DRS 2012 Bangkok
Chulalongkorn University
Bangkok, Thailand, 1–4 July 2012

Does SKETCHING Stand Alone as a Communication Tool during CONCEPT GENERATION in DESIGN Teams?

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Abstract

The present study investigates the relation between sketching and communication in teams during the idea generation process in early concept generation. A quasi-experiment study has been conducted with Masters students of Industrial Design Engineering at Delft University of Technology, Netherlands. Six groups consisting of three students had to solve a design problem in a given time. Whereas the experimental groups (n=3) were not allowed to talk during the design process, the control groups (n=3) did not face any restrictions. The experiments were recorded, observed and analyzed. As expected, both groups used communication to transfer and support their individual ideas. For the experimental groups, the written language became the medium of communication in detailing the information of sketches. These findings show that sketching cannot stand alone; design teams need to use sketching and verbal communication in conjunction not only to produce well-developed ideas, but also to transfer them.

Keywords: sketching, design thinking, design process, creativity, communication

Introduction

Sketching is an essential thinking medium in design. This is true for individual and team design processes. Sketching has traditionally been seen as a primary conceptual tool in the early stage of the individual design process (Fish & Scrivener, 1990). Research has shown that sketching is also used for exploration of solutions in terms of functions or/and forms, and for structuring the design problem in teams (Goldschmidt, 1991; van der Lugt, 2002).

Nowadays, most design activities are taking place in teams, and require the individual designer to communicate his/her own views about the problem and solution spaces to other team members. However, these ideas are often not well formulated and fuzzy upstream in the design process, and need more processing to become more transferable. Naturally, this task is even more demanding in interdisciplinary teams. Differences in goals, languages, and other cultural variables produce conflicting views which needs to be synchronized (Smulders, 2008) to make design decisions. In general, designers are trained to support their verbal explanations by visual representations in order to facilitate communication and mutual understanding, or vice versa. However, our understanding of the "dialog" between sketching and verbal communication is limited.

When addressing this issue, we first ask what cognitive processes are involved during the sketching process. The following model (Figure 1) depicts the most relevant stages from the introduction of the problem until its reinterpretation by the designer and the communication of the revised mental model.

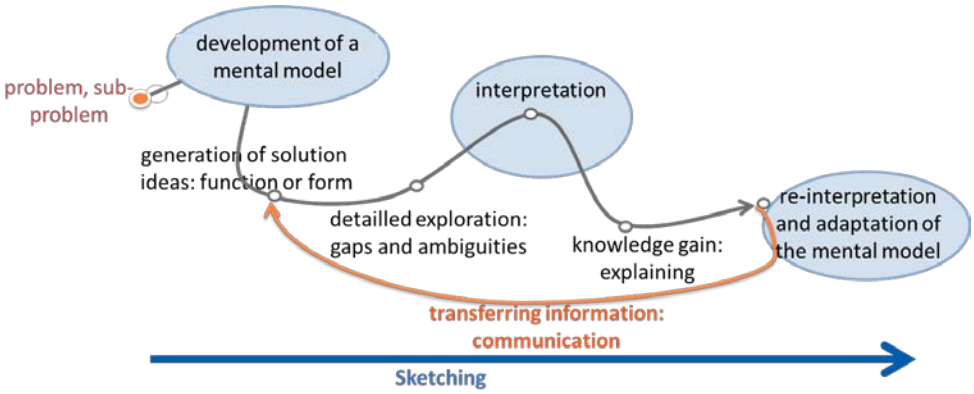

Figure 1: Cognitive activities during the sketching process

The introduction of the design problem will lead to a premature understanding of the problem, and thus, a rough mental model. Initial ideas about possible solutions are generated on the basis of that rough mental model. The processes depicted by the blue bubbles are internal activities such as mental models, which cannot be directly observed. These constructs need to be characterized by criteria which can be inferred through observations. Moreover, these constructs should be treated as elements of the whole process.

At the level of individual and team activities, sketching can be described as processing three main cognitive patterns:

1. Exploration–Interpretation–Re-interpretation cycle (see also Purcell & Gero, 1979): Cognitive processes during sketching can be described as a process of exploration, interpretation and re-interpreting cycles. The mental model is the cognitive structure, which provides 'questions' and 'answers' and 'instructions' what to explore and how to gain a comprehensive model for the further development of solutions. Starting point may be inconsistencies or also main

assumptions about the problem at hand, which requires special attention.

2. Defining uncertainties and ambiguities: As Figure 1 suggests, designing is not simply the implementation of knowledge and application of methods. Usually the designer chooses a partial aspect of the given problem, which he/she defines according to his/her knowledge and experience. This initial understanding of the problem leads to further exploration of goals and ambiguities. The results of these activities define the problem space, which is represented as a mental model, including gaps and ambiguities. Ambiguity and fuzziness can limit the completeness of the mental model, but they also are an opportunity for creative interventions. When designers start sketching, they rarely try to visualize the whole problem but choose those elements which they give priority due to criteria resulting from the exploration - interpretation – re-interpretation cycle, such as unclear, complex, intertwined elements. These are situations where solutions are needed, and creativity can is a function of to what extent gaps and ambiguities will be exploited to construct to new solutions. Thus, sketching provides opportunities to select the most relevant parameters in respect to creativity.

3. The knowledge gain – knowledge transfer cycle: the sketching process of individuals as well as of teams is accompanied by verbal explanations. Individual thinking processes and communication patterns in design teams both alternate between gaining knowledge and transferring and exchanging knowledge (Badke-Schaub & Doerner, 2002). The process of switching between generating and exchanging of knowledge is seen by some as the main source of creativity (Doerner, 2010). This assumption suggests that verbalization can be as important as visualization. Building on that inference, we hypothesize that if designers in a team are not be allowed to talk while sketching, they would be severely hampered to produce well-developed design solutions. In this paper, we present empirical results on the relationship between verbal communication and sketching in the context of the design process.

1. Research Questions

This study aims to explore the following research questions:

1. How will the sketching process be changed if verbalization during sketching activity is limited?

2. What role does verbal communication play in sketching activity?

2. Empirical Study

2.1. Method and data collection

The study was executed as a quasi-experiment. The participants were 18 Masters level design students in the Faculty of Industrial Design Engineering, Delft University of Technology. Participants were placed in six groups of three and asked to respond to a design brief. Three groups were assigned to the two conditions: experimental and control. The experimental groups were not allowed to speak to each other during designing, and thus are termed “silent” sketching groups. The control groups did the same design task without any limitation, and are termed “non-silent” sketching groups.

2.2. The design task

As shown in Figure 2a and Figure 2b, the experiment was divided into two phases. In the first phase, the groups were given 45 minutes to generate ideas. The task was to design

a product that helps blind people to cook. The teams were given 5 minutes for reading the design brief and in the next 10 minutes, each participant had to work individually to generate his/her own ideas without contacting the other group members – this condition was the same for the experimental and control groups. After that, the group members worked together and developed a final concept.

After a 10 minute break, the second phase started, which was intended as the "stimuli phase." A new set of instructions were provided to groups, which further specified the goal by stating "camping" as the context in which cooking takes place. The new instructions also contained pictures of existing outdoor cooking utensils as stimuli. The intent of the stimuli was to narrow down the solution space and to facilitate the process of reaching common agreement. In this phase, the groups had to complete the design task in 25 minutes, with 5 minutes for reading the instructions and 20 minutes for group work. In the last 5 minutes of the experiment, groups presented their final idea. A survey to assess the communication medium preference (sketch, written, and verbal) was administered to all participants before the task. All activities and the resulting sketches were video recorded, observed and analyzed.

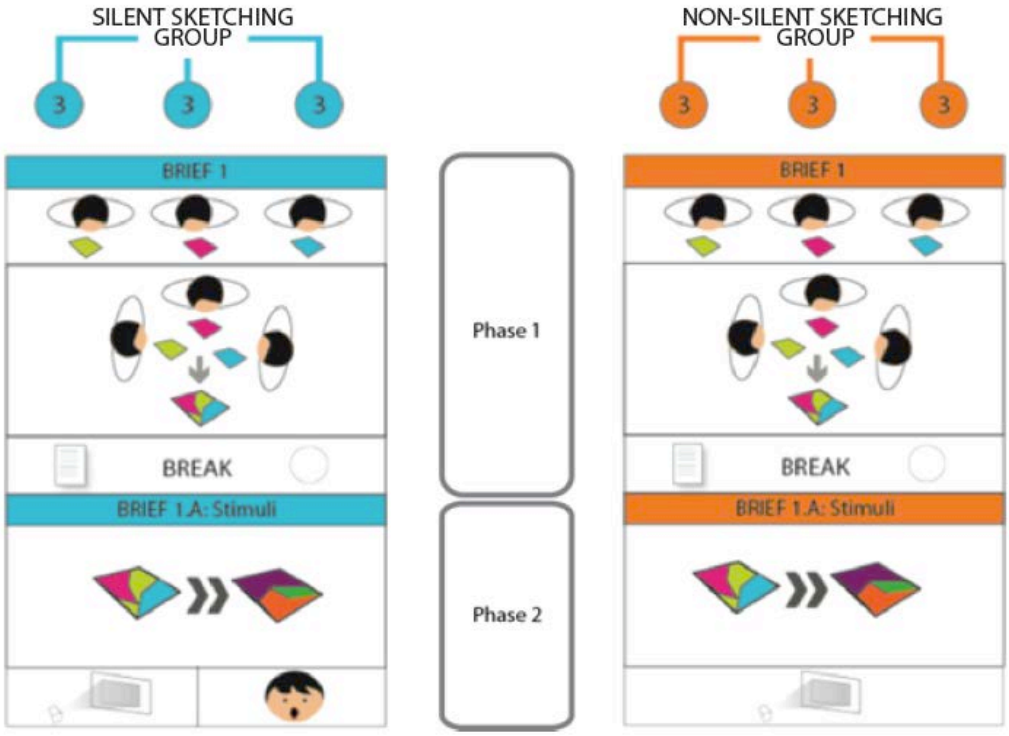

Figure 2a. Overview of experiment

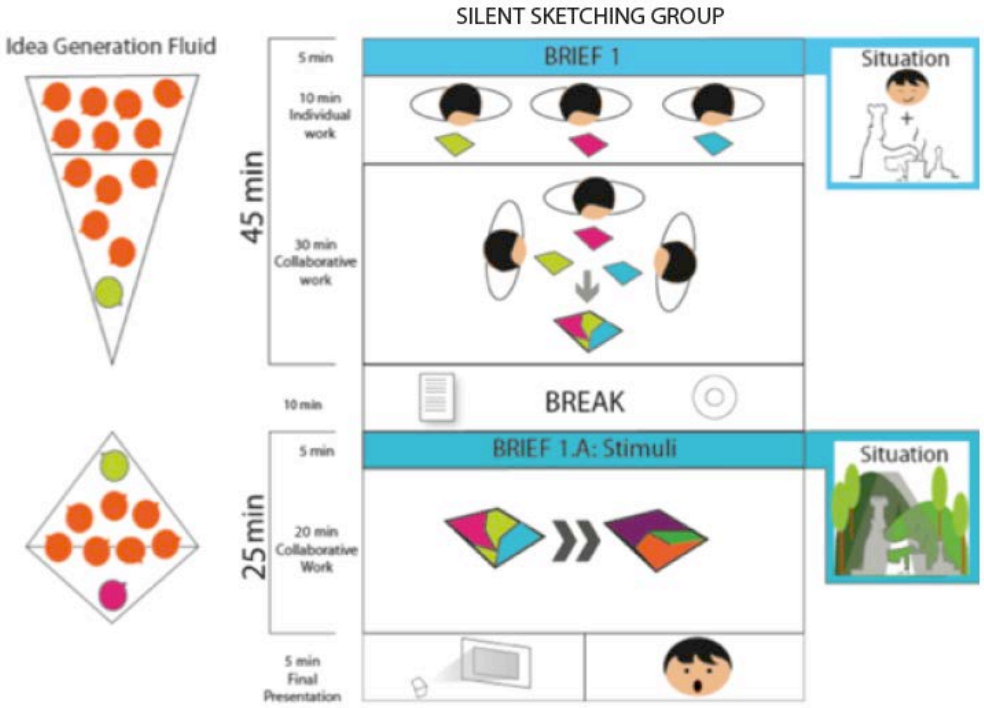

Figure 2b. Overview of sketching task

3. Data analysis

In this section, we discuss the analysis of the sketches and the design process. All sketches were decomposed into sketch elements, and the sketch elements were associated with (seen as the outcome of) four activity categories we constructed based on our observations during the experiments (see Figure 3):

4. Generate: Introduction of basic form and function elements in a sketch.

5. Detail: Extension of the sketch through the Exploration–Interpretation–Reinterpretation cycle (as discussed earlier).

6. Explain: Clarifying the meaning of sketch elements with annotations.

7. Transfer and Exchange: Negotiating the meaning of sketch elements through the sharing of information and dialog.

We postulate that these four activities are essential to fulfilling the two main requirements for coping with the given situation: Understanding and solving the design problem (design, see Figure 3) and making sure that the team members have the same understanding (communication, see Figure 3). In this paper, we focus on the role of the communication activities, which we further categorize into explanation, and transfer and exchange activities.

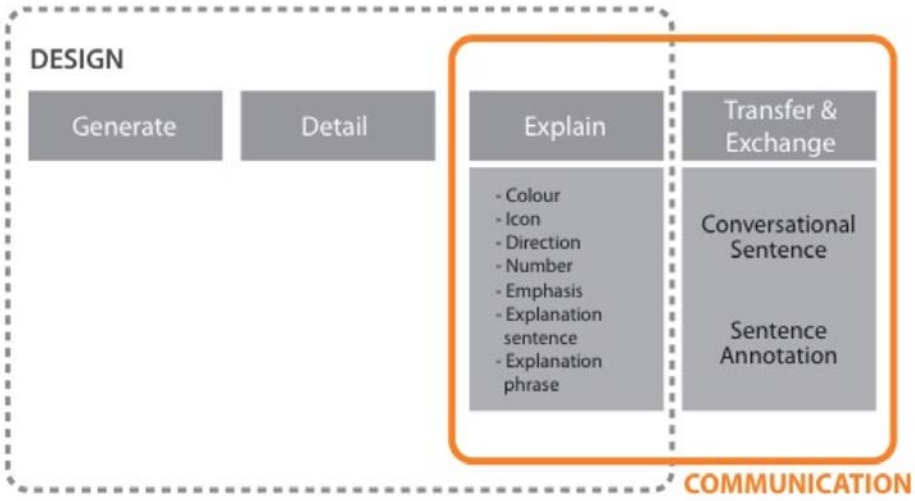

Figure 3. Sketching Activity Categorization framework

There were seven explanation elements to be distinguished in the explanation category, which are colour, icon, direction, number, emphasis, explanation sentence, and explanation phrase.

C*olour* is often used to indicate meaning. For example, red stands for hot. An *Icon* is a graphical symbol commonly understood within the group that is used to identify or communicate meaning. Can be very general such as the addition symbol "+", or can be internal to the group such as the group creating an icon to represent blind people. *Direction* is a mark that indicates direction (such as an arrow) from one point/area to another point/area on the sketch. A *Number* is an arithmetical value, expressed by a word, symbol, or figure, that is used to calculate, order in a series, or to identify. *Emphasis* is a special importance or prominence given to a sketch element such as underlining. *Explanation sentence* are notes written in the form of a sentence to further explain a sketch element. The *explanation phrase* is a brief textual annotation used to explain a sketch element.

There are two transfer and exchange elements, which are conversational sentence and sentence annotation. They refer to the written conversation that takes place in a sketch without explicitly referencing any sketch elements.

Conversational sentence is a note written in the form of a sentence to further explain a sketch element. *Sentence annotation* is a brief textual annotation used to explain a conversational sentence.

4. Results

In this section, we present the results our analysis, with emphasis on the outcomes of the categorization of the underlying cognitive processes associated with communication.

4.1. Design and Communication Activities

A total of 60 A3 size paper sheets with sketches were collected during the experiment. 23 sheets were from the non-silent sketching group, and 37 sheets were from the silent sketching group.

The main evaluation of the sketches was done by identifying the elements in the sketches and grouping them into the categories discussed in section 3. Sketching activities were counted and summed per experimental condition. Results are shown on Table 1.

Table 1. Cumulative sketching activity counts for the silent and non-silent experimental conditions

Sketching Activities		Experimental Condition	
		Silent	Non Silent
Generate	Count	40	40
	% of total	3.4%	9.8%
Detail	Count	43	16
	% of total	3.6%	3.9%
Explain	Count	973	287
	% of total	82.1%	70.2%
Transfer & Exchange	Count	129	66
	% of total	10.9%	16.1%
Total	Count	1185	409
	% of total	100%	100%

We have not conducted statistical analysis to test for the significance of the differences indicated on Table 1 given the number of groups in each experimental condition is small.

4.2 Communication Activities

Figure 4 shows the explanation activity counts per experimental condition. Silent sketching groups make extensive use of icons, directions, explanation sentences and sentence annotations. Their increased use of explanation sentences and sentence annotations than non-silent groups is particularly interesting; when speech is not an option, sketch elements are explained in writing. These results support our assumption that sketching and verbal communication need to be used in conjunction to produce well-developed ideas

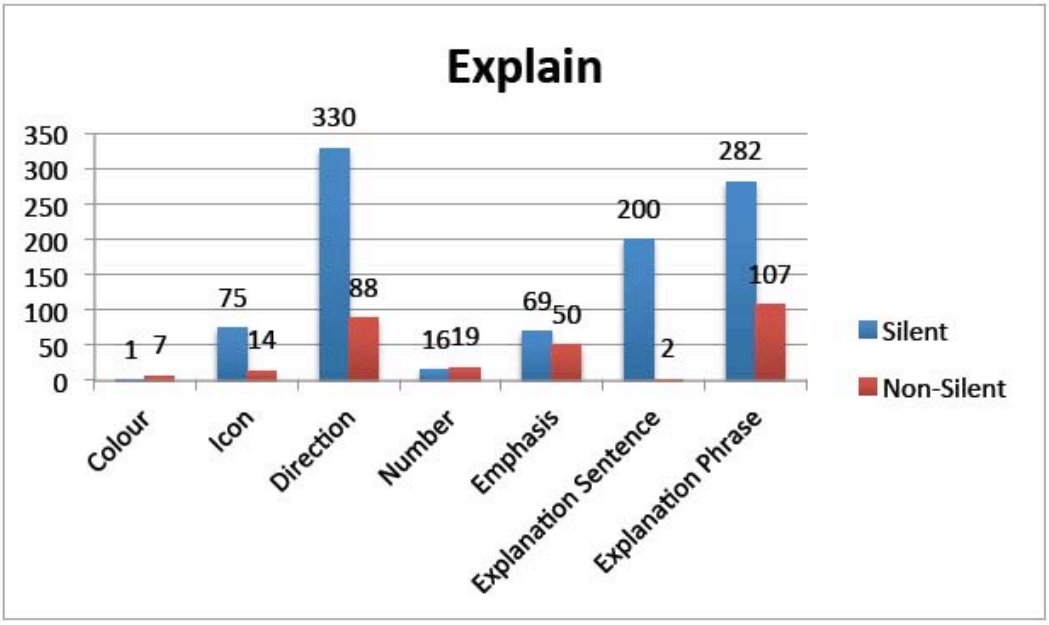

Figure 4. Explanation Element counts

Figure 5 shows the transfer and exchange activity counts per experimental condition. Whereas the conversation sentences are widely used in the silent groups, the non-silent groups make more sentence annotations. This might be explained by annotation being a faster way to draw attention to existing conversational sentences to be negotiated when one has access to speech to carry out the negotiation itself.

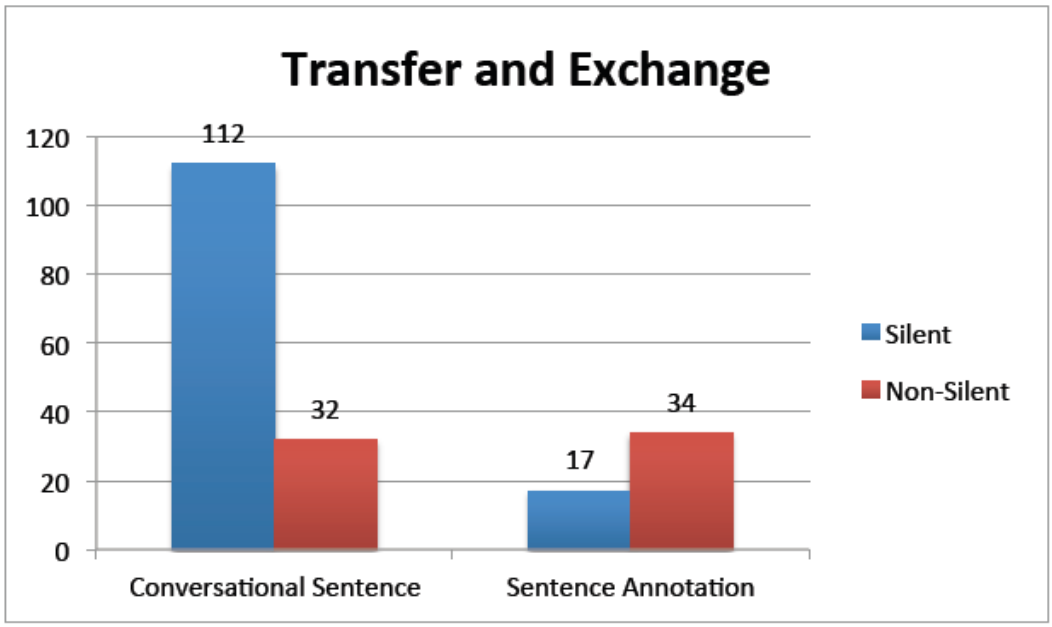

Figure 5. Data collection in Communication category

To summarize:

> *Written explanation sentences, explanation phrases and conversation sentences replace verbal discussions when verbal communication is not possible.*

When verbal description is restricted, the alternative is to use explanation sentences, explanation phrases, and conversation sentences to explain ideas and negotiating their meanings. Furthermore, the explanation sentences, explanation phrases, and conversation sentences produced by the silent groups are more detailed than the ones produced by the non-silent group.

4.3 Survey outcomes

A survey was administered to assess the communication medium preference (sketch, written, and verbal) of all participants before the task. More specifically, participants were asked how comfortable they feel with each medium to convey their ideas. The instrument utilized a 5-point response scale, where 1 represented “not comfortable at all,” and 5 represented “very comfortable.” The survey also contained an item asking if the participants had received formal sketching training, with “Yes” or “No” response options.

All 18 participants have formal sketching experience. Responses to the communication medium preference items were analyzed per study group. An ANOVA was conducted to identify any significant differences between the groups. There were no significant differences between the six study groups

5. Discussion

Sketching is a powerful tool for designers to visualize and transfer their ideas. Yet, to make the ideas more transferrable and clear to the other designers in a team, verbal communication is needed; language seems to be a necessary way to transfer details. Moreover, this study shows that the detailing process during sketching mainly refers to elements of explanation, and conversation to transfer and share ideas within the team when speaking is not allowed. With these elements included in the drawings, the ideas are more concrete, understandable and transferrable within the team. This is in line with the previous finding where sketches have been found to result in a more integrated group process [Van Der Lugt, 2005]. However, those elements are also part of a "normal" designing situation (non-silent sketching); they are needed in order to transfer the ideas in more concrete way.

Building on that, team members do not only develop shared mental models about the task at hand but also about the process and the team as they need to guide their group process accordingly. Doing so, they need a good understanding of each other's perspectives and what they are working on at the moment. This finding is also in line with one of our previous findings, that the common sketching and use of sketches in the team as a common ground can help to create shared mental models [Neumann, Badke-Schaub and Lauche, 2009].

Design students with some sketching experience participated in study. Even though this was appropriate for the simple conceptual design task used, experienced designers in real life settings might differ in their behavior. For example, expert designers are assumed to leverage sketches more than novices [Goldschmidt, 1991]. Moreover, practicing designers were found to be more interpretive and displayed more fixation-resistance than novices [Tversky, Suwa, Agrawala et al, 2007]. Studying the differences between novice and expert designers on how they use sketches to communicate during idea generation in teams would be an interesting follow-up study.

We plan to refine the design of the experiment and the analysis framework, and conduct the study with a larger number of participants in order to assess the generalizability of the findings.

6. Conclusion

Although many studies on sketching during the design process have been done in the past, there is still limited understanding when, how and to what extend sketching is used as a medium of communication. These findings reiterate the role sketching plays as a powerful tool for designers to communicate within oneself and in teams. The findings also demonstrate that, in a team context, verbal communication is needed to illustrate ideas in more detail, making sketches more concrete, visualizable, and transferrable.

Acknowledgement

We like to thank the Masters students of Delft University of Technology, The Netherlands for participating and contributing to this research.

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