improvements or entirely new products, services or processes, those ideas that seem absolutely preposterous or unachievable at first are needed (Basadur et al., 1982).

Empirical research has supported both the general separation of idea production from idea selection and the more specific ideation-evaluation process (Basadur et al., 1982; Basadur & Finkbeiner, 1985; Joyner & Tunstall, 1970; Parnes et al., 1977). There are many methods or techniques that can be used in order to ensure that ideation and evaluation are not done simultaneously. One of the oldest and most widely used approaches emphasizing this separation is the Osborn-Parnes model of creative problem solving. This model stresses four critical rules that must apply for successful ideation: 1) withholding judgment[2], 2) freewheeling[3], 3) generating a quantity of ideas[4], and 4) hitchhiking[5] on the ideas of others. These four rules reflect the fact that idea generation is both a cognitive and social process (Nagasundaram & Dennis, 1993; Dennis et al., 1999). People generally do not generate ideas in isolation. Often they work with others as part of a formal or informal group to generate ideas. Under these conditions, individuals first conceptualize an idea (cognitive process – e.g. by use of hitchhiking) and then choose whether or not to contribute it (social process – e.g. because of judgmental conditions) (Carfield et al., 2001).

2.3 Manifestations of convergent and divergent thinking in language

When ideas and comments are put forth, the characteristics and specific formulations of these contributions are important for group processes. That is, the words and sentences that are used when describing a situation and making contributions in group-based problem solving are often critical in determining whether the problem solvers are able to improve the situation and arriving at the best solutions. Referring to the impacts of "wrong" wordings in problem solving, Basadur (1995a) speaks of "killer phrases" in brainstorming sessions. These are expressions like "we already tried that", "it would cost too much", "all right in theory", or "yes, but...", and help to narrow down the options available in a given problem solving session. Sentences of this character are thus about convergence and not divergence, meaning that they should only be used during the latter part of the idea generation process (figure 2.1).

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[2] Research in biological psychology has shown that judging is perceived as a threat that inhibits creativity. Conversely, positive feedback increases the combination of divergent stimuli in new ways (Hughes, 1999).

[3] Freewheeling means that it is all right to be "off the wall" in the idea creation process.

[4] Experiments have shown that the last ideas, the ones beyond mental blocks and into the subconscious, are the highest quality ideas (Hughes, 1999).

[5] Hitchhiking involves creating ideas that combine the best ideas of other members of the team.

The counterparts of these expressions are sentences like "how might we...", "in what kind of ways...", and "what is our real problem...", and are more challenge-oriented. This means that problems are framed in a positive manner and refer to challenges rather than unwanted difficulties that have to be overcome.

I hold the view that environmental factors can influence (either facilitate or inhibit) both the cognitive and the social elements of idea generation (cf. the discussion of cognitive and social processes above). An important implication of this is that it may be possible to control or organize environmental factors that are important for these processes. Environmental factors like communication media capabilities are thus able (and likely) to encourage and discourage specific cognitions and behavior (e.g. formulations of ideas and comments) relevant for divergence and convergence in a group-based problem solving situation (the effects of communication media capabilities on individuals and group processes will be elaborated on in section 4.3). As discussed above, the particular selection of words and sentences can be perceived as manifestations of the contributor's thinking processes, and can thus be reflecting divergence and convergence. I therefore believe that a focus on manifestations of divergent and convergent thinking processes in language is suitable for answering the research question presented in section 1.1. The concepts of "divergent focus" and "convergent focus" will for that reason be used as dependent variables in the study.

2.3.1   Divergent focus

Words and sentences that reflect divergent thinking generate variability. These formulations are not about judgement and criticism, but rather encourage exploration of numerous ideas (figure 2.1). Individuals whose wordings are of this character are perceived to have a divergent focus of the idea generation process.

2.3.2   Convergent focus

Whereas words and sentences reflecting divergent thinking generate variability, formulations that result from convergent thinking generate orthodoxy. Thus, these are words and phrases that acts to narrow down the available solutions to a problem (figure 2.1). Use of words and

sentences of this character will in this study be regarded as a result of a convergent focus of the idea generation process.

2.4 Conclusion

Successful idea generation is in any given situation dependent on a number of factors. Bearing in mind that much problem solving in organizations involve group communication by use of information technology, it is important to investigate whether communication media can influence divergent and convergent thinking. How people think is manifested in their language, and divergent and convergent thinking result in use of dissimilar words and phrases when discussing and solving problems. I will use the concepts of "divergent focus" and "convergent focus" as variables in order to capture divergent and convergent thinking processes in this study.

3 Individual differences: Attitudes and cognitive style

In this chapter, I discuss the role of individual differences in idea generation. I focus on the concepts of attitudes (toward idea generation) and cognitive style, and the discussion results in a selection and definition of two attitudinal constructs and a cognitive style continuum that focuses on individuals' preferred strategies when solving problems. These constructs (both attitudes and cognitive style) will be moderating variables in the study.

3.1 Attitudes toward idea generation

The Osborn-Parnes model of creative problem solving shows that idea generation is not just a matter of cognition (cf. discussion in section 2.2.1). In this respect, Basadur and Finkbeiner (1985) view ideation (and evaluation) as having both *cognitive* and *attitudinal* elements. That is, in addition to the cognitive processes, "effective ideation may require specific attitudes favoring this kind of thinking, perhaps to help participants truly "let loose" and use more fully their unencumbered imaginations" (p. 38). In other words, successful ideation necessitates deferral of evaluation. Following this line of thinking, my understanding of idea generation does not just include the pure "generative" or cognitive part of the process, but it also contains individuals' attitudes that are related to the two distinct cognitive processes (ideation/divergence and evaluation/convergence) involved in idea generation. Such attitudes may for example impact on decisions of whether ideas that are produced should be put forth, and are therefore important aspects of the idea generation process. The reason for this is that ideas are of little value if they are not communicated and acted upon. Following this line of reasoning, positive ideative attitudes may enhance cognitive ideative processes and performance, and impair evaluative cognitive processes and performance. Conversely, positive evaluative attitudes may enhance evaluative cognitive processes and performance, while impairing ideative cognitive processes and performance. Accordingly, two important consequences follow. First, by extension, individuals' attitudes toward idea generation can indicate their potential for contributing positively (by convergent and convergent thinking) to the two stages in idea generation processes, and second, it will be possible to facilitate ideative and evaluative cognitive processes by controlling environmental factors that again influence the corresponding attitudes. For these reasons, I will include *attitudes toward idea generation* in this study.

Attitudes can thus be seen as antecedents of cognitive processes. This is consistent with several "general" theories concerning the linkage between attitudes and behavior, like Kraut's (1976) training model suggesting a causal chain whereby attitude change leads to performance change, and Fishbein and Azjen's (1975) theory of reasoned action proposing that behavior can be predicted by individual attitudes and social norms. Further, in the field of creativity research, Basadur et al. (1982) conducted a field experiment showing that practice-oriented training resulted in improvements in divergent thinking attitudes that accompanied improvements in divergent thinking practice and creative performance. Later, Basadur and Finkbeiner (1985) also modeled how divergent thinking attitudes enhance divergent thinking skills.

Basadur et al. (1982) and Basadur and Finkbeiner (1985) thus suggest that one may explain differences in degrees of success achieved when using ideation by citing attitudinal factors associated with the divergent thinking process. In other words, successful idea generation may be achieved by altering persons' attitudes toward ideation and evaluation. Changing attitudes is generally seen as a tardy process, however, and Basadur et al. (1982; 1986; 2000) stress enduring training in order to change persons' attitudes. That is, in several field experiments, they found that practice-oriented training resulted in improvements in divergent thinking attitudes that accompanied improvements in divergent thinking practice. However, the relationship between attitudes and behavior is problematic, and a focus on training effects on attitudes may indicate a reverse order of the relationship between attitudes and practice as suggested by the authors. That is, training in ideation forces the participants to perform divergent thinking which again may influence their attitudes toward ideation. This is in accordance with social perception theory (Bem, 1967), which proposes that people look back at their behavior, consider it in light of the circumstances, and then infer what their attitude about it must have been. Thus, even though persons have attitudes toward both ideation and evaluation, it is not apparent that these attitudes precede or determine their behavior, and that it is not the other way around.

Basadur and Finkbeiner (1985) view attitudes associated with idea generation as analogous to cognitive style. Cognitive style in creative problem solving, however, as measured by e.g. the Myers-Briggs Type Indicator (MBTI) (Mayers, 1987; Mayers & Briggs, 1952) or The Kirton Adaptor-Innovator (KAI) Inventory (Kirton, 1976; 1987), is held to be a stable personality trait, which is thus very hard to alter. People differ in their abilities to think divergently and convergently - it is a personality trait (Guilford, 1967). Brophy (1998) points out that different cognitive- and personality traits may accompany divergent and convergent thought. Divergent thinkers are more likely to process diverse stimuli, organize thoughts flexibly, seek knowledge about varied subjects, and form intuitions, and they are more intrinsically motivated to solve problems creatively. Most people are either divergers or convergers, a few are both.

In spite of this, Basadur and Finkbeiner (1985) argue that these attitudes can be moderated (e.g. by training in creative problem solving), and perceive the constructs to be alterable. I hold the view that cognitive style refers to more profound individual qualities underlying human behavior than what attitudes do, and I therefore make a distinction between attitudes toward idea generation and cognitive style. This means that while cognitive style is more or less stable across situations, I believe that attitudes are more tied to the specific situations, and can be altered and influenced (e.g. by environmental factors). In other words, when talking about preferences for specific behavior in a group-based problem solving situation, environmental factors play a significant role in inhibiting or endorsing these preferences. Thus, even though the participants in group-based problem solving have attitudes that are relatively stable across situations (when all other factors are excluded), it does not mean that these attitudes or preferences will prevail in situations where there are environmental factors that encourage or discourage specific attitudes or behavior. I therefore find it important to include *both* attitudes and cognitive styles relevant for idea generation and problem solving as moderators between situational variables (in this case media capabilities) and manifestations of divergent and convergent thinking processes.

Basadur et al. (1982) identified several *attitudinal constructs* related to ideation. Two of these constructs are "Preference for Ideation" and "Tendency to [Not] Make Premature Critical

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Evaluation of Ideas", and are measured by the *Basadur 14 item Preference Scale*[6]. Basadur and colleagues have also identified several other attitudes (and developed measurement scales) related to ideation. Two attitudes named "Valuing of New Ideas" and "Belief that Creative Thinking is [Not] Bizarre" were investigated by Basadur and Hausdorf (1996), and refined by Basadur et al. (1999). From this research, three new scales emerged (44 items), though without achieving the same level of validity and reliability as for the two former ideational measures. The attitudes were "Valuing New Ideas", "Belief that Creativity is Not Only for a Select Few", and "Not Feeling too Busy for New Ideas".

I will apply the two former constructs in this research, and there are two reasons for this selection. First, several studies focusing on scale validation have been carried out, and the *Basadur 14 Item Preference Scale* has been used in subsequent research (Basadur et al., 1986; 1990; 1992; Runco & Basadur, 1993). Second, I find these two distinct preferences as representing divergent and convergent processes in a group-based problem solving situation, and as described earlier, these two distinct processes are necessary for the realization of successful innovative thinking in idea generation. I therefore believe that these constructs may be significant when it comes to the specific framing of ideas and comments in a problem solving situation, and thus are important moderators of the relationship between environmental factors and the dependent variables (divergent focus and convergent focus).

3.1.1 *Preference for ideation*

The divergent aspect of the two-step thinking process described in the last chapter focuses on generation of options, different points of view, and perceptions of facts and ideas, without any critical judgment or analysis. As discussed in previous sections, there are attitudes related to divergence or ideation that are accompanied by these cognitive elements. This is in accordance with the view of Basadur and Finkbeiner (1985) who developed a model describing how attitudinal processes enhance cognitive processes in problem solving.

With their focus on attitudes toward idea generation, Basadur et al. (1982) and Basadur and Finkbeiner (1985) identified and refined the construct of "Preference for Ideation". The

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[6] A Norwegian version of this scale is presented in appendix C.2.

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denotation of this construct concerns mind-sets such as being "less likely to jump to conclusions as to what is the real problem", and "more open-minded to new ideas and approaches"; "reacting more positively to new, unusual product ideas"; "being less prone to negative evaluation during idea generation"; "achieving higher quantity and quality of problem finding"; "being more likely to consider different problem definitions prior to choosing one as best"; and "being more likely to pause to try new, unusual approaches" (Basadur & Hausdorf, 1996: p. 22). A high preference for ideation may thus be associated with performing the latter three operations or rules of the Osborn-Parnes creative problem solving methodology well, and thereby triggering ideation and prohibiting evaluation (Basadur & Finkbeiner, 1985).

3.1.2 Preference for evaluation

Another construct associated with an individual's attitude associated with ideation proposed by Basadur and Finkbeiner (1985), is "Tendency to [Not] Make Premature Critical Evaluation of Ideas". Originally, this construct measures premature convergence. However, with reference to the denotation of the construct "preference for ideation" described above, the mind-sets associated with this construct are more or less opposite. I therefore believe this construct to be useful for the purposes of this research.

Related to the Osborn-Parnes rules for successful ideation, a low tendency for critical evaluation of ideas might be associated with high scores on the first operation (Basadur & Finkbeiner, 1985). In contrast, a high score on this construct should result in low performance on the Osborn-Parnes rules for successful ideation. Basadur and Finkbeiner (*ibid.*) developed an internally valid and reliable measure of this construct. And as stated in the previous section, the construct is in many ways antagonistic to preference for ideation. I will therefore use the term "preference for evaluation" for this particular attitude in this study.
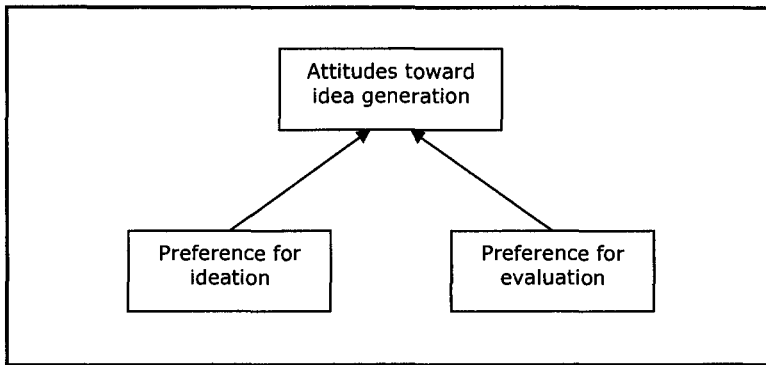
Figure 3.1: Idea generation attitude constructs

3.2 Cognitive style

In addition to evaluating an individual's idea generation performance based on the overall level of creativity, idea generation can also be viewed in terms of cognitive style and the types of innovative or creative products that are favored (Scott & Bruce, 1994). Individual preferences and cognitive style play a critical role in idea generation, and a significant amount of research focuses on identifying ways to systematically measure and use them (Amabile, 1983; Ford, 1996; Woodman et al., 1993). Some people tend to be systematic thinkers, building on ideas and facts in the problem and focusing on rationality and logic, while others rely more heavily on intuition and imagery, looking beyond current rules, boundaries, and rational logic (Garfield et al., 2001; Jabri, 1991; Scott & Bruce, 1994).

Cognitive style describes individual differences in information processing characteristics, that is, how individuals' thinking is affected by qualitatively different dispositions (Martinsen, 1995). There are many different style theories, but all of them attempt to do the same thing. They all try to categorise individuals as "types". Witkin (1962), for example, argued that there are essentially two kinds of cognitive style - the "field dependent" and the "field independent". Field dependent people tend to organize information into clustered "wholes" whilst field independent people organize information into conceptual groupings. Other early theories of cognitive style are the work of Pask (1972), who differentiated between "serialists" and "holists", and Kagan et al. (1964) who proposed the two dimensions of

"impulsive" and "reflective". One more recent theory is that of Riding (1991) who refined a great deal of the best work from which the two basic bipolar dimensions of cognitive style emerged. These are the "wholist-analytic" and the "verbal-imagery" styles. The former style determines whether an individual processes information as a whole or in parts, while the latter dictates whether an individual is inclined to represent information during verbal thought, or as mental images. One of the most influential researchers on the importance and effects of individuals' thinking styles is Robert Sternberg, who in his *theory of mental self-government* (Sternberg, 1997; Sternberg & Grigorenko, 1997) distinguishes between the legislative style (a person who enjoys generating ideas and doing things on his/her own), the executive style (a person who prefers to follow guidelines established by others and to utilize the ideas of others to do his/her work), and the judicial style (a person who prefers to evaluate the ideas of others). The theory suggests that everyone possesses every style to some degree, but that the strengths of preferences differ across individuals.

In general, cognitive styles are defined as bipolar (or in some situations as multipolar) constructs where the different poles have some attributes, and they should be uncorrelated with ability and describe "how" rather than "how much" (Martinsen, 1995). A case in point of this is the understanding of cognitive style found in The Adaptation Innovation Theory (Kirton, 1976; 1987; 1988). This is one of the most widely used theories of cognitive styles in creativity research, and posits that style differences lie on a normally distributed continuum, ranging from high adaption to high innovation. The theory sharply distinguishes between level and style of creativity, problem solving and decision making, and is concerned only with style. Both potential and evident capacity aside, the theory states that people are creative, solve problems, and make decisions in different ways. The key to the distinction is that the more adaptive prefer their problems to be associated with more structure, and tend toward using approaches that seek incremental changes that adapt or stretch the current problem elements or ideas. The more innovative individuals are comfortable solving problems with less structure and are less concerned about consensus regarding structure compared to the more adaptive individuals. They lean toward more revolutionary ideas by redefining or restructuring the problem rather than accepting the current situation as the starting point (Garfield et al., 2001).

Another theory that is related to The Adaptation Innovation Theory, is the cognitive style taxonomy developed by Kaufmann (1979; 1995). This is called the Assimilator-Explorer (A-E) theory of cognitive styles, and concerns individual differences in preferences for problem solving strategies. These strategies are described as rule-following and novelty-seeking strategies. In contrast to The Adaptation Innovation Theory, however, the A-E theory does not see individuals as rigidly looked into one style or another independent of the situation and task at hand. Rather, people are seen as "switchers" that are able to monitor their problem solving approach in various ways depending on the situation. Support of stability in strategy preferences across task scenarios has nevertheless been gained, and individuals may be reliably classified according to their (major) preferred orientation (Kaufmann, 1995). Naturally, this should have implications for individuals' idea generation processes in problem solving situations.

Based on the discussion of various cognitive style theories above, both the Adaptation Innovation Theory and the A-E theory are appropriate for the purposes of this research. Regarding the former theory, however, the question of whether measurement of cognitive styles as used in this theory really is an indicator of *level* of creativity has been raised as measures of innovative orientation often significantly and substantially correlate positively with various indicators of level of creativity (Goldsmith & Matherly, 1986; Isaksen & Puccio, 1988; Kaufmann, 1988; Kaufmann, 1995). Also, differences in availabilities of the measurement instruments favor the A-E theory, and I will therefore apply this theory of cognitive style in the study. The A-E theory distinguishes between Assimilators and Explorers as extreme points on a continuum, implying that individuals' cognitive styles include both "assimilative" and "explorative" elements. Keeping this in mind, individuals that have a propensity toward one of the two extremes will be labeled "Assimilator" or "Explorer", and in order to clarify the distinction between the two styles, the terms *Assimilators* and *Explorers* as used in the discussion below refer to the ideal types of the cognitive styles.

3.2.1 Assimilators

The problem solving behavior subsumed under Assimilator preferences is guided by what will be described as a "rational strategy" or a "rule-following strategy" (Kaufmann, 1995; Martinsen, 1995). The essence of this strategy is that individuals with this preference will tend

to follow established rules or schemes when solving problems. They will try to stretch established and well known principles as far as possible, and they are held to be more conformist, rule bound and rigid, less open and more anxious than Explorers. This rational strategy involves devoting maximum effort to upholding existing patterns of thought, and Assimilators are therefore seen as more prone to use logic, being more analytically oriented, and more efficient when it comes to computation procedures than Explorers (Martinsen, 1995). In novel problem situations, Assimilators' preferences are, according to Kaufmann (1995), "aimed at mapping the situation on to prototypical, previously mastered analogous situations" (p. 62).

3.2.2 Explorers

Kaufmann (1995) argues that the extreme "Explorer" preference, in sharp contrast to the rational strategy of Assimilators, "entails constantly seeking novel solution alternatives, even in problem situations that are easily mastered by the application of standard schemes" (p. 63). Further, compared to Assimilators, Explorers are more creative and better at restructuring because they are more open, novelty seeking, and flexible. The problem solving strategy associated with Explorers can thus be described as a novelty seeking strategy. In other words, the extreme explorer preference entails constantly seeking stimulus variability. Individuals with such a preference will be open for experiences, and tuned to a relatively high degree of uncertainty and variation as maximally attractive.

3.3   Conclusion

Attitudes toward idea generation and cognitive styles are significant factors when considering individuals' idea generation processes and abilities. I therefore believe that differences in attitudes and cognitive styles of individuals are believed to moderate the relationships between media capabilities and divergent and convergent thinking processes. I will now turn to a discussion of media capabilities that may be able to influence the constructs that are perceived to be manifestations of innovative thinking processes.

4 Communication media: Capabilities

This chapter starts with an introduction and overview of research on media capabilities or qualities, and based on the specific research focus and problem question, constructs (properties or affordances) from various contributions to this research field are discussed. The chapter is ended by a discussion of why and how the selected constructs (the independent variables) are important for divergent and convergent thinking processes (the dependent variables).

4.1 Introduction

New information and communication technologies enable extensive interaction and communication between individuals both within organizations and across organizational boundaries. This increase in electronically mediated interaction is not prolific *per se*, but requires well-considered choices regarding use of specific communication media in order for the interacting parties to obtain the desired outcomes. That is, all communication media have characteristics or qualities that lend themselves better to some situations than others. The choice of media must therefore be made on basis of the tasks at hand and the particular situation in which the interacting parties are in.

4.2 Characterization of capabilities

Many theories have been developed to categorize media qualities and explain media effects on communication outcomes (see e.g. Fulk & Boyd, 1991). One of the most widely used media categorization theories is *Media Richness Theory* (Daft & Lengel, 1986), which argues that task performance will be improved when tasks' information needs are matched to a medium's richness or it's capabilities to facilitate shared meaning. Daft and Lengel (*ibid.*) define information richness as the "ability of information to change understanding within a time interval" (p. 560), and further claim that the reasons for differences in richness include "the medium's capacity for immediate feedback, the number of cues and channels utilized, personalization, and language variety" (p. 560). Central to media richness theory is the idea that media capable of sending "rich" information are better suited to solve tasks where there are possibilities for multiple interpretations of the available information (high equivocality),

while media that are "lean" are best suited for tasks with uncertain information (low equivocality).

Empirical tests of media richness theory have not been very supportive, particularly for new communication media (most computer-mediated communication will by media richness theory be understood as "relatively lean" communication) (Burke & Chidambaram, 1999; Dennis & Kinney, 1998; Ngwenyama & Lee, 1997; Lee, 1994; Markus, 1994; Valacich et al., 1993; El-Shinnawy & Markus, 1992; Kinney & Watson, 1992; Rice & Shook, 1990; Trevino et al., 1990). A specific feebleness of the theory is that "richness" (or "leanness") is perceived as an intrinsic and unalterable property of communication media. However, media are not monolithic, and media richness is thus not invariant. The richness or leanness of one specific medium will to some extent depend upon how it is configured (e.g. one email system may provide a limited number of cues (text only), while another may also include graphics and video). Recognizing the weaknesses of Media Richness Theory, Dennis and Valacich (1999) introduced a new theory, *Media Synchronicity Theory*, which focuses on the abilities of media to support the communication processes used by individuals as they work on tasks. These authors suggest that media have five capabilities that are important in understanding the effects of media use on the ability to communicate and process information, which thus affect the efficiency and effectiveness of the communication processes. These capabilities are: 1) immediacy of feedback, 2) symbol variety, 3) parallelism, 4) rehearsability, and 5) reprocessability. The authors further argue that these media capabilities better reflect the potential of the media, and that task performance is enhanced by matching these capabilities to communication settings.

Both media richness theory and media synchronicity theory categorize media attributes in terms of what kind of properties or capabilities the different media possess. Adopting a wider perspective, Te'eni (2001) suggests the following characterizing media attributes of any electronically mediated communication: channel capacity, adaptiveness, and interactivity. Channel capacity is an important property determining media richness, and includes the potential to transmit a high variety of cues and languages. Adaptiveness refers to the potential to personalize a message to a particular receiver. Finally, interactivity is a multifaceted concept with many dimensions, and several taxonomies for categorizing electronic media according to interactivity level have been developed. Hoffman and Novak (1996) identify two

types of interactivity; machine interactivity and person interactivity. The first type refers to the extent to which users can participate in modifying the form and content of a mediated environment in real time. Person interactivity is defined as interactivity between people that occurs through a medium or is unmediated, as in the case of face-to-face interaction. Thus, machine interactivity is interactivity *with* the medium, while person interactivity is interactivity *through* the medium. These two interactivity characterizations relate to two research traditions occupied with the study of communication and interaction by means of electronic media; computer-mediated communication (CMC) and human-computer interaction (HCI). In the first perspective, media facilitate interactive person to person communication, and the in the latter perspective, interactivity is defined in terms of media characteristics (Thorbjørnsen, 2002). Because of the differences in the understandings of interactivity, the two research traditions, CMC and HCI, focus on different dimensions of the concept. While research on HCI emphasize properties like synchronicity, message relatedness, and contingency, the CMC tradition focus on concepts like participation, identification, and degree of social presence (*ibid.*).

Relevant to both person interactivity and machine interactivity, Burgoon et al. (2000a; 2000b) suggest two ways of characterizing the concept. First, it can be considered in terms of the structural properties of the medium, or second, by qualitative experiences as perceived by the user. Regarding the first categorization type, Burgoon et al. (*ibid.*) integrate the various analyses of media affordances into an extensive set of properties, consisting of: *1) participation* (the extent to which the interacting parties are actively engaged in the interaction), *2) mediation* (whether the interaction is mediated or not), *3) contingency* (the extent to which one party's queries, responses, and comments are dependent on the prior ones of the cointeractant), *4) media and information richness* (whether the format utilizes one or more modalities such as text, audio, visual, and the extent to which it supports symbol variety to present "rich" and "poor" social information), *5) geographical propinquity* (whether the parties are physically co-located or distributed), *6) synchronicity* (whether the interaction is same-time, which permits immediate bidirectional feedback, or asynchronous, which permits rehearsability and editability), *7) identification* (the extent to which participants are fully identified, partially identified or anonymous), *8) parallelism* (whether the format permits concurrent communication and multiple addressees, as in the case of electronic brainstorming,

or only permits serial messages), and *9) anthropomorphism* (the extent to which the system interface simulates or incorporates humanlike characteristics).

As shown in the discussion above, communication media can be described and evaluated in terms of their abilities to enable specific aspects or properties of the communication process. In other words, all communication processes can be characterized by certain *affordances* or *properties*, and communication media differ in their capabilities to support and enable these affordances. In this way, outcomes of mediated interaction can to some extent depend on the medium that is used. As situational factors determine which communication characteristics or affordances that must be present (or are preferred), users are likely to perceive the usefulness (and thus utilization) of different media in light of the situation or tasks that are to be solved. Based on this discussion, I find it purposeful to place emphasis on specific affordances that may influence divergent and convergent thinking processes in group-based problem solving, and not on the technology itself. The following affordances are perceived to be particularly relevant for the study: "synchronicity", "parallelism", and "identification". The rationale underlying this selection will be elaborated on in a later section, but first I discuss the denotations of synchronicity, parallelism, and identification, and present my theoretical definitions of these concepts.

4.2.1 Synchronicity

This affordance encompasses the capabilities that Dennis and Valacich (1999) labeled "immediacy of feedback" and "rehearsability", and it may also take in "reprocessability". Synchronicity refers to whether the interaction is same-time or not. A high level of synchronicity enables the interacting parties to give immediate feedback. Immediacy of feedback is the extent to which a medium enables users to give rapid responses to the communications they receive (Daft & Lengel, 1986; Te'eni, 2001). It is the ability of a medium to support rapid bidirectional communication, and has been shown to affect communication outcomes by increasing interaction between the parties, allowing rapid assessment and modification of the message (Zmud et al., 1990). Media that provide immediate feedback capabilities also enable the sender to encourage feedback from the receiver, or to use trial references for the receiver's agreement and understanding of the message. Dennis and Kinney (1998) found that the level of immediacy of feedback for a

given medium can impact the speed of the decision – use of media with more immediate feedback leads to faster decisions, but it did not affect other communication outcomes such as decision quality, consensus, or satisfaction, regardless of level of equivocality of the task.

Low degree of synchronicity enables *rehearsability*. This refers to the extent to which the media enable the sender to rehearse or fine tune the message before sending. The sender of a message is in this case given the opportunity to carefully formulate a message before it is being sent to ensure that the intended meaning is expressed exactly, with no extraneous information. Likewise, a low degree of synchronicity can also render possible *reprocessability*. This refers to the extent to which a message can be reexamined or processed again within the context of the communication event. This capability affects information processing by allowing individuals to revisit messages for further consideration and deliberation. However, a low degree of synchronicity is not sufficient for reprocessability to be possible; the medium must also enable the receiver to store the information. Low degree of synchronicity only gives the receiver more time to respond to messages.

Based on the discussion above, I define synchronicity as "the extent to which the participants engaged in a group-based problem solving situation can give immediate feedback to the postings of other group members, and receive immediate feedback on their own postings from other group members". I am concerned with the level of synchronicity *as perceived by the participants* in a group-based problem solving situation (as people may have different perceptions of affordances-levels provided by the same technology). The highest level of synchronicity is thus most likely to occur when interaction takes place in real time, and accordingly, the level will decrease along with increasing time lag between messages from one participant and responses to these messages from another participant. The level of synchronicity is in other words reverse proportional to the time passing by before feedback *can* be given. It is important to emphasize that, in this understanding of the concept, a high level of synchronicity does not assure immediate feedback; it is rather related to the *opportunities* that the participants have for giving rapid responses to the messages of others. Low synchronicity thus implies that the participants involved in interaction do not have the opportunity to give and receive feedback on an immediate basis.

4.2.2 Parallelism

Parallelism is the number of simultaneous conversations that can effectively take place. Many electronic media can be structured to enable multiple interacting parties in one session, thus parallelism can increase the amount of information that can be simultaneous transmitted and received, but it can also decrease the effectiveness of information processing as it may lead to information overload. I define parallelism as "the participants' opportunities to be engaged in simultaneous dialogues in a group-based problem solving situation". High parallelism thus gives the participants opportunities to be engaged in multiple dialogues at the same time, and therefore they do not have to take turns in utterance of contributions. Low parallelism, on the other hand, means that all participants have to be engaged in a single dialogue, implying that only one member of the group can utter his/her ideas and comments at the same time (as is the situation for FtF interaction). I am also for this affordance concerned with the levels as perceived by the participants in a group-based problem solving situation.

Given the understanding and definitions of parallelism and synchronicity outlined in the previous sections, I need to give specific attention to the relationship between these constructs. Although synchronicity and parallelism refer to distinct characteristics of communication processes, the constructs are not totally unrelated. In fact, the synchronicity level in a given situation *might* impact on the degree of parallelism that can be realized in the same situation. More specifically, in situations where the level of synchronicity is low, the level of parallelism will most likely be high. In situations where the level of synchronicity is high, however, the level of parallelism might be high *or* low. The reason for this is that the participants involved in interaction characterized by low synchronicity are given the opportunity to use more time to reprocess the received messages from others, and also use more time to formulate their own contributions. The group members do not expect immediate responses. Thus, as a consequence of the time lag of the interaction, the involved participants can probably focus on several dialogues at the same time. Further, the problem of simultaneous talking (parallel conversations or utterances) that might occur in synchronous interaction (e.g. face-to-face) is hard to imagine (non-existing as far as I know) in situations where the synchronicity is low. So when the level of synchronicity is low, the participants involved in interaction do not have to take turns uttering their contributions, but can probably attend to multiple dialogues simultaneously. This means that in situations where the level of

synchronicity is low, the level of parallelism is most likely high, but it does not imply that a reverse relationship exists. The level of parallelism in situations characterized by high synchronicity depends on the medium that is used for interaction, and can be located at any point on the parallelism scale/continuum.

4.2.3 Identification

There are various types and levels of anonymity, depending on the factors that lead group members to feel more or less anonymous, hence group interaction cannot be simply viewed as anonymous or identified (Valacich et al., 1992a; 1992b). Valacich et al. describe two types of anonymity. First, *content anonymity* is defined as "the extent to which group members can identify the source of a particular contribution to the group" (p. 224), and this anonymity type is provided when embedded identifiers, which identify a contributions' source, are absent. The second type of anonymity, *process anonymity*, refers to "the extent to which group members can determine whether or not another group member is participating" (Valacich et al., 1992b, p. 223), and is provided when the contributor cannot be determined by direct observation.

There are many factors that may affect the level of anonymity, and the particular configuration of the communication media is important in this respect (other factors are e.g. group size, group composition, and group member proximity). Content anonymity is easy to control and manipulate in communication systems, while process anonymity necessitates physical separation between the participants, and cannot be manipulated the same way as content anonymity by use of technological means. Despite acknowledging that full anonymity (and full identification) cannot be obtained solely by specific system configurations, I will not distinguish between these types of anonymity, but rather focus on the overall level of identification as perceived by the participants.

I define identification as "the extent to which the contributions (ideas and comments) of the participants in a group-based problem solving situation are linked with the identities of the contributors". The term "linked" in this definition is not to be understood in a solely technological sense, but may also represent a cognitive linkage made by the group members regarding the relationship between contributors and contributions. A lack of process

anonymity may therefore result in a high score on identification even though the communication medium is configured in a way that enables full content anonymity. The two extreme points on this scale are thus 1) a situation where the participants can put forth their ideas and comments without the other members of the group knowing the originator of these ideas and comments, and 2) a situation where all members of a group always know the identities of the contributors. Similar to the other affordances, I am also in this case interested in the level of identification as perceived by the participants in a group-based problem solving situation.

4.3   Influence of affordances on individuals and group processes

In a group-based problem solving situation, it is common to speak of process gains and process losses as results of elements like group characteristics, task characteristics, context characteristics, reward structure, etc. (McGrath, 1984). An individual's contribution (e.g. idea, comment, criticism, etc.) in group work is shaped by this context of enhancing and stifling forces (Valacich et al., 1992a). In other words, certain aspects of the situation improve outcomes, while others impair outcomes, and the results of problem solving activities are thus contingent upon the balance of the process gains and losses (Connolly et al., 1990). There are many different sources of gains and losses that can be attributed to situational factors of group interaction. Reviewing the work of Lamm and Trommsdorff (1973), Shaw (1981), Steiner (1972), Osborn (1957), Hackman and Kaplan (1974), Hill (1982), Diehl and Stroebe (1987), Jablin and Seibold (1978), Albanese and Van Fleet (1985), Hiltz and Turoff (1985), Hirokawa and Pace (1983), and Mintzberg et al. (1976), Nunamaker et al. (1991b) list several process gains and process losses that, depending upon the situation, vary in strength (or may not exist at all) (the list is presented in appendix A).

The occurrences (and strengths) of the group processes are contingent upon the characteristics and configurations of group-based work, and I will concentrate on sources of relevant process losses in the discussion of affordances and group processes. Characteristics of the technology used in a CMC setting may affect the process losses, and synchronicity, parallelism, and identification are among the most influential affordances in this respect.

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4.3.1 Importance of synchronicity

In an environment with high degree of synchronicity, verbal persons/extroverts often dominate the conversation, and some group members may therefore feel that their contributions are not required and are thus inclined to free ride. Free riding refers to the tendency of some group members to rely on other group members to accomplish the task without their contributions (Valacich et al., 1992a). Conversely, in situations with low degree of synchronicity, group members are not continuously updated on what the others are doing, and must therefore work more individually. In these situations, the participants feel more individually accountable for the results. Low degree of synchronicity may in this way reduce free riding and social loafing. Further, in such a situation, there may be more social pressure on all group members (as perceived by each participant) to make contributions. Asynchronous interaction also tends to be less disruptive to group members (Kock, 1997), thus low degree of synchronicity will also increase the time and amount of evaluation the participants can exert on their ideas. In other words, low degree of synchronicity may result in higher evaluation apprehension than we might experience in situations with high synchronicity. Further, CMC with low synchronicity enables high degree of parallelism, and in situations with low synchronicity, the process losses associated with low degree of parallelism discussed in section 4.3.2 will therefore be reduced.

4.3.2 Importance of parallelism

A significant problem that arises in problem solving groups is production blocking, which occurs when something prevents verbalization of ideas as they occur (Shepherd et al., 1995). In these situations, a participant may forget an idea while waiting for a turn to speak, or may devote attention to remembering an idea, and by this becomes too distracted to generate new ideas (Diehl & Stroebe, 1987; Nunamaker et al., 1991a; Nunamaker et al., 1991b). With parallel communication, process losses from air time fragmentation (i.e. the group must partition available speaking time among members), attenuation blocking (i.e. group members are prevented from contributing comments as they occur, or forget or suppress them later in the meeting because they seem less original, relevant or important), and concentration blocking (i.e. fewer comments are made because members concentrate on remembering comments, rather than thinking on new ones, until they can contribute them) can be significantly reduced (Nunamaker et al., 1991b). According to Nunamaker et al., the

importance of parallelism depends on the number of participants involved in interaction. For small groups, parallelism is of minor importance. In contrast, parallelism is found to be important for large groups because it enables all members to participate and be less susceptible to process losses that occur, regardless of the function performed (Dennis et al., 1997; Gallupe et al., 1992; Valacich et al., 1992a).

4.3.3 Importance of identification

In a group-based problem solving situation, an individual's inclination to act, and the nature of the act, are influenced by other group members' actions or just their mere presence. Previous research has shown that anonymity can influence the perceptions and social interactions of individual group members (Pinsonneault & Heppel, 1997). According to Diener (1979), anonymity is an important component of de-individuation[7], which can lead to behavior that is normally kept in check by social mechanisms. In group tasks like decision making, problem solving, and idea generation, the loosening of social bonds may have noticeable value as the participants are concerned about how others perceive their ideas (Connolly et al., 1990; Diehl & Stroebe, 1987; Nunamaker et al., 1991b). Several authors have identified the anonymity option as a particular virtue of Group Decision Support Systems in that anonymity encourages full participation of group members that otherwise would have been socially inhibited from expressing unpopular, novel or heretical opinions (Kraemer & King, 1988; Nunamaker et al. 1988). Common problems experienced by groups involved with decision making and problem solving include the extreme influence exerted by high-status members, the lack of acknowledgement of low-status members' ideas, and a low tolerance exhibited toward minority or controversial opinions (DeSanctis & Gallupe, 1987). On the positive side, the group might provide encouragement, stimulation or reward for creative contributions, and on the negative side, contributors might anticipate embarrassment, hostile evaluation, conformity pressures or other punishments for proposing unusual ideas (Collaros & Anderson, 1969). Thus, anonymity may reduce the pressure to conform and evaluation apprehension (i.e. fear of negative evaluation causes group members to withhold

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[7] De-individuation refers to the feeling of becoming submerged in the group, and of losing awareness of one's own individuality and that of other group members (Connolly et al., 1990).

ideas and comments), but it may also increase free riding as it is more difficult to determine when someone is free riding (Nunamaker et al., 1991b).

4.4   Conclusion

Communication media can be characterized by their abilities to support various aspects of communication processes. In order to say something about how successful a specific technology will be for solving a particular organizational task involving computer-mediated communication, it is necessary to determine what aspects of communication processes that are important for successful accomplishment of this task, and how well the technology is able to support these aspects. In this study I focus on three affordances that to certain extents are supported or enabled by various communication media; synchronicity, parallelism, and identification. These affordances are seen as particularly influential factors in group processes, and I will investigate how they may influence divergent and convergent thinking processes.

Part III

- Hypotheses -

Based on the theoretical discussions in the previous part of the dissertation, I first introduce the research model applied in the study. Thereafter, several hypotheses regarding the relationships between the constructs I use in the research model are put forth.

5   Research model and hypotheses

In this chapter, I first draw up the research model based on the discussion of the theoretical constructs relevant for the research question I will try to answer. In other words, the relationships between the variables I find important (and have chosen) are presented. Second, hypotheses regarding the relationships between independent, dependent, and moderating variables are proposed.

5.1   Introduction

In many situations, several communication technologies can be used for the same tasks, but with different outcomes or effects. That is, dependent on factors like audience/message receiver, motives of the sender, etc., one particular communication technology might be more efficient and effective than others, although several technologies can be used to transfer the same message. Selection of a dissemination medium most appropriate for a particular content and situation (e.g. purpose, receiver, etc.), then, is a complex and challenging task.

The importance of a deliberate selection of communication media may be enhanced as the media and formats available for dissemination are increasing rapidly with new technological development. In addition, in some situations, multifaceted approaches to communication can be required if the most efficient and effective information exchange is to be achieved, and this proliferation is thus helpful in meeting the need for various communication means. It is therefore important to investigate which media to use based on the motives and needs of the information receiver. That is, dependent on the situation that the information receiver is in, various elements or aspects of the interaction may be more important than others.

Many factors are important for innovative/creative problem solving. For example, Runco (2004) speaks of personal, social, and environmental factors when discussing the development and expression of creativity. These factors are probably not independent. The questions are, then, if environmental factors (e.g. qualities of communication media) can encourage or dissuade problem solving activities, and whether individuals' attitudes toward idea generation and cognitive styles are influential in this respect.

In this study, I focus on problem solving situations in general and innovative thinking in particular. The objective of the study is to investigate whether (and in case how) communication media can influence innovative thinking processes, and on this basis I have selected three distinct affordances that are perceived as particularly relevant.

5.2   Variables

Based on the theoretical review in the previous part, the following variables are included in the research model: First, the independent variables – "synchronicity", "parallelism", and "identification" – are distinct affordances of communication processes. Second, the dependent variables are manifestations of two distinct thinking processes involved in idea generation - "divergent focus" and "convergent focus". Cognitive styles of individuals – "assimilators" versus "explorers", and attitudes toward idea generation – "preference for ideation" and "preference for evaluation", are moderating variables (see figure 5.1).
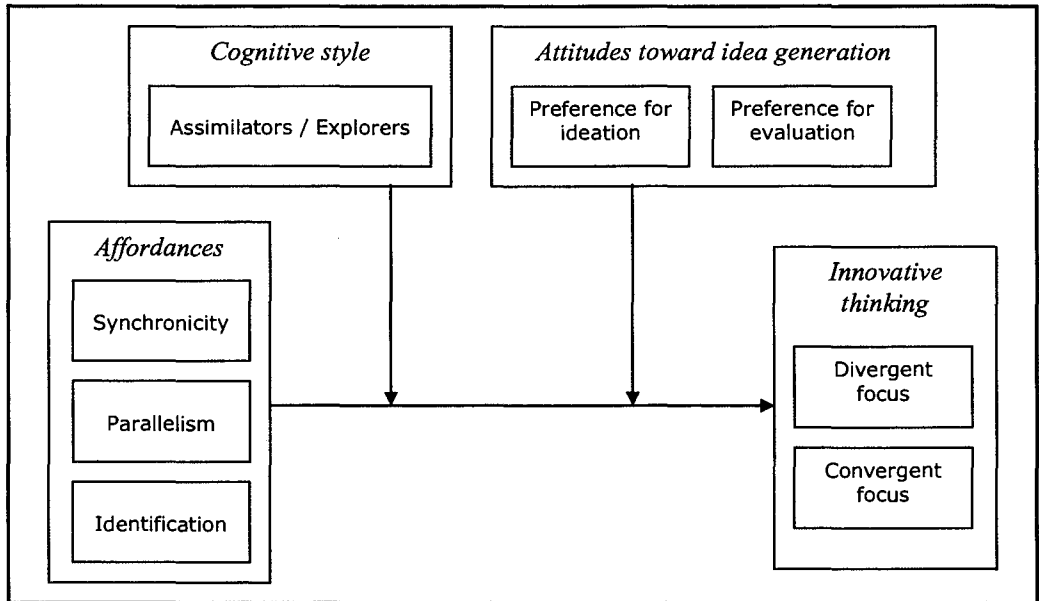
Figure 5.1: Research model

Information and communication technologies differ in their abilities to support affordances of the communication process. In chapter 4, it was argued that different levels of synchronicity, parallelism, and identification may be significant factors for group processes (gains and

losses) in a group-based problem solving situation, which again may either enhance or reduce the divergent and convergent focuses of the group members. As discussed in chapter 2, the concepts of divergence and convergence refer to distinct processes necessary for successful idea generation in group-based problem solving. In this respect, divergent thinking involves production of ideas without evaluation, while convergent thinking involves application of judgment and evaluation of the ideas that are produced. It was further discussed how these cognitive processes find expression in language, and the concepts of "divergent focus" and "convergent focus" were described as manifestations of the two thinking processes. Hence, I expect that the affordances will have different effects on divergent focus and convergent focus, and in this way, use of specific communication media (and different configurations) may influence the outcome of group-based problem solving.

Even though it can be argued for a direct relationship between communication affordances and innovative thinking as described above, individual factors are also expected to be influential in this respect. As can be seen in figure 5.1, both the participants' cognitive styles and their attitudes toward idea generation are depicted as moderators of the relationships between the independent variables and the dependent variables. That is, the effects of affordances on innovative thinking may vary depending on the individuals' cognitive styles and attitudes, and these variables must therefore be taken into consideration. Cognitive style refers to personal dispositions regarding information processing characteristics that affect individuals' thinking processes. I have used the distinction between assimilative and explorative cognitive styles as described by Kaufman (1979; 1995), which emphasizes the difference between two strategies (rule-following and novelty-seeking, respectively) in problem solving situations. Similarly, in research focusing on creative problem solving, attitudes toward idea generation have also been shown to influence the outcome of the process (e.g. Basadur et al., 1982). I have for that reason included two attitudinal constructs (preference for ideation and preference for evaluation) as moderators in the model. A high preference for ideation implies mind-sets that are expected to positively influence the divergent part of the problem solving process, and in contrast, a high preference for evaluation implies mind-sets that are expected to be in accordance with the convergent process of problem solving.

In sum, various communication media possess different characteristics or qualities, and therefore differ in their support of communication properties or affordances. The main objective of this research is to investigate the relationships between the selected affordances of the communication situation and divergent and convergent thinking processes. Further, the study aims at applying concepts related to attitudes toward idea generation and cognitive styles as moderators of the relationships between affordances facilitated by use of communication media and innovative thinking. I will now introduce a set of hypotheses regarding the expected relationships (effects) between the variables.

5.3 Hypotheses

In this section, I first put forth hypotheses regarding the main effects of the selected affordances of communication on "divergent focus" and "convergent focus". Second, I propose hypotheses regarding the moderating effects of individual differences (attitudes toward idea generation and cognitive styles) on the relationships between affordances and innovative thinking processes.

5.3.1 Main effects of affordances on innovative thinking processes

Divergent thinking is by some researchers juxtaposed with "creative thinking" (see e.g. Huitt, 1998), and divergent activities in a problem solving context thus involve creativity leading to new idea generation. Creativity is needed in order to come up with as many solutions to a problem as possible. Then, the question is which affordances are important for divergent thinking or ideation? The Osborn-Parnes model of creative problem solving (Parnes & Harding, 1992) stresses four critical rules that must apply to each divergent stage in process: withholding judgment, freewheeling, generating a quantity of ideas, and hitchhiking on the ideas of others. It can therefore be assumed that affordances supporting these rules are likely to positively influence a "divergent focus".

While the concept of divergence is related to creative thinking, *critical thinking* relates to convergence. That is, convergence involves an assessment of the significance, importance or quality of the various ideas that are put forth. And on this basis, a critical selection of possible solutions to a problem is made. I will now discuss and propose hypotheses regarding

relationships between affordances on the one side, and "divergent focus" and "convergent focus" on the other side.

Synchronicity

As discussed in chapter 2, deferral of judgement and allowing ideas to come forth freely, no matter how ludicrous or impractical they may seem, is critical to successful ideation or divergence. Often we are embarrassed to come out and state these ideas simply because they are outrageous. Hence, *judging*, maybe more than any other event, will shut down idea generation. Further, the social element in idea generation is also important in this respect, and the risk of getting negative comments may inhibit people from promoting solutions. This may be particularly valid for extreme (radically new) ideas.

Feedback is a powerful tool for innovation processes, and it is important to emphasize the role of immediacy of feedback (timing) as a particular collaboration characteristic in idea generation. That is, timing of feedback is important in order to avoid a situation where evaluation stifles innovation before it has a chance to develop. While there are many different methodologies about how to most effectively engage in idea generating activities, one element they have in common is that the free flow of initial ideas must occur without the interruptions of criticisms or evaluations.

As described in chapter 4, low synchronicity enables both rehearsability and reprocessability, which may be regarded as "evaluative or convergent activities". High synchronicity on the other hand, does not render possible a critical examination of neither the ideas that the sender is to put forth (rehearsability), nor the ideas or messages that an individual has received from other participants (reprocessability) before composing a response. Thus, interaction in same-time, although enabling interruption and immediate critical feedback, may have positive impacts on divergence. On this basis, the following hypotheses are put forth:

H1a: Participants involved in interaction with high synchronicity have a higher "divergent focus" than participants involved in interaction with low synchronicity, and

H1b: participants involved in interaction with low synchronicity have a higher "convergent focus" than participants involved in interaction with high synchronicity.

Parallelism

Parallelism refers to the number of simultaneous dialogues that can effectively take place at the same time. According to Van de Ven et al. (1999), an increase in the number of initiatives undertaken by a large number of interacting people enhances the probability of stimulating innovation. With reference to the distinction between ideation and evaluation, one aspect that supports the assertion put forward by Van de Ven et al. (*ibid.*), is that high degree of parallelism makes it difficult to reprocess ideas that have been put forth, while at the same time being attentive to the ongoing discussions. Hence, there is no room for a comprehensive critical evaluation of all ideas that are proposed.

Another important aspect of parallelism regarding idea generation, which may be a consequence of the absence of opportunities for critical evaluation as discussed above, is that it can create an environment of interaction and discussion that facilitates hitchhiking. However, there will not be an exponential increase in hitchhiking effects with increasing parallelism. The reason for this is that individuals' cognitive capacities are limited, thus there may be a problem of information overload if the number of participants exceeds a certain limit.

Conversely, low (or absence of) parallelism will probably result in more (and critical) rehearsability of the ideas that the participants are to suggest. In these cases, the participants are aware of that they have the other participants' full attention when contributing their ideas, and are thus likely to be more self-critical when communicating. However, in situations where the participants are anonymous, this effect may be weakened (or absent). Therefore, given that the number of participants in a problem solving situation are below the critical limit regarding information overload mentioned in the previous paragraph, the following hypotheses may be stated:

H2a: Participants involved in interaction with high parallelism have a higher "divergent focus" than participants involved in interaction with low parallelism, and
H2b: participants involved in interaction with low parallelism have a higher "convergent focus" than participants involved in interaction with high parallelism.

Identification

Participants in joint idea generating tasks are influenced by each other. This is particularly relevant when it comes to the participants' decisions of whether or not to contribute and express their ideas. Most individuals are concerned about how others perceive and think of them, and can therefore be reluctant to express unorthodox or non-conforming thoughts. Supporting this assumption, groups using anonymous electronic meeting systems have been found to generate more critical comments than groups using EMS where the author of each comment was identified (Connolly et al., 1990; Jessup et al., 1990; Valacich et al., 1992a). So, working in a group where the identities of the participants are known might inhibit a contributor who anticipates embarrassment, hostile evaluation, conformity pressures, or other punishments for proposing unusual ideas. In contrast, anonymity may lead to a reduction of these mechanisms. That is, it is reasonable to believe that the *fear* of getting negative comments will be lower if the interacting parties do not know the identity of each other, even though the nature (degree/strength) of the critical comments may be higher in anonymous environments than in identified environments (cf. research on electronic meeting systems cited above). In other words, the barriers related to idea expression that people experience, will be lower if the proposals can be done anonymously. This is particularly important considering that the last ideas, the ones beyond the mental blocks and into the subconscious, often are the highest quality ideas. In this sense, anonymity may facilitate high quality ideative thinking and behavior. In contrast, even though the barriers for utterances of extreme points of view (both ideative and critical) may decrease with increasing anonymity, the social mechanisms (e.g. fear of criticism) that come to play in identified environments will result in more self-critical thinking and behavior. Accordingly, the contributions may be more evaluative and based on established rules. Thus:

H3a: Participants involved in interaction with low identification have a higher "divergent focus" than participants involved in interaction with high identification, and

H3b: participants involved in interaction with high identification have a higher "convergent focus" than participants involved in interaction with low identification.

5.3.2   Moderating effects of attitudes and cognitive style

Individuals' attitudes toward idea generation and cognitive styles may moderate the relationships between affordances and innovative thinking processes, and hypotheses regarding the potential moderating effects of these individual differences are put forth in the following sections.

Moderating effects on the role of synchronicity

As assimilators prefer to follow established rules or schemes, and explorers have a strong need for novelty and stimulus variability (Kaufmann, 1989; Kaufmann & Martinsen, 1993), the ability to rehearse and critically evaluate a message before sending it to others is likely to be more important to people that are located at the "assimilative side" of the assimilation-exploration continuum than it is for explorative individuals. And as described earlier, the degree of synchronicity is important when evaluating the possibilities for rehearsal of ideas before they are expressed. Low synchronicity renders possible rehearsability and reprocessability (given that the information is stored). Consequently, assimilators may, to a larger extent than explorers, appreciate the opportunities for rehearsing and reprocessing ideas and comments that are present in low synchronous interaction. And therefore we may find that the wordings of contributions from assimilators are more evaluative compared to contributions from individuals with an explorative cognitive style. The same arguments hold for attitudes toward idea generation as well. More specifically, as low synchronicity renders possible evaluative activities, we may expect that low synchronous interaction is more suitable for individuals with a high preference for evaluation than for people with a low preference for evaluation. The following hypothesis can on this basis be put forth:

H4a: The effects of synchronicity on "convergent focus" will increase with
> *a) increasing assimilative cognitive styles*
> *b) increasing preferences for evaluation*

Explorative people, on the other hand, may be more satisfied with a communication process characterized by immediate feedback. They are less concerned with accuracy, rehearsability, and reprocessability than assimilative individuals. Their preferences for non-critical idea-generating processes are therefore in accordance with high synchronous interaction. Likewise,

the communication characteristics resulting from high synchronicity mentioned above also tally with high preferences for ideation in a problem solving situation. It may therefore be expected that manifestations of the divergent innovative thinking process become more distinct as the individuals' preferences for ideation increase. Thus:

H4b: The effects of synchronicity on "divergent focus" will increase with
    a) *increasing explorative cognitive styles*
    b) *increasing preferences for ideation*

Moderating effects on the role of parallelism

Communication media that limits the communication processes to include only two persons at a time, also pose limits on the amount of information that can be transmitted. By this, the potential for information overload decreases, and it gives the participants better opportunities to evaluate the information they receive. Evaluative activities like rehearsability and reprocessability are thus higher in situations with low parallelism than in situations with high parallelism. As described above, both assimilative cognitive styles and high preferences for evaluation are more "in accordance with" such an interaction environment, therefore:

H5a: The effects of parallelism on "convergent focus" will increase with
    a) *increasing assimilative cognitive styles*
    b) *increasing preferences for evaluation*

High parallelism is (in most situations) associated with a greater amount of information that can be simultaneously distributed to many participants compared to low (or absent) parallelism. Consequently, individuals that are comfortable in situations where neither the information flow nor the information "content" follow predefined structures, will be more comfortable with highly parallel interaction than people that prefer structured interaction. Moreover, this increase in information flow and interaction opportunities also facilitates hitchhiking on other participants' ideas, and reduces evaluation apprehension, concentration blocking, and air-time fragmentation. As these processes are positive for the ideative part of idea generation, the influence of high degree of parallelism on all of these group processes is probably more valued by a) explorative individuals than assimilative individuals, and b)

individuals with high preferences for ideation than people with low preferences for ideation. The results will thus be that the contributions in high parallel interaction will be more divergent for highly explorative and "ideative" individuals. Therefore:

H5b: The effects of parallelism on "divergent focus" will increase with
    a) increasing explorative cognitive styles
    b) increasing preferences for ideation

Moderating effects on the role of identification

In a situation with high identification, individuals may become more self aware, and experience more conformance pressure and evaluation apprehension than in a situation with low identification. As stated in hypothesis H3b, this may increase the evaluative and convergent activities of problem solving. Further, as the Assimilator-Explorer Theory posits that assimilators are more conformist and rule bound than explorers (Martinsen, 1995), individuals with the former cognitive style would probably be more satisfied with the effects of high identification than individuals located at the explorative side of the cognitive style continuum. This will probably also be the case for individuals with high preferences for evaluation compared to individuals with low preferences for evaluation. In other words, the effects of identification on innovative thinking processes will be strengthened by the cognitive styles and attitudes toward idea generation that fit best with the specific thinking process. Therefore:

H6a: The effects of identification on "convergent focus" will increase with
    a) increasing assimilative cognitive styles
    b) increasing preferences for evaluation

Above I argued that interaction with high identification tally with both assimilative cognitive styles and high preferences for evaluation. In situations with low identification, however, the interaction environment is more suitable for explorers and individuals with high preferences for ideation. That is, low identification of participants in group-based problem solving can result in situations where explorers and highly ideative people more freely can "live out" their preferences for going off in new directions, decreasing the inhibition explorers and ideative

individuals may experience in situations with high identification. As argued in previous sections, cognitive style and attitudes toward idea generation are believed to strengthen the effects of communication properties/affordances on the innovative thinking process that are closest to the cognitive style and attitudes of the individual. For explorers and individuals that score high on preference for ideation, I believe this to be divergent focus, therefore:

H6b: The effects of identification on "divergent focus" will increase with
   a) *increasing explorative cognitive styles*
   b) *increasing preferences for ideation*

5.4   Conclusion

In this part of the dissertation, I described the research model of the study. Thereafter, several hypotheses regarding the expected relationships between the constructs in the model were stated. First, hypotheses concerning the direct influence of affordances of communication processes enabled by electronic media on innovative thinking processes were put forth. And second, I posited hypotheses that focused on the attitudes toward idea generation and cognitive styles of the individuals involved in idea generation activities as moderators of the relationships between affordances and innovative thinking processes. I will now turn to a description of the methodological approach that was applied in order to test the hypotheses.

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Part IV

- Methodology and Analysis -

The purpose of the first chapter (6) in part IV is to describe the methodological foundation of the research. That is, I first devote the attention to a discussion of methodological issues regarding how to provide an answer to the research question, and report on the development of measures of dependent and independent variables. Finally, the results of the empirical tests of the hypotheses are put forth in chapter 7.

Subjects participating in the experiments were randomly distributed into groups (with 3-5 participants) that pertain to a specific experimental condition/group. One experimental condition consisted of several problem solving groups in which the participants were given a task that necessitated information exchange and interaction between the members in order to be accomplished. This communication was carried out by use of ICT. Within the experimental conditions, the affordances were manipulated in the same manner for all groups. See figure 6.1 below for an illustration of the relationship between experimental groups and problem solving groups.
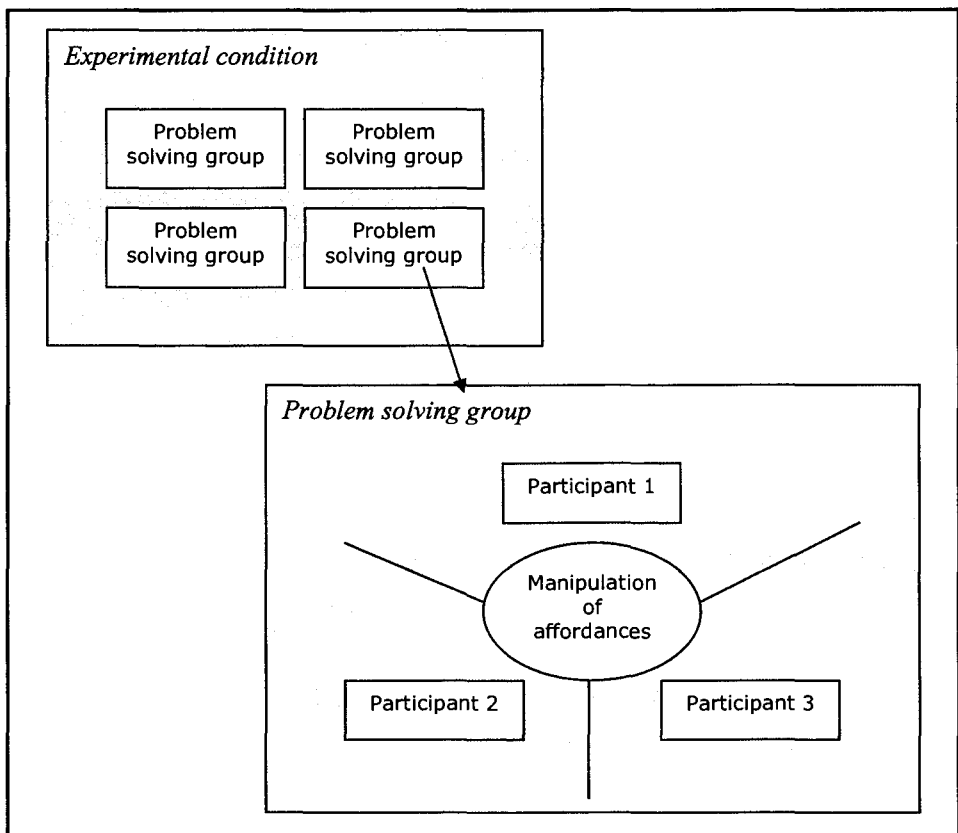
Figure 6.1: Experimental conditions and problem solving groups

As the objective of this study was to investigate the effects of specific affordances on innovative thinking processes, and not on revealing differences in effects of non-mediated versus electronically mediated interaction on these processes, I found it unnecessary to include face-to-face (FtF) interaction as an experimental condition in the study. Further, it is probably easier to control the situation when the interaction is mediated, meaning that it would have been problematic to attribute potential differences found between a face-to-face condition and electronically mediated interaction to one or several of the three affordances. It is difficult to manipulate one specific affordance by use of information technology while at the same time keep the levels of the other affordances the same as for FtF interaction. That is, as the interaction is "moved" from a physical FtF situation to a virtual context, several of the affordances will be altered, and the levels of the affordances as found in FtF situation cannot be copied by use of information technology. I therefore decided not to use FtF interaction as an experimental condition in this research.

On basis of these acknowledgements, one possible experimental design was to aim at approaching the FtF levels of all non-focused affordances in each condition. That is, all experimental conditions would be electronically mediated, and I would endeavor at approximating the levels of affordances that are characteristic for FtF interaction, except for the manipulated affordance. This approach would have required 4 experimental conditions. In the first condition, communication in the groups would be accomplished by use of technology that provided for affordances-levels that were close to FtF interaction. For the conditions from 2 to 4, the focus would be on specific affordances. The affordances would be manipulated such that the level of the affordance in focus contrasted the level found in condition 1, while the levels of the other affordances were the same as in condition 1. In this way, it would have been possible to compare the outcome on innovative thinking across these two conditions and evaluate whether the level of one specific affordance was important for the outcome as the levels of all other affordances were constant.

Even though the design depicted above would have given a straightforward basis for determining the effects of each affordance, it would have required a rather large amount of participants. I therefore decided to apply the design illustrated in figure 6.2 below, which required 3 experimental conditions. In this approach, the scores of the non-focused variables

within each experimental condition were used as frames of references for determining the effects of the focused (and manipulated) variables on the dependent variables.

	Condition 1	Condition 2	Condition 3
Synchronicity	Low	High	High
Parallelism	High	Low	High
Identification	Identified	Anonymous	Anonymous

Figure 6.2: Experimental design

When focusing on synchronicity, the aggregate (synchronicity-) score in conditions 2 and 3 was contrasted with the (synchronicity-) score in condition 1. When focusing on parallelism, the aggregate (parallelism-) score in conditions 1 and 3 was contrasted with the (parallelism-) score in condition 2, and when the focus was on identification, the aggregate (identification-) score in conditions 2 and 3 was contrasted with the (identification-) score in condition 1.

As can be seen from figure 6.2 above, this design does not discriminate between the groups that were to be contrasted when focusing on synchronicity and identification (group 1 versus groups 2/3). Originally, the participants in condition 2 were supposed to be identified (implying that the aggregate identification score in conditions 1 and 2 should be contrasted with the identification score in condition 3), but manipulation problems revealed in two pilot studies necessitated the design depicted above. This had consequences for the data analysis, and is addressed in the next chapter.

6.2.1   *Experiment overview*

The participants took part in a group-based problem solving session, where the interaction among the group members was based on *Groove* (version 2.5). General instructions regarding use of *Groove* were given to the participants in plenum. In addition, a letter explaining the task to be solved and the *specific* use of *Groove* was handed out. The letter also specified which computer the participants should use. Prior to the problem solving session, the computers that were used in the experiment were configured (according to the manipulation of affordances) and numbered. That is, each computer were assigned to one of the experimental conditions and configured based how the affordances should be manipulated.

The configuration also included grouping of the participants (meaning that the participants of the various "working spaces" in *Groove* were pre-defined), and the *Groove* workspaces on the computers were thus ready to be used as cooperative tools without further configuration. The only thing the participants had to do was to change the default machine identity with their personal identity (except for the participants in the anonymous conditions). As the participants were told which computer to use as they entered the room, they were randomly assigned to the experimental conditions/groups. When the subjects were finished configuring their computers (i.e. make the required adaptation of the *Groove* settings), they were told to answer the first questionnaire (cognitive style). Thereafter, the group problem solving session started, and after 30 minutes the participants were asked to fill out the second (attitudes toward idea generation) and third (perceived affordances) questionnaires.

The combination of *computer number* and *configuration* was used to relate the participants' answers on the questionnaires to the manipulation of affordances. When the questionnaires were completed, one participant in each group was instructed to save the discussion transcripts of his/her group (the instructions were included in the letter handed out prior to the problem solving session). These transcripts were objects for content analysis aiming at revealing the participants' divergent focus and convergent focus.

The task
Instead of selecting a task typical for creativity research, I wanted to let the participants work on a business related problem (or rather challenge) caused by new information and communication technology. A drawback of this was that the participants needed some basic knowledge of the problem beforehand. However, conversations with some of the participants immediately after the first pilot study revealed that most participants found the task (and the session) both interesting and challenging. The task is enclosed in appendix B.

6.3   Sample
The participants needed to be relatively experienced in using basic applications (word processing applications, web browsers, and electronic mail applications). I therefore drew a sample from students at NHH in Bergen. This also reduced the drawback of the characteristics

of the task pointed out above, as most students at NHH are familiar with the "Napster problem/challenge" (see appendix B).

6.3.1 Sample size

The research design more or less necessitated (or was at least well suited for) a sequential sampling procedure. As the problem solving sessions took place at a computer lab, a maximum of 25 people could participate in each session. Further, given the need for manipulation-specific instructions (tailored instructions for the participants in each condition), it was preferable to carry out each session with homogenous experimental groups. The computers also needed to be reconfigured before each session. It was for these reasons necessary to split the experiment into several sessions, and a minimum of one session was needed for each experimental group. I therefore decided to continue with sessions until acceptable group sizes were reached. In order to conduct analysis of variance, cell sizes of 30 are regarded as a conventional rule of thumb (Sawyer & Ball, 1981). Given a medium-to-large effect size, 30 participants per cell should lead to about 80% power (the minimum suggested power for an ordinary study) (Cohen, 1988). However, as no studies focusing on effects of synchronicity, parallelism and identification on divergent/convergent focus have been conducted (as far as I know), I did not know what effect sizes to expect. Hence, acknowledging the probability of low/moderate effects of the manipulations, a larger sample size than 30 per group was desirable. However, for practical and financial reasons this was not obtained.

6.4   Collaborative tools and manipulation of affordances

The experimental conditions represented the manipulations of the independent variables. The experiment was based on Internet technology; I used specific Internet-based software for group collaboration, which has a set of basic functions that form the basis for the interaction between group members. The various optional components of the software (*Groove*) allowed for different configurations to be used in order to test the hypotheses. That is, different levels of support related to the affordances affect the communication characteristics, and this was manipulated. Thus, for all experimental groups, the technology was based on the same

"framework", with the exception of the specific configuration that was needed in order to provide for variation in the levels of the focused affordances.

6.4.1 Basic tool kit

In general, participants in a group session using *Groove* as a means for interaction first create a *shared space* (meaning an interface that is shared by all participants) where the interaction takes place. Thereafter, as the *Groove* collaboration software is based on several optional components, the participants can select which components or tools that will be available for communication in their shared space. This selection is most often done by a *manager*. The manager is by default the person who initiates the collaborative session. After the manager has selected the tools to use in the session, s/he invites other people to be members of the shared space that is created. In this experiment, I took the role of the manager (without being active in the problem solving task) and configured the software in order to manipulate the affordances. In other words, in order to achieve the desired effects in perceived level of affordances, I controlled both the configuration of tools for collaboration that were used within the groups, and the specific group compositions (assignment of members to the various groups).

In the next sections, I will first present the operational definitions of the independent variables, and with reference to these operationalizations, I describe how the variables were manipulated. In order to do this, the basic components or collaborative tools that were used are discussed with the various affordances as structure.

Synchronicity

In chapter 4, synchronicity was defined as "the extent to which the participants engaged in a group-based problem solving situation can give immediate feedback to the postings of other group members, and receive immediate feedback on their own postings from other group members". Based on this conceptual definition, I operationalized the variable as *the time that elapses from the messages of one participant are posted to these messages are received by another participant.*

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For problem solving groups pertaining to conditions 2 and 3, I ensured (perceived) high synchronicity by letting the participants work online. By using the shared space in an online condition, the contributions of one participant popped up immediately on the other participants' computer screens. The interaction thus occurred in real time, and the synchronicity was high.

Parallelism

Parallelism refers to the participants' opportunities to be engaged in simultaneous dialogues in a group-based problem solving situation. In other words, the participants do not have to take turns speaking in communication environments that support high parallelism. Low parallelism on the other hand means that only one member of the group can speak at the same time (as is the situation in FtF interaction). Based on this, the operational definition of parallelism I used is as follows: *Parallelism refers to the degree to which it is possible for the participants to post their ideas and comments at the same time without interrupting others.*

In the shared work space of groups in conditions 1 and 3, the level of parallelism should be high. Implementing this characteristic means that all participants in the groups should be able to post their contributions simultaneously without interrupting others. Off course, the *opportunity* for parallel contributions did not assure *actual* parallel posting of ideas and comments. However, I am interested in the participants' perceived level of affordances, and naturally it is expected that the perceived level of parallelism is higher in situations where the opportunity for parallelism is high. The relationship between the perceived level of affordances and the *Groove* workspace tools that are available for communication were validated in a manipulation check.

Identification

Identification was defined as "the extent to which the contributions (ideas and comments) of the participants in a group-based problem solving situation are linked with the identities of the contributors", and on this basis I operationalized this affordance as *whether or not the identities of the participants in a group-based problem solving situation are displayed along with (and thus linked to) the contributions of the participants.* By using this definition of

identification, it was possible to manipulate what Valacich et al. (1992b) described as content anonymity, but not process anonymity. As all groups were located in the same room during the problem solving situation, there was not full process anonymity for any of the groups in the experiment. This again influenced the latitude regarding manipulation of identification. However, it is my opinion that content anonymity (in this situation) was more important for the overall perception of identification by the participants, and that by manipulating this anonymity type I would obtain sufficient variability in this variable.

In order to ensure *perceived identification*, the names of the contributors were displayed together with their postings, meaning that the contributors were identified. The participants in groups in condition 1 and 2 were instructed to create personal accounts before staring on the problem solving task. For participants in condition 2, the identities were not displayed along with the contributions because of the characteristics of the tools for interaction is this condition. In contrast, all messages that were put forth by the participants in condition 1 were coupled with the contributors' identities in the dialog box, and the identities of the participants (both online and offline) in the shared space were also shown in a "list of participants".

6.4.2 Manipulation of synchronicity

I operationalized synchronicity as *the time that elapses from the messages of one participant are posted to these messages are received by another participant.* In order to clarify the effects of synchronicity, the interaction in groups pertaining to condition 1 took place by use of technological facilities that did not enable synchronous communication. This was accomplished by instructing the the participants in the group to work offline (figure 6.3).

During the problem solving session, the participants logged on the shared group space every three minutes (one session lasted for 30 minutes). These online periods were as short as possible, only enabling the interfaces (shared work space) to be synchronized. After synchronization, the participants would again work offline. This means that there were time delays of maximum 3 minutes from the messages of one participant were posted to these messages were received by the other participants, and accordingly time delays of more than 3 minutes from the messages of one participant were posted to s/he got a response to these

messages. Thus, compared to conditions 2 and 3, the level of synchronicity in condition 1 was low.
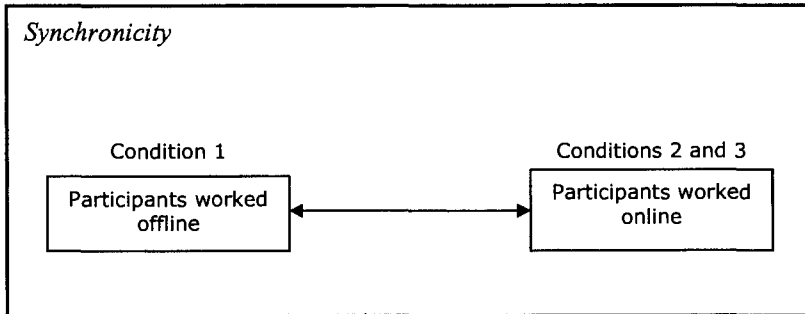
Figure 6.3: Manipulation of synchronicity

6.4.3 Manipulation of parallelism

Based on the operational definition of parallelism stated previously, high parallelism (conditions 1 and 3) was implemented as *a discussion forum that allow for simultaneous postings,* while the groups in condition 2 contributed their messages in a shared text editor (figure 6.4). It is worth notice that the collaborative software did allow for simultaneous postings in the text editor. However, this type of interaction is neither efficient (this will be the same as when people speak all at once in an FtF setting) nor in accordance with established communication etiquette.
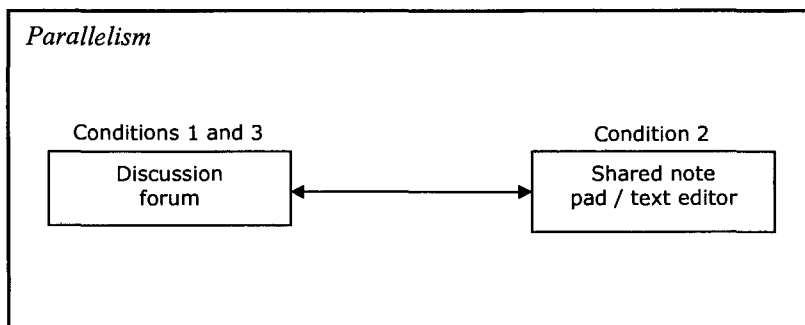
Figure 6.4: Manipulation of parallelism

6.4.4   Manipulation of identification

Identification was operationalized as *whether or not the identities of the participants in a group problem solving situation are displayed along with (and thus linked to) the contributions of the participants.* As illustrated in figure 6.5, the identities of the participants in problem solving groups belonging to condition 1 were displayed together with their contributions (input to the discussion) and their feedback to the other participants' ideas/contributions. Contrary, for groups in conditions 2 and 3, the identities of the participants were not displayed together with their contributions and feedback. This ensured *perceived anonymity.*
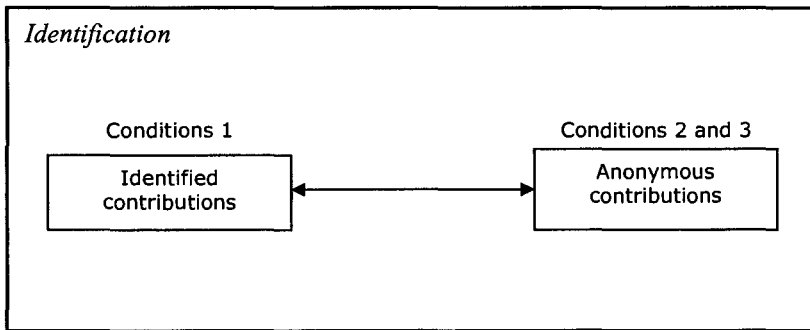
Figure 6.5: Manipulation of identification

6.5   Measurement

The measurement scales of the moderating variables (cognitive style and attitudes toward idea generation) have been validated in previous research. The measurement of dependent variables (innovative thinking processes) and independent variables (communication affordances), however, were not adopted from previous studies, and the development of these measures will be described below. In addition to the independent, dependent, and moderating variables, I also included sex, group size, and PC- and CMC literacy of the participants as control variables in the study.

6.5.1   Dependent variables: Innovative thinking processes

As described in chapter 2, innovative thinking processes are manifested in language, and in order to capture the participants' divergent focus and convergent focus in the group-based problem solving, it was thus necessary to investigate their contributions to the group work. Content analyses of the transcripts from the various groups were therefore undertaken.

Content analysis means that a set of procedures are utilized in order to make valid inferences from text (Weber, 1985), and researchers applying this methodology attempts to characterize the meanings in a given body of discourse in a systematic and quantitative fashion (Kaplan, 1943 p. 230). Central in content analysis is the idea that words and parts of a text are classified into fewer categories, which thus are presumed to have similar meanings (Weber, 1985). In order to draw valid inferences from the text, it is important that the classification procedures applied are consistent, and with that assure high reliability of the results. In other words, different people should code the text in the same way (*ibid.*). This data reduction process is the main problem in content analysis as reliability and validity problems usually grow out of the semantic ambiguity of words and phrases.

Acknowledging the pitfalls of using only one coder, all transcripts were analyzed and coded by three people (independently). The coders were given an introduction to the theoretical foundation underlying divergent focus and convergent focus (c.f. chapter 2), and were in the first instance instructed to read the transcripts and mark the phrases and words that indicated convergent and divergent thinking. Afterwards, they were instructed to go through their markings and assess the highlighted sentences/words on a 5-point scale ranging from high to low degree of divergence/convergence. Prior to the analyses, coding forms were developed. These forms were used to create measures of divergent focus and convergent focus of each participant in conditions 1 and 3, and aggregate measures of these dependent variables of groups in condition 2. In this latter condition, the ideas and comments that were typed into the notepad were not identified by machine number or name of the contributor, thus it was not possible to create measures of divergent focus and convergent focus on an individual level in this condition.

The dependent variables were constructed by use of the following formulas:

$$DF = \left(\frac{dg}{dc} \right) \left(\frac{dc}{n} \right) \Big/ N$$

and

$$CF = \left(\frac{cg}{cc} \right) \left(\frac{cc}{n} \right) \Big/ N$$

where

DF = Divergent Focus

CF = Convergent Focus

n = number of coders

dg = sum of divergent gradings from all coders

cg = sum of convergent gradings from all coders

dc = total number of divergent utterances identified by all coders

cc = total number of convergent utterances identified by all coders

N = total number of contributions pr. unit (group or individual)

As the number of contributions (i.e. ideas, comments, suggestions, etc.) put forth by the participants and groups varied (partly because of the manipulations and partly because of individual factors), this had to be accounted for when constructing the variables. By applying the formulas depicted above, the arithmetic means of the divergent and convergent gradings for all three coders were weighted based on the number of divergent and convergent utterances[8] (as assessed by the coders) relative to the total number of contributions within each unit of analysis (group or individual). It should be noticed that this is not the same as the

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[8] The term "utterance" does here refer to a word, sentence or a phrase assessed as either divergent or convergent by a coder.

percentage of convergent/divergent utterances of the total number of contributions as one single contribution may (but do not have to) contain several utterances (both divergent and convergent). That is, one comment or idea put forth by a participant may contain 1) one or several divergent utterance(s), 2) one or several convergent utterance(s), 3) both types of utterances, or 4) it may be evaluated as neutral (meaning that it does not contain neither divergent nor convergent utterances). Consequently, a high score on one focus-type does not necessarily imply a low score on the other focus-type. One unit of analysis may thus have a similar score on both divergent and convergent focus.

In sum, the variables computed (DF and CF) were based on a combination of the degree of divergent/convergent focus (the strength of the utterances) and the frequency of divergent/convergent utterances. DF and CF were calculated for every group in the experiment, and for each individual in experimental conditions 1 and 3.

6.5.2 Independent variables: Affordances

There are, as far as I know, no well-validated measures of synchronicity, identification, and parallelism. As described earlier, I focused on affordances levels as perceived by the communication media users, and based on the understanding of the different affordances described in chapter 4, along with the operational definitions proposed in section 6.4.1, I developed a scale for measuring affordances perceptions (the scale is presented in appendix C.1). In order to test this instrument and remove non-fitting items, factor analyses were conducted in SPSS. In these analyses, rotated factors were computed by use of VARIMAX rotation as it simplifies the interpretation of factors.

By running a factor analysis of the items related to synchronicity, 2 factors with eigenvalues equal to or greater than 1 were extracted. Inspection of the various items and the factor loadings indicate that the items loading on one factor concerned *time-related* aspects of feedback and responses received and given, while the items loading on the other factor were more related to the degree to which the participants could *thoroughly* formulate and evaluate the contributions. I found that the former factor or variable best reflects the concept of synchronicity (the latter factor may rather be a consequence of the first), and therefore decided to drop the items loading on the latter factor. In addition, many of the participants had

problems understanding the meaning of the first synchronicity-item ("the interaction with the other group members occurred in "real time""), and needed to be explained the denotation of this question before they could answer it. This item was therefore removed. The final measurement model regarding synchronicity thus consists of the following items:

- I could provide immediate feedback on other group-members' contributions.
- I could get immediate feedback on my contributions.
- My response time on contributions from other participants could be very low.
- The response time of the other group participants on my contributions could be very low.

The manipulations of parallelism in the first pilot study were unsuccessful, and the measures were most likely affected by this. Highly inconsistent results necessitated a thorough inspection of the parallelism-items. This inspection, together with feedback from participants in the pilot study, indicated that some changes in the parallelism measurement scale were required. The reason for this is as follows: All tools in *Groove* render possible parallel contributions of ideas and comments. However, when using *some* of the tools, parallel interaction will not be natural (similar to a face-to-face situation; it is possible to speak all at the same time, but it is not natural or good manners). I therefore slightly changed the wordings of the parallelism-items in order to adapt the measure to this distinction. Hence, the focus was moved from the participants' perceptions of what was *possible* to what the participants perceived as *both possible and natural* in a given situation. I further dropped one item as a high score on this would require the participants to violate the well established communication etiquette of taking turns speaking. That is, even though the *Groove* tools would render possible parallel or simultaneous conversations, the scores on this item would be low given that the participants follow common communication etiquette. Two additional items were dropped due to poor convergent and discriminant validity, ending up with the following measurement model:

- Thoughts and ideas that popped up could be presented without interrupting other group participants.
- Ideas and thoughts that popped up could be framed immediately without risking that we spoke all at once.

- It occurred that I delayed proposing thoughts and ideas that popped up because I didn't want to interrupt other group participants (R).

Factor analysis of the items intended to measure the identification affordance came out with one factor that accounted for approximately 77 % of the variance. Accordingly, no reasons for making any changes in this measure were found. Reliability analyses also showed a coefficient alpha of .92 for these items, hence the measure on this construct is sufficiently consistent. The measurement model regarding identification thus includes the following items:

- The other participants in the group knew which contributions that were mine.
- It was easy to know who presented an idea/comment.
- It was easy to relate a specific contribution to the person that proposed it.
- The contributors were generally unknown (R).
- The collaborative tool made it possible for me to present my contributions without the other participants knowing that it was my contributions (R).

6.5.3   Moderating variables: Cognitive style and attitudes toward idea generation

In order to measure the participants' cognitive styles, I applied the instrument of the Assimilator-Explorer theory, the A-E Inventory (Kaufmann, 1989; Kaufmann & Martinsen, 1993). There are 15 items that pertain to the assimilative cognitive style, and 15 explorer-related items. The total inventory consists of 34[9] questions that should be judged for appropriateness on a 5 point Likert-scale from "very poor description" to "very good description". The questionnaire is included in appendix C.3.

Basadur et al. (1982) and Basadur and Finkbeiner (1985) have developed internally valid and reliable measures of the preference for ideation (six-item scale) and tendency for premature critical evaluation of ideas (eight-item scale) (named preference for evaluation in this study) concepts. The two scales have been combined into one measure called the *Basadur 14 Item Ideation-Evaluation Preference Scale* (Basadur et al., 1999). I slightly modified or adjusted

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[9] Four of the items are distractors/lie indicators (items 1, 6, 15, and 26).

the items in this scale in order to achieve greater correspondence between the items and the particular context, and the participants were asked to complete the questionnaire with reference to the problem solving situation that they just had been participating in. The questionnaire is included in appendix C.2.

6.6   Conclusion

The accomplishments of the pilot studies were successful, and the manipulations seemed to function quite well. As the course of the main experiment were similar to the second pilot study (the only distinction was a reduction of one synchronicity-item and two parallelism-items), the participants involved in this study were also included in the main sample. I will now turn to a presentation of the analysis of the results of the main experiment.

7   Results and analysis

The purpose of this chapter is to form a basis for accurate and valid testing of the proposed hypotheses, and report on the statistical tests that were effectuated. I first present the descriptive statistics of the data and discuss the assumptions of the statistical analyses, and then the tests of the hypotheses are reported.

7.1   Data description

The total sample consists of 95 subjects (including the participants in the second pilot study carried out the 4th and 5th of March 2004), apportioned as follows: 32 subjects in condition 1, 32 subjects in condition 2, and 31 subjects in condition 3 (se table 7.1 below for a summary of the experimental sessions). Three participants belonging to one of the groups in condition 2 had to be excluded because of incomplete transcripts of their group discussion. Descriptive statistics for all variables in the study are presented in appendix D.1.

Table 7.1: Summary of experimental sessions

Date	Number of participants and groups	Participants C1 (sync)	Participants C2 (para)	Participants C3 (iden)
04.03.2004	2 groups * 3 participants	-	6	-
05.03.2004	1 group * 5 participants	5	-	-
10.03.2004	1 group * 5 participants	5	-	-
11.03.2004	2 groups * 3 participants	-	6	-
11.03.2004	2 groups * 3 participants	-		6
12.03.2004	2 groups * 3 participants	-	6	-
15.03.2004	2 groups * 4 participants, 1 group * 3 participants	-	-	11
15.03.2004	1 group * 4 participants, 1 group * 3 participants	7	-	-
30.09.2004	1 group * 4 participants, 1 group * 3 participants	-	7	-
01.10.2004	2 groups * 3 participants	-	-	6
01.10.2004	2 groups * 3 participants	6	-	-
16.02.2005	4 groups * 4 participants 1 group * 3 participants 1 group * 5 participants	9	7	8
	Total	**32**	**32**	**31**

7.2   Dependent variables

As described in section 6.5.1, the dependent variables were calculated based on a combination of the strength/degree of divergent/convergent focus and the frequency of divergent/ convergent utterances. The mean scores on divergent focus and convergent focus for all participants were 1.45 and 3.51 respectively. For participants in condition 1, the mean scores on divergent/convergent focus were 1.83 and 4.65 respectively. The corresponding scores for participants in group 3 were 1.32 and 3.16. As described earlier, it was not possible to create measures of divergent focus and convergent focus on an individual level for the participants in condition 2 as the ideas and comments that were typed into the notepad were not identified by machine number or name of the contributor. The group scores on divergent and convergent focus were therefore used as "proxies" of individual performances for the participants in condition 2. In other words, the scores on the dependent variables for the groups in this condition were assigned each participant in the group, resulting in mean scores of 1.18 (divergent focus) and 2.62 (convergent focus). Naturally, this has drawbacks as the value of the dependent variables for these participants to some extent are results of the performance of the whole problem solving group in which they belonged to. This experimental condition included at total of 10 groups and 32 participants (8 groups with 3 participants and 2 groups with 4 participants). As one of the groups with 3 participants had to be excluded because of incomplete transcripts, a total of 29 participants in 9 problem solving groups were given values of divergent focus and convergent focus by applying this procedure. By giving the members of the same groups the same values of divergent and convergent focus naturally results in smaller variances of the variables and imposes threats to the validity of the results of the data analysis, thus the outcome of the hypotheses testing has to be interpreted with caution.

7.3   Moderating variables

7.3.1 Attitudes toward idea generation

In order to test the measurement model of the attitudes toward idea generation, factor analysis applying traditional principal component analysis using VARIMAX rotation on the 14 attitude indicators was conducted (se table 7.2 below). As the instrument has been validated and applied in previous research, a predefined two-factor solution was chosen instead of

extraction of factors with eigenvalues equal to or greater than one. The eigenvalues of the extracted factors are 3.18 and 1.96 respectively, accounting for approximately 36.8 % of the variance in the items.

Table 7.2: Factor analysis - attitude indicators

	h^2	Component	
		1	2
EVAL1 (var2.1)	.15	.37	
EVAL2 (var2.2)	.22	.38	
EVAL3 (var2.5)	.42	.64	
EVAL4 (var2.6)	.30	.51	
EVAL5 (var2.7)	.22		-.45
EVAL6 (var2.10)	.64	.78	
EVAL7 (var2.11)	.52	.70	
EVAL8 (var2.14)	.53	.67	
IDEA1 (var2.3)	.32		.52
IDEA2 (var2.4)	.16	-.34	
IDEA3 (var2.8)	.46		.68
IDEA4 (var2.9)	.66		.80
IDEA5 (var2.12)	.37		.60
IDEA6 (var2.13)	.17		.33
% of variance extracted	36.8	22.7	14.1

According to Hair et al. (1998), factor loadings greater than +/-.50 are generally considered practically important. Based on inspection of the communalities and factor loadings in the table above, I removed indicators EVAL1, EVAL2, IDEA2, EVAL5, and IDEA6 from the subsequent analysis. The results of a factor analysis on the remaining indicators are shown in table 7.3 below. Eigenvalues of the extracted factors are 2.70 and 1.83 respectively. Inspection of the table shows that the convergent validity is acceptable for most indicators; however, one indicator (EVAL4) has a factor loading just below the significance level of .50. The discriminant validity is satisfactory for all indicators, except for EVAL8. I chose to keep EVAL4 (.499) in the scale as the factor loading is close to the suggested cut of level, but EVAL8 was removed because of poor discriminant validity. Cronbach's Alpha for the remaining evaluation indicators is then reduced from .71 to .67. All ideation indicators have satisfactory convergent and discriminant validity, and the Cronbach's Alpha for these items is

.65. The Alpha level does not improve by removing any of the indicators, and I therefore decided to keep the scale as it is. Both of these Alpha levels (ideation and evaluation) are lower than the suggested level of .70 (Nunnally, 1978), however, values down to .60 can be deemed acceptable (Hair et al., 1998).

Table 7.3: Factor analysis - selected attitude indicators

	h^2	Component	
		1	2
EVAL3 (var2.5)	.40	.59	
EVAL4 (var2.6)	.32	.50	
EVAL6 (var2.10)	.75	.86	
EVAL7 (var2.11)	.65	.79	
EVAL8 (var2.14)	.51	.59	-.41
IDEA1 (var2.3)	.40		.61
IDEA3 (var2.8)	.51		.71
IDEA4 (var2.9)	.66		.81
IDEA5 (var2.12)	.34		.57
% of variance extracted	50.2	29.9	20.3

All in all I concluded that construct validity was satisfactory and computed 2 variables for the hypotheses testing. The index-variable for evaluation thus consisted of items EVAL3, EVAL4, EVAL6, and EVAL7. The ideation variable consisted of items IDEA1, IDEA3, IDEA4, and IDEA5.

7.3.2 Cognitive style

According to the AI-theory, individuals have preferences for either assimilation or exploration when solving problems. Factor analysis on the moderator items was conducted, and a one-factor solution was chosen over extraction of factors with eigenvalues equal to or greater than one. The eigenvalue of the factor was 8.95, accounting for 29.83 of the variance in the items. In line with the theory, the analysis indicates that we are dealing with a single construct (cognitive style), and that assimilators and explorers are extreme points on a continuum. Following the suggested cut-off level of .50 (Hair et al., 1998), I removed 12 indicators. It should be mentioned that all but one of these indicators had factor loadings greater than .30,

which is the minimal acceptable level according to Hair et al. (*ibid.*) These indicators were nevertheless removed because of low communialities, and as only a small amount of the total variances in these indicators were accounted for by the factor (app. 10% for factor loadings of .30) (*ibid.*). Cronbach's Alpha did not suffer when removing these 12 items, as it was reduced from .92 to .91. Factor analysis of the remaining items showed that two additional indicators should be removed because of factor loadings below .50, ending up with a total of 16. Table 7.4 below shows the results of factor analysis of these final indicators, which has a Cronbach's Alpha of .91.

Table 7.4: Factor analysis - cognitive style indicators

	h^2	Component 1
Cognitive style - item 3	.48	.69
Cognitive style - item 4	.27	.52
Cognitive style - item 8	.41	.64
Cognitive style - item 9	.50	.70
Cognitive style - item 10	.45	.66
Cognitive style - item 11	.34	.58
Cognitive style - item 12	.42	.65
Cognitive style - item 13	.63	.79
Cognitive style - item 20	.60	.77
Cognitive style - item 22	.28	.52
Cognitive style - item 24	.49	.70
Cognitive style - item 25	.32	.57
Cognitive style - item 29	.31	.56
Cognitive style - item 31	.40	.63
Cognitive style - item 33	.46	.68
Cognitive style - item 34	.36	.60
% of variance extracted		41.98

Finally, factor analysis including the final indicators of both cognitive style and attitudes toward idea generation was conducted (see appendix D.2). This analysis indicated that two items pertaining to cognitive style (item 4 and 31 in table 7.4 above) should be removed from the scale because of high loadings on both the cognitive style factor and the "preference for ideation" factor. Based on these analyses, an index of the cognitive style construct was

created of the remaining indicators (Cronbach's Alpha = .90), which again was used as a moderator in the hypotheses testing.

7.4 Independent variables

By conducting a factor analysis of the independent items, three factors with eigenvalues equal to or above one (3.47, 3.18, and 1.94 respectively) were extracted, accounting for approximately 71.6 % of the variance in the items. The analysis showed a satisfactory discriminant and convergence validity of the constructs (table 7.5), and I created index-variables of the items pertaining to synchronicity, parallelism and identification. Cronbach's Alphas for the indicators were .87 (synchronicity), .77 (parallelism), and .88 (identification).

Table 7.5: Factor analysis - independent indicators

| | h^2 | Component | | |
		1	2	3
IDEN1 (var3.1)	.67	.81		
IDEN2 (var3.5)	.72	.81		
IDEN3 (var3.7)	.70	.83		
IDEN4 (var3.11)	.72	.82		
IDEN5 (var3.12)	.71	.82		
SYNC1 (var3.2)	.78		.88	
SYNC2 (var3.3)	.82		.90	
SYNC3 (var3.8)	.66		.79	
SYNC4 (var3.10)	.68		.82	
PARA1 (var3.4)	.75			.83
PARA2 (var3.6)	.71			.84
PARA3 (var3.9)	.69			.83
% of variance extracted	71.6	28.9	26.5	16.2

7.4.1 Manipulation checks

As shown in table 7.6, the mean score on synchronicity for group number one was 3.38 (st. d.=1.03), while the scores for groups two and three were 3.95 (st.d.=1.03) and 3.77 (st.d.=0.83) respectively. The hypothesis that all means are equal is rejected at the 10% level (F=2.74, d.f.=2, p<0.10) (see table 7.6 below). For synchronicity, t-tests show that the

difference in means between groups 1 and 2/3 is significant at the 5% level (t=2.24, d.f.=89, p<0.05). The difference in means scores on this variable between groups 2 and 3 is not significant (t=0.72, d.f.=58, p=0.47, n.s.).

For group number two, the mean score on parallelism was 2.97 (st.d.=0.97), and for groups 1 and 3 the corresponding mean scores were 4.25 (st.d.=0.67) and 3.94 (st.d.=1.00) respectively. The hypothesis that all means are equal is rejected at the 1% level (F=16.41, d.f.=2, p<0.00) (see table 7.6 below). For parallelism, t-tests show that the difference in means between groups 2 and 1/3 is significant at the 1% level (t=5.53, d.f.=89, p<0.00), while the difference between groups 1 and 3 is not significant (t=1.44, d.f.=52, p=0.16, n.s.).

For the last variable, identification, groups 2 and 3 had mean scores of 2.56 (st.d.=1.03) and 2.84 (st.d.=1.08) respectively, and group 1 had a mean score of 3.75 (st.d.=0.93). The hypothesis that all means are equal is rejected at the 1% level (F=11.44, d.f.=2, p<0.00) (see table 7.6 below). For identification, t-tests show that the difference in means between groups 2/3 and 1 is significant at the 1% level (t=4.66, d.f.=89, p<0.00), and that the difference between groups 3 and 2 is not significant (t=1.02, d.f.=58, p=0.31, n.s.).

Table 7.6: Analysis of variance - manipulations

Group	Variable	N	Mean	St. dev.	F	Sig.
1	Synchronicity	32	3.38	1.03	2.74	0.07
	Parallelism	32	4.25	0.67		
	Identification	32	3.75	0.93		
2	Synchronicity	29	3.95	1.03	16.41	0.00
	Parallelism	29	2.97	0.97		
	Identification	29	2.56	1.03		
3	Synchronicity	31	3.77	0.83	11.44	0.00
	Parallelism	31	3.94	1.00		
	Identification	31	2.84	1.08		

The manipulation checks reported above show that respondents in group 1 perceived the level of synchronicity to be lower than the perceived levels of this variable in groups 2 and 3. There

is a minor difference in means between groups 2 and 3 as well, but this difference is not significant. In group 2 the contributions were typed directly into the shared space and thus appeared on all members' screens immediately as they were typed. In group 3, the contributions were completed locally on the participants' computers, and thereafter published for the rest of the group members. This made it possible for the participants in group 1 to rehearse their contributions before they were sent to the shared space. In other words, although the technological tool kits in group 3 (discussion forum) and group 2 (shared notepad) did provide for high synchronicity, there is a small distinction between them regarding this affordance. However, I do not perceive this factor to represent a problem for the manipulations.

For parallelism, the respondents in group 2 perceived the level to be significantly lower than the corresponding levels in groups 1 and 3, and the difference in mean scores between these two latter groups is not significant. And finally, the participants in group 1 perceived the level of identification to be significantly higher than the corresponding levels in groups 2 and 3, while the mean scores on identification in groups 2 and 3 are more or less equal. In sum, the manipulations worked quite well, and are in accordance with the experimental design (figure 6.2). However, the experimental design does not discriminate between synchronicity and identification groups, as is necessary for analysis of variance. The differences in perceptions of the independent variables caused by the manipulations were therefore applied to create dichotomous variables of synchronicity, parallelism, and identification. Each respondent did in this way characterize the level of each independent variable to be low or high, and based on these dichotomous variables, analyses of variance were conducted in order to investigate whether affordances influence innovative thinking processes.

T-tests in order to test the differences in perceived values of the independent variables between groups used in the analyses of variance showed that the difference in score on synchronicity between the high/low synchronicity-groups was significant ($t=-12.94$, d.f.$=64$, $p<0.00$), while the differences in scores on parallelism and identification were not significant ($t=-0.72$, d.f.$=89$, $p=0.48$, n.s. and $t=-0.60$, d.f.$=89$, $p=0.57$, n.s., respectively). For the high/low parallelism-groups, the difference in scores on parallelism was significant ($t=-12.18$, d.f.$=57$, $p<0.00$), and the differences in scores on synchronicity and identification were not significant ($t=-0.82$, d.f.$=69$, $p=0.41$, n.s. and $t=0.43$, d.f.$=89$, $p=0.66$, n.s., respectively).

Similarly, the difference in scores on identification for the anonymous/identified-groups was significant (t=-18.15, d.f.=88, p<0.00), but the differences in scores on synchronicity and parallelism between these groups were not significant (t=0.71, d.f.=89, p=0.48, n.s. and t=0.01, d.f.=89, p=0.99, n.s., respectively).

In case of significant correlations between dependent variables, multivariate analysis of variance (MANOVA) should be considered instead of analysis of variance (ANOVA). Table 7.7 below presents correlations between independent variables, dependent variables, and moderating variables. As can be seen from this table, there is a significant correlation between divergent focus and convergent focus, and MANOVA was therefore preferred over ANOVA.

Table 7.7: Correlations - dependent, independent, and moderating variables

	1	2	3	4	5	6	7
Independent variables							
1. Synchronicity							
2. Parallelism	.19						
3. Identification	.01	-.00					
Dependent variables							
4. Divergent focus	-.02	.30**	.05				
5. Convergent focus	-.11	.42**	.16	.24*			
Moderating variables							
6. Pref. for ideation	-.04	.16	-.12	.12	-.20		
7. Pref. for evaluation	-.03	.09	.09	.01	.14	-.15	
8. Assimilator_explorer	-.04	-.05	.11	-.02	.01	-.06	.17

** Correlation is significant at the .01 level
* Correlation is significant at the .05 level.

7.5 Test of MANOVA assumptions

The hypotheses formulated in chapter 5 call for examination of differences between levels of independent variables in their effects on innovative thinking manifestations. There are three main assumptions that should be met in order to use MANOVA; i) the data should be

normally distributed, ii) homogeneity of variance-covariance matrices, and iii) independence between subjects belonging to the different experimental conditions. The latter assumption is met by the experimental design in which subjects were randomly assigned to one of the three conditions and as sampling was done from different classes. The other two conditions need to be addressed more carefully.

7.5.1 Normality

Skewness - which represents the symmetry of the distribution (the degree to which the mean score is in the center of the distribution), and kurtosis - the degree to which the distribution is "peaked" of "flat", are relevant statistics for testing the normality of distribution. As can be seen from the descriptive statistics in appendix D.1, 12 of the indicators have kurtosis values slightly above 1, and 5 indicators have skewness values above 1. The dependent variables, divergent focus and convergent focus, have kurtosis values of 3.84 and 2.28 respectively (skewness values of 1.54 and 1.56). Still, MANOVA is fairly robust to these violations because sample sizes are above 20 in each experimental group (Tabachnick & Fidell, 2001). Hence, the statistics indicate that there are no noteworthy distributional problems.

7.5.2 Homogeneity of variance

Homoscedasticity refers to the assumption that dependent variables have equal levels of variance across the range of predictor variables (Hair et al., 1998), and Levene's test of homogeneity was used to assess the homogeneity of variance across the experimental conditions (se table 7.8 below).

Table 7.8: Levene's test of equality of variances

Variable	F	df1	df2	Sig.
Divergent focus	18.87	2	89	0.00
Convergent focus	16.54	2	89	0.00

Table 7.8 shows that the assumption of equal variances across experimental groups is violated. This is expected as the participants in experimental condition 2 were provided group values of the dependent variables, which reduces the variances in divergent focus and convergent focus for these participants. However, in case of roughly equal group sizes, violation of the equality-of-variance assumption has little effect on the observed significance levels (Norusis, 2004). Hence, as the numbers of participants in the three experimental conditions are approximately the same, this violation has no major impacts (Hair et al., 1998) and is thus not serious enough to prevent the use of MANOVA. Box's M test for equal variance dispersion was also applied as more than one variable is being tested. The Box's M test is a statistical test for the equality of the variance-covariance matrices of the dependent variables across the groups, and the results are shown in table 7.9.

Table 7.9: Box's M test of equality of covariance matrices

Box's M	114.72
F	18.50
df1	6
df2	188537,8
Sig.	0.00

The p-value of 0.00 is significant, indicating that the null hypothesis that the observed variance-covariance matrices are equal across the experimental groups should be rejected. However, as for the Levens's test of equality of variance, robustness of significance tests is expected regardless of the outcome of Box's M test if sample sizes are equal (Tabachnick & Fidell, 2001) (i.e. if the largest group size divided by the smallest group size is less than 1.5) (Hair et al., 1998).

7.6   Test of hypotheses

The specific relationships between independent variables, the moderating variables, and the dependent variables in the research model (figure 5.1) are proposed in hypotheses H1a-H6b.

These suggest that synchronicity, parallelism, and identification influence divergent focus and convergent focus (H1a-H3b), and that the relationships between these independent and dependent variables are moderated by cognitive style and attitudes toward idea generation (H4a-H6b).

Multivariate analysis of variance (MANOVA) and analysis of covariance (ANCOVA) were conducted in order to test the proposed hypotheses. First, MANOVA using the dichotomous variables of the three affordances (independent variables) testing whether the scores on divergent focus and convergent focus are significantly different between the groups was conducted. Second, in order to test the potential existence of interaction effects between the moderating variables (cognitive style and attitudes toward idea generation) and communication media affordances hypothesized in H4a to H6b, analyses of covariance (ANCOVA) using the metric moderator variables as covariates, and the dichotomous communication media variables as fixed factors, were conducted. As the moderating variables included in the hypotheses where the dependent variable is divergent focus (H4b, H5b, and H6b) differ from the moderating variables included in the hypotheses where the dependent variable is convergent focus (H4a, H5a, and H6a), univariate analyses of covariance were conducted (ANCOVA was preferred over MANCOVA) in order to include only the relevant covariates in the tests.

7.6.1 Main effects

Effects of synchronicity
Hypotheses H1a and H1b state that people involved in interaction with high synchronicity will have a higher divergent focus than participants involved in interaction with low synchronicity, and that people involved in interaction with low synchronicity will have a higher convergent focus than participants involved in interaction with high synchronicity (H1a and H1b respectively).

Multivariate analysis of variance was conducted in order to test whether the scores on divergent focus and convergent focus were different between groups with high and low

synchronicity. The results from the between-subjects test of hypotheses H1a and H1b are presented in table 7.10.

Table 7.10: Main effects of synchronicity - between subjects

| Variable | F-value | p | Group means | |
			High (n=50)	Low (n=41)
Divergent focus	0.15	0.70	1.48	1.42
Convergent focus	0.92	0.34	3.37	3.68

Table 7.10 above shows that the null hypothesis that there are no differences between groups is not rejected, thus I do not find support for H1a and H1b.

Hypotheses H2a and H2b state that participants involved in interaction with high parallelism have a higher divergent focus than participants involved in interaction with low parallelism, and that participants involved in interaction with low parallelism have a higher convergent focus than participants involved in interaction with low parallelism (H2a and H2b respectively).

Multivariate analysis of variance was conducted in order to test whether the scores on divergent focus and convergent focus were different between groups with high and low parallelism. The results from the between-subjects test of hypotheses H2a and H2b are presented in table 7.11.

Table 7.11: Main effects of parallelism - between subjects

| Variable | F-value | p | Group means | |
			High (n=50)	Low (n=41)
Divergent focus	4.06	0.05	1.61	1.27
Convergent focus	11.13	0.01	3.96	2.95

The results show that the null hypothesis that there are no differences between groups should be rejected. The results show that individuals involved in interaction with high parallelism have a significantly higher divergent focus than individuals involved in interaction with low parallelism, hence providing support for hypothesis H2a. However, the results also show that individuals involved in interaction with high parallelism have a significantly higher convergent focus than individuals involved in interaction with low parallelism, which is opposite to the hypothesized relationship (H2b).

Effects of identification

Hypotheses H3a and H3b state that participants involved in interaction with low identification have a higher divergent focus than participants involved in interaction with high identification, and that participants involved in interaction with high identification have a higher convergent focus than participants involved in interaction with low identification (H3a and H3b respectively). As for the tests of main effects of synchronicity and parallelism, multivariate analysis of variance was conducted in order to check for differences between groups with high and low identification. The results from the between-subjects test of hypotheses H3a and H3b are presented in table 7.12.

Table 7.12: Main effects of identification - between subjects

Variable	F-value	p	Group means	
			High (n=44)	Low (n=47)
Divergent focus	0.20	0.66	1.49	1.42
Convergent focus	1.99	0.16	3.74	3.29

Table 7.12 above shows that the null hypothesis that there are no differences between groups is not rejected, thus lending no support for H3a and H3b.

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7.6.2 Moderating effects

In section 5.3.2, hypotheses concerning the moderating effects of cognitive style and attitudes toward idea generation on the relationships between communication affordances and innovative thinking manifestations were proposed. The results of the tests of these hypotheses are presented below.

Moderating effects on the role of synchronicity

Hypothesis H4a states that the effects of synchronicity on convergent focus will increase with increasing assimilative cognitive styles and increasing preferences for evaluation. The results of an ANCOVA test are presented in table 7.13 below.

Table 7.13: ANCOVA - effects of synchronicity and covariates on convergent focus

Dependent variable	Source	F-value	p
Convergent focus	Synchronicity	3.68	0.06
	Evaluation	0.53	0.47
	Assimilators/explorers	0.03	0.87
	Synchronicity * Evaluation	3.95	0.05
	Synchronicity * Assimilators/explorers	0.23	0.63

Table 7.13 above shows that the null hypothesis that there are no differences between groups on convergent focus independent of cognitive style can not be rejected, and hypothesis H4a(a) must therefore be rejected at this time. However, there is a significant interaction term at the 5 % level between synchronicity and preference for evaluation, and analyses of simple effects show that low synchronicity results in higher convergent focus for individuals with low preferences for evaluation, while an increase in preferences for evaluation is accompanied with an increase in convergent focus for individuals involved in high synchronous interaction (figure 7.1). The effects of synchronicity on convergent focus seem to increase with decreasing preference for evaluation, and this is opposite to the hypothesized moderating effect of this covariate (H4a(b)). Table 7.13 also shows that the main effect of synchronicity

on convergent focus turns out significant at the 10 % level when cognitive style and preference for evaluation are controlled for (estimated marginal means are 3.34 and 3.67 for high and low synchronicity respectively).
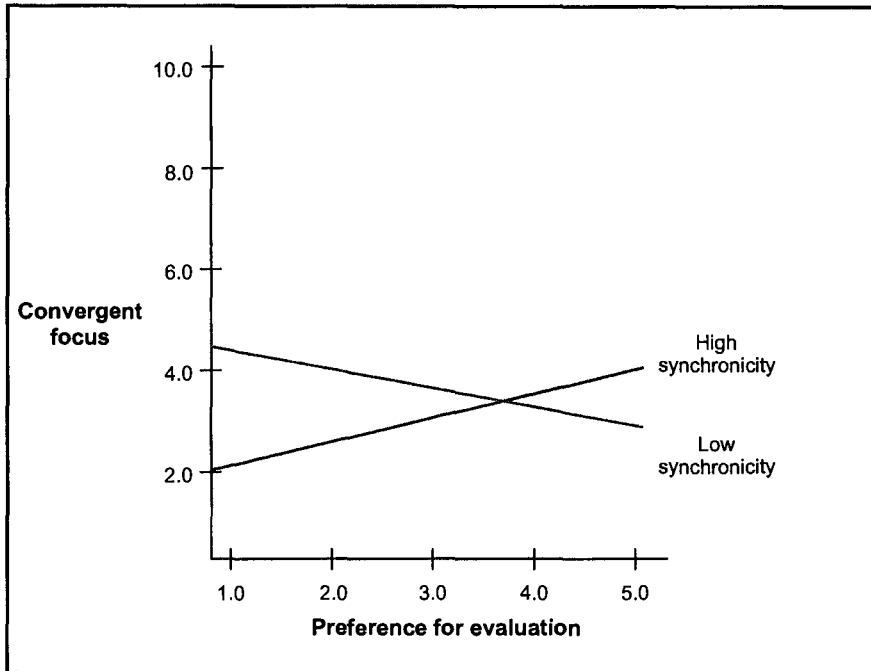
Figure 7.1: Convergent focus by synchronicity-preference for evaluation interaction

H4b states that the effects of synchronicity on divergent focus will increase with increasing explorative cognitive styles and increasing preferences for ideation. The results of an ANCOVA test including synchronicity and covariates are presented in table 7.14 below.

Table 7.14: ANCOVA - effects of synchronicity and covariates on divergent focus

Dependent variable	Source	F-value	p
Divergent focus	Synchronicity	0.96	0.33
	Ideation	0.92	0.34
	Assimilators/explorers	0.01	0.93
	Synchronicity * Ideation	0.05	0.83
	Synchronicity * Assimilators/explorers	2.30	0.13

Table 7.14 above shows that the null hypothesis that there are no differences between groups on divergent focus independent on cognitive style and preference for ideation can not be rejected, thus lending no support for hypothesis H4b.

Moderating effects on the role of parallelism

The first hypothesis regarding the moderating effects on the role of parallelism says that the effects of parallelism on convergent focus will increase with increasing assimilative cognitive styles and increasing preferences for evaluation (H5a). The results of an ANCOVA test are presented in table 7.15 below.

Table 7.15: ANCOVA - effects of parallelism and covariates on convergent focus

Dependent variable	Source	F-value	p
Convergent focus	Parallelism	0.49	0.49
	Evaluation	1.22	0.27
	Assimilators/explorers	0.00	0.97
	Parallelism * Evaluation	1.20	0.28
	Parallelism * Assimilators/explorers	0.42	0.52

Table 7.15 shows that the null hypothesis that there are no differences between groups on convergent focus independent of preference for evaluation and cognitive style can not be

rejected, lending no support for H5a. The table also shows that the introduction of the covariates abates the main effect of parallelism on convergent focus.

H5b proposes that the effects of parallelism on divergent focus will increase with increasing explorative cognitive styles and increasing preferences for ideation. The results of an ANCOVA test including parallelism and covariates are presented in table 7.16 below.

Table 7.16: ANCOVA - effects of parallelism and covariates on divergent focus

Dependent variable	Source	F-value	p
Divergent focus	Parallelism	0.01	0.95
	Ideation	0.85	0.36
	Assimilators/explorers	0.07	0.78
	Parallelism * Ideation	0.58	0.45
	Parallelism * Assimilators/explorers	0.06	0.81

Table 7.16 shows that the null hypotheses that there are no differences between groups on divergent focus independent of preference for ideation and cognitive style can not be rejected, thus lending no support for hypothesis H5b. Further, the main effect of parallelism on divergent focus reported in section 7.6.1 also turns out non-significant when the covariates are included in the model.

Moderating effects on the role of identification

Hypothesis H6a states that the effects of identification on convergent focus will increase with increasing assimilative cognitive styles and increasing preferences for evaluation. The results of an ANCOVA test are presented in table 7.17 below.

Table 7.17: ANCOVA - effects of identification and covariates on convergent focus

Dependent variable	Source	F-value	p
Convergent focus	Identification	0.37	0.55
	Evaluation	3.31	0.07
	Assimilators/explorers	0.59	0.44
	Identification * Evaluation	1.74	0.19
	Identification * Assimilators/explorers	1.85	0.18

Table 7.17 shows that the null hypothesis that there are no differences between groups on convergent focus independent of preference for evaluation and cognitive style can not be rejected, thus no support for H6a can be found.

H6b states that the effects of identification on divergent focus will increase with increasing explorative cognitive styles and increasing preferences for ideation. The results of an ANCOVA test are presented in table 7.18 below.

Table 7.18: ANCOVA - effects of identification and covariates on divergent focus

Dependent variable	Source	F-value	p
Divergent focus	Identification	1.31	0.26
	Ideation	1.16	0.28
	Assimilators/explorers	0.00	1.00
	Identification * Ideation	0.00	0.97
	Identification * Assimilators/explorers	3.00	0.09

Table 7.18 shows that the null hypothesis that there are no differences between groups on divergent focus independent of preference for ideation can not be rejected, which lend no support for H6b(b). However, there is a significant interaction term at the 10 % level between identification and cognitive style. Analyses of simple effects show that the level of divergent focus decreases in situations with high identification for explorers, while the level of

divergent focus is higher in situations with high identification than in situations with low identification for assimilators (figure 7.2). Thus, the positive effects of low identification on divergent focus increases with increasing explorative cognitive styles, indicating a relationship in accordance with hypothesis H6b(a).
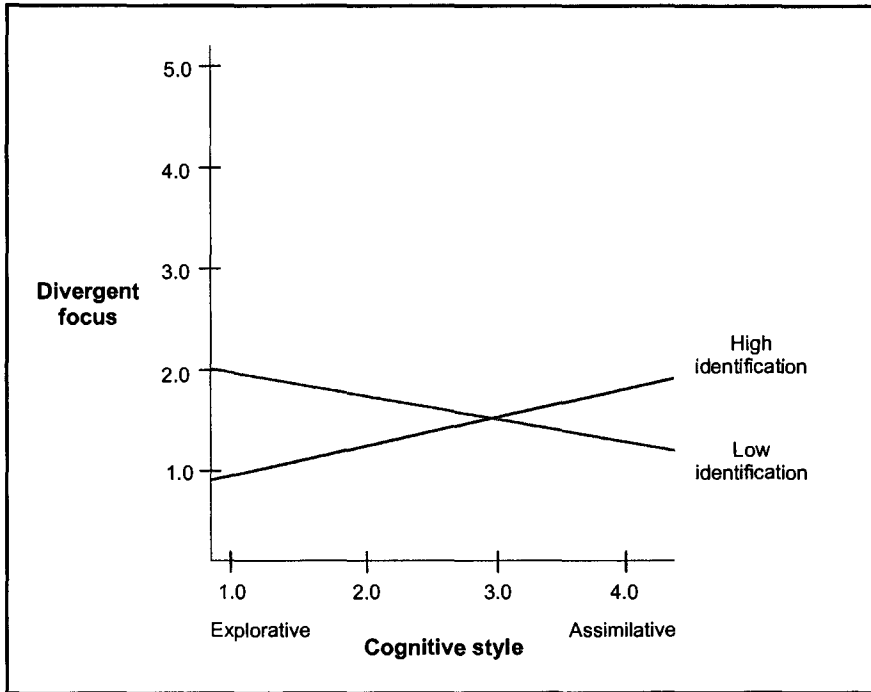
Figure 7.2: Divergent focus by identification-cognitive style interaction

7.8   Summary of results

The analyses of main effects of communication affordances and innovative thinking processes showed no effects of synchronicity and identification, while high parallel interaction seemed to lead to both higher divergent focus and convergent focus. However, the introduction of moderating variables abated the main effects of parallelism. In contrary, the main effect of synchronicity on convergent focus turned out significant when covariates aiming at testing the interaction effects between synchronicity and attitudes toward idea generation and cognitive style were introduced, lending support for hypothesis H1b. The other hypotheses regarding main effects of media affordances on innovative thinking processes (H1a, H2a, H2b, H3a, and

H3b) have to be rejected at this point. Possible explanations of the lack of main effects are discussed in the next chapter.

The tests of interaction effects revealed some interesting relationships. First, a significant interaction effect between synchronicity and preference for evaluation was found, indicating that the effects of low synchronicity of convergent focus increase with decreasing preference for evaluation, which is opposite to the relationship proposed in H4a(b). Second, a significant interaction effect (at the 10 % level) between identification and cognitive style on divergent focus was found. Low identification seems to be accompanied with higher divergent focus as the individuals move toward the explorative end of the cognitive style continuum. This is in accordance with hypothesis H6b(a). The tests of interaction effects thus lend partial support to hypothesis H6b, while hypotheses H4a, H4b, H5a, H5b, and H6a, should be rejected at this point. I will now turn to a discussion of the findings, and elaborate in greater detail on important factors that may explain the results of the experiment.

Part V

- Discussion -

First in this last part of the dissertation (chapter 8), I recapitulate on the objective of the research and the findings from the empirical work. Then I discuss the results of the hypotheses testing. Thereafter, in chapter 9, I point to the most important limitations of the study, and present both theoretical and practical implications that can be drawn. The last chapter is ended with some directions for future research.

8 Discussion

This chapter opens with a summary of the research objective, the theoretical constructs I focused on and investigated in the experiment, and the tests of hypotheses. Thereafter, I discuss the results and offer possible explanations of the findings.

8.1 Summary of findings

In the first part of the dissertation, the research question of whether, and in case how, electronic communication media influence individuals' innovative thinking processes was articulated. Three media affordances important for group interaction were then identified and selected as independent variables, and linguistic (semantic) manifestations of two distinctive thinking processes were used as dependent variables. Six hypotheses regarding the influence of media affordances on innovative thinking were proposed. In addition, I also discussed the role of individuals' cognitive styles and attitudes toward idea generation as moderators of the relationships between affordances and innovative thinking. Six hypotheses regarding the moderating role of these variables were put forth.

In order to test the hypotheses, an experiment that involved group-based problem solving and computer-mediated communication was designed. This was carried out as 12 experimental sessions, where the participants (in the groups) should discuss a problem and come up with suggestions for solutions. The media affordances were manipulated, and the participants' cognitive styles and attitudes toward idea generation were measured. Transcripts of the group discussions were saved and coded based on the degree and frequency of divergent/convergent focus of the various ideas and comments that were put forth (which was used as dependent variables).

The data was analyzed using multivariate analysis of variance and analysis of covariance. The findings of the hypotheses testing are summarized in table 8.1 below. One main effect of communication affordances on innovative thinking was found, and one of the hypotheses regarding the moderating effects of cognitive style was also partially supported.

No.	Independent	Moderators	Dependent	Finding
H1a	Synchronicity (high)	-	Divergent focus	Not supported
H1b	Synchronicity (low)	-	Convergent focus	Supported*
H2a	Parallelism (high)	-	Divergent focus	Not supported
H2b	Parallelism (low)	-	Convergent focus	Not supported
H3a	Identification (low)	-	Divergent focus	Not supported
H3b	Identification (high)	-	Convergent focus	Not supported
H4a	Synchronicity	- Cognitive style (assimilative) - Pref. for evaluation	Convergent focus	Not supported**
H4b	Synchronicity	- Cognitive style (explorative) - Pref. for ideation	Divergent focus	Not supported
H5a	Parallelism	- Cognitive style (assimilative) - Pref. for evaluation	Convergent focus	Not supported
H5b	Parallelism	- Cognitive style (explorative) - Pref. for ideation	Divergent focus	Not supported
H6a	Identification	- Cognitive style (assimilative) - Pref. for evaluation	Convergent focus	Not supported
H6b	identification	- Cognitive style (explorative) - Pref. for ideation	Divergent focus	Partially supported***

* Significant relationship at the 10 % level.
** Significant relationship opposite to the hypothesized direction was found.
*** Significant relationship at the 10 % level.

8.2 Discussion of explanations

There are several possible explanations of the findings of both main effects and interaction effects. In the subsequent sections I discuss possible alternative explanations of the (mainly lack of) main effects and interaction effects respectively.

8.2.1 Main effects

The first possible explanation behind the non-findings is naturally that communication affordances/properties do not have any effects on innovative thinking processes, or that the effects of communication affordances are of secondary importance compared to other situational and individual factors like group history, social bonds between participants, degree of physical proximity (dispersion) between the participants, etc. For example, several group characteristics can affect both processes and outcomes of group-based problem solving, and factors like group size, group proximity, group composition (peers or hierarchical), and group cohesiveness (Nunamaker et al., 1991a) have been shown to have impacts on the way individuals in groups involved with problem solving think and behave. In this study I did not focus on group characteristics, and variables like group composition, proximity, and cohesiveness were tried kept at the same levels for all groups by means of the experimental design (random assignment to treatments).

Effects of synchronicity on convergent focus

Analysis of covariance showed that high synchronous interaction is accompanied by a low convergent focus when preference for evaluation and cognitive style are at their mean levels. The effect is at the 10 % level (p=.06) and should therefore be interpreted with caution. However, without drawing any clear-cut conclusions regarding the impacts of high synchronous interaction on convergent focus, the relationship found in this study indicates that the level of convergent thinking (or at least manifestations of these thinking processes) can be reduced by increasing the level of synchronicity in group interaction. This may have important managerial consequences (which are addresses in the next chapter).

One plausible explanation of this relationship is that individual processes and group processes that are theoretically linked to convergence are reduced when the level of synchronicity in group interaction is high. That is, the abilities for reprocessability and rehearsability of the ideas and comments put forth are reduced when immediate responses are expected and required. Consequently, the amount (both frequency and level) of evaluative contributions is reduced.

The role of group size

When it comes to group size, groups consisting of 3, 4, and 5 participants were used in the experiment. Analysis of variance indicated that groups with 5 participants had a higher convergent focus than groups with 3 and 4 participants (F=9.68, d.f.=2, p<0.00). However, as the problem solving groups with 5 participants all belonged to experimental condition 1 (low synchronous communication), this had to be accounted for. Analysis of covariance with perceived synchronicity as a covariate indicated that group size does not have an effect on neither divergent focus nor convergent focus when the level of synchronicity is controlled for (F=0.99, d.f.=2, p=0.38). Nevertheless, group size may be important. Steiner (1972) argue that an increase in this variable typically "results in accelerating increases in process losses", and further claims that "size will eventually be reached beyond which group productivity will decrease" (p. 95). These process losses are for example information overload, air time fragmentation, attenuation blocking, and concentration blocking. Increases in these variables can result in a group culture with a higher threshold for proposing non-evaluated ideas (i.e. more critical evaluations of the ideas and comments that are put forth), and group size may thus be important for both divergent and convergent focus.

Group size may be a critical variable when considering the effects of specific communication affordances on manifestations of innovative thinking. That is, both synchronicity and parallelism might affect for example air time fragmentation and production blocking; however, it may very well be the case that these process losses are insignificant when group sizes are small, regardless of the level of synchronicity and parallelism. In other words, the importance of these communication affordances for innovative thinking manifestations may come into effect only for groups with a certain number of participants (e.g. groups that have reached the threshold that Steiner (*ibid.*) refers to), thus implying that the effects of synchronicity and parallelism on for example air-time fragmentation and production blocking will only occur when group sizes are larger than in this experiment. The consequences of this will be that the research model has to be modified with group characteristics (e.g. group size) as moderators of the relationships between communication affordances and innovative thinking.

The nature of the task

A second factor that may explain the lack of effects is the nature of the task that the participants were given. As described in section 6.2.1, the participants were asked to discuss the Napster-case[10], and come up with suggestions for products and services that are satisfying for both the professionals (e.g. firms in the industry and musicians) and for the private individuals that share and download music. This kind of task-type is not very representative for the tasks that are most often applied in research on problem solving and creativity/innovation in groups. Usually, the tasks in this research stream are rather artificial (from a managerial or business perspective), and designed in such a way that the scope of the potential artifacts and solutions can be as wide as possible, which allows for highly ideative thinking and behavior. For example, a typical task used in creativity research is the "additional thumbs problem", where the participants are asked to generate ideas and suggestions for products and services based on problems/challenges that would have come into being if all people had an additional thumb on each hand from next year onwards. In contrast to this, I used a more relevant business case, which naturally affects the rules of the game and puts limitations on the number and nature of ideas and suggestions for products and services regarding their appropriateness. In other words, I did not construct a setting that encouraged highly ideative thinking and utterance of ideas, thus the nature of the ideas and comments made in group discussions were not extremely ideative, which again did not elicit opposing (manifestations of) evaluative thinking. Consequently, the scope of the idea production process may have been too small for the communication affordances to have any impacts. The question is then, if the results would have been different if I had used a "typical" creativity task instead of the business relevant task. In such a situation, synchronicity, parallelism, and identification might have significant effects on the innovative thinking processes as the difference between divergence and convergence would have become larger and more distinctive. However, the managerial relevance of any relationships detected would in this case be reduced, and the potential relationships would thus have been interesting mainly on a theoretical point of view.

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[10] Problems and challenges related to private (non-commercial) Internet-based sharing of music files.

Relationships between communication affordances and group processes

A third possible explanation that needs to be considered concerns the relationships between communication affordances and group processes discussed in chapter 4 on the one hand, and the relationships between these processes and (manifestation of) innovative thinking processes on the other hand. In the theoretical parts of the dissertation, it was argued for and assumed that synchronicity, parallelism, and identification had certain effects on the group processes, and by this having impacts on innovative thinking, without actually measuring the group processes. In other words, the explanatory mechanisms underlying the hypotheses were not measured directly, thus the theoretical arguments linking communication properties to group processes may be different than expected. Similarly, the theoretical arguments linking group processes to innovative thinking may also be different than expected. Accordingly, I might have assumed the occurrence of specific group processes in the three experimental conditions, whereas I should have provided measures of the participants' perceptions of the relevant group processes. However, the relationships between communication affordances and group processes assumed in this dissertation are agreed upon and documented by several researchers (e.g. Nunamaker et al., 1991b), thus I do not perceive the underlying assumptions to be controversially and able to explain the lack of support of the hypotheses.

Weak manipulations

Given that the theoretical linking of communication affordances and group processes is coherent, a forth and more likely explanation is that the manipulations were too weak. In other words, it is plausible that more powerful manipulations would have amplified the process gains and process losses, which again might have influenced the thinking processes. For the matter of synchronicity, the time intervals (i.e. the offline periods) may for example not have been long enough in order to decrease the expectations of the participants to give immediate responses. In order to increase the length the offline periods, however, the duration of the whole experiment need to be longer. Such an increase would have lead to a more difficult situation regarding manipulation of affordances. For example, it would have been difficult to control the level of synchronicity, parallelism and identification if the group work had to be spread over several experimental sessions (e.g. over several days). Hence, there are trade-offs that have to be made. This is related to the weaknesses of the experimental design, and will be addressed in the next chapter.

Further, the differences in levels of rehearsability and reprocessability between groups with high and low synchronicity may accordingly have been too small in order to create any significant effects on the dependent variables. There is also a certain extent of uncertainty associated with the manipulation of synchronicity as the participants themselves were managing the time intervals during the experimental session and thus partly in control of the manipulations. For the other two independent variables, the manipulations were effectuated by pre-configuration of specific collaborative tools without requiring the participants themselves to take any actions in order to create differences between groups. However, the problem of weak manipulations still remains. For example, the difference in levels of parallelism between groups may have suffered from the low number of participants in each group, meaning that it may not have been a problem that the collaborative tool available for sharing ideas and comments imposed limitations regarding the effectiveness of communication involving several participants simultaneously. Likewise, the group sizes, and the fact that all group members were located in the same room, may also have been important to identification. That is, these factors may have caused the anonymous groups (conditions 2 and 3) to be only partially anonymous, and consequently, the difference in the levels of identification may have been too small to create any differences in group processes (e.g. free riding, conformance pressure, fear of negative evaluations, etc.). So, even though significant differences in perceptions of communication affordances between the various manipulations were found, the differences might not have been large enough to elicit the expected effects on innovative thinking processes.

8.2.2   Interaction effects

The discussion so far has concerned the main effects of synchronicity, parallelism, and identification on innovative thinking processes. The most plausible explanation of the (mainly) lack of significant main effects is a combination of the nature of the experimental task and weak treatments (including the duration of experimental session). These factors are also valid explanations of the (mainly) lack of findings of interaction effects. However, additional elements must be taken into consideration, and in the following I will first focus on attitudes toward idea generation, then the role of cognitive style as a moderator between communication affordances and innovative thinking processes is discussed.

The role of attitudes toward idea generation

The moderating effects of preference for evaluation on the impacts of synchronicity on convergent focus were argued for in chapter 5. It was hypothesized that low synchronous interaction would positively influence convergent focus (H1b), and further, that the effects of (low) synchronicity on convergent focus would increase with increasing assimilative cognitive styles and increasing preferences for evaluation (H4a). The analyses revealed that increasing preferences for evaluation combined with low synchronous interaction lead to a decrease in convergent focus, which is contrary to the expected impacts of this attitude in interaction with low synchronicity. The opposite relationship was found for high synchronous interaction. In this condition, an increase in preferences for evaluation leads to an increase in convergent focus. Explanations for this finding may be found when analyzing the relationship between synchronicity and group processes, and the perception of these processes with reference to the participants' preferences for evaluation. In other words, (the value/level of) this particular attitude may have lead to (or impacted on) the interpretation and valuation of the group processes in the first instance, and then elicited behavior that correspond to the perceptions in the second instance.

In previous sections, it was argued that the degree of synchronicity is of particular importance in view of the opportunities for rehearsal and reprocessability of the contributions it establishes. Further, it was also claimed that these opportunities (and processes) are more valued by individuals with high evaluative preferences. The results showed that participants with low preferences for evaluation have a low divergent focus in high synchronous interaction. This is natural as the communication environment supports group processes that correspond to behavior that are in accordance with low evaluative attitudes. Here, the expectations of rapid (reciprocal) feedback, which impact on the degree of rehearsability and reprocessability carried out by the participants, fit well with non-evaluative preferences. As the participants' preferences for evaluation increases, however, so do the level of convergent focus. This indicates that the effects of group processes effectuated by the high synchronicity of interaction on convergent thinking, is overruled by the individuals preferences for evaluation as these increase. It may also be the case that situations with high synchronicity, where the ideas and comments can be put forth immediately without critical examination,

elicit antagonistic convergent behavior for individuals with high preferences for evaluation. We also see that the difference in convergent focus between groups with low versus high synchronicity is greater for individuals with low preferences for evaluation than for individuals with high preferences for evaluation. The regression lines depicted in figure 7.1 indicate that the role of individuals' preferences for evaluation regarding convergent focus is more influential in high synchronous interaction than in low synchronous interaction. Individuals that are inclined to low evaluative thinking and behavior in general, may be more affected by the specific group processes that accompany high versus low synchronous communication environments.

In sum, for highly evaluative individuals, the degree of synchronicity plays a minor role for convergent focus. For individuals that score low on preference for evaluation, however, the degree of synchronicity seems to represent a factor that may influence the level of convergent focus in group discussions.

The role of cognitive style

In the theoretical sections of the dissertation, expected moderating effects of cognitive style on the role of identification on divergent focus were argued for. It was hypothesized that low identification would positively influence divergent focus (H3a), and that these effects would increase with increasing explorative cognitive styles and increasing preferences for ideation (H6b). The results of the hypotheses testing showed that the level of divergent focus decreases with increasing explorative cognitive styles in situations with high identification, and contrary, that divergent focus increases as the levels of explorative cognitive styles increase in situations with low identification. It must be noted that this interaction effect is at the 10 % level, and should therefore be interpreted as an indication rather than a confirmation of a relationship between the variables.

The positive effects of low identification on divergent focus for explorers are in accordance with the hypothesized relationship between these variables. Causes underlying this relationship can probably be attributed to both communication process factors and individual factors. More specifically, when analyzing the nature of the highly anonymous communication environment on the one hand, and the qualities of highly explorative cognitive

styles of the participants on the other hand, we find that both elements support/enhance ideative thinking and behavior. Group processes caused by a low degree of identification when proposing ideas and comments, like low evaluation apprehension, low fear of receiving negative and hostile comments, low conformity pressure, etc., increase the likelihood of achieving a high divergent focus in group interaction. These processes, again, are more appreciated by explorers as they prefer to investigate novel solutions in problem solving. One important factor for successful divergent (or ideative) behavior is that ideas should be articulated as they appear without making any reflections regarding their appropriateness or usefulness, and by this evaluate the ideas based on some presuppositions. Both theoreticians and practicians within the field of creativity stress the importance of eluding the appliance of evaluative frameworks when doing ideative thinking and behavior as innovative ideas often do not fit in with already established ways of perceiving the relevant issues (i.e. the problem that is to be solved). In other words, innovation and creativity are undisciplined, contrarian, and iconoclastic, and are encouraged by confusion and contradiction (Negroponte, 2003). This may explain the positive effects of low identification and explorative cognitive styles on divergent focus in group interaction.

The opposite relationship is found in situations with high identification. Here, the level of divergent focus is reduced as the level of explorative cognitive styles increases. This can be explained by examining the relationship between the group processes associated with highly identified communication and the nature of the cognitive styles, as done above. In this situation, we find that the communication environment do not eliminate/reduce the before mentioned group processes that fit well with explorative cognitive styles. Therefore, in environments with high identification, the social factors may affect explorers to a larger extent than assimilators as the social processes/factors discourage activities that participants with explorative cognitive styles prefer to undertake in problem solving situations.

Further, when analyzing the combinatory effects of strategy preferences in problem solving and group processes, a factor that may be able to explain why low degree of identification positively influences a divergent focus for explorers, but has the opposite effect for assimilators, concerns the possibilities and constraints that the participants perceive in situations with high versus low identification. In the former situation, the participants' preferences may be (socially) restricted, meaning that explorers are only comfortable

performing truly ideative behavior in situations with low identification. And conversely, assimilators may also experience social pressure to act supportive to ideas and comments that are put forth when the other group members know their identities. Hence, the absence of social factors like evaluation apprehension that positively influence ideative thinking and behavior for explorers, may contribute in the opposite way for assimilators. As the "assimilative participants" in anonymous interaction are not concerned with how other group members perceive their behavior, the social pressure to act supportive to unorthodox ideas that are put forth decreases. In this way, high identification may increase the ideative focus of assimilators through group process factors.

Taking these explanations a step further, it can be argued that a two-step approach is needed in order for the communication affordances to impact on innovative thinking processes. First, there must be a predisposition to act in certain ways, then environmental factors (i.e. degree of identification in interaction) may influence the effectuation of specific actions given that the predispositions/preferences for the behavior are in place. Hence, when it comes to the degree of divergent focus in group based problem solving, low identification of contributions may create an atmosphere where thinking and behavior that correspond to the participants' strategy preferences are strengthened.

The other hypotheses concerning the moderating role of cognitive style on the relationships between communication affordances and innovative thinking processes were not supported, and I perceive the factors that were addressed when discussing the lack of main findings to be valid explanations for the lack of interaction effects as well. However, as the participants' cognitive styles were measured prior to the problem solving task, the manipulations and nature of the task as discussed in section 8.2.1 can not have resulted in a narrow appraisal of the participants cognitive styles (i.e. low dispersion on the A/E-continuum), as may be the case for (the manifestations of) the innovative thinking processes. I should also notice that there were no correlations between cognitive style, attitudes toward idea generation, and the dependent variables, which I find rather strange. I would expect that, on a general basis, explorers were more ideative than assimilators, and the other way around. One factor that may account for this lack of correlations between the moderating variables concerns the relationship between cognitive style and attitudes in general discussed in the theoretical part of the dissertation. It was argued that cognitive style is different from attitudes as it refers to

more profound traits of people, while attitudes are more alterable and dependent on the situation. Further, in this experiment, I might have created a situation where there was little room for extreme ideative and evaluative thinking and behavior (because of the nature of the task discussed in the previous section), which again lead to a decrease in the correspondence between the participants' general strategy preferences for problem solving (their cognitive style), their perceptions of ideative and evaluative behavior in general (their attitudes), and their behavior in this specific situation (manifestations of innovative thinking processes).

Finally, in addition to measures of independent variables, moderating variables, and dependent variables, several control variables (sex, group size, and PC- and CMC literacy) were included in the study (effects of group size are discussed in section 8.2.1). As expected, neither significant main effects of sex and PC-and CMC literacy, nor significant interaction effects between the experimental treatments and these control variables, were found.

8.3   Conclusion

It is not an easy task to draw any clear-cut conclusions when explaining the findings of the study. There are probably no simple/single factors that lead to the results, but some are more influential than others. I probably have to draw on both the experimental setting, including the nature of the task, the manipulations, and the limited amount of time the participants were given to discuss the problem. These factors may be able to explain the mainly lack of support for the expected relationships between independent, dependent, and moderating variables. However, the results also show that group processes provoked by communication affordances (i.e. synchronicity and identification) should be given attention when explaining individuals' innovative thinking processes in electronically mediated group-based problem solving. It can also be inferred that cognitive style and attitudes toward idea generation are factors that have to be taken into consideration when the effects of communication affordances on innovative thinking processes are focused. These latter topics are also addressed in the next chapter.

9 Implications and concluding remarks

This chapter is organized as follows: First, I present theoretical, methodological, and managerial contributions of the study. Second, limitations associated with the experimental design and hypotheses testing are focused. The chapter is ended with some suggestions for future research.

9.1 Contributions to research

In this section I address the theoretical and methodological contributions of the present research. I first turn to the innovative thinking variables, then the focus is directed at cognitive style and attitudes toward idea generation. Finally, the contributions related to communication media capabilities are addressed.

9.1.1 Innovative thinking processes

Manifestations of divergent and convergent thinking processes were used as dependent variables in this study. Divergence and convergence are important processes involved in problem solving, and measures of manifestations of divergent and convergent thinking processes in computer-mediated group communication were developed. These variables, named "divergent focus" and "convergent focus", were calculated based on a combination of the strength of the divergent/convergent utterances as assessed by expert coders on the one hand, and the frequency of these utterances relative to the total number of contributions made by the unit of analysis (individual/group) on the other hand.

Development of these measures provides a contribution to the research field focusing on processes involved in creativity and innovation in groups. Dependent variables in this research stream are often outcome measures like number and/or quality of new ideas presented by the unit of analysis (individuals/groups). However, given that the processes of divergence and convergence are important in order to get high scores on these performance/outcome variables, it is crucial from both theoretical and practical points of view to be able to measure divergent and convergent thinking processes. As individual performance depends on cognitive, attitudinal and social factors (Fishbein & Ajzen, 1975; Kraut, 1976;

Basadur & Finkbeiner, 1985; Nagasundaram & Dennis, 1993; Dennis et al., 1999), measures of attitudes toward divergence and convergence as developed by Basadur et al. (1982) and Basadur and Finkbeiner (1985), are important and necessary in this respect, but not sufficient in order to understand the ideative and evaluative performance of individuals involved in group-based problem solving. More specifically, being able to measure manifestations of innovative thinking processes is important as there may be discrepancies between attitudes toward idea generation and actual behavior in a given situation. These inconsistencies may be attributed to social processes involved in group interaction, and this dissertation provides a thorough discussion of how communication affordances may influence social processes, which again may influence the decisions of the participants regarding the number and nature of the contributions they provide to the group work.

9.1.2   Attitudes toward idea generation

Preference for ideation and preference for evaluation, which are two attitudinal constructs related to idea generation, were included as moderators in this study. Basadur et al. (1982; Basadur & Finkbeiner, 1985) developed a 14-item measurement scale, where 8 items reflect openness to divergence attitudes and 6 items reflect tendency to convergence attitudes. These researchers use the ideation-evaluation (IE) framework when assessing the effects of ideative training. This research applies the IE-framework in relation to manifestations of divergent and convergent thinking processes in electronically mediated group problem solving, and shows that individuals' attitudes toward idea generation are relevant factors when studying the impacts of exogenous (environmental) variables on innovative thinking processes.

A business relevant task was applied in the experiment, and the attitudes were measured with reference to this specific situation. The IE-measures were on the whole in accordance with the results obtained by Basadur and Finkbeiner (1985) in their validation of the scale. The factor loadings they report correspond to the findings in this study, with some minor exceptions. That is, the items that were excluded when constructing the aggregate measures (the dependent variables) had lower factor loadings than in the study by Basadur and Finkbeiner (*ibid.*). Research that has applied the IE-scale has mainly focused on training in ideative thinking to solve organizational problems, and has also mainly involved managers. Both development and appliance of the framework have therefore to a large extent occurred in the

same setting and used the same type of subjects (though managers in different cultures have been involved in field experiments testing the IE-framework). This research thus extends the environment and the setting in which the IE-framework has usually been applied in.

There are some issues that have to be noticed when investigating the nature of the items that constitute the scale, however. That is, there may be factors exogenous to the individual that are influential for the assessment of the items that constitute the constructs. In this respect, I noticed that the scale consists of items with different points of reference regarding the focus that the participants have to adopt. First, the scale consists of items concerning "behavioral issues" (e.g. "I prefer that we cut of ideas when they get to ridiculous and get on with it") on the one hand, and items which are more general and not explicitly tied to an activity (e.g. "one new idea is worth ten old ones") on the other hand. Second, within the former category, there are items where the subject is asked to appraise his/her own situation (an example of this would be the item "I prefer to do some prejudgment of my ideas before I tell them to others"), and items that refer to the subjects' perceptions of how they prefer their counterparts to act (for example "I whish people would think about whether or not an idea is practical before they tell it to others"). There are also some items that have the problem solving group as reference point, for example "I think everyone should say whatever pops into their head whenever possible". Even though it can be argued that items that focus on all of these aspects have to be included in the scale as it makes it possible to embrace wider parts of the concepts (preference for ideation and preference for evaluation), the distinctions can be important as the appreciation of ideative and evaluative thinking and behavior in group-based problem solving may vary with changing points of references. This point may be important as we may have situations where participants do not appreciate ideative thinking and behavior themselves, while they hold the opposite opinion when they are to consider the optimal behavior of other group members, or vice versa. In this case, items pertaining to the same construct would be assessed different. Analyzing the role of situational factors on the convergent and discriminant validity of the scale (i.e. testing the measures in different settings) is a subject for future research.

9.1.3 Strategy preferences in problem solving

When it comes to the second moderating variable (cognitive style) in the study, there are two points that should be mentioned. First, the factor structure revealed when testing the cognitive style of the participants in the experiment fit by and large with previously obtained results. Hence, the findings support the validity of the AE-framework. However, contrary to the measurement of attitudes toward idea generation, the participants' cognitive styles were measured prior to the problem solving session and thus on a general basis. I have therefore not tested the AE-framework in a particular setting (group-based problem solving by use of CMC), and with reference to a particular problem, thus the study does not provide equally strong support regarding validity for the AE-framework as for the IE-framework. Second, and most importantly, I have demonstrated the usefulness of including group members' cognitive style when assessing the effects of exogenous/situational variables (i.e. communication affordances) on innovative thinking processes.

9.1.4 Communication media: Capabilities

The independent variables in the study were communication affordances/properties rendered possible by capabilities/qualities of the communication media used for interaction. I focused on synchronicity, parallelism, and identification, as these affordances were perceived as especially important for group-based problem solving involving CMC. The reasons for selecting synchronicity, parallelism and identification were moreover theoretically substantiated as I addressed the importance of the relationships between these communication affordances and process losses that may occur in group-based problem solving. I further provided conceptual and operational definitions of the concepts, and also developed a measurement instrument with high discriminant and convergent validity. Furthermore, all communication affordances were successfully manipulated in this study, and by means of experimental examination, expectations about the effects of synchronicity on convergent focus were supported. Interaction effects between synchronicity and attitudes toward idea generation on convergent focus, and identification and cognitive style on divergent focus, were also found. All in all the study provides a theoretical foundation of the relationships between communication affordances and personal factors when focusing on innovative thinking processes in CMC-based problem solving in groups.

9.2 Managerial implications

This research may prove useful in helping organizations and individuals better understand the influence of situational and individual factors on creative behavior through different thinking processes in group-based problem solving. The overall practical implication is that leaders and group facilitators responsible for "virtual" problem solving teams must consider how the software they use in general, and the specific configurations in special, might influence the results of the problem solving activities. That is, the technology has to be adapted to the objectives of the group work. As both divergent and convergent thinking processes are important in different phases of the problem solving process, the technology used for group interaction has to be tailored to the phase or stage in which the group currently works. The same technological configurations should not be used in phases that require divergent versus convergent thinking processes.

Virtual teams using a combination of telecommunications and information technologies to accomplish an organizational task are perceived as a means of firms to realize the competitive advantage that teamwork may represent and exploit the revolution in telecommunications and information technology (Townsend et al., 2000). In such teams, the notion of "always online" is often descriptive for the interaction environment they work in, and indicates that coworkers can communicate with each other in "real time" at a continuous basis. High synchronous interaction is thus becoming popular in business life. However, the empirical results from this research indicate that this may not be optimal for group work in all phases of the problem solving process. It was observed that high synchronous communication environments seemed to result in a decrease in convergent focus, and that individuals' attitudes toward idea generation are important in this respect. Consequently, in situations where evaluative behavior is preferable, managers should consider using collaborative tools where the interaction does not occur online. A certain time lag between the writing (sender) and reading (receiver) of contributions will increase the convergent focus.

The differences in effects across measures of attitudes toward idea generation and the participants' cognitive styles also have implications for managers. The findings indicate that the effects of synchronicity and identification on innovation processes through manifestations of divergent and convergent thinking are contingent on these variables. As the effects of

synchronicity on convergent focus depend on the participants' levels of preference for evaluation, and that the effects of identification on divergent focus differ for explorers and assimilators, both attitudes toward idea generation and the participants' cognitive styles have to be taken into consideration when determining what kind of technology to use for group work.

More specifically, managers should facilitate communication environments that allow for reprocessability and rehearsal of ideas (low synchronous interaction) when the participants have low preferences for evaluation and when the objective of the work is of evaluative character (i.e. in convergent phases of the problem solving process). This positive effect of low synchronous interaction on convergent focus is not found for individuals with high preferences for evaluation, however, which is also important for managers to notice. Further, when divergent processes are to be accomplished, facilitators should configure communication environments with low degrees of identification for group members with explorative cognitive styles. And contrary, communication environments that provide for high identification of contributors should be configured for participants with assimilative cognitive styles, as this seems to enhance their ideative behavior (divergent focus).

Hence, the study highlights the importance of considering individuals' cognitive styles and attitudes toward idea generation when composing groups for problem solving in organizations. It all depends on the objectives of the group work, and whether the group should endorse divergent or convergent thinking.

9.3 Limitations and suggestions for future research

Several limitations of the research should be mentioned. First, the degree to which the findings can be regarded as valid for other people and in other settings (i.e. external validity) must always be given special attention when applying an experimental design. In this case, I had to control the use of collaborative tools the participants used to discuss the problem, and by this I restrained the participants' abilities to communicate. Consequently, the communication may have felt unnatural for some. However, this was necessary in order to manipulate the communication affordances in the desired way, and thus also necessary in

order to ensure internal validity. Also, by using a business relevant problem the external validity was increased to some extent.

Another important limitation of the study was the length of the experiment. In order to ensure that the nature of the communication (i.e. level of communication properties) fit in with the levels required for testing the hypotheses (in accordance with the experimental design illustrated in figure 6.2), I had to use only one problem solving session without any breaks assuring that the participants did not meet and discuss the problem outside the computer lab. This would have changed the composition and levels of communication affordances, and thus severely threatened the internal validity of the research. However, given the relatively high complexity of the task, a longer time frame would have been desired. Future research should therefore apply a more longitudinal design and at the same time control the communication means during the whole experimental period. This can for example be solved by using groups with dispersed participants. Further, use of dispersed group members would also eliminated a threat to internal validity represented by the potential relationship between synchronicity and (process) anonymity occurring when the participants are located in the same room. That is, systems that enable group members to share information at the same time contributions are made (i.e. high synchronous interaction where the messages are composed online - as for the technological facilities used by experimental group 2) may be less anonymous than systems where the participants themselves decide when to post the messages (i.e. the technological facilities used by experimental group number 3). In the former situation the participants may be able to detect contributors by seeing who is typing and who is not, while this is not the case for groups using the latter type of technological facilities. This issue is non-existing in dispersed groups. Also, the results obtained by using a research design where the participants are not located in the same room would probably be of more practical importance as most problem solving groups that communicate by use of ICT are dispersed.

The measures of divergent focus and convergent focus for individuals belonging to groups in experimental condition 2 also represent a limitation of the study. As the transcripts of the group interactions in these groups did not render possible identification of individual contributions, divergent focus and convergent focus could only be calculated on group levels. Group measures were therefore used as proxies for individual performance, and the variances in the dependent variables were thus reduced for participants in this experimental condition.

Naturally, this represents a source of error as individual scores on the dependent variables for approximately 1/3 of the participants in the experiment to some extent are results of the performance of the other members of the same group.

The group sizes applied in the experiment may also have constituted a limitation. I used group sizes of 3, 4, and 5, which are common in many CMC-based problem solving experiments. However, larger group sizes may be necessary to more accurately measure the effects of communication affordances in general and anonymity in particular. That is, in smaller groups it may still be possible for the participants to identify the contributors even if the identity is not linked to the contribution. Larger groups would thus maybe enhance the benefits and drawbacks (process gains and process losses) of anonymous problem solving groups. This is also the case if the participants were dispersed, and not located in the same room. Also the likelihood of detecting effects of parallelism (if there are any) would probably be enhanced if group sizes were larger. Analyzing the effects of communication affordances in different sized groups is therefore a direction future research could take.

A comment should also be made regarding the manipulation of anonymity, as the majority of the participants knew each other before the experiments may represent a limitation. This limitation becomes even more evident as the participants were located in the same room. Although the participants did not chose their problem solving groups themselves, the level of familiarity may have affected the process losses (e.g. social pressure and evaluation apprehension).

A remark should also be made concerning the partly lack of control over the manipulation of synchronicity. As the participants in experimental group number one were asked to work offline and log on the shared workspace every three minutes, assuring the desired level of synchronicity for these problem solving groups was left to the participants. In problem solving groups with high synchronicity (experimental groups 2 and 3) in contrast, the participants were always working online and not given any instructions. The potential problem associated with the low synchronicity groups can be eliminated by use software which allows for a manager to control the duration of the shared online periods. A second solution to the problem can be to use a longitudinal research design with dispersed groups, and where the participants themselves can decide when to work on the problem. This would

probably have represented a situation with a relatively low degree of synchronicity (or at least assured for a variation in the degree of synchronicity), but the drawbacks would maybe overshadow the advantages as it would have resulted in problems controlling the levels of other communication affordances (e.g. parallelism). Also, increasing the length of the offline periods would have represented a stronger manipulation of synchronicity. This would have been problematic in this experiment as the problem solving session only lasted for 30 minutes. However, as the findings indicate that synchronicity may be important to innovative thinking processes, future research with more longitudinal designs should consider increasing the time lags between online periods in order to gain more knowledge regarding the effects of this communication property.

An important comment has to be made concerning the lack of measurement of the group processes that were assumed to be affected by communication affordances, as discussed in the theoretical parts of the dissertation. By providing a measure of the process losses, it would be possible to explain more evidently the linkage between communication affordances and innovative thinking processes, thus increasing the internal validity of the research.

Finally, by seeing the research in a wider perspective, an interesting and important issue for future research is how the findings correspond to performance measures (i.e. the quality and success of products and services that are developed). Further, as complete models of problem solving activities involve ideative and evaluative thinking and behavior in several phases of the total problem solving process, it is important to investigate the effects of communication affordances within each phase of the process. Basadur (1995b) found that the degree to which a person might accept and practice ideation and evaluation depends on whether the person is in the problem finding phase (stage I), the problem solution phase (stage II), or the solution implementation phase (stage III). So, the question is then if (an in case how) synchronicity, parallelism, and identification (and other communication affordances) influence divergent and convergent thinking processes in these stages.

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- Appendices -

A   Process gains and process losses in group work

Process gains	
More information	A group as a whole has more information than any one member
Synergy	A member uses information in a way that the original holder did not, because that member has different information or skills
More objective evaluation	Groups are better at catching errors than are the individuals who proposed ideas
Stimulation	Working as part of a group may stimulate and encourage individuals to perform better
Learning	Members may learn from and imitate more skilled members to improve performance
Process losses	
Air time fragmentation	The group must partition available speaking time among members
Attenuation blocking	Attenuation blocking occurs when member who are prevented from contributing comments as they occur, forget or suppress them later in the meeting, because they seem less original, relevant or important.
Concentration blocking	Fewer comments are made because members concentrate on remembering comments (rather than thinking on new ones) until they can contribute them.
Attention blocking	New comments are not generated because members must constantly listen to others speak and cannot pause to think.
Failure to remember	Members lack focus on communication, missing or forgetting the contributions of others.
Conformance pressure	Members are reluctant to criticize the comments of others due to politeness or fear of reprisals.
Evaluation apprehension	Fear of negative evaluation causes members to withhold ideas and comments.
Free riding	Members rely on others to accomplish goals, due to cognitive loafing, the need to compete for air time, or because they perceive their input to be unneeded.
Cognitive inertia	Discussion moves along one train of thought without deviating, because group members refrain from contributing comments that are not directly related to the current discussion.
Socializing	Non-task discussion reduces task performance, although some socializing is usually necessary for effective functioning.
Domination	Some group member(s) exercise undue influence or monopolize the group's time in an unproductive manner.
Information overload	Information is presented faster than it can be processed.
Coordination problems	Difficulty integrating members' contributions because the group does not have an appropriate strategy, which can lead to dysfunctional cycling or incomplete discussions resulting in premature decisions.
Incomplete use of information	Incomplete access to and use of information necessary for successful task completion.
Incomplete task analysis	Incomplete analysis and understanding of task resulting in superficial discussion.

B Problem solving task

(Translated from Norwegian)

The Napster-case: How can it be solved?

Background

Napster is a protocol for Internet-based sharing of music files (Mp3) between private individuals. Mp3 is the name of a decompressing technique that is used for transferring (rip) music files from their ordinary format. By use of this technique, the amount of data is reduced to app. 1/12 of the originally amount, and it will therefore be a lot quicker to download an Mp3-file than if the music should be downloaded in its original format.

The website Napster.com allowed their users to spread Mp3-files among their selves without the files being copied to Napster's server (all files were located at the users' computers), and without charging anything for the service. It was in other words private individuals that were copying the files, and the existing copyright was thus avoided. In their "days of glory", Napster had over 80 million users, but the (free) service has been offline since July 2001. The major record companies joined forces and went to court based on inventors' copyrights, and enforced Napster to pull out the plug. Now Napster has resumed the activities as a (corporate controlled) payment service. The CD-software producer Roxio, who took over the legal rights to use the Napster-brand in November 2002, has re-launched Napster as a payment service.

Problem: The stance of the parts and future challenges

The record business: The problem that the record business is facing is that this type of file sharing may lead to a reduction in record sales. According to the business, it is likely that thousands have downloaded music from Napster instead of buying the records in the store. However, in a lawsuit between the record business and the originator of Napster.no, the law found it less likely that all individuals that downloaded music from Napster.no would have obtained the music legally if the download site did not exist, as the record business claimed.

The users: Private copying of music has existed ever since the audiocassette was introduced to the market. The record companies have, until now, not found this especially problematic, but because of Internet and technological innovations, the extent will now increase considerably. In the lawsuit mentioned above, it was asserted that because of the Internet, the extent of this copying will be much more substantial than private copying in individuals' homes. However, the downloading that individuals do, have no other consequences for the copyright holders than if it a physical record was copied in a private home.

What happens? When Napster now has changed its business model, installed filter, and started charging for their services, many people expect that most individuals will look for other ways of getting free music. Napster was the first file-sharing network of significance, but there are lots of other file-sharing services on the Internet today (i.e. Kazaa and Gnutella). Some of these services

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are built on the same technological principles as Napster, but there are also others that use completely different techniques. So, apparently this seems like an insurmountable problem for the record business.

Group task: You are employees in the R&D department of a record company, and your task is to come up with ideas for products and/or services that solve this problem in a way that is satisfying for both (or all) parties.

C   Questionnaires

C.1   Original measurement scale - affordances

1)   The interaction with the other group members occurred in "real time".

2)   All participants in the group could present/frame their contributions simultaneously.

3)   The other participants in the group knew which contributions that were mine.

4)   I could provide immediate feedback on other group-members' contributions.

5)   I had to delay framing my contributions until the other group participants had framed their contributions.

6)   I could get immediate feedback on my contributions.

7)   Thoughts and ideas that popped up could be proposed immediately without interrupting other group participants.

8)   It was easy to know who presented an idea/comment.

9)   It was plenty of time to reflect on and formulate my contributions before I presented them to the other group participants.

10)   I often perceived that we spoke all at once.

11)   I had plenty of time for evaluation of other group participants' contributions before I had to provide feedback.

12)   It was easy to relate a specific contribution to the person that proposed it.

13)   I was often interrupted when I presented my contributions.

14)   My response time on contributions from other group participants could be very low.

15)   It often occurred that I didn't propose thought and ideas that popped up because I didn't wanted to interrupt other group participants.

16)   The response time of the other group participants on my contributions could be very low.

17)   The contributors were generally unknown.

18)   The collaborative tool made it possible for me to present my contributions without the other participants knowing that it was my contributions.

C.2 Attitudes toward idea generation

Nedenfor er det listet opp 14 utsagn. Kryss av for det svaralternativet (for hvert utsagn) som best beskriver din oppfatning/holdning <u>under</u> selve problemløsningsprosessen.

	Svært uenig				Svært enig
1) Jeg foretrekker å evaluere mine ideer før jeg legger dem frem for de andre i gruppen.	1	2	3	4	5
2) Jeg foretrekker at vi dropper ideer når de blir for tåpelige og fortsetter med problemløsningsprosessen.	1	2	3	4	5
3) Jeg mener at folk bør presentere samtlige ideer som de har fordi en aldri vet om en tilsynelatende vill idé viser seg å være den beste.	1	2	3	4	5
4) Én ny idé er like mye verdt som ti gamle ideer.	1	2	3	4	5
5) Kvalitet er mye mer viktig enn kvantitet for utvikling av ideer.	1	2	3	4	5
6) En gruppe må være fokusert og på rett spor for å utvikle ideer som det er verdt å arbeide videre med.	1	2	3	4	5
7) Mye tid kan kastes bort på ville ideer.	1	2	3	4	5
8) Jeg mener at alle bør si det som faller dem inn til enhver tid.	1	2	3	4	5
9) Jeg liker å høre på andres ville ideer ettersom den sprøeste ideen ofte leder frem til den beste løsningen.	1	2	3	4	5
10) Vurdering og bedømmelse er nødvendig i idegenereringsprosessen for å forsikre seg om at bare ideer av høy kvalitet utvikles.	1	2	3	4	5
11) En må være i stand til å oppdage og eliminere ville ideer under idegenereringsprosessen.	1	2	3	4	5
12) Jeg mener at alle ideer skal bli gitt like mye tid og evalueres med et åpent sinn uansett hvor tåpelige de ser ut til å være.	1	2	3	4	5
13) Den beste måten å generere nye ideer på er å høre på andre og henge seg på/bygge videre på ideene som legges frem.	1	2	3	4	5

14) Jeg skulle ønske at folk kunne vurdere hvorvidt en ide var "liv laga"
før de presenterte den for andre folk.   1   2   3   4   5

C.3 Cognitive style

i større grad ulike måter å gå frem på. I tillegg foretrekker folk ofte ulike typer arbeid, oppgaver eller situasjoner. Når du nå skal svare på spørsmålene under, prøv å tenke deg hvordan du pleier å gå frem når du løser problemer, enten det er i forbindelse med skole, arbeid eller annet. Vurdér også hvilke typer situasjoner du liker best. Du skal altså vurdere om hver av setningene nedenfor

INSTRUKSJON

Når vi arbeider med å løse problemer, enten det er i arbeid, utdanning eller i fritiden, har vi alle ulike måter å gå frem på. Noen har en tendens til å holde seg til en bestemt måte, andre holder seg mest til en annen måte, og noen kombinerer eller varierer

MEST TYPISK eller TIL VANLIG beskriver den måte du går frem på i problemløsning, eller hvilke typer situasjoner du vanligvis liker best. Sett et kryss på prikken som står i den kolonnen som passer best for deg, men sett kryss i kolonnen under "Nøytral" bare hvis du føler du må. Du skal sette ett kryss for hvert utsagn, og besvare alle spørsmålene. Det finnes ingen "gode" eller "dårlige" svar. Dette har ingenting med intelligens eller evner å gjøre.

Navn _____

Alder _____

Kjønn _____

Yrke _____

Utdanning _____

_____

	Stemmer Svært Dårlig	Stemmer Dårlig	Nøytral	Stemmer Godt	Stemmer Svært Godt
1. Jeg blir aldri sint når jeg står fast	•	•	•	•	•
2. Jeg foretrekker detaljearbeide som krever god orden	•	•	•	•	•
3. Jeg foretrekker situasjoner hvor en må holde seg til det som gjelder og går	•	•	•	•	•
4. Jeg liker best å arbeide uten å ha en på forhånd fastsatt plan	•	•	•	•	•
5. Jeg prøver meg ofte frem uten å planlegge systematisk	•	•	•	•	•
6. Jeg er alltid ærlig når jeg skal avgi et svar	•	•	•	•	•
7. Jeg foretrekker å holde meg til det jeg kan godt	•	•	•	•	•
8. Jeg prøver oftest å finne nye løsningsmetoder når jeg løser problemer	•	•	•	•	•
9. Jeg foretrekker å arbeide uten å ha klare retningslinjer å holde meg til	•	•	•	•	•
10. Jeg liker godt situasjoner hvor det er nødvendig å bryte med aksepterte oppfatninger	•	•	•	•	•
11. Jeg foretrekker å unngå større forandringer	•	•	•	•	•
12. Jeg kommer best til min rett i situasjoner som er ordnede og oversiktlige	•	•	•	•	•
13. Jeg foretrekker situasjoner hvor en må arbeide etter bestemte regler	•	•	•	•	•
14. Jeg vil helst finne ut av ting på egen hånd når jeg skal lære noe nytt	•	•	•	•	•
15. Det har aldri hendt at jeg har gjort større tabber når jeg løser problemer	•	•	•	•	•
16. Jeg foretrekker å planlegge og strukturere det jeg skal gjøre	•	•	•	•	•
17. Jeg egner meg best til arbeid som krever systematikk og nøyaktighet	•	•	•	•	•
18. Jeg har oftest en lekende og nysgjerrig innstilling i arbeidet	•	•	•	•	•
19. Jeg foretrekker å improvisere i forhold til mine gjøremål	•	•	•	•	•
20. Jeg foretrekker arbeid med faste rutiner	•	•	•	•	•
21. Jeg sprudler av ideer når jeg løser problemer	•	•	•	•	•
22. Jeg liker best situasjoner hvor en må gå på tvers av etablerte normer	•	•	•	•	•
23. Jeg liker best å arbeide med ting jeg ikke kjenner så godt fra før	•	•	•	•	•
24. Jeg foretrekker å ha klare retningslinjer å holde meg til i arbeidet	•	•	•	•	•
25. Jeg vil helst ha systematisk veiledning når jeg skal lære noe nytt	•	•	•	•	•
26. Det har aldri hendt at jeg har jukset	•	•	•	•	•
27. Jeg er utpreget nøyaktig og oppgaveorientert i arbeidet	•	•	•	•	•
28. Jeg liker situasjoner hvor en må aktivt søke ny kunnskap	•	•	•	•	•
29. Jeg holder meg stort sett til aksepterte oppfatninger	•	•	•	•	•
30. Jeg kommer best til min rett i uoversiktlige situasjoner	•	•	•	•	•
31. Jeg foretrekker å holde meg til en fastsatt plan når jeg arbeider eller løser problemer	•	•	•	•	•
32. Jeg kan forandre mine oppfatninger/ideer selv om situasjonen ikke krever det	•	•	•	•	•
33. Jeg prøver oftest å bruke velprøvde løsningsmetoder når jeg løser problemer	•	•	•	•	•
34. Jeg liker best å utforske nytt terreng	•	•	•	•	•

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C.4 Affordances/Communication properties

Nedenfor er det listet opp 12 utsagn. Ta utgangspunkt i problemløsningsprosessen du akkurat har vært gjennom, og kryss av for det svaralternativet du synes passer best. (I utsagnene nedenfor refererer begrepet "bidrag" til alle ideer, innspill, kommentarer, etc. som du eller de andre la frem under problemløsningsprosessen.)

	Svært uenig				Svært enig
1) De andre deltakerne i gruppen visste hvilke bidrag som var mine	1	2	3	4	5
2) Jeg kunne gi umiddelbar tilbakemelding på andres bidrag	1	2	3	4	5
3) Jeg kunne få umiddelbar tilbakemelding på mine bidrag	1	2	3	4	5
4) Tanker og ideer som dukket opp kunne legges frem til enhver tid uten å avbryte andre	1	2	3	4	5
5) Det var enkelt å vite hvem som la frem et bidrag	1	2	3	4	5
6) Tanker og ideer som dukket opp kunne presenteres når som helst uten å risikere at vi "snakket i munnen på hverandre".	1	2	3	4	5
7) Et bidrag kunne enkelt knyttes til personen som la det frem	1	2	3	4	5
8) Jeg kunne gi rask respons på bidrag fra andre i gruppen	1	2	3	4	5
9) Det hendte at jeg ventet med å legge frem tanker og ideer som dukket opp fordi jeg ikke ville avbryte andre	1	2	3	4	5
10) De andre i gruppen kunne gi rask respons på mine bidrag	1	2	3	4	5
11) "Bidragsyterne" var som regel ukjente	1	2	3	4	5
12) Samarbeidsverktøyet gjorde at jeg kunne presentere mine bidrag uten at de andre i gruppen visste at det var mine bidrag	1	2	3	4	5

Hvilken maskin brukte du? ☐ (Maskinnr.)

Til slutt noen utsagn/spørsmål som ikke er knyttet til selve problemløsningsprosessen:

	Svært uenig				Svært enig
Jeg er en erfaren PC-bruker	1	2	3	4	5
Jeg benytter meg ofte av elektroniske kommunikasjonsformer (for eksempel e-post)	1	2	3	4	5
Jeg bruker ofte Groove eller lignende programvare (for eksempel MSN Messenger)	1	2	3	4	5

Kjønn   Kvinne ☐   Mann ☐

Epost-adresse: [@   ]

Takk for hjelpen!

D   Statistics

D.1   Descriptive statistics

| | N | Minimum | Maximum | Mean | Std. Deviation | Skewness | | Kurtosis | |
						Statistic	Std. Error	Statistic	Std. Error
Assi_exp1	91	1	5	3,44	,968	-,688	,253	-,166	,500
Assi_exp2	91	1	5	3,42	,817	-,790	,253	,455	,500
Assi_exp3	91	1	5	3,58	,857	-1,344	,253	,979	,500
Assi_exp4	92	1	5	2,86	1,044	-,007	,251	-1,157	,498
Assi_exp5	91	1	5	3,46	1,014	-,318	,253	-,866	,500
Assi_exp6	92	1	5	2,99	1,000	-,180	,251	-,774	,498
Assi_exp7	92	1	5	3,26	1,047	-,428	,251	-,850	,498
Assi_exp8	91	1	5	2,95	,970	,037	,253	-,849	,500
Assi_exp9	92	1	5	2,63	,980	,377	,251	-,949	,498
Assi_exp10	92	1	5	3,47	1,010	-,399	,251	-,586	,498
Assi_exp11	92	1	5	2,97	1,063	,122	,251	-1,155	,498
Assi_exp12	92	1	5	2,47	1,063	,311	,251	-,959	,498
Assi_exp13	92	2	5	3,92	,788	-,691	,251	,492	,498
Assi_exp14	91	1	5	3,23	,978	-,046	,253	-,994	,500
Assi_exp15	92	1	4	2,43	,843	,379	,251	-,438	,498
Assi_exp16	92	1	5	2,88	1,015	-,013	,251	-1,082	,498
Assi_exp17	92	1	5	2,79	1,075	,044	,251	-,971	,498
Assi_exp18	92	1	5	2,78	,900	,262	,251	-,527	,498
Assi_exp19	92	2	5	3,25	,860	-,086	,251	-,946	,498
Assi_exp20	91	1	5	3,14	,926	-,463	,253	-,904	,500
Assi_exp21	92	1	5	3,39	,901	-,772	,251	-,315	,498
Assi_exp22	92	1	5	3,50	1,104	-,450	,251	-,752	,498
Assi_exp23	92	1	5	3,52	1,032	-,458	,251	-,843	,498
Assi_exp24	91	1	4	2,25	,889	,639	,253	-,191	,500
Assi_exp25	92	1	5	3,16	,929	-,586	,251	-,649	,498
Assi_exp26	92	1	5	3,18	,971	-,235	,251	-1,025	,498
Assi_exp27	91	2	5	3,51	,848	-,744	,253	-,543	,500
Assi_exp28	92	2	5	3,80	,650	-1,010	,251	1,736	,498
Assi_exp29	92	2	5	3,51	,777	-,467	,251	-,319	,498
Assi_exp30	92	1	4	2,71	,884	-,067	,251	-,778	,498
EVAL1	92	1	5	3,21	1,263	-,166	,251	-1,087	,498
EVAL2	92	1	5	3,54	1,113	-,624	,251	-,331	,498
IDEA1	92	2	5	4,29	,833	-1,068	,251	,566	,498

IDEA2	92	1	5	3,60	1,090	-,387	,251	-,574	,498
EVAL3	91	1	5	2,87	1,204	,142	,253	-,943	,500
EVAL4	92	1	5	3,52	1,094	-,700	,251	-,256	,498
EVAL5	92	1	5	3,15	1,167	-,133	,251	-,971	,498
IDEA3	92	1	5	3,20	1,170	-,181	,251	-,922	,498
IDEA4	92	1	5	3,49	,966	-,454	,251	-,314	,498
EVAL6	92	1	5	3,15	1,213	-,299	,251	-,876	,498
EVAL7	91	1	5	3,04	1,273	-,216	,253	**-1,116**	,500
IDEA5	92	1	5	2,92	1,251	,112	,251	-,975	,498
IDEA6	92	1	5	3,67	1,080	-,863	,251	,248	,498
EVAL8	92	1	5	2,16	,964	,492	,251	-,330	,498
IDEN1	89	1	5	3,30	1,228	-,228	,255	-,846	,506
SYNC1	91	1	5	3,66	1,231	-,596	,253	-,739	,500
SYNC2	91	1	5	3,65	1,205	-,611	,253	-,631	,500
PARA1	91	1	5	3,96	1,084	-,980	,253	,312	,500
IDEN2	91	1	5	3,00	1,506	,040	,253	**-1,521**	,500
PARA2	91	1	5	3,77	1,221	-,780	,253	-,449	,500
IDEN3	91	1	5	2,98	1,406	,113	,253	**-1,426**	,500
SYNC3	91	1	5	3,75	1,151	-,829	,253	-,078	,500
PARA3	91	1	5	3,48	1,393	-,469	,253	**-1,155**	,500
SYNC4	91	1	5	3,73	1,055	-,819	,253	,277	,500
IDEN4	91	1	5	2,92	1,376	,141	,253	**-1,252**	,500
IDEN5	90	1	5	3,12	1,421	-,028	,254	**-1,404**	,503
Divergent focus	92	,00	4,84	1,4549	,81066	**1,541**	,251	**3,842**	,498
Convergent focus	92	1,59	9,02	3,5061	1,50984	**1,555**	,251	**2,282**	,498

D.2 Factor loadings, moderating variables

	h^2	Component		
		1	2	3
Cognitive style - item 3	.55	.68		
Cognitive style - item 4	.38	.53	.32	
Cognitive style - item 8	.46	.66		
Cognitive style - item 9	.52	.70		
Cognitive style - item 10	.51	.67		
Cognitive style - item 11	.34	.58		
Cognitive style - item 12	.50	.62		
Cognitive style - item 13	.64	.79		
Cognitive style - item 20	.64	.79		
Cognitive style - item 22	.40	.56		
Cognitive style - item 24	.52	.70		
Cognitive style - item 29	.36	.58		
Cognitive style - item 31	.58	.61	.42	
Cognitive style - item 33	.46	.66		
Cognitive style - item 34	.44	.63		
EVAL3 (var 2.5)	.37			.56
EVAL4 (var 2.6)	.34			.50
EVAL6 (var 2.10)	.79			.89
EVAL7 (var 2.11)	.66			.80
IDEA1 (var 2.3)	.46		.68	
IDEA3 (var 2.8)	.44		.65	
IDEA4 (var 2.9)	.50		.70	
IDEA5 (var 2.12)	.39		.60	
% of variance extracted	48.7	28.6	11.2	8.9