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D2.5 Final report on Human Factors Evaluation

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Abstract: This report describes work carried out in WP2 Human Factors in the final year of the project. It covers two experimental studies: sentiment feedback in distributed meetings, and influencing meetings through ambient modalities, and one observational study on the coordination in distributed meetings.

Content

1 Introduction

The AMIDA project builds on the AMI project (IST FP6-506811, www.amiproject.org), that was aimed at enhancing meetings by developing tools for capturing, processing, searching and browsing multi-modal meeting information. The aim of AMIDA is to incorporate this technology into the concept of a *meeting assistant* that can understand what is happening well enough to play an active role in improving meetings, e.g., recognizing the activity level of participants and their attitudes towards each other, and influence the course of a meeting when the activity level and attitude is inappropriate for the particular phase of the meeting. Such new functionalities extent the more passive role a meeting browser plays.

AMIDA also extends its scope with remote meetings. Recently, it has become more and more common for colleagues and project teams to cooperate at a distance. This is partly caused by the fact that more people have started tele-working, i.e. "working in a location away from the main office or production facilities, without personal contact with colleagues, but instead through electronic communication (Cascio, 2000)". Another important reason is internationalization of work, for instance in the context of the European Union or multinational companies. Allowing people to be still able to cooperate when not co-located physically, is made possible through the advance of multiple Information and Communication Technology (ICT) applications, such as teleconferencing, electronic meeting rooms, chat, shared (network) disks and electronic cooperation spaces. Cooperation at a distance offers many advantages to the society, organization as well as employee, such as less traveling and saving the environment, a higher productivity and a higher work satisfaction. However, part of the other side of the medal is the fact that people who cooperate at a distance feel they lack personal contact with colleagues, diminishing social commitment, cohesion and team spirit, and find it hard to tune work to one another (Bailey & Kurland, 2002). They also have difficulties with coordinating their activities at a distance, which is important for tasks such as collaborative design.

This report describes research carried out on these issues in the last year of the AMIDA project. It covers three subjects:

- *Sentiment feedback in distributed meetings* (Chapter 2).
- *Coordination in distributed design meetings* (Chapter 3).
- *Influencing meetings through ambient modalities* (Chapter 4).

These subjects cover the upper-right part of the meeting assistant functionalities, as identified in a User Requirement Study previously carried out in this project (Post et al., 2008), and represented in Fig. 1.1.

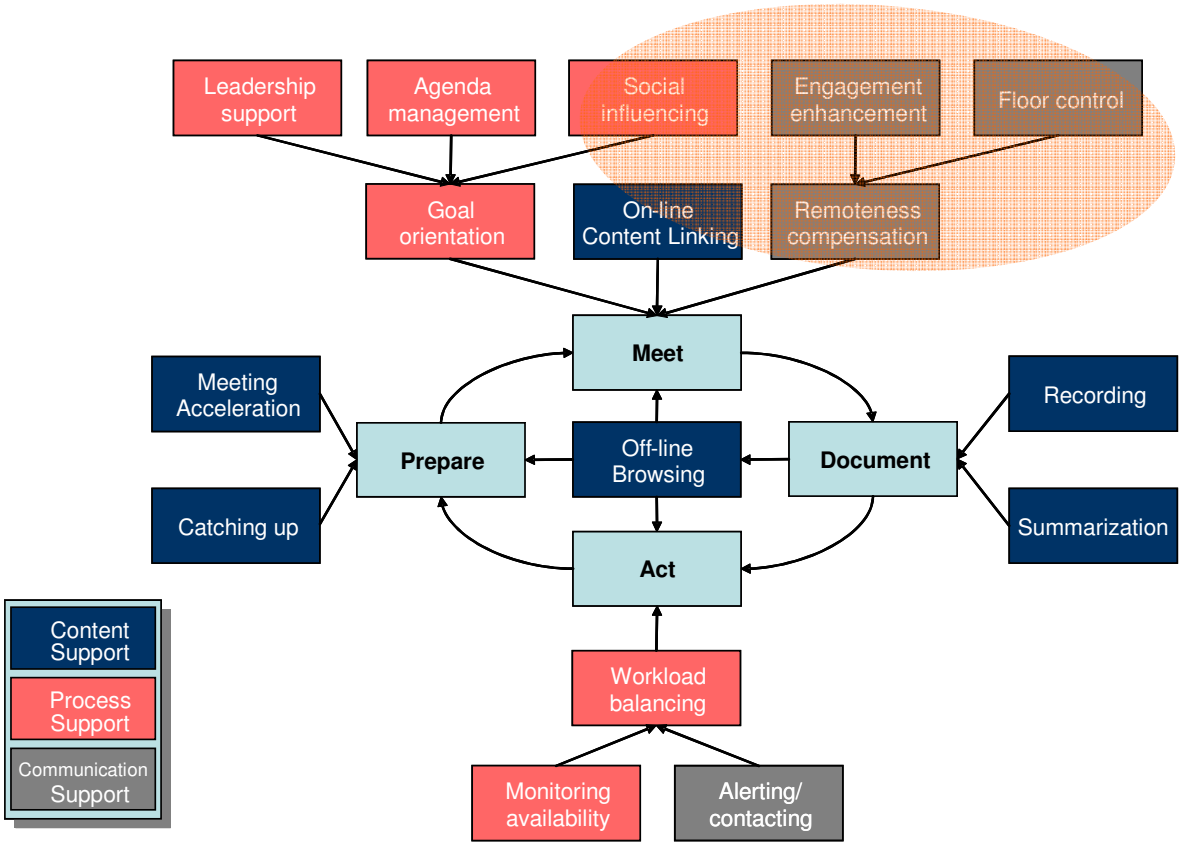


Fig. 1.1. Overview of potential Meeting Assistant functionalities. The oval indicates the functionalities addressed in this report.

2 Sentiment feedback in distributed meetings

In the last year of AMIDA, an experiment has been carried out on the effect of feeding back automatic recognized sentiments among negotiating parties. The aim is to enhance the use of poor media such as videoconference in such delicate tasks, with AMIDA technology. We will report on in total 120 negotiations of three parties took place in nine different conditions, varying on their remoteness (negotiating three-party face-to-face, two-party face-to-face/one remote, and fully distributed) and their sentiment feedback (no feedback, single only feedback, all feedback). We diverted from the design scenario here since sentiments were hardly there. In group negotiation, we do expect much more sentiments. Further, in any meeting some sort of negotiation take place. We will address the set-up of the experiment, the negotiation task, and the measurements. Some initial results are included. This experimental negotiation paradigm is also made available for the community for additional research.

2.1 Introduction

The aim of AMIDA is to develop technology for capturing, processing, searching and browsing multi-modal meeting information for meeting assistance. This is not exclusively support at the content level but also at the process level: supporting the meeting to accomplish its goal, e.g., by supporting leadership, agenda management, or by influencing the social system. A third level of support is at the communication level, to compensate for the disadvantages of remoteness, e.g., by actively enhancing remote participation, improving floor control and providing social cues (Post and Lincoln, 2008). This chapter reports on an experiment focused on that third level.

Since the start of the Internet, the possibilities to interact have increased tremendously. It enables people from different locations, backgrounds and organizations to work together to accomplish individual and shared goals, within teams, (virtual) organizations or consortia. Usually, once shared goals have been formulated and norms and values have been exchanged, co-workers collaborate well. This process has been extensively described, for example by Bruce Tuckman, with his Forming-Storming-Norming-Performing phases (Tuckman, 1963). But before the forming of any collaboration, there needs to be a phase in which necessary negotiations take place about aspects such as the common goal, the resources to invest, the individual priorities to deal with, and the distribution of the outcomes. Especially this phase is difficult to carry out over the Internet, since it requires a rich communication means. Even videoconferencing is regarded as a poor medium when it concerns tasks where trust and full appreciation of the situation are key. Small-scale negotiations may take place also in later stages, e.g., when actions have to be distributed among the members of a team. Enrichment of the communication during remote negotiation can therefore contribute importantly to the initiation of new collaborations, and the performance of existing ones.

How to enrich remote negotiations then? A better understanding of the social functions of emotional expression in negotiations (Morris and Keltner, 2000), together with recent successes with sentiment mining (e.g., Raaijmakers, Truong, and Wilson, 2008) provide us

the expectation that feeding back automatic recognized sentiments may overcome the lack of subtle information a remote negotiation party experiences. To know how to apply sentiment feedback, and how to measure the effect of it, we need to know more about negotiations. The task happens to be extensively studied two decades ago. Interesting experimental work has been done by Thompson, Mannix, and Bazerman (1988) and Mannix, Thompson, and Bazerman (1989). They distinguish, for example, different negotiation behaviors, with all different outcomes. Depending on the power balance, parties either strive for full integration (i.e., maximum outcome for the group as a whole), coalition (some parties maximize their shared outcome at the cost of others), domination (a single party strives for individual maximization, at the cost of others), compromise (give and take equally spread over a set of issues), majority preference (on each issue of a set, majority determines the agreement) and walk away (the negotiation is ended, with no outcome at all as a result). Recognizing sentiments and feeding them remotely may potentially lead to better negotiation of the individual, knowing what behavior works best for multiparty negotiations provides us opportunities to influence it as well.

There are four basic research questions

(1) How does negotiation behavior relate to being remote or not.
(2) Can negotiation sentiments be recognized in a practical way and at a sufficiently reliable level?
(3) Can negotiation sentiments be fed back such that it improves a remote party's negotiation?
(4) For what negotiation behavior does sentiment feedback works best?

To answer these questions, we will make an experimental comparison between negotiations by three parties, in different settings and differently supported with sentiment feedback. We have to deal with one pragmatic issue, however: for training automatic sentiment recognizers, a large data set is required. We have decided to collect those data during the experiment, and to fake the automatic recognition. We said to the participants in the experiment that our goal was to evaluate our recognizer, by comparing them to their assessment of the sentiments, which we asked on certain points in time. In fact we successfully fed back their assessments to the other parties. The next section explains the method we used. After that some initial results are provided. In the fourth and final section, we discuss our work.

2.2 Method

We set up an experimental comparison in which negotiations by three parties were carried out in nine different conditions made up of two dimensions:

- Remoteness: negotiating three face-to-face parties, two face-to-face parties/one remote party, and three distributed parties.
- Sentiment feedback: no feedback, feedback for one party, and feedback for all.

Our experiment is based on the design used in experiments carried out by Thompson and colleagues (Thompson et al. 1988; Mannix et al., 1989). They looked at the impact of various manipulations on the quality of the negotiated agreement of a negotiation, such as agenda, decision rule and power balance. Their experimental design, especially their use of mixed motive tasks that involve both cooperation and competition, the use of three parties, and their operationalisation of negotiation outcomes, offered an ideal basis for our experiment. The original negotiation tasks were not available anymore, unfortunately, and had to be redeveloped from scratch.

2.2.1 Participants

Ninety participants took part in our negotiation experiment. All were enrolled in or had finished a study at least at university or college level. Of the participants, 36 (40%) were female, 54 male (60%). Their age was between 18 and 35 years old (M = 24).They were invited in an experimental session lasting a full afternoon, nine participants at a time. Following a predefined scheme, they participated in four separate negotiations, each time with new opposite parties. They were compensated 55 euro and a reward was promised to the person who would get the highest score of all nine.

2.2.2 Negotiation tasks

Four different negotiation tasks on four different topics were developed. For each topic, the three parties have to reach an agreement on three issues. Within each issue there are five alternatives offered. Each alternative has associated values for each of the parties, which are of course private to each individual party. The four tasks were on Electronic Patient Dossier, Infrastructure, Railway Station Renovation, and Student Housing. As an example, the Railway Station Renovation is described in more detail below.

In the Railway Station Renovation task, the Railroad company, the Shopkeepers association and the Neighbours need to come to an agreement on the following three issues: Security (involving e.g., privacy violations, objected by the neighbours), Shop selection (e.g., the neighbours prefer a grocery), and Station square design. The latter involves differences in form, location, and existence of various objects such as a kiosk, the bus station, a taxi stand, a work of art, trees, the station entrance, a bike garage, etc. Two alternatives are shown in fig. 2.1.

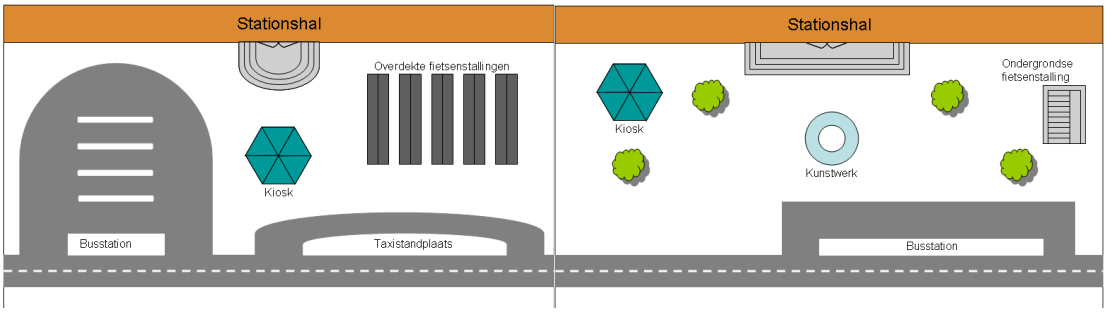


Figure 2.1: Design A and B of five alternative designs for the Station square.

The parties value each design differently, as is shown by table 2.1. For example, the Railroad prefers Design A, and the Neighbours Design B. According to the pay-off table, the Railroad and the Shopkeeper probably form a coalition on Design A, against the Neighbours. However, all three together would be better off when agreeing on alternative E (the total score on A is 150 and on E is 187,5), and especially on B (200). Here the need arises to negotiate this Station square design issue together with the other two issues (Security and Shop selection), which have their own pay-off schedule. The three pay-off schedules are specified in a way that the variation of negotiation behavior (i.e., integration, coalition, domination, compromise, etc.) is expected to be high.

Table 2.1: The pay-off schedule of the Station Square alternatives.

Design alternative	Railroad	Shopkeepers	Neighbours
A	100	50	0
B	0	0	200
C	50	25	100
D	75	37,5	50
E	25	12,5	150

2.2.3 Apparatus

The negotiations were conducted in the Collaboration Lab at TNO Human Factors. From a control room, four different rooms were observed: three rooms for three remote parties and one room for both three face-to-face parties and two face-to-face parties (with the remote party in one of the other rooms). In an additional room, the participants had to prepare a negotiation and fill out questionnaires.

Control

The experimenter starts the negotiations and recordings from the control room (see fig. 2.2). There, according to a strict protocol, he prompts the positions among the participants, scores the negotiation performance, and classifies the negotiation behavior (in terms of integration, domination, coalition, walk away, etc.).

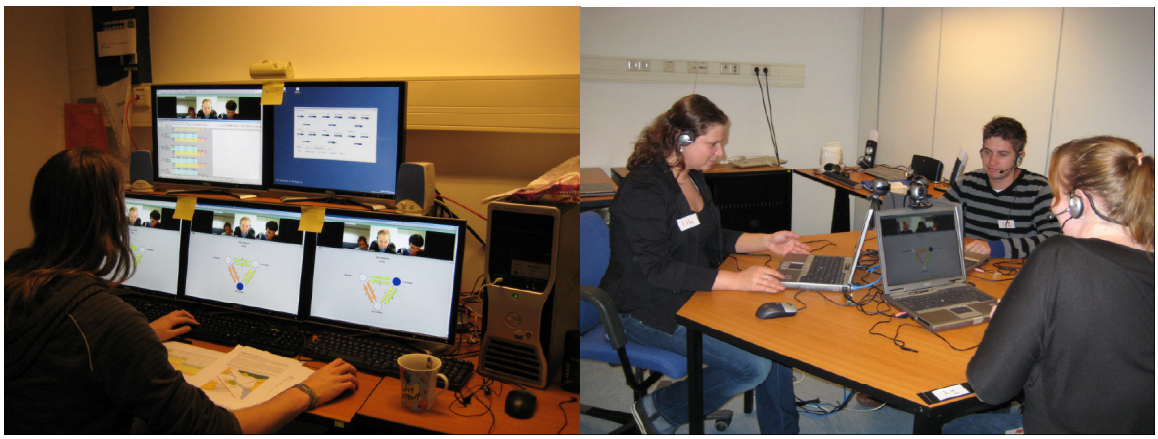


Figure 2.2: The picture on the left, the experimenter's control room. On the top left monitor, the control panel and the score sheet; on the top right monitor, the control

panel of the emotional feedback system. Below, the participants screens, via VNC. The picture on the right: the photograph of the face-to-face condition. The experimental control room.

Videoconferencing
We used Adobe Acrobat Connect Pro web conferencing software to enable remote negotiations as well as the capturing of both the remote and the face-to-face sessions. They were synchronized and stored remotely, at the instrumented meeting room facilities of the university of Edinborough (see [1] for the setup of remote recordings). We used Logitech QuickCam Pro webcams and Logitech PC Headset 120 headsets.

Interface
The participants have a laptop in front of them with on the top the video images of all parties, both in the face-to-face and the remote conditions (to minimize the differences between the conditions). Fig. 2.3 shows the interface. Underneath the images, three circles are shown, representing the three parties. Their particular role is written next to the circle. One's own role is shown in blue. At certain points in time, the participants are prompted to fill out their positions towards the other parties. They have been told earlier that this is for evaluating our automatic sentiment recognizer ("The very aim of this experiment."), but we use their answers for feedback, albeit with a 20% error rate, currently a usual rate for these algorithms. This feedback is presented in colored arrows between the parties' circles, with red for extremely negative position, and green for extremely positive position.

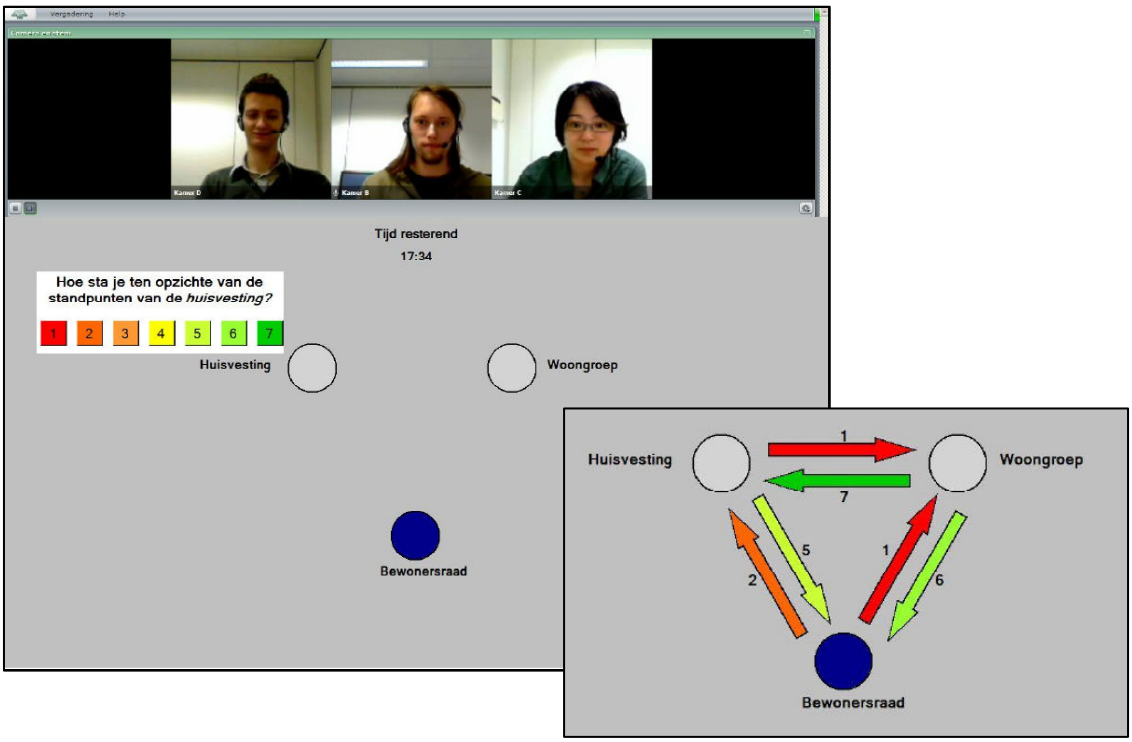


Figure 2.3: On the top, a screenshot of a participant's laptop during the negotiation. The participants have just received a question about their position towards the other

participants. Down-right, the way emotional feedback will be presented in the top screen, with green the extremely positive, and red the extremely negative position.

2.2.4 Measures

We derived objective outcome measures from the payoff schedules for each negotiation task: the individual scores for each issue, for each negotiation and for each session. Each participant participates in four negotiations, so we can compare the score of participants between different negotiations. Individual scores on individual issues can also be looked at. The payoff schedule is constructed in such a way that each individual has an important issue, an unimportant issue and one in between. On their most important issue they are alone, while on the two other issues they have a partner who will benefit the most from the same alternative. Further, team scores are calculated by adding up the individual scores of the parties. Besides the actual score we also looked at the distribution of the points between the group members, to classify the agreements into the six negotiation behavior classes:

(1) With integration agreement, a total team score of 600 can be gained, 200 points for each participant.
(2) With coalition agreement, when two participants gain points at the expense of the third party. Here, one party gains 300 points, one 250 points, and one 0 points. The total gain of 550 is high, although lower then integration, but one party receives nothing.
(3) With compromise agreement is reached when on every issue the middle ground solution is chosen. This results in an individual score of 175 each, and a total team score of 525
(4) With domination agreement, one party can get up to 373,5 points, at the costs of the others. The total score is then 512,5 at the most.
(5) With majority preference, the team score range from 450 to 487,5.
(6) With walk away, when the participants fail to reach an agreement on all three issues, no points are awarded.

Besides objective measures, the following subjective measures were taken:

- Pre-questionnaire (Kilman's test, demographics, self efficacy)
- Session questionnaire (trust, task evaluation, manipulation evaluation)
- Post-questionnaire (task evaluation, self efficacy)

2.2.5 Procedure

Each day, nine participants were expected at 12:30, to stay until 18:00. After an introduction, a pre-questionnaire about demographic information, experience in using video conferencing applications and negotiating, and a conflict handling personality test were filled out, taking about 30 minutes. Then, the negotiations started, in groups of three parties. The groups were randomly assigned to the conditions, in such a way that each

participant would engage in a negotiation with another participant only once. In total, the participants were engaged four times, during an afternoon.
The participants had 10 minutes to prepare each negotiation. Then, they were brought to one or more of the negotiation rooms where they had to come to an agreement with the other two parties in exactly 18 minutes. After that, they were brought to the previous room again, to fill out an electronic questionnaire about how they thought they performed the negotiation, and how useful they thought the sentiment feedback system was for them.

2.3 Results

The data collection has just finished before the submission of this paper. Some initial results are presented but a more thorough analysis will follow soon.
There seems to be a difference in the position parties have against each other's arguments, when negotiating face-to-face or remotely. Two face-to-face parties have a more positive position towards each other, and (slightly less) toward a remote party, than a remote party has towards the two face-to-face parties.

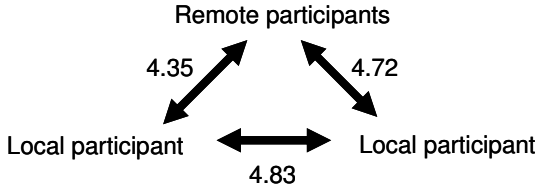


Fig. 2.4 The positions against the arguments of local and remote participants.

Initial results on the relation between the different negotiation behaviors, remoteness and sentiment feedback is shown in Table 2.2. Interesting to see, e.g., is that integration behavior is unpopular; walk away occurs often, that domination may profit from feedback and that walk away seems to diminish when feedback is given.

Table 2.2: Percentages negotiation behavior per condition.

Conditions	Integrative	Coalition	Dominance	Compromise	Majority	Walk away	N
0 Remote	11.11	30.56	25.00	13.89	5.56	13.89	36
1 Remote	12.50	25.00	16.67	14.57	8.33	22.92	48
3 Remote	5.56	16.67	33.33	13.89	0.00	30.56	36
0 Feedback	9.80	23.53	21.57	9.80	5.88	29.41	51
1 Feedback	15.00	25.00	30.00	10.00	2.50	17.50	40
3 Feedback	3.45	24.14	20.69	27.59	6.90	17.24	29
All	10.00	24.27	24.17	14.17	5.00	22.50	90

2.4 Discussion

We have developed and applied an experimental paradigm that enables us to investigate the research questions of this work. First, we have some initial results for our first research question: an interesting effect of remoteness on negotiation. Further analysis is under way. Second, we have created the conditions for answering our second research question: we have recorded 120 negotiations of 18 minutes each, and have annotation information of the sentiments available for that material. Sentiment mining can start. Third, we came up with a presentation of sentiment feedback the subjects subjectively assessed to be useful. We have now data available for objective proof. The fourth and final research question – for what negotiation behavior does sentiment feedback works best? – is also ready to be answered. Further details of this study can be found in deKok (2009).

3 Coordination in distributed design meetings

Abstract. Design is a ubiquitous, collaborative and highly material activity. Because of the embodied nature of the design profession, designers apply certain collaborative practices to enhance creativity in their everyday work. Within the domain of industrial design, we studied two educational design departments over a period of eight months. Using examples from our fieldwork, we develop our results around three broad themes related to collaborative practices that support the creativity of design professionals: 1) externalization, 2) use of physical space, and 3) use of bodies. We believe that these themes of collaborative practices could provide new insights into designing technologies for supporting a varied set of design activities, especially supporting distributed design activities. We describe two conceptual collaborative systems derived from the results of our study.

3.1 Introduction

A typical design studio (professional or academic) has a high material character – in the sense that it is full of material objects and design artefacts; office walls and other working surfaces full of post-it notes, sketches and magazine clips for sharing ideas and inspiration; physical models and prototypes lying on the desks and so on. The physical surroundings of a design studio and the persistence with which different material artefacts are arranged and represented are important to the design activity and serve as organizational memory (Ackerman and Halverson, 1995) and distributed cognition (Hutchins, 1995) for design teams.

This ecological richness of design studios stimulates creativity in a manner that is useful and relevant to the ongoing design tasks. Additionally, designers do not work in a stereotypical or mechanical fashion when designing interactive products. Designers tend to be innovative, creative and often playful in order to collaborate and successfully meet the demands of building new products and services. Methods frequently used by designers such as role playing (Boess, 2008), body storming, design choreography (Klooster and Overbeeke, 2005) and so on are not limited to problem solving but also include understanding interactional and experiential qualities in designing interactive products.

The role of collaboration between co-designers is critical to a design studio's creativity. As Engeström (2001) explains, the source of creativity is not inside a person's head, but it emerges in the interaction between a person's thoughts and his socio-cultural context. In design studios, communication and coordination between co-designers depend as much on different visual and physical aspects as they do on verbal aspects. During a typical collaborative design session, the type of information that is communicated between designers is multimodal, ubiquitous and touches the artistic, emotional and experiential side of the designers' thinking, in addition to their instrumental and practical reasoning.

Building on our previous work (Vyas et al. 2008; Vyas et al. 2009 and Vyas 2009), in this paper we focus on understanding collaborative approaches utilized by designers to aid creative support for ongoing design projects. We studied two industrial design departments over a period of eight months and explored three broad themes of

collaborative practices. These are 1) externalization, 2) use of physical space, and 3) use of body. The externalization theme encompasses any kind of design knowledge represented onto three-dimensional, physical medium (e.g. sketches, models, prototypes) that can be used for establishing common-ground amongst co-designers. The use of physical space theme refers to a kind of ecological setup within a design studio, full of different types of design materials and artefacts (e.g. sketches, posters, timetables, to-do lists) that help co-designers organize, coordinate and manage their design work. The use of body theme refers to a collection of design practices where designers' bodies play an important role in exploring and communicating design knowledge with a group of co-designers. These broader themes encompass both pragmatic and instrumental factors related to design activities as well as inspirational factors that are important to aid creativity in the design profession. These themes are not mutually exclusive; on the contrary, their combinations are frequently used and they are frequently complemented by the other generic ways of communicating, such as, talking, overhearing and so on. Depending on designers' points of view, the rationale behind applying these collaborative practices range from clearly defining design problems, exploring new possibilities, easing communicative difficulties, to developing a communication language with co-workers.

Our motivation to do this kind of research is multifaceted. First, although research in HCI and CSCW has increasingly started focusing on the 'design' of interactive and collaborative technologies, 'design as a profession' is largely untouched as a subject of empirical study, with a few exceptions such as (Jaccuci and Wagner, 2003; Schmidt and Wagner, 2002; Robertson, 1997). However, we do acknowledge that there has been a sufficient amount of work done in developing tools and techniques to support design (Arias et al. 2000; Everitt et al. 2003; Hartmann et al. 2006; Maldonado et al. 2006). Secondly, as a part of creative industry, design cannot be easily formalized or rationalized to a specific set of activities, tasks or other kind of stereotypes. For example, traditional ways of communicating and collaborating may not be so important for the design profession (as we will see later). Hence, there is a need to understand how designers differ from other knowledge workers in terms of their working practices. Thirdly, we believe that in order to better support designers' work and to develop new collaborative technologies, we need to understand how collaborative practices of designers enable creativity in their everyday work. An empirical investigation is required that specifically looks into the ubiquitous, collaborative and material nature of design practices.

In the rest of the paper, first, we will briefly describe background work that signifies the importance of embodiment in design work and some examples of augmented design environments. Next, we will describe our approach and methods used in understanding design environments in two industrial design departments. Next, we will describe the results of our study, focusing on the three themes of creative collaborative practices. And in the last section, we will discuss the implications of our results and provide a conceptual vision for developing technology to support collaborative design.

3.2 Related Literature

Our everyday communications and coordination acts go beyond linguistic signals and involve the use of material artefacts, locations and physical spaces (Clark, 2005). In fact, CSCW studies have increasingly shown the importance of material artefacts in coordinating distributed and co-located work (Hutchins 1995; Schmidt and Wagner, 2002; Sellen and Harper, 2002). Several authors (e.g., Kidd, 1995; Kirsh, 1995; Vyas, 2009) discuss how individuals intelligently make use of physical space and its affordances, in

order to establish communication within a group. Advocating the use of ethnographic studies for designing systems, Randall et al. (2007) indicate three major aspects of artefacts that are relevant for understanding group work: ecological, coordinative and organizational aspects.

Amongst the empirical work on understanding design practices, Tang's (1991) classic study focuses specifically on collaborative drawing, using observational video-tapes of three to four people collaborating at a table. Tang identifies several features of collaborative work activity that should be taken into account when designing collaborative technologies. These are: 1) the importance of gestures, 2) drawing space as a resource for collaboration, 3) the importance of the process of collaborative drawing itself (instead of the final result), 4) recognizing the mix of simultaneous activities, and 5) the spatial orientation of collaborative workers. Jacucci and Wagner (2003) study the everyday practices of students at an architecture design laboratory. Their focus is on integrating ubiquitous computing technologies to support students' embodied interaction and contextualize these technologies to architectural design situations. Their ethnographic research shows the importance of material richness and diversity of material artefacts. They also register the distributed character of architecture learning and the use of space as a resource for collaborative interactions. The coordinative nature and the resourceful materiality of informational artefacts such as architectural maps or physical models are echoed by the work of Schmidt and Wagner (2002). In their later work, Jacucci and Wagner (2007) show how the materiality of informational artefacts plays an important role for creativity.

Hornecker (2002) uses an experimental setup where a group of co-located participants uses an assembly of three-dimensional objects in order to carry out paper prototyping as a design activity. Generating implications from a set of video recorded paper-prototyping sessions, her goal is to develop a graspable interface using table-top display technologies in order to support co-located design work. She focuses on the role of embodied actions such as use of gestures, parallel activities of participants and alignment of gestures with design artefacts and talks. A similar study is done by Robertson (1997), who develops a taxonomy of embodied actions of designers while working on cooperative design projects. She suggests that the public availability of different artefacts and embodied actions of distributed participants in a cooperative process could support communicative functions. She also argues that flexible and mobile access to the publicly visible information could improve coordination.

On the technological advancements in supporting design activities, we observe that researchers have focused on supporting embodied interaction in their technologies utilizing tangible and ubiquitous computing. Envisionment and Discovery Collaboratory (EDC) is one such platform that integrates two working spaces where stakeholders can incrementally create a shared understanding through collaborative design (Arias et al. 2000). The Distributed Designers' Outpost (Everitt et al. 2003) is a remote collaborative system that allows designers to use physical post-it notes to support discussion while designing websites. The application allows synchronous communication between distant designers through the use of 'transient ink' and 'remote shadow' mechanisms in order to coordinate design tasks.

Maldonado et al. (2006) developed the iDeas design ecology, a collection of tools that combines a browser for text and sketch-based design content, mobile input mechanism for field observation data, and a vertical surface for collaborative creation and presentation. The d.tools toolkit (Hartmann and Klemmer, 2006) supports

iterative prototyping of information appliances by allowing integration of design, test and analysis activities.

3.3 Understanding Collaborative Design – Our Approach

We investigated collaborative design practices in two industrial design departments in academic settings. Our ethnographic approach was informed by ethnomethodology (Randall et al. 2007). We intended to understand the everyday work practices of designers, methods and procedures they use to support their work and the resources they use to make sense of their design world. We used naturalistic observations, contextual interviews and video recorded collaborative design sessions of designers and design students. Our fieldwork lasted approximately eight months.

In the naturalistic observations, we studied the collaborative aspects of the design studios. Our goal here was to understand the natural circumstances of designers' collaboration, the tools and methods they use, and how the creative process of design is achieved. We had contextual interviews with 10 Master's students of industrial design and 5 designers / design researchers. We asked questions on individual ways of designing and on how designers understood creative ways of working. We asked how they brainstorm, what methods they use to come up with design concept, how they convey ideas to each other, their preferred tools for designing, the perceived advantages of using such tools, and so on. We took opportunities to record design sessions of groups of student designers. In some cases, we were participant observers collaborating with design students and recording their design proceedings.

In our analysis we identified three major themes of collaborative practices amongst the designers: externalization, use of physical space, and use of body. Our aim here is to show how creativity becomes an integral part of designers' work when they apply these collaborative practices while working in groups. We also want to stress that these collaborative practices are not used separately in all the cases and are often used in combination with each other.

3.4 Themes of Creative Collaborative Practices

In the following, we give specific attention to the three themes of collaborative practices of designers: 1) externalization, 2) use of physical space and 3) use of body. Figure 3.1 shows a typical scenario of a design session, where all three themes of collaborative practice play their parts.

Figure 3.1: A typical collaborative design session at an industrial design department.

3.4.1 Externalization

This theme was frequently observed as a major resource for establishing and enhancing creativity as a collaborative process. Externalization carries a broad range of design practices and activities: externalization of thoughts, of ideas and of concepts on a range of physical media. Artefacts such as paper sketches, drawings, posters, cardboard, clay or foam-models, and physical prototypes are examples of design externalization. Designers' externalizing practices vary over time (at different stages of design), in modality (from paper sketches to physical models), in purpose (exploratory or definitive), and are subject to individual preferences. In a single design project, design practitioners produce and use a plethora of design artefacts to support their work. These are constructed and used in and through an ongoing process of design. Within the context of industrial design, the externalization theme can be seen as a 'mediator' as well as a 'product' of cooperative design.

CSCW studies have shown that artefacts such as papers play a critical role in supporting social interaction and collaboration (Sellen and Harper, 2002). For designers, paper-based sketches have also shown coordinative advantages (Baskinger, 2008). With examples from our fieldwork we will describe how externalization plays a collaborative role in different activities and aspects of design: exploration, thinking by doing, coordination, and empathy and experience.

Exploration. Designers explore new ideas and concepts at various stages of their design cycle using different material artefacts such as sketches, mock-ups, models, and working prototypes. The goal here is to spend reasonable effort in order to get a partial result quickly. As one designer commented, "in order to make design decisions you need to do explorations and for that you need to make different levels of prototypes". In design, everyday externalization practices involving sketches, foam or card-board could help designers explore new design ideas without too much effort. These types of external representations help designers to establish a creative sensibility. For example, sometimes sketching is used for visualizing designers' thinking as it stimulates creativity not only within their head but also with their hands. Figure 3.2a shows a brainstorming session where a group of designers are externalizing their ideas on post-it notes and at the same time giving a formal structure and category to their material. As one designer commented, "Sometimes it is also useful to get something out of your head (externalize the ideas). When I have a lot of ideas and I know that some of these are not good, I just try to make a sketch of all of them and so that even some less important ideas are stored somewhere. I think it's a good thing that it gets me going."

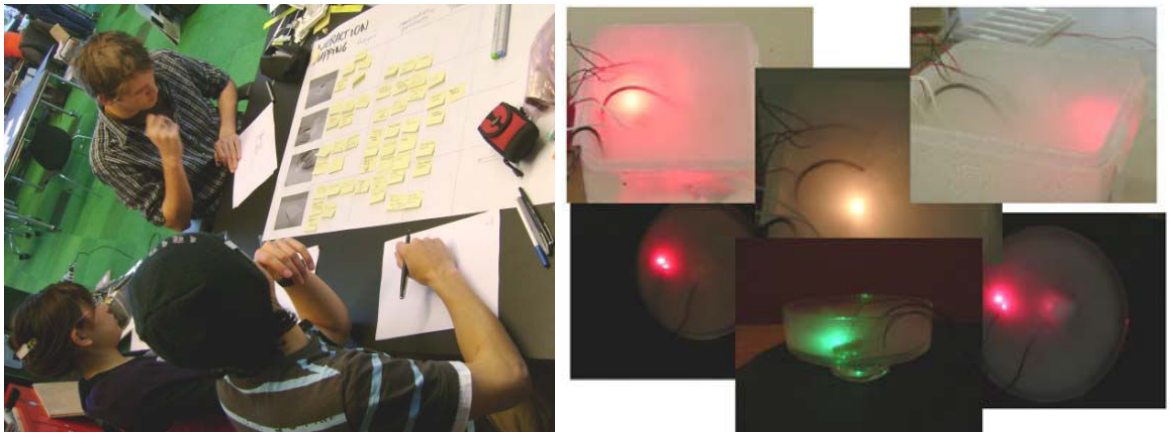


Figure 3.2: A structured brainstorming session using post-its to explore new ideas (a). Explorations of the effect of combining smoke and light (b).

We also observed that there are things that designers cannot easily envision through only drawing or sketching. They have to practically apply their ideas through different forms and textures of design models and prototypes to get a feel of their products. This kind of physical model allows designers to extend their mental conceptualization of their product to a sensory one. Figure 3.2b is an example of exploring the effect of smoke and different light colors in different shapes of glass. The idea here is to explore which combination would be suitable for a given situation. This designer explains that "there are certain things that you cannot envision in a normal situation, things like "smoke". So in order to understand the behavior and interaction with smoke and utilizing it into design you have to build some things and play with it." By joining the exploration of smoke with different kinds of lights, the designer explains, "even by playing with a light I can get several ideas about new ways of interacting with lights, like blinking, fading, making patterns, so expressing new behaviors through the use of lights and different colors of lights. This opens up my visualization skills and provides new spaces for design. In this case if I just sketch this smoke with light, I wouldn't get that feeling. Here you can play with your hands, move the smoke around, this is a very different kind of design expression and gives me a different feeling."

Thinking through Doing. Designers communicate through a varied set of design representations often involving different materials, modalities and scale. To an extent, the whole design practice progresses through the use and manipulation of these representations and iterative refinements of both the conceptual and physical forms of products to be designed. Through externalization designers can visualize their ideas and concepts by actually creating them (putting things into practice) and not just by thinking about them. The physical activities and tasks that designers carry out allow them to think about the design of their products in a better way. During an iterative design process design artefacts such as sketches or models 'talk back' to designers (Schön, 1983). The epistemic knowledge developed during the process of constructing different design artefacts and externalizing design ideas leverages the way designers deal with elements of surprise and unexpectedness.

Figure 3: Externalizing design knowledge on different materials such as paper based sketches (a) and physical models using clay, foam, cardboard and plastic (b). (Photo: courtesy of Connie Golsteijn)

Our fieldwork on designers underscores the centrality of 'thinking through doing' (or thinking though externalizing). It was observed that a single design team would collectively develop an average of 50 to 100 external representations of their design ideas, depending on the project. These vary from paper based sketches or cardboard models to physical models. Because different styles and levels of fidelity of a representation yield different perspectives, meanings and experiences, externalizing ideas through a variety of prototypes affords a richer understanding of a design. Figure 3.3 shows two different examples where different design representations are used to support discussions. Figure 3.3a shows a design group using a collection of paper based sketches, whereas figure 3.3b shows a table full of physical models made of clay, foam, cardboard and plastic. Being able to create more than one representation and alternatives of an idea and to try them out is in fact a major requirement for supporting creativity (Fischer, 2004). The thinking though doing theme suggests that the effort invested in developing different design alternatives helps co-designers to compare and judge important aspects such as the difficulty of building the final product.

Coordination. Several CSCW studies have shown that material artefacts play an important role in coordinating co-located and distributed activities (e.g. Sellen and Harper, 2002; Hutchins, 1995). Externalization of design ideas supports coordination within a team. The materiality of design artefacts provides information about the way they are created, used and manipulated, as well as about the process of design. Importantly, the temporality serves not only as indicative of different stages of a design process, it also serves accountability (planning, managing, budgeting, and so on) during the design work.

Figure 3.4: Group discussion of sketches (a) and result of a brainstorming session (b).

Different externalization techniques lead to creative methods of communication within a design team. Externalizations support creativity as they provide opportunities for others to interact with, react to, negotiate around, and build upon an idea. Externalizations contribute to a common language of understanding amongst a group of designers. For example, figure 3.4a shows a group of designers discussing different sketches at a table. Figure 3.4b shows results of another brainstorming session where the cooperative nature of design artefacts helped to develop new alternative concepts. The important issue here is that the materiality of different design representations can afford and trigger different collaborative actions in the team.

Empathy & Experience. In our field study, we saw several examples where designers created design representations based on observations of the real users. They tried to provide as much empathy towards the users through the development of such representations. One of the most powerful human capabilities relevant to designers is the intimate incorporation of an artefact into
physical experiences to the point where people perceive that artefact as an extension of themselves; they act through it rather than on it (Klemmer et al. 2006). Additionally, different design materials and artefacts allow direct and bodily engagement and hence broaden communicative resources by evoking sensual experiences. The multi-modality and ability to support and convey information through all senses, makes the use of a design artefact experientially rich (Vyas et al. 2009). In the case of joint design activities, co-workers do not just interact with these artefacts when they are designing, they actually get the feeling and experience each other's activities through these artefacts. The communication channels that are established by these multi-modal artefacts go beyond facilitating basic task-oriented activities.

3.4.2 Use of Physical Space

This theme refers to how design practitioners utilize their physical surroundings within a design studio in order to support collaboration and creativity in their work. In both of the design studios that we studied, we saw design teams use their office walls, whiteboards, clipboards, wooden panels and so on as carriers of their design-related information. The types of information that are attached to these spatial objects have instrumental and productivity related functions and can be seen in the form of design ideas, sketches, to-do lists, project-related information, work-in-progress data and other organizational details. At the same time, they also carry inspirational, provocative and other non-instrumental

details such as posters and innovative design sketches. The way information is represented in the space provides indication about collaborative and methodic practices of designers (Vyas 2009).

Figure 3.5: An example of creative ecology in a design studio.

Figure 3.5 gives a glimpse of a section of a design studio where a design team has used clipboards, large card boards and movable tables to develop a creative environment. In addition, there is information about project plan, post-it notes, design sketches on the clipboard, as well as the prototype on the table. An environment such as this establishes a 'creative ecology' within a design studio both at personal and social level. In the following, we will discuss how arrangements such as these help in establishing creativity.

Elaborate the Problem. One of the reasons to utilize space in such a way is to elaborate and divide design challenges so that detailed descriptions of different aspects of design can be generated, which in turn would help in resolving a particular situation. The way physical space allows the representation of design tasks can affect designers' reasoning abilities and performance. As one designer suggested, "I normally try to visualize all the material and data that I collected from my user studies and try to find out patterns and explore design opportunities from this data. I then make my own sketches and models and keep all these in a way that can help me find out new ideas".

Figure 3.6: A shared design environment, with pictures of different field studies and observations on walls and desk (a). Detailed personas on a wall of a design studio (b).

Several examples of this were seen in both of the design studios. Designers keep, for example, pictures from ethnographic or other field studies on their office walls and around their desks (figure 3.6a), or develop persona archetypes of their potential user groups and stick them on their shared working spaces (figure 3.6b). The aim here is not just to solve a design problem but to collect greater and useful insights into a given situation so that solutions can be envisioned.

Awareness. Within an ongoing design project, designers deal with a plethora of design materials, and being aware of different 'happenings' is an important issue. We observed that the way designers keep project-related design materials on different spatial objects within their studios improves the visibility and provides an overview of the work being carried out. Understanding how design artefacts within a work environment are organized, configured, manipulated and handled supports the awareness of co-workers' activities and, hence, contributes to the coordination of work. Design iterations, methods, and conventions can be easily extracted when design artefacts and related materials are kept in public visibility using physical space. The visibility of design activities is also manifested in and through the use of these artefacts. At the same time such a creative space could provide opportunities to reflect on the ongoing project and to allow designers to change, combine or divert aspects of their design process.

Organize and Manage. Design being a collaborative process requires organizing and managing the work of co-designers. The spatial aspects within design studios also play a role in supporting the organization and management of design projects. Figure 3.7 shows two examples (a & b) where design teams have used clipboards and movable drawing boards to show information related to project plans, data generated from brainstorming sessions, design concepts, work division within a team and to-do lists. Each individual piece of design-related information has a strong, even explicit link to some aspect of the project at hand. The ecology of these pieces information creates an information rich environment needed to stimulate creativity and to develop novel ideas.

Figure 3.7: Shared clipboards full of design-related materials to organize and manage ongoing projects (a & b). The personal workspace of a designer (c).

Personal vs. Shared. The way different information and design artefacts are arranged within design studios establishes a vague distinction between personal and shared spaces.

The above figures 3.7a and 3.7b show a physical space that is shared by a group of designers. However, designers also have their individual working space that they organize based on their own personality and reasons. As one of the designers commented about his private space, "the space allows me to organize my work and get reminded what I am doing daily. Also for the purpose of communicating with my peers I can very easily show what I am doing." As can be seen in figure 3.7c, these artefacts are indicative of different phases of the design process, the current state, and future planning. Another designer commented,"depending on the phase of the project, I arrange my surroundings. It's important for me to have these artefacts around so that I can register where I am at in the project". Hence, these design artefacts were markers for reminding. Personal spaces also allowed designers to create a portfolio-like arrangement of their workspaces expressing an identity or self-image.

3.4.3 Use of Body

During ongoing design projects, designers accomplish activities and tasks not only through their internal cognitive processes but by utilizing cooperative 'embodied' actions (Robertson 1997). The third theme that we discuss here is about how the specific use of designers' bodies helps in establishing creativity in collaborative design practices. The use of the body theme is central to externalization and utilizing the space (the above two themes) in all design activities. Designers creatively make use of their bodies while talking, while explaining a design sketch or in referring to spatial arrangements within a design studio. While the use of gestures and other bodily representations for discussing design ideas is common in design studios, there is an increasing use of design methods such as role playing, body storming or design choreography in groups (Hummels et al. 2007). Using these methods, designers explore and experience design possibilities for themselves, intentionally make these ideas public and allow other designers to reflect on these ideas. Here the design cooperation is achieved by the mutual perception of these actions as the basis for the ongoing creation of shared meanings in a particular design task. The use of bodies can be seen in different design stages to support different needs. In the following we will explain how the use of bodies helps in creativity.

Figure 3.8: Exploring design possibilities through performances. (Photo: courtesy of Rob Tieben)

Exploring Interactive Concepts. It has been suggested that bodily movements are suitable as a design technique, as our bodies convey emotions as well as geometry and interactions (Hummels et al. 2007). Role play methods allow designers to imagine and empathize a given design challenge. A physical activity is a primary source here to explore new possibilities. In our fieldwork we found that many of these bodily actions were aimed at better understanding of the design task context and at exploring new possibilities. Figure 3.8 shows two examples of exploring design possibilities. Here, the participants, using different bodily patterns, are exploring the possible behaviors of the product to be designed. The vividness of these experiences and the bodily understanding of a given design situation help designers to make better design decisions (Buchenau and Fulton Suri, 2000).

Improve Communications. Our verbal languages may not be enough when communicating issues related to complex technologies. While designing new technologies or products, designers have to think about out-of-the-box ideas that may be difficult to articulate using verbal means. One of the main objectives of applying role play methods is to communicate early design ideas and concepts in an engaging and participative way that could establish common-ground for the group of designers (Buchenau and Fulton Suri, 2000). Additionally, many product designers need to deal with issues such as branding, marketing and advertising. Methods such as role play help in dealing with all these issues in one package – that requires a combination of functionality, expression and communication.
Studies have shown that gestures, in addition to their purely communicative role, help lighten cognitive load when a speaker or performer uses them in combination with speech (Tang, 1991). Through role playing, a performer's ability to map his/her actions to certain features or tasks of design could help in understanding the envisioned product.

Exploring new Experiences. Supporting appropriate user experience is amongst the main goals within the design profession (McCarthy and Wright, 2005). Our physical bodies play a central role in shaping human experience in the world, in understanding of the world, and in interaction with the world (Klemmer et al. 2006). In addition to exploring new ideas and improving communication possibilities, we also observed that the use of role play and other participatory methods provided new perspectives on bodily experiences. When designers enact a particular scenario, they go through a set of emotional and experiential "phases" that not only make their actions personally meaningful but also lead them to envision how a potential experience should be.

Improving Design Practices. Echoing the claims of Fischer (2004), we observed that being able to move around the design environment and to interact with different design-related artefacts and with other designers can help in the understanding and learning of creative designing. This was in fact an important rule-of-thumb in one of the design studios that we visited. One of the professors
of the industrial design department frequently advised designers working in the studio to "move around and don't just sit at the desks" to generate creative ideas.
During the interview sessions with professional designers, we learned that on several occasions designers brainstormed by simultaneously drawing quick sketches and doodles on large sheets of paper in order to generate quick design ideas. Figure 3.9 shows design students at an industrial design department collaboratively exploring new ideas on a

large sheet of paper. In close proximity, designers can influence and inspire each other and at the same time adapt to each other's sketching styles. This theme suggests that creativity is an applied phenomenon, in full, creativity can be established by practicing and doing things in the real world, where bodies play a critical role.

Figure 3.9: Design students collaboratively sketching – influencing and inspiring each other.

3.5 Discussion and Design Concepts

The ethnomethodological approach allowed us to understand the current practices of designers to support creativity in their ongoing design work. In particular, the examples that are discussed in this paper point to the critical role of 'material collaboration' in supporting and enhancing creativity in the context of cooperative design. The three themes related to collaborative practices of designers that we have discussed here, namely, externalizing, use of space and use of bodies, provide insights into how material and physical signals can trigger creative thinking. We believe that there are important implications for the development of collaborative technologies for supporting professional designers. In the following we will describe these implications.

Spatial flexibility is an important factor for supporting group creativity of designers. It was apparent in our examples that designers develop a multitude of
design artefacts in the form of paper sketches, drawings, physical models and so on. The way designers keep these artefacts and organized them in their workspace affects their work organization, communication and coordination practices. It is this spatial flexibility of, for example, sticking sketches and drawings on a shared office wall or keeping physical models of different materials on a table that allows designers to discuss, criticize and explore new possibilities of their design work. In order to provide technological support for spatial flexibility, we need to think beyond desktop computers. Jaccuci and Wagner (2003) made an attempt to support spatial flexibility via mixing real work objects with virtual ones to support learning and collaborating amongst students of architecture.

Archiving materials used and produced during design processes helps co-designers get back to them whenever they need. There is creative value in allowing designers to associate and connect different design artefacts. We observed in our fieldwork that

designers attach paper based sketches, drawings and posters to their vertical surfaces for different purposes, creating a technological environment that allows designers to archive these design materials in such as way that could lead to supporting creative thinking.

Encouraging movement is an important aspect for aiding designers' collaborative creativity. As it was seen in the examples, designers' physical movements during explorative design stages and while using methods such as role playing or body-storming, support creativity in group sessions. Supporting the call for Design Movement (Hummels et al. 2007), we believe that technology should not hinder designers' physical capabilities but, on the contrary, should encourage freedom.

Sustaining ubiquity of design practices, especially when people collaborate from remote locations, could be a challenging task for developers. As was observed in our fieldwork, information related to a design project can be found in physical space and in material artefacts, as well as in designers' ability to utilize these material aspects. We believe that technologies that support live transmission of audio-video links may be able to support designers' conversations, but the pervasive nature of design practices requires the creation of technologies that go beyond these conversational paradigms.

Supporting thick practices of designers is a design challenge that should be taken into account. By this we mean that any new technology should acknowledge and take into account the primacy of real-world design practices. Technology should not just bring new ways of working but instead improve flexibility for the designers to use their methods. In this sense, a technology should carefully integrate physical and digital worlds to enable the improvisation of practices that the real world could offer.
Keeping these implications as a base, we have developed two conceptual systems that could potentially be used to support collaborative design activities. These are 1) the resource sharing concept and 2) the live discussions concept.

3.5.1 Resource Sharing Concept

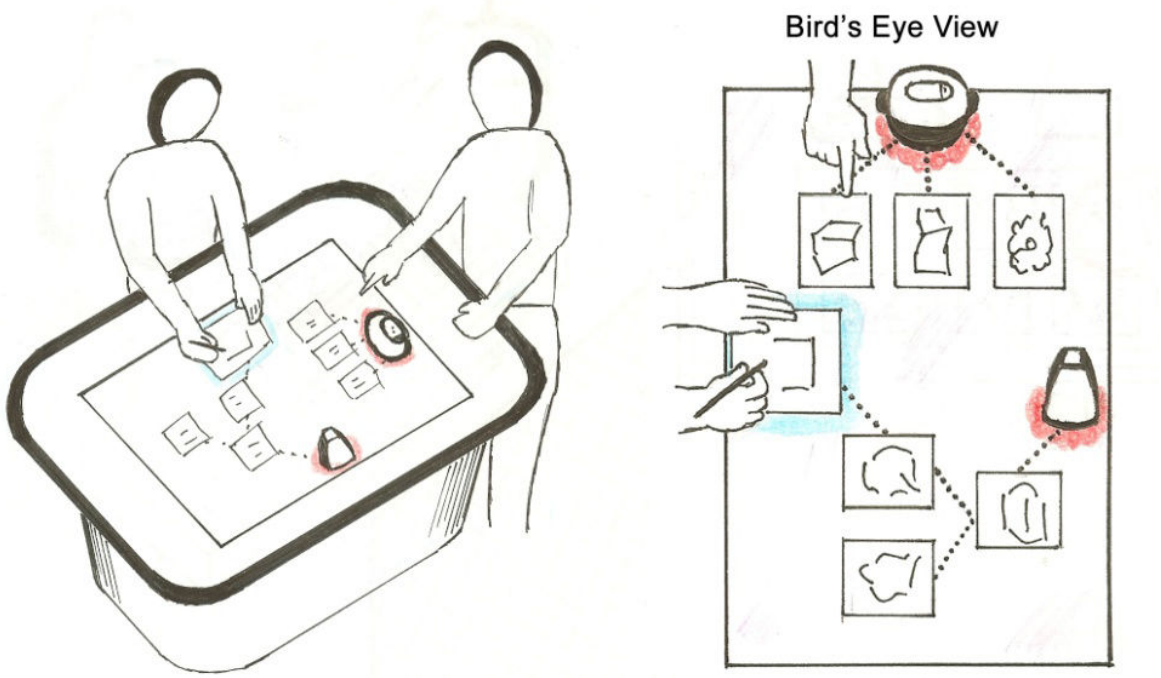


Figure 3.10: Resource sharing concept on a table-top workspace

The first of our concepts, Resource Sharing (figure 3.10), allows creative collaboration between designers in a co-located situation. The Resource Sharing concept uses a tabletop interface which allows designers to discuss and share design resources related to their products or prototypes. The tabletop interface can generate the design history of a physical product once it is kept on the surface of the table. The table shows the digital versions of the product ideas, associated sketches, annotated drawings and other historically important details in a hierarchical format. The table supports the use of multiple physical products or prototypes. As can be seen in the figure 3.10, using this tabletop interface, designers can look back in time, re-view the options they considered and reflect on them. The tabletop interface also allows designers to make new sketches on the interface based on what they are currently discussing in a design session.
This concept uses tabletop technology to allow designers a kind of spatial flexibility compared to a typical desktop based system. This spatial flexibility allows designers to collaboratively access multiple design artefacts (e.g. sketches) at the same time carry out brainstorm activities. In a sense, the table-top interface provides a mixed-reality interface to discuss real-world objects and associated digital artefacts, and it allows designers to sketch new design ideas on the surface of the table. The ability to connect, associate and compare multiple design artefacts on the table surface could enable designers' creative brainstorming activities. The tabletop interface does not impose any substantially new practice, it just allows new ways of interacting and storing design ideas in the table.
Realizing this kind of technology may not be too difficult as existing tabletop technology such as Microsoft Surface or Philips Entertaible can be used.

3.5.2 Live Discussions Concept

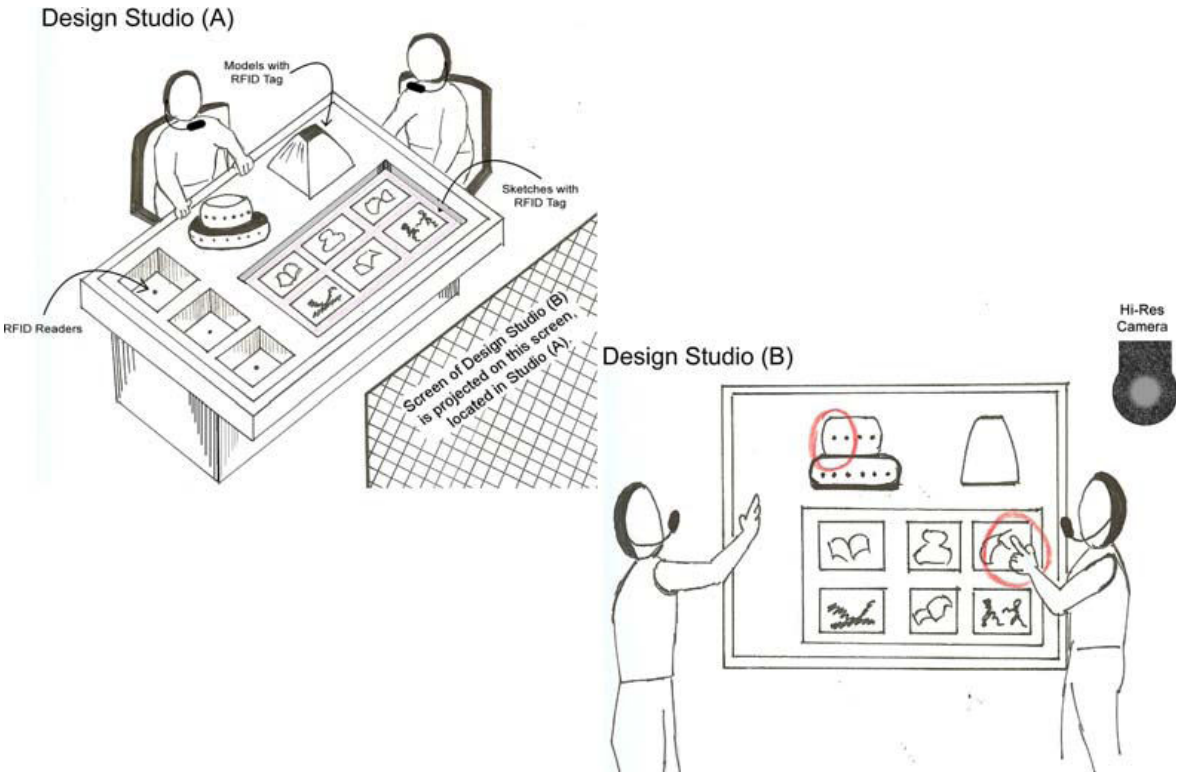


Figure 3.11: Live Discussions concept

The second concept, Live Discussions (figure 3.11), focuses mainly on remote collaboration, allowing designers to discuss three-dimensional and physical objects or prototypes as well as two-dimensional paper-based sketches without loosing information. As can be seen in the figure 3.11, design studio A has a table with dedicated planes (surface spaces) to allow communication of different types of design artefacts. Design artefacts have a RFID tag attached and different planes on the table are equipped with RFID readers. Design studio B is located at a distant place with other members of the same team. Studio B has a large-screen touch display where the view of the table in studio A is shown, with the help of RFID tags and readers. The dedicated planes on the table help to adequately represent the two-dimensional and three-dimensional information. In Studio B, designers can point, annotate or draw on a particular part of a design object and simultaneously communicate via microphones. Studio B is equipped with a hi-resolution camera that shows the live feeds of Studio B onto a display located in Studio-A. The concept is partly based on the work of Everitt et al. (2003), where design brainstorming was made possible through the use of post-it notes.
This concept is based on implications from our fieldwork. By allowing spatial flexibility though the use of a dedicated design table we could allow to discuss both two-dimensional and three-dimensional objects and to brainstorm over a distance.

3.6 Conclusions

The observations and ideas discussed above do not address the entire range of practices of the design studio culture. The three themes of collaborative practices that we discussed cover a broad spectrum of techniques that designers use to aid creativity in cooperative

design. Clearly, creativity is a critical aspect of design and needs to be supported though technological means. What has been presented here is an account of how creativity is applied by the designers of the two industrial design departments. An account of real-world design practices such as this could be very fruitful when we are to design collaborative technologies.

This study reflects the embodied nature of design practices. Our work shows: 1) how different externalization techniques utilizing seemingly mundane and simple design artefacts such as sketches, post-it notes, and physical models within a design studio play a role in supporting designers' everyday creative work; 2) how the intelligent use of physical space of a design studio helps designers to think creatively about their design work; and, 3) how bodies of designers play a pivotal role in experiencing and envisioning design aspects. The rationale behind applying these collaborative practices ranged from clearly defining design problems, exploring new possibilities, easing communicative difficulties, to developing a communication language with co-workers. All these reflections need to be taken into account when supporting the coordination within remote meetings.

4 Influencing meetings through ambient modalities

4.1 Introduction

The course of meeting processes depends on many different factors. First, characteristics of meeting components are important, in other words, what is the purpose of the meeting? Is it about information sharing, generating new ideas or is it a negotiation leading to a decision? Also, group characteristics affect the process, for example: how well do the participants know each other, what is their common goal? Next to group characteristics individual characteristics are important, for example character traits of participants such as dominance, their background knowledge and experience and their personal goals. Support tools can also influence the process. These tools can range from the use of certain methods and techniques, ICT support, to support by a human facilitator. Finally, environmental characteristics may be of influence: the layout of the meeting room and the lights, colors and possibly scents applied. During the meeting process, these factors may affect both the group functioning (e.g. trust, identity, support) and the individual performance (e.g. effort, attention, memory) of the meeting participants. Finally, all factors affect the outcome of the meeting process, in terms of effectiveness, efficiency and satisfaction of the participants. An important question is how these factors can be used to optimize the process and outcome of meetings.

Competent, experienced facilitators are essential for meeting processes, especially in meetings where various stakeholders have to achieve a common result, e.g. a design or a decision (Luck, 2007). The purpose of a facilitator is to ensure that the participants in the meeting quickly understand the subject under discussion, so that they can assess its relevance, and that they are encouraged to participate in the discussion. Competent facilitators: (a) clearly describe the purpose of each step in the process, (b) use understandable terminology, (c) involve the various participants in the discussion, (d) provide participants with background information, (e) use humor, (f) connect to experiences of the participants, (g) use a conversational style that is recognizable to the participants, and (h) stimulate discussion in the group. In order to be able to carry out these tasks, facilitators should make frequent assessments of the group performance at certain points in time during meetings. On the basis of these assessments, they should act appropriately. It is also possible to give direct feedback to the group about their performance.

This study deals with two specific meeting factors: meeting components and environmental factors. The first goal is to provide insight into how performance of various meeting components can be stimulated by certain environmental factors, in our case light, color and scent. The second goal is to find out how feedback of group performance during a meeting can be best presented to the group.

During real meetings, settings of the environment and feedback of group performance may be carried out by the facilitator. However, meeting facilitators are not very familiar with the use of all kinds of (electronic) tools to support the above-mentioned tasks. The result of the study can also be interpreted as a means of supporting the facilitator, if he or she considers it necessary. This requires a new way of working for the facilitator.

4.2 Ambient modalities

4.2.1 Color and light

Colors can evoke emotions and they can have either a stimulating (red) or a calming (blue) effect on the observer (Clarke & Costall, 2008; Detenber et al., 2000; Gao et al., 2007; Gao & Xin, 2006; Ou et al., 2004a; Ou et al., 2004b; Ou et al., 2004c; Valdez & Mehrabian, 1994). As a result, the color of an environment can strongly determine the extent to which people appreciate the environment (Franz, 2006; Kutchma, 2003, Yildirim et al, 2007). Furthermore, the color of a room also affects the functioning of people who work in the room. For example, a red environment stimulates performance of detail-oriented tasks, whereas a blue environment stimulates performance of creative tasks (Mehta & Zhu, 2009). Further, the color of was found to have an effect on short-term memory and problem solving tasks. Knez (2001) shows that people perform better in a 'warm' then in 'cool' artificial lighting.

4.2.2 Scent

The (often unconscious) perception of smell can cause many emotions and moods and incite certain memories (e.g. Moss & Cook, 2003), boost alertness, memory and responsiveness, and even influence behavior (Holland et al, 2005). For example, the scent of peppermint stimulates cooperation and helpfulness (James, 2006). Odor also greatly affects communication and social interaction between people (Glausiusz, 2008). For example, odor can determine social preferences: people find each other more (less) attractive in the presence of nice (bad) smells (Li et al, 2007). Scents may also determine how people appreciate an environment to a high extent. In commerce (e.g. in shops) this is put to good use (branding). Fragrances are applied to create associations with a certain product or quality of service. It is also known that certain odors can stimulate the memory of events or information that was stored in the presence of that odor (context dependent learning; Smith et al, 1992). Some odors (e.g. jasmine and orange) have a calming effect and reduce the stress level (Kutlu et al, 2008; Lehrner et al, 2000; Lehrner et al, 2005; Motomura et al, 2001, Redd et al, 2009), while other smells stimulate activity and raise the level of excitement. Pleasant odors may facilitate task performance in conditions of moderate stress (Baron & Thomley, 1994, Chu, 2008). The presence of a pleasant odor of jasmine not only improves performance of subjects carrying out a cognitive task, but it also stimulates their interest in the job and their motivation.

4.2.3 Interaction of color and scent

Observations of color and odor can greatly influence each other. Colors and scents arouse strong mutual associations (Demattè et al., 2006; Gilbert et al., 1996; Morrot et al., 2001; Österbauer et al., 2005; Schifferstein & Tanudjaja, 2004). A color can also determine the perceived intensity of a scent: a strawberry scent smells stronger when you see a red color (Zellner & Kautz, 1990). In the presence of matching colors (red, yellow), people are better able to differentiate between odors (strawberry, lemon) (Demattè et al., 2008). Also, more errors are made during an odor discrimination task when the color of the stimulus does not match the scent (e.g., strawberry and cherry in green water) than when this is the case (Stevenson & Oaten, 2008).

4.3 Influence Model

Our goal was to come up with a model for influencing meetings effectively. In some management literature it is claimed that (personal or organizational) effectiveness depends on two dimensions: Task orientation and Relation orientation (Reddin, 1987).With Task Orientation is meant: The extent to which a manager directs his efforts and those of his subordinates. These efforts are characterized by taking initiatives, organizing and giving instructions. With Relation orientation: The extent to which a manager maintains personal relationships. These relationships are characterized by listening, trust and encouragement. Effectiveness of a management style depends on the situation a manager has to deal with. A highly task oriented situation (e.g. working on an assembly line) asks for a different management style than a highly relation oriented situation (e.g., coaching). Likewise, we expect that effective behavioral influence within a meeting depends on the particular meeting situation. We reason that effective meeting management consists of:

- recognizing a particular meeting situation
- assessing whether that meeting situation is proceeding effectively,
- and, if not, influencing the meeting appropriately.

For recognizing a particular meeting situation, through brainstorming we came up with nine distinct meeting situations, or meeting components. For assessing a meeting component, we derived a norm, by positioning (through group consensus), the meeting components (enter/pause, introduce, inform, generate ideas, argument, negotiate, make decisions, analyse/reflect, evaluate) in a matrix with the previous mentioned dimensions Task Orientation and Relation Orientation (see Figure 4.1). For influencing the meeting appropriately, we will use proper ambient modalities to drive a meeting situation in the right direction within the matrix.

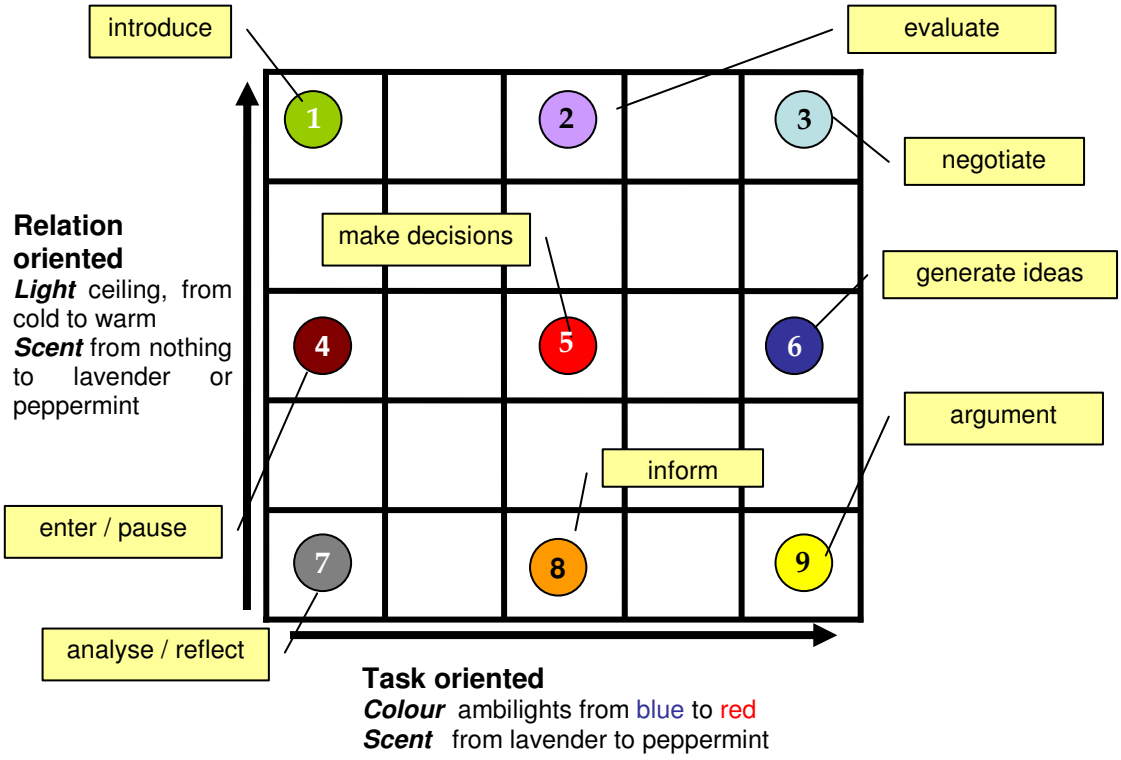


Figure 4.1: Model of meeting components related to the extent to which they need stimulation of task performance and/or relationships between group members. Tasks performance is influenced by certain colors (blue, red) and scents (lavender, peppermint), relationships by certain lights (cold/white, warm/yellow) and scents (lavender, peppermint).

The following findings from the literature on colors, lights and scents were implemented in the model:

- Colors: *blue* colors are supposed to enhance creativity, calmness and tranquility; *red* colors enhance concentration and eye for detail (Task orientation)
- Lights: *white* light creates a better individual performance; *yellow* light stimulates cooperation (Relation orientation)
- Scents: *lavender* is supposed to create a positive atmosphere, increase the level of cooperation, and reduce stress making people less alert; *peppermint* also increases the level of cooperation, but has a stimulating rather than relaxing effect (Relation orientation)

4.4 Method

4.4.1 Participants

A total of 39 participants took part in the experiment, in groups of 3-5 persons. All participants, 20 men and 19 women, were university students, between 20 and 30 years old.

4.4.2 Materials

Room ambiences

The experiment took place in the TNO 'project room' (see Figure 4.2). In this room, meetings can be held, where each participant has access to his/her own adjustable table with a stool. Participants can make use of modern facilities including individual laptops, and common large flat screen displays, a smart board on the walls and a multitouch table. Also, the room includes ambient lights on the walls, of which colors can be adjusted at will. There are ceiling lights that can vary in light intensity form very white to very yellow, and spotlights focused on the participants which can be remotely controlled. Finally, the room has scent dispensers (with 3 different scents), which can be used during meetings.

Figure 4.2: TNO project room, with red ambilights and a chart of team performance.

According to the model of task and relation orientation, linked to meeting components, the scents, lights and colors are defined in Table 4.1.

Table 4.1. Nine ambiences of ceiling lights, ambilights and scents related to meeting components according to the model (Figure 4.1).

Ambience	Meeting component	Task	Relation	Ceiling lights	Ambi lights	Scent
1	Introduce	Low	High	very yellow	Blue	strong lavender
2	Evaluate	Middle	High	very yellow	white	(none)
3	Negotiate	High	High	very yellow	red	strong peppermint
4	Enter / Pause	Low	Middle	neutral	blue	weak lavender
5	Decide	Middle	Middle	neutral	white	(none)
6	Generate ideas	High	Middle	neutral	red	weak peppermint
7	Analyse	Low	Low	very white	blue	(none)
8	Inform each other	Middle	Low	very white	white	(none)
9	Argument	high	low	very white	red	(none)

Group performance charts

Feedback of group performance was provided through charts (see Figure 4.3). The charts were based on 12 datasets of virtual scores of four individual group members about group performance (see Table 4.2). Each virtual group has provided 5 scores in the course of a meeting (t1-t5). How the scores were collected is not relevant for the experiment, it could be scores by the individuals provided at certain points in time, or scores provided by a

facilitator about the individuals. Group performance could relate to a number of meeting aspects: discussion, conflict, result orientation, heading in the same direction, high workload, understanding each other, satisfaction about the process, having influence on decisions, creativity, leadership, helping each other, reciprocal communication, presenting information to each other.

Table 4.2 Datasets of scores of 4 group members, at five points in time during a meeting.

Team performance in time Number of team members with similar scores	Neutral	Descending	Ascending	Fluctuating
4 group members	1	2	3	4
3 group members	5	6	7	8
2 group members	9	10	11	12

During the experiment the 12 datasets are presented in different ways (see Figure x):

- Presentation of points in time:
  - t5 only (now)
  - t4 and t5
  - t1-t5
- Presentation scores:
  - Individual scores of group members
  - Mean scores of the group
  - Mean scores of the group with standard deviations

A total of 36 charts was presented to all groups. Of the 36 charts, 12 were presentations of t5 only (now), 12 of t4 and t5 and 12 of t1-t5. These three groups of charts each consisted of 4 presentations of individual scores, 4 of mean group scores and 4 of mean group scores with standard variations. All of the 12 datasets were distributed randomly over the 36 charts, so that all data sets appeared 3 times. Randomization was different for the different participating groups. Finally, the order of presentation of the 36 charts in the experiment was randomized for each group.

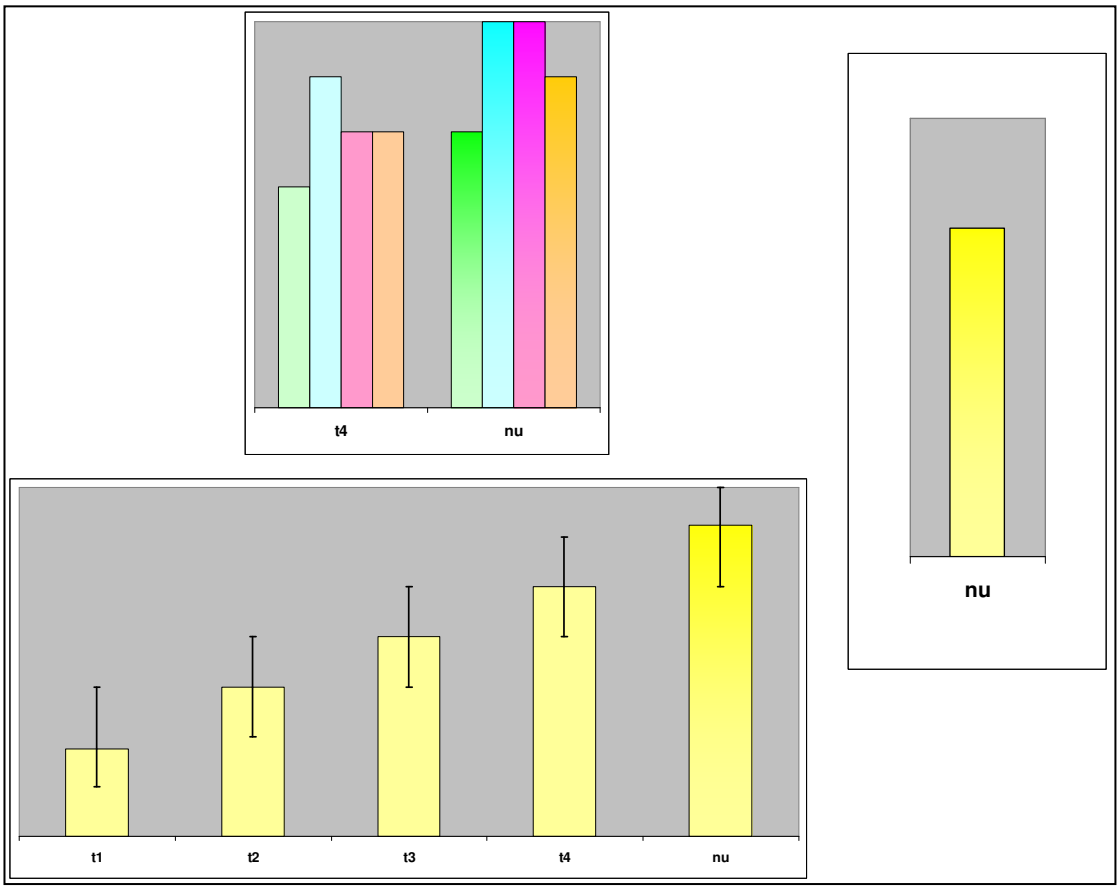


Figure 4.3: harts of group performance (top: individual, t4-t5; right: mean, t5; bottom: mean plus deviation, t1-t5).

Questionnaires
Measures were taken by means of questionnaires participants had to fill in for all five parts of the experiment. Details of the questionnaires are provided in section 4.4.3.

4.4.3 Procedure

The experiment consisted of four parts: A through D. Before, participants were given the following introduction: "This study deals with experiencing a meeting room where the ambience can be adjusted in various ways. You will sit down in the meeting room in a group of 3-5 persons and will give your individual opinion on various ambiences that are offered to you (it is about the personal experience of the room) or you answer questions about meetings."

Part A: Ambiences and task/relation orientation
The meeting room was brought into nine different ambiences successively. Orders of ambiences were varied between groups. For every ambience, participants were asked to indicate on a 7-point scale (prevents a lot, prevents, prevents a bit, neutral, stimulates a bit, stimulates, stimulates a lot) to what extent they thought that the ambience prevented or stimulated:

(1) their desire to work
(2) a good relationship with the other people present

They were asked to give their intuitive judgments, but to take at least one minute to experience the ambience before answering.

Part B: Team performance presentation
Participants were presented with images of 36 successive charts in a PowerPoint presentation. Orders of charts were varied between groups. Each chart remained visible for 10 sec., and was interspersed with a black plane that remained visible for 5 sec. The charts showed an impression of the performance of a team of 4 persons. For each chart the participants were asked to answer the following question: "How well does this team perform?" They were asked to indicate their intuitive opinions on a 5-point scale (very bad, bad, neutral, good, very good).

Part C: Ambiences and meeting components
The meeting room was again brought into nine different ambiences successively. Orders of ambiences were varied between groups. For every ambience, participants were asked indicate to what extent they found that it was suitable for certain meeting components, of which 10 were listed (enter, introduce, inform, generate ideas, argument, analyze, negotiate, decide, evaluate, and pause). They had to select 3 meeting components for which they thought the ambience was suitable and to indicate with 1, 2 and 3 the order of suitability (1 = most suitable). They were asked to give their intuitive judgment, but to take at least one minute to experience the ambience before answering.

Part D: Meeting components and task/relation orientation
Participants were provided with a list of 10 meeting components (enter, introduce, inform, generate ideas, argument, analyze, negotiate, decide, evaluate, and pause). For every component they were asked to indicate on a 7-point scale (very little, a little, slightly a little, neutral, slightly a lot, a lot, very much) to what extent they thought that the meeting component requires:

(1) a desire to work
(2) a good relationship with the other people present

4.5 Results

4.5.1 Ambiences and task/relation orientation

Figure 4.4 shows the results of the mean scores participants associated with various ambiences with respect to desire to work and relation. Table 4.3 compares the scores with the values of the model (Figure 4.1). All scores are in the middle range, from 3,21 to 4,74.
There are significant differences between ambiences with respect to desire to work: 6 differs from 1, 2, 3, 4 and 5. So Ambience 6 does not stimulate the desire to work. This finding does not match the model. With respect to the four ambiences with scent (1, 3, 4, 6) Ambience 6 does not stimulate the desire to work compared to the other three ambiences.
There are significant differences between ambiences with respect to relation. Ambience 7 differs from 2, 4 and 5, indicating that Ambience 7 does not stimulate the relation as much as the other three. This matches the model. No differences between the ambiences with scent were found.

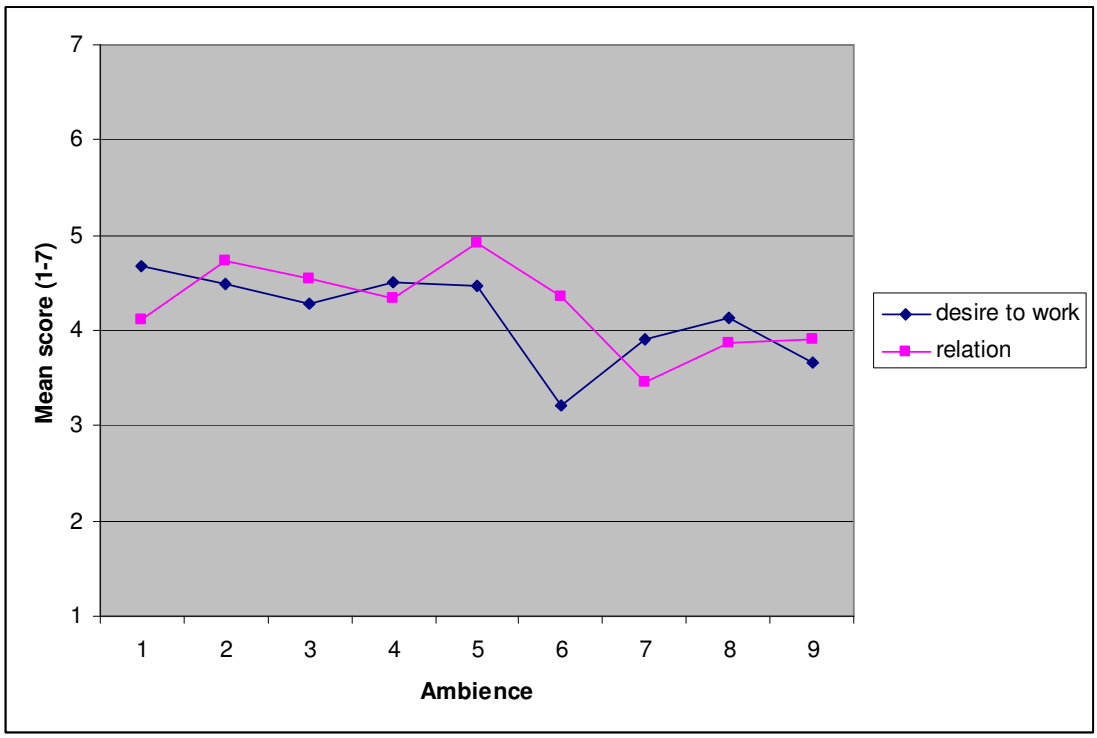


Figure 4.4: Mean scores participants attributed to nine ambiences with respect to stimulating the desire to work or the relationship with other people.

Table 4.3: Mean scores on a 7-point scale, for 9 ambiences stimulating a desire to work or the relation between other persons (higher number means a stringer stimulation).

	Score		Model	
	desire to work	**relation**	**task**	**relation**
1 (strong lavender)	4,67	4,12	low	high
2	4,49	4,74	middle	high
3 (strong peppermint)	4,28	4,54	high	high
4 (weak lavender)	4,51	4,33	low	middle
5	4,46	4,92	middle	middle
6 (weak peppermint)	**3,21**	4,36	high	middle
7	3,90	**3,46**	low	**low**
8	4,13	3,87	middle	low
9	3,67	3,90	high	low

4.5.2 Group performance presentation

Comparisons were made between the various types of data and presentations, in four different ways, see Table 4.4.

Table 4.4: Overview of data types and presentation types.

Data type **P**resentation type	Score course (neutral, descending, ascending, fluctuating)	Score-similarity (4vs0, 3vs1, 2vs2)
Time presentation (t1 t/m t5, t4-t5, t5)	Time presentation per score presentation, for score course per score similarity	Time presentation per score presentation, for score similarity per score course
Score presentation (individual, group mean, mean with deviation)	Score presentation per time presentation, for score course per score similarity	Score presentation per time presentation, for score similarity per score course

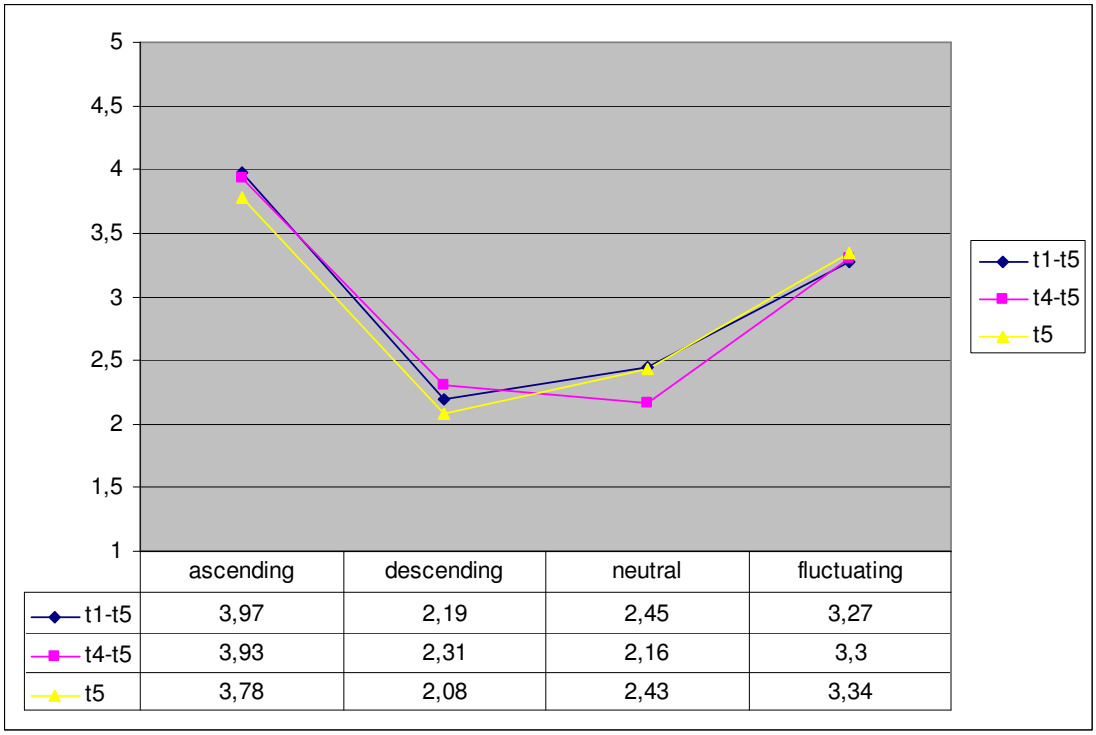
Time presentation versus score course

Figure 6 presents the scores for ascending, descending, neutral and fluctuating data sets, for charts that present t1-t5, t4-t5 and t5 only. In general, charts based on data sets ascending and fluctuating over time score higher than charts based on descending and neutral data sets. Charts with different time presentations (t1-t5, t4-t5, t5) are not scored differently. However, for neutral data sets, t4-t5 is scored lower than both t1-t5 and t5.

Time presentation versus score similarity

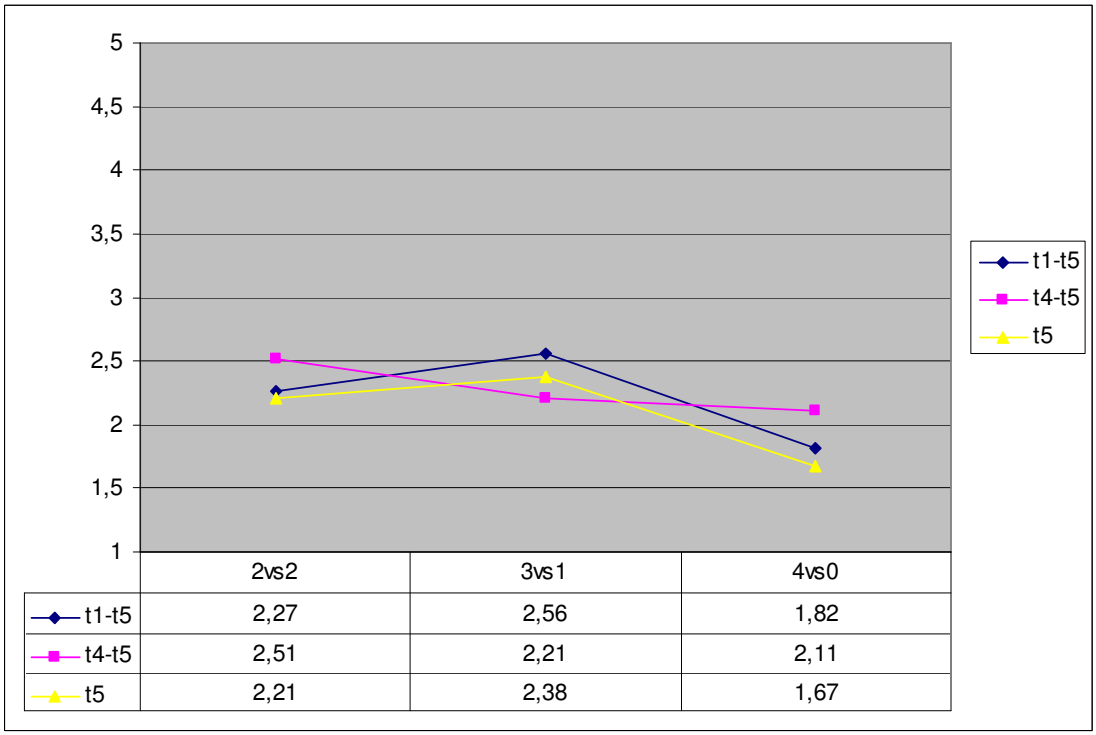
Figure 4.6 presents the scores for data sets describing groups where two times to group members are similar (2vs2), three members are similar (3vs1) or all members are similar (4vs0), for charts that present t1-t5, t4-t5 and t5 only. In general, charts based on data sets with two times two similar group members (2vs2) and three similar group members (3vs1) score higher than groups where all members are similar, although all scores are relatively low. Scores are similar for charts presenting t1-t5 and t5. Charts that present t4-

t5 differ in the sense that they score lower for groups with three similar group member (3vs1).



	ascending	descending	neutral	fluctuating
t1-t5	3,97	2,19	2,45	3,27
t4-t5	3,93	2,31	2,16	3,3
t5	3,78	2,08	2,43	3,34

Figure 4.5: Scores for ascending, descending, neutral and fluctuating data sets, for charts that present t1-t5, t4-t5 and t5 only.

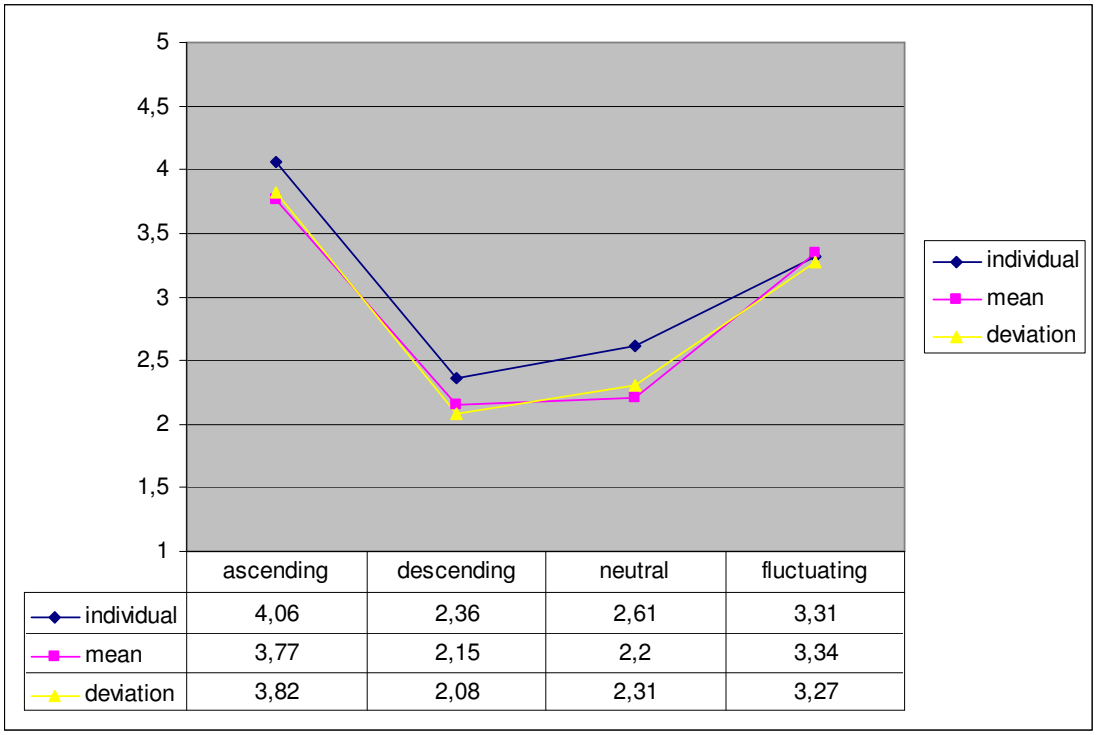


	2vs2	3vs1	4vs0
t1-t5	2,27	2,56	1,82
t4-t5	2,51	2,21	2,11
t5	2,21	2,38	1,67

Figure 4.6: Scores for data sets describing groups where two times to group members are similar (2vs2), three members are similar (3vs1) or all members are similar (4vs0), for charts that present t1-t5, t4-t5 and t5 only.

Score presentation versus score course

Figure 4.7 presents the scores for ascending, descending, neutral and fluctuating data sets, for charts that present individual scores, means group scores and mean group scores plus standard deviations. In general, again, charts based on ascending and fluctuating data sets are scored higher than those that are based on descending and neutral data sets. Also, charts that present individual scores are scored higher than charts that present means and means plus standard deviations, except when the data set is fluctuating where all three scores are similar.

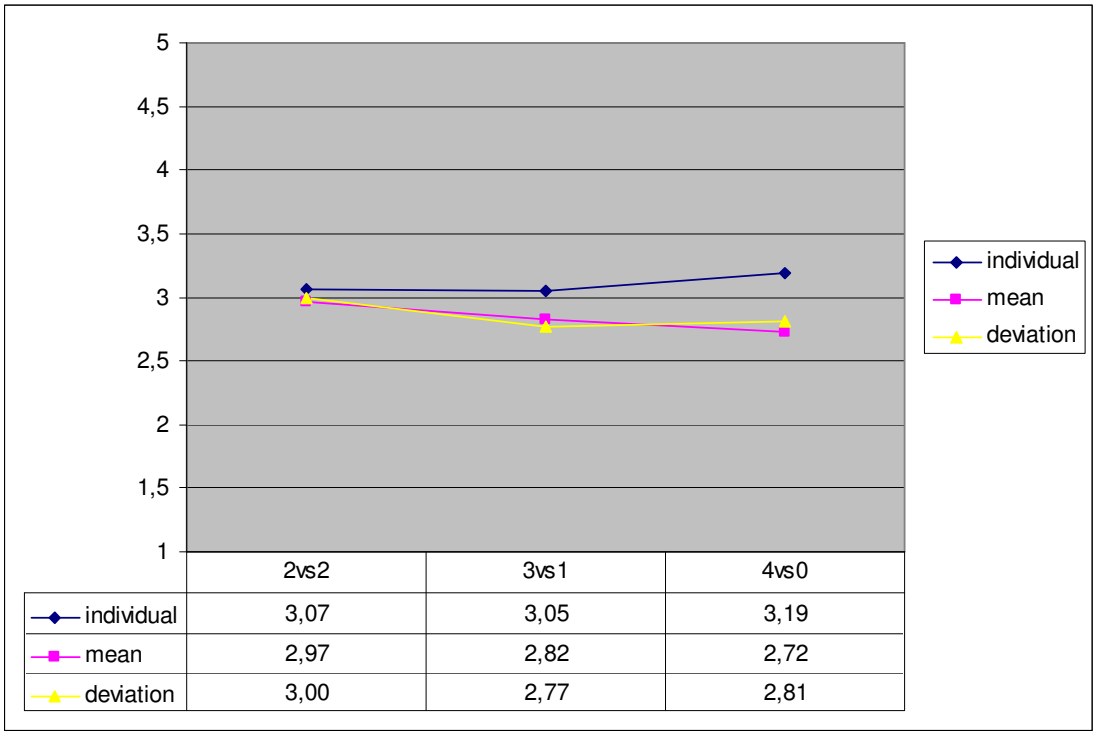


	ascending	descending	neutral	fluctuating
individual	4,06	2,36	2,61	3,31
mean	3,77	2,15	2,2	3,34
deviation	3,82	2,08	2,31	3,27

Figure 4.7: Scores for ascending, descending, neutral and fluctuating data sets, for charts that present individual scores, means group scores and mean group scores plus standard deviations.

Score presentation versus score similarity

Figure 4.8 presents the scores for data sets describing groups where two times to group members are similar (2vs2), three members are similar (3vs1) or all members are similar (4vs0), for charts that present individual scores, means group scores and mean group scores plus standard deviations. In general, no differences between charts based on homogenous or non-homogenous groups were found; they all score neutral. However, charts that present individual scores tend to score somewhat higher for fully homogenous groups (4vs0) than for the other two types of groups.



	2vs2	3vs1	4vs0
individual	3,07	3,05	3,19
mean	2,97	2,82	2,72
deviation	3,00	2,77	2,81

Figure 4.8: Scores for data sets describing groups where two times to group members are similar (2vs2), three members are similar (3vs1) or all member are similar (4vs0), for charts that present individual scores, means group scores and mean group scores plus standard deviations.

4.5.3 Ambiences and meeting components

Tabel 4.5 indicates per ambience the number of times that the ambience was *not* chosen first, second or third. The lower this number, the more participants thought that the ambience matched the meeting component. Between brackets, the number of times the ambience was chosen at the first position is indicated.

Table 4.5: Number of times an ambience was not chosen as first, second or third. Between brackets, the number of times the ambience was chosen at the first position is indicated.

Ambience	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
Enter	24(4)	**18(8)**	28(5)	25(7)	26(8)	32(2)	34(3)	29(5)	28(4)
Introduce	28(3)	**17(5)**	**20(8)**	26(3)	27(3)	**22(10)**	33(2)	29(2)	25(6)
Inform each other	30(4)	26(5)	28(0)	33(2)	**21(6)**	26(4)	24(4)	28(5)	27(3)
Generate ideas	27(5)	29(5)	**22(8)**	26(4)	28(4)	23(3)	31(2)	26(5)	27(3)
Argument	26(3)	32(2)	31(3)	26(4)	31(1)	28(5)	**24(5)**	31(6)	24(2)
Analyse	28(4)	31(2)	33(4)	24(6)	26(6)	34(1)	**21(10)**	23(5)	30(6)
Negotiate	30(2)	35(1)	32(0)	27(1)	30(1)	33(1)	**24(8)**	27(3)	25(5)
Decide	**23(8)**	31(3)	33(2)	22(7)	27(4)	29(4)	23(1)	30(1)	28(3)
Evaluate	29(2)	32(2)	21(4)	35(2)	26(3)	25(2)	25(2)	**21(5)**	29(3)
Pause	28(4)	22(6)	25(5)	29(3)	31(3)	**21(7)**	34(2)	29(2)	30(4)

The numbers indicate which ambiences match a certain meeting component best. The criterion for the choice of a certain ambience is a combination of the lowest number and the highest number at the first position.

- For Enter, Ambience 2 was considered most suitable.
- For Introduce, three ambiences were considered most suitable: Ambience 2 (lowest number), Ambience 3 and Ambience 6. Ambiences 2 and 3 have very yellow ceiling lights, Ambience 2 and 6 do not have similarities, Ambience 3 and 6 have red ambilights and a peppermint scent.
- For Inform, Ambience 5 is chosen.
- For Generate ideas, Ambience 3 is chosen.
- For Argument, Ambience 7 is chosen.
- For Analyse, Ambience 7.
- For Negotiate, Ambience 7.
- For Decide, Ambience 1.
- For Evaluate, Ambience 8.
- For Pause, Ambience 6.

Preferences for combinations of meeting components and ambiences were rather dispersed. This means that all ambiences have been indicated at least once as most suitable, except Ambience 4 and 9. Ambience 7 is found suitable for three meeting components, ambiences 2, 3 and 6 twice, but this is due to the fact that all three of them were preferred with Introduce. If we leave out 3 and 6, 2 is the only ambience preferred for two meeting components.

Table 4.6 shows that there are hardly any similarities with the model, there is only one match for Ambience 7 and Analyse. At the level of components of ambiences there are hardly any similarities. Only Inform, Generate ideas, Argument and Evaluate have two identical components, where no difference is made between a weak and strong scent. If we do not take the fact that there is no scent into account, there is only a match with Generate ideas.

Table 4.6: Comparison between the model and the preferences of participants for certain ambiences in relation to meeting components.

			similarity		
	Model	Preference	Ceiling lights	Ambilights	Scent
Enter	4	2	-	-	-
Introduce	1	2 3 6	very yellow very yellow -	- - -	- - -
Inform each other	8	5	-	white	(none)
Generate ideas	6	3	-	**red**	**peppermint**
Argument	9	7	very white	-	(none)
Analyse	**7**	**7**	very white	blue	(none)
Negotiate	3	7	-	-	-
Decide	5	1	-	-	-
Evaluate	2	8	-	white	(none)
Pause	4	6	neutral	-	-

4.5.4 Meeting components and task/relation orientation

Table 4.7 and Figure 4.9 present the resulting scores on a 7-point scale, for 10 meeting components, indicating the extent to which they require stimulating a desire to work or the relation between other persons present (higher number means a stronger stimulation). In general, the results are rather high for both desire to work and relation (higher than 4), indicating that both aspects are important for all meeting components. There is one exception, for Pause, where a desire to work should not be stimulated.
In particular, in order to generate ideas, argument, analyze, negotiate and make decisions a desire to work is required. In order to enter the room, introduce oneself and pause, the relationship with other persons present should be stimulated. Informing and evaluating require an equal simulation to work and to have a good relationship.
With respect to model fit (Table 4.6), there are four fits at the Task orientation axis, for: generate ideas, argument, negotiate and evaluate. Also, there are two fits at the relation orientation axis, for: introduce and negotiate. Thus, negotiate seems to be the only meeting component that was placed exactly at the right spot in the model.

Table 4.7: Mean scores on a 7-point scale, for 10 meeting components, indicating the extent to which they require stimulating a desire to work or the relation between other persons present (higher number means a stronger stimulation). Bold indicates model fit (low:1-3, middle: 3-5, high: 5-7).

	Desire to work	**Model task orientation**	**Relation**	**Model relation orientation**
Enter	4,55	low	5,13	middle
Introduce	4,42	low	**5,82**	**high**
Inform each other	5,21	middle	5,18	low
Generate ideas	**6,32**	**high**	5,24	middle
Argument	**5,92**	**high**	4,44	low
Analyse	5,64	low	4,41	low
Negotiate	**5,87**	**high**	**5,31**	**high**
Decide	6,00	middle	5,23	middle
Evaluate	**4,80**	**middle**	4,56	high
Pause	2,15	low	5,64	middle

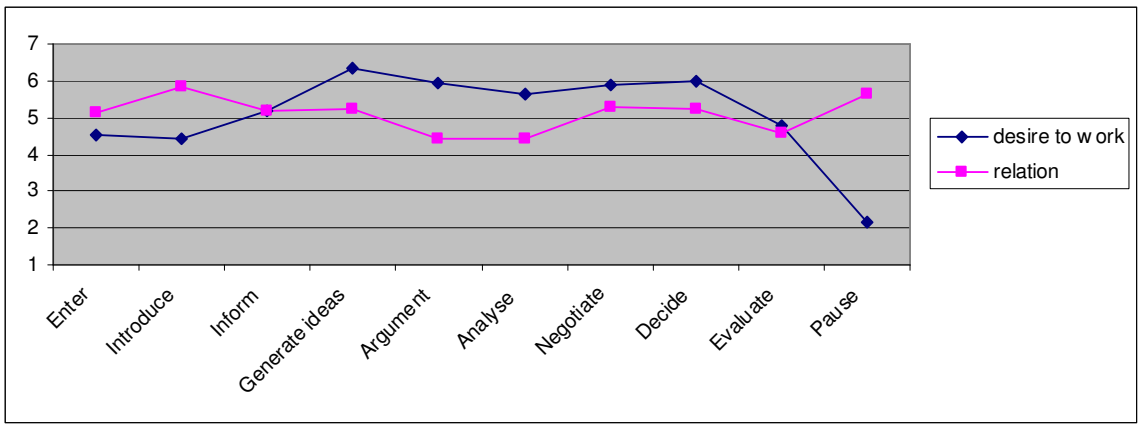


Figure 4.9: Mean scores on a 7-point scale, for 10 meeting components, indicating the extent to which they require stimulating a desire to work or the relation between other persons present (higher number means a stronger stimulation).

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4.6 Conclusions

4.6.1 Ambience

Only one fit was found with the model we proposed for the ambiences with respect to task and relation orientation, translated into colors, lights and scents. Almost all nine ambiences stimulated the task and relation orientation at about the same (rather neutral) level. There were two exceptions: Ambience 6 (no ceiling light, red, peppermint) does not stimulate task orientation (which does not fit the model); Ambience 7 (very white ceiling light, blue, no scent) does not stimulate relation orientation (which fits the model).
Also, only fit was found with the model for the ambiences with respect to meeting components, translated into colors, lights and scents. However, all ambiences were indicated at least once as most suitable, except ambiences 4 (no ceiling lights, no color, no scent) and 9 (very white ceiling light, white, no scent). The model fit was for Ambience 7 (very white ceiling light, blue, no scent) which was indeed preferred for the Analysis component.
Considering the results of the questionnaire which was designed to check the model, it is no surprise that hardly any model fits were found. From the results of the questionnaire, it can be concluded that participants find task orientation in particular necessary to generate ideas, argument, analyze, negotiate and make decisions. For generate ideas, argument, negotiate and evaluate there were model fits. Participants find relation orientation in particular required to enter, introduce and pause. Model fits were found for introduce and negotiate. Negotiate was the only meeting component that generated a model fit both for task and relation orientation. However, for the ambiences, the only fit was found for analysis.
In conclusion, on the basis of the results a new model should be designed and new ambiences should be linked to the model, in order to find better matches. Also, participants should experience the ambiences in real meeting settings, to allow them to judge the ambiences better. Finally, experiments should be conducted to find out the effects of various ambiences on efficiency and effectiveness of the meeting process and outcome and satisfaction of meeting participants.

4.6.2 Performance feedback

Differences were found for different presentations of performance feedback. In general, charts based on data sets ascending and fluctuating over time score relatively higher than charts based on descending and neutral data sets. Also, charts that present individual scores score higher than charts that present means and means plus standard deviations, except when the data set is fluctuating where all three scores are similar. Charts with different time presentations (t1-t5, t4-t5, t5) are not scored very differently. However, for both neutral data sets and groups with three similar group members, all points in time and now score higher than the last two times. Finally, no overall differences between charts based on homogenous or non-homogenous groups were found; they all score neutral. However, charts that present individual scores tend to score somewhat higher for

fully homogenous groups (4vs0). In contrast, homogenous groups score lower for charts based on data sets with two times (t4-t5).

In conclusion, if the meeting requires to give a positive impression of group performance, it is best to show individual scores. Also, if scores are ascending or fluctuating over time, the effect is even more positive. Finally, it is best to show all points in time for which scores are available or the current point in time only.

4.6.3 Meeting facilitation

If designed well, meeting facilitators could use ambience settings and performance feedback to improve meeting processes and outcomes. On the basis of own judgments or judgments by multimodal sensoring technology of what is currently happening in the meeting room, appropriate adjustments to ambience settings can be effectuated. Also, feedback of group performance can be selected in the appropriate presentation in order to achieve the intended effect.

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