

# Virtual Collaboration

An Investigation into the  
Influence of **Avatars** and  
**3D Virtual Environments**  
on **Team Effectiveness**



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## Acknowledgements

*“In the long history of humankind (and animal kind, too) those who learned to collaborate and improvise most effectively have prevailed.”*

Charles Darwin

An added advantage of writing a dissertation on collaboration is that I feel that I have simultaneously improved my own collaborative skills in the process. Some people say that writing a PhD dissertation is like running a marathon (which I actually did in New York City halfway through writing this dissertation), but apart from perseverance, I think effectively collaborating and having a great “support team” is one of the key factors in successfully reaching the finish line. This dissertation could not have been created without the kindness, insightful guidance and inspiration of many people to whom I am greatly indebted.

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General introduction

## Introducing the topic

On 28 February 2007, the VU University Amsterdam was the first Dutch university to announce that it would be present in *Second Life*. Soon afterwards their Second Life Project Team was besieged by the media, which resulted in a news item being shown on prime time national television as well as an item on AT5, the local Amsterdam broadcasting channel. Several articles also appeared in various national newspapers (Feldberg, Eliëns, Van der Land, Huysman, & Konijn, 2009). At the time, many companies were provoked by clever marketers to jump on the bandwagon and they were eager to be the first to claim their presence in this exciting new medium, called *Second Life*. Driven also by the 2008 financial crisis, which cascaded in huge cuts in corporate travel budgets (Telegraph, 2008), multinational companies such as IBM, ABN AMRO and Shell were willing to experiment and explore whether 3D virtual environments, such as *Second Life*, could serve as a substitute for the travel costs and time spent meeting face-to-face for globally dispersed teams.

3D virtual environments are generally defined as “online electronic environments that visually mimic complex physical spaces, where people can interact with each other and with virtual objects, and communicate via avatars - a digital representation of themselves” (Bainbridge, 2007, p. 472). One example of a 3D virtual environment that is used by companies, universities, and US government agencies is *OpenQwaq* (Businesswire, 2010; Korolov, 2011). In *OpenQwaq*, a 3D shared visual workspace is provided and a user can be represented by an avatar. The tools for collaboration in *OpenQwaq* are voice communication, video and text-based chat, which can be combined with multi-application and document sharing. Personally, I had the opportunity to experience *OpenQwaq*'s precursor *Teleplace* first hand when I was a member of *Proviwo*, a collaborative group of researchers affiliated with Stanford University (USA), Aalto University (Finland), Stockholm School of Economics (Sweden) and the VU University in the Netherlands (for more info, see <http://www.vmwork.net/projects/current-projects>). The *Proviwo* group used *Teleplace* particularly for small collaborative meetings in which we brainstormed to come up with research ideas while using the white board and in which we discussed our collaborative research endeavors. A picture of a collaborative meeting in *Teleplace* is depicted below (See Figure 1.1).

Another example how 3D virtual environments can be used in business for group decision making purposes is the case of *Star Wood Hotels*. In 2006, *Starwood Hotels* was one of the first chains to establish a hotel in the 3D virtual world *Second Life* (Jana, 2006). The purpose of this 3D visualization was to obtain feedback from potential customers, who were represented by avatars, about the hotel's design features. In this way, the costs of building a prototype in real life could be reduced, since the feedback





**Figure 1.1** Teleplace (Teigland, 2010)

that would be received on important design aspects could be incorporated into the final physical design of the hotel. The final design of the hotel was thus influenced by the “collaborative input” received by potential customers. Currently, 3D modeling techniques, an aspect of 3D virtual environments, are increasingly used by companies and are becoming a popular tool for helping potential customers to visualize a wide array of products, ranging from IKEA kitchens, to Philips LED televisions, to fancy sport cars (Morrisson & Skjulstadt, 2010; Suh & Lee, 2005).

Virtual worlds have also sparked the interest of researchers, particularly from the Information Systems (IS) community. Researchers have started to devote considerable research attention to virtual worlds, such as *Second Life*, *Active worlds*, *OpenSim*, and *Open Wonderland*. This has resulted in a wide range of conferences and journal publications, with the recent MISQ special issue on ‘New Ventures in Virtual Worlds’ being the most notable (Wasko, Teigland, Leidner, & Jarvenpaa, 2011). The rise of virtual world research within IS has grown parallel to the discipline’s interest in new media applications such as Web 2.0 and Social Network Sites. As such, the ‘3D Web’ was seen as the next logical step for online collaboration and decision making (Messinger, et al., 2009). A literature review on studies covering virtual worlds (Cahalane, Feller, & Finnegan, 2012) revealed that these research topics span a wide range: for example, online education (Chen, Siau, & Nah, 2010; Eschenbrenner, Nah, & Siau, 2008), business (Ahonen, Donnellan, Mahaley, O’Donovan, & Teigland) co-creation (Chaturvedi, Dolk, & Drnevich, 2011; Kohler, Fueller, Matzler, & Stieger, 2011), artifact trade (Guo & Barnes, 2011) and artifact design (Chaturvedi, et al., 2011).

Research on virtual worlds’ potential for team collaboration, however, remains rather underexplored. Despite a growing business and research interest in virtual worlds (Davis, Murphy, Owens, Khazanchi, & Zigers, 2009; Huang, Kahai, & Jestice, 2010), there is still a lack of empirical research on team collaboration in virtual worlds. Prior research traditionally focused on text and data-based technologies that investigate virtual team collaboration (Messinger, et al., 2009; Powell, Piccoli, & Ives, 2004), while 3D virtual worlds offer unique capabilities which may be particularly conducive to certain tasks and exert influence on effective team collaboration in new ways. Hence, the contribution of these 3D virtual environments to collaboration in dispersed teams is likely to differ from the traditionally studied virtual teams. Therefore, the purpose of this research dissertation is to examine how the unique characteristics of this new emerging medium of 3D virtual environments might possibly contribute to effective team collaboration and decision making. Through my research, I aim to contribute to the contemporary debate in the literature on organizational communication and information systems, and team collaborative behaviors in computer-mediated environments, in particular. Therefore, I seek to answer the following core research question: “How can 3D virtual environments be employed to enhance effective team collaboration?”

In the following sections, I will systematically describe the concepts and argue in favour towards the establishment of the conceptual framework. First, an introduction will be given to this specific field of research, 3D virtual environments. Subsequently, I will turn to the body of knowledge on this subject, as developed in the two basic lines of argumentation on which my conceptual framework has been based: the Media Synchronicity Theory (MST) and research on group behavior. After the presentation of the conceptual framework, I will briefly introduce the core concepts of our research, which will resurface to be discussed in further detail throughout this dissertation and particularly in Chapter 3. Finally, an overview of this dissertation’s chapters will be provided in which I describe the research strategy, and conclude with the publications which have resulted from the various studies that have been conducted up until now.



**Table 1.1** Examples of Virtual Environments

Medium	Characteristics
World of War Craft	Most popular online gaming environment, with over 9 million active accounts as of August 2012 <sup>2</sup>
Second Life	Launched in 2003 by Linden Lab. By July 2012, there are 30 million accounts, of which 1 million have been active in the past 60 days <sup>3</sup>
Active Worlds	The first widely used virtual world launched in 1995, then under the name of AlphaWorld <sup>4</sup> . Similar to Second Life, only less commercial, and with a smaller population. <sup>5</sup>
The Sims	One of the most successful video games series of all time <sup>6</sup> . As of May 2011, more than 150 million copies of these strategic, life simulation video games have been sold worldwide <sup>7</sup> .

### 3D Virtual Environments

Although the idea of virtuality is still very vivid in science fiction, as shown in the recent movie *Avatar* directed by James Cameron, computer scientists have sought to program virtual worlds for a long time. Since the early 1950s, the lure of the virtual has seduced thinkers, writers, designers and others with the idea that perhaps one day, we could accomplish what we have historically done physically via a computer in a virtual world, subsequently allowing us to part potentially with the physical (Bailey, Leonardi, & Barley, 2011). During the past two decades, considerable success has been made, especially in video gaming (Tschang, 2007). This can be seen, for instance, in the success of *World of Warcraft*, *Second Life*, *Active Worlds* and *the Sims* (see Table 1.1).

Today, virtuality has moved well beyond games. Sophisticated graphical simulations are now used to train pilots in flying aircrafts, to motivate obese people to exercise and lose weight via Wii-games (Lanningham-Foster, et al., 2009) and 3D models are used as a tool to help people visualize the end result of their still-to-be-built IKEA-kitchen (Morrisson & Skjulstadt, 2010). In today's world of work, teams routinely communicate and coordinate via email, instant messaging, and webconferencing applications without ever meeting in person. With the emergence of new technologies, such as 3D virtual environments, the possibility of working virtually is moving from the realm of science fiction to the everyday reality of the workplace (Bailey et al., 2011). To illustrate how virtual environments are being used, Scheme 1.2 offers a typology in which virtual environments are categorized according to two dimensions: 1) whether their orientation is a game scenario or a virtual life scenario orientation and 2) whether they are designer or user-developed (Wirth, Feldberg, Schouten, Van den Hooff, & Williams, 2011).

**Table 1.2** Typology of Virtual Environments Usage (Wirth et al., 2011)

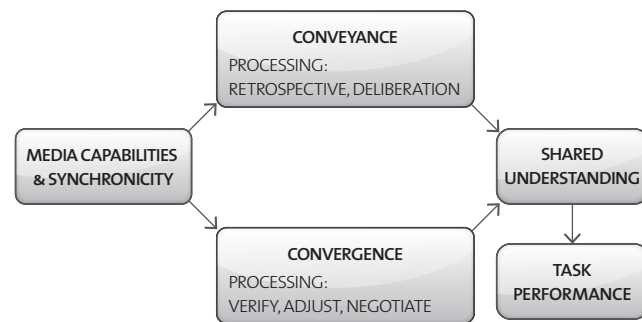
	Designer-developed	User-developed
Game scenario	Designers specifically create a virtual environment intended to enhance a game playing scenario. Examples: <i>Rock Band™</i> , <i>The Legend of Zelda™</i> , <i>Madden NFL™</i> , and <i>Warcraft™</i>	Users develop the virtual environments by creating objects and modifying aspects of the environment. These objects become part of the on-going game. Examples: <i>World of Warcraft</i> , <i>Guild Wars</i> , and <i>Lord of The Rings</i>
Virtual life scenario	Players cannot create the environment, but rather the designer can change the virtual environment as they see fit. The environment has been designed so that players can live out their virtual lives by navigating through these worlds. One example is Sony's <i>Home</i> .	Players can modify scenery and create objects, creating the worlds in which players navigate through. Players live out their virtual lives by doing a variety of activities and engaging with others as they would in everyday life. Examples: <i>Second Life</i> and <i>There.com</i> .

3D virtual environments are generally defined as “*online electronic environments that visually mimic complex physical spaces, where people can interact with each other and virtual objects, and communicate via avatars – a digital representation of themselves* (Bainbridge, 2007, p. 472).” From this definition it becomes clear that in comparison to traditional media, 3D virtual environments offer two unique characteristics in terms of 1) simulating a shared visual space and 2) being represented and communicating via an avatar (Van der Land, Schouten, Van den Hooff, & Feldberg, 2011). In my conceptual model, we define these characteristics as *3D virtual environment* and *avatar-based interaction*. I will further elaborate on these components and their relationship to effective virtual team collaboration in the discussion of our conceptual model, which appears later in this chapter.

### Effective Virtual Team Collaboration: a Media Synchronicity Theory Perspective

Driven by globalization and the advent of the internet, *virtual teams* have increasingly evolved as a new organizational form and a way of working (Martins, Gilson, & Maynard, 2004). *Virtual teams* are described as “*a group of people working together towards a common organizational goal, independent from geographical and temporal boundaries, relying on information and communication technology in their communication with each other*” (Townsend, DeMarie, & Hendrickson, 1998, p. 17). The strategic benefits of using virtual teams in organizations are indispensable, which involves attracting the best experts from the globe to be part of the team (Wenger, 1998), reducing the time and costs associated with travelling (Baskerville & Nandhakumar, 2007), and sustaining a better work-life balance (Fonner & Roloff, 2010).

A theoretical framework of the concepts that influence effective virtual team collaboration can be found in Media Synchronicity Theory (MST) (Dennis, Fuller, & Valacich, 2008; Dennis & Valacich, 1999). With its holistic overview of the various concepts, MST offers a good point of departure for this dissertation's research. MST incorporates the two distinct processes or "routes" for effective team collaboration that have been widely cited in virtual team research (for a review see Powell, et al., 2004) and which are supported by the current research on group behavior (Chang & Bordia, 2001; Deutsch & Gerard, 1955; Hinsz, Tindale, & Vollrath, 1997). Scholars have started testing MST's underlying theory (e.g. DeLuca & Valacich, 2006), but there is still more empirical work that must be done to fine-tune and to test the model's theoretical implications. The basic rationale of MST reads as displayed in Figure 1.2 below.



**Figure 1.2** Media Synchronicity Theory (based on Dennis et al. 2008, p. 582)

Media Synchronicity Theory (Dennis, et al., 2008) is based on the principle that shared understanding among team members is a prerequisite for the successful completion of any task that requires team collaboration (e.g. decision making, knowledge sharing or negotiation). Shared understanding is defined as “the assessment of the overlap and similarity in conclusions drawn by others” (Dennis, et al., 2008, p. 580). Shared understanding results from two fundamental communication processes. The first communication process is *conveyance* which refers to the individual process of making sense of new task-related information, by analyzing it and building a mental model. The second process is *convergence*, which refers to negotiating collectively on the meaning of the information in order to create a common understanding (Dennis, et al., 2008; Swaab, Postmes, Neijens, Kiers, & Dumay, 2002).

According to MST, different media capabilities are required for conveyance and convergence processes. To support the deliberate processing of information (conveyance), MST proposes a medium with a lower level of synchronicity, since this will allow individuals to take more time to analyze the information and to generate meaning from it. To support communication processes among team members (convergence), a medium providing high levels of synchronicity is beneficial since it enables individuals to use immediate feedback in testing mutual understanding.

This conceptual divide of the two distinct routes leading to shared understanding is also articulated and supported by contemporary research on group behavior. In this literature, a clear distinction has been made in regard to whether teams are understood in terms of cognitive-informational or social-relational factors (Chang & Bordia, 2001; Deutsch & Gerard, 1955; Hinsz, et al., 1997). The first stream of research focuses on the cognitive side of teams, and envisions individual team members as information processors, and is concerned with how a shared understanding can develop when information is exchanged among individual team members, and how this can have an effect on the team's performance (Hinsz, et al., 1997; Wegner, 1987). The second stream of research is principally concerned with the social side of teams, and deals with such questions as how the team's cohesion (Chang & Bordia, 2001) and team identification (Tajfel & Turner, 1986) can contribute to a team's performance. This distinction suggests that there are two fundamentally different routes through which team members can influence each other, which is clearly depicted in the dual process model (Deutsch & Gerard, 1955), and which corresponds to Media Synchronicity Theory.

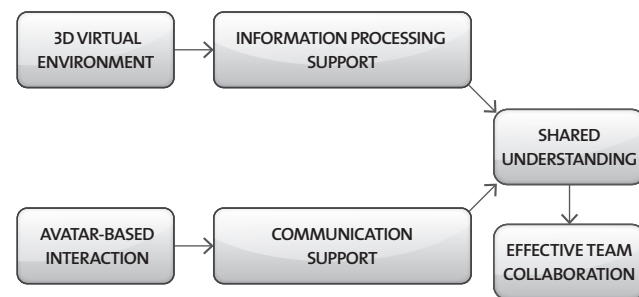
### Conceptual Framework

To date, MST's rationale has not yet been applied to the context of 3D virtual environments. Therefore, I will now systematically discuss the core concepts of our conceptual framework on effective collaboration in 3D virtual environments, as presented in Figure 3 below. The basic rationale of the model is that the two unique characteristics of 3D virtual environments are considered to support conveyance and convergence by influencing effective team collaboration (Van der Land, et al., 2011).

### 3D virtual environment

According to Suh and Lee (2005), 3D virtual environments comprise three capabilities that might affect team collaboration: presence, realism, and interactivity. First, the concept *presence* includes both immersion and involvement (Witmer & Singer, 1998). Immersion is the extent to which one feels perceptually surrounded in the virtual environment rather than one's physical surroundings (Banos et al., 2004; Guadagno et al., 2007; Witmer and Singer, 1998). Involvement relates to “focusing one's energy and attention on a coherent set of stimuli or meaningfully related activities and events in

the environment” (Witmer & Singer, p. 227). Second, *realism* is the extent to which one believes the virtual environment is real (Davis et al., 2009). The third concept, *interactivity* refers to the capability to move and navigate through a virtual environment in contrast to examining static 2D or 3D images the environment (Bishop et al., 2001), and the ability to interact with and control the environment in real time (Fox et al., 2009). Because 3D virtual environments offer high presence, realism and interactivity capabilities, users are active rather than passive in their engagement with the information, which might lead to more effective information processing (Pimentel et al., 1994).



**Figure 1.3** Conceptual Framework

### Avatar-Based Interaction

The second characteristic of 3D virtual environments that might support team collaboration is avatar-based interaction. In a 3D virtual world, users are represented in the environment by means of their avatar. An avatar is defined as “a digital representation of one’s identity” (Yee, 2007, p. 116), which is embodied and can navigate through the virtual space (Biocca, 1997; Mennecke, Triplett, Hassall, Conde, & Heer, 2011). Two capabilities that could affect team collaboration and which are in turn related to avatar-based interaction are: *social presence* and *self-representation*. The first concept, *social presence*, refers to the extent to which communicators have a “sense of awareness” of the other interaction partner (Short, Williams, & Christie, 1976) whereas the second capability, *self-representation*, refers to the control one has over one’s appearance in a 3D virtual world. In everyday life, self-presentation is an important social process that influences identification, group dynamics and collaboration within the team. These increased possibilities for social presence and strategic self-presentation could influence the effectiveness of virtual team collaboration.

### Information Processing Support and Communication Support

In this conceptual model, we distinguish between two different “routes” through which 3D virtual environments and avatar-based interaction can influence shared understanding, and - in so doing - effective team collaboration and decision making. The rationale behind these two routes as explicated in MST, is that teams not only need to individually understand the task-information they have (conveyance, cognitive-informational), but they must also understand how others interpret it, and as such, work well together socially as a team (convergence, social-relational), (Driskell, Radtke, & Salas, 2003; Mathieu, Heffner, Goodwin, Salas, & Cannon-Bowers, 2000).

In our research framework, the first route has been labeled the *information processing route*, which focuses on those processes related to the formation of cognition and individual information processing and is primarily based on the information-rich character of the 3D virtual environment. For example, in a group decision making task, individuals will require time to process the information, otherwise they will reach incorrect conclusions. The second route is labeled the *communication route*, which focuses on those processes related to the formation of cohesion and group dynamics, and which have primarily been instigated from the avatar-based character of the interaction in the 3D environment. For this process, social interactive aspects of team collaboration, such as cohesion and mutual trust among team members, come into play.

### Shared Understanding

Shared understanding is viewed as the successful sum of information processing and communication support. To reach a shared understanding, information processing is necessary as task-related information needs to be shared and processed in order for each team member to create an individual understanding of a task. The first step to be taken in order to reach shared understanding is to achieve individual understanding (Corning, 1986; Weldon & Bellinger, 1997). Communication support (convergence) is necessary in order to reach a shared understanding since the outcomes of the conveyance processes (e.g. the individual understanding) need to be shared and communicated in order to reach a common understanding (Dennis et al, 20008). Moreover, Driskell et al. (2003) stress that for teams to collaborate successfully, the team members do not only need to perform well on task-related functions, but they must also work well together socially as a team. Therefore, communication support also entails the social-relational aspects of team collaboration (Buss & Kenrick, 1998).

### Effective Team Collaboration and Decision Making in Virtual Environments

In many organizations, team collaboration seems to be a prerequisite for accomplishing most of the work tasks (Cronin & Weingart, 2007). Many current tasks can no longer be executed by a single individual because they require close collaboration with a

team of experts (Wenger, 1998). Team collaboration is often described “as any formal and permanent whole of at least two interdependent individuals who are collectively in charge of the achievement of one or several tasks defined by the organization” (Rousseau, Aubé, & Savoie, 2006, p. 541). Group decision making is defined as “a group of people who collectively make a choice from a set of alternatives, which is usually performed through debates and negotiations” (Karacapilidis & Papadias, 2001, p. 259). Both team collaboration and group decision making can be categorized as collaborative behaviors (Rousseau, et al., 2006). This trend towards viewing teams as a basic unit of structure in organizations, rather than the individual, is triggered by the fact that ‘knowledge-equity’ is what gives companies a competitive edge in today’s world of work (Ndofor, and Levitas, 2004).

Despite bridging time and place, one of the challenges virtual teams face is that most technologies still fail to replace important aspects of face-to-face communication. Most technology still lacks the availability of cues such as facial expressions, gestures and demographic information, which persist in face-to-face communication (Jarvenpaa & Leidner, 1998; Walther & Parks, 2002). With its avatar-mediated technology, 3D virtual environments may enable the transmission of more social cues for virtual team communication (Bailenson, Blascovich, & Guadagno, 2008). This, in turn, could influence social interaction processes and team performance (Davis, 2009 et al.; Bailenson & Yee, 2006). Other identified challenges for virtual teams that have been recognized are the mutual knowledge problem and problems with sharing knowledge and trust, which could be magnified in virtual teams (Cramton, 2001; Vlaar, van Fenema, & Tiwari, 2008). In conclusion, virtual teams offer many paradoxes and complications and therefore I am eager to explore how this new emerging medium of 3D virtual environments can cope with these challenges.

## Dissertation Outline

Through four different studies, we intend to gain a greater understanding of this dissertation’s topic, which concerns effective virtual team collaboration in 3D virtual environments. The relationship found between the four studies in this dissertation is visually depicted in Figure 1.4. In the final chapter of this dissertation, we will return to our central research question, “How can 3D-virtual environments be employed to enhance effective team collaboration?”, and thereupon we will elaborate on the theoretical and practical implications of this dissertation’s findings.

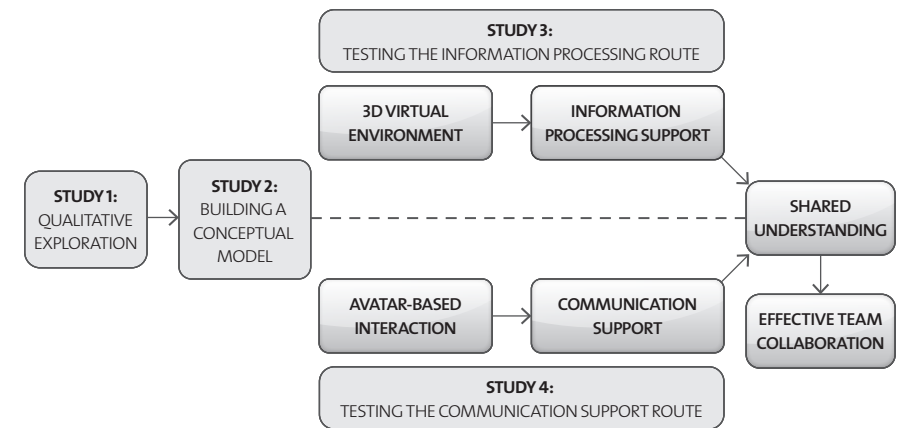


Figure 1.4 Research Model

### Chapter 2: a qualitative exploration

To begin with, we report on several exploratory studies which aimed to investigate *Second Life*’s potential as a platform for facilitating information processing and communication support. A qualitative, inductive exploration was chosen as a research strategy, since at this stage of the dissertation’s research cycle, *Second Life* and 3D virtual environments were a relatively new theoretical phenomenon in the context of organizational communication. An inductive, exploratory approach enabled concepts to emerge from the data rather than through the assumptions of prior theories (Bryman, 2012; Doorewaard & Verschuren, 2010). Moreover, it allowed for a close acquaintance with the phenomenon *Second Life*, which fostered finding the appropriate methodological approaches used in the subsequent studies in this dissertation. The findings of these explorative studies have been combined with insights derived from pedagogical research. The chapter concludes by presenting a research agenda which can serve as a guide for this dissertation’s further research.

### Chapter 3: building a conceptual model

In Chapter 3, a second study is examined in which a conceptual model for virtual team collaboration is provided based on the existing body of literature. To date, there have been very few studies that have offered systematic literature analyses on how the specific characteristics of 3D virtual environments could possibly contribute to effective collaboration of virtual teams (Davis et al., 2009; Messinger, et al., 2009). Therefore, this study fills this gap by critically reviewing the literature and building upon prior theories in order to develop an integrative conceptual model of team

collaboration in 3D virtual environments. This method has enabled us to broaden the knowledge obtained in Study 1 and it has helped to place it within a wider theoretical context. The paper ends by offering several propositions which served as input for further empirical testing in the third and fourth studies of this PhD research project.

#### **Chapter 4: an experimental test**

Subsequently, the third study of this dissertation, which is presented in Chapter 4, was aimed at testing the propositions related to the information processing route (the sequential route located at the top of the conceptual model). The research sub-question that this study seeks to answer is: *“How does visual representation of information in 3D virtual environments support both individual and shared understanding, and consequently contribute to group decision making?”* To test our hypotheses and answer our research question, an experiment was conducted. An experimental approach was selected as a research method since it allowed the greatest control to test a possible causal effect between the independent and dependent variables (Field, 2009). This deductive approach enabled us to falsify the established hypotheses and the inherent theories on which they were based (Field, 2009). The experiment in this study consisted of both an individual and a team phase, thus portraying the individual understanding and shared understanding elements involved in a team task. The central task in the experiment was to select an apartment based on the visual representation of information in teams consisting of three members. Three experimental conditions were created which visually differed in their degree of realism, immersion and interactivity: 1) a 2D condition in which the participants saw a 2D floor-plan of the apartments, 2) a 3D static condition in which participants had a bird’s-eye view of the apartments and were able to view the apartments from four different angles, and 3) a 3D immersive condition in which the participants could navigate through virtual replicas of the apartments from a first-person perspective in a 3D virtual environment. The results of the experiment suggest that the capabilities of 3D virtual environments do indeed contribute to individual understanding, but that these capabilities are inefficient and experienced as more cognitively taxing in group decision-making processes.

#### **Chapter 5: a multi-method study**

Chapter 5 presents the fourth and final study of this dissertation; a multi-method study that aims to investigate the second route of our conceptual model, namely, the communication route (the sequential flow located at the bottom of the conceptual model). The research sub-question that this study seeks to answer is: *“How does similarity and self-identity in avatar representations influence team performance in virtual teams?”* To answer this question, we first conducted an experiment for similar reasons as stated earlier in Study 3. The experiment differed in the degree of similarity and self-identity of avatar appearances that were present in the four experimental

conditions. For instance, “Morphed team avatars” were created through morphing techniques, which enabled us to integrate both similarity and self-identity. After that, a content analysis of the conversations was employed as a second research method in order to fully understand why the team members in the morph condition had performed best on the task. Through the rich descriptive data, this content analysis approach offered a more in-depth understanding of the dynamics involved in team collaboration and it complimented the quantitative experimental approach (Denzin & Lincoln, 2000). The implications of this multi-method study on the literature and the practice of management are discussed at the end of this particular chapter.

#### **Chapter 6: general discussion**

Finally, Chapter 6 provides a general discussion of the previous four chapters, as it aims to answer the central research question that has been put forward in this dissertation. A reflection on the initial framework of this PhD’s dissertation will be given, and thereafter we will merge our findings into a complete rendering of what has been discovered during this dissertation’s research project.

## Dissertation's output

In the table shown below, the publications which have been derived from the various studies relating to this PhD dissertation can be found.

	Title	Output
<b>Chapter 1</b>	General Introduction	-
<b>Chapter 2</b>	Feldberg, J.F.M., Eliëns, A.P.W., <b>Van der Land, S.</b> , Huysman, M.H. & Konijn, E.A. (2009). VU @ Second Life: A report on experiences with the development of a (virtual) community of learners. In N. Panteli (Ed.), <i>Virtual social networks: Mediated, massive and multiplayer sites</i> . London: Palgrave MacMillan.	Published as a chapter in a book
<b>Chapter 3</b>	<b>Van der Land, S.</b> , Schouten, A.P., Van den Hooff, B. & Feldberg, F. (2011). Modelling the Metaverse: A Theoretical Model of Effective Team Collaboration in 3D Virtual Environments. <i>Journal of Virtual Worlds Research</i> , 4(3), 1-18.	Published in <i>Journal of Virtual Worlds Research</i>  Presented at the International Communication Association Conference, Singapore, June 2010. (CAT Division)  Accepted for presentation at the OLKC Conference, Boston, June 2012
<b>Chapter 4</b>	<b>Van der Land, S.</b> , Schouten, A.P., Feldberg, F., Van den Hooff, B. & Huysman, M. (2012). Lost in Space? Cognitive Fit and Cognitive Load in 3D Virtual Environments. <i>Computers in Human Behavior</i> , 29(3), 1054-1064.	Published in <i>Computers in Human Behavior</i>
<b>Chapter 5</b>	<b>Van der Land, S.</b> , Schouten, A., Huysman, M., Van den Hooff, B., & Feldberg, F. (2012). Does Avatar Appearance Matter? How Avatar Representations Impact on Virtual Team Performance.	Presented at the Academy of Management Conference, Boston, August 2012. (OCIS Division)  To be submitted for publication in the Journal of Computer-Mediated Communication
<b>Chapter 6</b>	General Discussion	-

### (Endnotes)

- 1 In this dissertation, "I" is used in the introduction and the discussion Chapters to denote personal engagement. Since there are co-authors of the papers in Chapters 2-5, the word "we" is used.
- 2 (Blizzard World of Warcraft®, 2012)
- 3 (Lacy, 2012)
- 4 (Kaplan & Haenlein, 2009)
- 5 (Lensman, February 2012)
- 6 (Sacco, 2011, May 24th)
- 7 (Thang, 2008, March 19th)



# 2



## Study 1

### VU @ Second Life: a Report on Experiences with the Development of a (Virtual) Community of Learners

#### Published as

Feldberg, J.F.M., Eliëns, A.P.W., Van der Land, S., Huysman, M.H. & Konijn, E.A. (2009). VU @ Second Life: A report on experiences with the development of a (virtual) community of learners. In N. Panteli (Ed.), *Virtual social networks: Mediated, massive and multiplayer sites*. London: Palgrave MacMillan.



## Abstract

In this paper we report on several exploratory studies in which we investigated Second Life's potential use as a platform for facilitating information processing and communication support. After first providing a brief explanation regarding our motivations for exploring Second Life, we subsequently describe our experiences and the approach used, which ultimately resulted in the creation of a virtual campus. Our preliminary findings are combined with insights obtained from pedagogical research. This chapter ends with the presentation of a research agenda which can serve to guide us in our further research.

Keywords: virtual worlds, community of learners, Second Life

## Introduction

Online virtual worlds have been present for more than ten years and the recent substantial media attention on Second Life can be considered an indication that virtual worlds are no longer the domain of a selective group of fanatical online gamers. For example, the number of registered residents in Second Life increased from two million at the beginning of 2007 to over more than 12 million in February 2008, at times even reaching a growth of 1 million new registrations a month<sup>1</sup>. Big companies like Reebok, IBM, Philips, Randstad and ABN-AMRO organize press meetings to announce their presence in virtual worlds. Even governments, municipalities, and NGOs have entered Second Life with an eagerness comparable to the 'don't miss the boat' feeling experienced at the early days of the internet.

On February 28th 2007, the Vrije Universiteit Amsterdam announced its presence as the first Dutch university in Second Life. Why does a respectable university want to be present in Second Life? And what are the prospects for or benefits to an educational institute with a strong research reputation to be present in Second Life? Is it publicity we are after, the momentary attention of the press, taking profit from the (current) hype around Second Life? Or are there more sustainable reasons that make such a presence worthwhile, from both educational and research perspectives? In this chapter we address these questions and give an account of the process that led to our establishing a presence in Second Life.

The structure of this chapter is as follows: first, we explain our motivation(s) for entering Second Life and explore its potential as a pedagogical platform. Then we outline the actual building of our virtual campus and briefly report on our experiences when going live. After presenting some insights with the development of a community of learners in Second Life, we discuss the implications for practice and policymaking and suggest directions for further research. Finally, we present our conclusions.

## Creating a presence in a virtual world

In less than a decade since the publication of William Gibson's novel *Neuromancer*, the *metaverse* was realized, albeit in a primitive way, through the introduction of virtual reality modeling language (VRML)<sup>2</sup>, introduced at the International Web Conference of 1992 (Anders, 1999). The German company *blaxxun*<sup>3</sup>, named after the virtual environment in Neil Stephenson's *Snowcrash*, was one of the first to offer a 3D community platform. It was soon followed by *AlphaWorld*, which offered a richer repertoire of avatar gestures as well as limited in-game building facilities. However,

somehow 3D virtual communities never seemed to fulfill their initial promises. Furthermore the adoption of VRML as a 3D interface to the Web never really took off.

The history of Second Life is extensively described in the official *Second Life* guide, (Rymaszweski et al., 2007). Beginning in 2004, almost out of the blue, Second Life<sup>4</sup> appeared with a high adoption and low churn rate, and in the autumn of 2008 it had over 16 million inhabitants.<sup>5</sup> Considering the cost of ownership of virtual estate, which easily amounts to 200 per month rent after an initial investment of 1500 for a single piece of virtual land measuring 65,536 square meters, the adoption of Second Life by individuals as well as companies such as ABN-AMRO, Philips and institutions such as Harvard is surprising.

From a technical point of view, it seems that in comparison to other platforms for immersive worlds, including massively multiplayer online roleplaying games (MMORPGs)<sup>6</sup> such as World of Warcraft<sup>7</sup> and Everquest<sup>8</sup>, Second Life offers an optimal combination of avatar modification options, gesture animations, in-game construction tools, and facilities for communication and social networking such as chatting and instant messaging (Utz, 2003). Incorporating elements of community formation, commonly denoted as Web 2.0, and exemplified in MySpace, YouTube and Flickr, the immersive appearance, perhaps also the built-in physics and the inclusion of elementary economic principles, seems to be an important ingredient in the success of Second Life. In addition, the possibility of recording collaborative enacted stories (Davenport, 2000), using built-in *machinima*<sup>9</sup> certainly also contributes to its appeal. Next to these technical opportunities that Second Life has to offer, one of the decisive reasons for our university's creating a presence in Second Life is the opportunity to build a virtual platform for communication that may embody our so-called *community of learners* vision, where both staff and students collaborate in contributing content in the context of knowledge development.

## Building a virtual campus

To explore the opportunities virtual worlds can offer in support of the development of a community of learners we decided to build a virtual campus. In December 2006 we first discussed the idea of creating presence in Second Life. Our initial aim was to explore the opportunities of Second Life by building a prototype of our university campus, by developing tutorials for further content creation, and by analyzing the functional and technical requirements and opportunities for deployment in education and research.

Two-and-a-half months later we were online, with a virtual campus that contains a lecture room, a telehub from which teleports<sup>10</sup> are possible to other places in the building, billboards containing snapshots of our university's website from which the visitors can access the actual website, as well as a botanical garden mimicking the Vrije Universiteit's Hortus, and white-walled experimentation room suggestive of a 'real' scientific laboratory. A group of four students from all the faculties involved did all the building and scripting. A weekly walkthrough took place in our 'builder meeting' to reassess our goals and solve technical and design issues.

Our virtual campus (see Figures 2.1, 2.2 and 2.3) is meant to serve as an *information portal* and as a *meeting ground*, where students, staff and visitors can meet and communicate. It should also be a place where teachers and researchers can conduct experiments aimed at discovering new ways of teaching and doing research. The overall style is realistic, although not in all its detail. It was considered most important to create a visual resemblance and to offer visitors the opportunity to be presented with relevant information in easily accessible, yet immersive ways (e.g. Bolter and Grusin, 2000; Hoorn et al., 2003).

On 1 March 2007 we opened the doors of our virtual campus to the public. A university creating a presence in Second Life appeared to be an issue for the media. In the evening a news item on national television featured students showing the virtual campus and our project leader explaining the reasoning behind our presence in Second Life, and how to present a course in the virtual classroom. A similar item appeared on the local Amsterdam television channel, and various national newspapers published a multiple-column article reporting on our efforts. Not surprisingly, all the items focused on what we have characterized as the naïve interpretation of our efforts, exemplifying the old credo 'the medium is the message'.

The initial feedback on our virtual efforts exceeded our expectations. The students were praised for the results of our their building efforts, but more importantly, we were approached by many organizations, both corporate and non-profit, and asked to share our experiences of Second Life. We were also invited to participate in their educational, business and research projects.



Figure 2.1 VU campus – outside view

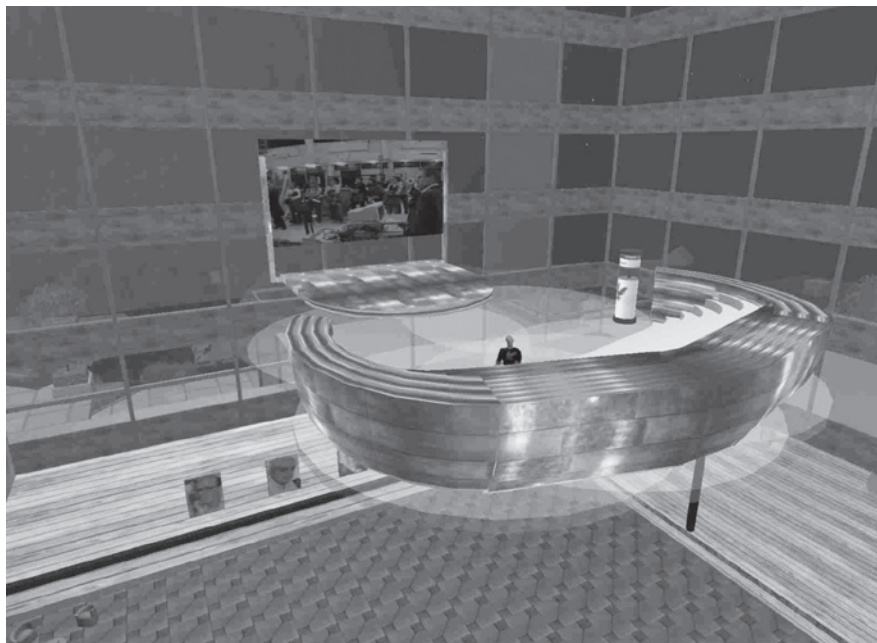


Figure 2.2 VU campus – inside view

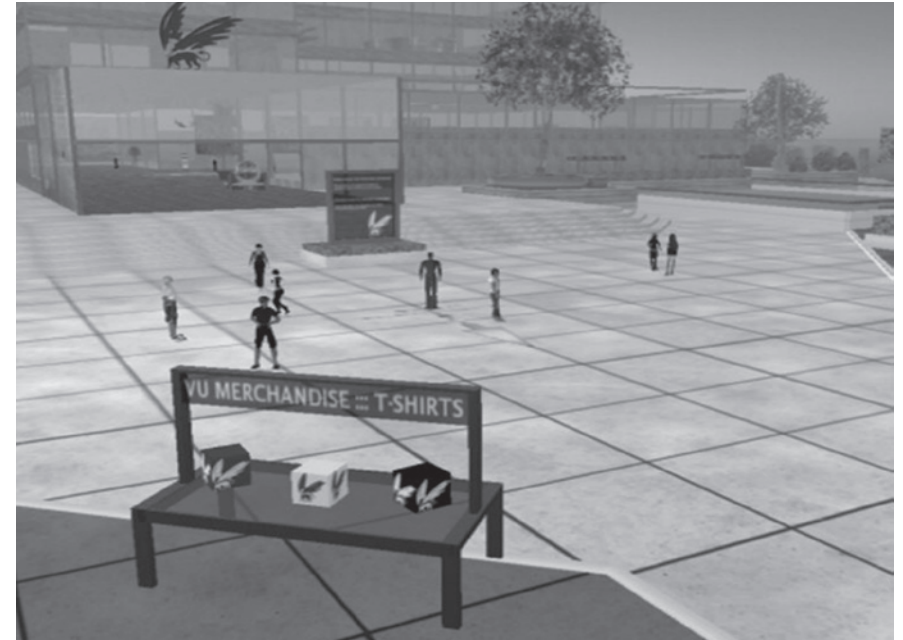


Figure 2.3 VU @ SL – visitors outside



Figure 2.4 Wheelchair race

## From project to process: Development of a community of learners

After the successful introduction of our university in Second Life the next challenge was the implementation of an important driver behind the 'raison d'être' for creating presence in this virtual world: to use Second Life to develop a *community of learners*. Although the initial project, which aimed at creating presence, showed that Second Life offers useful community support features (e.g. multimodal communication, group (membership) management, access management, etc.), our ultimate aim was to transfer the initial project findings to our daily educational and research practices. In order to do so many initiatives were undertaken, ranging from student thesis projects to courses which used Second Life as enabling technology. For example, a teacher from the Law Faculty used Second Life to explore the opportunities of virtual worlds for online dispute resolution. They also organized two tutorials in Second Life in which students and researchers from the Vrije Universiteit collaborated with a group of international students and researchers, who were geographically dispersed, on the solution of a relevant law case. To explore fully the opportunities of virtual worlds as enabling technology for the development of a community of learners we setup a dedicated 'master course' that among other educational objectives, specifically aimed at meeting the following 'community' requirements:

- multidisciplinary approach: participation of students and researchers from more than one faculty, and
- broad participation: participation of external parties (going beyond the boundaries of the university).

For the purpose of this course, called Capita Selecta Virtual Worlds, students and researchers from the faculty of Economics and Business Administration and the faculty of Sciences, as well as three external parties (ABN-AMRO<sup>11</sup>, an international bank, and two NGO's: the Dutch Red Cross<sup>12</sup> and the Disabled Sports Foundation (Fonds Gehandicaptensport<sup>13</sup>)), worked together as a community of learners. The primary objective of this community was to investigate the role virtual worlds can play in communicating the message of charities (short-term) as well as how they can be used for fundraising purposes (long-term). ABN-AMRO, one of the first commercial banks to be present in Second Life, offered the charitable institutions a piece of virtual land for free in order to help them explore the opportunities of virtual worlds for charities. Aware of the increasing attention society is giving virtual worlds, the charities were eager to learn more about this phenomenon. The activities of the community were organized around two explicit assignments that had to be completed by the students:

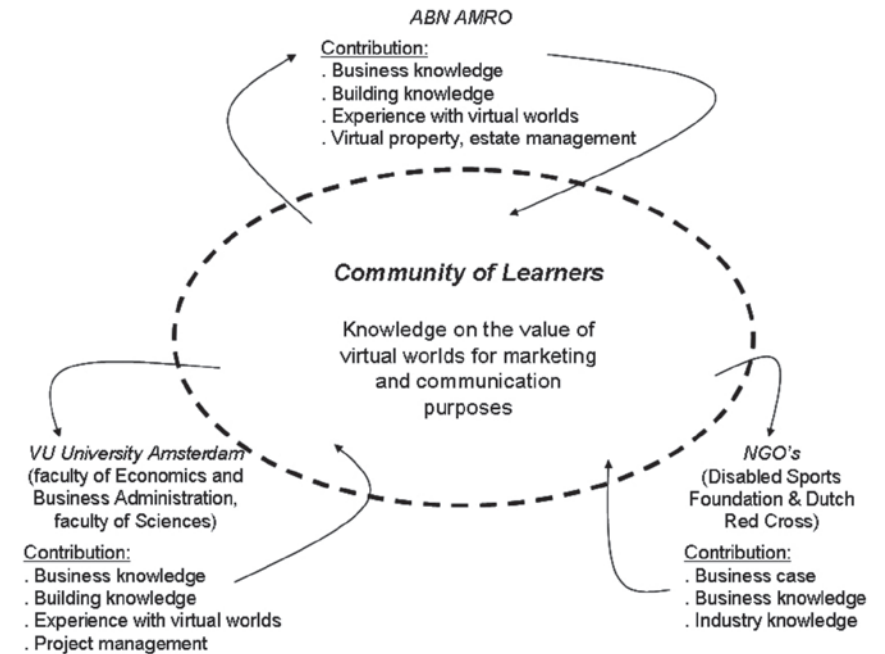


Figure 2.5 Participants Community of Learners

1. Write a report on the value of virtual worlds for the two NGOs involved, and answer the question: Can a presence in virtual worlds contribute to the missions of the NGOs?
2. Create a presence for both NGOs in Second Life by arranging a virtual location that best fits their missions. An overview of the contributions of each party is presented in Figure 2.5.

Figure 2.5 shows the final results. After completion of the project, we interviewed the participants and asked for their opinions on the role of Second Life in support of the development of a community of learners. The most important insights are:

- Second Life appears to facilitate low-level entry for anyone who wishes to participate in the community. It should be noticed that running Second Life smoothly requires a state-of-the-art personal computer and the availability of a broadband internet connection.
- The 3D user interface positively contributed to the feeling of social presence (Walther, 1995), which, according to the participants, contributed to a feeling of being a team/community.



- Participants mentioned that Second Life supported efficient and effective communications. It was very easy to organize meetings since the platform really reduces time and location barriers.
- The 3D user interface made it possible to present, visualize and discuss relevant project results almost instantaneously, which in turn reduced development lead times and gave rise to a feeling of 'co-creation'.
- From the beginning of the project, the participants treated one another as equals and did not experience a sense of hierarchy. The participants were evaluated according to their contribution to the final results or: as one of the charities' project managers put it: "I did not treat the students as 'students', but as knowledgeable team mates from which I could learn a lot." The fact that participants were represented by their avatars might have contributed to this process (Walther, 1995).
- The game-like experience induced a sense of involvement. According to the charities, 3D virtual worlds offer more opportunities to create involvement than 2D websites do. For example, the Disabled Sports Foundation offered visitors of their location the opportunity to participate in a wheelchair race, and 'experience' how it must 'feel' to be disabled (see figure 2.4). The charities consider involvement as an important issue, because it is positively associated with loyalty (Park, 1996).
- The Second Life tools allow for the (rapid) development of 3D prototypes. This, in combination with the presence of elementary economical principles and the opportunity to restrict access to certain areas, makes Second Life a suitable platform in which to conduct experiments.
- The number of avatars that can come together on one location without inducing serious performance problems is limited. Roughly speaking this number is limited to 30 avatars for a single virtual island.
- Second Life appeared to be valuable in support of communication processes, however, the possibilities for interfacing and interaction with external systems are less developed, if not insufficient.
- Since Second Life is 'texture based', it is very well suited to store visual appealing graphical objects. However, the other side of this 'texture based' coin is that it is very difficult to store and retrieve data and information, not to mention knowledge in Second Life.

Aware of the limitations of our observation (single case, limited number of young participants), we nevertheless believe these preliminary insights illustrate that Second Life has the potential to contribute to the development of a community of learners, primarily through its communications support features and 3D user interface. However, owing to its limitations regarding interaction with external systems, as well as the limited opportunities it offers to store data and information, additional

technological and human interventions will be needed if the activities of the community require more than communications support alone - for example, knowledge management features. In Eliëns et al. (2007) we explored the use of Web services, not only as an enhancement to the functionality of our world(s), but, more importantly, also as an infrastructure for data repositories collecting information about users and their behavior.

## Implications for practice and policy making

The first idea that comes to mind, naturally, is to use Second Life to offer courses online. But, although we organized lectures in Second Life, this approach might be considered an outdated paradigm of learning in our virtual campus, where there might be more appealing alternatives. Similarly, using the virtual laboratory for experiments might not be the best way to offer courses, although, for example, we do intend to provide a 3D model of a living cell, allowing students to study the structure, functionality and behavior of organic cells in virtual space.

Considering the success of our multidisciplinary building team, it seems more worthwhile to take the cooperative effort of building as a model, and switch to a paradigm of learning in which in-game exploration and building plays an important role. It is no secret that many students enjoy gaming, and although some might think that gaming is a waste of time, many authors, including Gee (2003) and Vorderer & Bryant (2006), think that gaming and game-related efforts provide a form of *active learning*, allowing the gamer to experience the world(s) in a new way, to form new affiliations, and to prepare for future learning in similar or even new domains.

More importantly, owing to the intense involvement and the need to analyse game challenges, according to Gee (2003), gaming even encourages *critical learning*, that is to think about the domain in a meta-level as a complex system of interrelated parts, and the conventions that govern a particular domain, which Gee (2003) characterizes as *situated cognition* in a *semiotic domain*.<sup>14</sup>

## Implications for research

In this section, we will discuss the relevant research implications based on combining the exploratory findings obtained during the preliminary studies presented in the previous sections of this chapter and the findings derived from established pedagogical research. In our effort to identify which direction future research should take, we are,

at the same time, seeking to explore further its potential for e-learning. In doing so, we focus on the following three aspects which seem to be of particular relevance for further research on the pedagogical potential of virtual worlds, namely:

1. equality of participation,
2. involvement,
3. simulations.

### 1. Equality of participation

In the current body of pedagogical research (e.g. Rogoff et al., 1996), various approaches are discussed to transmitting knowledge to students, such as ‘adult-run’ (top-down), ‘child-run’ (bottom-up), or a ‘community of learners’ (COL) (reciprocal) approach. Particularly the latter, COL, is of interest in the context of virtual worlds. The characteristics of a COL are such that all participants are active, there is a shared responsibility, and no one is passive (Rogoff et al., 1996). This means that COL is based on equality. According to Hiltz et al. (2001), the active participation of all members in the collaboration process is necessary in order for students to deduce the lessons they had intended to learn from their studies.

In our preliminary research on Second Life’s pedagogical potential, we established a COL that, besides students and researchers at our university, included ABN AMRO, the Disabled Sports Foundation, and the Red Cross. These four parties collaborated with one another in order to share knowledge and learn from one another’s experiences. In this study, we found that the participants did not experience any feelings of hierarchal preference and that they treated each other as equals in the virtual community. The participants were evaluated according to the contribution they made to the final results. This process of equality may have been influenced by the fact that the participants were represented by their avatars, and did not display visual cues that signaled social status (Walther, 1995; Berdahl and Craig, 1995).

In order to make generalizations based on these preliminary findings about a virtual world’s potential for pedagogical use, it is necessary to conduct further research among a greater population to address questions such as: What determines successful ‘equality of participation’ of students in pedagogical projects employed in a virtual world? To what extent does the ability to control visual cues (i.e. physical appearance) in a virtual world diminish feelings that hinder equality of participation, such as hierarchy, power, and status? How do these visual controls contribute to successful learning? And, on a more technical note: To what extent does the accessibility of the Second Life medium stimulate equality of participation?

### 2. Involvement

To increase the success of a pedagogical project, it is of importance that students experience a sense of involvement. Without feeling involved, a student may not feel intrinsically motivated to do his or her best during the project (Paas et al., 2005). In the context of e-learning, Conole and Oliver (2007) state that the concept of involvement is rather complex and is situationally dependent on whether people maintain a certain degree of involvement. In their words: ‘Rather than being “types”, people should be understood as having a complex profile of engagement with technology, with other and with ideas’ (Conole and Oliver, 2007, p. 218). One theory that seeks to explain these underlying social psychological mechanisms of involvement is Baumeister and Leary’s (1995) ‘need to belong theory’. According to this theory, the ‘need to belong’ to a group, thus to feel *involved*, can be considered as a fundamental human motivation. Baumeister and Leary (1995) proclaim that this need presumably has an evolutionary basis, since some survival tasks are best accomplished by *group cooperation*.

In our preliminary research, we found that the game-like experience of Second Life in fact induced such feelings of involvement. For example, the Disabled Sports Foundation offered visitors of their location the opportunity to participate in a wheelchair race, and to ‘experience’ how it must ‘feel’ to be disabled (see figure 2.4). Furthermore, the 3D user interface positively contributed to the feeling of social presence (Walther, 1995), which, according to the participants, contributed to a feeling of being a team or a community.

In order to make generalizations based on these preliminary findings, it might be interesting to conduct further research on which characteristics of 3D virtual worlds induce involvement, and to examine whether a 3D virtual context influences involvement in an e-learning context in any way? Other interesting research issues in this context are: What personal characteristics determine the level of involvement induced by being present in virtual worlds? How can educational institutions anticipate on the underlying mechanisms in order to increase the success of learning? To what extent does the level of involvement in a virtual world project differ from that in a project in the real world? And how can these levels of involvement be reliably and validly measured?

### 3. Simulations

Simulations have been widely recognized as an efficient and effective way of teaching and learning complex dynamic systems (Parush et al., 2002, Lu et al., 1996, Plaisant et al., 199; Rose et al., 1998). According to Wagner (2008), the ability to simulate is one of the greatest benefits of virtual worlds.

In the pedagogical literature there has been a shift from top-down content delivery, towards student-centred models, with an increasing emphasis on the skills that support independent, self-motivated learning (Cullen et al., 2002; Rogoff et al., 1996). This is called the *constructivist* approach to learning (Conole and Oliver, 2007). Particularly virtual worlds offer the possibility of an alternative, constructivist perspective to traditional linear ways in which knowledge may be presented and understood (Doherty et al., 2006). Imagine, for instance, the concept 'apple'. In a two-dimensional (2D) world one would see a picture of an apple, whereas in a three-dimensional (3D) simulative world such as Second Life one would have the opportunity to view the apple as a 3D model, yet one would also have the ability to look inside the apple and observe the structure of the molecules contained in it (Doherty et al., 2006).

In other words, in a 3D environment such as Second Life, the students' understanding of complex concepts can be broadened as they are able to obtain 'first-hand experience' of how one such concept relates to another. This simulative of *immersive* experience is of high pedagogical relevance (Chittaro and Ranon, 2005). Antonietti and Cantonia (2000) demonstrated that some beneficiary effects of a 3D environment cannot feasibly be obtained in a traditional 2D environment. Their study indicated that when students were asked to evaluate an unfamiliar painting in a 3D environment in comparison to a 2D environment, their conceptual comprehension was increased (Antonietti and Cantonia, 2000).

Another immersive experience of virtual worlds such as Second Life is that they allow one to explore different roles, for instance in the context of MMORPGs (Knutsson et al., 2004). We have already conducted a business simulation in Second Life in which supply chain partners were supposed to play the role of the counterparts they were used to negotiating with in real life. The Waagsociety<sup>15</sup> in the Netherlands, for instance, uses Second Life as a platform to allow socially impaired children to practice their social interaction skills. Simulations in 3D virtual worlds typically allow for the playing of different roles, and as such contribute to learning through experimenting<sup>16</sup>. Relevant research questions in this context are: To what extent does roleplaying in 3D virtual environments contribute to successful learning? To what extent can the activities in Second Life improve skills that can be transferred to other group work in an educational and business setting? Which skills can, and which skills cannot, be transferred?

## Conclusions

In this chapter we have reported on our experiences in building a virtual campus, giving our university a presence in Second Life; and we have delineated the prospects of Second Life as a platform for education and research, embodying our university's credo: to be a *community of learners*. So far, based on our observations and experiences, we can conclude that Second Life can be employed to support communication processes in the context of community development. However, support for the integration of interactive interfaces with external systems is less developed in the Second Life systems' environment, and as such we need to reflect on the technical requirements that must be met to deploy Second Life effectively as a platform for education and research in the future. And, perhaps more importantly, what further research and paradigm of learning it is necessary to adopt in order to benefit from the full potential of virtual worlds in general and Second Life more specifically. We propose a research agenda which has a specific focus on the influence of virtual worlds on equality of participation and involvement in educational processes, and how virtual worlds can be deployed for educational experiments.

### (Endnotes)

- 1 [http://secondlife.com/whatis/economy\\_stats.php](http://secondlife.com/whatis/economy_stats.php)
- 2 [www.web3d.org](http://www.web3d.org)
- 3 [www.blaxxun.com](http://www.blaxxun.com)
- 4 [www.secondlife.com](http://www.secondlife.com)
- 5 [http://secondlife.com/whatis/economy\\_stats.php](http://secondlife.com/whatis/economy_stats.php)
- 6 Massively Multiplayer Online Role Playing Game
- 7 [www.worldofwarcraft.com/index.xml](http://www.worldofwarcraft.com/index.xml)
- 8 <http://everquest.station.sony.com/>
- 9 [www.machinima.org/](http://www.machinima.org/)
- 10 Technology that enables one to travel from one point to another without physically crossing the distance.
- 11 [www.abnamro.com](http://www.abnamro.com)
- 12 [www.rodekruis.nl](http://www.rodekruis.nl)
- 13 [www.fondsgehandicatsport.nl](http://www.fondsgehandicatsport.nl)
- 14 A domain, that is, in which signs and symbols and their interpretations are significant.
- 15 The Waag Society is an internationally renowned interdisciplinary media lab located in Amsterdam, which develops creative technology for social innovation ([www.waag.org](http://www.waag.org))
- 16 More information about this project, which is called *Selfcity*, can be found on: <http://www.waag.org/project/selfcity>



# 3



## Study 2

### Modelling the Metaverse: A Theoretical Model of Effective Team Collaboration in 3D Virtual Environments

#### Published as

Van der Land, S., Schouten, A.P., Van den Hooff, B. & Feldberg, F. (2011). Modelling the Metaverse: A Theoretical Model of Effective Team Collaboration in 3D Virtual Environments. *Journal of Virtual Worlds Research*, 4(3), 1-18.

## Abstract

In this paper, a theoretical model of effective team collaboration in 3D virtual environments is presented. The aim of this model is to enhance our understanding of the capabilities exerting influence on effective 3D virtual team collaboration. The model identifies a number of specific capabilities of 3D virtual worlds that can contribute to this team effectiveness. Compared to “traditional” computer-mediated collaboration technologies, 3D virtual environments support team collaboration primarily through (a) the shared virtual environment, and (b) avatar-based interaction. Through the shared virtual environment, users experience higher levels of presence (a feeling of actually “being there”), realism and interactivity. These capabilities increase the users’ level of information processing. Avatar-based interaction induces greater feelings of social presence (being with others) and control over self-presentation (how one wants to be perceived by others), thus increasing the level of communication support in the 3D environment. Through greater levels of information and communication support, a higher level of shared understanding is reached, which in turn positively influences team performance. Our paper concludes by presenting several propositions which allow further empirical testing, implications for research and practice, and suggestions for future research. The insights obtained from this paper can help developers of these virtual worlds to design standards for the capabilities that influence effective team collaboration in 3D virtual environments.

## Introduction

Increasing competition, globalization of markets, and the rampant geographical dispersion of organizations make it more and more important for organizations to enable team collaboration regardless of time and place (Lipnack & Stamps, 2000; Lurey & Raisinghani, 2001; Maznevski & Chudoba, 2000). With the advent of worldwide connectivity through the Internet and the advancement of digital technologies, the use of virtual teams, due to their feasibility and cost-effectiveness, is becoming commonplace in organizations (Martins, Gibson & Maynard, 2004). Virtual teams are teams that work together on a common task, independent from geographical, temporal and relational boundaries, supported by information and communication technologies (Lipnack & Stamps, 2000). Up until now, most scholars investigating virtual teams have focused on text- and data-based technologies, such as group support systems, that allow teams to work together virtually (Zigurs & Buckland, 1998). With the rise of three-dimensional (3D) virtual environments, however, it seems that richer forms of collaboration in virtual teams can be supported. Thus far, however, there is no systematic analysis of how these environments can contribute to improved collaboration in virtual teams. To fill this gap, this paper develops a theoretical model to explain how three-dimensional virtual environments may support virtual team collaboration.

3D virtual environments might offer unique opportunities for virtual collaboration. 3D virtual environments are defined as “online electronic environments that visually mimic complex physical spaces, where people can interact with each other and with virtual objects, and communicate via avatars - a digital representation of themselves” (Bainbridge, 2007, p. 472). The potential of such a rich and engaging medium for knowledge sharing and virtual collaboration has been recognized by both practitioners (e.g. IBM) and academics (Wilson, 2009). Academics have started to examine, for instance, how virtual doctor-patient consultations might benefit from the aspect that 3D virtual worlds resemble face-to-face communication in a way that no other medium has ever done before (Bainbridge, 2007; Maged, Lee, & Steve, 2007).

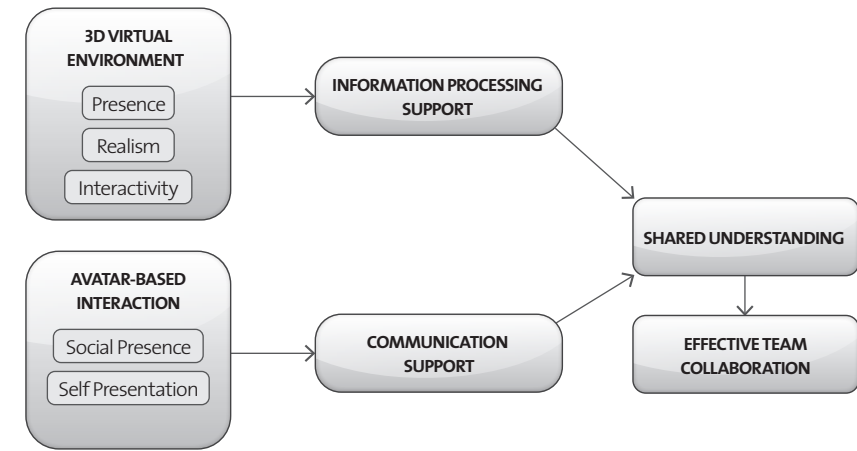
Despite this increasing attention paid to 3D virtual environments in the literature, less attention has been paid to how the unique capabilities of 3D virtual environments might affect virtual team collaboration (Konsynski, 2007; Kahai, Carroll, & Jestice, 2007; Roche, 2007). For effective team collaboration, two types of communication tasks need to be performed (Dennis et al., 2008). First, information about the task at hand needs to be transmitted and processed by individual members of the group, a process called information support. Second, group members need to communicate socially-related information and need to reach a common understanding based on

the individually-processed information, which is called communication support. To date, there is no theoretical model of 3D virtual environment that takes into account the unique media capabilities of 3D virtual environments for supporting these two processes. Existing frameworks of virtual worlds are generally too broad to be applied to virtual team collaboration, as they include a wide range of characteristics of which only some are relevant in this context (Messinger et al., 2009).

Therefore, the purpose of this paper is to present a theoretical model specifically focused on the effectiveness of 3D virtual team collaboration. For practice, this paper is relevant for developers of 3D virtual worlds, as they can use the insights derived from this framework in order to design standards for the capabilities that influence team collaboration in 3D virtual environments. In building our theoretical framework, we use insights from media synchronicity theory (Dennis et al., 2008), theories on CMC (Short et al., 1976; Walther, 1996) and group decision support literature (DeSanctis & Galuppe, 1987). Our central assumption is that characteristics of 3D virtual environments support both information and communication processes (Dennis et al., 2008). That is, 3D virtual environments support information processes because 3D virtual environments allow the ability to manipulate and present information that is relevant for forming mental models of a certain situation (Rosenhead, 1989). Communication processes are supported because 3D virtual environments allow for rapid and rich communication and the strategic manipulation of avatars, giving great control over common information that is transmitted. This will help teams in reaching a shared understanding and mutual agreement. These two processes, in turn, are likely to enhance effective team collaboration. In Figure 3.1, our theoretical model is presented which shows the components that we argue are fundamental in exerting influence on effective team collaboration (i.e., collaboration through which the team achieves its purposes) via 3D virtual environments.

### Capabilities of 3D virtual environments to support team collaboration

Compared to traditional technologies that support team collaboration and decision making, the specific capabilities that 3D environments provide, result from two unique characteristics derived from these environments that might support team collaboration (Davis et al., 2009): (1) the 3D environment in which participants are immersed, and (2) the avatar-based interaction through which all communication in 3D virtual environments takes place. In Table 3.1 the five capabilities that are offered through these two characteristics are presented in comparison to traditional collaboration technologies. This is further explained below.



**Figure 3.1** Theoretical model depicting how capabilities of 3D virtual environments affect information processing and communication processes, leading to shared understanding

#### 3D virtual environments

The first characteristic of 3D virtual environments that might support team collaboration is the 3D environment itself. A 3D environment offers many visual cues: the environment can be a city, a street, a building, a meeting or conference room, an airport, a tropical island – whatever the preferred design is. Virtual worlds also offer the possibility to integrate different applications into the interaction – for instance, a video can be shown on a screen in a virtual room, a Power Point presentation can be displayed, and so forth. Moreover, 3D virtual environments offer the ability to manipulate the 3D design for task relevant purposes. For instance, in the context of spatial planning issues, the medium allows users to virtually walk through a hotel lobby or sushi bar, which has yet to be constructed in real life, and to personally experience the final result.

According to Suh and Lee (2005), the shared environment in 3D virtual environment offers three capabilities that could affect team collaboration: presence, realism, and interactivity.

**Presence.** First, 3D virtual environments offer a greater degree of ‘presence’ than traditional technologies (e.g. Instant Messaging and email) that support team collaboration. According to Witmer & Singer (1998), presence consists of both immersion and involvement. Immersion is the extent to which one feels perceptually surrounded in the virtual environment rather than ones physical surroundings (Banos et al., 2004; Guadagno et al., 2007; Witmer and Singer, 1998). Involvement relates to



**Figure 3.2** The lobby of a Starwood hotel in Second Life (Jana, 2006)

“focusing one’s energy and attention on a coherent set of stimuli or meaningfully related activities and events in the environment” (Witmer & Singer, p. 227). 3D virtual environments could stimulate immersion because they offer a higher level of stimuli and experiences than other, less rich environments, leading to a stronger feeling of being immersed in the environment. Moreover, 3D virtual environment may stimulate involvement because participants are attentive to relevant visual cues the environment offers that might help them process information (Grigorovici, 2003; Scaife & Rogers, 2001).

**Realism.** Second, realism is the extent to which one believes the virtual environment is real (Davis et al., 2009). Davis et al. (2009) argue that representation and rendering are important technological capabilities of 3D virtual worlds, both of which refer to the process of creating life-like images on screen as well as to how realistically objects are represented in the three-dimensional space. For instance, in a virtual environment one can navigate through the environment to virtually experience physical locations that do not (yet) exist in real life, for example a virtual representation of an architectural design. Compared to 2D representations, 3D virtual environments offer more cues and provide a higher degree of reality, which might positively affect information processing (Daft et al., 1986; Scaife et al., 2001).

Interactivity. Third, 3D virtual worlds offer a higher level of interactivity than many traditional collaboration technologies. Interactivity refers to the capability to move and navigate through a virtual environment in contrast to examining static 2D or 3D images the environment (Bishop et al., 2001), and the ability to interact with and control the environment in real time (Fox et al., 2009). For example, 3D virtual environments such as Teleplace allow people to give presentations in and interact with the environment by using tools such as a shared whiteboard and a shared presentation space. Second Life also offers a basic scripting language which allows one to program interactions with the environment (Wirth et al., in press). Because 3D virtual environments are highly interactive, users are active rather than passive in their engagement with the information, which may lead to more effective information processing (Pimentel et al., 1994). In conclusion, these arguments lead to the following proposition:

P1. Compared to traditional collaboration technologies such as Instant Messaging, email and group decision support systems, virtual team members will experience higher levels of (a) presence, (b) realism and (c) interactivity in a 3D virtual environment.

### Avatar-based interaction

The second characteristic of 3D virtual environments that provides capabilities that might support team collaboration is the avatar-based interaction through which all communication takes place. In 3D virtual environments, people are represented by avatars, virtual representations of themselves in a variety of forms (Yee, Bailenson, Urbanek, Chang, & Merget, 2007). Based on Yee et al. (2007), we define avatars as “a digital representation of one’s identity.” Avatar-based interaction is a rich form of interaction in which team members can use a variety of cues to communicate, such as text-based chat, audio, pre-recorded animations (e.g., dance moves, gestures). Moreover, most virtual environments allow participants to create and adapt their own avatar. This also allows team members to add cues to their communication, such as clothing style and physical appearance. Two capabilities related to avatar-based interaction may especially support team collaboration in virtual environments: social presence and control over self presentation through the ability to manipulate avatars. These two capabilities are discussed below.

**Social presence.** Social presence is generally defined as the awareness of being present with others in a mediated environment combined with a certain degree of attention to the other’s intentional, cognitive, or affective states (Biocca & Harms, 2002; Green & Taber, 1980). Avatar-based interaction offers a wide array of symbol sets: it is synchronous, uses text or voice interaction, and offers more cues than text-based

interaction, such as gestures, avatar appearance and avatar behavior. These cue-rich forms of interaction could enhance social presence (Short et al., 1976). Moreover, people in virtual worlds also experience co-presence because they feel they are in a world together (Biocca et al., 2002). Combining the feeling of being together with possibilities for rich interaction, social presence thus relates to the extent to which participants feel that the team members who are interacting within the 3D virtual environment are really present in that environment.

**Self-presentation.** 3D virtual environments offer great control over the appearance of one's avatar. Self-presentation is an important social process in everyday life (Goffman, 1959; Leary, 1995). However, in real life there are physical boundaries that limit one's ability for strategic self-presentation. Online, these boundaries exist to a lesser extent. People have more freedom to present themselves the way they would like to (Ellison et al., 2007). These opportunities for strategic self-presentation also exist in 3D virtual environments through the manipulation of avatars. For instance, avatars can be manipulated to look like real-life representations of the participants, or, conversely, to be made anonymous and similar to other team members' avatars. Choices made with regard to avatar manipulation will affect the level of identification (with the avatar, and/or with the team), group dynamics and collaboration within the team. Thus, the increased possibilities offered for self-presentation in 3D virtual environments through avatar manipulation is an important capability in terms of team collaboration effectiveness. In Table 3.1 below, a comparison of different media on all of the five capabilities is presented.

**Table 3.1** Comparison of Selected Media and their Capabilities

	Presence	Realism	Interactivity	Social Presence	Self Presentation
3D virtual worlds	High	High	High	High	High
Video conference	Medium-High	High	Medium	Medium-High	Medium
Instant Messaging	Medium	Medium-Low	Medium	Medium	Medium-High
Telephone Conference	Medium-Low	Low	Medium-Low	Medium-Low	Low
Email	Low	Low	Low	Low	Low

Together, these arguments lead to the following proposition:

- P2. Compared to traditional collaboration technologies, virtual team members will experience higher levels of (a) social presence and (b) control over their self-presentation in a 3D virtual environment.

### Information processing and communication support in 3D virtual environments

We propose that the above capabilities of 3D virtual environments could support team collaboration. To identify the processes through which the capabilities of 3D virtual environments support effective team collaboration, we first turn to the literature on group support systems. Group support systems are "A set of communication, structuring and information processing tools that are designed to work together to support the accomplishment of group tasks" (Zigurs & Buckland, 1998, p. 319). Research generally distinguishes three ways in which group support systems could facilitate team collaboration:

- Communication support: the support of group members' capabilities to communicate with each other,
- Information processing: the support of group members' capabilities to gather, share and process information
- Process structuring, support of the process by which group members interact, such as agenda setting, facilitation and creating records (Zigurs & Buckland, 1998, p.319, Desanctis & Galuppe,1987).

The specific capabilities of 3D virtual environments are likely to support primarily both communication and information processing. Specifically, the presence, realism, and interactivity that a 3D virtual environment offers, aid information processing for tasks that require visual and spatial components. Avatar manipulation and social presence offered by avatar-based interaction will provide communication support. Thus, our general assumption is that, compared to traditional collaboration technologies, the specific capabilities of a 3D virtual environment will imply that such an environment offers higher levels of information processing and communication support.

### Information processing capabilities

We will now elaborate on why the capabilities presence, realism and interactivity experienced in 3D virtual environments will lead to greater information processing.

First, presence may increase information processing because team members feel immersed and involved in the 3D environment. For example, when team members are actually present in the environment, they may feel more immersed and involved in the



decision task about a spatial planning issue (Schouten et al., 2010; Grigorovici, 2003; Scaife & Rogers, 2001). As such, they are more devoted to giving attention to the source of information, which is the primary prerequisite to how thoroughly information is processed (Lamme, 2004; Ledoux, 1998).

Second, realism could support information processing because the more one experiences the 3D virtual environment as being real, the better one is able to make visualizations and understand the desired outcome of a team task (Baker et al., 2009). Visualization aids (e.g. 3D representations of buildings, charts, images) are extremely powerful in simplifying complex issues and tend to minimize the chance of having divergent interpretations by group members (Rosenhead, 1989). Thus, the higher degrees of realism experienced in a virtual environment are positively related to depth and effectiveness in information processing (Grigorovici, 2003; Scaife & Rogers, 2001).

Thirdly, the interactivity offered by 3D virtual environments might stimulate information processing because the environment is perceived as more natural than 2D representations (Zhou et al., 2007; Tavanti & Lind, 2001). Scholars found that dynamic, moving cues resulted in more attention than static cues (Cheal & Chastain, 1998) and that interaction attributes, such as movement can be more easily detected and processed (Khakimdjanova & Park, 2005). Because 3D virtual environments are highly interactive, users are active rather than passive in their engagement with the information, which could lead to more effective information processing (Pimentel et al., 1994). Together, these arguments lead to the following proposition:

P3: The higher levels of (a) presence, (b) realism and (c) interactivity experienced in a 3D virtual world relative to traditional collaboration technologies will lead to a higher level of information processing in these environments.

### Communication support

Avatar-based interaction in a 3D virtual environment can offer communication support to teams working together on a task, for the following reasons:

First, social presence offers communication support because it enhances the social-relational processes needed for effective team collaboration. Avatar-based interaction in virtual worlds offers immediate feedback, multiple cues to be transmitted simultaneously, and a wide range of symbol sets to communicate. Therefore, avatar-based interaction is a rich form of interaction, which is a prerequisite for establishing interpersonal relationships (Short et al., 1976). For example, Ducheneaut et al. (2006) conducted a longitudinal study on the social dynamics within the 3D virtual game World of Warcraft (WoW). Their research revealed that social presence, the “realness” of interacting with

other people in the virtual environment in WoW, was the main attraction for most players to the game.

Second, self-presentation through avatar manipulation may be strategically employed by teams to maximize team collaboration and team outcomes. In order for teams to be willing to collaborate and to share information needed to complete a task, team members need to feel as if they are part of their team (Sassenberg 2002, Tajfel et al., 1972). Manipulating avatars' appearance, by for instance giving team members avatars that look similar to each other, may lead to this form of belonging (Brewer, 1979; Oakes & Turner, 1980). It may also lead to more equal participation in a virtual project (Postmes, Spears, Sakhel, & de Groot, 2001; Straus, Miles, & Levesque, 2001) and result in more original solutions in a team task (Connolly, Jessup, & Valacich, 1990). Bailenson & Beall (2006) morphed (digitally manipulated) a team manager's avatar face in order to represent equally a division of his three team members real-life facial features. Their research showed that this resulted in the manager being perceived as more sympathetic and credible (Bailenson & Beall, 2006). Based on Walther's (1996) hyperpersonal theory, the combination of higher social presence and increased control over self-presentation in 3D environments could lead to hyperpersonal effects, creating increased social attraction among team members. Therefore, we argue that the strategic manipulation of avatars offers communication support.

P4. The higher levels of (a) social presence and (b) self-presentation experienced in a 3D virtual world relative to traditional collaboration technologies will lead to a higher level of communication support in these environments.

### Information processing and communication support, shared understanding and effective team collaboration in 3D virtual environments

According to Dennis et al. (2008), both information processing support (conveyance) and communication support (convergence) are necessary in order for a team to reach a shared understanding. Shared understanding refers to reaching a common understanding of a task or problem, an understanding of each other's viewpoints (Weick, 1985), and an overlap in possible solutions (cf Hinds & Weisband, 2003; Swaab et al., 2002). Information processing is necessary for shared understanding as task-related information needs to be shared and processed in order for each team member to create an individual understanding of a task. Achieving an individual understanding of task-related information is the first step to reaching a shared understanding (Corning, 1986; Weldon & Bellinger, 1997). Communication support

contributes to shared understanding since the outcomes of the conveyance processes (i.e., the individual understanding) need to be shared and communicated in order to reach a common understanding (Dennis et al., 2008). Moreover, Driskell et al. (2003) stress that in order for teams to collaborate successfully team members do not only need to perform well on task-related functions, but they must also work well together socially as a team. Therefore, communication support also entails the social-relational aspects of team collaboration (Buss & Kenrick, 1998). In sum, in order to reach shared understanding, information processing and communication support is necessary because teams must (a) share task-related information in order to form an individual understanding of a team task, and (b) share and discuss the outcomes of this individual process in order to reach a common understanding. Therefore, we offer the following proposition:

P5. The higher levels of a) information processing and b) communication support experienced in a 3D virtual world relative to traditional collaboration technologies will lead to a higher level of shared understanding in these environments.

### Shared understanding and effective team collaboration

Shared understanding, in turn, is considered to be a prerequisite for effective team collaboration (Matthieu et al., 2000; Swaab et al., 2002; Thompson & Fine, 1999; Tindale & Kameda, 2000). Group members are likely to process any information about the task at hand from a shared viewpoint, which facilitates task performance, especially in decision making and negotiation tasks (Swaab et al., 2002; Thompson & Fine, 1999; Tindale & Kameda, 2000). Furthermore, shared understanding is an important prerequisite for positive group outcomes such as cohesion and other task performance measures (Mohammed & Ringseis, 2001).

The concept of effective team collaboration can be broken down into two major constructs: performance and satisfaction (Gladstein, 1984; Lin et al., 2008; Lurey & Raisinghani, 2001; McGrath, 1984). Performance is the actual outcome that is generated by the collaboration process, an output measure that rationally and objectively measures whether earlier defined goals have been achieved. For instance, when outcome refers to productivity level, it can be measured objectively by the sheer quantity of products a team has produced. Alternatively, when outcome refers to the decision a team has made as result of collaborating, performance, it is measured in a more subjective way (e.g. by asking a manager or customer to rate the quality of the decision (Galegher & Kraut, 1990).

Satisfaction refers to how team members themselves have experienced the process of collaboration (Lin et al., 2008). Satisfaction is viewed as a more emotional, subjective

measure that reflects how the team members have experienced the process of collaboration. Satisfaction is strongly related to performance (Kirkman, Rosen, Tesluk, & Gibson, 2004; Montoya-Weiss, Massey, & Song, 2001). Satisfaction, however, is a subjective construct and captures the perceptions of the individual team members. Campion, Medsker, and Higgs (1993) demonstrated that satisfaction is a valid predictor of the team's effectiveness in terms of performance, since team members are central to the task, and thus subsequently directly influence the team's productivity. All in all, we expect shared understanding to be positively related to the components that together determine effective team collaboration. Thus, our final proposition is:

P6. The higher level of shared understanding in a 3D virtual world relative to traditional collaboration technologies will lead to a higher level of team collaboration effectiveness in these environments.

## Conclusion and future directions

In the previous section, we have presented our argumentation to support a theoretical model of effective team collaboration in 3D virtual environments. This argumentation leads us to expect that, compared to "traditional" collaboration technologies 3D virtual environments have a number of specific capabilities that could very well enhance the effectiveness of collaboration within virtual teams. The two main characteristics of virtual environments that support team collaboration are (a) the shared virtual environment, and (b) avatar-based interaction. The shared environment offers capabilities that support information processing during team collaboration. An increased presence in the environment leads to immersion in the world and involvement in the task, leading to more depth in information processing. The higher degree of realism and interactivity offered by the 3D environment also aids information processing when a task consists of visual or spatial components.

Avatar-based interaction offers capabilities that foster communication support in team collaboration. The social presence offered by avatar-based interaction enhances the feeling of being together and creates a willingness to share information and to cooperate. Moreover, the ability to control self-presentation through the manipulation of avatars might even increase communication support because, based on what the task requires, individual differences in a team can be accentuated or attenuated, which in turn allows for different forms of group attachment. More specifically, when avatars are homogeneous this could lead to common information being inflated, resulting in increased feelings of belonging to a group (Walther, 1996, Postmes et al., 1998). Both information processing and communication support can lead to a shared



understanding which, in turn, results in effective team collaboration in terms of performance and satisfaction.

### **Contribution to research**

Our model provides a theoretical basis for conducting empirical research on the potential of 3D virtual environments for team collaboration. Up until now, no research papers have provided a theoretical framework which could be empirically tested related to team collaboration in virtual worlds. Other frameworks of virtual worlds are generally too broad to be applied to online collaboration, including a plethora of virtual world characteristics that may or may not be relevant in certain circumstances (Messinger et al., 2009). Based on our model, we can specifically argue under which circumstances the capabilities of virtual worlds will lead to effective collaboration.

This article contributes to theory by building upon earlier models of computer mediated collaborative work, and media synchronicity theory in particular. We specifically show the capabilities that are offered by virtual worlds and how they can support either information processing (conveyance) or communication (convergence) processes. For example, when a task requires a common focus, it may be best to make all avatars look similar, as this draws attention to group commonalities, and will yield the best outcomes. On the other hand, if individual input is required for a task, it might be best to create avatars which are different from one another and resemble real life persona. Future research can empirically test the propositions of our model, which will lead to further understanding and development of both this theory, and the theory of media synchronicity in a virtual world context.

### **Implications for practice**

This paper identified the capabilities that influence effective team collaboration in 3D virtual environments. Based on the insights obtained from this paper, developers of virtual worlds can design standards for these capabilities to improve 3D virtual team collaboration. This could change long-accepted ways of working and interacting, and change how task-information is understood and how people socially interact with each other. As often is the case with new technology in its infancy stages, the question remains how the technology will eventually be used (DeSanctis & Poole, 1994). We believe that metaverse developers should think creatively about how the unique media capabilities of 3D virtual environments can be used for interaction, knowledge sharing and collaboration, rather than continuing to seek the simulation of face-to-face interaction across distributed sites and contexts. The challenge in understanding 3D virtual environments' potential for practice is to grasp what is different in terms of capabilities as well as their relationships to the foundational theories that have guided our thinking about virtual teams in the past.

# 4



## Study 3

### Lost in Space? Cognitive Fit and Cognitive Load in 3D Virtual Environments

Published as

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## Abstract

In this paper, we explore how visual representations of information in 3D virtual environments (3DVEs) supports both individual and shared understanding, and consequently contribute to group decision making in tasks with a strong visual component. We integrate insights from cognitive fit theory and cognitive load theory in order to formulate hypotheses about how 3DVEs can contribute to individual understanding, shared understanding, and group decision making. We discuss the results of an experiment in which 192 participants, in 3-person teams, were asked to select an apartment. As proposed by cognitive fit theory, our results indicate that 3DVEs are indeed more effective in supporting individual understanding than 2D information presentations. Next, in line with cognitive load theory, the static presentation of 3D information turns out to be more effective in supporting shared understanding and group decision making than an immersive 3DVE. Our results suggest that although the 3DVE capabilities of realism, immersion and interactivity contribute to individual understanding, these capabilities combined with the interaction and negotiation processes required for reaching a shared understanding (and group decision), increases cognitive load and makes group processes inefficient. The implications of this paper for research and practice are discussed.

Keywords: 3D virtual environment, Cognitive fit, Cognitive load, Individual understanding, Shared understanding, Group decision making

## Introduction

In 2006, Starwood Hotels was one of the first chains to establish a hotel in the 3D virtual world Second Life (Jana, 2006). The purpose of this 3D visualization was to gain feedback from potential customers about the hotel's design features. This feedback could then be incorporated in the physical design of the hotel, reducing the costs of building a prototype in real life. Currently, 3D modeling techniques for the design, construction and purchase of physical objects are becoming increasingly popular in different sectors, from real estate agents to IKEA (Morrisson & Skjulstadt, 2010), construction firms (Li et al., 2008) and architects (Boland, Lyytinen, & Yoo, 2007), manufacturers in the automotive and aerospace industry (Regenbrecht, Baratoff, & Wilke, 2005) and many others. While the product of interest may differ between these companies, the main implications of using a 3D tool is to help visualize the physical end results, be it a prospective IKEA kitchen, a newly built or renovated house, a car or an airplane. Basically, the idea is that visualization in a 3D virtual space helps provide a better understanding of what a product will look like in a physical space, how it will function, and what its most important design parameters will be.

Besides this individual understanding of the specifics of an object or environment, 3D visualization can also affect the shared understanding among members of groups, teams or innovation networks (Boland et al., 2007). The emergence of collaborative 3D virtual environments such as Second Life, Active Worlds and Teleplace has also made 3D visualization available for team work (Wirth, Feldberg, Schouten, Van den Hooff, & Williams, 2011). Group decision making in virtual teams can be enhanced by using 3D virtual environments because they offer a higher sense of social presence and provide multiple cues which, in turn, creates a higher degree of immersion in the environment (Schouten, Van den Hooff, & Feldberg, 2010).

In this paper, we explore how a 3D virtual environment can enhance group decision making by influencing both individual and shared understanding. Based on accepted definitions of "understanding", we define individual understanding as an individual's ability to perceive and comprehend the nature and significance of an object, task or situation (Anderson, 2000). Shared understanding refers to reaching a common comprehension of an object, task or situation, and an understanding of each other's viewpoints (Weick, 1985). Despite the growing business interest in, and use of, 3D visualization technologies, little empirical research has investigated how information presented in 3D virtual environments influences individual and shared understanding (Suh & Lee, 2005).

Previous research on consumer decision making in 3D virtual environments, for instance, showed that individuals tend to understand products better, prefer them to other products, and are more inclined to buy products when they are presented in 3D rather than in 2D (Daugherty, Li, & Biocca, 2008). Other studies investigate to what extent and under what conditions 3D virtual environments may support shared understanding and group decision making (Huang, Kahai, & Jestice, 2010; Kohler, Fueller, Stieger, & Matzler, 2011; Schouten et al., 2010). To the best of our knowledge, however, research has not yet addressed how both individual and group processes may be affected by 3D visualizations.

This is a relevant theoretical omission since group decision making is largely determined by the interaction between individual and group processes (Dennis, Fuller, & Valacich, 2008; Kwok & Khalifa, 1998). Although there has been a steady line of research on the social and emotional aspects (e.g. trust, group identification) impacting group decision making (Jarvenpaa & Leidner, 1999; Walther & Bunz, 2005), the scope of the present study is on cognitive processes. More specifically, there is an interesting difference in the cognitive processes required for individual understanding and shared understanding (Dennis et al., 2008; Weick, 1985). Generating individual understanding involves gathering a variety of information from a variety of sources, information which is subsequently subjected to slow retrospective examination to find patterns and draw conclusions. Reaching a shared understanding, however, requires examining others' individual understandings, and negotiations about these understandings so as to arrive at a mutually agreed-upon meaning (Weick, 1985). This requires a faster transmission and exchange of "distilled" information; information which has already been processed at the individual level (Dennis et al., 2008). Hence, the requirements placed upon the cognitive processing of information for individual or shared understanding are different, and the question is raised how the capabilities of 3D virtual environments relate to these requirements. Consequently, the scope of the present study is on these cognitive processes.

Two theories that can provide insight into the influence of 3D virtual environments on these processes are cognitive fit theory and cognitive load theory. Central to both these theories is the human mind and the limitations of working-memory capacity. The relevance of both these theories for this study is that they propose different strategies to present information (multiple representations) in a way that the information can easily be processed, and hence promote learning (Kirschner, 2002). On the one hand, cognitive fit theory poses that a match between the way information is presented and users' tasks enhances task performance (Goodhue & Thompson, 1995; Vessey & Galletta, 1991). Thus, in tasks where the visual element is important (such as designing or choosing a building, a kitchen or a car) a 3DVE may support understanding of the task at both the individual and the group level.

On the other hand, cognitive load theory states that learners' cognitive capacity may be overloaded by the richness of 3D virtual environments (Paas, Tuovinen, Tabbers, & Van Gerven, 2003). Being immersed in an information-rich environment (providing multiple cues about various aspects of the task), while at the same time discussing possible solutions in a team, may create too much cognitive input to be able to effectively process information and come to an understanding (Schrader & Bastiaens, 2011). Thus, for tasks with a strong visual component, cognitive fit theory and cognitive load theory seem to lead to diverging assumptions with respect to the possible contribution of 3D virtual environments to understanding and performance.

This paper contributes to the literature by empirically investigating how visual representation of information in 3D virtual environments supports both individual and shared understanding, and consequently contributes to group decision making in tasks with a strong visual component. In doing so, this study does not focus on the process of learning and learning outcomes, concepts which are traditionally related to cognitive load theory (van Merriënboer & Sweller, 2005). Instead, based on cognitive fit theory, we assume that 3D virtual environments may support individual understanding since these environments are able to provide the visual cues that help individuals comprehend the nature and significance of various elements of the tasks. At the same time, however, cognitive load theory leads us to assume that 3D virtual environments could impede the reaching of a shared understanding since the richness of information provided in these environments distracts too much from the communication process. The realism, immersion and interactivity of the visual cues that characterize a 3D virtual environment are likely to enhance the individual processing of visual information. Nevertheless, they are likely to slow down the sharing and transmitting of that information. We investigate this in an experimental setting in which the central task is one where the visual element is indeed important: the selection of an apartment. The participants face a task of selecting an apartment in three different conditions: a 2D condition (a floor plan), a 3D static condition (bird's-eye view from different angles) and a 3D immersive condition (in which they can navigate through virtual replicas of the apartments).

This study makes three contributions to research and practice. First, we seek to clarify the contradictory findings on the influence of 3D technology on individual and shared understanding (e.g., Beale, Kato, Marin-Bowling, Guthrie, & Cole, 2007; Schrader & Bastiaens, 2011) by integrating insights from cognitive fit theory and cognitive load theory. Secondly, we empirically investigate how 3D virtual worlds contribute to individual and shared understanding, and group decision making, by focusing on tasks with a strong visual component. This is an important contribution given the relative scarcity of experimental research on collaboration in 3D virtual environments and the

impact of these environments on individual and shared understanding (Davis, Murphy, Owens, Khazanchi, & Zigurs, 2009; LaFrance, 1982; Walsh & Pawlowski, 2002). Thirdly, this study generates design guidelines for effective virtual team collaboration. Guidelines yielded from our findings will enable practitioners to have a more informed understanding about which tasks are most conducive for virtual team collaboration.

This paper is organized as follows. First, we review the relevant literature on how the visualization of information in 3D virtual environments may support individual and shared understanding, and team decision making. Subsequently, hypotheses are established and tested empirically in an experiment conducted among 192 participants. Finally, we discuss our research findings and provide implications for research and practice.

## Theory and hypotheses

Three-dimensional virtual environments or 3DVEs are defined as “online electronic environments that visually mimic complex physical spaces, where people can interact with each other and with virtual objects, and communicate via avatars – a digital representation of themselves” (Bainbridge, 2007, p. 472). Based on Suh and Lee’s (2005) analysis of the role of virtual environments in enhancing consumer learning about products, three specific capabilities of such environments have been distinguished which are likely to affect information processing: realism, immersion and interactivity.

### 3DVE Capabilities: Realism, immersion and interactivity

First of all, realism refers to the extent to which one believes the virtual environment is real (Davis et al., 2009) – the degree to which one feels the virtual space represents the actual physical space. The extent to which a virtual environment is experienced as being similar to a non-virtual environment for which an actual decision is to be made, is expected to be relevant for its contribution to understanding and decision making. Davis et al. (2009) argue that representation and rendering are important technological capabilities of 3D virtual worlds, both of which refer to the process of creating lifelike images on screen as well as to how realistic objects are represented in the three-dimensional space. These capabilities are closely related to the concept of presence, which is defined as the perceptual illusion of non-mediation (Blascovich, 2002; Lombard, 2000). For instance, in a virtual environment one can virtually experience physical locations that do not (yet) exist in real life, for example, a virtual representation of an architectural design. Compared to 2D representations, 3D virtual environments offer more cues and provide a higher degree of reality, which may positively affect information processing (Daft & Lengel, 1986; Scaife & Rogers, 2001).

Secondly, 3D virtual environments are immersive. Immersion is the extent to which one feels perceptually surrounded in the virtual environment rather than one’s physical surroundings (Guadagno, Blascovich, Bailenson, & McCall, 2007; Witmer & Singer, 1998). In a 3D virtual world, users are represented in the environment by means of their avatars, enabling them to move around and interact with the 3D virtual environment. This creates a higher level of stimuli and experiences in 3D virtual environment than in other, less rich environments, which leads to a stronger feeling of being immersed in the environment (Witmer & Singer, 1998; Verhagen, Feldberg, Van den Hooff, Meents, & Merikivi, 2012). This immersion, in turn, may lead to users paying more attention to relevant stimuli in the environment, aiding information processing (Kim & Biocca, 1997).

Thirdly, 3D virtual worlds offer a high degree of interactivity, which is the capability to interact with and control the environment (Fox, Arena, & Bailenson, 2009). Interactivity refers to the ability to move and navigate through a virtual environment in contrast to examining static 2D or 3D images of the environment (Bishop, Wherrett, & Miller, 2001). Because 3D virtual environments are highly interactive, users are active, rather than passive in their engagement with the information, which may lead to more effective information processing (Pimentel & Teixeira, 1994).

### 3DVE Capabilities and individual understanding

As argued above, the 3DVE capabilities of realism, immersion and interactivity are likely to positively influence information processing. Such information processing is often perceived as an antecedent to learning (MacInnis & Jaworski, 1989), or individual understanding. The way in which individuals process information is primarily determined by the amount of attention they are willing to devote to the source of information (Lamme, 2004; Ledoux, 1998). Most dual-processing models (Fazio & Towles-Schwen, 1999; Petty, Gleichter, & Jarvis, 1993) claim that deliberate cognitive processing only occurs if a person is motivated and has the opportunity to engage in the effort of thoroughly analyzing the information content. When motivation and opportunity are lacking, information processing is assumed to take place on a more implicit, tacit and unconscious level (Petty et al., 1993). Because 3D virtual environments are highly realistic, immersive, and interactive, this is likely to have a beneficial effect on the extent to which users are engaged and to which they pay their attention to the information they are processing, which leads to a greater individual understanding of the presented information than in less immersive environments.

Cognitive fit theory posits that if a match is realized between the users’ tasks and visual presentation of information, this will lead to greater individual understanding (Vessey, 1991). Vessey and Galletta (1991) have shown that 3D representations aid

spatial recognition, which is essential for sense making of physical spaces. Moreover, 3D graphs outperform 2D graphs in terms of understandability (Kumar & Benbasat, 2004). Therefore, cognitive fit theory would suggest that representing a physical space in a 3D virtual environment would lead to more effective information processing concerning the space compared to 2D representations, subsequently resulting in a better understanding of the physical space (Goodhue & Thompson, 1995; Vessey & Galletta, 1991).

Realism, immersion and interactivity have been shown to be positively related to depth and effectiveness of information processing, which is related to understanding (Grigorovici, 2003; Scaife & Rogers, 2001). We therefore argue that the capabilities of 3D virtual worlds in terms of realism, immersion and interactivity, can enhance individual understanding about the object to be investigated, namely the apartment in this study (Kim & Biocca, 1997; Li, Daugherty, & Biocca, 2003). Building on that, we expect that participants in the 3D immersive condition in our experiment (expected to score highest in terms of realism, immersion and interactivity) will show the highest level of individual understanding. This then leads to the following hypotheses:

*Hypothesis 1:* Realism, immersion and interactivity will positively influence individual understanding.

*Hypothesis 2:* Compared to the 2D floor plan condition, individual understanding will be higher in the 3D static condition, and it will be the highest in the 3D immersive condition.

### 3DVE Capabilities and shared understanding

During the past decade, a broad line of research has devoted attention to how groups, teams and networks gain an understanding of phenomena that is not merely grounded on the individual level, but also shared among group members (Cannon-Bowers, Salas, & Converse, 1993; Klimoski & Mohammed, 1994; Swaab, Postmes, Neijens, Kiers, & Dumay, 2002; Wegner, 1987). This broad scholarly interest in notions of shared understanding in groups has resulted in an equally broad conceptualization. For example, the terms mutual understanding (Postrel, 2002), intersubjectivity (Plaskoff, 2003), team mental models (Klimoski & Mohammed, 1994) transactive memory systems, (Wegner, 1987), and shared mental models (Cannon-Bowers et al., 1993) have all been concepts that are closely related to an understanding of phenomena that is grounded in individual cognition as well as shared among members of groups. The difference between, for instance “intersubjectivity” and the concept of “transactive memory systems”, is that intersubjectivity refers to “shared meanings” achieved through interactions between people, whereas transactive memory systems commonly refers to “knowing who knows what” (Wegner, 1987).

In this study, shared understanding refers to reaching a common comprehension of an object, task or situation, and an understanding of each other’s viewpoints (Weick, 1985). This definition has been chosen as it explicitly acknowledges that shared understanding requires the examination of others’ individual understandings, as well as coming to a mutually agreed-upon meaning among team members. In other words, the greater the extent to which team members envision the problem in a similar way and are on par with each other about a possible solution, the greater the degree of shared understanding they will experience (Swaab et al., 2002). Such shared understanding, in turn, is often found to be positively related to team performance and decision making (Cannon-Bowers, Salas, & Converse, 2001). In order to relate the 3DVE capabilities of realism, immersion and interactivity to shared understanding, we turn to cognitive load theory.

Cognitive load theory is concerned with “the manner in which cognitive resources are focused and used during learning” (Chandler & Sweller, 1991, p. 294). The importance of cognitive load theory in relationship to shared understanding lies in the fact that the theory can provide insight into ways of presenting information that enhances performance. Cognitive load theory is especially relevant in light of the fact that, as argued above, reaching a shared understanding requires the rapid transmission and exchange of less detailed information (interaction), as opposed to the slow, in-depth processing required for individual understanding. At the centre of cognitive load theory is the human memory system, in particular the relationship between limited working memory and unlimited long-term memory (Anderson, 2000). This implies that learning depends on the efficiency of the use of available, but also the limited cognitive capacity that learners bring to learning task (Schraeder & Bastiaens, 2011). Cognitive load is determined by the relationship between such cognitive capacity on the one hand, and the amount of cognitive processing required for a task on the other.

The triarchic theory of cognitive load (Sweller, 1999, 2005) argues that there are three kinds of cognitive processing that can contribute to cognitive load: (a) extraneous processing, referring to processing that does not support the task objective but results from inappropriate task design (for instance, providing too few or too many cues), (b) intrinsic processing which is essential for task understanding and is related to task complexity, and (c) germane processing which refers to deep cognitive processing such as mentally organizing task elements and relating this to prior knowledge, influenced by motivation and prior experience. The 3DVE capabilities of realism, immersion and interactivity are likely to influence the cognitive load experienced when conducting tasks, especially in terms of extraneous processing since they are related to the design of the task, and not to its inherent characteristics or to the participants’ motivation or experience. As argued above, these characteristics lead to



the processing of more cues (realism), and stimuli (immersion), in a more active way (interactivity). On the one hand, it could be argued that the simultaneous presence of team or group members in a 3DVE will contribute to reaching a shared understanding – members are simultaneously interacting with each other and the environment, which may lead to a convergence of their understandings of the environment. On the other hand, reaching a shared understanding requires not only information processing to create an individual understanding of tasks and objects, but it also requires communication in order to share these individual understandings and converge them into a shared understanding (Dennis et al., 2008; Van der Land, Schouten, Van den Hooff, & Feldberg, 2011). Thus, in reaching a shared understanding, extraneous cognitive load is increased by the 3DVE capabilities of realism, immersion and interactivity that lead to more active processing of more cues and stimuli. This increase in cognitive load does not mean that reaching an individual understanding is hampered, since this requires rich, yet slow information processing (Dennis et al., 2008). Reaching a shared understanding, does however, require processes of interaction, adjustment and negotiation, which are supported by leaner and faster information transmission (Dennis et al., 2008). This leads to the assumption that the combination of realism, immersion and interactivity in 3DVEs supports individual understanding, but that it creates an extraneous cognitive load which is too high to effectively support the process of reaching a shared understanding.

At the same time, however, it can be argued that extraneous processing is increased when the task design provides insufficient information about the task. As Münzer and Holmer (2009) argue, extraneous working memory load is increased when information is presented in an incoherent, or disparate way. Therefore, if the environment in which the task is to be conducted provides only very limited information about the actual space on which the task focuses, uncertainty will increase and participants will have to integrate information from other sources (their own assumptions, other participants' opinions, external sources) into their processing effort. The split-attention effect (Kalyuga, Chandler & Sweller, 1999) argues that such integration efforts indeed lead to a higher extraneous cognitive processing load.

In conclusion, we expect that the combination of 3DVE capabilities and the requirements in terms of interaction and negotiation will result in a higher extraneous cognitive load in a 3DVE than in other conditions. We also expect that the limited information in the 2D condition will require more extraneous processing of external information, subsequently leading to a higher cognitive load. As higher extraneous cognitive load has been found to negatively influence performance (Chandler & Sweller, 1991), and shared understanding has been found to positively influence team decision making (Cannon-Bowers et al., 2001), we expect decision performance to be

higher where cognitive load is lower. In a decision making task in which there is no correct answer (such as the one in our experiment), appropriate measures for team performance include consensus about the group decision (Swaab et al., 2002), and the time needed to reach a decision (Adams, Roch, & Ayman, 2005; Hinds & Weisband, 2003).

Consequently, we expect the extent to which a shared understanding is reached to be highest in the 3D static condition compared to both 2D and 3DVE, and we expect that team performance (in terms of consensus and decision time) will also be higher in the 3D static condition than in the other two conditions. In other words, we expect the 3D static condition to represent an “optimal cognitive load”, combining the advantage of 3D representation in terms of information processing with the advantage of not overloading team members so as to hamper reaching a shared understanding. Therefore, we pose the following hypotheses:

*Hypothesis 3:* Cognitive load will be lower in the 3D static condition than in the 3D immersive condition and the 2D condition.

*Hypothesis 4:* Compared to the 3D immersive condition and the 2D condition, (a) shared understanding and (b) consensus will be higher in the 3D static condition, and (c) decision time will be lower in the 3D static condition.

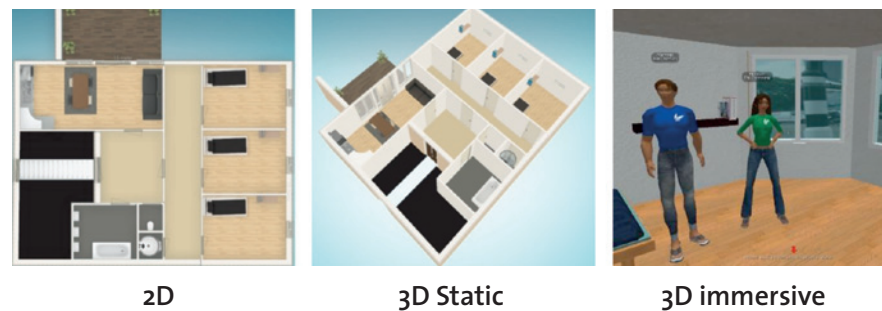
## Method

To test our hypotheses, we conducted a laboratory experiment in which the central task was the joint choosing of an apartment in teams of three participants. We compared three experimental conditions which differed in the degree of realism, immersion and interactivity: (1) a 2D condition in which the participants saw a 2D floorplan of the apartments, (2) a 3D static condition in which participants had a bird's-eye view of the apartments and were able to view the apartments from four different angles, and (3) a 3D immersive condition in which the participants could navigate through virtual replicas of the apartments from a first-person perspective in a 3D virtual environment. A visual presentation of these conditions is provided in Fig. 4.1.

## Participants

Participants were students who were enrolled in an undergraduate course in Business Administration. A total of 192 students participated in the experiment (68.80% male), with a mean age of 19.88 (SD = 1.55), ranging between the age of 18 and 28 years old. Most of the participants considered themselves to be experienced with text-based





**Figure 4.1** Visual presentation of the apartments in the three conditions

CMC (5.85 on a 7-point scale) and most participants had experience with instant messaging (84.9%). 36 participants were familiar with virtual worlds, most notably World of Warcraft ( $n = 13$ ). Participants received course credits for participating in the experiment.

### Task

Participants were given a situation in which they had to select one of three apartments that were to be shared with two other students. This apartment selection task is a common task in behavioral decision making research (e.g. Payne, 1976) as well as in IS research (e.g. Todd & Benbasat, 1992, 1999). Other research on decision making support in the context of spatial planning employed a similar set up (e.g., Chu & Eric, 2000; Payne, 1976; Swaab et al., 2002). Moreover, the task reflects a real life situation for most students.

Participants first viewed each of the three apartments (A, B, and C) individually, after which they made a choice regarding one of the three apartments and filled in a short questionnaire about their decision processes. Subsequently, the participants were teamed up in groups of three. They were told that the three of them were to share the apartment together and that they should decide which of the three apartments would be best for them to share. After the team made a final decision regarding one of the apartments, participants were again asked to fill out a short questionnaire. In this way, both individual information processing and group decision making could be studied.

The three apartments differed in terms of seven characteristics, all of which could be represented visually: the size of one's own room, the window size, the outside view, the kitchen, the communal space, the outdoor space, and the bathroom facilities (see Table 4.1). These characteristics were distributed evenly among the apartments so that there was no obvious best alternative. The apartments were similar in all other

ways. They were all part of the same apartment block and cost the same rent and has the same amenities. The floor plan of the apartments is shown in Appendix 4A.

The experimental task matches our research goals in that the successful completion of the task relies on assessing the valence and the importance of the apartments' characteristics based on the visual information provided. The task consists of an individual phase and a team phase, both representing the individual understanding and shared understanding elements of a team task. First, the participants are to individually form an understanding based on new information. Then afterwards, they need to reach a shared decision concerning one of the apartments with their team members.

### Experimental design and procedure

Sixty-four 3-person teams were randomly assigned to one of the three experimental conditions: 2D condition ( $n = 60$ ), 3D static condition ( $n = 63$ ), and 3D immersive condition ( $n = 69$ ). In the 2D condition, participants were shown a two-dimensional floor plan of the apartments on a computer screen. The 3D static condition showed a three-dimensional model of the apartments on a computer screen so that the participants had a bird's-eye view of the apartments. The participants could rotate the 3D models so that the apartments could be viewed from different angles, allowing for more depth and detail. The virtual world Second Life was used to create the 3D immersive condition in which the participants could navigate through virtual replicas of the apartments from a first-person perspective that allowed them to investigate the spatial and visual dimensions of the apartments.

One week before the experiment, participants were asked to enroll for a specific time slot. Precautionary measures were taken to avoid that subjects who were acquainted with one another enrolled in the same session. Nine participants were scheduled during a single time slot. These nine participants were randomly spread across three teams, so the participants would not know with whom they would be interacting. After the participants had signed a non-disclosure statement, they received written and oral instructions related to the experimental procedures and the decision making task. After receiving the general instructions, the participants were distributed among three different computer rooms, so that all of the participants of a team were physically separated from one another. Each computer room was supervised by an instructor. During the experiment, all instructions were provided on-screen.

The experiment consisted of two phases. In the first phase of the experiment, which was aimed at the individual decision making process, participants viewed the apartments individually, after which they individually chose for an apartment,

**Table 4.1** Apartment characteristics

	Apartment A	Apartment B	Apartment C
Own room's size	3 rooms of 12m <sup>2</sup> each	3 rooms of 16m <sup>2</sup> each	3 rooms of 20m <sup>2</sup> each
Window size	Small window in student rooms (42x50cm)	Door + large window in student rooms (130x190cm)	Window bay with three large windows (250x190cm)
View	A great view over a canal	Small garden and balconies of other apartments	A busy road
Kitchen	Shared simple open kitchen of 5m <sup>2</sup> in the communal space	Shared luxurious closed kitchen (10m <sup>2</sup> ), with room for a dinner table	Shared closed kitchen of 10m <sup>2</sup>
Communal space	Shared communal space of 15m <sup>2</sup> (including kitchen)	No communal space	Separate communal space of 15m <sup>2</sup>
Outdoor space	Shared rooftop terrace of 15 m <sup>2</sup>	Student rooms have a small private balcony (1x2.5m)	No outdoor space
Bathroom facilities	Shared toilet and bathroom	Sinks in student rooms, shared toilet and bathroom	Private shower and toilet in each room

followed by a short questionnaire. In the second (team) phase of the research, the participants teamed up in 3-person groups and had to reach a shared decision about which apartment to choose. All of the groups interacted using a text-based chat application similar to an Instant Messaging application. Team members were identified by generic nicknames that were assigned to them by the chat application based on the participant's gender. Participants were asked to enact their roles as being a student on the lookout for a shared apartment. They were asked to use their nicknames consistently and to not ask for each team member's real names. The teams had 30 min to make the decision about the apartment. All of the teams managed to reach a decision within this time limit.

In the 2D and 3D static conditions, the groups interacted using text-based chat that was provided in a browser window using a java-based chat applet. The groups could also view the apartments while chatting, in a similar fashion as during the individual phase. In the 3D immersive condition, participants virtually met up with their "future roommates" in the hallway connecting the three apartments. From the hallway they could walk to the three apartments to view these again when needed. The groups interacted using the text-based chat function available in Second Life. The team

members were identified with avatars which were of average attractiveness and who were uniformly dressed wearing a T-shirt and jeans. Participants were assigned a male or female avatar depending on their gender. After a team's choice was recorded, a post-experiment questionnaire opened automatically.

## Measures

### Manipulation checks

Unless otherwise indicated, all items were measured on a 7- point scale ranging from 1 (completely disagree) to 7 (completely agree). All scales and items employed in this study are listed in Appendix 4B. Cronbach's alphas are listed in Table 4.2. As a manipulation check, realism, immersion, and interactivity were measured. These scales were also used as independent variables in the testing of hypothesis 1. Realism was measured with six items based on the naturalness scale by Witmer and Singer (1998) and assessed the extent to which the participants thought that the apartments had been displayed realistically and accurately. We used five items to measure immersion based on the scales by Kim and Biocca (1997) and Nichols, Haldane, and Wilson (2000). The items in this scale measured the extent to which participants experienced a feeling of "being there" whilst being in the virtual environment. Interactivity was measured with three items based on the scale by Sundar and Kim (2004) and the involved/control subscale by Witmer and Singer (1998). The items investigated measured the extent to which the participants felt that the system allowed them to interact with, and control, the environment.

### Outcome variables

Individual understanding was adapted from Zigurs, Buckland, Connolly, and Wilson (1999). The seven items assessed the extent to which participants thought they had been able to collect all the information they would need in order to make a correct decision regarding the apartments. Cognitive load was assessed with a single item which asked the extent to which participants experienced the decision making process as difficult (Paas, van Merriënboer, & Adam, 1994). The scale ranged from 1 (not difficult at all) to 7 (very difficult). Shared understanding was measured with four items measuring the extent to which group members understood each other's viewpoints and had a shared perception of the decision task (Swaab et al., 2002). Consensus was measured with five items that asked the extent to which participants had agreed with the decision made by the group and how convinced they were that the best solution had been chosen (Green & Taber, 1980; Jarvenpaa, Rao, & Huber, 1988). Finally, the time the teams took to reach a shared decision was automatically recorded by the system.

## Data analysis and results

### Correlations and manipulation checks

The correlations between the constructs in our analyses are shown in Table 4.2. For manipulation checks and the testing of hypotheses 2, 3 and 4, we conducted one-way ANOVAs with Tukey B correction for post hoc tests. Table 4.3 compares the means of all outcome variables across the three conditions. The results of our manipulation checks showed that the three conditions were found to differ in realism,  $F(2, 189) = 6.46, p = .002, \eta^2 = .064$ , immersion,  $F(2, 189) = 16.88, p < .001, \eta^2 = .152$ , and interactivity,  $F(2, 189) = 61.83, p < .001, \eta^2 = .396$ . Post-hoc analyses showed that the 2D condition was seen as less realistic and interactive than the 3D static and 3D immersive conditions (see Table 3). There was no difference between the 3D static and 3D immersive condition in how realistic or interactive the apartments displays were perceived. The 3D immersive condition was judged to be more immersive than the 3D static and 2D conditions. In conclusion, the results showed that the 3D static and 3D immersive conditions differed only in how immersed the participants felt while viewing the apartments. Both 3D conditions were seen as more realistic and interactive than the 2D condition.

**Table 4.2** Correlations between variables

	1	2	3	4	5	6	7	8
1 Realism	.87							
2 Immersion	.48**	.87						
3 Interactivity	.52**	.47**	.75					
4 Cognitive load	-.05	-.04	.11	-				
5 Individual understanding	.71**	.43**	.55**	-.03	.87			
6 Shared understanding	.01	-.02	.01	-.07	.48**	.82		
7 Consensus	.01	-.08	.01	.03	.39**	.65**	.93	
8 Decision Time	.10*	.16*	.18*	.14*	-.33**	-.21**	-.20**	-

\*  $p < .05$ ; \*\*  $p < .01$ ; values on the diagonal are the Cronbach's alpha's of the scales.

Hypothesis 2 posed that individual understanding would be the lowest in the 2D condition, higher in the 3D static condition and the highest in the 3D immersive condition. This hypothesis was partially supported. The analysis showed that there was a significant main effect between the three conditions for individual understanding,  $F(2, 189) = 3.50, p = .032, \eta^2 = .036$ . Post-hoc analyses (Tukey B) only

**Table 4.3** Variable means across the three conditions

	2D (n=60)	3D static (n=63)	3D immersive (n=69)
	Mean (SD)	Mean (SD)	Mean (SD)
Realism	4.36 <sup>a</sup> (1.03)	4.88 <sup>b</sup> (0.92)	4.95 <sup>b</sup> (1.03)
Immersion	2.74 <sup>a</sup> (1.05)	2.99 <sup>a</sup> (1.12)	3.83 <sup>b</sup> (1.20)
Interactivity	3.20 <sup>a</sup> (1.09)	4.76 <sup>b</sup> (1.06)	5.03 <sup>b</sup> (0.82)
Cognitive load	4.42 <sup>a</sup> (1.77)	5.68 <sup>b</sup> (1.32)	4.54 <sup>a</sup> (1.55)
Individual understanding	4.72 <sup>a</sup> (1.14)	5.09 <sup>ab</sup> (0.83)	5.15 <sup>b</sup> (0.96)
Shared understanding	5.43 <sup>a</sup> (1.17)	6.01 <sup>b</sup> (0.94)	5.17 <sup>a</sup> (0.98)
Consensus	6.32 <sup>ab</sup> (1.04)	6.56 <sup>b</sup> (0.81)	6.10 <sup>a</sup> (0.86)
Decision time	9:36 <sup>a</sup> (5:46)	8.16 <sup>a</sup> (3:34)	15:22 <sup>b</sup> (5:33)

Note. Different superscripts indicate significant differences among the three conditions with  $p < .05$  with Tukey's B correction. Decision time displayed in minutes:seconds

revealed a significant difference between the 3D immersive condition and the 2D static condition, with the 3D static condition not differing from either of the other two conditions. However, since the difference between the mean scores in the 2D and 3D static conditions is considerable (.37), we also checked other post hoc tests to explore the differences between these conditions. Both Least Square Differences ( $p < .05$ ) and Tukey HSD ( $p < .10$ ) indicate that these conditions do differ (at least at the  $p < .10$  level), whereas Bonferroni ( $p = .12$ ) shows the difference to not be significant. Hence, our conclusion is that the 2D and 3D static conditions differ considerably, but not at a consistently significant level.

Hypothesis 3 predicted that cognitive load would be lower in the 3D static condition than the 3D immersive and the 2D condition. This hypothesis was supported,  $F(2, 189) = 12.78, p < .001, \eta^2 = .119$ .

Finally, hypothesis 4 formulated the expectation that shared understanding and consensus would be higher in the 3D static condition than in the 2D condition and the 3D immersive condition, and that decision time would be lower in the 3D static condition than in the 2D condition and the 3D immersive condition. The results mostly supported this hypothesis. First, the shared understanding was higher in the 3D static condition than in the 2D condition and the 3D immersive condition, with the latter two conditions not differing on this variable,  $F(2, 189) = 11.44, p < .001, \eta^2 = .108$ . Consensus also differed between conditions,  $F(2, 189) = 4.27, p = .015, \eta^2 = .043$ . Post-hoc

analyses revealed that the 3D static condition resulted in a higher consensus than the 3D immersive condition, with the 2D condition in between. Finally, decision time was higher in the 3D immersive condition than in the other two conditions, which did not differ between themselves,  $F(2,189) = 36.80$ ,  $p < .001$ ,  $\eta^2 = .280$ . All in all, the results showed that the performance in the 3D immersive and 2D condition was lower than in the 3D static condition.

## Discussion

By integrating insights from both cognitive fit theory and cognitive load theory, our study provides clarification into the mechanisms underlying the contribution, (or lack thereof, of 3D virtual environments to individual and shared understanding, as well as group decision making.

The results of the experiment indicate that 3D virtual environments contribute to the individual understanding for those tasks which include a visual component (e.g. selecting an apartment). The mechanisms underlying this contribution are the 3DVE's capabilities of realism and interactivity. Contrary to our expectations, it appeared that immersion was not of influence on individual understanding as anticipated by previous research (Suh & Lee, 2005). Next, although we do see a clear trend in terms of both 3D conditions scoring higher than the 2D condition, the difference in increasing individual understanding was only significant between the 3D virtual environment and the 2D condition. These findings are largely in line with cognitive fit theory which proposes that in order to generate individual understanding for a task which involves visual representations of physical spaces, a rich environment, such as a 3D virtual environment is more effective.

The results of the experiment's group decision making phase, however, showed that the 3D static environment contributed to a greater shared understanding among team members than a 3D virtual environment did. In the 3D static condition the participants significantly reported to be "more on par with each other about the group's final decision" and shared "more similar views of the problem" while conversing with their team members via the chat-application than in the other conditions. This finding supports the notion of cognitive load theory which states that shared understanding was higher in the condition in which the participants experienced an optimal extraneous cognitive load (e.g. 3D static), whereas a higher cognitive load was reported in the 3D immersive environment and the 2D condition. Finally, when it comes to performance, the condition with the lowest cognitive load (3D static) outperformed the 3D immersive condition in terms of consensus and decision time.

## Theoretical implications

This study contributes to theory in numerous ways. First of all, this one of the first studies to empirically investigate how both individual and shared understanding are affected by 3D visualizations of information for group decision making tasks. This is an important contribution due to the relatively scarcity of this research in the field of virtual team collaboration (Davis et al., 2009; LaFrance, 1982; Walsh & Pawlowski, 2002) and consumer learning (Suh & Lee, 2005).

Secondly, we have integrated both cognitive fit theory and cognitive load theory in order to explain the contribution of a 3D virtual environment to group decision making tasks on physical spaces. With this theoretical integration, our study helps to clarify the contradictory results that were found in earlier research (e.g., Beale et al., 2007; Schrader & Bastiaens, 2011). For instance, cognitive fit theory explains how 3D representations can aid spatial recognition, which supports individual understanding in tasks in which the spatial element is relevant (Schrader & Bastiaens, 2011; Suh & Lee, 2005). Cognitive load theory, on the other hand, explains how the combination of realism, interactivity and immersion can create an extraneous cognitive load that, in combination with the cognitive processing required for group processes, in the end negatively influences group processes (Paas et al., 2003).

Drawing on cognitive fit theory (Vessey & Galletta, 1991), our results show that greater individual understanding is reached when information is presented in 3D virtual worlds. This finding corresponds to previous research on consumer learning in 3D virtual environments (Suh & Lee, 2005). Another reason why this individual understanding was greater in the 3D virtual environment might be attributed to the virtual experience of the participants navigating through a rich, immersive environment. This "virtual experience" could have generated greater emotional and motivational engagement, which may have lead to greater information processing and learning as earlier research pointed out (Li et al., 2003; Grigorovici, 2003; Scaife & Rogers, 2001). In this way, our findings can have theoretical implications for theories on the self-regulation of learning, motivational and emotional processes in 3D virtual environments.

In terms of cognitive load theory, our findings on group decision making are somewhat less straightforward and have interesting implications. Our findings demonstrate that the mechanisms which create a higher extraneous cognitive load are vastly different in the 3D immersive condition than in the 2D condition. Where uncertainty is the main driver for cognitive load in the 2D condition, overload would seem to be the main driver in the 3D immersive condition. In the 3D immersive condition, the extra cues and stimuli that a rich environment offers only seem to distract from the group

process, leading to decreased performance. Where individual understanding requires the slow processing of rich information, the interaction and negotiation required for shared understanding build on the fast exchange of leaner information (Dennis et al., 2008). Hence, we conclude that the combination of realism, immersion and interactivity in 3DVEs supports individual understanding, but the interaction and negotiation requirements raise the extraneous cognitive load, which in turn appears to undermine the process reaching a shared understanding.

In the 2D condition, however, the lean information provided by the 2D floorplan in itself is insufficient to fully understand the task (hence the low score on individual understanding). This necessitates that the participants turn to other sources of information (their own assumptions, others' understandings, external sources) and that they integrate these sources into their processing. In that sense, the situation can be compared to a split-source format (Cierniak, Scheiter, & Gerjets, 2009), in which information that is needed to conduct a task is dispersed across different sources. The processing required to integrate this information (from different sources, in different formats) creates a higher extraneous cognitive load (Chandler & Sweller, 1996; Kalyuga et al., 1999). This corresponds to the inverted U-shaped relationship between information load and performance: beyond a certain optimum cognitive load, more information leads to less performance (Schroder, Driver, et al., 1967).

The results from this study also have implications for Daft and Lengel's Media Richness Theory (1987). Our study did not provide support for Media Richness Theory's assumption that rich media is more efficient when performing equivocal tasks (such as group decision making). This research suggests another decision rule for group decision making: when task performance relies on both group communication and task-information processing, media which requires lower cognitive demands should be selected (e.g. a 3D static environment). Our finding is in line with prior research which demonstrates that Media Richness Theory has difficulty predicting the efficiency of new media usage (Dennis & Kinney, 1998).

Finally, our findings are in line with a central assumption regarding Media Synchronicity Theory or MST (Dennis et al., 2008). According to this theory, any task that requires team collaboration (e.g., decision making, knowledge sharing or negotiation) consists of two fundamental communication processes (Weick, 1985). The first is conveyance, which is viewed as the transmission of new information that is primarily related to individual understanding. The second process is convergence, which refers to the discussion of preprocessed information contributing to shared understanding. Our findings in terms of cognitive fit and cognitive load echo the assumptions that conveyance (i.e., reaching an individual understanding) requires an in-depth processing of

a variety of information, whereas convergence (i.e., coming to a shared understanding), is characterized by the faster transmission of more abstract information. Moreover, by using cognitive fit and cognitive load theory as a framework for the analysis of these processes, our study provides a new and more in-depth explanation (relative to MST) for the differences between conveyance and convergence.

### Practical implications

From our findings the following implications and contributions to practice have emerged. Firstly, practitioners who seek to design a virtual environment which fosters individual understanding should first determine how to present the relevant information attributes of the product or task as clearly as possible. For instance, if an architect seeks to convince a client of the end results of a rather radical and controversial design solution for his/her home (e.g. sacrificing a bedroom to become a kitchen), the architect will be more likely to do so by using a 3D virtual world representation. When a person can virtually navigate through this new kitchen, and see and "feel" how this positively affects the dimensions in his/her own house, the personal experience will be greater, leading to a greater impact on the person's understanding of the design solution. Translating this into concrete design guidelines, it is imperative for practitioners to comprehend that the features implemented in the design should directly aim at enhancing participants' understanding. This will improve individual understanding and foster decision making.

However, as for group decision making, our study results suggest that using a 3D virtual environments does not necessarily improve decision making. For instance, for tasks in which a decision needs to be made regarding different options by a team or group (e.g. a comparison between different products), it is more efficient and effective to use 3D static representations. In such representations, an overview and images of relevant spaces and objects from different angles can be provided (such as a 3D static representation), which also allows participants to discuss their opinions.

Our results also suggest that teams need to employ different technologies in different phases of the group decision making process. In phases involving a group process in which creating an individual understanding of a space or object is primarily important, an immersive 3D virtual environment can be very valuable. In phases of the group process in which negotiation processes are important, technology support should be aimed at team interaction rather than further information processing. These technologies should mainly provide communication support with only a few possibilities for information processing, because this could distract from effective team interaction (Zigurs & Buckland, 1998).

### Limitations and further research

This study has several limitations. First, college students were used as a convenience sample. Although these were students of Business Administration, they do not represent the professionals who are currently using virtual environments for dispersed work. Hence, we should be cautious when generalizing these findings to practice. On the other hand, this research is more focused on understanding the processes involved in group decision making than on generalizability. Moreover, given that the task of collectively selecting an apartment as future flat-mates is a rather common task among students, we are less concerned with using students as a sample. Still, future research is needed to confirm our findings using different samples and tasks.

Second, for the purpose of empirical testing, we selected and thus isolated the mechanism of processing task-related information as an outcome measurement. Hence, we did not explore the actual interaction processes between team members in the different conditions leading to their final choice in selecting an apartment interaction. In a future study, a content analysis of the chat conversations could be conducted to investigate how the process of sharing of experiences took place. Moreover, to fully understand effective group decision making and shared understanding, more social variables should be taken into account as well. It would be interesting, for instance, to study the interaction effects of social variables by focusing on the manipulation of avatar appearances. Subsequently, we could study which tasks would be the most useful to manipulate avatar appearance, such as e.g. negotiating or brainstorming.

Our study highlights three important issues for future researchers. First, more effort should be placed on examining the specific aspects of a task, and how 3D virtual environments can support this process. Second, we believe that 3D virtual environments should be studied more intricately by focusing on the capabilities of the medium. Third, since this study did not focus on the process of learning and learning outcomes in 3D virtual environments concepts traditionally related to cognitive load), further research is encouraged regarding this particular aspect.

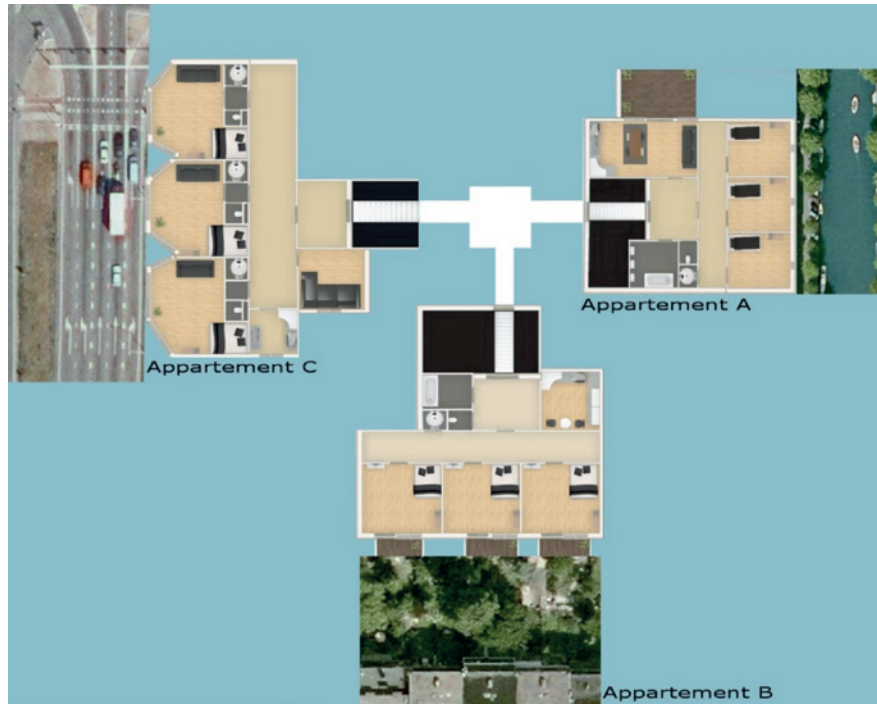
### Conclusion

This study investigated how the presentation of visual information in 3D virtual environments affects collaborative decision making. As proposed by cognitive fit theory, our results indicated that 3D immersive environments are indeed more effective in supporting individual understanding than the 2D information presentations. Next, in line with cognitive load theory, the 3D static information presentation

appears to be more effective in supporting group decision making than the 3D immersive environment presentation. The 3D static information presentation offers an optimal balance in supporting information processing and negotiation processes between team members. Our results suggest that teams need to employ different technologies during the different phases of the group decision making process. This can be achieved by focusing on efficient information processing when it comes to individual support, while at the same time focusing on efficient communication support when group processes are relevant. For tasks with a visual component, technologies should offer realistic and interactive presentation of the relevant information.



### Appendix 4A. 2D overview of the three apartments



### Appendix 4B. Survey items

Realism	<p>I felt the apartments were presented realistically.</p> <p>I got a good impression of the apartments.</p> <p>I think my mental image of the apartments resembles how they really are.</p> <p>I obtained a complete impression of the apartments.</p> <p>I felt the apartments were realistically displayed.</p> <p>Viewing the apartments this way resembled a real life visit.</p>
Immersion	<p>During the presentations of the apartments, I felt like being present in the apartments.</p> <p>During the presentations of the apartments, I felt I was in the world the system created.</p> <p>During the presentations of the apartments, I had the sense of "being there".</p> <p>When I finished viewing the apartments, I felt like I had returned from a real life inspection.</p> <p>To me, the virtual environment became a reality.</p>
Interactivity	<p>I could control the presentation of the apartments.</p> <p>I could view the apartments from many different perspectives.</p> <p>How interactive would you rate the presentation of these apartments in terms of the ability to navigate through it? (1 = non-interactive, 7 = very interactive)</p>
Individual understanding	<p>I was very well able to imagine the pros and cons of every apartment.</p> <p>The way the apartments were presented allowed me to estimate how appropriate each apartment was for me.</p> <p>I got a clear image of the pros and cons of every apartment.</p> <p>The way the apartments were presented enabled me to thoroughly examine the apartments.</p> <p>The way the apartments were presented helped me to collect the information necessary for the task.</p> <p>The way the apartments were presented offered insight in which information was relevant and valuable.</p> <p>The way the apartments were presented allowed me to choose the apartment that was most appropriate for me.</p>
Cognitive load	<p>How difficult was it for you and your team members to make a decision? (1 = very difficult, 7 = very easy)</p>
Shared understanding	<p>The members of my team were on par with each other.</p> <p>The members of my team were at one about the decision.</p> <p>The members of my team had the same view of the problem.</p> <p>The members of my team have pretty much the same opinions.</p>
Consensus	<p>I agree with my group's decision.</p> <p>I accept the outcome of my group's decision.</p> <p>I think we have made the right decision.</p> <p>I am satisfied with the result of our group decision.</p> <p>My team chose the best option.</p>

# 5



## Study 4

Does Avatar Appearance Matter? How Avatar's Representations Impact on Virtual Team Performance

## Abstract

This multi-method study aims to investigate the influence of avatar appearance on virtual team performance. This study is the first to integrate two contrasting frameworks: the social identity model of deindividuation effects (SIDE) and self-identification, by creating “morphed team avatars”; avatars whose appearances combine both a high degree of team similarity and self-identification. The results obtained from a 2 (similar vs. different team avatars) x 2 (avatar similar to self vs. different to self) experiment (n = 240) have confirmed the prediction that teams in the morph condition performed best on the task, and liked each other more than teams in the other three conditions. Moreover, content analysis showed that teams in the morph condition were significantly more committed to the task than the teams in the other three conditions. The implications of this study for theory and practice are discussed.

Keywords: avatars, decision making in virtual teams, self-presentation, similarity, self-identification, organizational communication.

## Introduction

Driven by globalization and the advent of the internet, working together in virtual teams has increasingly emerged (Martins, Gilson, & Maynard, 2004). Virtual teams are teams that work together on a common task supported by communication technologies, independent from geographical and temporal boundaries (Lipnack & Stamps, 2000). The strategic benefits of virtual teams for organizations are indispensable and include attracting the best experts from the globe to be part of the team (Townsend, DeMarie & Hendrickson, 1998) reducing time, costs, and the carbon footprint associated with travelling (Baskerville & Nandhakumar, 2007). Moreover, they sustain a better work-life balance (Fonner & Roloff, 2010). However, studies have shown that the potential advantages of virtual teams are challenged in many ways including the lack of cues (e.g. facial expressions, gestures, demographic information) offered in comparison to those that occur in face-to-face communication (Jarvenpaa & Leidner, 1998; Walther & Parks, 2002).

In virtual teams, communicating via an avatar may influence social interaction processes and team performance (Davis, Murphy, Owens, Khazanchi & Zigers, 2009; Bailenson, Yee, Merget & Schroeder, 2006). An avatar can be defined as an “online digital representation of the self” (Bainbridge, 2007, p. 472), and it often functions as a vehicle for generating first impressions, similar to how people’s appearances can generate first impressions in real life (Goffman, 1959). In computer-mediated communication (CMC), there are hardly any limitations which restrict how individuals can craft the appearances and identities of their avatars (Turkle, 1995). Not only highly realistic 3D avatars in virtual environments (e.g. SecondLife, World of Warcraft) can be seen as avatars, but also the more mainstream online self-representations on social network sites (e.g. a picture on LinkedIn, Facebook or VoIP services such as Skype) are regarded as avatar representations (Bailenson et al., 2006; Ellison, Heino, & Gibbs, 2006; Ong, et al., 2011).

There are two contrasting theoretical frameworks that might possibly explain how virtual team members could best be visually represented in online interactions. The first framework assumes that for team members to work together efficiently, it is best if they are represented similarly (e.g. with a similar avatar). According to the social identity model of deindividuation effects (SIDE; Lea & Spears, 1991), sharing a similar visual cue in an otherwise anonymous virtual environment can function in a similar way as, for example, wearing a uniform in face-to-face contexts (Tajfel and Turner, 1986). SIDE has its roots in social identity/self-categorization theory (Tajfel & Turner, 1986) and proposes that under the conditions of relative anonymity (e.g. absence of social cues in CMC) this sense of depersonalization magnifies the perceptions of the group, thus leading to a shift in focus from the individual to the social identity. Most

of SIDE-based computer-mediated communication (CMC) studies have shown that this anonymity can be accomplished through visual similarity, by diminishing the focus that people have on their individual differences, and increasing the salience of their group membership (e.g. Lea, Spears, & de Groot, 1998; Postmes, Spears & Lea, 2002; Postmes, Spears, & Lea, 1998). This, in turn, may lead team members to experience less conflict when working together on a task (Staples & Zhao, 2006). Thus team similarity, the extent to which team members' avatars look alike, may affect team performance.

The second framework, self-identification theory, argues that individual team members are more likely to contribute to team performance if they can identify with the avatar with whom they are represented in their virtual team. According to the so-called "proteus effect" (Yee & Bailenson, 2007), the appearance of your avatar can shape your behavior and social interaction with others. For instance, Yee & Bailenson (2007) found that when participants were assigned a taller avatar in a 3D environment, a more confident and aggressive behavior in negotiations was induced in comparison to when the participants had been assigned shorter avatars. Self identification may strengthen this effect, since studies have shown that when avatars are more physically similar to their users, they tend to identify more with them (Bailenson, Blascovich & Guadagno, 2008a). Thus self-identity, the extent to which one recognizes oneself in their avatar, might also affect team performance.

Up until now, these two contrasting theoretical perspectives posed a dilemma: for best performance it would be preferable if team members were similar to each other, while at the same time allowing each individual team member to recognize oneself in one's avatar. However, due to technological advancements such as morphing techniques, it might now be able to solve this dilemma as it is now possible to enhance both similarity and self-identity. Through digital software programs such as Fantamorph<sup>1</sup>, the facial similarity of team members can be created by means of blending their facial features based on their photograph (see DeBruine, 2002), and hence combining both similarity and self-identity.

In this study, we combined the two theoretical perspectives in order to answer the following research question: "How do similarity and self-identity in avatar representations influence team performance in virtual teams?" To answer this question, we analyzed whether the interaction of virtual teams which were visually represented by different avatars depending on the condition, had influenced complex group decision making, based on an experimental setup in combination with content analysis.

<sup>1</sup> Retrieved June 2011 from [www.fantamorph.com](http://www.fantamorph.com)

This study makes three contributions. First, as one of the few studies that investigates the implications of morphing technologies on team performance, our study can contribute to the field of knowledge concerning these phenomena. Second and closely linked, this study extends SIDE's theory by adding the dimension of *self-identity*. Previous studies drawing upon SIDE, assigned cartoonlike avatars to participants to study conformity behavior and the development of group identity (Kim, 2009; Lee, 2004). However, it remains unclear whether SIDE's proposed effects would also have occurred if the team had been represented by an avatar that partly reflected its individual members' *physical self*. Third, by coding the discursive practices of team interaction, this study goes beyond most traditional experimental virtual team studies that rely mainly on self-report data. In fact, by analyzing the actual content of the team interactions, we can gain an understanding of the process of team interaction, and we can observe the extent to which avatar representations exert an influence on communication behavior.

The remainder of this paper is structured as follows. First, we review the theoretical background of the avatar representation-performance link. Second, we describe the setup and results of the experiment we conducted to test our theoretical assumptions. Thirdly, a content analysis of the conversations between team members during the experiment has been conducted in order to explore the potential differences in discursive practices across the conditions that are more conducive to team performance. Finally, the implications of this multi-method study for theory and practice are discussed.

## Theory and Hypotheses

### The Role of Visual Similarity in Avatar Representations

In virtual team settings with limited cue availability, impressions based on the cues that are available may be stereotyped and magnified according to CMC theories such as SIDE (Lea & Spears, 1991) and the hyperpersonal model (Walther, 1996). For instance, if in a virtual team visual similarity between team members' avatars is the only cue available, this could generate a *hyperpersonal effect*, an effect which leads the participants to categorize each other in terms of a shared group membership and to judge each other as being more sympathetic, trustworthy and friendly (Walther, 1996; Walther, Slovacek, & Tidwell, 2001). Furthermore, similarity in physical appearance can strategically be altered via morphing techniques which influence behavior, and which is referred to as *transformed social interaction* (Bailenson & Beall, 2006). Bailenson, Iyengar, Yee and Collins (2008) found that even someone's voting preference for a politician can be influenced by digital mimicry: if a picture of a participant was subtly morphed into the

picture of a politician, participants considered the politician to be more favorable. As such, the similarity of avatars in a CMC environment can elicit strong effects.

The effects of similarity on performance are well-established in social psychological research. In accordance with the similarity-attraction paradigm (Byrne, 1997), individuals are attracted to similar others (Shanteau & Nagy, 1979). Similar others are also considered trustworthy (DeBruine, 2002; Donath, 2007). When team members meet each other face-to-face for the first time, first impressions are established in which the recognition of similarity (e.g., gender, ethnicity) plays a vital role in the team social process, and may impact team performance (Harrison, Price, & Bell, 1998). Although the diversity found in team members' knowledge and skills has been related to team performance in terms of creativity and innovation (see for a review, De Dreu, & Weingart, 2003), the team members' perceived similarity has also been associated with greater team commitment (Watson, Johnson, Kumar & Critelli, 1998), which could lead to enhanced performance (Dunlop & Beauchamp, 2011).

We expect team commitment to mediate the relationship between team similarity and team performance. Team commitment is operationalized in terms of three related variables, all of which may be positively influenced by being represented with similar avatars: social liking, trust and group identification (Haslam, Powell and Turner, 2000; Bailenson et al., 2008; Byrne, 1997; Tanis, & Postmes, 2005). First, Bailenson et al. (2006) demonstrated that *social liking* could be induced by morphing a participant's portrait with that of another participant. Second, similar avatars are considered as more trustworthy than non-similar avatars (DeBruine, 2002; Donath, 2007). Third, SIDE-based studies found that team members with similar avatars experience greater feelings of *group identity* than team members who were represented by different avatars (Kim, 2010; Lee, 2004). All in all, similarity may increase team commitment, which consists of social liking, trust, and group identification (Tajfel & Turner, 1986; Berscheid & Walster, 1979).

Team commitment, in turn, can mediate team performance. Teams with a more diverse composition often lack the commitment that is more present in high similarity teams (Watson et al., 1998). Particularly in complex tasks that cannot be tackled individually, the success of the team largely depends on the extent to which interpersonal relationships with team members are positive (Buss & Kenrick, 1998). Research has shown that the more team members are inclined to like each other socially, the more (quality) time they will naturally devote to social interaction (Berscheid & Reis, 1998). Thus, we suggest that the extent to which team members are represented similarly will affect team performance due to the mediating effects of team commitment. Therefore, we pose the following two hypotheses:

*Hypothesis 1a:* Greater degrees of team similarity will lead to higher levels of team performance.

*Hypothesis 1b:* Team commitment will mediate the relationship between team similarity and virtual team performance.

### The Role of Self-Identity in Avatar Representations

*Self-identity*, the extent to which people recognize themselves in their avatars, may also affect team performance. It has been argued that virtual teams perform best in rich environments that allow for a high degree of social presence (Daft & Lengel, 1986). Cues to identity (e.g., a picture of a team member versus a cartoon figure) can function as an important indicator to make sense of each other in online interactions, reducing anonymity and leading to higher levels of trust and performance (Kiesler, Zubrow, Moses, & Geller, 1985; Tanis & Postmes, 2005).

Furthermore, self-identification could stimulate individual team members to contribute more. Studies have shown that when avatars are more physically similar to their users, people tend to identify more with them (Kil-Soo, Hongki, & Eung Kyo, 2011; Bailenson et al., 2008a). When team members identify with their avatars, this could result in greater social presence, reducing the risk of dysfunctional group processes such as social loafing (Forsyth, 1999). Moreover, people may also feel more personally accountable for their performance because they cannot hide behind an anonymous avatar, which may cause people to put more effort into their task behavior (Forsyth, 1999).

Yee, Bailenson and Ducheneaut (2009) conducted numerous studies that showed how avatar's self-representation can influence performance, which he coined the "proteus effect". The proteus effect states that the appearance of an avatar can have an impact on its user's behavior. For instance, the participants assigned to taller avatars behaved more confidently and performed better on a negotiation task than the participants assigned to shorter avatars (Yee et al., 2007). Moreover, in a recent study, Fox & Bailenson (2009) found that the participants were more motivated to exercise when they saw an avatar which was similar to them losing weight, than when their avatars were dissimilar. Thus, there appears to be a link between self-identity and performance.

By adding the dimension of *self-identity* to our study, we propose that then more cues to identity will be available for team members so that they can make sense of each other. According to a cues-filtered-out perspective, more cues will lead to higher team commitment, thus evidenced in higher levels of trust (Rousseau, Sitkin, Burt, & Camerer, 1998), social liking (Kiesler, Siegel, & McGuire, 1984), and group identity



(Kiesler et al., 1985). Moreover, it has been argued that if an avatar resembles a person's perception of self in a virtual team collaboration setting, this person is more likely to focus closely on a task and to be more motivated to perform better (Kil-Soo, Hongki, & Eung Kyo, 2011; Cui et al. 2009; Galanxhi & Nah 2007). Thus, we suggest that the extent to which avatars represent the identity of the individual team members will affect team performance due to the mediating role of team commitment. Therefore, we propose the following two hypotheses:

*Hypothesis 2a:* Greater degrees of self-identification will lead to higher levels of team performance.

*Hypothesis 2b:* Team commitment will mediate the relationship between self-identification in virtual team performance.

### Interaction between Similarity and Self-Identification in Avatar Representations

Current technological progress enables us to combine the aforementioned frameworks. Via morphing techniques (e.g. using digital software programmes such as Fantamorph), an avatar can be created in which team members look alike, while also resembling their physical self. When combining the two frameworks discussed above, it would be best for virtual team members to be represented by an avatar that is both similar to all of the team members as well as uniquely representing each team member.

Combining both similarity and self-identification in an avatar can solve the tension between two opposing human needs. On the one hand, people seek to be different from others (Snyder & Fromkin, 1980), while on the other hand, they want to belong to the group (Baumeister & Leary, 1995). The need to be different from others is elaborated in uniqueness theory (Snyder & Fromkin, 1980), and refers to the human motive to maintain a sense of differentiation from others (Vignoles, Chryssochoou, & Breakwell, 2000). One is most at ease, when perceiving a moderate level of similarity between oneself and others (Snyder & Fromkin, 1980). However, the need to be part of the group is another human motivation (Baumeister & Leary, 1995). Not feeling accepted by others may lead to severe ill effects, such as depression (Baumeister & Leary, 1995). Thus, to improve team performance, a balance or an *optimal distinction* as Brewer (1991) postulates it, needs to be generated in an avatar between these two contrasting needs. Therefore, we hypothesize:

*Hypothesis 3a:* Teams who have a high degree in both team similarity and self-identity will perform better.

*Hypothesis 3b:* Team commitment will mediate the relationship between virtual team performance for teams who have a high degree in both similarity and self-identification.

## Method

### Sample

A total of 255 participants, with a mean age of 19.93 ( $SD = 1.60$ ) participated in our experiment. Of the participants, 69.6% were male and 30.4% were female. Participants were students enrolled in an undergraduate course in business administration. Participants were randomly assigned to one of the four experimental conditions. However, people with glasses were excluded from the morph condition, due to software program incompatibility issues. All teams were same-sex teams in order for the morphed avatar to be realistic.

To form teams, participants were randomly assigned to groups consisting of three members. Two groups were not included because the content analysis revealed that the team member's had revealed each other's identity. Three groups were not included because the groups could not reach agreement within the assigned time limit. Therefore, the final analyzes were based on 80 groups ( $n = 240$ ). The group, rather than the individual participant, was used as the unit of analysis, because the dependent variable reflected the performance of the group.

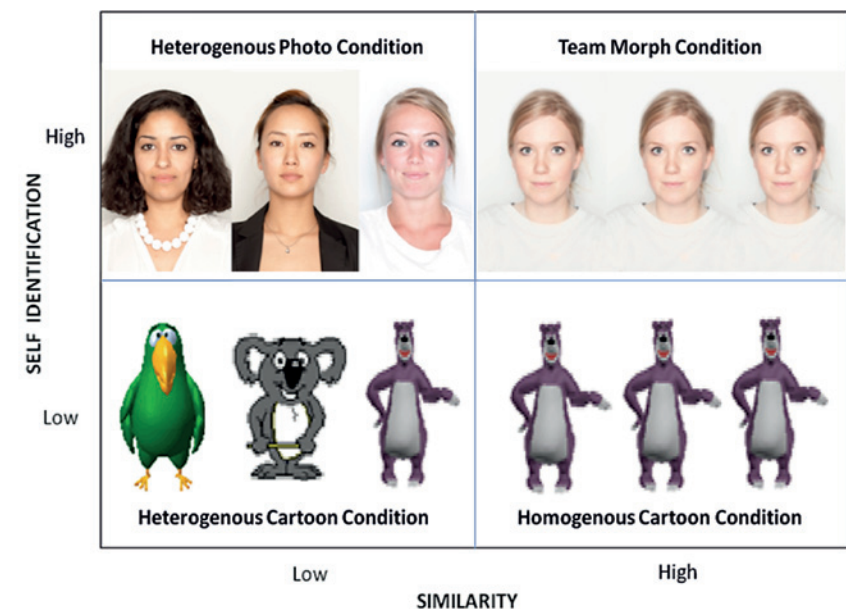


Figure 5.1 Visual Overview Of Conditions



### Experimental Design

This study employed a 2 (similarity: different vs. same avatar for all team members) x 2 (self-identity: cartoon vs. avatar similar to self) between subjects design (see Figure 5.1). Similarity was manipulated by representing team members with either heterogeneous or homogenous avatars. Self-identity was manipulated by representing individual team members with either an avatar that resembled them (i.e., a photo) or an avatar that did not resemble them (i.e., a cartoon character). The two cartoon conditions are identical to previous studies that used SIDE as a point of departure (Lee, 2004). Combining these two manipulations yields the four experimental conditions as visually depicted in Figure 1.

The conditions were created as follows. Two weeks prior to the experiment, a photo session was scheduled in order to take a portrait picture of each participant. All of the participants were asked to wear a white T-shirt in order to keep the clothing displayed on the picture consistent. Pictures of the participants were only needed for the two high self-identity conditions, but all of the participants had their pictures taken in order to reduce procedural bias.

For the first condition “morphed team avatar”, team members were identified using a morphed photo which was produced in a similar manner to that used in previous studies regarding facial resemblance (DeBruine, 2002), using Fantamorph as manipulation software. Team members were told that a “team morph” had been created that consisted of a blend of all three team member’s facial features. However, the shape and color of the participant’s face (their base identity) was blended with the face of a model from the same sex that was recruited from a different university. This was done to control for unwanted group interaction effects such as familiarity and attractiveness (Berscheid & Walster, 1979). The final team morph consisted of 60% of the participant’s self-face and 40% of the facial shape and color of the model. This division was used to increase the participant’s perception of self-identity (Kil-Soo, Hongki, & Eung Kyo, 2011). When necessary, morphed pictures were corrected by a graphic designer to make the morphs as realistic as possible (e.g. no conspicuous or odd features).

In the second condition (heterogeneous photo), each team member was identified using his or her own photograph. Team members saw their own photograph plus the supposed photographs of the other two team members. Again, to avoid confound effects due to being recognized by fellow students (Berscheid & Walster, 1979), these photographs were not the actual team members, but instead were models that had been recruited from a different university, which allowed us to ensure that no team members would recognize a fellow student as a team member. To emphasize the



Figure 5.2 Original and Morphed Faces

differences in individual appearance between the participant and the two same sex models, the models were chosen based on a contrast in hair color. For instance, a blonde female participant communicated with two brunette females, which were visually represented as team members in the chat. In total, a set of 8 models was created, consisting of two blond females and two blond males, plus two brunette females and two brunette males. These final 8 models were selected and rated from a larger set of 20 models by 3 judges as being the most neutrally attractive and sympathetic looking.

For the other two conditions, team members were represented as cartoon figures. The design of the cartoon figures was based on a previous experiment by Lee (2004). In line with the two conditions high in self-identity, we created a low and high similarity condition. In the low similarity / low self-identity condition, team members were represented by different cartoon characters (i.e., a bear, a bird and a mouse), and in the high similarity / low self-identity condition team members were represented with a similar cartoon character (i.e., a mouse).

### Task

For the experimental task, we used a hidden profile “murder mystery” task similar to the task employed by Stasser and Stewart (1992). Each participant received a booklet which included information about a homicide investigation. Three people are described as suspects in a murder investigation (Bram, Ed and Marcel). Twelve unique clues were equally distributed among the three team members’ booklets. Only by pairing the unshared information (i.e., the unique clues) teams would be able to correctly identify

one of the suspects as the actual killer (Ed), since otherwise they would identify one of the other suspects as the culprit. Therefore, this task allows for making inferences about the actual performance of the team (correct identification of the killer), but also about the decision making process (i.e., the actual information shared).

### Procedure

Upon arrival at the laboratory, the participants were told that the study was designed to investigate how groups make decisions. Participants were invited to take a place in front of a computer and to read the information booklet on the murder. They were then asked to individually identify the guilty suspect. Next, the participants were told that they were taking part in a real-time discussion with two students from the same university that had been situated elsewhere. In reality, their team members were their fellow classmates. This was done so participants would not try to find out which fellow students they were interacting with.

Before the interaction started, participants saw a welcome screen. Depending on the condition they were assigned to, they were introduced to their team's avatar or the individual team members' avatars. The participants were then logged in to a custom built text-based chat application in which they could hold a discussion with their fellow team members. To avoid unwanted hierarchical and recognition effects, the team members were identified not by their real names but by 'member X', 'member Y' and 'member Z'. Depending on the condition, the participants also saw their team's avatar or the team members' avatar at the top of the screen, and smaller icons of these avatars on the left side of the screen. Teams could discuss for a maximum of 40 minutes, which was similar to the time allowed in earlier studies which investigated decision making by using a hidden profile task in mediated environments (Campbell & Stasser, 2006). Conversations were automatically logged and stored in digital files. After 40 minutes or perhaps even sooner, at the moment when the team indicated they had reached a decision, the participants were redirected to the post-experiment questionnaire.

### Self-report measures

*Team performance* was measured by checking if the team had found the correct solution to the murder mystery or not. *Group identification* measured the extent to which team members felt a part of the team as a whole and was measured by four items derived from the scale by Cheney (1983). The four items formed a one-dimensional scale with a Cronbach's alpha of .91. *Social liking* measured the extent to which team members liked individual team members and was measured using the social attraction scale developed by McCroskey, Richmond, & Daly (1975). One item ("It would be difficult to meet and talk to my team members") did not load on the scale.

The remaining five items formed a one-dimensional scale with a Cronbach's alpha of .78. *Trust* was measured by four items which were derived from Lee (2004), and formed a one-dimensional scale with a Cronbach's alpha of .91. Group identification, social liking and trust were all adopted from Lee (2004).

As a manipulation check, *Similarity* and *Self-identity* were measured. To check if our measure of *Similarity* was successful, we measured the extent to which team members felt represented as being distinct from the other group members (reversed). We used three items based on the scale by Kim (2011). Cronbach's alpha was low at .56, but we retained the scale as the items formed a one-dimensional scale accounting for 69% of the variance and with factors loading of .83 for each item. For our manipulation check of *Self-identity*, we measured the extent to which the team members identified with their avatars, using a scale based on the extended self-presence scale of Ratan & Hasler (2009). Cronbach's alpha was .97. Except for performance, all of the items were measured on a 7-point Likert scale ranging from 1 (*completely disagree*) to 7 (*completely agree*). The scales and items are listed in Appendix 5A.

### Content Analysis

Because a goal of the study is to investigate the decision making process in the various conditions, we conducted a content analysis of the chat conversations. The 80 conversations were coded by a research assistant who was blind to the goal of the study. The first author of this paper also coded 50 conversations (62.5%), which could be considered as a reliable sample (Lombard, Snyder-Duch, Bracken, 2002). In Table 3, examples of the coded variables can be found. To check the reliability of the coding scheme, the two coders first jointly coded the chat conversations of those teams that were successful, one for each condition, and chat conversation of those teams that were not successful in their decision making. Based on this test, coding problems and disagreements were discussed and the instrument was revised. This procedure was repeated until they had achieved 100% agreement and when they believed the instrument would permit reliable coding. To calculate intercoder reliability, the number of occurrences for each coded variable in each conversation was compared across both coders by calculating the intra-class correlation coefficient (ICC).

First, the number of unique clues was coded as the unique occurrence of a specific unique clue in the chat conversation. A unique clue was coded for instance when the participants mentioned that the man who was murdered, had had an affair with his secretary. Twelve unique cues were distributed equally among the team members, and only when these cues were shared, could the team members find the correct answer. The number of unique clues thus could vary between 0 (no clues shared) and 12 (all clues shared). Percentage agreement between coders was 88%, and ICC = .99.

Second, the number of total clues shared refers to the sum of all the unique clues that were shared and/or repeated in the chat. For teams to come up with a correct solution, not only simply sharing a cue is important, but the number of times a specific cue is shared is important as well. Repetition of shared information is an important prerequisite for team performance because only by repeating shared information can this information be stored in the collective memory of the team (Stasser & Titus, 1985). Percentage agreement between coders was 72%, and ICC = .86.

Third, we coded incidences when the teams suggested using a specific strategy to fulfill the task. In order for teams to reach a decision, it is not enough to simply share information. Shared information needs to be processed and specific strategies need to be employed to process this information and come up with a decision. We coded specific instances when a team member suggested using a specific strategy to solve the case. Examples of utterances that pointed to such strategies were: “I think we have all received different info and we can solve this together if we share our info”, and “Okay, if everyone tries to summarize the story from the beginning to the end in one message, then we can compare everything and form a mutual opinion.” The percentage agreement between coders was 72%, and ICC = .84

Fourth, we coded occurrences of motivation. An important factor that influences decision making is whether teams are motivated to work on the task and to reach a correct decision. Therefore, we coded instances in which a team member displayed joy, pleasure or other forms of affection in the task or the decision making process, or instances in which team members motivated each other to work on the task. Examples of utterances are: “I’m so afraid that we are missing something”, and “Let’s do this right.” Percentage agreement between coders was 88%, and ICC = .61. Finally, decision time and the messages transferred were automatically coded from the time stamps in the conversation logs.

## Results

### Manipulation Checks

First, we checked whether our manipulation of similarity and self-identity indeed represented their intended effects. In Table 5.1, we present means and standard deviations for the variables across the conditions on the team level. Pearson’s correlation between the variables is presented in Table 2. Teams in the high similarity conditions felt significantly less represented as being distinct from the other group members ( $M = 4.00$ ,  $SD = 0.73$ ) than those teams in the low similarity conditions ( $M = 4.48$ ,  $SD = 0.62$ ),  $F(1, 76) = 10.74$ ,  $p = .002$ ,  $\eta^2 = .124$ , indicating that our manipulation of

**Table 5.1** Means and Standard Deviations of Variables per Condition

	High Self-identity				Low Self-identity			
	High similarity (Morphed Team Avatar (N=20))		Low similarity (Hetero photo (N=20))		High similarity (Homo cartoon) (N=20)		Low similarity (Hetero cartoon) (N=20)	
	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>
Performance (%)	70	.47	35	.48	50	.51	50	.51
Social liking	4.52 <sup>a</sup>	0.33	4.16 <sup>b</sup>	0.49	4.38 <sup>ab</sup>	0.51	4.47 <sup>a</sup>	0.48
Group Identification	4.37	0.82	3.97	0.77	4.20	0.90	4.35	0.81
Trust	5.11	0.43	4.76	0.76	4.79	0.56	4.95	0.59
Unique clues	7.20 <sup>a</sup>	2.95	6.40	2.87	6.10	2.83 <sup>a</sup>	6.40	2.87
Total clues	13.10	7.53 <sup>a</sup>	11.05	7.06	11.20	8.32 <sup>a</sup>	11.05	7.06
Strategic remarks	2.15 <sup>a</sup>	1.66	0.75 <sup>b</sup>	1.16	1.40 <sup>ab</sup>	(1.43)	1.75 <sup>ab</sup>	1.62
Motivating remarks	0.95 <sup>a</sup>	1.19	0.25 <sup>b</sup>	0.55	0.35 <sup>b</sup>	0.75	0.25 <sup>b</sup>	0.55
Decision time (minutes)	25.43	10.90	18.56	11.96	17.91	7.81	18.63	10.15
Message count	194,80	109,00	162,00	118,96	143,05	66,31	179,30	87,36

Note. Standard deviations between parentheses. Different superscripts within rows relate to significant differences between conditions,  $p < .05$ , one-tailed.

similarity was successful. Teams in the high self-identity conditions identified with their avatars to a greater extent ( $M = 4.23$ ,  $SD = 0.99$ ) than those teams in the low self-identity conditions ( $M = 2.42$ ,  $SD = 0.79$ ), indicating successful manipulation of self-identity as well  $F(1, 76) = 84.75$ ,  $p < .001$ ,  $\eta^2 = .527$ . Our manipulation of similarity in the high self-identification conditions worked, since team members in the low similarity condition (who were represented with their own photograph) felt more distinct from each other ( $M = 4.40$ ,  $SD = 0.65$ ) than the teams in the high similarity “morphed team avatar” condition ( $M = 4.08$ ,  $SD = 0.75$ ),  $F(1, 76) = 4.81$ ,  $p = .036$ ,  $\eta^2 = .060$ . For both of these high self-identification conditions, no differences in avatar identification were observed when comparing the hetero photo condition to the morphed team avatar condition,  $F(1, 76) = 3.36$ ,  $p = .071$ ,  $\eta^2 = .042$ , nor was there an interaction effect,  $F(1, 76) = 0.49$ ,  $p = .492$ ,  $\eta^2 = .006$ . No interaction effects between similarity and self-identity were observed,  $F(1, 76) = 1.15$ ,  $p = .281$ ,  $\eta^2 = .015$ . Therefore, we can conclude that our manipulations were successful.

### Performance

Our first hypotheses (H1a) posed that team performance would be greater in the high similarity conditions than in the low similarity conditions. Given the binary nature of

**Table 5.2** Correlations between the variables

	1	2	3	4	5	6	7	8	9	10
1 Performance	-									
2 Social Liking	.21*	-								
3 Group Identity	.09	.69**	-							
4 Trust	-.05	.45**	.49**	-						
5 Unique clues	-.03	.16	.32**	.32**	-					
6 Total clues	-.08	.12	.26*	.29**	.87**	-				
7 Strategic remarks	-.04	.10	.15	.15**	.52**	.48**	-			
8 Motivating remarks	.16	.14	.11	.19	.22*	.25*	.34**	-		
9 Decision Time	.21*	.03	.21*	.27**	.75**	.77**	.58**	.34**	-	
10 Message count	-.137	.07	.28**	.36**	.62**	.69**	.48**	.41**	.81**	--

\* Correlation is significant at the  $p = .05$  level (1-tailed).

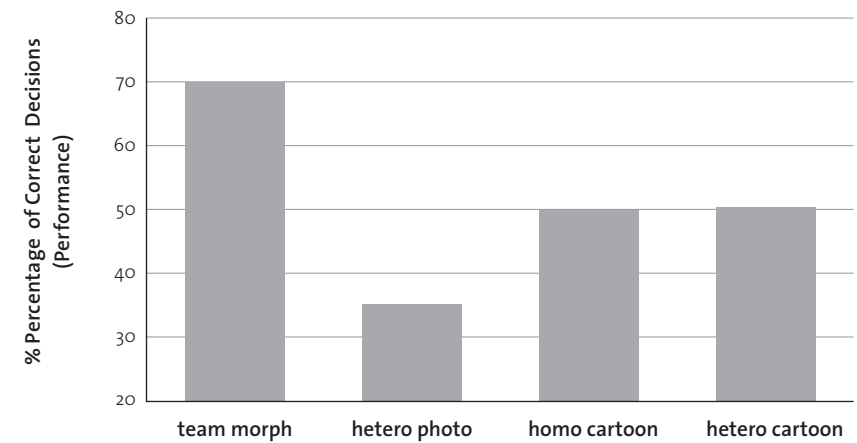
\*\* Correlation is significant at the  $p = .01$  level (1-tailed).

the dependent variable, we conducted logistical regressions comparing the number of correct and incorrect decisions for both the low similarity and high similarity conditions. Results showed that there was no difference between conditions ( $b = .00$ ,  $p = .50^2$ ,  $OR=1.00$ ), thereby disconfirming H1a.

Hypothesis 2a posed that performance would be greater in the high self-identity conditions than the low self-identity conditions. This hypothesis was not confirmed, ( $b = -.619$ ,  $p = .169$ ,  $OR = .54$ ). Thus, hypothesis 2a has been rejected.

The supposed interaction effect between similarity and self-identification on performance was confirmed (hypothesis 3a). Results of a logistic regression showed that the teams in the “morphed team avatar” condition close to significant outperformed teams in the other three conditions, ( $b = 1.47$ ,  $p = .056$ ,  $OR = 4.33$ ). In keeping with hypothesis 3a, team performance was the highest in the high similar and high self-identity (“morphed team avatar”) condition. Further analysis revealed that the difference in performance between both high self-identity conditions is significant,  $Z = 2.22$ ,  $p = .013$  (see Figure 5.3). Of the participants in the “morphed team avatar” condition (high self-identity, high similarity), 70% selected the correct solution, whereas only 35% of participants who were represented in the hetero photo condition (high self-identity, low similarity) selected the correct solution. When looking at both

<sup>2</sup> All our results are presented one-tailed, which is justifiable because our hypotheses have a clear direction (Field, 2009)

**Figure 5.3** Impact of Experimental Conditions on Decision Quality

conditions low in self-identification, the results suggest that being represented by a cartoon figure, neither helps nor hinders team performance, as an equal number of teams (50%) selected an incorrect solution.

### Mediation of Team Commitment

To test whether team commitment (consisting of group identification, trust and social liking) indeed mediated the relationship between our independent and our dependent variable, we followed the Baron and Kenny (1986) approach. According to this procedure, mediation is present when (1) there is a significant effect between the independent variables regarding team similarity and/or self-identity on the dependent variable performance; (2) there is a significant effect between the team similarity and/or self-identity and the mediator team commitment; (3) the mediator team commitment is significantly related to the dependent variable performance; while (4) the effect of the independent variables on the dependent variable performance is reduced in magnitude when the mediator is included in the model. As described in the previous analyses, the first criteria of a significant relationship between the independent and dependent variable *performance* only appeared to hold for the interaction between team similarity and self-identity (H3a). Therefore, we only focus on the mediating role of this interaction effect.

The second step states that there should be a direct effect between the independent variables on the mediating variables. To perform this step, we conducted regression analysis in SPSS with team commitment consisting of group identity, trust and social

liking as mediating variables, and the interaction effect between similarity and self-identification as a fixed factor. For group identification, there was a marginally significant interaction effect of similarity and self-identity, ( $\beta = .291, p = .069$ ), excluding group identification as a mediating variable. The variable trust was not significant ( $\beta = .137, p = .239$ ). However, for social liking, there was a significant interaction effect of similarity and self-identity on social liking, ( $\beta = .412, p = .016$ ). Post-hoc tests revealed that this difference in social liking was particularly greatest between the “morphed team avatar condition” and the hetero photo condition, as team members in the first condition (high similarity and high self-identity) were significantly more socially attracted to each other than the team members that were each identified with their own photograph (high self-identity and low similarity),  $F(1, 76) = 5.96, p = .008, \eta^2 = .073$ . Thus, it can be concluded that the second criteria was met for social liking only.

For the third step of our mediation we conducted logistical regressions to test whether there was a relationship between the mediating variable social liking and the dependent variable team performance (see also MacKinnon, Fairchild, & Fritz, 2007; Baron & Kenny, 1986). Results showed that there was a significant relationship between the mediating variable social liking on the dependent variable performance ( $b = .951, p = .034, OR = 2.58$ ). Moreover, the interaction effect of similarity and self-identity on the dependent variable decision quality, when controlling for the mediating variable social liking, is no longer significant ( $b = 1.17, p = .110, OR = 3.22$ ). Thus, the fourth criteria regarding our mediation analysis was met, which indicates full mediation of social liking on performance for the interaction of self-identity and similarity.

The results so far confirm the prediction that those teams in which the avatar appearance combined both a high degree of group similarity and self-identification (“the morphed team avatar” condition) performed best on the task, and showed higher levels of team commitment. However, contrary to our predictions, it appeared that team performance was only mediated by social liking, and not by group identity as anticipated by previous research. In contrast to prior SIDE-based studies (Lee, 2004), we found that being represented as a homogenous or heterogeneous cartoon figure, neither helped nor hindered team performance. Moreover, being represented by a photograph (low similarity, high self-identity) in contrast to being represented by a “morphed team avatar” (high similarity, high self-identity), has proven to lead to the lowest team commitment and performance. In order to study why teams represented by “morphed team avatars” performed better than the other teams, we studied the content of the team’s discussions, of which the results will be discussed in the following section.

### Findings Content Analysis

A limitation of an experimental approach is that it primarily focuses on the outcome measures, and as such it remains unclear how the experimental manipulations influenced the *process* of group decision making. Therefore, we have decided to delve deeper into the richness and content of these conversations between the group members, in order to investigate the process of group decision making, and complement the findings of our prior experiment.

Results of the content analysis revealed that the amount of time that the teams dedicated to their discussions about making the decision, was slightly longer in the high similarity and self-identification condition (morphed team avatar), ( $M = 25.43$  minutes,  $SD = 10.9$  minutes) than in the other conditions, yet it was not significant ( $M = 18.3$  minutes,  $SD = 9.7$  minutes),  $F(1,76) = 2.69, p = 0.53, \eta^2 = .034$ . To control for possible effects of conversation duration, we also conducted the following analyses controlled for duration, which yielded similar results. Thus, the duration of the conversations apparently did not influence decision making.

### Unique clues

With respect to information exchange, the results show that there were no differences in the unique number of clues that were exchanged in the discussions between any of the conditions. Similarity did not influence the number of unique clues shared, since there was no difference between teams in the low team similarity condition and teams in the high similarity condition,  $F(1, 76) = 0.31, p = .290, \eta^2 = .004$ . Neither did self-identity affect the number of unique clues shared,  $F(1, 76) = 0.41, p = .239, \eta^2 = .007$ . Although teams in “morphed team avatar” condition shared the most clues on average ( $M = 7.2$  out of 12 unique clues;  $SD = 2.95$ ), this interaction effect between high self-identity and high similarity was not significant,  $F(1, 76) = 1.41, p = .120, \eta^2 = .018$ .

### Total clues

We also tested if the conditions differed in the total number of clues that were exchanged, which is the total number of times a clue has been mentioned. The analysis yielded similar results in regard to the exchange of unique clues. No main effects of team similarity,  $F(1, 76) = 0.08, p = .192, \eta^2 = .001$ , and self-identity were observed,  $F(1, 76) = 0.92, p = .171, \eta^2 = .012$ . Moreover, there was no interaction effect between team similarity and self-identity,  $F(1, 76) = 0.75, p = .159, \eta^2 = .010$ .

### Motivation

Pairwise comparison showed that teams in the “morphed team avatar” condition significantly expressed more remarks associated to being motivated to perform the task ( $M = 0.95; SD = 1.19$ ), than the teams in the high self-identity, low similarity



condition ( $M = .25$ ;  $SD = .55$ ),  $F(1, 76) = 7.60$ ,  $p = .004$ ,  $\eta^2 = .091$ . This effect was less strong for both cartoon conditions ( $M = .30$ ;  $SD = .13$ ),  $F(1, 76) = 2.77$ ,  $p = .050$ ,  $\eta^2 = .035$ . Similarity had a significant effect on the remarks associated with being motivated to perform the task, although the total number of motivating remarks was low across all conditions  $F(1, 76) = 4.96$ ,  $p = .015$ ,  $\eta^2 = .061$ .

### Strategies

Not only were the teams in the morphed avatar condition more motivated, they also employed more strategies when trying to solve the murder mystery. The strategies used were, for instance, elimination or creating an overview of all of the information available by summarizing it. There was an interaction effect between team similarity and self-identity,  $F(1, 76) = 6.98$ ,  $p = .005$ ,  $\eta^2 = .084$ . Pairwise comparison showed that teams in the high self-identity high similarity condition (morphed team avatar) were significantly more strategic in their problem solving ( $M = 2.15$ ;  $SD = 1.66$ ) than teams in the low team similarity, high self-identity condition ( $M = 0.75$ ;  $SD = 1.16$ ),  $F(1, 76) = 8.92$ ,  $p = .002$ ,  $\eta^2 = .105$ . Regarding similarity, however, the teams in the low team similarity condition did not exert more strategic remarks than teams in the high team similarity conditions,  $F(1, 76) = 2.51$ ,  $p = .06$ ,  $\eta^2 = .032$ . Neither did these effects account for self-identity, teams in the high self-identity conditions did not make more strategic remarks than in the low self-identity conditions  $F(1, 76) = 0.14$ ,  $p = .353$ ,  $\eta^2 = .002$ . All in all, the results indicate that the teams in the morph condition outperformed the teams in which the team members each were identified with their own photographs.

In general, the results of the content analysis complemented the findings of the experiment and showed that the teams in the high similarity and high self-identification conditions proved to be more motivated, and employed more successful strategies in their problem solving than other teams. With respect to task-information, although not significant, there was a general trend that those teams in the high similarity and self-identification condition shared more unique clues and more clues in total than the other teams did.

### Discussion

In this study, a multi-method approach was used to investigate the interplay between similarity and self-identity in avatar representations and their impact on team performance and social interaction in virtual teams.

Results of the experiment confirm the prediction that teams in which the avatar appearance combined both a high degree of group similarity and self-identification

(“the morphed team avatar” condition) performed best on the task, and showed the greatest team commitment albeit only in terms of social liking. Moreover, our results showed that for the dimension of self-identification the proposed effects were the strongest. Being represented by a photograph (heterogeneous cues) in contrast to being represented by a “morphed team avatar” (homogeneous cues), has led to the lowest team commitment and performance. Whereas in contrast to prior SIDE-based studies (Lee, 2004), we found that being represented as a homogeneous or heterogeneous cartoon figure, neither helped nor hindered team performance.

Results of the content analysis suggest that the process underlying the ability of groups to reach correct decisions may be influenced by factors that relate to the task commitment of team members. Teams in which the avatars combined both a high degree of group similarity and self-identification devoted slightly more time to the task and there was a slight indication that more unique clues were shared. Moreover, content analysis revealed that those teams which employed “morphed team avatars” were significantly more motivated to complete the task successfully than the teams with cartoon avatars or photographs of avatars. Moreover, we found that the teams in the “morphed team avatar” condition were more strategic in their decision solving practices.

The insights gained from this multi-method study provide partial support for the possibility that the visual cues available in the “morphed team avatar” enable bonding among team members. Through visual similarity, the individuals’ sense of group inclusion was boosted (Tajfel & Turner, 1986), which, in turn, led to greater team commitment. In addition, through the visual cue of self-identity, individuality was retained (Snyder & Fromkin, 1980), which also affected task commitment. This led to greater team performance.

One reason why task commitment does not necessarily result in improved team performance, may be due to the relatively small sample size. In the content analysis, the number of counted and coded incidences associated with motivation and strategy in the team conversations was relatively small, which as a result decreases the statistical ability to find significant differences (Bearden, Sharma & Teel, 1982). However, our analysis revealed that those teams represented by a morphed avatar felt more committed not only to the team (evidenced by higher levels of social liking) but also by the task, evidenced by the number of clues that the teams shared, the expressed strategies they employed, the motivation to reach the right decision and the length of time that these teams used to solve the problem. We believe that having a morphed avatar resulted in the team members feeling both committed to the team as well as the task. However, results showed that only social liking was significantly higher in the



morphed avatar condition than the other conditions. No differences between conditions were found for trust and group identity.

An explanation accounting for why a mediating effect of trust and group identity could not be found, might have to do with how this study was designed. Previous studies exploring how visual avatar similarity enhances trust are highly experimental in which discussions between the participants were preprogrammed via the computer, and thus less real (Kim, 2010; Lee, 2004; DeBruine, 2002). In the design of this study, we anticipated Kim's (2011) call to make future SIDE-based studies less experimental, and to allow for natural interaction between participants. Our findings, however, have led us to think that when natural discussions occur between actual participants, the effect of stereotyping regarding the available social cues is reduced. In SIDE-based studies, the participants would, for instance, typically have to determine based on very minimal cues (e.g. gender, similar cartoon figure), and under high time pressure, whether or not to trust the other participant. Under such methodological circumstances, it is perhaps more likely that the ample cues breeding familiarity are magnified. Thus, this study shows that under different methodological circumstances, SIDE effects may not occur.

Another explanation for the absence of an expected mediation effect may be found in Social Information Processing theory (SIP) (Walther, 1996). Most SIP studies are usually longitudinal, demonstrating that in virtual teams "trust can be established without touch", yet it takes more time than in face-to face communication due to the fewer cues available (Walther & Bunz, 2005). Since the participants in this study communicated with their team members only during a single incidence, and during a relatively short period, they may not yet have established deeper feelings of trust and connection with each other that could be measured via self-reported measures.

This study makes several contributions. First, this is one of the first studies that has investigated the implications of the novel technology of morphing in a virtual team context. It was only since recently that we have been able to create morphed team avatars that can pose an optimal balance between similarity and self-identity, and the possibilities for further research on this topic are infinite. Future work may investigate the effects of "morphing" in different and more complex task settings. For instance, in tasks in which a positive first impression is necessary (e.g. a job interview), it could be examined whether morphing a job candidate's LinkedIn profile picture with the recruiter's LinkedIn picture might increase the chance of landing a job interview due to the recruiter's recognition of similarity.

Second, this study tested previous studies based on SIDE theory in a real life setting. In contrast to prior studies, we found that being represented by a similar cartoon-like avatar as used in prior SIDE studies, depicting non self-identity (Lee, 2004; Kim, 2009), did not generate the expected effects. Simply sharing the same cue, represented by a cartoon figure, did not lead to greater group identification, nor did it help or hinder virtual team performance. These results may be due to the fact that we used real team interaction instead of a pre-programmed interaction. Interaction between participants may have reduced social identification and therefore may have reduced the possible effects predicted by SIDE. Future research could investigate how much information needs to be exchanged in order for SIDE-effects to be subdued.

Third, although there are only a few studies that have conducted a content analysis of virtual team interaction (Antheunis, Schouten, Valkenburg & Peter, 2012; Dennis et al., 1996; Braithwaite, Waldron & Finn, 1999; Chidambaram, Lai & Lai, 2005), these studies are quite scarce and they do not always focus on the discursive practices of team interaction. Therefore, this study goes further than most experiments reported in prior studies. Through this multi-method approach, not only were we able to quantitatively measure the performance of teams on the task and self-reported perceptions of team commitment, we were also able to analyze the process leading to the final decision, by delving deeper into the richness of the communication between teams.

These insights enabled us to understand to what extent a team member's avatar can influence people's commitment to the task. The findings of this study might also have implications for practice, for instance in those cases in which organizations are seeking to enhance the performance of virtual teams. Based on the findings of this study, we recommend that organizations develop guidelines on how to design avatars. Vendors of solutions supporting virtual teams are recommended so as to integrate features and functions that allow for the implementation of the treatments used in this study.

There are several limitations to the study. First, college students were used as a convenience sample. Although the participants were students of Business Administration, they do not represent those professionals who are currently using virtual environments for dispersed work. Hence, researchers should be cautious when generalizing our findings to practice. However, given that this research selected and isolated certain constructs for the purpose of empirical testing, we focused more on understanding how avatar appearance influences team performance and social interaction than on generalizability. Thus, using a subset of students as our sample can be justified. With respect to the task, it is a realistic scenario that virtual teams with no common work history are supposed to solve a highly complex and ambiguous task within a short

time. Although solving a murder mystery might seem farfetched at first, this task by Stasser & Stewart (1992) is a well-established task in psychology literature and it is often used to observe collaboration between team members. Nevertheless, future research is needed to confirm our findings by using different samples and tasks.

Another question that has arisen from this study is whether these findings might also apply if this study were to be replicated using 3D avatars in a 3D virtual world. Currently, however, it is nearly impossible to manipulate avatars in a 3D virtual world to the same extent as we did in our study. Although it is possible to create realistic avatars, and although it might even be possible to create morphed avatars in a 3D virtual environment, doing this in the limited time constraints of an experiment, makes it still quite challenging. From our study we could imply that the avatars used in virtual teams, for example, in current Instant Messenger or Skype practices, but also in 3D virtual worlds, are preferably morphed avatars, hence representing the team as well as the individual members.

## Conclusion

This study investigated how the appearance of avatars affects group decision making. Our results generally indicate that avatars that combine both similarity and self-identity in their appearance indeed are more effective in generating team performance and social liking than avatars that do not combine these features. Our results of the content analysis also show that the teams in the “morphed team avatar” condition shared more unique clues during discussions, and that they are more motivated and more strategic in their problem solving. Apparently, the visual cues that are available in a “morphed team avatar”, lead to greater team commitment to the task. The insights gained from these findings demonstrate that avatar appearance does matter, and that in attempts to improve group decision processes and team performance, an avatar that combines both similarity and self-identity seems to be the most conducive when tackling such a group task.

## Appendix 5A. Questionnaire items

Convergent validity and reliability statistics ( $n=240$ )

Construct	Items	Factor loadings (varimax rotation)
Similarity (reversed)	I could be easily distinguished from others in my group	.83
	I was represented different from other members of my group	.83
Self-identity	I see my avatar as part of myself	.95
	I identify with my avatar	.95
	I feel connected to my avatar	.93
	My avatar is related to my personal identity	.93
	My avatars appearance is related to my personal identity	.94
Trust	I can trust the other team members	.89
	I can trust the information presented by the other team members	.92
	I feel that the other team members are honest	.93
	I feel that the other team members are trustworthy	.87
Group Identification	I see myself as a member of this group	.88
	I identify with this group	.91
	I'm happy to belong to this group	.92
	I feel connected with this group	.89
Social Liking	I think my team members could be friends of mine	.85
	I would like to have a friendly chat with my team member.	.72
	My team members and I could never establish a personal friendship with each other (reversed)	.73
	My team members would be pleasant to be with	.69
	I think my team members are quite pretty	.69

# 6



General Discussion

## General Discussion

The four studies of this dissertation have all concentrated on 3D virtual environments' potential for effective team collaboration and group decision making. The first study was an exploratory study (Chapter 2), the second study was a conceptual study (Chapter 3), the third study was an experimental study investigating information processing (Chapter 4) and the fourth study was a multi-method study investigating communication support (Chapter 5). All four studies have contributed to answer our overarching research question: "*How can 3D virtual environments be employed to enhance effective team collaboration?*" In the following pages, I will summarize the main findings for each chapter. These findings are presented in Table 6.1, and afterwards an answer to this dissertation's main research question will be provided. Subsequently, the implications to theory and practice are discussed. Next, an elaboration will be given of these studies' limitations and directions for further research will be offered. This particular chapter will end with a discussion in which several future scenarios are depicted for collaborative 3D virtual environments to support team processes.

### Chapter 2

In Chapter 2, several exploratory studies are discussed which aimed to investigate Second Life's potential use as a platform for facilitating information processing and communication support (referred to as the "pedagogical potential" in this chapter). The findings showed that there are three aspects which seem to be of particular relevance for conducting further research on the potential of 3D virtual worlds. First, in our preliminary research we found that participants experienced *equality of participation*. In our study, we found that although the participants formed part of a rather diverse community of learners which consisted of four different parties (VU University Amsterdam, ABN Amro, the Disabled Sports Foundation, and the Red Cross), they reported that they felt as if they had been treated as equals and that they had not experienced any feelings of hierarchy. A capability of virtual environments that could perhaps be responsible for this equality is the fact that all of the participants were represented by avatars, and these avatars did not display any social status cues (Walter, 1995). Prior research has emphasized that when participation is based on equality, active participation is stimulated, which in turn has a beneficial effect on information processing and communication (Hiltz et al., 2001). Secondly, the "gamelike" experience of *Second Life* induced feelings of *involvement*. For instance, the participants who participated in a wheelchair race in Second Life that had been initiated by the Disabled Sports Foundation were able to experience how it must "feel" to be disabled. In prior research, this feeling of involvement in a 3D virtual environment has been related to enhanced information processing and learning (Grigorovici, 2003; Scaife & Rogers, 2001). Thirdly, our findings indicate that one of the

most promising capabilities of 3D virtual environments may very well be the ability to offer 3D *simulations*. Simulations have been widely recognized as an efficient and effective tool for learning and processing complex information (Parush, Hamm, & Shtub, 2002; Wagner, 2008). Based on our observations and experiences, we have proposed a research agenda which can be used to research the influence of 3D virtual environments' potential for team collaboration further. These capabilities, *equality of participation, involvement and simulations*, provided the input for the definite formulation of sub-research questions in the following chapters.

### Chapter 3

The aim of Chapter 3 was as follows: a) to systematically review the literature on what capabilities influence effective team collaboration and group decision making in 3D virtual environments, b) to integrate these insights into a theoretical model, and c) to offer propositions that enable further empirical testing. In building our theoretical model, we used insights from media synchronicity theory (Dennis, Fuller, & Valacich, 2008), social psychological group research (Chang & Bordia, 2001; Hinsz, Tindale, & Vollrath, 1997), computer-mediated communication (Walther & Parks, 2002) and group decision support literature (DeSanctis & Gallupe, 1987). Our central finding and assumption is that, compared to traditional technologies, 3D virtual environments provide two unique characteristics that could support effective team collaboration: 1) the 3D virtual environment in which participants are immersed, and 2) the avatar-based interaction through which communication in 3D virtual environments takes place (Van der Land, Schouten, Van den Hooff, & Feldberg, 2011). These unique characteristics offer different capabilities that can support either information processing or communication via two distinct routes. In particular, the 3D virtual environment supports information processing because it creates the ability to manipulate and present information in a relevant way in order to increase *individual understanding* of task-related information. Communication processes are supported by the strategic manipulation of avatars, which gives greater control over the social-relational aspects of team collaboration. Both information processing and communication support are prerequisites for shared understanding which, in turn, result in effective team collaboration in terms of performance and satisfaction. This study contributes to theory as it is one of the first studies to provide a theoretical framework that can be related to team collaboration in 3D virtual environments. The findings and propositions of this framework can be used as a stepping stone for future empirical testing.

### Chapter 4

In Chapter 4, we investigated the information processing capabilities of 3D virtual environments. An experiment was conducted in an effort to investigate whether 3D virtual environments can help the decision making process in dispersed situations.

Based on *cognitive fit theory* and *cognitive load theory* (van Merriënboer & Sweller, 2005; Vessey, 1991), hypotheses were formulated which aimed to answer the following research question: "How does visual representation of information in 3D virtual environments support both individual and shared understanding, and consequently contribute to group decision making?" In teams of three, participants were asked to make a decision regarding an apartment choice task. The visual representation of the apartments was manipulated, so that there were three conditions. In the first condition teams could navigate through a 3D virtual simulation of the different apartments from a first-person perspective in such a way that they felt as if it was a real life experience. In the second condition, teams were provided with a 2D floor-plan of the apartments. Whereas in the third and last condition, the teams had a bird's-eye view of the apartments and were able to view pictures of the apartments from different angles (the 3D static condition).

The results of this experiment were quite surprising. Contrary to what was expected, the 3D static condition better supported the group decision making process than the immersive 3D virtual environment and the 2D floor plan condition. Our findings indicated that, in line with the *cognitive load theory*, both the 2D and the 3D virtual environment conditions were experienced as being highly cognitively taxing with regard to the task of making a group decision. Cognitively taxing refers to that a high amount of cognitive input was required to be able to effectively process information and negotiate different solutions in order to reach a group decision in these environments (Schrader & Bastiaens, 2011). The 2D condition was taxing due to the leanness of information provided by the 2D floor plan, which may have resulted in more uncertainty regarding the task-information. The 3D virtual environment was taxing due to the overload of detailed information, the extra cues and the stimuli that a rich environment offers, thus distracting from the group decision making process. In contrast, teams in the third condition, the 3D static condition, experienced the least amount of cognitive load of all the conditions, perhaps because it may have offered an optimum balance between overview and detail information. In this condition, shared understanding (the extent to which the teams were on a par with each other) was also higher than in the 3D virtual environment condition and the 2D condition.

However, the 3D virtual environment was found to effectively support the *individual understanding* of the apartments to a greater extent than the 2D visual representation, which was in line with *cognitive fit theory*. The results showed that the mechanisms behind this increased individual understanding are 3D virtual environments' capabilities of *realism* and *interactivity*. The findings of this chapter suggest that 3D virtual environments may best be employed selectively during the different phases of the group decision process. In particular, 3D virtual environments could support the

individual decision making process because the information rich environment enables individuals to make a thorough decision. However, when much team interaction is required, a 3D virtual environment may hamper the group decision making process because the environment provides too much distracting information which impedes team communication. This chapter contributes to our understanding of virtual team collaboration as it indicates which tasks and what type of information presentation regarding these tasks are most conducive in 3D virtual environments.

## Chapter 5

In Chapter 5, a multi-method study was conducted to investigate whether the appearance of avatars can enhance group decision making in virtual teams. Based on two contrasting frameworks, (a) the social identity model of deindividuation effects (SIDE, Postmes, Spears, & Lea, 1998) and (b) self-identification (Bailenson, Blascovich, & Guadagno, 2008), hypotheses were formulated to answer the following research question: “How do similarity and self-identity in avatar representations influence team performance in virtual teams?” In three-person groups, participants were asked to solve a “murder mystery” similar to the hidden profile task employed by Stasser and Stewart (1992). The visual representation of avatars was manipulated, so that there were four conditions which combined different levels of similarity and self-identity. The first condition, “the morphed team avatar”, combined both a high level of team similarity and self-identity in the facial characteristics of the team members, and it was created by using morphing techniques. In the second condition, participants were represented by their photographs, combining both a high level of self-identity, but a low level of team similarity. The third and fourth conditions were both low in self-identity, and represented either similar or dissimilar cartoon figures which had been derived from prior research (Lee, 2004).

It was found that the teams which communicated via a “morphed team avatar”, an avatar whose appearance combined both high team similarity and self-identity, were better able to find the correct solution in the group decision making task and that they liked each other more. In contrast, the low team similarity, high self-identity condition in which participants were represented by a photograph of themselves (which resembles current Instant Messaging practice), performed the worst. For the other two conditions, which represented team similar or dissimilar cartoon figures, no significant differences were found in performance, social liking or group identity. Secondly, the content analysis that was made of the conversations between team members showed that teams in the morph condition are significantly more committed to the task, than the team members in the other three conditions. These findings suggest that for team tasks in which a common focus is important, a morphed avatar that represents both a high degree of self-identity and similarity of team members, is

beneficial. This chapter contributes to our understanding of virtual team collaboration as it attempts to unravel the mechanisms which are responsible for achieving effective avatar representations in virtual team collaboration.

## This Dissertation’s Central Research Question

The purpose of this dissertation was to answer the following central research question “How can 3D virtual environments be employed to enhance effective team collaboration?” Based on the insights derived from the various studies, the findings of this dissertation show that effective team collaboration in 3D virtual environments depends on two different processes.

The first process refers to 3D virtual environments’ ability to support information processing. Our findings show that when 3D virtual environments are employed as a visual simulation tool for tasks of which the related information is visually complex (e.g., an apartment choice task), a rich immersive 3D virtual environment fails to sufficiently support group decision making processes. The results show that the amount of cognitive input required to effectively process the relevant information and negotiate different solutions to reach a group decision in these environments is experienced as being cognitively taxing. In contrast, the 3D virtual environment was found to effectively support individual understanding of the apartments to a greater extent than the simple and lean 2D representation. Thus, 3D virtual environments are particularly conducive for visual information tasks that require individual understanding.

The second process refers to 3D virtual environments’ ability to support communication processes. Our findings show that the ability of 3D virtual environments to alter avatars’ self-presentation, positively affects team collaboration. The results show that when team members communicated via a team avatar that had been ‘morphed’, an avatar that increased the similarity of the team members’ facial characteristics, the team performance and team commitment was greater than in the other conditions. Thus, particularly for tasks that require a positive first impression among dispersed team members, “morphing” the appearance of team members’ avatar can enhance effective team collaboration. To conclude, this dissertation’s studies show that 3D virtual environments may best be employed selectively, during different phases of the virtual team collaboration process.



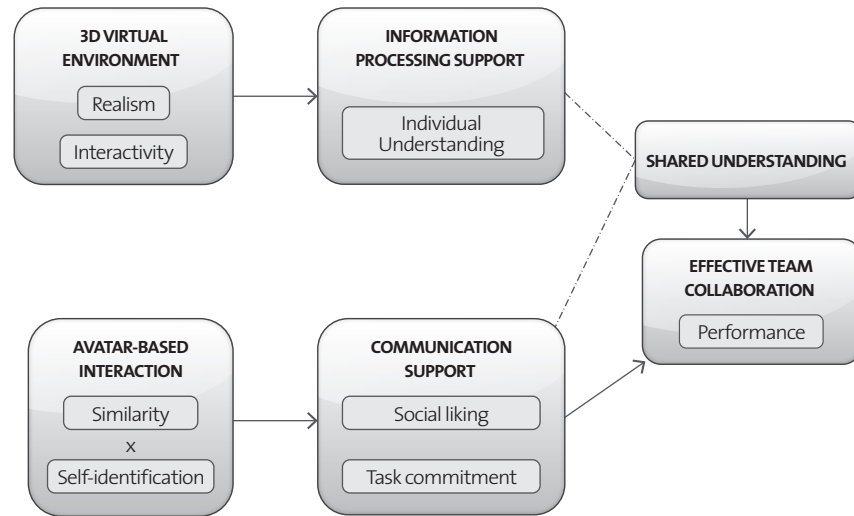
**Table 6.1** Overview of the main findings of this dissertation's studies

Study	Research Question/Aim	Method	Data Source	Key Findings
Study 1: Exploratory (Chapter 2)	To explore the collaborative benefits for an organization to be present in Second Life.	Qualitative	- Exploratory studies	- Three aspects seem of particular relevance for further research: 1) <i>equality of participation</i> 2) <i>involvement</i> and 3) <i>simulations</i> . A research agenda is proposed to further research the influence of 3D virtual environments' potential for team collaboration.
Study 2: Conceptual (Chapter 3)	To present a conceptual model specifically focused on the effectiveness of 3D virtual team collaboration	Literature Review	- Existing literature	- 3D virtual environments can support two processes vital to effective team collaboration: 1) information processing support through the manipulation of visual information presentation. 2) communication support through the manipulation of avatar appearances
Study 3: Experimental (Chapter 4)	How do visual representation of information in 3D virtual environments support both individual and shared understanding, and consequently contributes to group decision making?	Experiment	- Self-report	- As proposed by <i>cognitive fit theory</i> , our results indicate that 3D virtual environments are indeed more effective in supporting individual understanding than 2D information presentations - In line with <i>cognitive load theory</i> , the static presentation of 3D information turns out to be more effective in supporting shared understanding and group decision making than an immersive 3D virtual environment.
Study 4: Multi-method (Chapter 5)	How do similarity and self-identity in avatar representations influence team performance in virtual teams?	Multi-Method	- Experiment - Content analysis of logged chat conversations	- Results of the experiment confirm that teams in which the avatar appearance combined both a high degree of group similarity and self-identification, represented by a morphed team avatar, performed best on the task and liked each other more. - Content analysis of the conversations between team members shows that participants in the morph condition are significantly more committed to the task than those team members who used avatars which did not correspond to themselves as well as the team.

## Theoretical Contributions

The previous section discussed the main findings of the four studies in this dissertation regarding 3D virtual environments' potential for effective team collaboration. In this section, the broader theoretical implications of this dissertation's findings are discussed. This dissertation is one of the first to establish and empirically test a theoretical framework of effective team collaboration and group decision making in the context of 3D virtual environments. To date, most theoretical frameworks for effective team collaboration are generally too broad to be applied to the context of 3D virtual team collaboration because they have not been designed with the specific capabilities of

3D virtual environments in mind (Messinger, et al., 2009). An important theoretical point of departure in forming this dissertation's theoretical framework was media synchronicity theory (MST) (Dennis et al., 2007). In the four different studies of this dissertation, the MST framework was further developed by extending its premises with insights from different streams of existing literature (Chapter 3), cognitive fit and cognitive load theory (Chapter 4), and SIDE and self-identity theory (Chapter 5), in order to test the hypotheses of our research questions. Based on the results, the theoretical findings of this dissertation are embedded in a final theoretical framework, which is presented in Figure 6.1.



**Figure 6.1** Final Theoretical Framework

### Information Processing Support and Effective Virtual Team Collaboration

The dissertation's research has shown that the 3D virtual environment's capability *presence* was not a significant predictor of the individual understanding regarding the task information. Our findings show that *realism* and *interactivity* were more beneficial in enhancing individual understanding than the mere feeling of being *present* in a 3D virtual environment. Although this finding conflicts with prior research (Grigorovici, 2003; Scaife & Rogers, 2001), it nevertheless provides initial support to a more recent theory, namely Virtual Space and Place theory (Saunders et al., 2011). This theory argues and provides a tentative empirical test that shows that *interactivity* with a virtual object in 3D virtual environment stimulates *presence*. This interactive experience can even occur without an avatar, and it is crucial to the understanding of the virtual object (Saunders et al., 2011). Thus, this study contributes to Virtual Space and Place Theory and the recognition that the concept of *interactivity* with virtual objects is of crucial importance in the understanding of these virtual objects.

This dissertation's findings also have implications for the proposed relationship between individual and shared understanding, which is central to MST. Based on MST and cognitive-informational theories (Weldon & Bellinger, 1997; Dennis et al., 2008), it was assumed that the capabilities of a 3D virtual environment would support individual understanding via information processing, which in turn would lead to an enhanced shared understanding (Weick, 1985). However, in Chapter 4, it was found

that there was no significant relationship between individual understanding and shared understanding in the context of 3D virtual environments. In other words, the theoretical idea that the sum of the individual members' understanding evidently positively affects shared understanding was not supported by the empirical findings of this dissertation. Therefore, in Figure 6.1, a dotted line is displayed between the variables of individual understanding and shared understanding. The implications of these findings may be interpreted in such a way that one might conclude that individual understanding of task-related information may not necessarily be a prerequisite to achieve shared understanding. A possible explanation for this may be that reaching shared understanding is more of an iterative group process and that social factors come in to play when creating a shared understanding (Driskell et al., 2003).

### Communication Support and Effective Virtual Team Collaboration

Due to the accumulation of insight regarding *shared understanding* in Chapter 4, it was decided that shared understanding would not be the focus of the fourth and last study in this dissertation. Instead, the focus of this last study was directly aimed at the dependent variable *effective team collaboration*. A closer reading of the literature showed that a more substantial contribution could be made to the literature if this dissertation would build on prior work of Bailenson et al. (2006) and Lee (2004), by placing it in the context of effective virtual team collaboration and the role of avatar self-representation. For the final theoretical framework in Figure 6.1, this implied that the initial concepts of avatar self-based interaction '*social presence*' and '*self-presentation*' as presented in the model of Chapter 3, were specified by the concepts *similarity* and *self-identity*.

The empirical findings of this dissertation show that the mechanisms studied concerning *similarity* and *self-identity* of avatar's appearances, can contribute to a greater virtual team performance. More specifically, this dissertation is one of the first to show in a virtual team context, that the strategic manipulation of an avatar's self-presentation via the novel technique of "morphing" increases social liking among team members. Morphing techniques enable one's avatar's facial characteristics to become similar to the other avatars, while at the same time an optimal balance in self-identity of the user is maintained. Particularly regarding the communication between team members, the content analysis results showed that when team members were visually presented as "morphed team avatars", they expressed greater task commitment in their communicative behaviors. In turn, a greater team performance was achieved when these mechanisms of self-identity and similarity were optimally utilized, than when avatars were represented to be dissimilar and cartoon figures. These findings theoretically complement prior studies, drawing upon

SIDE, which focused on the appearance of cartoon figures (Kim, 2009; Lee, 2004), with the dimension of *self-identity*, in which one's physical appearance is represented.

The empirical findings of this dissertation imply that for the social identity model of deindividuation effects (SIDE), under different methodological circumstances the impact of avatar representation on social interaction between team members may not occur. SIDE proposes that under the conditions of visual anonymity (e.g. absence of visual cues in CMC), the visual similarity of avatars can diminish the focus that people have on their individual differences, and increase the salience of their group membership. In prior SIDE-based studies, the participants would, for instance, typically have to determine whether or not to trust the other participant by basing this on only a minimal number of cues (e.g. similarity of a cartoon figure), and under great time pressure. In such circumstances, it is perhaps more likely that the ample cues which breed familiarity have been magnified. This dissertation's research anticipated Kim's (2011) call to make future SIDE-based studies less experimental and to allow natural interaction, thus not pre-programmed via the computer. In contrast to these prior SIDE-based studies, the empirical findings of this dissertation showed no differences between the conditions in group identity and trust, which may imply that when natural discussions occur between the actual participants, the effect of stereotyping regarding the available social cues is reduced.

### Implications for Effective Virtual Team Collaboration

In the introduction chapter of this dissertation, I wrote that the idea of *virtuality* has always seduced thinkers, writers, designers and others, and that maybe one day we could accomplish via a computer in a virtual world what we have historically done physically, allowing us to part with the physical. But more than half a century of research on organizational communication and information systems has shown that there are many challenges that still must be overcome in order for this idea to become reality (Contractor, Monge, & Leonardi, 2011; Jarvenpaa & Leidner, 1998; Thompson & Bates, 1957).

From a historical perspective, most group researchers initially agreed that effective team collaboration is inextricably intertwined with the nature of the tasks being performed (Gladstein, 1984; McGrath, 1984; Rousseau, Aubé, & Savoie, 2006; Straus, 1999). However, studies on task-technology fit have not yielded consistent results regarding the effects on task performance (Daft, Lengel, & Trevino, 1987; Mennecke, Valacich, & Wheeler, 2000; Straus & McGrath, 1994). Therefore, MST (Dennis, et al., 2008) proposed that the concept of fit should be rethought, and suggested that the success of any given task that requires team collaboration (e.g. decision making), is determined by shared understanding, which is influenced by either convergence or

conveyance processes. This dissertation contributes to MST on effective virtual collaboration, by acknowledging both information and communication support processes, and by adding empirical proof for the notion that effective collaboration consists of different "task" phases. For instance, this dissertation showed that the individual phase of understanding the task may benefit from the richness of 3D virtual environments' representation of information. However, when negotiating with team members forms a relevant phase of the task, a medium which supports communication processes is more appropriate for this specific phase of the collaborative task.

Moreover, this dissertation shows that the "shared understanding" seemed to be of less importance to effective team collaboration in 3D virtual environments than it was initially hypothesized. In Chapter 4, we showed that 3D representations stimulate individual understanding of a task, but it did not stimulate shared understanding. When groups needed to make a shared decision, the extra visual cues and stimuli that a rich 3D virtual environment offers seem to cause a cognitive overload among the team members. For group decision tasks, the rich 3D virtual environment seemed to impair the communication processes of discussing preprocessed information with team members. In other words, the multitude of visual cues in the 3D virtual environment hindered, rather than helped the establishment of shared understanding. A leaner environment, such as the 3D static environment provided a more optimal balance in presenting information and enhanced the decision making process in such group tasks.

However, the study in Chapter 5 showed that the strategic manipulation of avatars in a decision task led to increased team performance. Although shared understanding was not measured directly, significant differences were found in the decision making strategies between the conditions. More specifically, the teams in the morphed avatar condition exerted more strategic remarks and they made more motivating comments than the teams in the other three conditions did. Therefore, this clearly demonstrates that these teams were better able to exchange information and share their perceptions regarding the task at hand, which is considered as creating shared understanding (Dennis, et al., 2008; Swaab, Postmes, Neijens, Kiers, & Dumay, 2002). This ultimately led to increased performance. Therefore, in Figure 6.1, a dotted line is displayed between the variables of communication support and shared understanding. Moreover, a recent study by Schouten, Van den Hoof & Feldberg (2010) also showed that avatar-based interaction in a shared environment increased the shared understanding in a decision making task, which in turn, subsequently led to increased performance.

Thus, this dissertation's studies show that 3D virtual environments may best be employed selectively, during different phases of the virtual team collaboration process. It appears that individual and shared understanding are two different processes, each of which

may be supported by different technologies. A rich 3D environment can indeed help to process information in order to create an individual understanding of a task. However, a too rich environment distracts from the group process and therefore hampers the development of shared understanding and ultimately, team performance. The capability of 3D virtual environments to manipulate avatar-based interaction, on the other hand, does to a certain extent seem to stimulate shared understanding. Therefore, it can be concluded that the 3D presenting of information may best be employed in an individual information processing phase of a team task, whereas avatar-based interaction in a leaner environment may better support the communication phase of a team task.

## Practical implications

This dissertation has several practical implications for organizations regarding the potential contribution of 3D virtual environments for virtual team collaboration and decision making, which will be further elaborated below.

First, the empirical findings of this dissertation indicate that 3D virtual environments might be particularly useful for visually complex tasks (e.g. simulations). For such tasks, the main implications in using a 3D simulation is to help visualize and enhance individual understanding of the physical end results of, for instance, the design of a hotel. Used in such a manner, a 3D virtual space can help to provide a better understanding of how this hotel would appear in the physical world. Applied in a different context, if for instance, an architect seeks to convince a client of the end results of a rather radical design solution for his/her home (e.g. sacrificing a bedroom to create a kitchen), the architect will be more likely to do so by using a 3D virtual world representation. When a person can virtually navigate through this new kitchen, and see and “feel” how this positively affects the dimensions in his/her own home, the personal experience will be greater, leading to a greater impact on the person’s understanding of the design solution. When translating this into concrete design guidelines for practitioners, it is imperative to comprehend that the features implemented in the design should directly aim at enhancing the participants’ understanding. Evidently, this may improve individual understanding and enhance decision making.

Secondly, our results from Chapter 4 show that in regard to the use of technology for collaborative purposes, there is no “one size fits all-model”. For different phases of a group decision making process, different technologies seem most conducive. For instance, for tasks in which immediate feedback and negotiation with different team members (such as deciding on an apartment together) is required, a leaner medium that supports these communication processes is of more importance than in a rich 3D

immersive environment. Ideally, for such tasks a medium that provides an optimal balance between overview and detailed information is provided, which reduces a team member’s tendency to feel cognitively overloaded (Birnholtz, Ranjan, & Balakrishnan, 2010). As a general rule of thumb, I would recommend practitioners to carefully analyze the specific characteristics of the task, in order to determine whether (or not) to use 3D virtual worlds for collaborative purposes.

Thirdly, platform developers of 3D virtual environments may translate the findings of this dissertation into future applications which are aimed at supporting effective team collaboration. For instance, developers may implement “morphing” functionalities into their future collaborative software. Based on the empirical findings of Chapter 5, particularly in tasks that require a positive first impression, “morphing” the appearance of team members’ avatar could perhaps contribute to effective team collaboration. The theoretical implications of this dissertation’s finding on the impact of avatar appearance may, albeit with certain caution, transfer to other tasks and media such as Skype or LinkedIn (Bailenson, Yee, Merget, & Schroeder, 2006). For instance, for a negotiation task, in which a positive first impression is necessary, morphing your Instant Messenger profile picture with the other negotiator’s Instant Messenger profile picture may increase the chance of a favorable outcome for you in the negotiation, due to the other negotiator’s recognition of similarity in combination with self-identification. Moreover, in tasks in which participants are unfamiliar with each other (e.g. an avatar-based job interview, see Behrend et al., 2012), morphing your avatar’s face with the face of the other interviewer may function as a “social glue”, due to the interviewer’s recognition of facial similarity in combination with self-identification. This is in keeping with research conducted by Bailenson et al. (2008) which found that in the context of influencing voting preference for a political candidate, a person is more likely to express his/her positive preference towards a political candidate when that person’s picture is subtly morphed into the picture of a political candidate. Thus, particularly for tasks that require a positive first impression, “morphing” the appearance of the team members’ avatars may contribute to effective team collaboration. Of course, it is important to note that generating a strong first impression may not be relevant for all tasks. Some tasks may require the establishment of more long-term collaboration, which might influence the effects of these “morphing” mechanisms.

## Limitations and Future Research

As is the case in every study, there are several limitations to this dissertation’s studies. The main limitations of this dissertation are the use of experiments as a methodology and students as a convenience sample.

For the purpose of empirical testing, we selected and thus isolated the two different routes and their mechanism of processing task-related information and communicating processes via an avatar. In doing so, we could objectively measure whether our manipulation of either the 3D virtual environment or avatar based-interaction attained its hypothesized effects. However, a potential disadvantage from this isolation is that the interaction between these two processes could not be studied. Therefore, a possible starting point for future research would be to employ a socio-materiality perspective on effective virtual team collaboration (Orlikowski, 2010). A social-materiality perspective envisions that the effects that an intervention or a medium have on the behavior of individuals is not a causal relationship, but a continuous process. This perspective strongly advocates against treating technology as an exogenous force. Future research that builds on this social-materiality perspective should study a medium's *affordances* as a way "to explain the increasingly symbiotic relationship between IT and organizations" (Zammuto, Griffith, Majchrzak, Dougherty, & Faraj, 2007, p. 752). In order to study these affordances, social-materiality states that existing theories fall short and calls for ethnographic research approaches that allow new theory development. However, one might also question whether 3D virtual environments nowadays actually are "socially embedded" in practice. An example of a "more socially embedded" medium could be for instance, a smart phone, since this medium is used in a more symbiotic way. Nevertheless, a social-materialistic research perspective may shed light and unravel insights that cannot be found through experimental testing alone.

Secondly, college students were used as a convenience sample. Although the participants were students of Business Administration, they do not fully represent the professionals that are currently using virtual environments for dispersed work. Moreover, the results of this dissertation may not hold outside of the lab, due to the susceptibility to extraneous "uncontrolled" variables in real-life settings (Parikh et al., 2001). Therefore, researchers should be cautious when generalizing our findings and applying them to practice. However, given that this research selected and isolated certain constructs for the purpose of empirical testing, this dissertation focused more on understanding the factors involved in team collaboration than on generalizability. Future research is encouraged in which different samples are used, such as professionals (instead of students), different tasks, and the use of 3D virtual environments in real-life settings on effective virtual team collaboration should also be investigated.

Thirdly, to answer this dissertation's research questions, an experimental methodology was chosen, and as a result, the two different routes were isolated for the purpose of experimental testing. However, one could imagine that these two routes may not be completely unrelated. Studies on group research have begun to argue that cognitive-

informational and social-relational influence cannot be seen as separate, but that they represent different aspects of the same process (Swaab, Postmes, van Beest, & Spears, 2007; Turner, 1991). For instance, in the context of this dissertation's research, it could be that the cognitive process of sharing the same point of view or preference regarding the choice of an apartment (Chapter 4), may be the basis upon which the team members begin to develop feelings of commitment. While conversely, if team members are committed to one another such as expressed in Chapter 5, one could infer that there is a basis from which people can begin to understand each other's views, which may, in turn, provide a basis for shared understanding. Despite such theoretical reasons which assume that cognitive-informational and social-relational influences might be related, empirical evidence is still scarce. It remains questionable, if, and how cognition and commitment are related. Therefore, further research is encouraged to investigate the relationship and integration between these two routes.

#### Potential Future Scenarios for Collaborative 3D Virtual Environments

After having discussed this dissertation's work on 3D virtual environments' potential for team collaboration, where do we go from here? If I were to speculate about the future of 3D virtual worlds and their consequences regarding future ways of virtual team collaboration (with the risk of being accused of "science fiction"), it can be noticed that two aspects of 3D virtual environments have in the meantime become part of more mainstream applications. Over the four-year span of this dissertation, these two aspects of 3D virtual environments may have survived the rise and fall of 3D virtual environments.

First, a clear example of this is the increasing use of 3D visualizations (Lee, Li & Edwards, 2012; Morrisson & Skjulstadt, 2010; Li et al., 2008). As indicated in Chapter 4, a wide array of companies, ranging from Philips to IKEA to real estate agencies, are using 3D visualizations of their products as a popular tool to help people visualize the end result of how their products will appear in their homes, or how stunning a real estate property will look after investing an X-amount of money for renovating it. An example of how 3D visualizations are being used in a work-related collaborative context is the case of Yuansantze Flood Diversion Works Project, in which a 3D virtual environment was used as a visualization tool to improve public participation and communication between stakeholders (Lai et al., 2011). Moreover, in the medical field, highly realistic 3D simulations of an emergency room are currently being used for distributed virtual training purposes (Kränge, Moen, Ludvigsen, 2012). I expect that as using and creating 3D visualizations will become more mainstream and user-friendly, that certain aspects of 3D visualizations (e.g. simulations to increase individual understanding) will gradually transfer to the realm of virtual team collaboration.

A second prominent aspect is avatar representation. In today's world, the use of an avatar (e.g. a picture) to represent oneself on social network sites such as LinkedIn, Facebook or VoIP services such as Skype has become widespread (Ellison, Heino, & Gibbs, 2006; Ong, et al., 2011). This number of avatar usage is even greater in game-like settings such as *World of Warcraft*, *Habbo-hotel*, and the *Wii* (Ducheneaut, Wen, Yee & Wadley, 2009; Lanningham-Foster, et al., 2009). One reason for the popularity of avatar-based interaction is that some people do not always want to be confronted with their "real selves" in the virtual realm. For instance, studies on the 3D virtual environments show that most avatars are a younger, skinnier and a more attractive version of peoples' real selves and that they are their *ideal self* so to speak (Dunn & Guadagno, 2012; Ducheneaut et al., 2009; Heider, 2009; Turkle, 1994). Next, another advantage of avatar usage is that it could serve as a mask, helping the shy. Research has shown that in the virtual realm under conditions of "relative anonymity" people feel more comfortable disclosing personal things they would otherwise feel hesitant saying in a face-to-face setting (Antheunis, Schouten, Valkenburg & Peter, 2012). When translating this to the context of collaborative virtual environments, it could be argued that in order to improve task performance, people should have the ability to pick an avatar that resembles their perception of self (Kil-Soo, Hongki, & Eung Kyo, 2011; Cui et al. 2009; Galanxhi and Nah 2007). All in all, I expect that as avatar-based interaction will become more and more an integral part of our everyday communication, this will gradually transfer to the realm of virtual team collaboration.

The success of future application of 3D virtual environments for virtual team collaboration may also depend on whether these environments are able to discard the so-called "horseless-carriage syndrome". When the first automobiles emerged, they resembled horseless carriages. The design of these automobiles reflected the lens of a paradigm that had been dominant for centuries, and thus resembled a vehicle similar to the horse and carriage, but then without the horse, and it even included a special place for the horse whip. The dominant paradigm regarding most of the current work on 3D virtual environments' potential (including some of our own) focuses on translating traditional face-to-face tasks (e.g. participating in a lecture) to a "realistic" 3D virtual environment setting. I believe that there may be a future for collaborative 3D virtual environments, but that it will require a shift away from using traditional virtual team work as a frame of reference, towards innovatively applying 3D virtual environments in practice. To conclude, the main challenge for future researchers and developers of 3D virtual environments will be to try and imagine how the unique affordances of 3D virtual environments can be applied in ways that are not limited by the existing paradigms, but ways that transcend the boundaries of what is possible in the physical world in terms of presenting task-related and social information.





References

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## References

- Adams, S. J., Roch, S. G., & Ayman, R. (2005). Communication medium and member familiarity. *Small Group Research, 36*(3), 321–353.
- Ahonen, M., Donnellan, B., Mahaley, S., O'Donovan, B., & Teigland, R. (2008). "Panel: Going Virtual: Are there Real Opportunities for Business in Virtual Worlds?" *ECIS Proceedings*, Paper 124.
- Anders P. (1999). *Envisioning Cyberspace -- Designing 3D Electronic Spaces*, New York: McGraw-Hill.
- Anderson, J. R. (2000). *Cognitive psychology and its implications*. New York: Worth Publishers.
- Antheunis, M. L., Schouten, A. P., Valkenburg, P. M., & Peter, J. (2012). Interactive uncertainty reduction strategies and verbal affection in computer-mediated communication. *Communication Research, 39*, 757-780.
- Antonietti, A. & Cantoia, M. (2000). To see a painting versus to walk in a painting: An experiment on sense-making through virtual reality. *Computers and Education 34*(3-4), 213-223.
- Bailenson, J., & Beall, A. (2006). Transformed social interaction: exploring the digital plasticity of avatars. In *Avatars at Work and Play: Collaboration and Interaction in Shared Virtual Environments* (pp. 1-16 ). London: Springer-Verlag.
- Bailenson, Yee, N., Merget, D., & Schroeder, R. (2006). The Effect of Behavioral Realism and Form Realism of Real-Time Avatar Faces on Verbal Disclosure, Nonverbal Disclosure, Emotion Recognition, and Copresence in Dyadic Interaction. *Presence: Teleoperators and Virtual Environments, 15*, 359-372.
- Bailenson, J. N., Blascovich, J., & Guadagno, R. E. (2008a). Self-Representations in Immersive Virtual Environments. *Journal of Applied Social Psychology, 38*(11), 2673-2690.
- Bailenson, J. N., Iyengar, S., Yee, N., & Collins, N. A. (2008b). Facial Similarity between Voters and Candidates Causes Influence. *Public Opinion Quarterly, 72*, 935-961.
- Bailey, D. E., Leonardi, P. M., & Barley, S. R. (2011). The Lure of the Virtual. *Organization Science, 23*(5), 1485-1504.
- Bainbridge, W. S. (2007). The Scientific Research Potential of Virtual Worlds. *Science, 317*(5837), 472-476.
- Baker, J., Jones, D., & Burkman, J. (2009). Using visual representations of data to enhance sensemaking in data exploration tasks. *Journal of the Association for Information Systems, 10*(7), 533-559.
- Banos, R. M., Botella, C., Alcaiz, M., Liao, V., Guerrero, B., & Rey, B. (2004). Immersion and emotion: Their impact on the sense of presence. *CyberPsychology & Behavior, 7*(6), 734-741.
- Baron, R., & Kenny, D. (1986). The moderator-mediator variable distinction in social psychological research: Conceptual, strategic, and statistical considerations. *Journal of Personality and Social Psychology 51*(6), 1173-1182.
- Baskerville, R., & Nandhakumar, J. (2007). Activating and perpetuating virtual teams: now that we're mobile, where do we go? *Professional Communication, IEEE Transactions on, 50*, 17-34.
- Baumeister, R.F., & Leary, M.R. (1995). The Need to Belong: Desire for Interpersonal Attachments as a Fundamental Human Motivation. *Psychological Bulletin, 117*(3), 497-529.
- Beale, I. L., Kato, P. M., Marin-Bowling, V. M., Guthrie, N., & Cole, S. W. (2007). Improvement in cancer-related knowledge following use of a psychoeducational videogame for adolescents and young adults with cancer. *The Journal of Adolescent Health: Official Publication of the Society for Adolescent Medicine, 41*(3), 263–270.
- Bearden, W., Sharma, S., & Teel, J. (1982). Sample size effects on chi square and other statistics used in evaluating causal models. *Journal of Marketing Research, 19*(4), 425-430
- Berdahl J.L., and Craig, K.M. (1995). Equality of participation and influence in groups: The effects of communication medium and sex composition. *Computer Supported Cooperative Work, 4*(2-3), 179-201.
- Behrend, T., Toaddy, S., Foster Thompson, L., Sharek, D. J. (2012). The effects of avatar appearance on interviewer ratings in virtual employment interviews. *Computers in Human Behavior, 28*(6), 2128-2133.
- Berscheid, E., & Reis, H. (1998). *Attraction and close relationships*. New York: McGraw-Hill.
- Berscheid, E., & Walster, E. (1979). *Interpersonal attraction*. Menlo Park, CA: Addison-Wesley.
- Biocca, F. (1997). The Cyborg's dilemma: Progressive embodiment in virtual environments. *Journal of Computer-Mediated Communication, 3*(2), 1-29
- Biocca, F., & Harms, C. (2002). What is social presence? In F. Gouveia & F. Biocca (Eds.), *Presence 2002 Proceedings*. Porto, Portugal: University of Fernando Pessoa Press.

- Birnholtz, J., Ranjan, A., & Balakrishnan, R. (2010). Providing Dynamic Visual Information for Collaborative Tasks: Experiments With Automatic Camera Control. *Human-Computer Interaction*, 25(3), 261-287.
- Bishop, I. D., Wherrett, J. R., & Miller, D. R. (2001). Assessment of path choices on a country walk using a virtual environment. *Landscape and Urban Planning*, 52(4), 225-237.
- Blascovich, J. (2002). *Social influence within immersive virtual environments*. In R. Schroeder (Ed.), *The social life of avatars* (pp. 127-145). London: Springer-Verlag. Blizzard World of Warcraft®. (2012). World of Warcraft currently down to 9.1 million subscribers. Retrieved September 15, 2012: <http://wow.joystiq.com/2012/08/02/world-of-warcraft-currently-down-to-9-1-million-subscribers>
- Boland, R. J., Lyytinen, K., & Yoo, Y. (2007). Wakes of innovation in project networks: The case of digital 3-D representations in architecture, engineering, and construction. *Organization Science*, 18(4), 631-647.
- Bolter J.D and Grusin R. (2000), *Remediation -- Understanding New Media*, Cambridge, Mass: MIT Press.
- Braithwaite, D. O., Waldron, V. R., & Finn, J. (1999). Communication of social support in computer-mediated groups for persons with disabilities. *Health Communication*, 11, 123-151.
- Bray, D., & Kossynski, B. (2007). Virtual worlds: Multi-disciplinary research opportunities. *The DATABASE for Advances in Information Systems*, 38(4), 17-25.
- Brewer, M. (1979). In-group bias in the minimal intergroup situation: A cognitive-motivational analysis. *Psychological Bulletin*, 86(2), 307-324.
- Brewer, M. B. (1991). The Social Self: On Being the Same and Different at the Same Time. *Personality and Social Psychology Bulletin*, 17(5), 475-482.
- Bryman, A (2012). *Social Research Methods*. Oxford: Oxford University Press. Businesswire. (2010, May 12th). USDA Awards Contract for Teleplace as a vGov Virtual World Platform Retrieved September 16th, 2012: <http://www.businesswire.com/news/home/20100512005562/en/USDA-Awards-Contract-Teleplace-vGov-Virtual-World>
- Buss, D. M., & Kenrick, D. T. (1998). Evolutionary social psychology. In D. T. Gilbert, S. T. Fiske, and G. Lindzey (Eds.), *The Handbook of Social Psychology* (4th ed., Vol. 2, pp. 982-1026). New York: McGraw-Hill.
- Byrne, D. (1997). An Overview (and Underview) of Research and Theory within the Attraction Paradigm. *Journal of Social and Personal Relationships*, 14(3), 417-431.
- Cahalane, M., Feller, J., & Finnegan, P. (2012). *Making Sense of Immersion and Emergence: The State of IS Research on Virtual Worlds*. Paper presented at The International Conference on Information Systems, Orlando, USA.
- Campbell, J., & Stasser, G. (2006). The Influence of Time and Task Demonstrability on Decision-Making in Computer-Mediated and Face-to-Face Groups. *Small Group Research*, 37(3), 271-294.
- Campion, M. A., Medsker, G. J., & Higgs, A. C. (1993). Relations between work group characteristics and effectiveness: implications for designing effective work groups. *Personnel Psychology*, 46(4), 823-850.
- Cannon-Bowers, J. A., Salas, E., & Converse, S. A. (2001). Shared mental models in expert team decision making. In N. J. Castellan, Jr. (Ed.), *Current issues in individual and group decision making* (pp. 221-246). Hillsdale, NJ.: Erlbaum.
- Chang, A., & Bordia, P. (2001). A Multidimensional Approach to the Group Cohesion-Group Performance Relationship. *Small Group Research*, 32(4), 379-405.
- Chaturvedi, A. R., Dolk, D. R., & Drnevich, P. L. (2011). Design Principles For Virtual Worlds. *MIS Quarterly*, 35(3), 673-684.
- Cheal, M., Chastain, G., & Lyon, D. R. (1998). Inhibition of return in identification tasks. *Visual Cognition*, 5(5), 365-388.
- Cheney, G. (1983). On the various and changing meanings of organizational membership: A fieldstudy of organizational identification. *Communication Monographs*, 50(4), 342-362.
- Cierniak, G., Scheiter, K., & Gerjets, P. (2009). Explaining the split-attention effect: Is the reduction of extraneous cognitive load accompanied by an increase in germane cognitive load? *Computers in Human Behavior*, 25, 315-324.
- Chandler, P., & Sweller, J. (1991). Cognitive load theory and the format of instruction. *Cognition and Instruction*, 8(4), 293-332.
- Chandler, P., & Sweller, J. (1996). Cognitive load while learning to use a computer program. *Applied Cognitive Psychology*, 10, 151-170.
- Chen, X., Siau, K., & Nah, F. F. H. (2010). *3-D Virtual World Education: An Empirical Comparison With Face-To-Face Classroom*. Paper presented at the International Conference on Information Systems, Saint Louis, Missouri.
- Chidambaram, L., & Lai Lai, T. (2005). Is Out of Sight, Out of Mind? An Empirical Study of Social Loafing in Technology-Supported Groups. *Information Systems Research*, 16(2), 149-168.
- Chittaro, L., and Ranon, R. (2005). Web3D technologies in learning, education and training: Motivations, issues, Opportunities. *Computers and Education*, 49(1), 3-18.
- Chu, P. C., & Eric, E. S. (2000). The joint effects of effort and quality on decision strategy choice with computerized decision aids. *Decision Sciences*, 31(2), 259-292.
- Cui, J., Aghajan, Y., Lacroix, J., Halteren, A. V., and Aghajan, H. (2009). Exercising at Home: Real-Time Interaction and Experience Sharing Using Avatars. *Entertainment Computing* (1), 63-73.
- Connolly, T., Jessup, L. M., & Valacich, J. S. (1990). Effects of Anonymity and Evaluative Tone on Idea Generation in Computer-Mediated Groups. *Management Science*, 36(6), 689-703.
- Conole, G. & Oliver, M. (2007). *Contemporary Perspectives in E-Learning Research*. Themes, Methods and Impact on Practice. London, UK: Routledge.
- Contractor, N., Monge, P. R., & Leonardi, P. (2011). Multidimensional networks and the dynamics of sociomateriality: Bringing technology inside the network. *International Journal of Communication*, 5, 682-720.
- Cramton, C. D. (2001). The Mutual Knowledge Problem and Its Consequences for Dispersed Collaboration. *Organization Science*, 12(3), 346-371.
- Cronin, M. A., & Weingart, L. R. (2007). Representational Gaps, Information Processing, And Conflict In Functionally Diverse Teams. *Academy of Management Review*, 32(3), 761-773.
- Cui, J., Aghajan, Y., Lacroix, J., Halteren, A. V., and Aghajan, H. (2009). Exercising at Home: Real-Time Interaction and Experience Sharing Using Avatars. *Entertainment Computing* (1), 63-73.
- Cullen J., Hadjivassiliou, K., Hamilton E., Kelleher J., Sommerlad E., Stern E. (2002). *Review of current pedagogic research and practice in the fields of postcompulsory education and lifelong learning*. London: Tavistock Institute, 2002. Retrieved 8 November 2008 from: <http://www.tlrp.org/pub/acadpub/Tavistockreport.pdf>
- Daft, R. L., & Lengel, R. H. (1986). Organizational information requirements, media richness and structural design. *Management Science*, 32(5), 554-571.
- Daugherty, T., Li, H., & Biocca, F. (2008). Consumer learning and the effects of virtual experience relative to indirect and direct product experience. *Psychology and Marketing*, 25(7), 568-586.
- Davenport G. (2000). Your own virtual story world. *Scientific American*, November: 61-64. Davis, A., Murphy, J., Owens, D., Khazanchi, D., & Ziguers, I. (2009). Avatars, People, and Virtual Worlds: Foundations for Research in Metaverses. *Journal of the Association for Information Systems*, 10(2), 90-117.
- DeBruine, L. M. (2002). Facial resemblance enhances trust. *Proceedings of the Royal Society of London. Series B: Biological Sciences*, 269(1498), 1307-1312.
- De Dreu, C. K. W., & Weingart, L. R. (2003). Task versus relationship conflict, team performance, and team member satisfaction: A meta-analysis. *Journal of Applied Psychology*, 88(4), 741-749.
- DeLuca, D., & Valacich, J. S. (2006). Virtual teams in and out of synchronicity. *Information Technology & People*, 19(4), 323-344.
- Dennis, A. R., Fuller, R. M., & Valacich, J. S. (2008). Media, tasks, and communication processes: a theory of media synchronicity. *MIS Quarterly*, 32(3), 575-600.
- Dennis, A. R. (1996). Information Exchange and Use in Group Decision Making: You Can Lead a Group to Information, but You Can't Make It Think. *MIS Quarterly*, 20(4), 433-457.
- Dennis, A. R., & Kinney, S. T. (1998). Testing media richness theory in the new media: The effects of cues, feedback, and task equivocality. *Information Systems Research*, 9, 256-274.
- Dennis, A. R., & Valacich, J. S. (1999). *Rethinking Media Richness: Towards a Theory of Media Synchronicity*. Paper presented at the Proceedings of the Thirty-Second Annual Hawaii International Conference on System Sciences, vol. 1

- Denzin, N. K., & Lincoln, Y. S. (2000). *Handbook of qualitative research (2nd ed.)*. Thousand Oaks, CA: Sage Publications.
- DeSanctis, G., & Gallupe, R. B. (1987). A foundation for the study of group decision support systems. *Management Science*, 33, 589-609.
- DeSanctis, G., & Poole, M. S. (1994). Capturing the complexity in advanced technology use: Adaptive Structuration Theory. *Organization Science*, 5(2), 121-147.
- DeSanctis, G., Poole, M., Zigurs, I., & Associates (2008). The Minnesota GDSS Research Project: Group support systems, group processes, and outcomes. *Journal of the Association for Information Systems*. 9(10), 551-608.
- Deutsch, M., & Gerard, H. B. (1955). A study of normative and informational social influences upon individual judgment. *The Journal of Abnormal and Social Psychology*, 51(3), 629-636.
- Doherty, P., Rothfarb, R., & Barker, D. (2006). Building an interactive Science Museum in Second Life. In: Livingstone, D. & Kemp, J. (2006). Proceedings of the Second Life Education Workshop at the Second Life Community Convention San Francisco. Retrieved 5 November 2008 from: <http://www.simteach.com/SLCCo6/slcc2006-proceedings.pdf>
- Donath, J. (2007). Virtually Trustworthy. *Science*, 317(5834), 53-54.
- Doorewaard, H. & Verschuren, P. (2010). *Designing a Research Project*. Boom Lemma: Utrecht
- Driskell, J. E., Radtke, P. H., & Salas, E. (2003). Virtual Teams: Effects of Technological Mediation on Team Performance. *Group Dynamics: Theory, Research, and Practice*, 7, 297-323.
- Ducheneaut, N., Yee, N., Nickell, E., & Moore, R. (2006). "Alone together?" *Exploring the Social dynamics of massively multiplayer online games*. Paper presented at the Proceedings of the SIGCHI conference on Human Factors in computing systems.
- Ducheneaut, N., Wen, M. H., Yee, N., & Wadley, G. (2009, April). Body and mind: a study of avatar personalization in three virtual worlds. In Proceedings of the 27th international conference on Human factors in computing systems (pp. 1151-1160). ACM.
- Dunlop, W. L., & Beauchamp, M. R. (2011). Does similarity make a difference? Predicting cohesion and attendance behaviors within exercise group settings. *Group Dynamics: Theory, Research, and Practice*, 15(3), 258-266.
- Dunn, R. A., & Guadagno, R. E. (2012). My avatar and me – Gender and personality predictors of avatar-self discrepancy. *Computers in Human Behavior*, 28(1), 97-106.
- Eliëns A., Feldberg F., Konijn E., Compter E. (2007), *Mashups in Second Life @ VU*, In Proc. GAME-ON 07, Nov 20-22, University of Bologna, Marco Rocchetti (ed.), pp. 130-134, EUROSIS-ETI Publication.
- Ellison, N., Heino, R., & Gibbs, J. (2006). Managing Impressions Online: Self-Presentation Processes in the Online Dating Environment. *Journal of Computer-Mediated Communication*, 11(2), 415-441.
- Ellison, N. B., Steinfield, C., & Lampe, C. (2007). The benefits of Facebook "friends:" Social capital and college students' use of online social network sites. *Journal of Computer-Mediated Communication*, 12(4), 1143-1168.
- Eschenbrenner, B., Nah, F. F. H., & Siau, K. (2008). 3-D Virtual Worlds in Education: Applications, Benefits, Issues, and Opportunities. *Journal of Database Management*, 19(4), 91-110.
- Fazio, R., & Towles-Schwen, T. (1999). The MODE model of attitude-behavior processes. In S. Chaiken & Y. Trope (Eds.), *Dual-process theories in social psychology* (pp. 97-116). New York: The Guilford Press.
- Feldberg, F., Eliëns, A., Van der Land, S., Huysman, M., & Konijn, E. (2009). VU @ Second Life: a report on experiences with the development of a (virtual) community of learners. In N. Pantelli (Ed.), *Virtual Social Networks: Mediated, Massive and Multiplayer sites*: Palgrave MacMillan, UK.
- Field, A. (2009). *Discovering statistics using SPSS*. London: Sage.
- Fonner, K. L., & Roloff, M. E. (2010). Why Teleworkers are More Satisfied with Their Jobs than are Office-Based Workers: When Less Contact is Beneficial. *Journal of Applied Communication Research*, 38(4), 336-361.
- Forsyth, D. (1999). *Group dynamics* (3rd ed.). New York: Brooks/Cole-Wadsworth.
- Fox, J., Arena, D., & Bailenson, J. N. (2009). Virtual Reality. *Journal of Media Psychology: Theories, Methods, and Applications*, 21(3), 95-113.
- Fox, J., & Bailenson, J. N. (2009). Virtual Self-Modeling: The Effects of Vicarious Reinforcement and Identification on Exercise Behaviors. *Media Psychology*, 12(1), 1-25.
- Galanxhi, H., and Nah, F. (2007). Deception in Cyberspace: A Comparison of Text-Only vs. Avatar-Supported Medium. *International Journal of Human-Computer Studies* 65(9), 70-783.
- Galegher, J., & Kraut, R. (1990). *Computer-mediated communication for intellectual teamwork: a field experiment in group writing*. Paper presented at the Proceedings of the 1990 ACM conference on Computer-supported cooperative work.
- Gee J.P. (2003). *What video games have to teach us about learning and literacy*, New York: Palgrave Macmillan.
- Gladstein, D. (1984). Groups in context: A model of task group effectiveness. *Administrative Science Quarterly*, 29(4), 499-517.
- Goffman, E. (1959). *The presentation of self in everyday life*. Garden City, NY: Doubleday.
- Goodhue, D. L., & Thompson, R. L. (1995). Task-technology fit and individual performance. *MIS Quarterly*, 19(2), 213-236.
- Green, S. G., & Taber, T. D. (1980). The effects of three social decision schemes on decision group process. *Organizational Behavior and Human Performance*, 25(1), 97-106.
- Guo, Y., & Barnes, S. (2011). Purchase behavior in virtual worlds: An empirical investigation in Second Life. *Information & Management*, 48(7), 303-312.
- Grigorovici, D. (2003). *Persuasive effects of presence in immersive virtual environments*. Amsterdam: IOS Press.
- Guadagno, R. E., Blascovich, J., Bailenson, J. N., & McCall, C. (2007). Virtual humans and persuasion: The effects of agency and behavioral realism. *Media Psychology*, 10(1), 1-22.
- Harrison, D.A., Price, K.H., & Bell, M.P. (1998). Beyond Relational Demography: Time and the Effects of Surface- and Deep-Level Diversity on Work Group Cohesion. *The Academy of Management Journal*, 41(1), 96-107.
- Haslam, S. A., Powell, C., & Turner, J. (2000). Social Identity, Self-categorization, and Work Motivation: Rethinking the Contribution of the Group to Positive and Sustainable Organisational Outcomes. *Applied Psychology*, 49(3), 319-339.
- Heider, D. (2009). Identity and Reality: What does it mean to live Virtually. *Living Virtually. Researching New Worlds*, New York, 131-143.
- Hiltz, S., Coppola, N., Rotter, N. and Turoff, M. (2001). Measuring the Importance of Collaborative Learning for the Effectiveness of ALN: A Multi-Measure, Multi-Method Approach. In: Bourne, J., (2001). *Online Education. Learning Effectiveness and Faculty Satisfaction*. Sloan Consortium.
- Hinds, P., & Weisband, S. (2003). Knowledge sharing and shared understanding in virtual teams. In C. B. Gibson & S. G. Cohen (Eds.), *Virtual teams that work: Creating conditions for virtual team effectiveness* (pp. 21-36). San Francisco, CA: Jossey Bass.
- Hinsz, V. B., Tindale, R. S., & Vollrath, D. A. (1997). The emerging conceptualization of groups as information processors. *Psychological Bulletin*, 121(1), 43-64.
- Hoorn J.F., Konijn E.A., Van der Veer G.C. (2003), Virtual reality: Do not augment realism, augment relevance. *Human-Computer Interaction: Overcoming Barriers*, 4(1), 18-26.
- Huang, R., Kahai, S., & Jestic, R. (2010). The contingent effects of leadership on team collaboration in virtual teams. *Computers in Human Behavior*, 26(5), 1098-1110.
- Jana, R. (2006, August 23). Starwood Hotels explore Second Life first. *Business Week*. <[http://www.businessweek.com/innovate/content/aug2006/id20060823\\_g25270.html](http://www.businessweek.com/innovate/content/aug2006/id20060823_g25270.html)> Retrieved December 2011.
- Jarvenpaa, S. L., Rao, V. S., & Huber, G. P. (1988). Computer support for meetings of groups working on unstructured problems: A field experiment. *MIS Quarterly*, 12(4), 645-666.
- Jarvenpaa, S. L., & Leidner, D. E. (1998). Communication and Trust in Global Virtual Teams. *Journal of Computer-Mediated Communication*, 3(4), 791-815.
- Kahai, S., Carroll, E., & Jestic, R. (2007). Team collaboration in virtual worlds. *SIGMIS Database*, 38(4), 61-68.
- Kalyuga, S., Chandler, P., & Sweller, J. (1999). Managing split-attention and redundancy in multimedia instruction. *Applied Cognitive Psychology*, 13, 351-371.
- Kaplan, A. M., & Haenlein, M. (2009). The fairyland of Second Life: Virtual social worlds and how to use them. *Business Horizons*, 52(6), 563-572.



- Karacapilidis, N., & Papadias, D. (2001). Computer supported argumentation and collaborative decision making: the HERMES system. *Information Systems*, 26(4), 259-277.
- Khakimjanova, L., & Park, J. (2005). Online visual merchandising practice of apparel e-merchants. *Journal of Retailing and Consumer Services*, 12(5), 307-318.
- Kiesler, S., Siegel, J., & McGuire, T. W. (1984). Social psychological aspects of computer-mediated communication. *American Psychologist*, 39(10), 1123-1134.
- Kiesler, S., Zubrow, D., Moses, A. M., & Geller, V. (1985). Affect in Computer-Mediated Communication: An Experiment in Synchronous Terminal-to-Terminal Discussion. *Human-Computer Interaction*, 1(1), 77-104.
- Kil-Soo, S., Hongki, K., & Eung Kyo, S. (2011). What If Your Avatar Looks Like You? Dual-Congruity Perspectives For Avatar Use. *MIS Quarterly*, 35(3), 711-733.
- Kim, T., & Biocca, F. (1997). Telepresence via television: Two dimensions of telepresence may have different connections to memory and persuasion. *Journal of Computer-Mediated Communication*, 3(2).
- Kim, J. (2009). "I want to be different from others in cyberspace" The role of visual similarity in virtual group identity. *Computers in Human Behavior*, 25(1), 88-95.
- Kim, J. (2010). Balancing uniqueness and assimilation in computer-mediated groups. *Computers in Human Behavior*, 26(4), 778-784.
- Kim, J. (2011). Two Routes Leading to Conformity Intention in Computer-Mediated Groups: Matching Versus Mismatching Virtual Representations. *Journal of Computer-Mediated Communication*, 16(2), 271-287.
- Kirkman, B., Rosen, B., Tesluk, P., & Gibson, C. (2004). The Impact of Team Empowerment on Virtual Team Performance: The Moderating Role of Face-to-Face Interaction. *Academy of Management Journal*, 47(2), 175-192.
- Kirkman, B. L., & Mathieu, J. E. (2005). The Dimensions and Antecedents of Team Virtuality. *Journal of Management*, 31(5), 700-718.
- Kirschner, P. A. (2002). Cognitive load theory: Implications of cognitive load theory on the design of learning. *Learning and Instruction*, 12(1), 1-10.
- Klimoski, R., & Mohammed, S. (1994). Team mental model: Construct or metaphor? *Journal of Management*, 20, 403-437.
- Knutsson, B., Lu, H., Xu, W. & Hopkins, B. (2004). Peer-to-Peer Support for Massively Multiplayer Games. INFOCOM 2004. Twenty-third Annual Joint Conference of the IEEE Computer and Communications Societies, 1: 96-107.
- Kohler, T., Fueller, J., Matzler, K., & Stieger, D. (2011). Co-Creation in Virtual Worlds: The Design of the User Experience. *MIS Quarterly*, 35(3), 773-788.
- Kohler, T., Fueller, J., Stieger, D., & Matzler, K. (2011). Avatar-based innovation: Consequences of the virtual co-creation experience. *Computers in Human Behavior*, 27(1), 160-168.
- Korolov, M. (2011, December 23rd ). Teleplace gone; 3D ICC steps in to help customers. Retrieved September 16th, 2012, from Hypergrid Business: <http://www.hypergridbusiness.com/2011/12/teleplace-gone-3d-icc-steps-in-to-help-customers/>
- Krange, I., Moen, A., & Ludvigsen, S. (2012). Computer-based 3D simulation: a study of communication practices in a trauma team performing patient examination and diagnostic work. *Instructional Science*, 1-19.
- Kumar, N., & Benbasat, I. (2004). The effect of relationship encoding, task type, and complexity on information representation: An empirical evaluation of 2D and 3D line graphs. *MIS Quarterly*, 28(2), 255-281.
- Kwok, R. C. W., & Khalifa, M. (1998). Effect of GSS on knowledge acquisition. *Information & Management*, 34(6), 307-315.
- Lacy, S. (2012). Philip Rosedale the media is wrong: Second Life didn't Fail. Retrieved September 15, 2012: <http://pandodaily.com/2012/07/06/philip-rosedale-the-media-is-wrong-secondlife-didnt-fail/>
- LaFrance, M. (1982). Posture mirroring and rapport. In M. Davis (Ed.), *Interaction rhythms: Periodicity in communicative behavior* (pp. 279-298). New York: Human Sciences Press.
- Lai, J. S., Chang, W. Y., Chan, Y. C., Kang, S. C., & Tan, Y. C. (2011). Development of a 3D virtual environment for improving public participation: Case study—The Yuansantze Flood Diversion Works Project. *Advanced Engineering Informatics*, 25(2), 208-223.
- Lamme, V. A. F. (2004). Separate neural definitions of visual consciousness and visual attention' a case for phenomenal awareness. *Neural Networks*, 17, 861-872.
- Lanningham-Foster, L., Foster, R. C., McCrady, S. K., Jensen, T. B., Mitre, N., & Levine, J. A. (2009). Activity-Promoting Video Games and Increased Energy Expenditure. *The Journal of Pediatrics*, 154(6), 819-823.
- Lea, M., & Spears, R. (1991). Computer-mediated communication, de-individuation and group decision-making. *International Journal of Man-Machine Studies*, 34(2), 283-301.
- Lea, M., Spears, R., & de Groot, D. (1998). Knowing me, knowing you: Effects of visual anonymity on stereotyping and attraction in computer-mediated groups: *Manuscript submitted for publication*.
- Leary, M. (1995). *Self-presentation: Impression management and interpersonal behavior*. Madison, VA: WI Brown & Benchmark Publishers.
- Ledoux, J. (1998). *The emotional brain: The mysterious underpinnings of emotional life*. London: Weidenfeld & Nicolson.
- Lee, E. J. (2004). Effects of Visual Representation on Social Influence in Computer-Mediated Communication. *Human Communication Research*, 30(2), 234-259.
- Lee, K., Li, H., & Edwards, S. M. (2012). The effect of 3-D product visualisation on the strength of brand attitude. *International Journal Of Advertising*, 31(2), 377-396.
- Lensman. (February 2012). Peacekeeper Tips. Retrieved 23 October, 2012 <http://www.activeworlds.com/newsletter/0212/peacekeeper-tips.html>
- Li, H., Daugherty, T., & Biocca, F. (2003). The role of virtual experience in consumer learning. *Journal of Consumer Psychology*, 13(4), 395-407.
- Li, H., Huang, T., Kong, C. W., Guo, H. L., Baldwin, A., Chana, N., et al. (2008). Integrating design and construction through virtual prototyping. *Automation in Construction*, 17(8), 915-922.
- Lin, C., Standing, C., & Liu, Y.-C. (2008). A model to develop effective virtual teams. *Decision Support Systems*, 45(4), 1031-1045.
- Lipnack, J., & Stamps, J. (2000). *Virtual Teams: Working across boundaries with technology*. New York: Wiley.
- Lombard, M. (2000). Measuring presence. a literature-based approach to the development of a standardized paper-and-pencil instrument. In *Presence 2000: The third international workshop on presence*.
- Lombard, M., Snyder-Duch, J., & Bracken, C. C. (2002). Content Analysis in Mass Communication: Assessment and Reporting of Intercoder Reliability. *Human Communication Research*, 28(4), 587-604.
- Lu, G.B., Oveissi, M., Eckard, D. and Rubloff, G. (1996). Education in semiconductor manufacturing processes through physically-based dynamic simulation. *Proc. Frontiers in Education '96*, IEEE pp. 250-253.
- Lurey, J. S., & Raisinghani, M. S. (2001). An empirical study of best practices in virtual teams. *Information & Management*, 38(8), 523-544.
- MacInnis, D. J., & Jaworski, B. J. (1989). Information processing from advertisements: Toward an integrative framework. *Journal of Marketing*, 53(October), 1-23.
- MacKinnon, D., Fairchild, A., & Fritz, M. (2007). Mediation Analysis. *Annual Review of Psychology*, 58, 593-614.
- Maged, N. K. B., Lee, H., & Steve, W. (2007). Second Life: an overview of the potential of 3-D Virtual worlds in medical and health education. *Health Information & Libraries Journal*, 24(4), 233-245.
- Martins, L. L., Gilson, L. L., & Maynard, M. T. (2004). Virtual Teams: What Do We Know and Where Do We Go From Here? *Journal of Management*, 30(6), 805-835.
- Mathieu, J. E., Heffner, T. S., Goodwin, G. F., Salas, E., & Cannon-Bowers, J. A. (2000). The influence of shared mental models on team process and performance. *Journal of Applied Psychology*, 85(2), 273-283.
- Maznevski, M., & Chudoba, K. (2000). Bridging space over time: global virtual team dynamics And effectiveness. *Organization Science*, 11(5), 473-492.
- McGrath, J. E. (1984). *Groups interaction and performance*. Englewood Cliffs, NJ: Prentice-Hall.
- McCroskey, J. C., Richmond, V. P., & Daly, J. A. (1975 ). The development of a measure of perceived homophily in interpersonal communication. *Human Communication Research*, 1(4), 323-332.
- Mennecke, B. E., Valacich, J. S., & Wheeler, B. C. (2000). The Effects of Media and Task on User Performance: A Test of the Task-Media Fit Hypothesis. *Group Decision and Negotiation*, 9(6), 507-529.

- Mennecke, B. E., Triplett, J. L., Hassall, L. M., Conde, Z. J., & Heer, R. (2011). An Examination of a Theory of Embodied Social Presence in Virtual Worlds\*. *Decision Sciences*, 42(2), 413-450.
- Messinger, P. R., Stroulia, E., Lyons, K., Bone, M., Niu, R. H., Smirnov, K., et al. (2009). Virtual worlds — past, present, and future: New directions in social computing. *Decision Support Systems*, 47(3), 204-228.
- Mohammed, S. & Ringseis, E. (2001). Cognitive diversity and consensus in group decision making: The role of inputs, processes, and outcomes. *Organizational Behavior and Human Decision Processes*, 85(2), 310-335.
- Morrisson, A., & Skjulstadt, S. (2010). Unreal estate: Digital design and mediation in marketing urban residency. In I. Wagner, T.Bratteteig & D. Studahl (Eds.), *Exploring Digital Design: Multi-Disciplinary Design Practices*. London: Springer Verlag.
- Münzer, S., & Holmer, T. (2009). Briding the gap between media synchronicity and task performance. Effects of media characteristics on process variables and task performance indicators in an information pooling task. *Communication Research*, 36(1), 76–103.
- Nichols, S., Haldane, C., & Wilson, J. R. (2000). Measuring presence and its consequences in virtual environments. *International Journal of Human-Computer Studies*, 52(3), 471–491.
- Oakes, P. J., & Turner, J. C. (1980). Social categorization and intergroup behaviour: Does Minimal intergroup discrimination make social identity more positive? *European Journal of Social Psychology*, 10(3), 295-301.
- Ong, E. Y., Ang, R. P., Ho, J., Lim, J. C., Goh, D. H., Lee, C. S., & Chua, A. Y. (2011). Narcissism, extraversion and adolescents' self-presentation on Facebook. *Personality and Individual Differences*, 50(2), 180-185.
- Orlikowski, W. J. (2010). The sociomateriality of organisational life: considering technology in management research. *Cambridge Journal of Economics*, 34(1), 125-141.
- Paas, F., van Merriënboer, J., & Adam, J. (1994). Measurement of cognitive load in instructional research. *Perceptual and Motor Skills*, 79, 419–430.
- Paas, F., Tuovinen, J. E., Tabbers, H., & Van Gerven, P. W. M. (2003). Cognitive load measurement as a means to advance cognitive load theory. *Educational Psychologist*, 38(1), 63–71.
- Paas, F., Tuovinen, J., Merriënboer, J. and Darabi, A. (2005). A Motivational Perspective on the Relation Between Mental Effort and Performance: Optimizing Learner Involvement in Instruction. *ETR&D*, 53(3), 25-34.
- Park, S.H. (1996). Relationships Between Involvement and Attitudinal Loyalty Constructs in Adult Fitness Programs. *Journal of Leisure Research*. 28(4), 233-250
- Parush, A., Hamm, H., and Shtub, A. (2002). Learning histories in simulation-based teaching: the effects on self-learning and transfer. *Computer & Education*, 39(4), 319-332.
- Payne, J. W. (1976). Task complexity and contingent processing in decision making: An information search and protocol analysis. *Organizational Behavior and Human Performance*, 16(2), 366–387.
- Petty, R. E., Gleichter, F., & Jarvis, W. B. G. (1993). Persuasion theory and AIDS prevention. In J. B. Pryor & G. D. Reeder (Eds.), *The social psychology of HIV infection* (pp. 155–182). Hillsdale: Lawrence Erlbaum Associates.
- Pimentel, K., & Teixeira, K. (1994). *Virtual reality: Through the new looking glass*. New York: McGraw-Hill, Inc..
- Plaisant, C., Rose, A., Rubloff, G., Salter, R., and Shneiderman B. (1999). The design of history mechanisms and their use in collaborative educational simulations. Proc. of the Computer Support for Collaborative Learning, CSCCL' 99, Palo Alto, CA. 348–359.
- Plaskoff, J. (2003). Intersubjectivity and community building: Learning to learn organizationally. In M. Easterby-Smith & M. A. Lyles (Eds.), *The Blackwell handbook of organizational learning and knowledge management* (pp. 161–184). Malden, MA: Blackwell.
- Postmes, T., Spears, R., & Lea, M. (1998). Breaching or building social boundaries? SIDE-effects of computer-mediated communication. *Communication Research*, 25(6), 689-715.
- Postmes, T., Spears, R., & Lea, M. (2002). Intergroup differentiation in computer-mediated communication: Effects of depersonalization. *Group Dynamics: Theory, Research, and Practice*, 6(1), 3-16.
- Postrel, S. (2002). Islands of shared knowledge: Specialization and mutual understanding in problem-solving teams. *Organization Science*, 13(3), 303–320.
- Powell, A., Piccoli, G., & Ives, B. (2004). Virtual teams: a review of current literature and directions for future research. *SIGMIS Database*, 35(1), 6-36.
- Ratan, R. A., & Hasler, B. (2009). *Self-Presence Standardized: Introducing the Self-Presence Questionnaire (SPQ)*. Paper presented at the Proceedings of the 10th Annual International Workshop on Presence, Los Angeles, USA.
- Regenbrecht, H., Barattoff, G., & Wilke, W. (2005). Augmented reality projects in the automotive and aerospace industries. *IEEE Computer Graphics and Applications*, 25(6), 48–56.
- Roche, E. (2007). Setting The Research Agenda. *The DATABASE for Advances in Information Systems*, 38(4), 7-10.
- Rogoff, B., Matusov, E. and White, C. (1996). Models of Teaching and Learning: Participation in a Community of Learners. In: Olson, D. & Torrance, N. (1996). *The Handbook of Education and Human Development* (pp. 388- 433). Massachusetts: Blackwell Publishers.
- Rose, A., Eckard, D., & Rubloff, G.W. (1998). An application framework for creating simulation-based learning environments. University of Maryland, Department of Computer Science, Technical Report CS-TR-3907, UMIACS-TR-98-32, College Park, MD.
- Rose, F. D., Attree, E. A., Brooks, B. M., Parslow, D. M., & Penn, P. R. (2000). Training in Virtual environments: transfer to real world tasks and equivalence to real task training. *Ergonomics*, 43(4), 494-511.
- Rosenhead, J. (1989). *Rational analysis for a problematic world*. New York: Wiley.
- Rousseau, V., Aubé, C., & Savoie, A. (2006). Teamwork Behaviors. *Small Group Research*, 37(5), 540-570.
- Rousseau, D., Sitkin, S., Burt, R., & Camerer, C. (1998). Not So Different After All: A Cross-Discipline View of Trust. *Academy of Management Review*, 23(3), 393-404.
- Rymaszewski M., Au W.J., Wallace M., Winters C., Ondrejka C., Batstone-Cunningham B. (2007). *Second Life - the official guide*. New York: John Wiley.
- Sacco, D. ((2011, May 24th) ). The Sims 3: Generations | games industry | MCV. Retrieved October 8th, 2012: <http://www.mcvuk.com/retail-biz/recommended/read/the-sims-3-generations/02925>
- Sassenberg, K. (2002). Common bond and common identity groups on the internet: Attachment And normative behavior in on-topic and off-topic chats. *Group Dynamics*, 6(1), 27-37.
- Saunders, C., Rutkowski, A. F., von Genuchten, M., Vogel, D., & Orrego, J. M. (2011). Virtual space and place: theory and test. *MIS Quarterly*, 35(4), 1079-1098.
- Scaife, M., & Rogers, Y. (2001). Informing the design of a virtual environment to support learning in children. *International Journal of Human-Computer Studies*, 55, 115–143.
- Schouten, A. P., Van den Hooff, B. & Feldberg, F. (2010). Real decisions in virtual worlds: Team collaboration and decision making in virtual worlds. In *ICIS 2010 Proceedings*, paper 18.
- Schrader, C., & Bastiaens, T. J. (2011). The influence of virtual presence. Effects on experienced cognitive load and learning outcomes in educational computer games. *Computers in Human Behavior*, 28(2), 648–658.
- Schroder, H. M., Driver, M. J., et al. (1967). *Human information processing: individuals and groups functioning in complex social situations*. New York: Holt, Rinehart and Winston, Inc.
- Shanteau, J., & Nagy, G. (1979). Probability of acceptance in dating choice. *Journal of Personality and Social Psychology*, 37(4), 522-533.
- Short, J., Williams, E., & Christie, B. (1976). *The Social Psychology of Telecommunications*. New York: John Wiley and Sons, Inc.
- Suh, K.-S., & Lee, Y. E. (2005). The effects of virtual reality on consumer learning: An empirical investigation. *MIS Quarterly*, 29(4), 673–697.
- Schultze, U., & Orlikowski, W. J. (2010). Research Commentary---Virtual Worlds: A Performative Perspective on Globally Distributed, Immersive Work. *Information Systems Research*, 21(4), 810-821.
- Short, J. A., Williams, E., & Christie, B. (1976). *The Social Psychology of Telecommunications*. New York, John Wiley & Sons.
- Snyder, C. R., & Fromkin, H. L. (1980). *Uniqueness: Human Pursuit of Difference*. New York: Plenum.
- Staples, D., & Zhao, L. (2006). The Effects of Cultural Diversity in Virtual Teams Versus Face-to-Face Teams. *Group Decision and Negotiation*, 15(4), 389-406.
- Stasser, G., & Stewart, D. (1992). Discovery of hidden profiles by decision-making groups: Solving a problem versus making a judgment. *Journal of Personality and Social Psychology*, 63(3), 426-434.



- Stasser, G., & Titus, W. (1985). Pooling of unshared information in group decision making: Biased information sampling during discussion. *Journal of personality and social psychology*, 48(6), 1467.
- Straus, S. G., & McGrath, J. E. (1994). Does the medium matter? The interaction of task type and technology on group performance and member reactions. *Journal of Applied Psychology*, 79(1), 87-97.
- Straus, S. G. (1999). Testing a Typology of Tasks. *Small Group Research*, 30(2), 166-187.
- Straus, S. G., Miles, J. A., & Levesque, L. L. (2001). The effects of videoconference, telephone, and face-to-face media on interviewer and applicant judgments in employment interviews. *Journal of Management*, 27(3), 363-381.
- Suh, K.-S., & Lee, Y. E. (2005). The Effects of Virtual Reality on Consumer Learning: An Empirical Investigation. *MIS Quarterly*, 29(4), 673-697.
- Swaab, R. I., Postmes, T., Neijens, P., Kiers, M. H., & Dumay, A. C. M. (2002). Multiparty Negotiation Support: The Role of Visualization's Influence on the Development of Shared Mental Models. *Journal of Management Information Systems*, 19(1), 129-150.
- Swaab, R., Postmes, T., van Beest, I., & Spears, R. (2007). Shared Cognition as a Product of, and Precursor to, Shared Identity in Negotiations. *Personality and Social Psychology Bulletin*, 33(2), 187-199.
- Sweller, J. (1999). Instructional design in technical areas. Camberwell, Victoria, Australia: ACER Press.
- Sweller, J. (2005). Implications of cognitive load theory for multimedia learning. In R. E. Mayer (Ed.), *Cambridge handbook of multimedia learning* (pp. 19-30). New York: Cambridge University Press.
- Tajfel, H., Billig, M., Bundy, R., & Flament, C. (1971). Social categorization and intergroup behaviour. *European Journal of Social Psychology*, 1(2), 149-178.
- Tajfel, H., & Turner, J. C. (1986). *The social identity theory of intergroup behaviour*. In S. Worchel & W. G. Austin (Eds.), *Psychology of intergroup relations* (pp. 7-24). Chicago, IL: Nelson-Hall.
- Tanis, M., & Postmes, T. (2005). A social identity approach to trust: interpersonal perception, group membership and trusting behaviour. *European Journal of Social Psychology*, 35(3), 413-424.
- Tavanti, M., & Lind, M. (2001). *2D vs 3D, Implications on spatial memory*. Paper presented at The Proceedings of the IEEE Symposium on Information Visualization 2001 (INFOVIS'01).
- Teigland, R. (2010, December 15th). Overview of a Meeting in Teleplace. Retrieved September 16th, 2012: <http://nordicworlds.net/page/16/>
- Telegraph, T. (2008) Financial crisis forces cuts in business travel. Retrieved from September 15th, 2012: <http://www.telegraph.co.uk/travel/travelnews/3235079/Financial-crisis-forces-cuts-in-business-travel.html>
- Thang, J. (2008, March 19th). The Sims 3 Set for Global Launch in 2009 Game's official website goes live. Retrieved October 8th, 2012: <http://www.ign.com/articles/2008/03/19/the-sims-3-set-for-global-launch-in-2009>
- Tindale, R. S., & Kameda, T. (2000). 'Social sharedness' as a unifying theme for information Processing in groups. *Group Processes & Intergroup Relations*, 3(2), 123-140.
- Thompson, J. D., & Bates, F. L. (1957). Technology, organization, and administration. *Administrative Science Quarterly*, 2(3), 325-343.
- Thompson, L., & Fine, G. A. (1999). Socially shared cognition, affect, and behavior: A review And integration. *Personality and Social Psychology Review*, 3(4), 278-302.
- Todd, P., & Benbasat, I. (1992). The use of information in decision making: An experimental investigation of the impact of computer-based decision aids. *MIS Quarterly*, 16(3), 373-393.
- Todd, P., & Benbasat, I. (1999). Evaluating the impact of DSS, cognitive effort, and incentives on strategy selection. *Information Systems Research*, 10(4), 356-374.
- Townsend, A. M., DeMarie, S. M., & Hendrickson, A. R. (1998). Virtual teams: Technology and the workplace of the future. *Academy of Management Executive*, 12(3), 17-29.
- Tschang, F. T. (2007). Balancing the Tensions Between Rationalization and Creativity in the Video Games Industry. *Organization Science*, 18(6), 989-1005.
- Turkle, S. (1994). Constructions and reconstructions of self in virtual reality: Playing in the MUDs. *Mind, Culture, and Activity*, 1(3), 158-167.
- Turkle, S. (1995). *Life on the Screen: Identity in the Age of the Internet*. New York: Simon & Schuster.
- Turner, J. C. (1991). Social influence. Buckingham, England: Open University Press.
- Utz S. (2003). *Social identification and interpersonal attraction in MUDs*, *Swiss Journal of Psychology*, 62, 91-101.
- Van der Land, S., Schouten, A.P., Van den Hooff, B. & Feldberg, F. (2011). Modelling the Metaverse: A Theoretical Model of Effective Team Collaboration in 3D Virtual Environments. *Journal of Virtual Worlds Research*, 4(3), 1-18.
- Van Merriënboer, J. J. G., & Sweller, J. (2005). Cognitive load theory and complex learning: recent developments and future directions. *Educational Psychology Review*, 17(2), 147-177.
- Verhagen, T., Feldberg, F., Van den Hooff, B., Meents, S., & Merikivi, J. (2012). Understanding users' motivations to engage in virtual worlds: A multipurpose model and empirical testing. *Computers in Human Behavior*, 28(2), 484-495.
- Vessey, I. (1991). Cognitive fit: A theory-based analysis of the graphs versus tables literature. *Decision Sciences*, 22(2), 219-240.
- Vessey, I., & Galletta, D. (1991). Cognitive fit: An empirical study of information acquisition. *Information Systems Research*, 2(1), 63-84.
- Vignoles, V. L., Chrysoschoou, X., & Breakwell, G. M. (2000). The Distinctiveness Principle: Identity, Meaning, and the Bounds of Cultural Relativity. *Personality and Social Psychology Review*, 4(4), 337-354.
- Vlaar, P. W. L., van Fenema, P. C., & Tiwari, V. (2008). Cocreating Understanding and Value in Distributed Work: How Members of Onsite and Offshore Vendor Teams Give, Make, Demand, and Break Sense. *MIS Quarterly*, 32(2), 227-255.
- Vorderer, P. and Bryant, J. (eds.). (2006). *Playing computer games - Motives, responses, and consequences*, Mahwah, NJ: Lawrence Erlbaum Associate.
- Wagner C. (2008). Learning Experience with virtual Worlds. *Journal of Information Systems Education*, 19(3), 263-266.
- Walsh, K. R., & Pawlowski, S. D. (2002). Virtual reality: A technology in need of IS research. *Communications of the Association for Information Systems*, 8, article 20.
- Walther, J.B. (1995). *Relational Aspects of Computer-mediated Communication: Experimental Observations over Time*, *Organization Science*, 6(2), 186-203.
- Walther, J. B. (1996). Computer-Mediated Communication: Impersonal, interpersonal, and hyperpersonal interaction. *Communication Research*, 23(1), 3-43.
- Walther & Bunz, U. (2005). The rules of virtual groups: Trust, liking, and performance in computer-mediated communication. *Journal of Communication*, 55(4), 828-846.
- Walther, J. B., & Parks, M. R. (2002). *Cues filtered out, cues filtered in: Computer-mediated communication and relationships*. Thousand Oaks, CA: Sage.
- Walther, J. B., Slovacek, C., & Tidwell, L. (2001). Is a Picture Worth a Thousand Words?: Photographic Images in Long-Term and Short-Term Computer-Mediated Communication. *Communication Research*, 28(1), 105-134.
- Wasko, M., Teigland, R., Leidner, D., & Jarvenpaa, S. (2011). Stepping into the Internet: New Ventures in Virtual Worlds. *Management Information Systems Quarterly*, 35(3), 645-652.
- Watson, W. E., Johnson, L., Kumar, K., & Critelli, J. (1998). Process gain and process loss: comparing interpersonal processes and performance of culturally diverse and non-diverse teams across time. *International Journal of Intercultural Relations*, 22(4), 409-430.
- Weick, K. E. (1985). Cosmos vs. chaos: Sense and nonsense in electronic contexts. *Organizational Dynamics*, 14(2), 51-64.
- Wegner, D. M. (1987). *Transactive memory: A contemporary analysis of group mind*. New York: Springer-Verlag.
- Weldon, M., & Bellinger, K. (1997). Collective memory: Collaborative and individual processes in remembering. *Journal of Experimental Psychology*, 23, 1160-1175.
- Wilson, N. (2009). *Virtual Worlds for Business*. Retrieved January 28, 2010 from: <http://cleverzebra.com/system/files/VW4B-2009-Q2.1.pdf>.

- Wirth, J., Feldberg, J. F. M., Schouten, A. P., Van den Hooff, B., & Williams, K. (2011). Using Virtual Game Environments to Study Group Behavior. In A. B. H. a. M. S. Poole (Ed.), *Research Methods for Studying Groups and Teams. A Guide to Approaches, Tools, and Technologies*. New York: Routledge.
- Witmer, B. G., & Singer, M. J. (1998). Measuring presence in virtual environments: A presence questionnaire. *Presence, Teleoperators & Virtual Environments*, 7(3), 225-240.
- Yee, N., Bailenson, J. N., Urbanek, M., Chang, F., & Merget, D. (2007). The unbearable likeness Of being digital: The persistence of nonverbal social norms in online virtual environments. *CyberPsychology & Behavior*, 10(1), 115-121.
- Yee, N., & Bailenson, J. (2007). The Proteus Effect: The Effect of Transformed Self-Representation on Behavior. *Human Communication Research*, 33(3), 271-290.
- Yee, N., Bailenson, J. N., & Ducheneaut, N. (2009). The Proteus Effect. *Communication Research*, 36(2), 285-312.
- Zammuto, R. F., Griffith, T. L., Majchrzak, A., Dougherty, D. J., & Faraj, S. (2007). Information Technology and the Changing Fabric of Organization. *Organization Science*, 18(5), 749-762.
- Zhou, Z., Cheok, A. D., Qiu, Y., & Yang, X. (2007). The role of 3-D sound in human reaction and Performance in augmented reality environments. *IEEE Transactions on Systems Man and Cybernetics, Part A: Systems and Humans*, 37(2), 262-272.
- Zigurs, I., & Buckland, B. K. (1998). A theory of task/technology fit and group support systems effectiveness. *MIS Quarterly*, 22(3), 313-334.
- Zigurs, I., Buckland, B. K., Connolly, J. R., & Wilson, E. V. (1999). A test of task/technology fit theory for group support systems. *DataBase*, 30(3), 34-50.

## Nederlandse Samenvatting

### Virtueel Samenwerken:

#### Een Onderzoek naar de Invloed van Avatars en 3D Virtuele Werelden op Teameffectiviteit

#### 3D Virtuele Werelden en Effectieve Teamsamenwerking

Op 28 februari 2007 kondigde de Vrije Universiteit in Amsterdam als eerste universiteit in Nederland aan dat ze te vinden was op *Second Life*, een 3D virtuele wereld. Niet lang daarna werd haar Second Life Projectteam platgebeld door de media, wat resulteerde in een nieuwsitem op *prime time* nationale televisie evenals een item op AT5, de Amsterdamse lokale zender. Een aantal artikelen verscheen ook in verschillende nationale kranten (Feldberg, Eliëns, Van der Land, Huysman, & Konijn, 2009). Destijds werden veel bedrijven opgestookt door slimme marketeers om de boot niet te missen en verdrongen ze elkaar om als eerste aanwezigheid te kunnen claimen in dit boeiende nieuwe medium genaamd *Second Life*.

Over het algemeen worden 3D-virtuele werelden gedefinieerd als “*online elektronische omgevingen die visueel complexe fysieke omgevingen nabootsen, waar mensen met elkaar en virtuele objecten kunnen interacteren, en communiceren via avatars- een digitale representatie van zichzelf* (Bainbridge, 2007, blz. 472).” Naast aandacht van organisaties hebben virtuele werelden zoals *Second Life* ook de aandacht getrokken van wetenschappers, vooral van de Information Systems (IS) community. Een literatuuronderzoek naar studies die virtuele werelden behandelen (Cahalane, Feller, & Finnegan, 2012), toonde aan dat de onderzoeksonderwerpen erg divers zijn, bijvoorbeeld: online educatie (Chen, Siau, & Nah, 2010; Eschenbrenner, Nah, & Siau, 2008), bedrijven (Ahonen, Donnellan, Mahaley, O’Donovan, & Teigland) co-creatie (Chaturvedi, Dolk, & Drnevich, 2011; Kohler, Fueller, Matzler, & Stieger, 2011), handel in goederen en objecten (Guo & Barnes, 2011) en toegepaste vormgeving (Chaturvedi, et al., 2011).

Desalniettemin, ondanks een groeiende interesse van het bedrijfsleven en de wetenschap in virtuele werelden (Davis, Murphy, Owens, Khazanchi, & Zigurs, 2009; Huang, Kahai, & Jestice, 2010) is er nog steeds weinig empirisch onderzoek naar effectieve samenwerking van teams in virtuele werelden. De bijdrage van 3D virtuele werelden aan samenwerking van virtuele teams die onafhankelijk van tijd en plaats werken zal waarschijnlijk verschillen van traditioneel bestudeerde virtuele teams. 3D virtuele werelden bieden namelijk twee unieke eigenschappen zoals 1) de simulatie van een gedeelte visuele omgeving en 2) de representatie en communicatie die door middel van een avatar gaat, bevorderlijk zou kunnen zijn voor verschillende taken en op

**Tabel A** Overzicht van de belangrijkste bevindingen van de studies van deze dissertatie

Studie	Onderzoeks-vraag/doel	Methode	Data Bron	Hoofdbevindingen
Studie 1: Exploratief (Hfst 2)	Onderzoeken welk voordeel de aanwezigheid in Second Life een organisatie verschaft m.b.t. samenwerking	Kwalitatief	- Explorerende studies	- Drie aspecten blijken van specifiek belang voor vervolgonderzoek: 1) equality of participation 2) involvement en 3) simulations. - Een onderzoek agenda wordt voorgesteld voor vervolgonderzoek naar de invloed van 3D virtuele werelden en de potentie voor samenwerking in teamverband.
Studie 2: Conceptueel (Hfst 3)	Een conceptueel model te presenteren dat specifiek focust op de effectiviteit van 3D virtueel samenwerken.	Literature Review	- Bestaande literatuur	- 3D virtuele werelden ondersteunen twee processen die cruciaal zijn voor effectieve teamsamenwerking: 1) information processing support door de manipulatie van visueel gepresenteerde informatie. 2) Ondersteuning in de communicatie door de manipulatie van het uiterlijk van een avatar.
Studie 3: Experimenteel (Hfst 4)	Hoe ondersteunen visuele presentaties van informatie in een 3D virtuele wereld zowel individueel als gezamenlijk begrip, en dragen zodoende bij aan het maken van een groepsbeslissing?	Experiment	- Zelf rapportage	- Zoals voorgesteld door <i>cognitive fit theory</i> , laten onze resultaten zien dat informatie gepresenteerd in een 3D virtuele wereld inderdaad meer effectief is in het ondersteunen van individueel begrip dan informatie gepresenteerd in een 2D omgeving. - Echter, in lijn met <i>cognitive load theory</i> , blijkt een statische 3D presentatie van informatie, meer effectief te zijn in het ondersteunen van gezamenlijk begrip en het proces van groepsbeslissing, dan de presentatie van informatie in een 3D virtuele wereld waardoor kan worden genavigeerd.
Studie 4: Multi-method (Hfst 5)	Hoe beïnvloeden <i>similarity</i> en <i>self-identity</i> in avatar representaties de prestaties van virtuele teams?	Multi-Method	- Experiment - Content analyse van de logged chat conversations	- Resultaten van het experiment bevestigen dat teams van wie de avatar een hoge mate van groep <i>similarity</i> en <i>self-identification</i> combineerden (gerepresenteerd door een " <i>morphed team avatar</i> "), het beste presteerde op de taak en elkaar veel aardiger vonden dan in de overige drie condities. - Content analyse van de conversaties tussen de teamleden laat zien dat teamleden in de <i>morph</i> conditie significant meer betrokken waren bij de taak dan teamleden die gerepresenteerd waren door een avatar die niet correspondeerde met zichzelf en het team

nieuwe manieren invloed zou kunnen uitoefenen op effectieve teamsamenwerking (Van der Land, Schouten, Van den Hooff, & Feldberg, 2011). Daarom is het doel van dit proefschrift te onderzoeken of en hoe de unieke eigenschappen van dit nieuwe opkomende medium van 3D virtuele werelden kunnen bijdragen aan effectieve teamsamenwerking. Het resultaat van dit onderzoek draagt bij aan het hedendaagse debat in de literatuur over organisationele communicatie en informatiesystemen in het algemeen, en specifiek met betrekking tot teamgedrag in een computer gemedieerde

omgeving. De hoofdonderzoeksvraag is als volgt geformuleerd: "Hoe kunnen 3D virtuele werelden worden ingezet om effectieve teamsamenwerking te versterken?"

### Theoretische basis

Een theoretisch raamwerk van de concepten die invloed hebben op effectieve virtuele teamsamenwerking kan worden gevonden in Media Synchronicity Theory (MST) (Dennis, Fuller, & Valacich, 2008; Dennis & Valacich, 1999). MST incorporeert twee

verschillende communicatieprocessen of “routes” om *shared understanding* (gedeeld begrip) en effectieve samenwerking te creëren. Het eerste communicatieproces is *conveyance* wat refereert aan het individuele proces van het bevatten van nieuwe taak gerelateerde informatie door de informatie te analyseren en een nieuw mentaal model te bouwen. Conveyance richt zich dus op het individueel begrip op een taak en is in deze dissertatie gedefinieerd als *information processing support*. Het tweede proces is *convergence* wat refereert aan collectief onderhandelen en discussiëren over de betekenis van de informatie met het doel om gezamenlijk begrip te creëren. Convergence richt zich ook op de sociale aspecten van het samenwerken zoals teamcohesie (Chang & Bordia, 2001) en teamidentificatie (Tajfel & Turner, 1986) en wordt in deze dissertatie gedefinieerd als *communicatie support*.

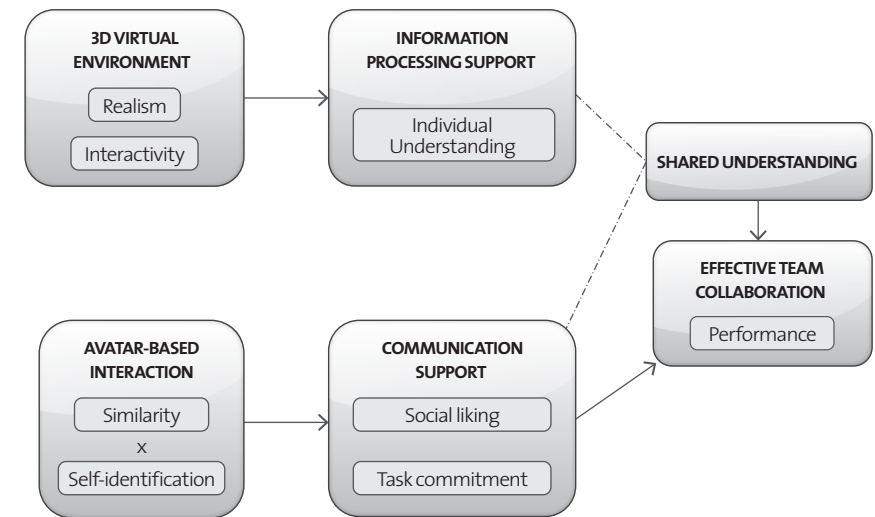
Dit conceptuele onderscheid tussen de twee verschillende routes die tot *shared understanding* leiden wordt ook ondersteund en weergegeven in hedendaags onderzoek naar het gedrag van groepen. In deze literatuur wordt een *dual process model* (Deutsch & Gerard, 1955) gepresenteerd dat overeenkomt met MST. Er kan een duidelijk onderscheid worden gemaakt of teams in termen van cognitieve-informationele of sociaal-relatieve factoren worden geclassificeerd (Chang & Bordia, 2001; Deutsch & Gerard, 1955; Hinsz, et al., 1997).

Tot op heden is MST's gedachtegoed en het dual process model nog niet toegepast in de context van 3D virtuele werelden. In dit proefschrift verdiep ik me in het begrip van virtuele teamsamenwerking en groepsbeslissingen in 3D virtuele werelden door vier verschillende studies. De resultaten van deze studies worden besproken in hoofdstuk 2-5 en zijn in tabel A schematisch weergegeven.

## Theoretische Implicaties

Dit proefschrift is een van de eerste die een theoretisch raamwerk voor effectieve teamsamenwerking in de context van 3D virtuele werelden heeft ontwikkeld en empirisch getest. Tot op heden waren de meeste theoretische raamwerken te breed om toegepast te worden in de context van 3D virtuele samenwerking, omdat ze niet zijn ontworpen vanuit de specifieke karakteristieken van 3D virtuele werelden (Messinger, et al., 2009). Een belangrijk theoretisch vertrekpunt in het vormen van het theoretisch raamwerk van dit proefschrift was media synchronicity theory (MST) (Dennis et al., 2007). In de vier verschillende studies van dit proefschrift werd het raamwerk van het MST raamwerk en zijn theoretische veronderstellingen verder ontwikkeld door middel van inzicht uit verschillende stromen van bestaande literatuur (hoofdstuk 3), *cognitive load theory* (hoofdstuk 4), en *SIDE and self-identity theory*

(hoofdstuk 5), om de hypothesen te testen van de onderzoeksvraag. Gebaseerd op de resultaten van dit proefschrift zijn de theoretische bevindingen weergegeven in een definitief theoretisch raamwerk, welke visueel is weergegeven in figuur A.



Figuur A Definitief Theoretisch Raamwerk

### Information Processing Support en Effectieve Virtuele Team Samenwerking

Het onderzoek uit dit proefschrift laat zien dat de concepten *realisme* en *interactiviteit* meer bijdroegen aan individueel begrip dan het concept *presence*, het gevoel aanwezig te zijn in een 3D virtuele wereld. Hoewel deze bevinding conflicteert met eerder onderzoek (Grigorovici, 2003; Scaife & Rogers, 2001), ondersteunt het een meer recente theorie, namelijk *Virtual Space and Place theory* (Saunders et al., 2011). Dit onderzoek draagt bij aan de Virtual Space and Place theory door de constatering dat het concept *interactiviteit* met virtuele objecten van cruciaal belang is voor het begrip van deze virtuele objecten.

De bevindingen uit dit proefschrift hebben ook implicaties voor de veronderstelde relatie tussen individueel en gezamenlijk begrip, welke centraal staan in MST. In hoofdstuk 4 bleek dat er geen significante relatie tussen individueel begrip en gezamenlijk begrip te zijn in de context van 3D virtuele werelden. Met andere woorden, het theoretische idee dat de som van individuele teamleden hun gezamenlijk begrip positief beïnvloed, wordt niet ondersteund door de empirische resultaten van dit proefschrift. Daarom is in figuur A een gestippelde lijn weergegeven tussen de variabelen

*individual understanding* en *shared understanding*. De implicaties van deze bevindingen duiden erop dat gezamenlijk begrip wellicht meer een interactief groepsproces is en dat sociale factoren een grotere invloed spelen in het creëren van gezamenlijk begrip (Driskell et al., 2003).

### Communication Support en Effectieve Virtuele Team Samenwerking

Dit proefschrift is een van de eerste die laat zien dat in een virtueel teamverband de mechanismen *similarity* en *self-identity*, welke inherent zijn aan de zelfpresentatie van avatars, kunnen bijdragen aan een betere virtuele teamprestatie. Door de nieuwe techniek van “morphing”, kunnen de gelaatstrekken van een avatar meer overeenkomsten vertonen met die van andere avatars, terwijl tegelijkertijd de zelf-identiteit van de gebruiker (het eigen gezicht) optimaal kan worden weergegeven in het gezicht van de avatar. Wanneer deze mechanismen optimaal worden ingezet, leidt dit er toe dat teamleden elkaar aardiger vinden en beter presteren dan wanneer zij waren weergegeven als cartoonese figuren die ofwel homogeen of heterogeen waren weergegeven. Uit de content analyse bleek dat teamleden die visueel waren gerepresenteerd als “morphed team avatars”, meer toewijding aan de taak uitten in hun communicatieve gedrag. Deze bevinding complementeert theoretisch eerdere studies die gebaseerd waren op het *social identity model* of *deindividuation effects* (SIDE) en zich focusten op het uiterlijk van cartoonfiguren (Kim, 2009; Lee, 2004), met de dimensie van de eigen identiteit, waardoor iemands eigen fysieke uiterlijk wordt gerepresenteerd.

De empirische bevindingen van dit proefschrift impliceren voor (SIDE) dat, onder verschillende methodologische omstandigheden, de impact van avatar representatie op sociale interactie tussen teamleden niet kan ontstaan. Het onderzoek van dit proefschrift anticipeerde op Kims (2011) oproep om toekomstige studies gebaseerd op SIDE minder experimenteel te maken en meer ruimte te creëren voor natuurlijke interactie, in plaats van voorgeprogrammeerde discussies via de computer. Echter, in tegenstelling tot deze eerdere op SIDE gebaseerde studies toonde dit proefschrift aan dat er geen verschillen werden gevonden in groepsidentiteit en vertrouwen onder de verschillende condities. Dit kan impliceren dat wanneer natuurlijke conversatie tussen echte participanten plaatsvindt, het effect van stereotypering met betrekking tot de aanwezige sociale *cues* wordt verkleind.

### Implicaties voor Effectieve Virtuele Team Samenwerking

Dit proefschrift draagt bij aan MSTs notie over effectieve virtuele samenwerking doordat het zowel de informatie als processen van communicatie support erkent en empirisch bewijs geeft voor de notie dat effectieve samenwerking bestaat uit verschillende “taak” fases. Bijvoorbeeld, dit proefschrift toonde aan dat de individuele

fase van begrip van een taak kan profiteren van de rijkheid van een 3D virtuele wereld en de vele mogelijkheden om informatie weer te geven. Echter, wanneer het discussiëren met teamleden over de verschillende opties een relevante fase is van de taak, is een medium dat communicatie processen ondersteunt meer geschikt voor deze specifieke fase van deze samenwerkingstaak.

Dit proefschrift laat zien dat “shared understanding” minder belangrijk bleek met betrekking tot effectieve samenwerking in 3D virtuele werelden dan aanvankelijk was veronderstelt. In hoofdstuk 4 lieten we zien dat 3D representaties het individuele begrip van een taak stimuleren, maar niet gezamenlijk begrip. Wanneer groepen een gezamenlijke beslissing dienen te maken, blijken de extra visuele cues en stimuli die een rijke 3D virtuele omgeving bieden te resulteren in *cognitive overload* bij de teamleden. Voor taken met betrekking tot het maken van groepsbeslissingen bleken de 3D virtuele werelden het communicatieproces van het discussiëren over eerder verwerkte informatie tussen teamleden te belemmeren. Met andere woorden, de overvloed aan visuele informatie in de 3D virtuele wereld hinderde meer dan dat het hielp bij het creëren van gezamenlijk begrip. Een minder rijke omgeving, zoals de 3D statische omgeving, bleek een meer optimale balans in het presenteren van informatie te bieden, en verbeterde het beslissingsmakingsproces van zulke groepstaken.

Daarentegen, het onderzoek in hoofdstuk 5 liet zien dat de strategische manipulatie van avatars in een beslissingstaak juist resulteerde in verbeterde groepsprestaties. Hoewel gedeeld begrip (*shared understanding*) niet direct werd gemeten, was er een significant verschil in de beslissingsstrategieën tussen de verschillende condities in deze studie. Teams in de *morphed team avatar condition* bleken namelijk meer strategische en gemotiveerde opmerkingen te uiten dan teams in de andere drie condities. Dit toonde aan dat dergelijke teams beter in staat waren informatie uit te wisselen en gedeelde percepties hebben over de taak die zij uitvoeren, wat gezien kan worden als het creëren van *shared understanding* (Dennis, et al., 2008; Swaab, Postmes, Neijens, Kiers, & Dumay, 2002). Uiteindelijk resulteerde dit in verbeterde prestaties. Daarom is in figuur A een gespikkelde lijn weergegeven tussen de variabelen van communicatie support en *shared understanding*.

Concluderend tonen de studies in dit proefschrift aan dat 3D virtuele werelden het best selectief kunnen worden gebruikt in verschillende fases van het virtuele teamsamenwerkingsproces. Individueel begrip en *shared understanding* lijken twee verschillende vormen van begrijpen te zijn, welke ieder het beste ondersteund kunnen worden door verschillende technologieën. Een rijke 3D omgeving kan inderdaad helpen om informatie te verwerken met het doel om individueel begrip van een taak te creëren. Terwijl een te rijke omgeving juist afleidt van het groepsproces en daardoor belemmerend



werkt voor de ontwikkeling van *shared understanding* en teamprestaties. Aan de andere kant lijkt de mogelijkheid van 3D virtuele werelden om avatar-based interactie te manipuleren, tot op bepaalde hoogte *shared understanding* te bevorderen. Daarom kan worden geconcludeerd dat de presentatie van 3D informatie het beste toegepast kan worden in de individuele informatieverwerkingsfase van een groepstaak. Terwijl avatar-based interactie in een minder rijke omgeving juist de communicatiefase van een groepstaak lijkt te ondersteunen.

## Praktische Implicaties

Dit proefschrift heeft verschillende praktische implicaties voor organisaties met betrekking tot de potentiële contributie van 3D virtuele werelden voor virtuele samenwerking.

Ten eerste tonen de empirische bevindingen van dit proefschrift dat 3D virtuele werelden wellicht het meest geschikt zijn voor visueel complexe taken (b.v. simulaties). Voor zulke taken impliceert het gebruik van 3D simulaties dat ze helpen om te visualiseren en individueel begrip genereren van het fysieke eindresultaat van, bijvoorbeeld, een hotel dat nog gebouwd moet worden. Op zo'n manier gebruikt, kan een 3D virtuele omgeving helpen om een beter begrip te genereren van hoe dit hotel eruitziet in de fysieke wereld. Gebaseerd op de bevindingen van deze studie kunnen gebruikers wellicht ontwerprichtlijnen destilleren in het ondersteunen van effectieve teamsamenwerking via 3D virtuele werelden.

Ten tweede laten de resultaten zien dat met betrekking tot het gebruik van technologie voor samenwerking, er geen "one size fits all" model is. Voor verschillende fases van het groepsbeslissingsproces zijn verschillende technologieën het meest geschikt. Voor taken die onmiddellijke feedback en onderhandeling vereisen, is een minder rijk medium dat dit communicatieproces ondersteunt belangrijker dan een te rijke 3D virtuele wereld (Birnholtz, Ranjan, & Balakrishnan, 2010). Concluderend moeten gebruikers dus nauwkeurig analyseren wat de karakteristieken van de taak zijn, om te kunnen bepalen of ze wel of niet een 3D virtuele wereld inzetten voor samenwerkingsdoelstellingen.

Ten derde, kunnen platformontwikkelaars van 3D virtuele werelden wellicht de bevindingen van dit proefschrift vertalen in ontwerprichtlijnen om effectieve samenwerking te ondersteunen. De resultaten van hoofdstuk 5 laten zien dat het design van het uiterlijk van een avatar invloed kan hebben op de effectiviteit van de virtuele groepssamenwerking. Vooral voor taken die een positieve eerste indruk vereisen, kan het "morphen" van het uiterlijk van de verschillende teamleden bijdragen

aan de effectiviteit van de samenwerking. Natuurlijk is het belangrijk op te merken dat het genereren van een sterke eerste indruk misschien niet relevant is voor alle taken. Sommige taken vereisen wellicht de ontwikkeling van een meer lange-termijn-samenwerking, wat het effect van zulke "morphing" mechanismen kan beïnvloeden.

## Toekomstige Scenario's voor Samenwerking in 3D Virtuele Werelden

Is er een toekomst voor 3D virtuele werelden als technologie om virtuele samenwerking te ondersteunen? Twee aspecten van 3D virtuele werelden kunnen worden opgemerkt die al onderdeel zijn geworden van gangbare applicaties.

Ten eerste worden 3D visualisaties steeds meer gebruikt door organisaties (Lee, Li & Edwards, 2012; Morrisson & Skjulstadt, 2010; Li et al., 2008). Een breed spectrum van organisaties, van Philips tot Ikea, tot makelaars, gebruiken 3D visualisaties als een populair hulpmiddel om mensen te helpen visualiseren hoe hun producten er mogelijk eruit zien. In het medische veld worden zeer realistische 3D simulaties van een Eerste Hulp afdeling momenteel gebruikt voor gedistribueerde virtuele trainingsdoelstellingen (Krange, Moen, Ludvigsen, 2012). Ik verwacht dat naar mate 3D visualisaties steeds gebruikelijker zullen worden, deze technieken langzamerhand zullen transfereren naar het gebied van virtuele samenwerking, en dat ze hun waarde kunnen bewijzen.

Een tweede aspect is avatar representatie. Tegenwoordig is het gebruik van een avatar om jezelf te representeren op *social networksites* zoals LinkedIn, Facebook of VoIP services zoals Skype wijdverspreid (Ellison, Heino, & Gibbs, 2006; Ong, et al., 2011). Het gebruik van avatars is zelfs groter in game-achtige settings zoals World of Warcraft, Habbo hotel, en de Wii (Ducheneaut, Wen, Yee & Wadley, 2009; Lanningham-Foster, et al., 2009). Een reden voor de populariteit van avatar-based interactie kan zijn dat mensen in de virtuele omgeving niet altijd zichzelf willen presenteren als hun *echte* zelf, maar liever als hun *ideale* zelf (Dunn & Guadagno, 2012; Ducheneaut et al., 2009; Heider, 2009; Turkle, 1994). Vertaald naar de context van virtueel samenwerken kan beargumenteerd worden dat om prestaties te verbeteren mensen de mogelijkheid zouden moeten hebben om een avatar te kiezen die hun perceptie van het zelf representeert (Kil-Soo, Hongki, & Eung Kyo, 2011; Cui et al. 2009; Galanxhi and Nah 2007). Alles overziend, naarmate avatar-based interaction een meer integraal onderdeel wordt van onze alledaagse communicatie, kan worden verwacht dat dit ook geleidelijk zal worden toegepast op het gebied van virtueel samenwerken.

Het succes van toekomstige applicatie van 3D virtuele werelden voor virtueel samenwerken kan ook afhangen van de mate waarin deze technologie in staat is om los te komen van het zogenaamde "horseless carriage syndrome". Toen de eerste auto's



ontstonden, werden ze “wagens zonder paard” genoemd. Het ontwerp van deze auto’s reflecteerde het paradigma dat eeuwenlang dominant was, en leek dus heel erg op een paard en wagen, zelfs zonder het paard, met zelfs een speciale plek voor de paardenzweep. Het dominante paradigma van het meeste hedendaagse onderzoek naar de potenties van 3D virtuele werelden (inclusief bepaalde delen van ons eigen onderzoek) is de focus op het vertalen van traditionele face-to-face taken (bijvoorbeeld het participeren in een klaslokaal) naar een “realistische” 3D virtuele wereld setting. Ik geloof dat er een toekomst is voor 3D virtuele werelden en samenwerking, maar het zal een shift vereisen van het gebruiken van traditioneel virtueel teamwerk als referentiekader naar het innovatief 3D virtuele werelden toepassen in de praktijk. Concluderend: de hoofduitdaging voor toekomstige onderzoekers en ontwikkelaars van 3D virtuele werelden is de unieke *affordances* van 3D virtuele werelden toe te passen op een manier die de grenzen van wat mogelijk is in de fysieke wereld overschrijdt.

## About the Author



Sarah van der Land received her VWO diploma from the Berger Scholengemeenschap, in Bergen (NH), the Netherlands in 2001. In that same year, she started studying Communication at the Raboud University Nijmegen, specializing in International Business Communication. During her studies, she obtained a minor in Social Psychology, participated in the interdisciplinary Honours Programme, and co-organized the first *Cultfestival* on campus. In 2006, she graduated *cum laude* with her Master’s thesis “Trust, Lust and Latex”, which was on effective health communication. For this thesis, she carried out research in South Africa for 6 months under the supervision of prof. dr. Carel Jansen and prof. dr. Leon de Stadler. This work was also awarded with the Radboud University Nijmegen Thesis Award and has led to a publication in the *Information Design Journal*.

After having worked for the Amsterdam-based advertising agency THEY, she returned to academia to work for SWOCC (the Foundation for Scientific Research on Commercial Communication) where she co-authored a book on how advertising influences you unconsciously. It was there, at the University of Amsterdam’s *Oost-Indisch Huis* that her ambition to pursue a PhD was initially sparked. Soon afterwards, in November 2008, she started her PhD study at the VU University Amsterdam under the supervision of prof. dr. Marleen Huysman, dr. Frans Feldberg and dr. Alexander Schouten. The current PhD research was conducted at the Faculty of Economics and Business Administration between 2008 and 2012, and her work resulted in two journal articles, one book chapter, and presentations at the International Communication Association Conference and the Academy of Management Conference. During her PhD studies, Sarah was a Visiting Scholar at Michigan State University’s Department of Telecommunication, Information Studies and Media. Sarah van der Land is currently a lecturer/researcher at the University of Amsterdam’s Department of Communication Science, where she teaches courses on Corporate Communication and Virtual Groups and conducts Social Media-related research.



