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ORIGINAL ARTICLE

Antti Oulasvirta · Esko Kurvinen · Tomi Kankainen

Understanding contexts by being there: case studies in bodystorming

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Abstract A thorough appreciation of physical, social, interactional, and psychological contextual factors is crucial in the design of ubiquitous computing applications. This paper investigates the benefits of a method called *bodystorming* for carrying out design sessions in the original context, 'in the wild', instead of the office. A location is selected that is identical or similar to the original environment. Innovation, carried out on-site, is based on ethnographical data presented as concrete design questions. Individual solutions to design questions are brainstormed and discussed on-site. Facets of data collection and preparation, formulation of design questions, selection of locations, session administration, and evaluation of design ideas are presented. We found that bodystorming permits immediate feedback for generated design ideas, and can provide a more accurate understanding of contextual factors. Bodystorming sessions were found memorable and inspiring. It is best suitable for designing for activities that are accessible and unfamiliar to the researchers.

Keywords Bodystorming · Brainstorming · Context:Context-awareness · Ubiquitous computing · User-centered design

1 Introduction

1.1 Understanding contextual factors in ubiquitous computing

Mark Weiser, widely acknowledged as the father of ubiquitous computing, envisioned ubiquitous computing as a technology embedded in the physical environment, providing useful services without disturbing the natural flow of human activities [1, 2]. Ubiquitous computing would "fade into the background" and incorporate what he called "natural user interfaces". Guided by this vision, researchers' attention was drawn to the question of what detectable attributes of the context are important in making the user interface seem natural. Awareness of these contextual attributes was seen as a prerequisite for introducing ubiquitous computing products into everyday activities. Early research in context-awareness can be characterised as an attempt in finding *universal* context attributes that would be needed for many (or all) ubiquitous computing applications (see Pascoe et al [3]; for a critical review, see Dey [4]). Some attributes, such as location and time, were indeed repeatedly found important for many applications. Today, however, many researchers would agree that a more worthwhile approach is to determine the contextual attributes for each application individually (e.g. see *Personal and Ubiquitous Computing* (Vol 5 No 1) or *Human-Computer Interaction* (Vol 16 Nos. 2–4)). The overarching goal in the design of any ubiquitous computing application is, then, to discover the *specific* physical, social, interactional, and/or psychological contextual factors that are important in making the flow of human-computer interaction natural.

A variety of user-centered design process models have been proposed for this purpose [5–8]. All models subsume following three stages: (1) *observation* of user activities; (2) *documentation* of the observations; and (3) *design* based on the documentation. Data collection methods typically draw from anthropological and ethnographic research orientations (e.g. Emerson et al [9]), whereas documentation methods can range from story-like descriptions of actions (e.g. Cooper [7]) to systematic turn-by-turn ethnographic transcriptions of the event (e.g. Hutchby and Wooffitt [10]) to box-and-arrow diagrams depicting different aspects of the activity (e.g. Beyer and Holtzblatt [5]). The purpose of the two first stages is to provide enough information for the last stage to design the context-aware system. Within these models, the quality of design ideas crucially depends upon the quality of the documents.

A. Oulasvirta (✉) · E. Kurvinen · T. Kankainen
Helsinki Institute for Information Technology,
P.O. Box 9800,
02015 HUT, Finland
E-mail: antti.oulasvirta@hiit.fi

During years of user-centered study, our research team has become aware of three consequential shortcomings. First, because studied activities are complex, documents representing this complexity, unless extremely carefully written, are long and complex. Without a substantial investment of time in studying documents, adequate understanding of context is not achieved within the design team. Second, because all documentation is based on interpretations of one individual, documents are inherently inaccurate or biased. As a researcher observes user activities, s/he already pays attention to some aspects while disregarding others. As observations are documented, meaningful interpretations are given and missing information is filled with prior knowledge about the phenomena. This reconstruction leads to omissions, irrelevancies, and distortions in documents. Thus, designs would too often be based on misconceptions of the problem domain. Third, it is often practically impossible to notice or correct these misconceptions without conducting another round of observation or documentation, or both.

1.2 Potentials of bodystorming

The primary purpose of this paper is to present and evaluate a possible solution to these shortcomings, termed elsewhere as *bodystorming* [11]. Briefly stated, the method is as follows: Before a bodystorming session, a preliminary observation and documentation is conducted. From the documents, interesting phenomena are selected and edited into easily readable *design questions* (see Fig. 2). A design question represents the phenomenon as a problem in the events, experiences, and/or practices of users. Participants go to a representative environment, e.g. if studying shopping malls, designers will go to a representative shopping mall. One design question at a time is given to participants. The attempt to solve the problem occurs in a place where the phenomena (or parts of them) are directly observable. This is in direct contrast to what we call here 'traditional' brainstorming, which is conducted in office environment *un*representative of the studied environment. In some cases, to encourage further re-enactment, participants in a bodysession are not just passive observers but are asked to act out the activities. Generated ideas are recorded on-site and later discussed and elaborated in groups.

We argue that bodystorming can reduce the amount of time needed to study documents of user observations. People can more quickly and with less effort build a mental model of the surrounding, directly observable environment. In contrast, in traditional brainstorming, documentations of contextual factors, be they textual or pictorial, tend to be lengthy and take long to study. The key idea in bodystorming is that the descriptions of a problem domain (i.e. design questions) given to bodystorming participants can concentrate more on the description of aspects of the problem that are not observable, e.g. psychological (e.g. user needs), social (e.g. interpersonal relationships) or interactional (e.g. turn-taking in conversations). We also hypothesise that bodystorming can enhance the accuracy of conceptions of the problem domain. Many potentially important aspects that are omitted from documents of situated action may be directly observable in a bodystorming session and erroneous conceptions in documents may be rejected. Finally, we hypothesize that bodystorming enhances design ideas by permitting the evaluation of invented design ideas already on-site. Simulation and testing of generated ideas is easier and less error prone when the physical environment with its relevant constraints and affordances is directly observable. In traditional brainstorming, no feedback is available for this purpose. In addition, we believe that directly observable environment – in comparison to one based purely on documents – can free mental resources for decision making, problem solving, and reasoning needed in the design phase. Indeed, externalising representations, in comparison to keeping them in working memory, is known to reduce cognitive workload [12]. Moreover, contextual cues help retrieving relevant personal memories more effectively [13]. Contextual cues also facilitate recognising analogies in personal knowledge [14]. Moreover, contextual cues can facilitate directing attention to important features [15]. These properties of bodystorming, we believe, can make it suitable particularly for the design and innovation of ubiquitous computing applications.

1.3 Precursors of bodystorming

The idea of bodystorming is not novel, but its application to ubiquitous computing is. Apart from information technology products, designers have applied 'hands-on' approaches to the design of physical problems already in the 1960s. In the IT development, the method has emerged relatively recently. The term bodystorming was coined by Burns et al [11] while designing a computer workstation for a hairdresser who insisted that a computer "would not help her to run her business." Burns et al created a small-scale project studio where the design team acted and improvised based on collected observational data. They used low-fidelity mock-ups to present design ideas in the course of innovation. They conclude: "By designing in an enactive way, we were able to build an increased empathy for the people that we had identified as the users we were designing for." A year later, Burns et al [16] defined bodystorming as "reenacting everyday peoples' performances and living with data in embodied ways by performance and improvisation."

In their recent paper exploring a method they call *experience prototyping*, Buchenau and Suri [17] describe a bodystorming case where they investigated passenger needs for a new rail service by role-playing and improvisation during a real train journey – instead of using a

studio with props like Burns et al [11]. Scenes were introduced to the participants with cards and a professional actor acted as the supervising moderator. All ideas were documented during breaks after each scene.

Our attention was drawn to bodystorming when we realised that 'hands-on' experience could enhance design ideas specifically in the design of ubiquitous computing. We noticed that the particular researchers that collected the data were always better than others in the team in understanding the phenomena, coming up with design ideas related to their studies and evaluating them critically. Bodystorming could provide every member of the design team this kind of first hand experience. We also noted that some of our problems in developing contextually intelligent applications might stem from the fact that the existing models of user-centered design focus on well-defined tasks carried out on desktop-based computers where contextual attributes do not play as important role.

Bodystorming is, essentially, simply brainstorming conducted 'in the wild'. Brainstorming is not the only method for inducing creative ideas in design (e.g. Weisberg [18]), and not necessarily even the most suitable for our purposes. The key idea studied about bodystorming in this paper, however, is not the idea of using brainstorming for inducing creative ideas, but the idea of 'being there' and living with data in embodied ways. Bodystorming involves being physically present in the context of interest instead of staying at the office that has no real resemblance to the context of interest. We note that there are numerous modifications to brainstorming mentioned in the literature. For example, in their recent book, Kelley and Littman [19] suggest seven habits for successful brainstorming: (1) sharpening the focus, (2) not critiquing emerged ideas, (3) indexing invented ideas, (4) monitoring different stages of 'jumping and building' during brainstorming, (5) externalizing ideas for others to see, (6) doing mental exercises to 'warm up' the brainstorming group, and (7) getting physical by bringing real material to the brainstorming session or by situating brainstorming physically. In addition, Kelley and Littman stress that brainstorming methods should be practiced on a daily basis to be effective. Some practical considerations like these are briefly presented in our case study. Many of the good practices in brainstorming are compatible with bodystorming.

2 Four case studies

In the following we present four case studies. Our primary purpose is to present the method and its variations. The three important factors considered in the case studies are (1) the richness of information given to participants, (2) the potential benefit of acting on-site, and (3) the degree of similarity of the bodystorming environment to the studied environment. We go through in concrete detail how to conduct bodystorming. We report our reflections of how these variations affected the session and generated innovations. We also compare the quality and quantity of generated ideas obtained in these four bodystorming sessions and other traditional brainstorming sessions conducted by our team. By comparing expert sociologist's comments of the acquired results from traditional versus the bodystorming session, we provide a tentative evaluation of how important 'being there' is for understanding contextual factors.

2.1 Preliminary data collection

In our project, BETWEEN, at the Helsinki Institute for Information Technology, we are innovating product concepts for ubiquitous computing technologies by employing user-centered design methods. Altogether 25 people from five different user groups participated in our user research: elderly, young singles, journalists, amateur actors, and middle-aged apartment house neighbors. Data were collected in a series of focus groups, photo diary review sessions, interviews, and participatory observations conducted during summer 2001. All observations were documented in a *story format* (following Erickson [20]). (For a more detailed description of our method, see 4. Kankainen and Oulasvirta [21]). Our next task, together with our industrial partners, was to design product concepts based on the data. A series of bodystorming sessions were conducted for this purpose.

2.2 Case 1 – Bodystorming in original location

Purpose of this session was to try a 'full-fledged' bodystorming by conducting sessions in the original places visited by our elderly user group. At this point we had collected observational data and documented them in a story format. From the set of all stories, five places that were frequently visited and conveniently near each other were selected. Places included an old age service house, subway station, the subway, a mall, and a grocery store at a mall (see Fig. 1). A whole day was spent on bodystorming in these locations in Helsinki.

Before the session, three researchers had examined all the *stories* related to each selected location to find recurring *problems* in carrying out activities in those locations. Problems were formulated as *design questions*. For example, we found that users in the elderly group often had difficulties in finding products at the mall. Consequently, we formulated a design question related to remembering what to buy and what was bought (see Fig. 2). We enclosed 1 to 3 stories (about half a page each) taken from our data to accompany each design question to facilitate concrete understanding of the design question. Design questions and related stories were stapled together and put into a carton folder that was delivered to each participant.

Ten bodystorming *participants* consisting of researchers and industry representatives were divided into two groups of five people. All of the participants

Fig. 1 Conducting bodystorming at a grocery store. Benches located near cashiers' desks provided a convenient place to observe customer activities without disturbing them. Carton folders were provided for hand-outs to support writing and preventing from losing papers

had at least a moderate knowledge of ubiquitous computing technologies. Within both groups, one researcher acted as a moderator and one researcher as a group leader. The *moderator* wrote down all ideas emerged in the discussions, and the *group leader* introduced participants to the design problem, decided when to conclude and to continue to next problem, and when to move to next location. On each location, one design question at a time was introduced to participants. The task was to propose a ubiquitous computing device that solved the problem. Each participant thought about the particular problem at-hand alone for 10 minutes and wrote down ideas to paper. These *design ideas* were then introduced to the group and discussed on-site, when possible. Based on the discussion, the group wrote down ideas as scenarios. A *scenario* (see Nielsen [22]) depicts a user, a problem, and a technological solution to the problem in a storylike format. Drawings and written text were used as media for scenarios.

In comparison to Cases 2 and 3, less effort was spent for preparations – one researcher selected the pieces from data related to the selected places, and on that basis another researcher made the design questions. In addition to preparation costs, we noticed that bodystorming conducted in this manner was exhausting for the participants and required several breaks during the day. Finally, we conducted a preliminary quantitative evaluation of the generated design ideas by calculating the proportion of ideas later accepted by our industrial partners for further development. This bodystorming session was moderately productive in this regard in comparison to other cases. We further discuss Case 1 in Sect. 2.5 and in the final section.

2.3 Case 2 – Bodystorming in similar location

The purpose of this bodystorming session was to investigate the possibility to conduct bodystorming in an easily accessible 'real-world' location that was not identical but only resembled the location visited by our users. In comparison to Case 1, where all the bodystorming locations were places visited by the users, the café in the present case was one from the office building of the authors. It was never visited by any of the users. It was thought that the selected café would share the essential contextual properties of those cafés mentioned in our data. In many respects, it was different, however. The table occupied by the participants was close enough to customers to make observations, but distant enough not to disturb them (see Fig. 3).

Fig. 2 A design question in Case 1 included a short title describing the problem, 5–10 lines of concrete description and a summarizing question. To facilitate the understanding of the practical aspects of the problem, few longer stories from user data were enclosed

Forgetting Product Information

Buying product supplies, for example writable CD's for a CD-RW, may require remembering several pieces of information about the product. On the other hand, some times we would like to remember specific details about some products we have seen at a store. For example, Elisabeth, an elderly woman, likes to browse new cosmetics products at her favorite supermarket. Since she is allergic to some ingredients, she has to carefully examine product information.

Q: How could technology help elderly people in remembering product information?

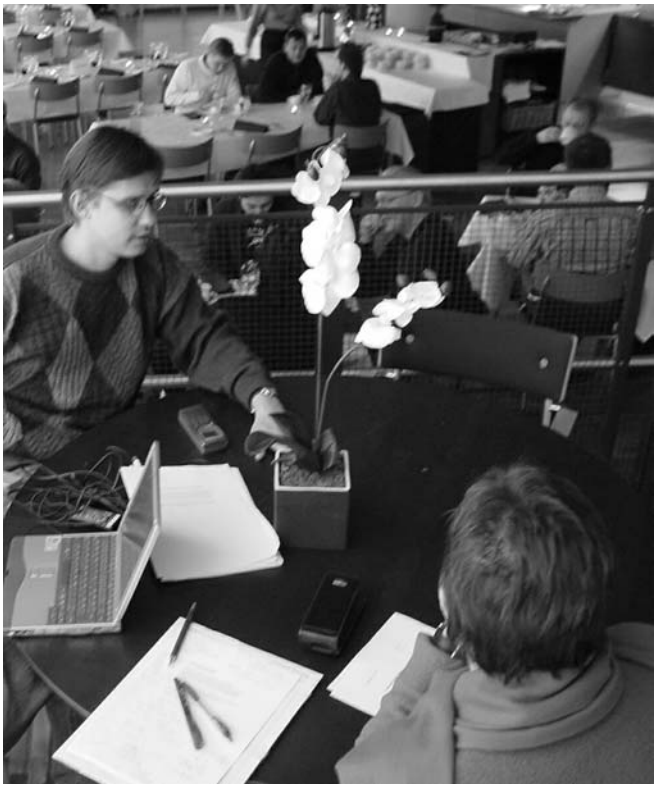

Fig. 3 Bodystorming session in a café resembling those visited by users. In many respects, however, it was different: The customers were businessmen instead of young urbanites and the view from the café windows was of seaside instead of city streets. The table occupied by the participants was close enough to customers to make observations, but distant enough not to disturb them

Materials and preparation were similar to Case 1. Design questions were elicited from a variety of stories related to cafés (see Fig. 4). This time, however, stories were not enclosed with questions. Only two design questions were included in this session.

Participants were mainly the same as in Case 1. Again, participants were divided into two groups of five people. The two groups went to two different cafés. In other respects, the method was similar to that described in Case 1. A question was introduced and each participant considered it alone for 10 minutes. All generated design ideas were then discussed within the group for approximately 20 minutes. In both groups, one researcher acted as the moderator and another as the group leader. The moderator wrote down all design ideas that emerged in the discussions. Afterwards, the two groups gathered back in the office. Moderators presented design ideas, which were then further discussed. Based on this discussion, the moderators later wrote down the design ideas as scenarios.

As measured by the number of product concepts later selected for further development, this session was not very productive. However, it was also the shortest. Since the context, a café, was very familiar to the participants, generated ideas were dominated by examples drawn from participants' own experiences in similar situations. Nevertheless, there was much discussion and evaluation of the innovated ideas. This kind of 'what if' talk was based on observing customers in the café – ideas were 'tested' on-site, as we proposed in Introduction. A café seems to provide a relatively relaxed environment necessary for this kind of elaborative discussion.

2.4 Case 3 – Bodystorming at office

The purpose of this bodystorming session was to investigate the possibility to conduct bodystorming in our own office. Without staging (see Case 4), we had to focus on only one of our five user groups, the journalists, whose user data were collected from an editorial office. The editorial office was, however, not accessible to a group of 12 outsiders. We thought that our own office would be similar enough to regard the session as bodystorming. It was different, however, in many important respects. For example, our office space had some open areas but mostly spaces separated by doors and high dividers (see Fig. 5), whereas the editorial office was an all open area, with low space dividers. In our office, majority of contacts to co-workers was made by email or phone calls, whereas in the editorial office, communication was mainly face-to-face and so on. None of the editorial activities were observable in our office. Because of these and other dissimilarities, this case was the 'weakest' bodystorming case presented here when considering the similarity between the bodystorming location and the studied location. Participants were required to imagine and mentally reconstruct many contextual factors of editorial office that were not present in our office environment (see Fig. 5). Had we not used office

Fig. 4 A design question in Case 2. No stories were enclosed with design questions in Case 2

Evaluating People

After work, Maria (23 yo) and Josefina (22 yo) can easily spend hours at Café Kafka. They like the big windows there. Josefina says that they can just sit there and look at all the people passing by, knowing that the people being watched cannot see them. They can freely talk about clothes and hair-dos of the by-passers.

Q: Observe people in one of the cafés downstairs. Design a system for categorizing and evaluating people.

Fig. 5 Bodystorming in an office. Resemblance to the studied environment, namely an editorial office, was minimal. Participants were thus required to imagine and mentally reconstruct many contextual factors that were not present in the directly observable office environment

related design questions, we would have considered this as a regular brainstorming session.

Stories of the journalist user group were examined beforehand to find interesting phenomena. Observed phenomena were formulated as design questions (see Fig. 6). No stories were included this time.

Participants were the same as in Case 2. Again, participants were divided into two groups of 5–6 people. Participants were given handouts describing the questions to be solved. Each participant considered the problem at-hand alone for 10 minutes, after which proposed solutions were documented and discussed in group for 20 minutes. Within both groups, one researcher acted as the moderator and another as the group leader. The moderator wrote down all ideas emerged in the discussions, and the group leader decided when to conclude and continue to the next problem. Afterwards, moderators presented the group's results to all participants and solutions were again discussed. Based on this discussion, moderators wrote down scenarios.

This session was considerably productive when measured by the proportion of innovated product concepts that were selected by our industrial partners for further development. The session was least time-consuming as it concerns preparations – one researcher examined stories suitable for the office context and formulated questions of interesting phenomena. However, we found that design ideas were dominated by participants' vast body of prior memories related to office environments, most likely because the similarity between the editorial office and our office is minimal. The bodystorming context thus acted as a trigger for office related memories, but did not encourage understanding of the *particular* situation. Thus, in cases where the studied location and activities are apparently familiar to the participants, the advantages of bodystorming over brainstorming may be negligible.

2.5 Case 4 – Bodystorming and acting in a staged office

The purpose of this case study was to bodystorm in a staged office. It was thought that staging would also allow us to try acting, which was impossible in Cases 1 and 2 where acting would have attracted unnecessary attention of real customers. Acting was thought to encourage empathy towards users. We thus expected that design ideas would be more sensitive especially to interactional and sociological contextual factors. The session was conducted indoors in our office space. The office was staged to resemble locations described in selected stories. Staged contexts included a cafe, bus interiors, a nightclub, and a bus stop (see Fig. 7).

Participants were mainly the same as in Case 1. After introducing the participants to the brainstorming process, they were divided into pairs. The pairs were evenly distributed to three *checkpoints*. In each checkpoint there were two researchers. In each checkpoint, 3–5 design questions (see Fig. 8) had to be solved by acting. Each participant played one role in the script. Participants were introduced to their roles and the design problem. Acting was carried out to the point where the problem occurred. The pair's task was to generate design solutions *ad hoc*. One researcher acted as the moderator and another as the group leader. The moderator wrote down all ideas that emerged in the discussions, simulated the innovated design ideas in use, while the group leader introduced participants to the problem and their roles, and decided when to conclude and guide participants to the next checkpoint. To encourage empathising,

Fig. 6 A design question in Case 3. No stories were enclosed

Informal Collaboration in Office.

Tero, an office worker in senior position, has the habit of fetching coffee from the office kitchen several times a day. After refilling his coffee mug, he usually stops by some co-worker's desk and talks about work-related topics. When Tero returns to his desk with the coffee mug, he often e-mails additional material to the co-worker.

Q: Think of other possible ways to enhance and invite informal collaboration in an office environment.

Fig. 7 Bodystorming and acting at a staged bus stop in Case 3. A cabinet with a 'bus stop' sign (in the background) was a marker for the bus stop. Participants were trying to solve a proposed problem by inventing ubiquitous computing technology applications. The narrow hall represented a narrow halting place with limited personal space. One researcher (on right) acted with participants

researchers asked such questions as: "What would your character do in this situation?" To probe innovation, researchers asked: "How could ubiquitous computing technology help in this situation?" If the proposed design was based on an old technology (e.g. mobile phone), the moderator probed further thinking by asking participants to propose alternative solutions; for example: "What other solutions can you imagine?" or "Is there something in the environment that could involve ubiquitous technology?" Some of the innovated ideas were simulated with paper mock-ups quickly drawn by a researcher. Proposed solutions were then acted with the mock-ups. Afterwards, collected ideas were discussed in a larger group. Based on this discussion, moderators wrote down design ideas as scenarios.

This session was moderately productive when measured by the number of innovated product concepts selected for further development. However, some drawbacks were observed. Some participants commented that acting was difficult. Indeed, within only one session of practice, it can be hard for, say, a 40-year-old businessman to play a role of, say, a 20-year-old single woman. In such a situation, acting seemed as an unnecessary factor frustrating participants. This frustration was often managed by jokular overacting, very much opposite to the original goal – that is, emphasising users in action. This is understandable, because, in contrast to Buchenau and Fulton Suri [17], we did not have a possibility to practice acting in the guidance of a professional actor. Participants also felt that the method of 'forced innovation' (requiring participants to come up with new technological solutions) was exhausting, especially when it required imagining some aspects of our world as unexisting. For example, the participants insisted that many of the problems could be handled with a simple mobile phone call, which was categorically excluded by the method. Because innovations could not be built on existing practices and technologies, some ideas turned rapidly into science fiction, which again amplified the negative loop and made acting even more difficult. Requiring pairs to innovate a proper solution to every problem on-hand, however, enabled us to gather rather many independently generated ideas. In addition, necessary preparations for the session, such as setting up the work place to resemble user data locations, selecting suitable stories, formulating questions, and sequencing the checkpoints to form a temporal continuum were time-consuming, requiring approximately two days of work from four researchers. Moreover, acting and playing with the paper mock-ups was rare due to implicit assumptions on the "obviousness" of the proposed solutions.

2.6 Evaluating results

We shall now discuss whether 'being there' in design session has any value for ubiquitous computing community. It was speculated that bodystorming would reduce the amount of time needed to get familiar with the data. There seems to be at least two threats to that

Fig. 8 A design question in Case 3

Missing a Bus

Ann-Sofie has promised to her friend Berta that she would take care of Berta's children this evening. On her way to Berta's house, and having picked up own her kids, Ann-Sofie stops at a fast food restaurant to eat. After finishing her lunch, Ann-Sofie takes her kids with her and rushes to a bus station at Kamppi. Unfortunately, they miss the bus.

Q: When is the next bus leaving? How could Ann-Sofie inform Berta about being late? How could an ubiquitous computing service help Ann-Sofie in this situation?

benefit. First, preparation costs in bodystorming are considerable, especially with staged contexts (Case 4). Secondly, training costs are also noticeable. Since this is a novel method, participants must be trained during several sessions. Only over several sessions can bodystorming eventually become less time-consuming than brainstorming.

In the Introduction, it was also proposed that bodystorming would facilitate the acquisition of more accurate conceptions of the problem domain. To evaluate this claim, we decided to compare the design ideas generated in our traditional brainstorming sessions to those generated in the four bodystorming cases[1]. This comparison is justified, since the methods in bodystorming and non-bodystorming sessions were very similar. Brainstorming sessions were carried out in our office in a similar fashion as bodystorming: Participants were divided to pairs or small groups and given sets of stories describing activities related to the same phenomenon. In contrast to the bodystorming sessions, however, design questions were not given, but participants themselves had to find interesting patterns from the stories. Each pairs' task was then to create a scenario as in bodystorming. Brainstorming sessions were carried out interspersed with the bodystorming sessions.

We first compared the mere number of ideas between the two methods. There were no differences in the number of ideas selected by our industrial partners for further development. No salient qualitative differences were found when we compared ideas collected by the methods side-by-side. Ideas gathered from traditional brainstorming sessions did not seem to be more or less 'sensitive' to physical, social or interactional details than ideas from bodystorming sessions. Finally, we asked an interaction-oriented sociologist to evaluate our scenarios' sociological and interactional plausibility. His comments were categorized as negative (i.e. doubts whether users would actually behave in a way described in the scenario) or positive. For brainstorming and bodystorming, 43% and 42% of the scenarios were satisfactory, and 33% and 32% of them unsatisfactory, respectively, according to the expert. However, it should be kept in mind that these comments represent opinions of only one expert, who was not able to thoroughly consider the issue in the limited time frame, and that the underlying data set is small. In sum, both methods seemed to be equally 'sensitive' to contextual factors.

Nevertheless, when we examined the ideas as a temporal continuum starting from the first session, we made an interesting observation: Several ideas that emerged during bodystorming sessions were 'reinvented' in later sessions, be they brainstorming or bodystorming. It seemed that the ideas invented during bodystorming were highly memorable and inspiring. Enacting activities is known to facilitate later recall [23]. Bodystormed experiences might indeed be better remembered and utilized in later design sessions. We also observed that researchers, after a bodystorming session in a previously unfamiliar place, were more eager to further continue with stories related to that place or related activity. Bodystorming thus seems to inspire researchers to get familiar with new contexts (e.g. elderly service house in Case 1).

We acknowledge, however, that the evaluation presented here is tentative. Complex creative processes like bodystorming or brainstorming are difficult to subject to rigorous experimental control. Several factors are confounded when comparing results from the present case studies to results from brainstorming sessions: participants were different from one session to another; lengths of the sessions were different; different questions were asked and different stories studied in different ways; etc.

The third claim made in the Introduction was that bodystorming allows us to 'test' our hypotheses on-site; that is, directly observable environment allows simulating or imagining how the generated ideas will appear. In Case 4, where mock-up simulation of ideas was required, testing did not work out as well but only caused frustration. In Case 2, however, we noticed that participants spontaneously evaluated the proposed ideas by discussing what contextual factors could hinder their use.

3 Discussion

This paper presents a first attempt to use bodystorming in the design of ubiquitous computing applications. The first purpose was to present the method. We presented in detail how data was collected and prepared for the sessions, how the design questions were formulated, how the bodystorming locations were selected, how the sessions were administered, and the collected ideas evaluated. Across the four case studies, the importance of three factors were studied:

1. *Similarity of the bodystorming environment to the studied environment* was considered an important factor, and identical or very similar locations preferred over staged, because of getting accurate conception of the studied activity. The ability of bodystorming participants to observe the environment directly is necessary. In carrying out bodystorming sessions, one should favor selecting easily accessible locations where the design team can have an unobstructed view to the activities.
2. *Acting out* was observed to be frustrating and causing costly preparations. It was speculated, however, that acting could be useful in the long run when participants can get used to the method.
3. *Inclusion of stories* from user data to accompany design questions was considered useful, although not necessary.

[1] Since it would be unfeasible to present all scenarios, and because some of them are selected by our industrial partners for further development, we do not present the scenarios here. However, some scenarios are presented in another paper by A. Kankainen and Oulasvirta [22].

Concrete stories can help researchers to focus participants' attention to different aspects of context that would otherwise easily go unnoticed. In addition, we stress the importance of a skillful group leader that is able to probe participants to discuss how design ideas would work in the observable context. Moreover, we noticed that independent of the quality of the instructions given or roles taken, participants inevitably participated bodystorming as themselves. To be freed from tensions and reservations is not always straightforward because potential social sanctions are not projected to our role characters but to ourselves as employees, bosses, clients and producers.

An observed limitation to the method is that some activities or locations are not accessible. Some locations are not *physically accessible*. For example, entering private homes is often out of the question. In such cases, staging might be an option (Case 4). Some activities, on the other hand, are not *cognitively accessible*. Such activities require prolonged participatory observation or training to be understood (e.g. Hutchins [24]). Some activities are not *socially accessible*, by which we mean that the presence of a group researcher taking notes and discussing can change the studied activity itself. Our solution to this problem was to find a location where bodystorming participants did not attract particular attention (see Figs 1 and 3). A potential threat is, however, that we easily look up for the protection of a quiet corridor or corner table of a cafeteria, thereby organising our bodystorming or brainstorming session too isolated from the outsiders, the real users of the space. Finally, some activities are not *ethically accessible*, such as health care centers. Even though our focus was on frequent, everyday activities shared by a group of people, these practical limitations were apparent.

We also noticed two important factors that affected what aspects of the context participants attended to in bodystorming. Background information in most of our questions was narrowed to one dimension of context, the setting, as defined by Goodwin and Duranti as ''the social and spatial framework within which encounters are situated'' ([25]; see also Fig. 1). This dimension includes institutional roles of users and other aspects of extrasituational context [26], but does not deal with actions through which people, at will, can enable contexts or frameworks of activity. We do not know how this focus affected the quality of the generated ideas. Selection of location also affects the focus. For example, in Case 4, in the process of staging the office space we implicitly selected some elements and disregarded others (see Fig. 7) that may have an importance in reality.

The second purpose was to evaluate the method's suitability for the design of context-aware applications. In the Introduction, we presented arguments why bodystorming could benefit researchers and practitioners in context-awareness. We hypothesised, first, that being physically present in the 'real' environment saves time from the design group in studying user data. However, in the case studies, this was observed to hold only in a long run when time costs from preparations are minimised. Secondly, it was hypothesized that bodystorming would provide more accurate understanding of contextual factors. Our comparison between brainstorming and bodystorming does not give direct support for this claim, but the issue needs further attention. Bodystorming sessions were considered, however, more memorable and inspiring. Thirdly, bodystorming was thought to provide immediate feedback for generated design ideas already on-site. In the case studies, it was observed that this kind of evaluative and elaborative thinking required a relaxed atmosphere.

Finally we want to emphasise that bodystorming should be viewed as complementing, not replacing, other methods in the design of contextually sensitive applications. Ethnography is largely based on long-term stay within a culture, conversation analysis on tape recorded data distributed and analysed in data sessions, and contextual design on the simultaneous use of several representation formats. In respect to these methods, the contribution of bodystorming lies in the utilisation of collected user data in a contextually situated design session. This provides a possibility for a larger group of people not familiar with the data to innovate product concepts.

4 Conclusions

To summarise, bodystorming should be seen as a way of working (and playing) with data in embodied ways, 'being there'. Bodystorming seems particularly suitable for getting familiar with unfamiliar activities in easily accessible locations. Embodiedness and creative problem-solving on-site will enhance understanding of the problem domain. Bodystorming therefore seems useful for the design of context-sensitive computing applications. We continue to examine variations of the method by conducting case studies. For example, the third author of this article is involved in a project where professional actors, scriptwriters and dramaturgists cooperate using a bodystorming-like improvisation method. The aim is to convey technological scenarios to a broader audience.

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