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5 SENSES OF INTERACTION - A MODEL FOR CATEGORISING COLLABORATIVE TOOLS AND CREATIVE METHODS

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1. Introduction

Today, global collaboration is a reality in industry. Although there exists expensive high-end collaborative tools, such as telepresence, real world project collaboration tools are often limited to H.323 videoconferencing, where audio and video quality are generally low due to bandwidth restrictions and poor interoperability between videoconferencing systems. Often, collaborative sessions are restricted to telephone conferencing combined with a shared application, such as Adobe Connect Pro, Web ex or similar solutions. This type of collaboration is often not adapted to the real needs of the collaborators. Is there a killer application that is suitable for all types of collaboration or do we have to choose the tool based on the type of interaction?

Much work regarding video collaboration technology has focused on creating the best collaborative platform with as high quality as possible. Telepresence tools seek to replicate the physical meeting, i.e. real size videoconferencing, using conferencing rooms where the local and remote room blends together into a shared environment. Most telepresence systems are also designed for management meetings - recreating the boardroom table where half of the table is represented by the telepresence system. This type of setup is often far from the work practice in a creative collaborative session, which may look chaotic from a bystanders view.

In typical creative sessions, several persons interact simultaneously with a whiteboard, posting Post-Its and sketches on the whiteboard, annotates on their own and others ideas. Post-its used for brainstorming are clustered and moved around the whiteboard. Sketches and additional documents are lying around. The communication is hectic and individuals can change quickly between a local conversation and discuss the general topic with the rest of the designers. Often, several parallel discussions are occurring. [Larsson et al. 2002].

However, imitation will never substitute the real thing, and from this principle, these technologies will never fully achieve this goal. Instead, research should look for new forms of interaction, better than those in co-located meetings. Holland and Stornetta [Holland and Stornetta 1992] introduced the notion of *"Beyond being there"*, where collaborative tolls should provide something better than just "*being there*" (e.g. recreating the physical meeting). To create these tools, Holland and Stornetta suggested *"framing the problem in terms of needs, media, and mechanisms. The goal then becomes identifying needs which are not ideally met in the medium of physical proximity, and evolving mechanisms which leverage the strengths of the new medium to meet those needs"* [Holland and Stornetta 1992, p.7].

The reminder of the paper is organised as follows. Section 2 presents the research design and in section 3, we describe the theoretical framework. Section 4 reveals the model developed, and in

Section 5 provide the analysis of both methods and collaboration technologies. Finally we discuss the theoretical and industrial implications before addressing limitations and future research.

2. Method

The general aim of this paper is to not follow the path of most tele-collaboration research, which is to create a system that affords us the same richness and variety of interaction when we are physically proximate. Instead, the aim is to find useful input for products that go beyond *being there* [Holland and Stornetta 1992]*,* i.e. tools that fill our interaction need better than in co-located environments. Only by studying the interaction of a group, regardless of the medium, can we achieve a truly innovative point of view.

To determine the features of tele-collaboration technologies, as in any product development process, it is paramount to determine what the real needs of this collaboration are. However, a team of designers may need to interact in many ways. This paper focuses on the study of creative design meetings, where problems are stated and concepts are created and evaluated.

An effort has been made towards an understanding of how people interact in these kinds of meetings, both facilitated by creative methods and ad hoc meetings. The hypothesis that guides this work is that: *different meetings have different interaction needs.*

The two guiding research questions arose from the study of creative meetings:
- *RQ1:* to find out the interaction needs in creative design meetings
- *RQ2:* design a model that can be used to describe these needs in an intuitive way.

3. Theoretical framework

The theoretical framework of this paper consists of three areas: group interaction in creative design meetings, shared understanding and how objects in design are used.

3.1 Group interaction in creative design meetings

Creative design meetings (a divergent process where new ideas or concepts are created) are performed throughout the whole product development process, but usually occur with a higher frequency during the early stages of the product development process.

This process is often preformed in a larger group, where the diversity of the group can increase the probability for innovation [Flemming 2004]. Often, it is recommended that the participants of a design meeting should be as heterogeneous as possibly and also include as many of the stakeholders as possible (i.e. engineers of different fields, architects, designers, people from marketing, clients, a customer service rep and the costumers themselves) in the project take part in these creative sessions. These participants have different competencies, skills, responsibilities and interests; because they live in different worlds and as such see the object differently [Bucciarelli 2002], while sharing a common goal.

However, this diversity is not only positive, and research has shown that the diversity, if managed poorly, can decrease the performance of the team due to the increased problem of understanding each other [Flemming 2004]. The aim of these meetings is not only restricted to classical design problems and may also include solving a financial problem, finding a new business plan, or improving an existing product or system.

Therefore, three elements define these meetings: the knowledge of the participants, their cognitive skills and limitations, and their communication skills. These creative meetings are not only about applying known knowledge; to be effective, the team individuals must understand how to discuss, deliberate and negotiate with other [Bucciarelli 2002]. Hence, a design process can be seen as an integration of a technical process, a cognitive process, and a social process.

As Larsson points out, *"the social character of design activity is not separated from the technical results"* [Larsson 2003, p.153].

In this phase of product design, the official role of the participants is assigned, due to their hierarchal relationships. However, informal role adoption is being developed during the creative sessions by means of repeated behavioural patterns or types of comments by the individuals. For example, some

of the members can take leadership roles, or a 'centre stage' role, whereas others are apparently non-active in leadership (maybe working independently, drawing or pursuing another line of thought) [Harrison and Minneman 1996]. This work held in conjunction to a main discussion is common and a natural part of creative teamwork. These conversations were mainly used to clarify things and to discuss vague ideas or personal disagreements [Larsson et al. 2002]. Another interesting aspect of the sessions is that the participants, in a sense, are in competition with one another. Sometimes, claims and proposals of one individual will conflict with those of another, and team members may find it necessary to persuade the others of the value of a concept they particularly favour (usually a concept they generated themselves).

3.2 Presence and awareness of the team members

In a co-located conversation, we normally keep our partner constantly in our vision field and have a high sense of presence and awareness. In the communication, there are additional modalities such as gestures, facial expressions, eye contact and gazing or pointing help to find a common ground when explaining and debating concepts. Also, co-located meetings enable useful forms of communication like embodiment representations, i.e. the use of the body (and additional physical objects) to animate and visualize ideas. Larsson [Larsson 2003] states that this type of gesture is used to visualize what they wanted to 'say' when verbal language was insufficient, i.e. using your body to express ideas and concepts in more efficiently. It can be combined with verbal language, and also can imply the interaction with design objects.

In a workspace where the group interaction takes place, the awareness of other users is not only defined by its physical boundaries, but by the lived relationship between the people in the space. Also, the position or presence of team members in their work environment at a given time should indicate to the others their focus of concern, or they level of activity. For instance, a designer sitting far away from the whiteboard in a creativity session expresses a low level of activity, or maybe that he is working on another approach to the problem, while standing next to it expresses an active input to the idea creation. Sharing the manipulation of objects is afforded as well, requiring a certain level of proximity between collaborators and objects, and often a level of mobility within the workspace is necessary [Wolff et al. 2007].

3.3 Shared understanding

One of the first things that a team must come up with is a shared understanding of the problem. This does not imply an agreement of which solution must be achieved, but a common ground of the boundaries, rules and needs of the product. However, this common ground can be built and rebuilt through the moment-to-moment interaction of team members [Clark and Brennan 1991], in an iterative cycle. This is accomplished thanks to an efficient communication between members, which can be made through different channels, not only verbally, but also using facial expressions, gestures, and design artefacts.

This process is normally quicker in a homogenous team, but as mentioned above team diversity enhance the creativity and knowledge in the group. And designers with little common understanding and agreement will come up with a wider set of ideas and concepts, often new, often unexplored [Arias et al. 2000]. Bergström writes that *"the differences in opinion are a source of inspiration"* [Bergström 2009, p.63]. Also, the limited knowledge about the problem to be solved leads to a wilder and more unlikely solutions [Flemming 2004].

3.4 Objects in design

An important issue of collaborative design is the use of artefacts, since they have an important role as a communicative resource. Artefacts allow the externalization and representation of objectives, constraints, form, function, assembly, materials, etc. Two types of artefacts in design are suggested [Perry and Sanderson 1998]. *Design artefacts* are sketches, models, prototypes, etc., and *procedural artefacts* are things such as office memos, letters, Gantt charts, etc. *"Design artefacts represent a thought about design, whereas procedural artefacts convey the anticipated design process and help to orient people to it"* [Perry and Sanderson 1998, p. 275]. Perry and Sanderson conclude, *"Computer technologies*

designed to facilitate the design process have so far not attempted to link design artefacts to their role in communication and coordination." [Perry and Sanderson 1998, p. 287].

Robin Wolff et al define shared object manipulation as *"the simultaneous action of modifying an object through its attributes, such as position or colour"* [Wolff et al. 2007, p. 5]. They distinguish between two classes of shared object manipulation: sequential and concurrent manipulation. Sequential manipulation occurs when attributes are modified in sequence, whereas concurrent manipulation occurs when attributes are modified simultaneously. They also classify scenarios where simultaneous actions are independent and co-dependent. Independent actions are where distinct object attributes are modified. Co-dependent actions are modifications of the same object attribute. An example of independent action is when three people are painting an object together, where one person controls the position attribute by holding the materials in place, while another controls the colour attribute by holding the material in place, while another controls the colour attribute by painting it. An example of concurrent manipulation is the joint lifting of a heavy object where the position attribute is dependent on the actions of both participants.

4. Five senses of interaction

The model developed to categorise and evaluate distributed tools for creative collaborative work is based on the *five senses of interaction*:

- *Sense of presence,* describes the social presence – the feeling of being together that comes from the interactions between people.
- *Sense of space,* the interaction between the designer and the environment.
- *Sense of sharing,* describes the interaction possibilities around shared design objects.
- *Sense of time,* describes the sense of time and how events unfold - asynchronous or synchronous, and deals with the delay of communication.
- *Sense of naturalness,* describes how intuitive the system are.

4.1 Sense of presence

The understanding of sense of presence in this paper is similar to the definition of *social presence* by Ijsselsteijn and Riva *"social presence refers to the feeling of being together, of social interaction with a virtual or remotely located communication partner"* [Ijsselsteijn and Riva 2003]. We also consider that social presence is built by means of communication channels, such as spoken language, written messages, sketching, embodiment, etc. and the awareness of our interlocutor. Obviously, both factors are strongly connected, since highly interactive communication channels like eye gazing need great awareness.

4.2 Sense of space

Considered as the interaction between the designer and the environment where all design activities occur. In a good environment, we can walk around, see the creations of other people, find our own room for thinking or for acting, etc. We can easily and quickly contribute to the design creation, without moving long distances. We are able to look at design objects from different angles as well, and access them from any angle. An awareness of the position of the other designers informs us of the level of activity and the focus of concern.

4.3 Sense of sharing

Is defined as the interaction possibilities around design objects. Since design objects help to create a common ground of the problem, they should be shareable and modifiable by all designers. A private/public modality of the design object's sharing should be "afforded", as well as "custom" views concerning different properties, the object's creator, old versions, etc. Simultaneous communication between designers is important for object sharing.

4.4 Sense of naturalness

Is defined as the interaction between the designer and the interface of the *medium of collaboration*. This means, for instance, how intuitive is to use the new videoconferencing system implanted in the conference room, or how easy it is to sketch on a digital whiteboard. Naturalness of human-computer interaction is likely to increase performance, because people do not need to compensate for the technology, allowing the users to concentrate more on the task, not the interface. Essentially, users should be able to naturally use their already learned skills, without noticing the technology as a challenge. Scientific disciplines such as CSCW (Computer Supported Cooperative Work) seek to understand how people work together to design adequate computer-based technologies for cooperative tasks.

4.5 Sense of time

Is defined as the quality of time continuity while communicating. When sharing the same space, time is not a major concern, since the transmission of information is shared synchronously. However, in distributed communication, a fluent and comprehensible exchange of information is mandatory to avoid time delays. Moreover, if the teams are spread throughout different time zones, it could be necessary to find the right time interval that overlaps the work hours of the different teams. In an asynchronous communication, e.g. e-mail conversation, time is no longer an important restriction.

4.6 Visualization of the senses

Although some of these communication aspects may seem to not apply to a physically located meeting, like sense of naturalness, studying each medium with the same principles, both co-located and distributed, both physical and computer mediated, may reveal which aspects could benefit from one another.

The motivation to define these senses is that they cover every aspect of the interactions conducted in a design meeting very well. The idea proposed is to use pentagons to represent the creative techniques and tele-collaboration tools, assigning each one of the senses to one of its vertex. This approach allows an analysis of both creativity techniques (the senses become *needs*) and tele-collaboration tools (the senses become *technical features*).
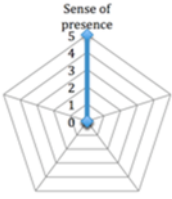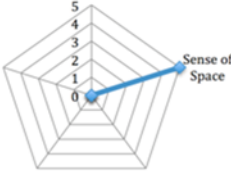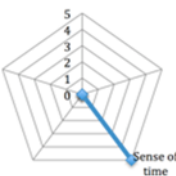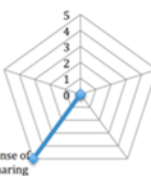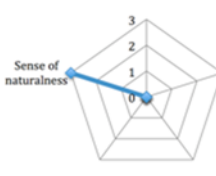
By analysing them using the same visual method, useful information and a starting point to 'couple' them will emerge. The senses will be evaluated through different levels, usually from 0 to 5 (except *sense of naturalness*, which is from 0 to 3). Each of these levels represents a different group interaction situation, see Table 1.

Generally, a higher degree stands for an interaction closer to the physically located. However, as we pointed out before in "*Beyond being there*", this is not always the best solution. For instance, level 2 for *Sense of time* would be an asynchronous instantly shared communication, such as when using e-mail. From level 3, we refer to a synchronous communication for sense of time, as in videoconferencing. However, e-mail is one of the most successful telecommunication technologies nowadays, and its asynchronous communication has several advantages over videoconferencing (e-mails usually contain formal information that can be reused, quoted, etc., and both sender and receiver do not have to be simultaneously online to start a conversation).

In some cases, an in *Sense of sharing*, we also observe that computer mediated collaboration offers obvious advantages over physically located communication. For instance, in a digital medium we can layer design objects, retrace them, and observe them in different views – all actions that are not possible in co-located meetings.

The *Sense of naturalness* takes on a slightly different meaning when referring to computer-mediated communication, and when talking about design and creativity methods. In the former, it refers to the ability of the technology to "afford" the already acquired techniques and methods of the designer. Design methods refer to the "allowance" of the method to use this knowledge.

Table 1. Description of the 5 senses of interaction

	Sense of Presence	Sense of Space	Sense of time	Sense of sharing	Sense of naturalness
0	No communication channels available	No sense of space	No time sharing	No object sharing	Incomprehensible communication
1	Online/Offline signal- Written messages	Movement around the space allowed	Asynchronous communication. The information is not instantly received	Design objects can be viewed	Unfriendly interface
2	Voice communication	Awareness of the other designers' level of activity and position in the space	Synchronous communication with time delays	Design objects can be discussed, working as a common ground	
3	Voice and video communication	Swift between side conversations and public conversations enabled	Asynchronous communication. The information is received instantly	Private/Public modality can be chosen	Friendly interface, unnatural
4	Non-verbal cues like embodiment, eye gazing/contact, pointing…	View of design objects from any position in the environment	Synchronous communication without time delays	Design objects can be modified by all the designers	
5	Integration of interpersonal space and workspace	Manipulation of design objects from any position in the environment	We can go "back in time" on a design meeting (time machine feature)	Different views of the same design object can be performed at the same time. Views from different angles, layered views.	Natural techniques, as sketching, grouping, browsing - enabled in an intuitive way

It is important to point out that some of these senses are related between them. For instance, if we use a Voice communication (i.e. level 2 for *sense of presence*), inevitably we will have a third or higher level for *sense of time*, since it will surely be a synchronous communication. Similarly, if we have level 4 or 5 for *sense of space* (i.e. we can either view or modify design objects from any position in the environment), the *sense of sharing* level will be at least 1 in the first case and at least 4 in the second case. Also the *sense of naturalness* is related to the other senses, a high level on the other senses will probably give a high rating on the *sense of naturalness*.

5. Assessing creative methods and collaboration technologies

In this section, creative methods and collaborative systems are evaluated with the proposed model. Thereby it is possible to compare the interaction needed by the creative method vs. the interaction

provided by the collaboration system. Due to the space limitations of this paper, only three different methods and tools are assessed briefly; for more examples, see the thesis [Garrido 2009].

5.1 Assessing different types of creative methods

All methods are done in different stages where each identified stage is assessed using the model. The methods chosen in this paper illustrate how the model is used and how the assessment can be done.

5.1.1 Classical brainstorming

This version of brainstorming used below includes an introduction, clarifying and restatement phase before the brainstorming stage (Stage 1-3). The 4:th stage is a very active phase where the participants preferable stands in front of a whiteboard, write down their ideas on Post-It notes, and place them on the whiteboard. This stage is often perceived as quite chaotic and includes multiple side conversations, parallel interaction and rapid shifting between private (Post-It pad in hand) and shared space (Post-It pad on whiteboard).

Table 2. Assessment of classical brainstorming

Stage 1	Stage 2	Stage 3	Stage 4	Stage 5	Summary
State the problem and discuss	Approach the problem in terms of "How to…"	Select a restatement of the problem and write it down	Brainstorming	Create a list of the "wildest idea" achieved	The aggregated interaction need for Brainstorming
Stage 1 to 3: There is still no idea generation; hence, no need for a high presence level or sense of sharing. Sense of space decreases as the problem is stated, since fewer side-conversations are necessary. Stage 4: Brainstorming sessions need high levels of communication efficiency. The interaction between designers should be through as many communication channels as possible and design objects must be shareable and modifiable in a quick, synchronous manner.					

5.1.2 Brainwriting 6-3-5

Brainwriting or 6-3-5 method includes six persons each writing 3 ideas down on a worksheet every 5 minutes, after each 5 min stage the worksheet is passed to the person to the right. Participants are encouraged to build on others' ideas for inspiration, thus stimulating the creative process. After 6 rounds in 30 minutes the group has thought up a total of 108 ideas. Some variants of the 6-3-5-method focus on text and others allow sketches. Assessment the 6-3-5 method using the 5 senses of interaction is done in Table 3.

Table 3. Assessment of brainwriting 6-3-5

Stage 1	Stage 2	Stage 3	Stage 4	Summary
Everyone writes the problem topic on his sheet	Write 3 ideas in 5 minutes	Pass the worksheet and write 3 more ideas	Repeat the process until the sheet is finished	The aggregated interaction need for Brainwriting.

The interaction requirements for this technique are very low, since there is barely the need of interaction between designers. The interaction between designers and design objects should afford private and public sketching/writing though, and time delays are allowed as well.

5.1.3 Word association

This is a simple exercise to create a common ground in a group, what is the essence - the meaning of a word or topic, often used initially in a creative meeting. The exercise begins by writing down the topic or word, from which all participants associate and attempt to describe their view and their understanding of words and what their significance is. Thus a topic map is created using Post-It notes. The Post-Its are then clustered after topics and voting can be used to identify important topics.

If the team has a heterogeneous background there will be quite different views on what the topic actually means. The important part of this exercise is to visualise and acknowledge different views, not try to create a common definition. The different stages in the Word Association exercise is assessed by the 5 senses of interaction, see Table 4.

Table 4. Assessment of word association

Stage 1	Stage 2	Stage 3	Summary
Write the topic on the Whiteboard	Create a topic map (meaning)	Clustering and voting for important topics	The aggregated interaction need for word association.
Stage 1 to 3: As the stages progresses in this technique, the sense of time and sense of sharing requirements increase, since a closer interaction with design objects is necessary (emit votes).			

5.1.4 Comparison of the creative methods

When the different stages in the creative method are aggregated (see the rightmost pentagon in Table 2, Table 3 and Table 4), the integrated need is visualised. Some similarities can be observed, *sense of Presence* and *sense Space* is quite low in all two of the methods, but the sense of naturalness (ease of use) is high in all. By comparing the aggregated spider-web diagrams for the different methods, it is clear that classical brainstorming requires much more interaction than the other two methods. Therefore demand more from a collaborative environment, which includes integration of interpersonal space and workspace, manipulation of design objects etc.

5.2 Assessing collaborative tools

The assessment of collaborative tools is done in a similar way as the collaborative method above. The tools chosen are two tools often used in industrial collaboration, *Audio-conferencing* and *Videoconferencing*. The third tool is a tool more specifically designed to solve some of the problems when performing a distributed brainstorm – *The designers' outpost*. The assessment of the different tools are visualised in Table 5.

5.2.1 Audio-conferencing

Audio conferencing the advantage of large penetration, but citing Wolff "*The telephone is an ubiquitous technology, but it has severe limitations supporting essential social cues and object sharing*" [Wolff et al. 2007].

5.2.2 Normal videoconferencing

Videoconferencing allows communication with audio and video, though it has several limitations on the sense of space axis. It's difficult to have different viewpoints, and allows very limited interaction with physical objects. As well, non-verbal communication is limited and eye contact is difficult to achieve.

5.2.3 The designers' outpost

The designers' outpost [Everitt et al. 2003] tries to replicate the collaborative interaction in a brainstorming interacting with Post-Its on a whiteboard. The designers' outpost is a remote collaborative system that uses Post-Its as interaction primitives. The physical Post-Its in one location become digital in the other and vice-versa, using a double video camera system that also shows the shadow of the designers. Drawing on the board is also enabled, using a digital pen with transient ink. This collaborative system combines gestures, and awareness of other users with the possibility to interact with both physical and virtual objects in a distributed setting.

5.3 Comparison of collaboration tools and creative methods

By comparing the different tools above and visualized using the pentagon, see Table 5. It is easy to see that the *Designers outpost* is a preferred tool for a distributed session of *word association*. And that other collaboration tools lack several important part of the interaction needed to perform a *word association*.

Table 5. Summary of different technologies compared to the word association method

Audio conferencing	Videoconferencing	The designers outpost	Word association

It seems like many collaborative tools are weak on sharing objects and sense of space, which is quite natural in a co-located session. In a creative session we can move from individual (private) work, share ideas and sketches with others, and at the same time have an awareness of the activity of other participants in the room. This is lacking in most collaborative tools today.

6. Conclusion and future work

The work presented in this paper was based on the underlying hypothesis that all meetings are different and the collaboration is often not adapted to the real needs of the collaborators, instead the collaborators has to adapt to the existing technology. Also there is a trend of creating telepresence with as high quality as possible trying to recreate a boardroom meeting where half of the table is represented by the telepresence system. This type of setup is often far from the work practice in a creative collaborative session, where engineers interact with whiteboards, Post-Its, sketches etc. So there was a need to understand, visualise and categorise different types of meetings and collaboration technologies. The aim of the presented work was to explore the designer's behaviour in collaborative design meetings (with a focus on creative meetings), and find the different types of interaction needs. The aim was also to design a model to describe these needs in an intuitive way.

The result is a graphic approach that is based on a categorisation into five senses of interaction; *sense of presence*, *sense of space*, *sense of sharing*, *sense of time* and *sense of naturalness*. These senses describe different types of interaction between the participants in the meeting, and are assessed by the level of interaction, see Table 1. The assessment of the different senses is combined and visualised in a spider-graph. The assessment can be used to evaluate the interaction needs for a meeting or for assessing an existing collaborative technology.

By using the assessment with 5 senses of interaction it's clear that different types of creative methods have different types of interactions requirements. The visual method can also help the user to find out a suitable collaboration tool. The graphic nature of the method allows a rapid, intuitive match between techniques and technologies to be performed.

The 5 senses of interaction also provide a quick categorisation of the requirements when designing new collaboration tools. By examining existing collaborative technology some general conclusions can be made. It seems that they are generally low on *sense of presence* and *sense of space*. Further, the

tools poorly support the *sense of sharing* and *sense of time*, which are present in co-located meetings. None of the examined tools lacked support for highest level of *Sense of naturalness*, identifying an important area for future work. These findings can be used when designing the next generation of collaborative tools for creative meetings.

Acknowledgement

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