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Back in Sight, Back in Mind: Picture-Centric Support for Mobile Counseling Sessions

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ABSTRACT
This paper explores unique challenges of mobile consultancy and offers a picture-centric solution. We study the example of a policeman counseling a homeowner on how to prevent burglary. As in a stationary set-up, consultants and clients collaborate to co-create solutions to match the clients' problems. Concurrently, in a mobile set-up, problem and solution information are bound to the physical environment of the house. Moving through the house, both clients and consultants forget crucial location-bound information, severely impairing their collaboration. We propose supporting such collaboration with a tablet-based application that is centered on pictures of the physical environment, called *SmartProtector*. In an evaluation, we show that both clients and consultants remember substantially more information when using the *SmartProtector*. With this study, we contribute to the ongoing research discussion on collaborative memory, memory aid systems and mobile collaboration, highlighting the roles of pictures and their large potential to enhance collaborative work practices.

Author Keywords
mobile collaboration; collaborative memory; memory aid; counseling service; working with pictures; design science

ACM Classification Keywords
H.5.2 [Information Interfaces and Presentation]: User Interfaces – Screen design

INTRODUCTION
Mobile counseling sessions between a consultant and a client, e.g., crime prevention counseling or energy counseling sessions at a client's home, are knowledge-intensive and require high cognitive capabilities from both actors. A mobile counseling session is a collaboration between a consultant and a client, where first, the physical environment is an essential part of the collaboration, containing crucial information. Second, the actors are moving around during their collaboration collecting information from the surrounding environment. In such mobile collaborations, actors not only have to exchange information with one another but also need to process information from the surrounding environment. In our investigation of mobile crime prevention counseling, we observed that while consultants and clients move through the client's house, they frequently forget crucial location-bound information: in their on-site discussions, consultants and clients refer to physical objects in their immediate surroundings to explain specific issues, e.g., the front door with a specific lock. Once they move on, they struggle to remember detailed information related to this object, e.g., the particular type of door lock. As a result, they have to interrupt their collaboration to bring the respective information "back into mind", by, e.g., physically revisiting the front door. We refer to this generally well-known phenomenon as the "out of sight, out of mind" (OOS-OOM) phenomenon. This forgetting, as well as the individuals' strategies of dealing with it, shapes - to an amazing degree - the process of mobile counseling sessions and how actors behave and interact with one another.

These cognitive challenges have been addressed by current research. In the psychology research literature, the cognitive capabilities of individuals and the role of the physical environment thereupon are discussed extensively [cf. 27,28,31]. Research on memory aid systems highlights suitable technical support to recall information [cf. [11,15,16,21]. However these current research discussions address mostly the individual level or single-user scenarios, and insights on the cognitive aspects in mobile collaborations and how the individuals' cognitive capabilities influence their collaborative behavior are scarce. To provide appropriate support, it is important to understand the role of the OOS-OOM phenomenon in mobile collaborations. This brings us to our first research question: **RQ1**: *How does forgetting influence mobile counseling sessions*?

The cognitive aspects in collaborations are broadly discussed in research on computer supported collaborative work (CSCW). Researchers provide high-level insights on the concept of *collaborative memory* [2,24] and extensively discuss how to support collaboration partners to create and use a collaborative memory [1,2,19]. However, current research focuses mostly on stationary scenarios, and insights on the novel challenges and their influence on group members' cognitive capabilities and the creation of a collabora-

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tive memory are lacking. Current research on mobile memory aid systems addresses the individual's cognitive capability, and presents diverse solutions to facilitate memory cue creation [15,16,21]. However, research insights on suitable support accounting for multiple users are scarce. Both the collaborative situation of the client-consultant relationship and the mobile setting give rise to new challenges for developing suitable support systems. We thus asked ourselves how an appropriately designed "memory aid" could support actors to create and use a collaborative memory in their mobile collaboration. After reviewing related literature on psychology research, CSCW-research and memory aid systems, as well as discussing different design options, it was "working with pictures" that turned out to be a surprisingly useful concept for responding to the characteristics of mobile collaborations and to bring information back into the minds of the actors. Thus, in this study we further pursue the second research question **RQ2**: *How can pictures improve the memories of consultants and clients in their mobile collaboration?*

We follow a design science research approach [7,23] for providing an in-depth problem specification and designing a concept for picture-centric mobile counseling support. We instantiate the concept in the *SmartProtector* prototype, that supports consultants and clients in their mobile crime prevention counseling sessions and evaluated it in a user test with real consultants and clients. By means of our exemplary instantiation of the picture-centric support, we highlight the powerful roles of pictures in mobile collaborations supporting all participants to overcome the cognitive challenges from the OOS-OOM phenomenon and establish a fruitful collaboration. Finally, we discuss the meaning and effects of our insights: on current CSCW research on collaborative memory, on memory aid systems research and on counseling support systems research. This research output is relevant beyond the emerging research stream of mobile counseling services. It can be generalized to other face-to-face collaborations between actors where the physical environment contains crucial information, e.g., an architect discussing structural changes with workers at a construction site.

RELATED WORK

The mobile counseling encounter between consultants and clients represents a knowledge-intensive collaboration. The main objective of this consultant-client-collaboration is to enable clients to resolve their problems on their own [33]. To reach this objective, they develop solutions (the consultant's area of expertise) that suit the client's problems (the client's area of expertise). To explore clients' problems in the mobile counseling session, the consultants and clients move from one physical problem object (e.g., the kitchen window) to another, thereby continuously integrating new information originating from the changing physical environment. These interactions require high cognitive capabilities from participants, as they constantly need to remember, exchange and process information.

The actors' cognitive processes not only comprise the individual's internal mental processes, but also their interactions with others as well as with the physical artifacts in the surrounding environment. In this context, the changing environmental context can influence individual's cognitive capabilities considerably. In psychology research literature, researchers discuss extensively the individual's cognitive processes and the role and effects of the environmental context on an individual's cognitive capabilities [cf. 3,8,10,27,28,31]. Studies report on different effects (e.g., environmental reinstatement [28], where changing the physical environment causes individuals to remember fewer memories) and propose measures to reduce the resulting context-dependent forgetting (e.g., multiple-learning-context-technique [27], where individuals learn information in different environmental contexts rather than one). Whereas these studies provide useful insights on how to enhance a human's cognitive capabilities, they mainly discuss them on the individual level, when reporting on several actors and how they influence each other's memories, discussions remain mostly conceptual. These interactions between actors can enhance individual's cognitive capability, e.g., by either cross-cueing [9], where information from others trigger memories of an individual that s/he would not have remembered alone, or impair it, e.g., by the "outshining"-effect [28], where an individual's memories are "outshone" by easier-to-access information. However, current research studies barely provide insights how corresponding effects influence actors' behaviors in collaborations.

Current research on counseling support systems investigates consultants' and clients' collaborative work practices from different perspectives. Novak [17] describes the hampering effects of *information overload* in shared problem solving, where actors' ability to make decisions deteriorates due to the presence of too much information. Novak and Schwabe [18] highlight the impact of *sticky* information that is bound to a specific location (physically, mentally) aggravating the exchange of information. Nussbaumer et al. [20] discuss the information asymmetry between consultants (as experts) and clients (as laypersons), and report on the negative effects, thwarting collaborative interactions. Schmidt-Rauch and Nussbaumer [25] give insights into actors' collaborative task of co-creating the value of counseling and show how to design appropriate support to help them becoming more equal co-creators. In their solutions, these researchers give insights into collaborative work practices in counseling collaborations, showing how technical support systems should be designed to support users appropriately. However, they rarely consider the individuals' cognitive aspects in storing and recalling information, and do not discuss how they influence the individual's collaborative behavior. Furthermore, they focus mostly on stationary scenarios, disregarding the actors' physical environment and its role and effects within the consultant-client collaboration.

Current research on memory aid systems attempts to increase individuals' cognitive capabilities. Lin et al. [15], for

instance, describe how micro-notes support individuals in recalling memories. They claim that for ideal support: corresponding technical devices need to be continuously present and the phase of recording should be simple and fast. In a health-related context, Palen and Aalokke [21] analyze how elderly manage remembering to take their medicine, and derive principles for the design of assistive health technology, e.g., technology by invitation or support of personalized medication management. Similarly, McGee-Lennon et al. [16] formulate technology guidelines for assisted living, addressing design aspects like personalization, autonomy, or shared spaces. While these studies provide useful insights into designing IT-based memory support, they focus mostly on single user scenarios, neglecting the influence of human-human interactions on individuals' cognitive capabilities. These interactions between actors can affect the individual's cognitive capability (e.g., by cross-cueing [9]) or impairing it (e.g., by the "outshining"-effect [28]).

Since the 1980s, researchers in CSCW-research discuss extensively the support of synchronous collaborations [cf. 1,2,12,13,14,19]. One of the core discussion topics is how actors can create and use a shared *collaborative memory* [2,24], for larger groups it is also called group memory. Collaborative memory describes a common repository containing the issues and minutes of a group discussion so that it is available for future review by the collaboration partners [2,24]. It is required to get a tangible product at the end of collaboration [14] as well as to have partial results of single collaborative tasks to be reused during ongoing collaboration [2,19]. Collaborative memory is created during the actors' information sharing activities. Specifically, actors have to share information in a "memory-able" form, meaning that it could be reused for later recall of information, e.g., writing on a flipchart to explain an idea and refer to the writings in a later discussion. The lack of an effective collaborative memory has been found to negatively affect group member's task performance and decision making [1].

In the current research discourse, researchers extensively discuss how to create collaborative memory during group work. Kane et al. [14], for instance, discuss the creation and validation of collaborative memory. They describe the fundamental preconditions, that collaborative memory should be created without diverting from the face-to-face collaboration, it should require only little (if any) processing, and provide for a multitude of potential uses. Kalnikaite et al. [12] address the specific note-taking activities of individual actors during collaboration. Their solution based on automatic speech recognition and annotation possibilities, should reduce the individuals' cognitive workload in order to maintain their verbal contribution to the collaboration while taking notes. With their "Livenotes"-system, Kam et al. [13] present a solution for cooperative note-taking between students, emphasizing the value of co-created notes to facilitating more efficient reuse of collaborative memory.

Current research studies in CSCW provide useful insights on the creation and use of collaborative memory, describing how corresponding support can be designed and applied. However, researchers focus mostly on stationary collaborations and rarely discuss mobile collaboration scenarios and the novel challenges that occur. It is important to understand these challenges and their implications on the design of suitable support systems: The integration of the changing physical environment in the mobile collaboration can increase the cognitive workload for the actors substantially, causing them to struggle more with information overload and ultimately hampering their collaborative work severely.

RESEARCH APPROACH

To answer the research questions, we followed a design research approach proposed by Peffers et al. [23], consisting of six activities to be followed when conducting a design science research project: 1) defining and justifying the research problem, 2) defining the objectives for a solution, 3) designing and developing the artifact, 4) demonstrating the use of the artifact, 5) evaluating the artifact and 6) communicating the results. We address these activities in the following four sections:

Problem specification: To answer the first research question (RQ1), we engaged in the first activity of justifying the core problems that consultants and clients experience due to the OOS-OOM phenomenon. We conducted an exploratory field study in the context of mobile crime prevention counseling services. In November 2012, two researchers conducted semi-structured interviews with four clients and two consultants from the crime prevention department of the police of a major Swiss city. The clients for the semi-structured interviews were randomly selected from the usual clients of the police's counseling service. Furthermore, the researchers observed the same two consultants in three counseling sessions (one consultant twice) with three additional clients, and interviewed the consultants and clients afterwards to uncover their collaborative behavior. These three clients were also randomly selected from the police department's usual clients. The observed counseling sessions lasted 45 minutes, on average. The observation guidelines and the interview questions were based on: Wilson's model of human information behavior [35], the *needs-driven approach* [26], and the *servqual* measuring tool [22].

Design: To address the second research question (RQ2), we engaged in further activities proposed by Peffers et al. [23]. We first derived specific goals that an artifact resolving the OOS-OOM-related problems should accomplish (activity no. 2). Second, we described the key design ideas for picture-centric mobile counseling support and comprehensively illustrated our design rationale, based on current research literature. Third, we implemented a prototypical system to support consultants and clients in their mobile crime prevention counseling sessions (activities no. 3 and no. 4).

Evaluation: We applied experimental techniques to evaluate the extent to which the developed artifact helped accomplishing the goals. We conducted a within-subject user

test, where the same two consultants from the police gave advice to 12 clients (activity no. 5). Detailed set-up of the experiment is described in the evaluation section.

Discussion: We discussed the findings of our research, highlighting the powerful roles of pictures in mobile collaborations. We discussed the meaning and effects of current research on CSCW research, memory aid systems and counseling support systems (activities no. 6).

PROBLEM SPECIFICATION: COGNITIVE CHALLENGES IN MOBILE CONSULTANT-CLIENT COLLABORATIONS

The mobile counseling session is characterized by intensive information exchange: between consultants and clients, and between the actors and their physical environment. All information has to be memorized, processed and integrated into the problem-solving activities to advance the collaboration, working toward the counseling objective to develop solutions matching the client's problems. These solutions may not be accomplished without input from both actors. The client provides information about her needs and preferences (her area of expertise) and the consultant provides information about possible solutions (his area of expertise). Thus, solutions developed in the counseling session must be co-created. The consultant and the client get involved in expert-layperson collaboration, where their respective roles can influence their respective behavior substantially.

Current work practices in crime prevention counseling

A normal citizen not only has little knowledge on crime prevention but also has difficulties in explaining her problem situation. Therefore, a consultant from the police visits the client "on site." In a briefcase, the consultant carries paper-based standardized information on home security or fact sheets on security products, i.e., security locks or safes.

In the counseling session's first phase, the consultant and client move around the house exploring the physical problem objects, where burglars could break in, "on site" (e.g., the front door). They collectively examine structural weaknesses while exchanging information to establish a shared problem understanding. The client provides information about her needs; the consultant asks detailed questions to refine the problem understanding. He also addresses simple solution possibilities, e.g., "always turn the key in the lock twice." During their tour around the house the consultant carries his briefcase with him, but usually does not make use of it. We call this phase the *"mobile exploration" phase*.

In the second phase, the consultant and client sit together at a central location, e.g., the client's kitchen table. They readdress the problems verbally and discuss possible solutions. In their discussions, the consultant takes some brochures and flyers from his briefcase to show the client standard product information, e.g. a security lock information sheet. Meanwhile, the client provides the consultant with information about her criteria for suitable solutions, e.g., price range. Together, they evaluate the different solution possibilities in order to choose the most suitable one. We refer to this second phase as the *"discussion" phase*.

Finally, the consultant creates the final product of the counseling session, the "security plan." This consists of a few handwritten notes, e.g., on buying a new door lock or an alarm system. Together with some product brochures, the consultant hands over to the client the notes that document the collectively developed security recommendations.

The OOS-OOM phenomenon in crime prevention counseling sessions

In their mobile crime prevention counseling sessions, consultants and clients face a number of cognitive challenges. In the following paragraphs, we report from an explorative field study (cf. research design section for details) where we identify the most influential collaboration problems caused by the OOS-OOM phenomenon.

The client forgets: the problem of information incoherence

The clients in all observed counseling sessions reported that although they could remember the developed solutions, they could not remember all discussed details regarding the corresponding problems. As a result, they were later unable to sufficiently explain the solutions, e.g., to their partner or a security firm's employee. One client stated: "As I told my husband about the lock bars, I remembered the consultant saying something about the bathroom window, but I couldn't recall it […]. We had to call the consultant, who told us that our wall was too thin." (All quotes were translated into English by the authors). The consultants also mentioned this issue: "Quite often, clients come back after some months, to ask again how a solution fits their problem […] extremely time consuming." Furthermore, there were negative effects during the actual counseling encounter: all three clients repeatedly had difficulties in understanding the explanations of the consultant and interrupted the counseling process with clarifying questions, e.g., "This safety lock should be applied where? The front or the terrace door?" A major reason for the clients' shortcoming was the lack of environmental context in the "discussion" phase of the counseling session. Differing environmental contexts negatively affect an individual's capability to remember information significantly [27,28]: The client cannot sufficiently link the solutions to the corresponding problems. We refer to this as the *problem of information incoherence* ***(P1)***.

Why traditional pen-and-paper is insufficient: The paper-based documents that consultants mostly use consist of standardized information. These technical drawings or standard product fact sheets often do not match the actual problem object. As a result, the consultant's solution explanations detach even further from the original environmental context of the problem and increasingly impede the client's efforts of recalling the corresponding context.

The consultant forgets: the problem of outshone information

In their discussion on-site of a physical problem object, consultants provided solution information constituting an important part of the final solutions. However, our observation revealed that none of the consultants re-addressed these solutions and thus did not include them in the final security plan. As a result, the clients missed important information for later implementation of the solutions. We explain this forgetting via *the outshining effect* [27,28], which describes the effect when memory cues bound to a specific environment are later "outshone" by stronger, non-contextual memory cues, e.g., verbal cues [28]. The consultants also referred to this *problem of outshone solution information (**P2**)*. One consultant stated: "I would mention this information in the final discussion, if I remembered it […] I rely on my documents to explain the security measures and hardly remember other measures I proposed."

Why traditional pen-and-paper is insufficient: The standardized documents provide consultants with context-independent memory cues. These cues help them to recall information about the specific product, e.g., the price of a security lock. But they do not help them to recall previously discussed solution information, as these memory cues do not contain information about the physical problem objects. In the end, the context-independent memory cues in the documents "outshine" the more-difficult-to-access mental cues on the solution information discussed on-site.

Consultant and client fail to synchronize: the problem of asynchronous information levels

The counseling encounter is also a collaboration between an expert and a layperson [25]. Consultants take on the role of experts, applying their expertise to establish a shared problem understanding with the client, enabling them to co-create suitable solutions. However, the knowledge and experience asymmetry causes the consultant and client to show different cognitive behaviors, affecting their collaboration negatively: In the "discussion" phase of the observed sessions, the client (as layperson) at some point faces more difficulties than the consultant in recalling the "out of sight" problems. Clients needed clearer and/or more memory cues to remember the location-bound problems and start lagging behind in their mental processing. Our observations revealed that the lack of a clear understanding of a problem hindered the client from participating as active co-creator in the development of solutions. Two clients specifically mentioned this aspect of "can't contribute to developing the solution" in the interviews. Additionally, the clients' delayed mental processing also resulted in delayed comprehension questions, disrupting the counseling process. As a result, consultants repeatedly had to help the clients to re-establish a sufficient understanding of the problem before proceeding with co-creating solutions. In two cases of the observed counseling sessions, this even forced actors to interrupt their discussions since they needed to revisit the physical problem object to renew their problem understanding. The measures of re-synchronizing the information levels increase the cognitive workload for both actors and complicate developing a coherent security plan. We refer to this as the *problem of asynchronous information levels (**P3**)*.

Why traditional pen-and-paper is insufficient: The paper-based documents (e.g., product fact sheets) do not provide any information about the client's actual physical problem objects. In consequence, consultants and clients have to depend on their cognitive capabilities to recall the problems in their mind and link them to the solution information presented in the standardized brochures, thus increasing the actors' cognitive workload substantially.

In answering RQ1, we identified three problems representing the negative influences of the OOS-OOM phenomenon on the mobile consultant-client collaboration. To show how an IT-artifact can be designed to support consultants and clients to overcome the identified problems (P1 to P3), we derive three specific design goals.

First goal (addressing P1): The clients' difficulties in linking received solution information to the individual location-bound problems (P1) affect them severely, not only during their collaboration with the consultants (inability to actively collaborate), but also after the counseling session (restricted ability to implement the solutions). Thus, we formulate a corresponding first design goal *to improve linking of location-bound problem and solution information*.

Second goal (addressing P2): Both actors frequently fail to recall essential information during their collaboration: 1) the consultant forgets essential parts of the solution when they get "outshone" and 2) the client struggles to link the problems with the developed solutions, as the missing local context hampers their recall. To help the consultant access the "outshone" solution information and the client to recall "out of sight" information, we state a second design goal: *to improve the recall of problem and solution information*.

Third goal (addressing P3): The missing synchronicity of the actors' cognitive processing strongly influences the mobile collaboration between consultants and clients, and thus hampers their joint problem-solving activities. Therefore, a supportive artifact should *increase information synchronicity between consultants and clients*.

SOLUTION: PICTURE-CENTRIC MOBILE COUNSELING

The OOS-OOM-phenomenon can strongly affect consultants and clients in recalling information. To respond to the identified challenges, we designed the concept of a picture-centric mobile counseling service addressing the developed goals and instantiated this concept in the *SmartProtector* (an 11.6' tablet computer with the corresponding software).

Key design ideas

To show how a corresponding artifact should be designed to address the occurring challenges in mobile collaborations (RQ2), we developed a set of key design ideas. These design ideas can be seen as technological guidelines that

should be considered when developing IT-artifacts supporting mobile collaborations between consultants and clients.

"Taking pictures" *for fast and simple externalization of information:* To facilitate linking location-bound problems with solutions (first goal), consultants and clients need a profound problem understanding. When they manipulate shared external representations, they explicate their meanings and beliefs, thus facilitate establishing a shared problem understanding [30]. Thus, external representations may encourage the client to become an active co-creator, helping her to internalize the problems. In the mobile counseling session, the actors need to capture the physical environment, containing the problem, and create external representations. In doing so, the pictures become external memory cues reminding actors of previously discussed ideas [30]. They can facilitate actors' cognitive process by serving as substitute reference for the actual problem object [3]. Externalization of information should not disturb the evolving consultant-client-relationship. Thus, the switching cost between problem exploration and memory cue creation should be low, as Lin et al. called for in their work [15]. Hence, we argue that supportive artifacts should *enable users to take pictures* (design idea 1) for capturing the physical environment and easily document discussed problem information.

Figure 1. Picture-centric notecard in the *SmartProtector*

"Drawing on pictures" *to create memory cues:* We argue that "taking pictures" alone does not suffice. For better recall of information (second goal), the information that matters on the picture needs to be highlighted to differentiate surrounding context from kernel memory cues. Customizing the representation can support reasoning and problem solving [10]. Additional explanatory information on the problem object needs also to be added to the corresponding picture to link them together (third goal). Similar to "taking pictures," actors need to make these refinements without disturbing their work relationship. Drawing on the pictures constitutes a suitable means to add additional information, not only because it is an intuitive and self-evident action on pictures, but drawing and the actors' concurrent verbal discourse occupy different mental resources (visual and verbal) and thus can prevent increasing the cognitive workload of the actors [cf. 34]. Furthermore, memory cue creation activities need to be quick and easy [15]. Therefore, we argue that supportive artifacts should *enable drawing on pictures* (design idea 2) to allow users to create additional memory cues. Therewith, actors should be able to better integrate the memory cue creation activities into their ongoing verbal discussion. Figure 1 shows the picture that the consultant and the client took from the front door and on which they draw additional information about structural weaknesses.

"Creating picture-centric notecards" *to promote cross-linking location-bound problem and solution information:* In the mobile counseling session, the problems are mostly discussed on-site of the physical problem object (cf. Figure 2), whereas the discussions of solutions take place location-independent, e.g., at the kitchen table. Thus, it is useful to cross-link the pictures of the individual problems, e.g., a door lock, with corresponding solution information, e.g., a product information sheet. We argue that creating these links by adding solution information to a picture of an individual problem should preserve this connection (first goal). Therefore, we propose that supportive artifacts should enable actors to *create picture-centric notecards* (design idea 3). These notecards contain the problem information organized around the physical problem objects' picture and provides additional means to externalize information on solutions. The picture-centric notecard can function as boundary objects that both actors can use to explain their thoughts and ideas on discussed problems. Boundary objects are objects that are shareable across different problem solving contexts [5], thus can help to establish a shared context [29]. The picture-centric notecards can facilitate establishing a shared understanding as starting point for collaborative problem-solving (third goal). Integrating picture-centric notecards as integral part of the collaboration allowing them to physically refer to the problem objects (or their representations), which can facilitate their cognitive processes [3].

Figure 2. The *SmartProtector* in use during mobile exploration

Working with pictures as a simple, but surprisingly powerful concept

"Working with pictures" is a simple, but powerful core concept. Pictures serve as shared artifacts and boundary objects. Both consultants and clients can create their shared understanding based on a jointly viewed picture and process it with their individual cognitive capabilities. Pictures can also serve as collaborative memory aid, allowing both actors to recall information concurrently, to synchronize their knowledge levels and help them to collaborate more effectively. Furthermore, pictures are useful information carriers:

drawing on pictures enables the actors to refine the information content and create a more in-depth problem description. The actors can distribute the multitasking workload of documenting information and discuss it on different mental resources, thus facilitating their collaborative work [34]. "Taking pictures" captures a lot of information in a very short time. Writing down the information allows users to create more personal memory cues, but creating them takes too much time. Recording on video would be a fast and easy way to store information, but reviewing continuous video data during collaborative work is simply impractical [11]. Thus, we argue that taking pictures, drawing on them and referring to them in later discussions will overcome the deficiencies of current approaches and allow users to establish a balanced effort-benefit ratio to store and recall information. Figure 3 summarizes the roles of pictures in our picture-centric support concept for mobile collaborations.

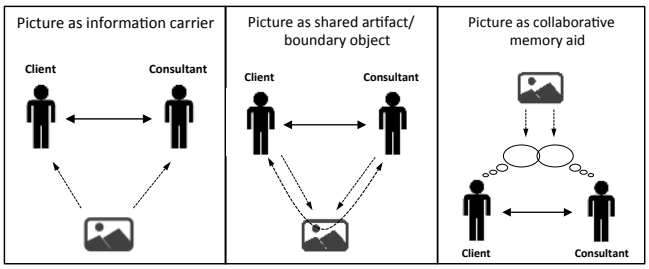

Figure 3. The roles of pictures to support mobile collaborations between consultants and clients

EVALUATION

Following the methodology of Peffers et al. [23], we assessed the extent to which the IT-artifact helped to accomplish the formulated goals (cf. problem specification section). We evaluated the *SmartProtector* in a within-subject test (in April 2013), collecting data about the differences between conventional and artifact-supported counseling sessions. The two consultants from the police gave advice to 12 clients (12 conventional and 12 artifact-supported sessions). Each client received one conventional and one artifact-supported session (experiencing both consultants). Afterwards they reported on the differences between the two sessions. Each consultant conducted six conventional and six artifact-supported counseling sessions in alternating order. Afterwards, they reported on the differences between the two kinds of counseling sessions. The clients were recruited among the crime prevention department's usual clients. Seven clients were male and five female; average age was 44. A counseling session lasted about 45 minutes; the duration did not vary, on average, between conventional and artifact-supported sessions.

We recorded all 24 counseling sessions on video and encoded them manually. We collected all discussed problems and solutions (including who addressed them, content and start/end time of discussion). We could thus see how much and which information was externalized or recalled. We collected all questions asked by the clients to provide us with observable characteristics of the clients' cognitive processing. Furthermore, we complemented our analysis with participants' direct feedback in a questionnaire and semi-structured interview. The questionnaire was used to assess the IT-artifact's fit within the consultant-client collaboration. It included items for technology acceptance [32], e.g., intention to use: "I plan to use the IT-tool in the next few month.", and user satisfaction [4], e.g., "I'm satisfied with using the IT-tool in the counseling session.". The semi-structured interviews were based on the same topics as the questionnaire, helping us to understand the reasons behind the actors' behavior during the counseling sessions.

Results

In general, the *SmartProtector* was well accepted and successfully integrated into the mobile counseling sessions. Participants valued their perceived satisfaction with the tool well (on average 6.5 for clients and 6.7 for consultants on a Likert scale; 7 = pos. max.). In addition, five of twelve clients especially highlighted the improved personal relationship with the consultant experienced during the artifact-supported session (despite their inverse expectations).

During the artifact-supported sessions, consultants and clients recalled and re-addressed during the final "discussion" phase, on average, 91% of the initially discussed information. In contrast, they only re-addressed, on average, 68% during the conventional sessions. The difference is significant (two-sided t-test, $T(22)=3.53$, $p=0.002$). This result gives the first evidence that the *SmartProtector* supports consultants and clients in recalling substantially more information. In the following paragraphs, we report the extent to which the individual goals were accomplished.

Externalize and link location-bound problem with solution information: The video analysis of the counseling sessions showed that the consultants externalized substantially more of the discussed information while using the *SmartProtector*. They externalized, on average, six problems and six solutions in the artifact-supported sessions, whereas in the conventional sessions, they externalized only three problems and four solutions. In this context, the clients accentuated the feature of taking a picture and attaching it to a notecard. They confirmed that this was both a fast way to capture the visited problems and also beneficial, as the picture facilitated the subsequent recalling and discussion of the problems. In addition, the *SmartProtector* encouraged the clients to participate more actively in the counseling sessions, helping them to internalize the new information: in the artifact-supported sessions, the clients asked more questions about the implementation of specific solutions than they did in the conventional ones (on average four questions in the artifact-support session, but only one in the conventional sessions). One client stated afterwards: "I knew directly when the consultant opened a [memo] card that the information would be linked with it […] I could concentrate on understanding the solution."

Recall problem and solution information: In the conventional counseling sessions, the consultants only re-addressed 68% of the problem information during the final "discussion" phase, i.e., they forgot 32%. This happened due to the consultant prematurely closing some issues (by providing both problem and solution information on-site of the problem) without documenting them. Whereas most of this information got lost in the conventional sessions, consultants and clients recalled them in the artifact-supported sessions. Concretely, the picture-centric notecards encouraged consultants to provide more detailed information: our video analysis revealed that whenever they saw the picture of a discussed problem or the remarks drawn upon, they repeated the problem information. The consultants explained their behavior and one stated: "I wanted to explain to the client what we already documented […] to check if we forgot something." Another consultant stated: "I really like the photographs with the remarks. They remind me of the conversation […] I was able to repeat all the details."

Establish information synchronicity: Lacking information synchronicity (P3) between consultants and clients manifested most strongly in the form of "delayed" questions. That is, while the consultants moved from discussing one problem and its solution to the next one, the clients stayed behind mentally, asking questions about the "old" discussion. The results indicate that in the artifact-supported sessions, consultants and clients could establish information synchronicity better. In the artifact-supported setting, the average number of delayed questions was less than one, whereas in the conventional setting, they asked three delayed questions, on average. Furthermore, the video analysis revealed that pictures were the main triggers, activating the clients to ask their questions: 70% of all questions asked by clients during the "discussion" phase coincided with them looking at one of the pictures. The picture is always one of the first things appearing on a notecard, thus clients were encouraged to take on the role of the active co-creator early in the problem-solving process, allowing them to comprehend and memorize the solution better [25].

When not working with pictures…: In the artifact-supported sessions, whenever consultants needed to make written notes in addition to taking pictures, they had to interrupt the verbal conversations. In twelve sessions 18 corresponding situations occurred. These interruptions negatively influenced the evolving consultant-client relationship. The consultants pointed out these negative effects. One consultant stated: "When I wrote information in the tool, I had to interrupt the conversation."

DISCUSSION

The evaluation revealed that the picture-centric support concept implemented in the *SmartProtector* helped consultants and clients to externalize and recall substantially more information, overcoming the cognitive challenges of the OOS-OOM phenomenon (cf. P1 to P3). As a consequence, consultants and clients could establish and reuse a collaborative memory more effectively. In their picture-centric mobile collaboration, the actors could become more equal and more active co-creators of the counseling's value.

Whereas previous CSCW research discuss group members' activities for creating a collaborative memory in stationary collaborations [cf. 1,2,12,13,14,19], mobile collaborations create novel challenges. We could show, that the OOS-OOM-caused problems that consultants and clients face in mobile collaboration (cf. P1 to P3) do severely influence them in creating and using a collaborative memory. In answering our research questions, we contribute to the ongoing scientific discussion on collaborative memory in CSCW. In greater detail, we continue and extend the work of, e.g., Kalnikaite et al. [12], Berlin et al. [2] or Kane et al. [14] by highlighting, first, the influences of mobility on the creation and use of collaborative memory, and, second, how they can be diminished:

Actors create collaborative memory while sharing information in "memory-able" form. In doing so, the effort to create corresponding information represent an influential determinant of the actors' collaborative behavior in mobile collaborations. In the mobile collaboration, the physical environment becomes an essential part of these information sharing activities, increasing the actors' cognitive workload and affecting them to create an adequate collaborative memory. Current CSCW-research focus on facilitating the actors' writing activities and complementing them with voice entry possibilities to enable more efficient creation of collaborative memory [cf. 12,13,14].

Based on our research insights, we argue that when supporting mobile collaborations, another improvement is necessary: from writing or speaking to *working with pictures*. Using pictures is an appropriate and necessary extension to (re-)establish an adequate ratio between the efforts of creating and the benefits of using collaborative memory: First, "taking pictures" allow actors to collect comprehensive information on location-bound problems in short time and with barely disrupting their verbal discussions, as also Lin et al. [15] called for. Writing or voice entry possibilities do hardly fit the task as resulting records do restrict on the (presumably) essential information and missing necessary environmental context information. Second, whereas for written and spoken documentation support, actors have to explicitly create "memory-able" information, taking pictures do not require such processing and thus do not additionally burden the actors' cognitive workload and allow them to focus on their collaboration. In addition, creating sharable information using pictures do not require actors to search for and explain technical terms, but to simplify documentation and to focus entirely on their collaboration, while still creating a comprehensive collaborative memory. Researchers can profit from our insights and learn about actors' collaborative behaviors in mobile collaborations, its triggers, and how working with pictures can represent a suitable next step for support systems for mobile collabora-

tions. Developers of future IT-artifacts can benefit and use our key design ideas to improve system design, creating mobile collaboration support that allows for a more balanced effort-benefit-ratio to increase the effective creation and use of collaborative memory.

In mobile collaborations, the actors' cognitive capabilities to memorize and recall location-bound information come to the fore. Thus, preventing cognitive "overload" should guide the design of future IT-systems supporting mobile collaborations. Using pictures in mobile collaborations, help actors to distribute their cognitive workload on different mental resources (visual and verbal) and thus diminishing the risk of cognitive "overload". Furthermore, using pictures can facilitate the creation of a information space for distributed cognition [8], where the changing physical environment is integrated as cognitive resource. With our research, we contribute to the ongoing scientific discussion on the design of IT-system supporting mobile collaborations by highlighting the benefits of a picture-centric support concept. In detail, we continue the work of, e.g., Kalnikate et al. [12], Kam et al. [13] or Lin et al. [15], showing how to design IT-systems that not only facilitate creating collaborative memory in mobile collaborations but concurrently help preventing cognitive "overload" and maintain the actors as active contributors to the collaboration.

In contrast to the related work on memory aid systems focusing on single users [e.g., 15,16], the situation of the mobile consultant-client collaboration can substantially differ. Collaboratively used memory aid systems require addressing the users' different cognitive styles to memorize and recall information. Researchers and developers of memory aid systems can benefit from our insights on the powerful and diverse roles of pictures with the capability of supporting multiple users in their collaboration in creating and using a collaborative memory. Therewith, we contribute to the current scientific discussion on memory aid systems, deepening the understanding of the novel application area of expert-layperson collaborations. Allowing users to take pictures, to draw on them for refinements and to integrate them (cf. key design ideas) into the collaborative work combines both memory aid and collaboration support capabilities, and thus should be considered by developers when designing future collaboratively used memory aid systems.

With our research insights on mobile consultant-client collaborations, we also contribute directly to the current research discourse on IT-enabled collaborative work practices in consultant-client collaborations. The cognitive perspective on the actors' collaborative behaviors provides corresponding researchers with a deeper understanding of the underlying reason for collaborative behavior. We continue and extend the work from, e.g., Heinrich et al. [6] or Schmidt-Rauch and Nussbaumer [25], by adding the neglected perspective of memory support. Extending their solution artifacts with our research findings on how to integrate pictures into consultant-client collaborations adds to their developed solutions, bringing us closer to providing comprehensive counseling support, comprising all collaboration-relevant characteristics.

We argue that the picture-centric design concept instantiated in the *SmartProtector* can be generalized to similar face-to-face collaborations. Counseling collaborations with the same role allocation (expert/layperson) and setting, e.g., energy counseling at one's home, are very similar. Potentially, other mobile collaborative settings, such as mobile learning with an equivalent role allocation (teacher/pupil, etc.) could also profit from our insights, as the identified OOS-OOM caused problems are not domain specific.

Whereas "working with pictures" provides suitable support for quick and simple creation of a collaborative memory in mobile collaboration, the study also revealed that consultants repeatedly had to interrupt the verbal conversation with the clients when adding written notes. In the design of suitable systems supporting mobile collaborations, these issues could be addressed through implementing, e.g., speech-recognition functions, location-aware notification functions or using more ubiquitous technology (e.g., google glass) to facilitate note-taking.

CONCLUSION AND LIMITATIONS

In this paper, we identified the novel (cognitive) challenges occurring in mobile collaborations between consultants and clients. We, first, highlight how these challenges influence actors' collaborative behavior to create and use a collaborative memory and, second, developed a picture-centric design concept for IT-systems supporting mobile collaborations addressing these challenges.

While working with real consultants allowed us deep insights, the setup also comes with limitations. Our study is based only on two consultants, as the city (500,000 citizens) does not have more consultants. Thus, the results could be biased and need to be validated in other settings before we can develop a more rigid design theory. At the time of this writing, the *SmartProtector* has moved on from the experimental stage to the pilot stage in which two consultants use *SmartProtector* as part of their everyday work. Furthermore, additional tests with six consultants from other Swiss cities are currently running. This offers the opportunity to deepen our research and validate our research findings.

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