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Sketching and Contextual Input: Exploring Creativity in Design Groups

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SYNOPSIS:

This Master's thesis is about how sketching and contextual input combined can contribute to the process of creativity in idea generation groups. Studies of creativity in idea generation groups today, show that idea generation within a group comes at a cost of less novel ideas and negative social influences. Theoretically, using sketching as the primary interaction technique should help embrace the participants in the group and minimise the negative influences. Findings, however, show that is not the case. This study therefore revolves around three types of experimental idea generation sessions, which explore whether the influence of contextual input (context cues) can stimulate the participants' thinking pattern in the process of developing new ideas through sketching.

In this thesis we hypothesise that contextual input presented in the right form can: 1) support and stimulate both the individual and the group in the creative process, 2) support the group in thinking more innovative, 3) and support the group's access to a larger spectrum of knowledge. A method is introduced that allows us to measure the effect of context cues through each participant's linking behaviour. Out of the six sessions, two involved stimulation of concrete contextual input, two involved stimulation of abstract contextual input, and two were not stimulated. Variations in the individual designer's linking behaviour for these three approaches were compared. The results provide support for all of the three hypothesises.

Resume

Dette speciale tager udgangspunkt i de problemer, der opstår i den kreative proces i designgrupper. Problemer, som skyldes gruppens sociale struktur, det vil sige, den indflydelse som gruppens medlemmer gensidigt har på hinanden. Selvom der kan opstilles teori for en øget produktivitet i disse grupper, viser studier, at dette ikke er tilfældet. Vores undren er forankret i disse grupperelaterede problemer, og hvorvidt kreativiteten kan stimuleres i idegenereringsfasen ved hjælp af *sketching* og *kontekstuel input* i form af kontekstkort (også kaldet *context cues*).

Litteraturstudier omkring gruppers sammensætning, kreativitet i grupper, sketching og sketching i grupper har bidraget til de tre fremsatte hypoteser, som vi ønsker at besvare:

Præsenteret i den rette form kan kontekstuelt input:

- støtte og stimulere den enkelte person såvel som hele gruppen i den kreative proces,
- støtte gruppen i at tænke mere innovativt, og
- støtte gruppens adgang til et bredere spektrum af viden.

Besvarelsen af disse tre hypoteser tager udgangspunkt i et eksperiment bestående af seks brainsketching-møder. Af de seks møder bliver to stimuleret med konkrete kontekstuelle input, yderligere to møder bliver stimuleret af abstrakte kontekstuelle input, mens der ikke bliver tilført stimulering af nogen art til de resterende to møder. I alt 15 deltagere fordelt på tre grupper deltager i eksperimentet. Deltagerne er alle erfarende indenfor design såvel som idegenerering.

En metodisk behandling af resultaterne fra de seks afviklede møder danner grundlag for en kortlægning af hver enkelt deltagers *linking behaviour*. Med andre ord gør metoden (*linkography*) det muligt at sammenligne såvel den individuelle deltagers adfærd, såvel som gruppernes. Variationer i disse resultater giver anledning til en besvarelse af de tidligere nævnte hypoteser. Resultaterne viser, at alle tre hypoteser vedrørende inddragelse af kontekstuelt input bliver understøttet:

Context cues er med til at stimulere den kreative proces, hvilket ses gennem en 25 % højere linking behaviour. Denne adfærd indikerer, at kontekstuelt input stimulerer den individuelle såvel som hele gruppen i den kreative proces, hvorved den første hypotese understøttes.

Resultater viser endvidere, at idegenereringsmøder stimuleret af kontekstuelt input har en langt højere andel af nyskabende ideer set i forhold til møder uden stimulation, hvorved hypotese to understøttes. Møder med abstrakte kontekstuelle input har endvidere en mærkbart højere andel af tangentielle links i forhold til møder med konkrete kontekstuelle input. Derudover viser resultaterne en tendens til, at deltagerne generelt har et lavere antal *self-links* i relation til idegenerering under indflydelse af kontekstuelt input, hvorved hypotese tre også understøttes.

Preface

This Master's thesis is composed in the spring 2011 at Aalborg University, Information Systems (IS) by two postgraduate Informatics students.

The research, which is the foundation for this thesis, is inspired by publications about creativity from *The International Journal for Design*. On this basis, the thesis is elaborated as and formatted on requirements for Design Studies with the objective of later publication.

Design Studies
The International Journal for Design Research in Engineering, Architecture, Products and Systems
http://ees.elsevier.com/destud/

The article is accompanied by two appendices and a DVD which contain material from the entire thesis, including data from the research.

- The first appendix contains all the documentation for the conducted experiment, the analyses of the experiment, the link matrices and the results.
- The second appendix contains all the sketches and their descriptions.
- The DVD contains video recordings of the experiment.

We would like to thank our supervisor Jesper Kjeldskov for his guidance and feedback throughout this Master's thesis.

We hope you will enjoy reading this article as much as we enjoyed writing it!

Aalborg, June 2011

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Sketching and Contextual Input: Exploring Creativity in Design Groups

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This Master's thesis is about how sketching and contextual input combined can contribute to the process of creativity in idea generation groups. Studies of creativity in idea generation groups today, show that idea generation within a group comes at a cost of less novel ideas and negative social influences. Theoretically, using sketching as the primary interaction technique should help embrace the participants in the group and minimise the negative influences. Findings, however, show that is not the case. This study therefore revolves around three types of experimental idea generation sessions, which explore whether the influence of contextual input (context cues) can stimulate the participants' thinking pattern in the process of developing new ideas through sketching.

We hypothesise that contextual input presented in the right form can: 1) support and stimulate both the individual and the group in the creative process, 2) support the group in thinking more innovative, 3) and support the group's access to a larger spectrum of knowledge. A method is introduced that allows us to measure the effect of context cues through each participant's linking behaviour, i.e. how each participant relates to experience, ideas, and context, whether this being personal or presented by other participants, or through contextual input. The method includes a technique that considers sketching as the primary way of expressing ideas between each group member. Out of the six sessions, two involved stimulation of concrete contextual input, two involved stimulation of abstract contextual input, and two were not stimulated. Variations in the individual designer's linking behaviour for these three approaches were compared. The results provide support for all of the three hypothesises.

Keywords: context related design, creativity, design cognition, drawings, problem solving

Being innovative in early phases of conceptualising design can sometimes be challenging, therefore designers commonly apply different idea generation techniques, such as the brainstorming technique, as a means to stimulate divergent thinking in the pursuit of novel and good ideas. Furthermore, many of these techniques are used in a collaborative process, where designers rely on each other. Even though working collaboratively does have its advantages studies have shown that there are some social implications connected to it, which may affect the process thus leading to a lesser outcome of creative ideas (O'Neill and Warr, 2005). This suggests that the result does not simply rely on creativity but also on factors such as how designers relate to each other, i.e. how ideas, experiences, and knowledge are propagated between designers. Natural language is an example of how designers can interact, but as this is a descriptive system which communicates information extrinsic, i.e. something described by a word is solely associated with information by means of external definition, it has some

communicative limitations. Sketching, however, contributes the ability to facilitate the transition of general descriptive knowledge into more specific depictions, therefore helping the designers in propagating their ideas to others, e.g. a sketch of a telephone may contain the quality of the object in form and colour. (Fish and Scrivener, 1990)

Context (e.g. settings, people, activities, artefacts, technologies, and time) is also of interest. Earlier work suggests that including context in the idea generation process generates new insight, insight that contributes to a better and more complete understanding of the problem area (Boennerup et al., 2011). On this basis contextual knowledge may facilitate the designers' understanding for the possible interplay between context and user behaviour.

This study, therefore, explores how to incorporate context in the idea generation process through sketching, thereby facilitating and stimulating the participants into generating ideas.

In this paper, the main objective is to explore whether the influence of *context cues* can stimulate the idea generation process in a design group. If this is the case, understanding and utilizing this influence may diminish some of the problems related to working in *real groups*. Therefore, we will address these problems, and in which degree sketching and contextual input may affect them. To examine the influence of context cues in design groups, a technique is introduced, which considers sketching as the primary interaction technique for the designers to express their ideas to co-designers. Then we will explain the research method used, called *linkography*. Our perspective here will be on the process, i.e. we are focusing on the quality of the different connections, rather than the quality of the developed ideas themselves. Next, we will look into the results of an experimental study, which consists of six idea generation sessions in which context cues are applied on four of them. Finally, we will address some of the limitations discovered in this research project. Furthermore, we will look into suggestions for future research and for further introduction of context cues in idea generation techniques.

1 Related work

1.1 Nominal and real groups

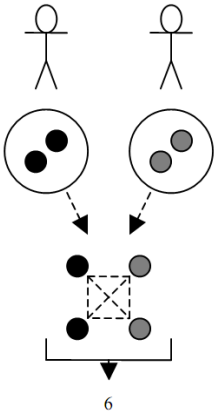

Figure 1 - Creative ideas produced by a real group (O'Neill and Warr, 2005)

Design as a social activity endures some problems such as social influences on creativity in design groups. A design group can organise their work, so they either proceed as what is called *nominal* or *real groups*. In a nominal group two or more individuals work independently on creative problem solving, where in real groups they all work together on the problem. (O'Neill and Warr, 2005)

In theory, one of the major advantages that real groups offer over nominal groups is their shared resources as each individual possess a unique domain of knowledge. Within this domain, each individual has a collection of thoughts which they can access, i.e. in real groups each member has the opportunity

to interact with each other, externalising their thoughts and thereby giving other group members the possibility to access and use them. As figure 1 show, two members with two thoughts each, can combine these thoughts through interaction in several ways, and produce new ideas. In this case six ideas are produced. In nominal groups, as figure 2 shows, the opportunity for accessing each other's thoughts through interaction is non-existing, thereby leaving the group with only two ideas. (O'Neill et al., 1999) (O'Neill, 2000)

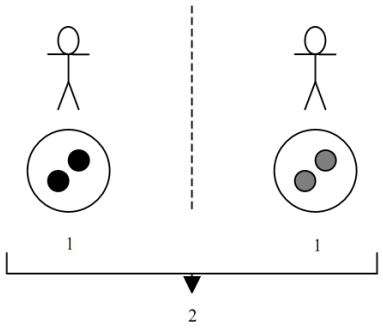

Figure 2 - Creative ideas produced by a nominal group (O'Neill and Warr, 2005)

In reality social influences have a negative effect on creativity in real groups. This negative effect has been explored thoroughly in relation to creativity in design groups, and three major explanations have been found: production blocking, evaluation apprehension, and free riding. (O'Neill and Warr, 2005)

Production blocking is a problem experienced frequently, especially when ideas are expressed verbally in groups. Essentially, the problem arises in the interaction form itself because verbal dialogue is asynchronous, i.e. only one person can express his or her ideas at one given time, thereby simultaneously prohibiting other group members in expressing their ideas. The consequences may be that group members forget or suppress their ideas due to the feeling that their ideas are less relevant as the session evolves. Another problem is that group members may rehearse their ideas internally, with a goal of making a better presentation, preventing them from focusing on what is currently going on in the group.

A known brainstorm rule defined by Osborn (1957) is '*the deferment of judgment*', i.e. any idea is welcome in the idea generation session no matter how crazy it is. However, fear of criticism is still an issue and this may prevent the group members from expressing themselves and sharing their ideas, i.e. externalising their thought for each other. Evaluation apprehension, therefore, has a negative effect on the group as it reduces the quantity of ideas produced, and furthermore has a detrimental effect on creativity itself. (O'Neill and Warr, 2005)

Free riding, commonly known as social loafing, is the result of members within the group becoming lazy, and thereby relying on other members' work or in this case creativity and ideas.

To diminish some of these problems when working in real groups, researchers have to move towards using more synchronous interaction techniques, thereby allowing designers to express their ideas simultaneously, such as writing or sketching ideas and distributing them between the group members. However, by changing the technique of how ideas are externalised, the possible effect of production blocking and the variable of evaluation apprehension also changes. (O'Neill and Warr, 2005)

1.2 Sketching as interaction technique

In a design phase, sketches can serve the designers in understanding their own ideas better. Sketches are incomplete drawings and can be interpreted in a lot of different ways. Goel (1995) referrers to this as *ambiguity* or *indeterminacy*, this gives the designers the opportunity to re-interpret their idea again and again, and thereby enhancing their understanding. According to Purcell and Gero (1998), this interaction between designer and sketch is very important to the creative process.

Van der Lugt (2005) emphasises, in his work that sketching can affect the idea generation process in a design group, that brainsketching can contribute to a better individual idea generation process by providing new directions for idea generation, and that sketches can provide a more integrated group process by providing better access to earlier ideas. Especially, the access to earlier ideas supports that a more synchronous interaction within groups are beneficial. However, his work also shows that sketching does not support creativity by inviting re-interpreting of each other's sketches in the design group. This result is in line with Neumann et al. (2009), which examine the effect of individuals sketching together, i.e. when individuals sketch together on an idea, it provides a common ground within a design group. The focus area is on what effect this technique will have on productivity and creativity. The result shows that idea generation within a group comes at a cost of productivity losses and lesser creative ideas.

1.2.1 The disregard and detach effect

We are puzzled by these findings which indicate a lack of re-interpretation of each other's sketches in the idea generation process, especially when sketching supports richer descriptive information, and channels creativity through ambiguity, which should lead to a more novel outcome. Furthermore, sketching should minimise the production blocking effect by being a more synchronous interaction form. On this basis, we believe that a fourth factor exists, a factor which suppresses the creativity in design groups. This claim of a fourth factor is supported by earlier findings described by Boennerup et al. (2011), which suggest that individual group members in a design phase found it difficult to disregard and detach themselves from ideas currently in focus within the group. Results show that many of the ideas generated by the group had a lot of similarities, and thereby not being that creative. (pp. 66-68) Furthermore, this result is consolidated by the work of Linsey and Becker (2011) who studied the effectiveness of the brainwriting technique in relation to both real and nominal groups. Their result, however, shows that under the right conditions real groups may outperform nominal groups.

We believe that production blocking, evaluation apprehension, and free riding are effects that need to be considered within design group, but also the disregard and detach effect needs to be addressed. We find it particularly interesting to examine what initiative can be made to stimulate the creative process in design groups working on idea generation through sketching, thereby unlocking the potential of sketching, and securing the conditions for better outcome, i.e. more and novel ideas.

1.3 The effect of contextual input

As Schmidt (2000) mentions, context is used in many different ways, and relies on our individual experience and perception as human beings. In a

design phase the knowledge about the context must therefore be characterised as very important as each unique design must adapt to a specific context. With that in mind we believe that it is necessary to stimulate the creative process by facilitating contextual input in groups as we theorise that the disregard and detach effect diminishes the individual participant's ability to relate to both personal and interpersonal experience, i.e. the context.

To summarise the literature findings, we hypothesise the following potential effects of context cues in idea generation sessions:

Context cues

- Support and stimulate both the individual and the group in the creative process.
- Support the group in thinking more innovative.
- Support the group's access to a larger spectrum of knowledge.

2 Research method

2.1 Brainsketching

Three variants of a technique called brainsketching were used as representatives of idea generation technique that use sketching.

Brainsketching is a visual variant of the better known brainwriting technique (Van der Lugt, 2002) which is also a non-verbal variant of brainstorming. While in brainwriting you write down your ideas on papers, brainsketching makes use of sketching. Sketching is used to come up with a broad and large amount of quantitative ideas. During the brainsketching process, as described by Van Gundy (1988), participants sketch their ideas individually in short rounds which last around five to six minutes. After each round they switch papers and use the ideas present on the worksheets as a source of inspiration for the next round. This procedure is usually repeated about five times (Neumann et al., 2009). In his work, about how sketching can affect the idea generation process in design group meetings, Van der Lugt added an extra detail to the brainsketching technique. Unlike the brainsketching described by Van Gundy, a short verbal exchange takes place during the switch of group members' sketches where members in turn briefly explain their sketched ideas in Van der Lugt's variant of brainsketching. The reason behind the explanation of the ideas is to promote the group members to use each other's ideas. Participants are encouraged to first check already sketched ideas on the worksheet carefully before they begin to generate ideas, and by sharing their ideas briefly it is expected that the understanding of other's ideas are strengthened, creating a greater chance in using them as an inspiration and build on them.

Even though the results of Van der Lugt's research, show that the addition of the brief explanation did cause more building on each other's ideas, most of the sketched ideas were either modifications or supplementary of the source of inspiration. This led us to make another variant of brainsketching, where we kept the brief sharing of ideas between the rounds, and added contextual input via context cues in order to increase the linking behaviour in the group, i.e. stimulating the participants in accessing new perspectives in their creative process of developing ideas.

2.1.1 Context cues

A context cue is a way of reminding or stimulating people of concrete or abstract knowledge, e.g. settings, people, activities, artefacts, technologies, and time. In this particular case, the context cue is developed as a large card with picture and text, i.e. *context card*.

2.1.2 Brainsketching with context cues

Brainsketching with context cues is a slight variation on the brainsketching techniques used by Van der Lugt (2005). It is basically structured as the brainsketching described previously, the difference being in relation to this technique is context cards with various contextual inputs will be used as the main goal to stimulate the idea generation process further. By continually giving the participants context related input, it is expected, with the basis of the input they come up with more and novel ideas. For this brainsketching technique we distinguish between abstract and concrete context cues. It is used either with concrete or abstract context cards only, and not mixed in this experiment.

For brainsketching with concrete context cues, the experiment proceeds as follows: Participants sketch ideas individually in short rounds of six minutes. After each round they briefly share their ideas, and hand the worksheet to the person on their left side. Before the beginning of each round excluding the first, the group will be given a concrete context card. In the next round, they can use the context card and the ideas already present on the worksheet as a source of inspiration. This procedure is repeated five times where four context cards are included. The brainsketching with abstract context cues follows the same procedure with the exception that abstract contextual input is used. All context cards were carefully selected so they did not act as limiting or closing off the participants' idea generation, but on the contrary would contribute to increase the idea generation in various ways. The concrete context cues were technology oriented. Examples of concrete context cards are *augmented reality* and *motions sensor*. The abstract context cues, on the other hand, were not centred on anything specific, but covered a wide field, it be *the family*, *stressful situations*, *the weather*, or *the environment*. In order to check the feasibility for our variant of brainsketching and see if something should be improved, a pilot study for brainsketching with concrete context cues was conducted before the main research started.

2.2 Procedure

To this research project, six experimental sessions were conducted in order to explore the influences of contextual input on the outcome of group idea generation. Brainsketching, brainsketching with concrete context cues, and brainsketching with abstract context cues were each applied on two experimental sessions with two different cases.

	Brainsketching	Brainsketching with concrete context cues	Brainsketching with abstract context cues
Case 1	Group1	Group2	Group3
Case 2	Group3	Group1	Group2

Table 1 - The experiment setup

A within-subject design tested with a between-case design was used, i.e. each idea generation technique was applied to two different groups of participants. There were a total of three groups, and each group consisted of five participants. Each group participated in two sessions with two different brainsketching techniques. This meant that the first group would participate in a ordinary brainsketching session (G1-C1) and a session with brainsketching with concrete context cues (G1-C2); the second group would participate both in a brainsketching with concrete context cues (G2-C1) and brainsketching with abstract context cues (G2-C2), while the third group would participate in a brainsketching with abstract context cues (G3-C1) and ordinary brainsketching (G3-C2) in that order. Since the brainsketching techniques are similar in their process, and since the participants would be involved twice in this main research, the brainsketching techniques were performed on two different cases. This was done to avoid influencing the second brainsketching session by the prior session.

Each session was moderated by a facilitator, and observations were noted by a logger. To avoid influence if done by different persons, the roles of the facilitator and the logger were maintained by the same two persons in all six sessions.

2.3 Participants

The 15 participants (1 female, 14 males; mean age = 25.9, SD = 2.1) were HCI (Human-Computer Interaction) postgraduate students on their final year from the Computer Science department of Aalborg University. Approximately a week before the start of the experiment, a questionnaire was sent out to the participants. The questionnaire contained questions on a 5-point Likert scale about their sketching skills, how they work, and their personality. The three groups were then created based on their answers from the questionnaires, and how well the participants knew each other with the purpose to create three groups as homogenous as possible. Figure 3 shows the homogeneity for the three groups. According to O'Neill and Warr (2005), real groups have the theoretical potential to outperform nominal groups[1] in producing creative

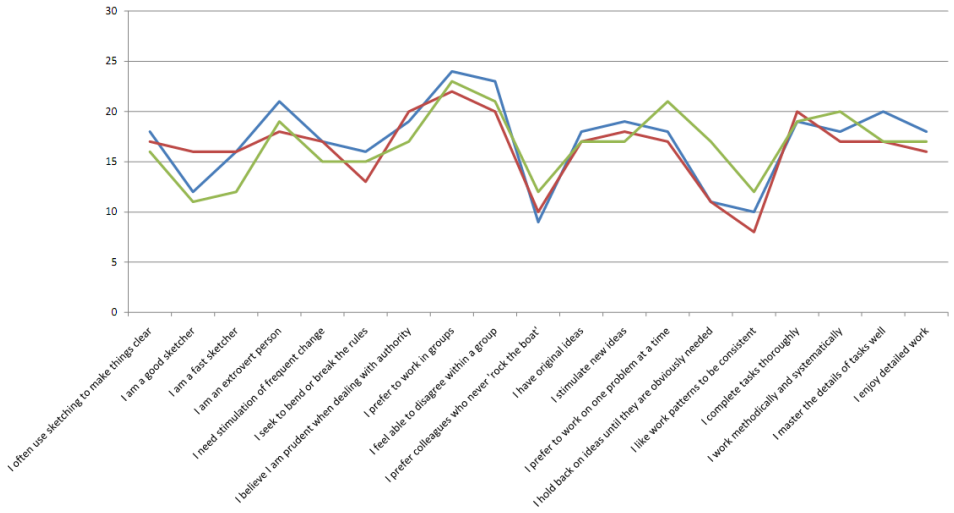

Figure 3 - Group homogeneity

[1] Individuals working on their own and then collating their outputs to form a cumulative output are defined as a nominal group (O'Neill and Warr, 2005).

ideas, but social influences impede the creativity. By placing the participants in groups with people they are familiar with, we sought homogeneity to avoid the negative influences as evaluation apprehension.

2.4 The two cases

Two different cases were used since the participants would take part in the experiment twice. As the processes of the brainsketching techniques are quite similar there was a chance the experience and the ideas produced from the first session would impact the second session (where another brainsketching technique was applied) if the cases were the same or far too alike. That is why we found it necessary to employ two cases which differed from each other, but at the same time were relatable to the participants so they would not have issues acquainting themselves into the problem statement of the case. On a similar note the cases should be some kind of relevant and interesting. The two cases were:

- How to make travelling by car fun for children
- The future mobile phone

The first case the participants got was about how you could make it more entertaining for children to travel in cars since they tend to get bored quickly. The task for the participants was to generate ideas which dealt with this problem, including how to interact with the car in a new way, based on the car having a flexible interior making it suitable for having various functionalities. In the second case, the participants were asked to come up with ideas for tomorrow's mobile phone, including how it could be interacted through innovative and different ways in relation to various activities. Where the previous case was about children, the target group of this case was young people and adults.

3 Linkography

For understanding how participants work with ideas among themselves in idea generation groups and how they relate to each other, it is necessary to find a method that allows us to measure and understand this linking behaviour.

Despite great interest in research of creativity thinking, not many of the existing research methods take a process perspective in use to access the effectiveness of the idea generation techniques. They rather see the design process as a '*rational decision making or reasoning process*' (Van der Lugt, 2001, p. 60). There is a need for an approach that does not rely on regarding designing as a rational decision making process, but takes into account the association processes which occur while group members generate ideas. Goldschmidt's (1996) linkography is such one. Linkography was introduced to evaluate a designer's cognitive activities by detecting links between design moves in a design process. According to Goldschmidt, a design move is *'...a step, an act, an operation, which transforms the design situation relative to the state in which it was prior to that move' (p. 72).* Linkography is not interested in the quality of the outcome, but by analysing the linking among the moves it purports to: *'...be instrumental in comprehending structural patterns of design reasoning' (p. 72).*

The linkography method was adapted by Van der Lugt (2001) for his research. Instead of investigating the linking among design moves, design ideas were identified in order to make it possible to address the building on each other's ideas, as it is impractical to identify moves during divergent phases since it is impossible to speak of *'a relative state of the design (problem solving) situation'*. (p. 64) Furthermore, he adds different types of link categories to the linkography so that a possible transformation taking place between different ideas can be examined.

As this research project tries to explore whether the influence of context cues can stimulate the participants in coming up with additional and more novel ideas, it makes it relevant to apply the linkography method which addresses building on input by connecting them. Our analysis is based on Van der Lugt's variant of linkography, which we have adjusted a bit in order to make it applicable to our brainsketching sessions with context cues.

The process of identifying ideas and the links between them are determined by evidence, which is found by evaluating sketches, video recordings, and log-files. Evidence on how ideas relate to each other can be found through similarities between ideas, or in the context the idea is originated from. Evidence can also be found in how the individual designer interacts with other designers or his sketches itself, this through gestures, dialogue, or even symbols.

The main research resulted in six sessions: two brainsketching, two brainsketching with concrete context cues, and two brainsketching with abstract context cues. The links for each session were determined after which the divergences between the link systems were re-evaluated, which provided the final link system. For verification purposes, the process of determining the links were done by two persons individually, the final link system was done together though. Cohen's Kappa was used to determine the inter-rater agreement. The results indicate that there are substantial levels of agreements between the link systems produced by the two raters:

- Brainsketching: K = 0.752
- Brainsketching with concrete context cues: K = 0.769
- Brainsketching with abstract context cues: K = 0.776

3.1 Constructing the link matrices

The data used in constructing the matrices consisted of evidence collected from the video recordings of the six idea generation sessions, and the sketches made during these sessions. For each session, determined ideas were listed into a protocol with a brief description including the related sketches. The found ideas were then put into a matrix display. In scoring the links, Goldschmidt's method by determining the backlinks was followed. Backlinks are links that a specific idea has with each of the previously generated ideas. In the matrix, backlinks are marked in the column above the idea. Forelinks on the other hand signify the specific ideas impact on idea generation to come and are marked in the row next to the idea. (Van der Lugt, 2000) As we bring contextual input into play through context cards, we have adapted the linkography by adding an extra row before the beginning of each round except the first. These rows are reserved for the context cards used in the session.

In the sample from a link matrix on figure 4, idea 5 has four forelinks (with ideas 8, 9, 10, and 12) and no backlinks. Idea 12 has no forelinks but two backlinks (with idea 5 and the context card *motion sensor*).

Since the brainsketching process happens over rounds the participants will in each round individually generate ideas in parallel, which means most likely there will not be any direct links between the participants' ideas within the same round. Those rounds are marked as white in the link matrix.

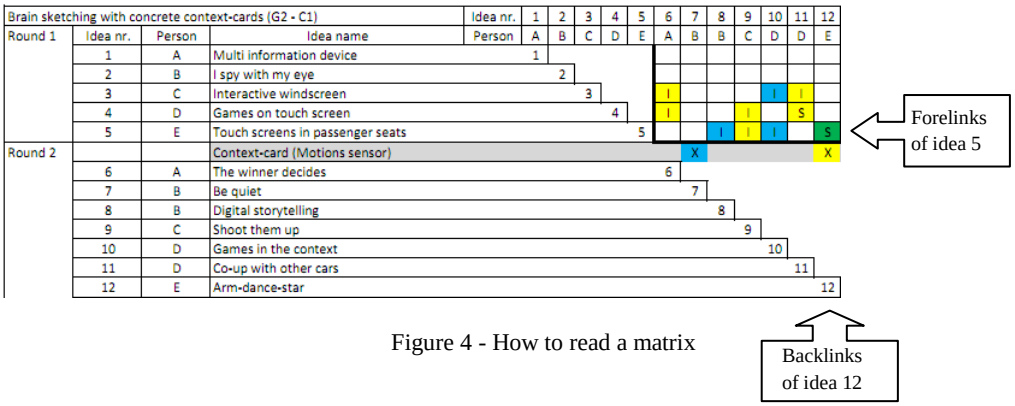

Figure 4 - How to read a matrix

3.1.1 Link density

Determining the links between ideas is not enough though. To be able to compare the link matrices, a more relative measurement is needed. Link density is an indicator for the degree of interconnectedness of the ideas, and can be determined within a link system. It divides the total number of links with the total number of ideas generated. (Van der Lugt, 2000)

LD = [Number of links] / [Number of ideas]

If the link density is high it indicates that the ideas have many connections with earlier ideas which means the participants have been building on earlier ideas.

3.1.2 Types of links

Furthermore the types of links made are also of interest. In order to see the possible transformation between two or more ideas we categorise the links in types. We make use of following three link categories (Van der Lugt, 2000):

Supplementary: Changes which are small and auxiliary. The relationship between ideas is based on minor improvements on the same general idea.

Modification: The existing line of thought is kept, but structural changes in the idea are provided for a modification link.

Tangential: The tangential links are based on the free association and indicate the big leaps between ideas.

We made another change to the linkography by giving these three link categories different colours which should make it visually easier to read the link matrices. Supplementary links are marked yellow, modifications are marked blue, and tangential links are green in the link matrices.

The way we decided whether a link was supplementary, modification, or tangential were based on common sense and assessment. For instance within

the sample of link matrix over brainsketching with concrete context cues, the link between idea 3 (Co-up with other cars) and idea 11 (Interactive windscreen) is supplementary, which it is because idea 11 builds on the idea about kids playing in cars, by adding the opportunity to let them play against kids from other cars as well. There is a modification link between idea 5 (Touch screens in passenger seats) and idea 10 (Games in the context). The latter idea builds on the use of the context, and provides a game which makes use of the surroundings of the place they are currently driving past. The link between idea 5 (Touch screens in passenger seats) and idea 12 (Arm-dance-star) is tangential, where the sketch for idea 5 of a person interacting with a touch screen inspired the participant to come up with idea 12.

Regarding the types of links between ideas and context cues, the categorisation was also based on common sense. We mainly looked at how far or how close the idea was to the given contextual input. For instance in the sample there is a supplementary link between idea 12 and the context card Motions sensor because some kind of motions sensor technique have to be used in the solution sketched.

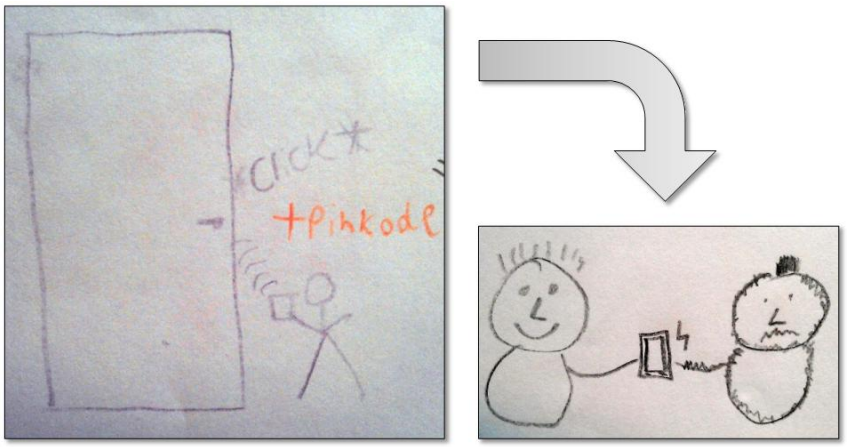

Figure 5 - Example of link between two sketches

Figure 5 shows two sketches (G3-C2: idea 11 and 28). There is a modification link between these two sketches about how you can protect your phone with simple security. The first sketch shows a person using his phone as a key to (un)lock a door. To avoid misuse of this function if the phone gets stolen or lost, a pin code has to be typed. The other sketch takes the security element further and comes up with another way to secure ones phone by giving an unauthorised person an electric shock.

We constructed a link matrix for each of the six experimental sessions. One of the link matrices for the brainsketching sessions with context cues is presented in figure 6. The links in the matrix are coloured according to their link-type, e.g. a supplementary link is yellow. All the links are furthermore marked X, I or S. X indicates that it is a link back to a context cue. S stands for self-link, and indicates that a participant built on his own idea, whereas I referrers to interpersonal link, which indicates that a participant built further on another participant's idea.

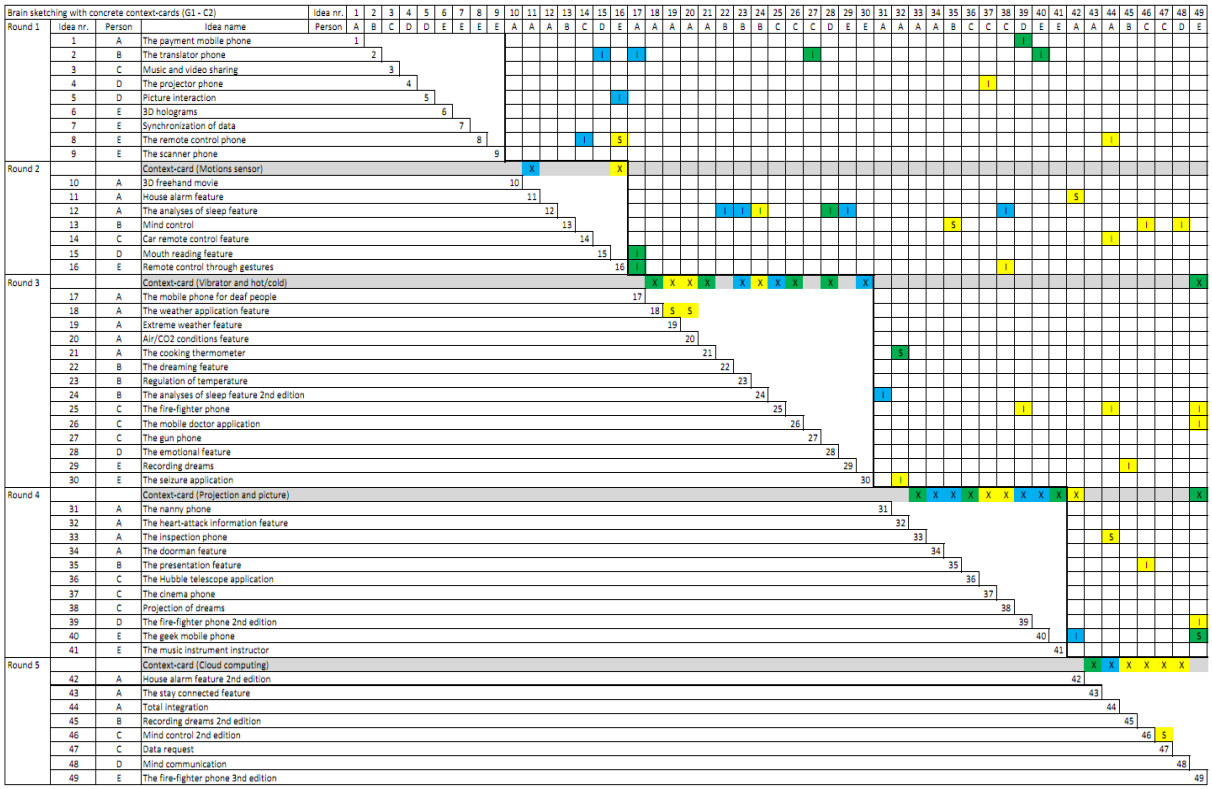

Figure 6 - Matrix for brainsketching with context cues

4 Results

The results are based on the divergences in the link density in the different brainsketching sessions. By investigating these results we can get an understanding on how the context cues have influenced on the idea generation sessions. Table 2 shows the results of each of the six sessions, and how they relate to each other.

The first pattern that is noticeable in table 2 is that the general link density is about 25% higher for all the brainsketching sessions involving context cues. For validating this result, we will look at the results (see table 3) that Van der Lugt reached in his work from 2001. Here we compare the results of the two newly conducted brainsketching sessions (G1-C1, G3-C2) with the four brainsketching sessions conducted by Van der Lugt. The link densities for the four original sessions are x = 1.17, x = 1.25, x = 1.12, and x = 1.54 with a SD = 0.35. The link densities for the two new brainsketching sessions are x = 1.18 and x = 1.16, thereby matching the mean of x = 1.27 for the four old brainsketching sessions. We therefore suggest that it is possible to compare the new result with the old ones on a general basis.

By comparing the designer's individual link density in the four original idea generation sessions to the four newly conducted sessions under influence of context cues (G1-C2, G2-C1, G2-C2, and G3-C1), we see the same pattern of 25% higher link density.

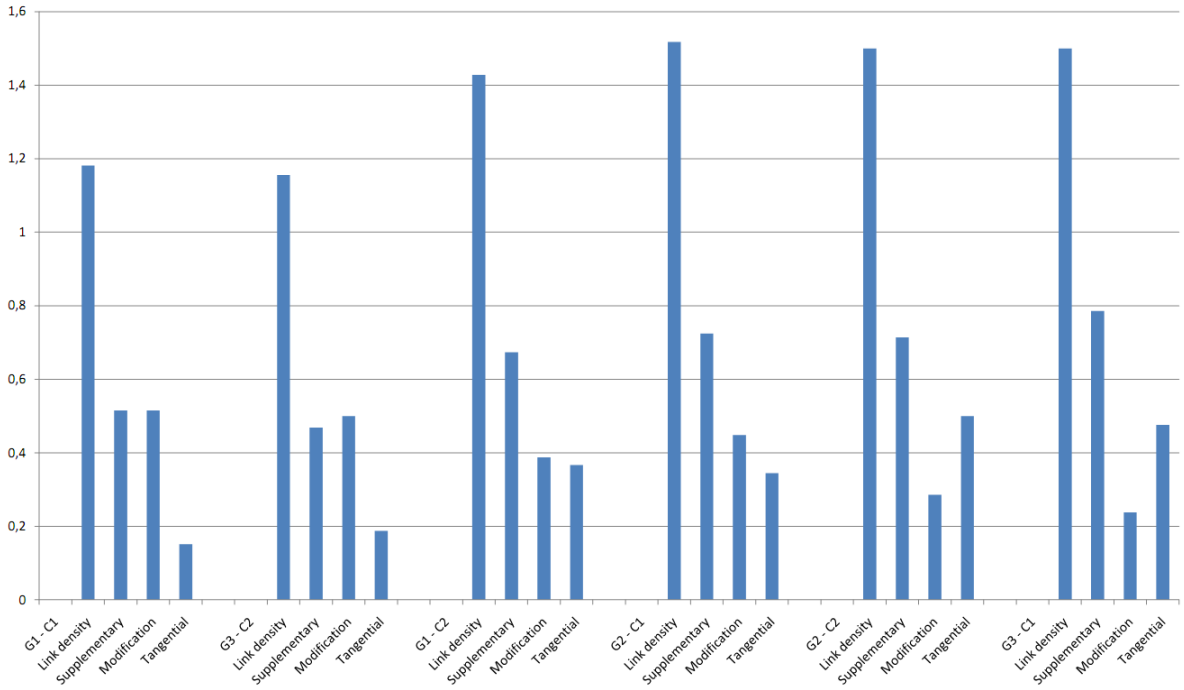

Table 2 - Link density for the six sessions

The result shows that the designers have significantly ($p < 0.05$) more connections with ideas when under the influence of context cues. The mean link density for the four original brainsketching sessions is $x = 1.27$, $SD = 0.35$; and the link density for the four new sessions under the influence of context cues is $x = 1.50$, $SD = 0.36$. This suggests that each group member is stimulated in the process of creativity, by the fact, that more connections are drawn between each idea, i.e. each group member relates more to the available data in each session whether this being ideas or contextual input.

Old sessions

1 session	Brainsketching					
	Total ideas	51	Links	59	L.D.	1,17
2 session	Brainsketching					
	Total ideas	51	Links	64	L.D.	1,25
3 session	Brainsketching					
	Total ideas	48	Links	54	L.D.	1,12
4 session	Brainsketching					
	Total ideas	42	Links	65	L.D.	1,54

New sessions

G1-C1	Brainsketching					
	Total ideas	33	Links	39	L.D.	1,18
G3-C2	Brainsketching					
	Total ideas	32	Links	37	L.D.	1,16

Table 3 - Old sessions vs. new sessions

The second pattern that is noticeable in table 2 is how the link densities for the three types of link indices evolve from ordinary brainsketching, to brainsketching under the influence of concrete contextual input, and to brainsketching under the influence of abstract contextual input. As table 4 indicate, the mean for the tangential link density in the three types of brainsketching evolves from x = 0.17, SD = 0.03 for ordinary brainsketching, x = 0.36, SD = 0.02 for brainsketching under the influence of concrete contextual input, to x = 0.49, SD = 0.02 for brainsketching under the influence of abstract contextual input. This development in the density for the tangential links signifies that the number of novel ideas generated by different designers increases, but it also signifies that the cost of these more novel ideas, is a higher number of supplementary links as the density for this index also increases.

G1 - C1	Brainsketching						
Link density	Total ideas	33	Links	39	L.D.	1,18	SD 0,018
Supplementary				17	L.D.	0,52	SD 0,033
Modification				17	L.D.	0,52	SD 0,011
Tangential				5	L.D.	0,15	SD 0,025
G3 - C2	Brainsketching						
Link density	Total ideas	32	Links	37	L.D.	1,16	SD 0,018
Supplementary				15	L.D.	0,47	SD 0,033
Modification				16	L.D.	0,50	SD 0,011
Tangential				6	L.D.	0,19	SD 0,025
G1 - C2	Concrete context cues						
Link density	Total ideas	49	Links	70	L.D.	1,43	SD 0,063
Supplementary				33	L.D.	0,67	SD 0,036
Modification				19	L.D.	0,39	SD 0,043
Tangential				18	L.D.	0,37	SD 0,016
G2 - C1	Concrete context cues						
Link density	Total ideas	29	Links	44	L.D.	1,52	SD 0,063
Supplementary				21	L.D.	0,72	SD 0,036
Modification				13	L.D.	0,45	SD 0,043
Tangential				10	L.D.	0,34	SD 0,016
G2 - C2	Abstract context cues						
Link density	Total ideas	28	Links	42	L.D.	1,50	SD 0,000
Supplementary				20	L.D.	0,71	SD 0,051
Modification				8	L.D.	0,29	SD 0,034
Tangential				14	L.D.	0,50	SD 0,017
G3 - C1	Abstract context cues						
Link density	Total ideas	42	Links	63	L.D.	1,50	SD 0,000
Supplementary				33	L.D.	0,79	SD 0,051
Modification				10	L.D.	0,24	SD 0,034
Tangential				20	L.D.	0,48	SD 0,017

Table 4 - General link density for the six new brainsketching sessions

Furthermore, both of these patterns give an indication of how the design groups utilize the broader spectrum of knowledge that they are being exposed to, i.e. through brainsketching with concrete and abstract context cues. What is more, is that this result is consolidated by how the links are divided between self-links and interpersonal links in each brainsketching session. The results show that the six ordinary brainsketching sessions (the four old and the two new) have a much higher concentration of self-links (mean x = 28.3%, SD = 7.31) than the four sessions involving context cues (mean x = 19.4%, SD = 6.12), which indicates that participants in these sessions have a higher number of links to other participants or the involved context cues, i.e. each participant is relating to a broader spectrum of knowledge.

5 Discussion

5.1 The influence of contextual input

An interesting finding during this research project is that participants are more innovative in the idea generation process when using brainsketching with context cues. For brainsketching under influence of concrete contextual input, both the supplementary and the tangential link-type indices are noticeably higher than for ordinary brainsketching. The same applies for brainsketching under influence of abstract contextual input. Furthermore, the interesting part is the modification link-type indices for sessions including abstract context cues are extremely low compared to the ordinary brainsketching sessions and the sessions with concrete context cues. This indicates that it does make a difference whether you use concrete or abstract contextual input. The results suggest that by including context cues in the idea generation process, participants provide a higher number of supplementary and tangential links than when using ordinary brainsketching. This indicates that the contextual input contributes to a better outcome in the form of more novel ideas, but also leads to a lot of noise in the form of supplementary links, i.e. the outcome of similar ideas increases.

5.2 The problems with real groups

In relation to the conducted experiment and the problems that idea generations endure when used in real groups, i.e. production blocking, evaluation apprehension, free riding, and the disregard and detach effect, we can state that the conducted experiment theoretically should indicate a reduction in the effect regarding production blocking and evaluation apprehension as the experiment combines asynchronous and synchronous interaction, i.e. dialog and sketching. This should give the participants the opportunity to communicate their thoughts in the moment and without fear of judgment from other group members. Unfortunately, this experiment as a standalone is not sufficient for supporting this hypothesis. When we look at the problems regarding free riding there is no theoretical support for a reduction of free riding in this study, nor is there any indication of improvement or impairment in the conducted experiment. Regarding the disregard and detach effect, we believe that there is evidence that signifies improvement. By breaking the work pattern in the design groups by systematically introducing contextual input for the participants, it is possible to overcome some of the problems with participants being locked by each other’s ideas, thereby securing a better outcome.

5.3 Using contextual input in a design method

In a design method developed by Jesper Kjeldskov, described by Boennerup et al. (2011), which explains how a context centred design process can be structured in four phases (investigative, explorative, explanatory, and persuasive), an interesting perspective would be whether the context cues would be beneficial for the process since the model also is centred on the use of sketching. As the context cues have been proven to stimulate creativity in groups as well as individually, it would be reasonable to believe that the context cues would have a positive effect when included in the model. Especially, since it is necessary for the participants to be mindful of the context, e.g. settings, people, activities, artefacts, technologies, and time throughout the four phases of the model.

The investigative phase is tightly connected with earlier stages in a design process where it is necessary to examine the problem space, and be aware of the context. The second phase, explorative, is about making design proposals while still being aware of the context, and evaluating them on the basis of the results from the investigative phase. This would suggest that the context cues not alone would be beneficial for the investigative phase but the explorative as well, and as the design method is about developing the right design early in the process, one perspective that would be worth exploring could be the contribution of both abstract and concrete context cues to the method; with the contribution of abstract input in relation to the first phase, and concrete input in relation to the second phase, thereby developing ideas through both abstract and concrete context cues.

As the model is based on the idea, that it is crucial to come up with the right idea early in the design process, it is important to stimulate creative thinking from the beginning. Since our results show that involving abstract context cues leads to a potential larger amount of novel ideas, including it in the investigative phase seems reasonable as it is in this phase one has to get good and novel ideas. Contributing concrete context cues in the explorative phase is due to the fact, that one here already has a hold of the problem statement, but needs to come up with possible solutions. In this case it is not vital coming up with new novel ideas but more supplementary. Involving, e.g. technology in the form of concrete context cues may help the designers in thinking more specific and edging closer to the final result.

5.4 Applying context cues on brainstorming

Since context cues have a positive effect on the outcome and novelty of ideas generated in design groups, a different approach could be to apply context cues on other idea generation techniques such as brainstorming. Would it be as efficient as in brainsketching and help reducing the blocking factors which have been characterising real groups during the idea generation process? If we take brainstorming, one will not have to deal with the issues related to their sketching skills even though they will only be able to support their ideas verbally. On the other hand this means it can be difficult for others to understand the idea in full, since the idea is communicated extrinsic, and thereby is externally defined.

We believe there is a large chance that adapting contextual input to brainstorming will stimulate the participants in coming up with more and different ideas, giving the fact that the new input will stimulate the participants

in relating to a broader perspective of knowledge. Another possible advantage compared to brainsketching sessions where participants can be reluctant in ruining sketches with their own lines, is that the participants may be more prone to add additions to existing ideas since it is conducted verbally.

Regarding sketches, a disadvantage of brainsketching with context cues is that the participants have to wait for certain sketches before they can add or redesign the idea. If using brainstorming with context cues the participants will have access to the ideas throughout the session since they are written on the whiteboard, but the synchronous interaction is gone. The asynchronous interaction combined with contextual input can potentially lead to the previously mentioned problems, e.g. production blocking, since the participants have to wait for their interaction turn.

6 Conclusion

To answer the first hypothesis, which suggests that context cues presented in the right form can support and stimulate both the individual and the group in the creative process, the answer is yes. By involving both concrete and abstract cues in the form of text and pictures, it is possible to stimulate the participants in the group to obtain a higher linking behaviour in the process, which indicates improvement in creativity. This suggests that each participant relates more to the data presented in the current idea generation session, whatever the data is presented by other members or in the form of contextual input.

Furthermore, the second hypothesis is supported by the results which suggest that context cues can stimulate the group in a way so the ideas generated are more innovative, especially abstract contextual input can stimulate the participants in coming up with more novel ideas. Thereby, the group also welcomes and exploits the larger spectrum of knowledge added to the idea generation process. This finding is consolidated by the fact that participants involved in sessions with contextual input have a lower self-link behaviour, by which the third hypothesis of context cues is also supported.

7 Final remarks

7.1 Evaluation of link-type index

When looking closer at the new and the old results from 2001, regarding the three link-type indices, we have refrained from comparing the results at this level, due to the fact that the frame of reference is not comparable, this is indicated by the difference in the overall tangential link-type index (New = 0.17, SD = 0.03) and (Old x = 0.32, SD = 0.15). These results signify that the frame of reference regarding the new results have been more demanding in the sense of novelty. However, we still believe that a general comparison is possible, since the implementation and execution of the two experiments remain the same.

7.2 External memory

During the brainsketching with context cues sessions the participants mainly built on existing ideas from the previous round. They were more inclined to

get inspired or build on ideas from the last round. This can be explained by a model introduced by Van der Lugt, about external memory available to group members. Here he distinguishes between individual and shared external memory, which are divided into remote and direct, respectively, where the latter are notations which are available to the group members. Results suggest that the participants remember the latest shared ideas and thoughts the most, which is in line with findings by Van der Lugt (2005).

7.3 Getting the right context cues

After having tried both the brainsketching techniques including abstract and concrete context cues, some of the participants indicated that they found the concrete context cards restricting compared to the abstract context cards. This can be due to the natural distinction between something being abstract or concrete, where abstract context cards can be interpreted in more than a number of ways. Therefore, it is essential to consider what kind of context cards you contribute to the idea generation process. You have to carefully select the text and the matching picture. There is a chance the matching pictures can be limiting the creative thinking depending on whether the visual part of the context card is good or bad. An alternative is to have more than one picture on a context card, which the participants will not have to rely too much on one specific picture.

In the experiment, some of the context cues were already brought up by the participants before they got introduced to the group. To avoid a scenario where you give participants a context cue they already have touched earlier in the process it will be practical to have more than one context cue in reserve.

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