CREATIVE PROCESSES IN GROUPS – RELATING COMMUNICATION, COGNITIVE PROCESSES AND SOLUTION IDEAS

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Abstract: In technical product development group creativity sessions are performed to develop new and unobvious solution ideas. Different factors, e.g. creativity methods, influence the creative process and consequently the created solution ideas. The analysis of the communication within the group in addition to the evaluation of the solution ideas provides a deeper understanding of the impact of these influencing factors. In this work, we develop an approach to analyse the communication process in group creativity sessions. We relate communication elements to cognitive effects such as production blocking known from psychology research. This approach allows for the detailed analysis of the development of solution ideas – from their emergence to their documentation or rejection.

Keywords: creative process, solution search, communication

1. Introduction

Creativity plays an important role for solving tasks and problems in daily life. Correspondingly, in technical product development, engineers also ask for creativity to solve problems. Particularly for the phase of generating solution ideas, a number of methods and recommendations to increase creativity exist. One controversial recommendation is to perform group creativity sessions to combine the individuals' knowledge for creating "better" solutions (Lindemann 2009, Nijstad & Stroebe 2006, Pahl et al. 2007).

Figure 1shows a model of the creative process in group creativity sessions. Several participants of the group creativity session develop solution ideas based on their previous knowledge and cognitive processes. They communicate these ideas to the other participants. The communication has an influence on the participants' cognitive processes and the development of the solution ideas. Additionally, influence factors such as methods, the composition of the group etc. have an impact on the development of solution ideas. With regards to the documentation of solution ideas, we observed

in previous work that groups given the instruction to document all solution ideas, did not document about 50% of the communicated solutions ideas (Hashemi Farzaneh et al. 2012).
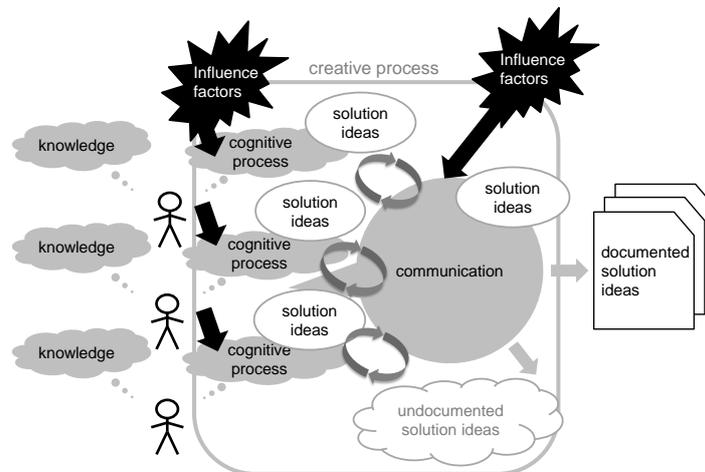

Figure 1. The creative process in group creativity sessions

In order to evaluate the impact of influence factors, the creative process can be regarded in addition to the developed solution ideas. In the creative process, the cognitive processes remain invisible to the observer. However, Stempfle & Badke-Schaub (2002) state, *"communication provides a prime access to the thinking and problem-solving process of the design team".*

Therefore, this work focusses on the analysis of the communication in group creativity sessions in order to integrate the developed solution ideas into the context of the creative process. By this means, the development of specific solution ideas can be regarded in detail, from the emergence to the documentation or rejection.

To start with, we give an overview of literature on the creative process in groups in the disciplines of psychology and in technical product development. Then, we introduce an approach to break protocols of verbal communication into communication elements and to relate them to cognitive effects. As an example, we analyse the communication involving one solution idea in detail.

2. Literature review: analysis of the creative process

Analysing and understanding the creative process is a research field that has been regarded from multiple perspectives according to different areas of research. However, Cross (2001) reviewed protocol studies of design processes in different disciplines and found "a number of striking similarities". He identifies *problem framing*, *co-evolution* and *conceptual bridging* as distinctive characteristics related to the generation of creative solutions (Cross 2001).

In this section, we start with an overview on psychology research relevant to understand basic cognitive effects that influence creative processes. Then, we focus on the technical product development perspective.

2.1 Psychology

In psychology, researchers have closely observed and analysed creative processes, particularly in laboratory experiments. With regards to group creativity, several cognitive effects have been identified which influence the creativity of the participants of the group negatively.

One of the negative cognitive effects is *social inhibition* (also called *evaluation apprehension*) (Diehl & Stroebe 1987), the fear of the participants that their idea will be considered unfavourably by the others.

Social loafing and *matching* are negative cognitive effects attributed to the individual participant's tendency to reduce the efforts in a group. *Social loafing* (also called *free riding*) describes the reduction of productivity because the individual participant is not held responsible for the creative output of the group (Diehl & Stroebe 1987). *Social matching* is the adaption to the least productive participant of the group creativity session (Paulus & Dzindolet 1993).

Another negative cognitive effect is *production blocking* which is explained by the fact that participants of a group creativity session cannot express their idea when it occurs to them. Instead, they have to wait for their turn to speak and are detracted by the other participants' ideas (Gallupe et al. 1991, Diehl & Stroebe 1987). Nijstad and Stroebe (2006) explain *production blocking* by stating that only one idea at a time can be processed in the individual participant's working memory which is "forgotten" as soon as he or she is distracted. *Production blocking* is considered to be particularly relevant for unsuccessful brainstorming (Nijstad and Stroebe, 2006). Methods such as electronic brainstorming or brainwriting that allow participants to document their ideas continuously have been developed to prevent *production blocking* (Gallupe et al. 1991).

2.2 Technical product development

As in technical product development "creative" solutions search is often recommended to solve technical tasks, the complexity of the tasks plays an important role. To that effect, Shah & Vargas-Hernandez (2003) state that the evaluation of the creativity process as a cognitive process is complicated by the fact that cognitive models developed by psychologist are based on relatively simple laboratory experiments and not on experiments with technical tasks. Therefore, in technical product development a number of studies focus on the evaluation of the documented ideas, solutions or products (Shah & Vargas-Hernandez 2003). Still, a number of researchers regard the (undocumented) solution ideas which are developed during the creative process. For example, Srinivasan & Chakrabarti (2010) regarded individual designers and include their utterances asking them to "*think aloud*" for the assessment of the novelty of concepts at various levels of abstraction. Hashemi Farzaneh et al. (2012) analysed group creativity sessions by considering all solutions mentioned by the participants.

In addition to the research centred on solution ideas, there is a research focus on product development or design process models and their stages. The creative process can be analysed and mapped to the stages of different process models. Stempfle & Badke-Schaub (2002) examined group creativity sessions identifying four basic proposed cognitive operations *generation*, *exploration*, *comparison* and *selection* and map them to design process stages. Gero et al. (2011) developed a software tool to assign verbal communication in group creativity sessions to elements of the design process. As an outcome, these researchers regard the amount of time spent on specific stages of the process which allows for conclusions on the validity of the product development or design processes for real group creativity processes.

3. Communication elements and cognitive effects in creativity sessions

In technical product development, one research focus is the development of metrics to evaluate the creativity of the solution ideas generated in creativity sessions (Shah & Vargas-Hernandez 2003,

Sarkar & Chakrabarti 2011). As described in section 2.2, another research focus is the creative process in group creativity sessions (Stempfle &Badke-Schaub 2002, Gero 2011).

To assess the impact of different factors on group creativity sessions, the analysis of the creative process in addition to the analysis of the solution ideas allow for a more detailed assessment. Particularly interesting are two questions:

- Which processes in creativity sessions lead to creative solution ideas?

- What triggers groups to document some of these ideas and to "forget" others?

To answer these questions, the evaluation of the creativity of solution ideas has to be combined with an analysis of the creative process. As shown in Figure 1, the creative process includes the cognitive processes of the individual participants of the creativity sessions and the communication. As we can only observe the communication, we have to relate it to cognitive processes for a better understanding of the overall creative process.

The goal of this work is to develop an approach to analyse the communication of group creativity sessions and relate it to cognitive processes. Figure 2 illustrates the approach. In a first step, the verbal communication is divided into elements el_1 to el_n. These communication elements are assigned to several cognitive effects ef_1 to ef_n known from psychology research described in section 2.1. In a next step, the development of solution ideas s_1 to s_n can be regarded. We can analyse which communication elements and cognitive effects act on the development of a solution idea from its emergence until the documentation or its rejection. This is done exemplarily for a documented solution idea in section 4.
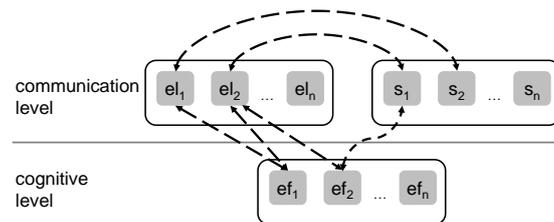

Figure 2. "Mapping" of solution ideas to communication processes

3.1 Communication elements

To analyse the communication process recorded in protocols, we define communication elements, i.e. utterances about a certain topic. On the basis of Stempfle & Badke-Schaub (2002), process-related elements and content-related elements are defined. In groups, organisation-related communication is necessary to organise the group process. An example is the assignment of tasks to specific participants of the creativity session. The organisation-related communication can be divided into elements such as *planning*, *analysis*, *evaluation*, *decision* and *control* (Stempfle & Badke-Schaub 2002). We define content-related elements according to the Munich Procedure Model (Lindemann 2009) into *goal analysis*, *goal planning*, *task structuring*, *generate solution ideas*, *properties assessment*, *decision making* and *ensuring goal achievement*. For completeness, these elements include all stages of the technical process development. Despite this, the assumption is that in a group creativity session for *generating solution ideas*, the focus of the communication is mostly on the first elements and not on *decision making* and *ensuring goal achievement*.

To allow for a more detailed analysis of the *generation of solution ideas*, we further divide the element *generating solution ideas*. Following Nijstad and Stroebe (2006), when a succession of ideas are generated, they can be in one ore different "categories". In a cognitive process, two ideas from one

category are based on the same image in the working memory of an individual; a change of category is equivalent to the activation of a new image in the working memory. It is not possible to observe the cognitive process, but it is possible to identify ideas of one category by their semantic relation in the communication (Nijstad and Stroebe, 2006).

The following elements are used for the *generation of solution ideas*:

- *solution idea – new category*: a solution idea which is in another semantic category than the previous idea

- *solution idea – variation*: a solution idea which is semantically related to the previous idea (same category) and represents a variation of the idea

- *solution idea – concretization*: a concretization of the previous solution idea (same category)

- *solution idea – expansion of the scope*: an expansion of the scope of the previous solution idea (same category)

- *solution idea – repetition*: a repetition of a solution idea that has been developed previously

- *classification of solution ideas*: one or several solution ideas are classified, i.e. put into context, in relation to other solution ideas

As the positive, negative statements and questions for the *properties assessment* of the solution ideas are critical for the group's decision to document them, this communication element is further divided into:

- positive statements/ questions

- neutral statements/ questions

- negative statements/ questions

A verbal communication contains utterances that are neither process- nor content-related. An example is the replication of another participant's statement or jokes and laughter. We use the communication elements *replication*, *jokes and laughter* and *other verbal communication*, i.e. all utterances that cannot be assigned to any of the other elements. *Documentation* is added as an element, to explain the participants' actions such as *sketching* even though this is no verbal communication.

3.2 Cognitive effects

As explained in section 2.1 a number of cognitive effects have been identified in psychological research. In laboratory experiments, researchers have shown that particularly the cognitive effects *social inhibition*, *social loafing* and *production blocking* diminish the number of solution ideas generated by groups that use creativity methods such as brainstorming (Nijstad and Stroebe, 2006). Therefore, we choose these three cognitive effects as examples and relate them to communication elements. We depict the relation on excerpts of protocols from a group creativity session.

This group creativity session was performed with three mechanical engineering students (different semesters, age: 20-25, no personal relationships). The task was to *"design a way that allows people parking and leaving their bike secured"*. The students were asked to generate as many solution ideas as possible and to document them by means of sketches with textual descriptions. The duration of the

creativity session was thirty minutes. The students were not asked to follow a specific procedure or to use a creativity method.

3.2.1 Social loafing

Social loafing can be recognised in a creativity session if one or several participants do not contribute solution ideas for a noticeable period of time or if they do not participate at all in the discussion. In relation to communication elements this corresponds to

- a period of time in which a participant does not make utterances belonging to the communication elements *solution idea - new category, - variation, – concretization, – expansion of the scope*

- a period of time in which a participant does not make any utterances

The excerpt depicted in Figure 3 shows an example of participants not making any utterances. Two participants of the creativity session observed the third participant sketching a solution idea and agreed that they would not sketch an idea (communication element *planning*). This resulted in a delay of 20 seconds, in which both of them remained passive before one of them started talking about a solution idea that had been mentioned before.
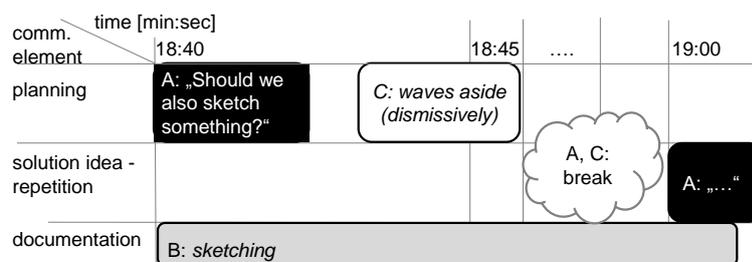

Figure 3. Social loafing (A: participant A, B: participant B, C: participant C)

3.2.2 Social inhibition

Social inhibition is triggered by the fear of participants that their ideas will be judged negatively by the other participants. This cannot explicitly be observed in the communication elements, because in most cases the participants do not express this feeling. Still, if their fear is confirmed by negative criticism as shown in Figure 4, this can increase *social inhibition*. In this excerpt, participant C suggested to *spray tear gas*, a *solution idea in a new category*. The solution idea is immediately criticised by both other participants. Negative criticism corresponds to

- utterances belonging to the communication element *negative statements/ questions*

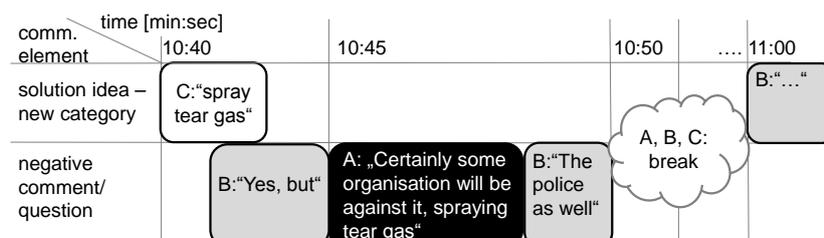- the communication element *jokes and laughter*

Figure 4. Social inhibition (A: participant A, B: participant B, C: participant C)

3.2.3 Production blocking

Production blocking means that the participants do not mention all solution ideas they have because they are distracted when they are waiting for their time to speak. This cognitive effect is explicit when several participants mention semantically different ideas in a short period of time as shown in Figure 5: Participant C suggests one solution idea and participant B suggests a semantically different solution idea. Then participant C "jumps" to one more semantically different solution idea. This solution idea is then pursued and concretized by participant B. Both previous solution ideas are "forgotten".

Another example of *production blocking* is that one participant concentrates on one aspect of a solution idea and is "interrupted" by a participant who broadens the idea or inversely. As to the communication elements, this corresponds to

- many utterances belonging to the element *solution idea – new category* in a short period of time.

- change from the element *solution idea – concretisation* to *solution idea – expansion of the scope* or inversely.


Figure 5. Production blocking (A: participant A, B: participant B, C: participant C)

4. Detailed analysis of the development of a solution idea

In this section, the communication with regards to the solution idea *throw-lock* is shown exemplarily. This solution idea was documented in a sketch with textual descriptions. Examples for undocumented solution ideas can be taken from Figure 4 (*tear gas*) and Figure 5 (e.g. *electric immobiliser system*). To start with, we explain the solution as it was documented in the group creativity session: It is described by the group as a lock consisting of a steel cable and two magnets. The lock can be "thrown" at the bike and the object to which the bike should be fixed. The magnet force actuates as a locking mechanism. The group stated that the difficulty of this solution idea is the opening mechanism. Based on the initial questions, we examine the process of the solution idea's emergence and development until its documentation in a sketch. Figure 6 depicts the communication elements involving the solution idea. The communication elements include the following utterances:

Participant B mentioned in minute 11 *throwing* a device. After other utterances, he mentions the idea of the *throw-lock* in minute 13. Participant A varies the idea by suggesting throwing *the bike somewhere*. Participant B gives positive feedback to this, but he returns to his initial idea when participant C asks about the functionality. Participant B explains it by referring to bracelets with a bistable functionality that "snaps" around the arms. Subsequently he passes on to other solution ideas.

In minute 22, he sketches the solution idea despite the negative questions of participant A and the joke of participant B.
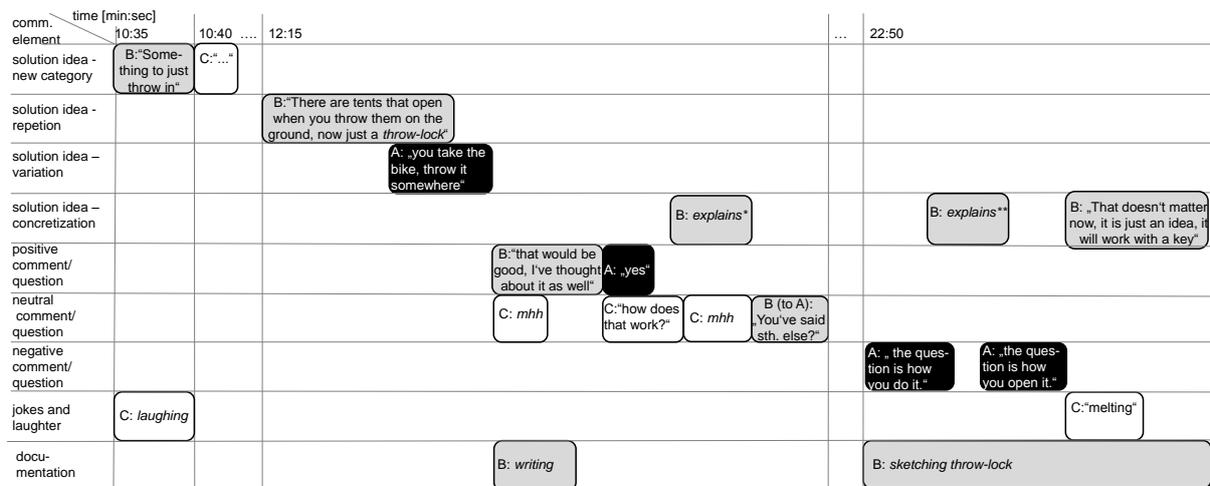
Figure 6. Solution idea casting lock (A: participant A, B: participant B, C: participant C)

The analysis of the process of this solution idea's development shows its emergence out of the image of *throwing* that participant B has in his mind. This image and the analogies to other products (tent, wristlet) endure the emergence and development of *solution ideas in new categories* so that participant°B continues developing it afterwards. Participant B is so convinced of this solution idea that he sketches it even though the other participants express their criticism with utterances belonging to the communication elements *negative comment/ question* and *jokes and laughter*.

In conclusion, this example shows that the participants of creativity sessions can pursue solution ideas despite the impact of the communication element *solution ideas – new category*. This does not necessarily distract the participants from one idea and cause the cognitive effect *production blocking*. In addition, utterances of the communication element *negative comments/ questions* do not inevitably trigger the cognitive effect *social inhibition*.

5. Discussion

The analysis of communication in group creativity sessions allows for several observations: To start with, the communication elements were defined according to process elements concerning the organisation of the group and content. We observed that not all of the defined communication elements were used by the observed groups. The duration of the creativity sessions (30 minutes) can be a limiting factor at this point. As to the cognitive effects, three negative cognitive effects were taken as examples and related to communication elements by the authors. There are a number of other, positive and negative cognitive effects which can also be regarded. In addition, the analysis performed in section 4 shows that the communication elements associated with certain cognitive effects do not necessarily trigger these cognitive effects: This does not prove that there is no relation between cognitive effects and elements, it depicts that there is no causal relation.

6. Conclusion and outlook

In this work, we analyse communication in group creativity sessions performed for solution search. We fragment the communication into utterances and assign them to communication elements depending on their topic. These communication elements are then related to cognitive effects such as *production blocking*. Communication elements and cognitive effects can positively or negatively affect the development of solution ideas. With this approach, a specific solution idea can be set into the context of the creative process so that the emergence, development or rejection of the solution idea can be analysed. This research provides a number of starting point for future work:

More cognitive effects can be regarded, especially positive cognitive effects. As to relating utterances, communication elements and cognitive effects, the inclusion of more evaluators in addition to the authors can give a broader view. Then, the analysis of the communication can be related to the evaluation of the solution ideas. Specific solution ideas evaluated as creative or not, can be regarded in detail. Referring to the questions asked at the beginning of section 3, we can detect the communication elements and cognitive effects preceding and possibly triggering their creation. Then, the influence of communication elements and cognitive effects on the process of developing or changing the solution idea can be regarded. We can analyse which communication elements and cognitive effects have an impact on the documentation or the rejection of the idea.

As a next step, the influence factors depicted in Figure 1 can be analysed, such as the creativity methods recommended in technical product development: How do they influence the communication and its elements? Which cognitive effects do they trigger? How is the development of solution ideas influenced? This approach supports a more differentiated view on influence factors such as creativity methods and can help to improve them.

Acknowledgement

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