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Let's Take Photos Together: Exploring Asymmetrical Interaction Abilities on Mobile Camera Phones

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ABSTRACT
Mobile phones have become common tools for photography. Despite the fact that photos are social artifacts, mobile phones afford the act of photo taking only as an individual activity. Photo taking that involves more than one photographer has been envisioned to create positive outcomes and experiences. We implemented this vision with mobile camera phones, exploring how this would influence photo taking practices and experiences. We conducted a user study where altogether 22 participants (11 pairs) were using a novel mobile photography method based on asymmetrical interaction abilities, comparing that with two traditional methods. We present the collaborative practices emerged in different photography methods and report user experience findings particularly with regard to enforced collaboration in mobile photo taking. The results highlight benefits and positive experiences in collaborative photo taking. We discuss lessons learned and point out design implications that come into play when designing for mobile collocated collaboration.

Author Keywords
User study; digital photography; collaboration; collocated interaction; photo taking; asymmetry; design research; user experience.

ACM Classification Keywords
H.5.2. Information interfaces and presentation (e.g., HCI): User Interfaces: User-centered design; H.5.3. Group and Organization Interfaces;

INTRODUCTION
Typical HCI research usually supports users having same information and controls—i.e., symmetry. In contrast, Voida et al. state that *asymmetry* exists in all collaborative systems, and it is often overcome through social conventions [38]. They present different forms of asymmetry (e.g., media, fidelity, participation, etc.) and provide examples and values of asymmetry in a remote awareness system.

Interestingly, mobile devices are designed for single-user activities and thus perceived as personal devices [13]. Small display size of mobile device limits the viewing angle, interaction capabilities and sharing the activity with other collocated people [22]. In other words, mobile devices manifest inherent asymmetry in the capabilities between the user and other collocated people. When mobile devices are involved in an activity, they often draw users' attention and keep them engaged with the human-technology interaction, creating "private bubbles" around themselves [34,37]. As a result, mobile device might not be the most affordable tools for collocated collaboration.

In this paper, however, we are interested in how to turn asymmetry into a positive design aspect, rather than trying to compensate its negative effects. We utilize interaction asymmetry in the design of a system to promote collocated collaboration in an activity that involves mobile devices (i.e., photography). Photo taking is one of the most common uses of mobile phones [35]. The emergence of mobile camera phones has allowed new photography practices. The development of camera technology and introduction of point-and-shoot interfaces has turned photo taking into an activity for anyone. People start to capture not only special occasions or events but also mundane activities and objects in everyday life for multiple purposes [15]. As a consequence, photography has become a way for people to present and express themselves and reflect how they look at the world [12].

Photography is not necessarily a solitary activity [28] and photographs also have many social dimensions (e.g., documenting joint activities and events, mementos, self-expression, and art) [10,17]. While several professional photographers actually collaborate on photographing (e.g., Inez and Vinoodh[1] or Bernd and Hilla Becher[2]), this collaboration is not as common with mobile camera phones. Personal devices like mobile phones as tools for photography seem to afford mainly solitary actions. As a result, this sometimes leads to a situation where photographers

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[1] https://en.wikipedia.org/wiki/Inez_and_Vinoodh

[2] https://en.wikipedia.org/wiki/Bernd_and_Hilla_Becher

disconnect themselves from joint group activities and suspend the ongoing social situation temporarily—i.e., create a bubble around themselves. This is supported by a statement from Sontag: "picture-taking is an event in itself, and one with ever more peremptory right—to interfere with, to invade, or ignore whatever is going on […] the photographer stays behind his or her camera, creating a tiny element of another world: the image-world that bids to outlast us all" [36]. One concrete example of this is when a group of friends are traveling together one notices something picture-worthy and stops to take a photo. This likely results in pausing an ongoing conversation with the others, slowing them down, or being left behind.

While most of the collaboration around photos takes place after they are captured, Plodderer et al. argue that the process of photo taking itself can provide satisfaction and thus should not be overlooked [31]. They envision that connecting photographers together before and during the photo taking process could possibly enhance the photography experience. We base our study on this vision and look into the process of photo taking to explore interaction asymmetry, using mobile camera phones as tools to capture photos. Our work is driven by the overall questions: 1) *how does the practice and experience of photography change when introducing collaborative aspects into it*; 2) *how does interaction asymmetry affect the practices and experiences in a collocated activity.* At a more general level, this work contributes to the understanding of designing mobile technology to encourage collocated collaboration and social interaction in general.

RELATED WORK

Photography usually involves activities of planning, capturing, editing, and sharing [6]. Photography as a research topic has gained much attention in the HCI community over the last decades. For example, Kirk et al. present an overview of photo manipulation activities after capturing and design implications for photo management tools [18]. Frohlich et al. delved into photo sharing and social behavior around photos, and derived design implications for future technology that supports photo sharing [10]. Also several other researchers adopt different approaches to explore and enhance the experience of collocated photo editing and sharing (e.g., [16,26]).

Some others look into instant photo sharing and how it might affect collocated interaction between people. Mobiphos is an automatic mobile photo sharing application that simultaneously shares the recently taken pictures to a common image pool [7]. Other collocated group members have access to the images in real time. This instant sharing was found to affect the photos that the participants decided to capture and lead to various interactions and collaboration between the collocated group members (e.g., serving as a conversation topic between group members). Their decisions to take photos were affected by various social elements (e.g. audience and purposes of sharing). Automics [8] provides instant sharing and collaborative editing between collocated group members. The shared pool in Automics was appreciated for allowing the users to get photos from situations they might have missed and, allowing them to pay attention to other ongoing activities while some others take care of photographing. Editing and annotating photos taken by others was also appreciated personalization.

Others have taken a step further by augmenting the photo capturing process. Audiography is a digital camera with the ability to capture sound during the time the photo is captured [11]. Photo and sound are shown to complement each other when people view the photos and reminisce about the event. As it turned out, some apparently bad photos were still appreciated with the augmented sound attached to them. Similarly, Ljungblad studied a context camera that involves surrounding environmental parameters, movement and sound level, turning them into additional visual effects added to the photo at the moment of capture [24]. The context camera emphasizes the contexts that photos are taken which makes the final photos more interesting to the users. Ljungblad also conducted another study to explore photography experience with a fully automated camera [25]. The author argues that photographers appreciated the opportunity that they can be involved in an ongoing situation and capture the moment at the same time. The results of these studies, however, discuss mainly the post-photography experiences, not the experience during capturing actions.

As shown above, sharing and annotating photos is very collaborative and social by nature; particularly editing photos is argued to have good potential to allow collaboration [23]. The process of capturing photos, on the other hand, has been taken for granted and received little attention from collaboration point of view. In this study, we focus on photo capturing and introduce social and collaborative aspects into the process. A few earlier studies look closer to photo taking. For example, Yousies is a mobile application that offers an opportunity for its user, e.g., a solo traveler, to get his/her photo taken by a stranger, another user, without a need to pass the device around [39]. Our focus is not only about a person taking a photo for another – like in Yousies – but, in fact, to perform the photo taking together. Fischer et al. introduced InstaCampus and looked into collaborative photo taking and notification management in a small collocated group [9]. In the study, groups of 3-4 participants were to take photos of their campus together by using two camera phones. A condition in balanced number of photos for different aspects of the campus is set to encourage collaboration. Various types of interaction were observed in different groups of participants, including discussion and negotiation, as well as ignoring others and notifications leading to lack of collaboration during the photo taking activity. While the paper focused mainly on understanding mobile notification management between group members – using photo taking as a context to study the phenomenon – we explore how different methods of photo taking would affect user experience and photo taking

practices. Additionally, George Square is a mobile system intended for tourists to share their visits with their remote friends and family [5]. The authors claim that instant photo sharing in the system led to collaboration in taking photos between participants in the physical and remote locations. This included, e.g., requesting the visitors to take particular photos, rejecting taken photos and asking for a new one. Differently from George Square, our focus is in the context of collocated groups or pairs.

DESIGN OF THE USER STUDY

As mentioned, our goal is to explore photo taking as an activity that a pair of collocated people would perform together. Taking photos together can manifest itself in many ways. A group of friends wandering around together and each having their own camera can be perceived as one common practice. Alternatively, a spectator observing his/her photographer friend takes a photo through the screen of the camera and commenting on the photos being taken can also be argued as a collaborative action [20]. The interactions and collaboration in these examples are voluntary and the photo taking is still largely defined by the person holding the camera. We also want to understand photo taking as a collaborative practice. Therefore, we included enforced collaboration as one method in the study to explore if this would engender additional benefits.

Theoretical Foundations: Enforcing Collaboration with Asymmetrical Interaction Abilities

Petersen and Krogh have studied photo sharing, which they consider to be a rather passive activity [29], and ways to make it more collaborative. They propose a new interaction model called *collective interaction*, defined as: "*…when multiple and collocated users share both one logical input channel and one logical output channel. The input channel may consist of a number of interaction instruments, which are logically coupled in the interaction. Thus Collective Interaction requires more than one user for controlling and taking full advantage of the system. Through their interaction and negotiation, the users must actively coordinate their actions toward a shared goal*" [19]. Their design experiments imply that making interaction difficult to be done alone will force users to cooperate.

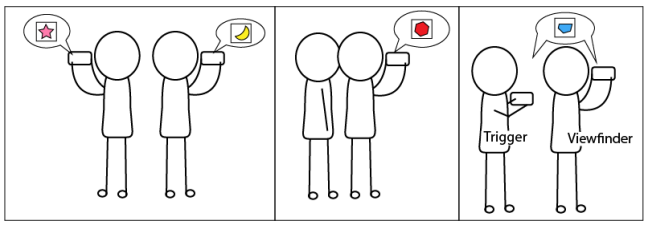
The concept of *asymmetry* could be considered as one approach to implement *collective interaction*. *Asymmetry* is commonly used to *encourage* or *enforce* collaboration and engagement in games [40]. While in *collective interaction* users may have either same or different interaction abilities, *asymmetry* emphasizes on different users having different interaction abilities or accesses to different information, and they are formally assigned. A simple example of asymmetric abilities is hide-and-seek; the seeker has the ability that differs from the rest of the players; the seeker seeks, the others all hide. These roles provide an inherent foundation for the activity. In line with this, Björk and Holopainen have described the gameplay design patterns of *asymmetric abilities* and *asymmetric information* [4]. Following up on this, Lundgren et al. [27], have repurposed this notion of asymmetry in their framework on how to design for collocated interaction.

These approaches of *collective interaction* and *asymmetry* have been utilized particularly in the field of tabletop and tangible interaction. Applying the approaches have yielded positive results regarding collaboration between users (e.g., [1,30]). Similarly, there are studies where both approaches are employed in mobile technology (e.g., [2,9]). In this paper, we focus on the *asymmetrical interaction abilities* approach and aim to explore its potential in enforcing meaningful collaboration in photo taking activity.

Photo Taking Methods

We focused on three methods for a pair to take photos together: 1) both with their own personal devices; 2) with one device; 3) with two devices with asymmetric abilities that require both devices to take part in the activity (Figure 1 summarizes all the methods use in this study).

The first method, *Separate Cameras*, employs two cameras. Each participant has a camera of their own and can take photos in the traditional fashion. This method is considered as a baseline method that people already have experience. The second method, *Shared Camera* employs only one camera for each pair of participants. It is up to them how they would like to manage the photo taking process. The last method, *Collaborative Camera* employs two devices but with different abilities; one camera provides the viewfinder, the other the trigger button. Both of them see the same content with a small delay on the camera displays. This represents *enforced collaboration*, inspired by the *Collective Interaction* approach [19] in that both users need to take part, and this is being instantiated by the *Asymmetrical Interaction Abilities* (of viewfinder vs. trigger), suggested by Lundgren et al [27]



Separate Cameras	**Shared Camera**	**Collaborative Camera**
One camera per user	One camera per a pair of users	One element of camera, two devices with different abilities (viewfinder & trigger) to contribute to the same photo

Figure 1. Summary of the studied photography methods.

Apparatus

The first two methods, *Separate Cameras* and *Shared Camera*, utilized the default camera application that comes with Android smartphones. For the last method,

Collaborative Camera, RemoteShot[3], a camera application for Android phones, is used in our study due to its stability, minimal design, and the ease of use. The app is intended to be used as a helper for taking selfies. The application allows us to use one smartphone as the *viewfinder* and another as the *trigger*. The two smartphones need to be connected to the same Wi-Fi access point to be able to use the application. The *viewfinder* device only has the camera while the *trigger* has the shutter button. The *trigger* device shows the live view as on the *viewfinder* device. It has almost the same content displaying, with only a delay of approx. half a second. When the shutter button is pressed from the *trigger* device, the *viewfinder* device will play a feedback sound that a photo is taken.

Overall Study Organization

We conducted a qualitative user study where a pair of recruited users used all the three different photography methods. We organized 11 sessions with altogether 22 participants. The first sessions was considered as a pilot session to test the study setup and technical practicalities, however, no major change was made after the pilot, so the session is also included in the data.

Participants and Recruiting

In total of 22 participants, there were 11 males and 11 females. The age distribution was 18-36 years, with an average age of 26. The participants were mainly university students from various fields and cultures, representing nine different nationalities (with Finnish as the most common). The recruitment of the participants was done via a bulletin board in the university intranet. The volunteers were asked to bring along one person as a partner for the study in the registration, meaning that most pairs were familiar with each other. Table 1 shows the relationships between each pair of participants. By having three pairs of strangers we could explore the methods also in social situations between people without established trust relationship, norms, or practices.

Relationship	Number of Pairs	Sessions
A Couple	5 (F-M x 5)	1, 7, 8, 9, 10
Friends	1 (F-F)	6
Colleagues	2 (F-M, M-M)	0, 4
Strangers	3 (F-F,M-M, F-M)	2, 3, 5

Table 1. Relationships and genders in the participated pairs.

All the participants reported to have a smartphone with a camera. About half of the participants (13) reported to take pictures with it at least a couple times a week, three at least once a day, and five several times a day. Only one participant said to rarely take pictures, which means that overall the studied sample can be considered as rather active mobile photographers. In fact, five of them stated photography as a hobby and five considered themselves as semi-professional photographers.

Study Procedure and Data Analysis

Each session started with a semi-structured interview regarding the participants' practices in taking and sharing photos. This was followed by an introduction to the upcoming photo taking activity and a brief explanation of the different photo taking methods. To provide a meaningful task for taking photos, the participants were asked to focus on "Things I would like to remember about this city". This theme is based on one of the most common uses of camera phones–to record memories [15]. However, the participants were free to modify the focus based on their personal interests.

Next, the pair walked around the campus and nearby areas to take photos, using all the methods one by one. The order of the methods was randomized. They were given approximately 15 minutes for each method but they could end earlier if they felt that they were done with the task. A researcher followed the participants and video recorded their photo taking activity, trying to avoid affecting the interaction within the pair. As there was only one researcher, one participant in each pair was asked to wear a cap with a camera attached to it, as a backup camera in case the researcher miss any interesting moments. After the approx. 45 minutes, first a short discussion about the taken photos and then a semi-structured interview followed. The interview focused on their experience and their mutual interactions during the activity. Each session lasted approximately 90 minutes.

The pre- and post- photo taking interviews were audio and video recorded. The audio recordings were transcribed in verbatim and the video recordings were analyzed to identify details of interactions during the photo taking activities: sequences of activities and interaction between participants before, during, and after a photo is taken. Both video and audio records were analyzed with qualitative content analysis [41], in particular with an affinity diagram [3] that produced a data-driven and bottom-up hierarchy of themes. The emerged themes are reported in detail in the following section. Two researchers participated in transcribing the data. One researcher was responsible for analysis the data with two senior researchers being involved in discussions to form common interpretations of the findings.

FINDINGS

Even though the photo taking activity was given as a task to the participants, they got more engaged in to the activity over time, especially with the *Collaborative Camera*; for example, one participant said to her partner (boyfriend) while taking a photo with the method: "*we should do this more often*". Another pair (strangers) stated during the interview that "*in the beginning I didn't feel so inspired, but*

[3] RemoteShot: https://goo.gl/WCOm9y

later on, it was more inspiring. When we were using [Collaborative Camera], it was an inspiring method. Gave us new ideas". Half of the participants (10/22), asked the researcher to send them the photos they took during the study. Overall, the participants seemed to enjoy the photo taking activity and considered it to be an interesting experience, especially with the *Collaborative Camera*. Participants on average took 31.9 photos with *Separate Camera*, 22.9 photos with *Shared Camera*, and 25.6 photos with *Collaborative Camera*. Based on the observation of all the three methods, the participants generally spent quite much time looking for photo opportunities and discussing with others more than actually taking photos. In the next three sections, we report the interactions in more detail for each of the three methods separately. In the end of the results we discuss the user experience of taking photos together with each method.

Observations of Separate Cameras

This method was considered as the baseline that represents the current practices of photography in a group. When the participants started using this method, most of them discussed the places to go to and what kind of photos they could take. However, 3/11 pairs (who were already in the field as this was not the first method they started with), just took off and took photos individually, without any discussions beforehand. Overall, with this method, the participants were mostly focusing on their own photo taking activity. They sometimes became unsynchronized and unaware of each other during the activity (see Figure 2).

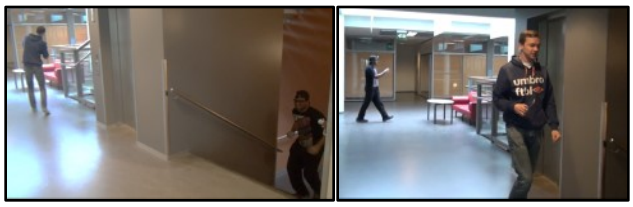


Figure 2. A participant in session 3 (A3) stopped to take a picture while another participant (B3) already went down the stairs. B3 ran back and started looking for a place to shoot, but when B3 started to take a photo, A3 was already done and going down for other locations.

If the participants stayed collocated, they naturally had conversations with each other. The activity, even if performed with separate devices, gave the participants an opportunity to share their knowledge about specific places or objects. The participants suggested each other a photo spot when they saw something interesting. For example, one participant saw her partner taking a photo of flowers, and she then told him about a nearby location where there were also nice flowers. Participants usually left a space while waiting for their pair and did not look closely what another participant was taking; they just looked at the object being taken. Overall, in most cases the interactions between participants took place after they had already taken the photo(s), while waiting, or walking to the next location.

Observations of Shared Camera

Shared Camera gives the control to operate the (one) camera to only one user at a time. Similar to *Separate Cameras*, the participants frequently discussed the places to go and what could be captured. Using a shared tool gave an impression that they should be working together: "*now we have to share our brains*" – (B3, M, 26). Collaboration between participants was observed particularly in the beginning of the method. However, closer to the end of this method, the photo taking practices and interaction between participants varied quite much. The collaboration and engagement in the photo taking with this method highly depended on the participants' eagerness to participate and collaborate with each other. The interactions and photo taking practices are described in more detail in the following, being presented in the order of how collaborative the activity was.

One Camera Used as a Team

Not having a camera does not necessarily mean that one cannot participate or contribute to the photo taking activity. Participants having the camera often followed suggestions from their partners. This practice was observed in the beginning of all the sessions. Only one pair (session 7, a couple) actively collaborated throughout this method. The pair perceived this method as a collaborative task that they should discuss before the act of taking a photo. For example, the participant with the camera, B7, always let the other, A7, know before she took a photo (see Figure 3). Even though one participant had the camera all the time, they still considered the resulted photos to be their joint creations as the photos were based on their ideas and discussions.

Figure 3. Left: The Participant without the camera explaining how he wanted a picture to be captured. Right: The participant with the camera asking for more details.

Photographer and Supporter

In other eight sessions, the participants with the camera took a leading role in the activity. They decided how a photo should be captured and, often, just took photos without informing their partners. Furthermore, when participants without the camera suggested a target for a picture, they did not necessarily explain how the picture should be composed and captured. They mostly just pointed out the spot and let the participant with the camera compose the pictures. Only one pair (Session 5, strangers) closely collaborated and shared the workload: "*with [Shared Camera] collaboration also works if there is a decision that one is good at taking*

photos and the other is good at pointing out the view. Then, this is good" – (B5, F, 22). However, most of the time explanations or suggestions from A5 came after B5, the other participant with the camera, had already found a composition, e.g. "*it is also nice with table*" or "*maybe in portrait?*", and helped when being asked or when she was not satisfied with what was being captured.

Participants without the camera closely observed what their partners were capturing (Figure 4). They gave feedback and comments during or after the photos were captured; however, they were simple comments like "*nice*", "*good*", or "*okay*". As time passed, many lost interest in keeping up with the active observation. In two sessions, those without the camera shifted their attentions to something else while their partners were taking photos; for example, looking for other good photo spots nearby or even taking a rest.

Figure 4. Participants observing closely to see what their pairs are capturing. Left: a couple; Right: strangers.

Figure 5. Participants (A5 and B5, strangers) agreed to take a picture of a place. B5 could not manage to do so. She passed the camera to A5 and also explain what she intended to do.

Turn-Taking

In six sessions, we observed participants passing around the camera during this method. One reason is because participants with the camera could not capture the same photos as what their partners had in mind. Thus, instead of explaining their ideas further, some acquired the camera to take a photo by themselves. Those with the camera also happily passed the camera to the other. Other reasons also include running out of ideas, feeling that s/he had taken enough, or not managing to capture a photo that would satisfy themselves and their partners (e.g. Figure 5). Another interesting reason is about not wanting to spoil the photos: "*we exchanged the camera when there was something that related to you. I trusted that you can make better photos [of the target]. I didn't want to take a crappy photo for you*" – (B0, F, 36,).

Solo Photographers

Passing the camera around was rarely observed in five sessions. Interestingly, four of these pairs were couples and one was colleagues. It seemed that the pairs that know each other well have established roles also in regard to photography. However, in three out of these five sessions (couples), the participants were satisfied with this inequality. They pointed out that this is their natural way of taking photos together if there is only one camera: "*it usually goes like this because he has better technical skills when it comes to photographing. […] I let him hold the camera*" – (B1, F, 32).

In two sessions (4 and 9), participants with the camera used the camera as if they were the only photographers, ignoring their partners. Session 4 was between two colleagues where one of them rarely takes photos. Thus, his partner took all responsibility for photo taking. There was no discussion related to the photo taking activity. In the interview, the passive participant stated that he was aware of what his partner was doing and this is how the situation usually is. Between a couple in session 8, the situation was different. Participant A8 wanted to contribute but B8 preferred to retain the full control of the camera: B8 possessed the camera almost the whole time. The situation also led to a small argument between them as described in Figure 6.

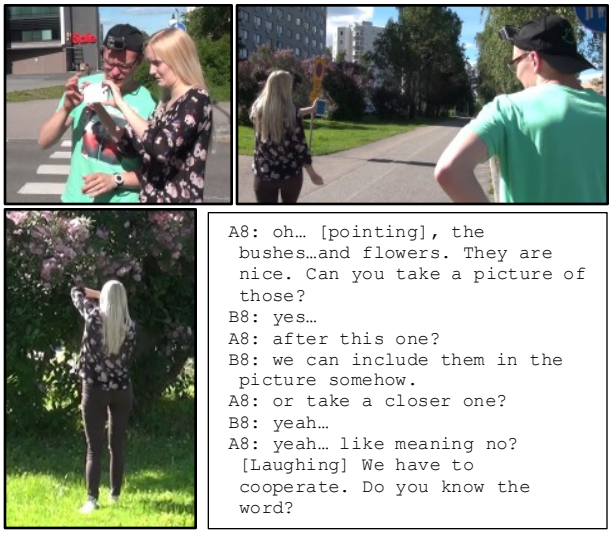


Figure 6. Top left: B8 asked A8 to take a photo for him from the exact spot where he gave her the device. Top right: after several tries but seemed to fail, A8 refused when B8 asked to see the photo, only showing it at a distance. Bottom left: A8 grabbed the camera from B8 and took a photo of the bushes and flowers she wanted. Bottom right: an excerpt conversation between A8 and B8.

Observations of Collaborative Camera

With this method, the participants had to collaborate in order to be able to create any meaningful photos, taking on the roles of the *viewfinder* and the *trigger*. Interaction between participants changed considerably. For example, the couple (session 8) who did not collaborate well with *Shared*

Camera, managed really well in this method. Also participants who were passive when using the *Shared Camera* got generally more active in this method.

Most participants (8 pairs) considered the role of the viewfinder to have slightly more control in the photo taking activity: one can manipulate what to capture by moving around and aiming at different directions. The trigger was, thus, in a supporting or assisting role. However, in most of the sessions, acquiring the trigger role did not stop the participants from having a discussion or share their ideas with their partners. The viewfinders did not ignore them but, in fact, also expected some contributions from the triggers: "*I am also expecting that [the trigger] would say that it is not good because he can see it*" – (B0, F, 36). Furthermore, the participants acquiring the trigger role were quite active. Some even acted as the "director" of the photo taking action, providing detailed suggestions for a picture. The viewfinder, then, was more like a practitioner providing feedback to the triggers' ideas (see Figure 7).

B5: Let's shoot the front yard from there crossing to this side. Let's see if you can hide the construction yard.
A5: but there is also a construction yard
A5 points the camera to the other direction.
A5: like this?
B5: yes, with the tower…looking from the left
A5 moves the camera more to the left.
B5: like these trees with the bench
A5: aha…
B5 takes the picture.

Figure 7. Participant B5 (trigger) being very detailed in how she wanted a photo to be taken.

As in other methods, discussions about the places and what to shoot were common. However, the discussions went to a much more detailed level. The collaboration was said to be more equal and involved more discussion and collective decision making than in other methods. For example, a participant with the trigger gave detailed suggestions while the other was creating a composition (e.g. Figure 8) and could reject the viewfinder's suggestions (e.g. Figure 9).

Participants in two sessions valued the viewfinder role much more than the trigger. They argued that finding a good photo spot and composition is the most important thing in photography. For them, the trigger was merely the operator of the shutter button. When they acquired the viewfinder, they actively provided suggestions and directed their partner what to do and where to go. On the other hand, those who acquired the trigger role in these two sessions were mostly passive and waited for the commands from the viewfinder to press the shutter button. They did not comment in detail or suggest adjustments to the composition unless they were explicitly asked: "*I think the person who was the camera was more responsible for the photos. [The trigger] was just basically moving his thumb, not doing anything creative. [The viewfinder] was searching for creative things*" – (B3, M, 26). Moreover, if the trigger took a photo without the permission from the viewfinder, it was considered to be a mistake.

A2: now, this thing, the logo.
B2: oh yes. That's cool…maybe a bit like from the lower.
A2 gets on his knee.
B2: yes…good. Yep
B2 presses a button to take a picture

Figure 8. Pair in session 2 taking a photo with Collaborative Camera.

Figure 9. Participant B1 (trigger) refused to take a picture of what A1 (viewfinder) suggested.

Experiences of Taking Photos Together

Participants considered the *Separate Cameras* to be a normal way of taking photos. Both participants had full control of their cameras, which allowed them to photograph whatever they preferred. The resulting photos were, thus, seen as tokens of their own stories and experiences. The collaboration was very shallow, even if there were some social interactions before and after the photo taking.

Using *Shared Camera* as a tool in taking photo together offers an opportunity for the participants to observe, inspire their photographer partners, and comment on what is being captured. Such behavior was not observed when using *Separate Cameras*. The photos taken with this *Shared Camera* were mainly reported to be mixed between a combination of an individual's ideas (e.g. a participant's favorite café) and shared ideas (e.g. participants' mutual favorite spots of the university). Participants' perceptions of the outcomes photos are also mixed depending on interaction and collaboration between the participants during the time the photos were created. However, *Shared Camera* lacks a possibility to get involved into the details of the activity; photo taking with that method was still considered to be a one-person activity. Thus, several participants gave more

credits to the one who actually captured the photo: "*[With Shared Camera,] whoever has the phone has the full control. If you have the camera, they are mostly your pictures. Or if I have the camera, they are mine. Well, you can say to the other person to take this and that, but still… the other actually took it*" – (A0, M, 29) Moreover, participants also mentioned in the interview that sometimes they did not understand why their partners took some of the photos, which is also an indicator for lack of collaboration [21].

Collaborative Camera was considered to be a novel approach to take photos. Most of the participants reported to have enjoyed taking photos together and that the method provided them with delightful experiences and an interesting approach they had not considered before. Some participants were concerned about the practicality of the method as it is not the most practical choice and a typical photo taking method allows them to take photos allows more freedom to take photos: "*I don't know what would motivate me to start using this option*" – (B0, F, 36). However, others consider this method to be for special occasions, when they would like to get something more than just photos. For example, to be inspired for new ideas: "*it might be an interesting option when I would like to take photos but don't have ideas. Somebody else could point out an idea then I take a photo.*" – (B1, F, 32).

Communication and Sharing

Communicating photo ideas to their partners was not easy and sometimes participants had to compromise with the outcomes. Taking turns in acquiring the camera was an approach to overcome this situation with *Shared Camera*. *Collaborative Camera* was found to encourage communication and discussion within pairs: "*we talk to each other more with [Collaborative Camera]. For [Shared Camera], it was like you hold the camera, it's your turn, your photos, my turn, my photos. When we were using [Collaborative Camera], we had some discussion, so we know what to do*" – (B2, F, 25). The method was also said to assist idea sharing: "*it is easier to share ideas when we both can view the same thing*" – (B1, F, 32). Furthermore, a need to involve another person into photo taking activity results in participants thinking more about the motives of the photos they were taking. This is related to the fact that participants had to communicate their intentions to their partners: "*I need to think more in what I am doing. It is a good thing that we have to discuss what we want and what kind of photos we want to make*" – (A1, M, 31). Participants reported that photos taken with *Collaborative Camera* are not just something random to be deleted later, but rather something they want to keep. Participants also mentioned that they made an extra effort when taking photos with the *Collaborative Camera*: "*I think pictures from [Collaborative Camera] is something that is ours. We both own them, so maybe they should look a bit better just for the other*" – (B0, F, 36). Additionally, because the participants usually discussed while taking pictures together, they considered this social interaction as an additional layer of the memory about the photos: "*I noticed that we have more communication in [Collaborative Camera]. I think it is good. The photos we took are more meaningful. […We discussed and agreed to take a photo…] From this, we got a shared memory of doing it together*" – (B2, F, 25).

Furthermore, most participants considered photos taken with *Collaborative Camera* to be their shared ideas, results of collaboration, or at least something they both agreed upon, co-creation: "*it is a bit like the creative part from both minds. One is searching for the photo one wants to take and the other can still correct a little bit*" – (A10, M, 26). *Collaborative Camera* was also appreciated as an approach to allow participants know a little bit more about each other, especially between acquaintances with distant relationship, such as colleagues: "*I found it is interesting to see what [B0] wants to take photos, what kind of things were interesting for you*" – (A0, M, 29)

Sense of Involvement

Most participants considered *Collaborative Camera* to provide an opportunity for another person to get involved. Participants mentioned that seeing and commenting on what their partners were focusing on and trying to capture gave them stronger feelings of involvement in the photography activity: "*[Collaborative Camera] somehow changed the situation that [my partner] got more involved in [how to capture a photo] and somehow I felt more involved in collaboratively thinking about what we were going to shoot*" – (A1, M, 31). Furthermore, a few participants (Session 8 and 10, couples) also stated that because they were involved in the photo taking activity, they felt less impatient when having to wait for their partners adjusting or playing around with the camera: "*When there is just one camera and [my partner] wanted to play around I tended to not notice him stopping or got impatient. This is not the case with [Collaborative Camera] because we should help each other*" – (B10, F, 24). Moreover, *Collaborative Camera* allowed easily looking at things from the other's perspective (e.g., how the other composes a photo) which was found inspiring and educational.

Challenges of Collaborative Photo Taking

Participants could quickly decide and take a photo with *Separate Camera* and *Shared Camera*. *Collaborative Camera*, on the contrary, usually requires discussion which takes time. This sets limits to types of photos that can be captured and the efficiency of taking photos, which can be considered as a drawback in some situations. "*It is a good thing that we have to discuss what we want. The photos are probably better, but it takes time to discuss. If we are walking around somewhere and we don't have time, then we won't take a picture. If we have own cameras, we might just shoot and run*" – (A1, M, 31).

Not every participant appreciated *Collaborative* Camera. Three participants commented that the abilities of the viewfinder and trigger are too different: the viewfinder does all the preparation for a photo and the trigger just presses the

button. More importantly, the roles are static. The two roles can be seen to give the impression "*now it is your turn, so you look for a photo*", which is basically the same as turn-taking in *Shared Camera*. Some participants suggested that the roles could be more dynamic: e.g., one is the viewfinder for one photo and then becomes the trigger in the next. This way, both can be looking for photography opportunities and, at the same time, help the other in the current photo taking activity. One participant further emphasized that the value of taking photos together is the interaction between partners. If there is no interaction, *Collaborative Camera* is just adding an extra cumbersome to photo taking; in such cases it is better to use a *Shared Camera* or *Separate Cameras*.

DISCUSSION

The findings indicate that the three photography methods had clear effects on photo taking practices and interaction and collaboration amongst the pairs. The choice of method apparently influenced participants' perceptions of how the activity could be approached. However, it is not the only factor; photo taking practices are also influenced by social aspects such as relationship between the partners and habits of photo taking, attitudes towards collaboration, as well as the personal photo taking skills. For example, *Shared Camera* gives an impression of working together, but does not suggest how to perform photo taking. Consequently, the participants came up with different strategies how to work together and took different social aspects into consideration. In one session, a participant let her boyfriend partner have the camera for the whole time because of known difference in skill levels and the pair's usual habits. In some other sessions, the participants simply took turns using the camera. These various social aspects also contributed to the diversity with respect to the form and amount of collaboration between pairs.

However, with *Collaborative Camera*, these aspects were less influential: diversity in the collaboration between pairs was observed smaller during this method. The asymmetric interaction abilities defined by the devices assigned a role for each user, which creates a so called "magic circle" [33] around the activity. That is, participants repositioned themselves in the activity defined by the given roles, creating new behavior around the activity that differs from their usual. Consequently, norms and other habitual and social aspects that influence the activity are mitigated.

Asymmetrical interaction abilities break a task – in this case, taking a photo – into sub-tasks that each is a responsibility of one user. This forces the users to communicate, collaborate, and come to agreements to perform a common task together and achieve mutually satisfactory results. Interaction asymmetry in our photo taking activity created sequential interactions where one sub-task could take place only after the other is done (composing followed by capturing).

Hornecker et al. suggest avoiding such enforced sequential interactions because negotiation between participants could hamper the fluency of human-technology interaction – in their case, interaction with an interactive surface [14]. With *Collaborative Camera* it was the other way round. The interaction dependency caused by asymmetry might slow down the photo taking process and can create a sense of poor usability, as brought up by some participants. However, it does not interrupt the creative practices in photography. *Interaction asymmetry* actually increased verbal interaction between the participants, created an opportunity for two persons to properly and meaningfully get involved in the activity, and encouraged idea sharing and co-creating photos. Even though the task performance related to human-technology interaction was negatively affected, the asymmetrical interaction abilities enriched the actual activity at hand. This engendered several positive experiences [31] that, in many cases, seemed to exceed the negative effects.

Implications for Design

The findings suggest that employing asymmetrical interaction abilities is a promising design approach for increasing collaboration. It encourages communication, negotiation, idea sharing, and motivates users to keep engaged in the activity. In other words, we argue that meaningful collaboration can also take place even though users do not have equal access to information and control (cf. [32]). The following discusses further the design considerations in using *asymmetric interaction abilities* in encouraging collocated interaction. We highlight particularly the aspects of *balancing interaction engagement* and *the significance* of the interaction abilities.

Engagement and Significance of the Interaction Abilities

With *Collaborative Camera*, majority of the participants were engaged in taking photos together as a shared activity. One reason for this is maybe the impression–or affordance–of a need for collaboration. Another reason might be that the asymmetrical interaction abilities in *Collaborative Camera* require participants to pay attention to (1) their own interactions with the camera device they are responsible for; (2) the interaction with their partners; and (3) the interactions the partner performs with their device. Without this interaction dependency, we would probably have observed rather individual and asynchronous photo taking practices similar to those with the *Separate Camera*. Furthermore, the duration of the task of taking a photo was rather short: the participants did not have to wait for a long time for their partners to finish their sub-tasks before they could perform their own. Having to wait for their turn could easily lose their engagement in the activity, as in *Shared Camera*.

Additionally, the significance of the interaction abilities also contributes to users' level of engagement during the activity. In our study, the *viewfinder* needed the *trigger* to be successful in any photo taking actions. However, in this design, the perceived significance of the two roles varied between the pairs. For instance, the *viewfinder* was, in some cases, perceived to be more important than the *trigger*. Consequently, the *viewfinder* might dominate the activity

and the *trigger* could merely follow the *viewfinder* without actually engaging in the activity.

To summarize, we argue that in order to employ interaction asymmetry successfully in an activity, there should be: (1) a balance in the required attention and engagement between interacting with other users and completing the sub-tasks one is responsible for; (2) the duration of each interaction in a sub-task should not be too long, to avoid unnecessary waiting; and (3) the interaction abilities of the roles should be all be equally important–i.e., there is a real need for the roles, which creates a sense of significance of one's tasks.

Risks and Limitations of Asymmetric Properties

Interaction abilities scaffold participants' behavior during the activity. On the one hand, it allows users to participate in the activity in the way that is different from their usual. On the other hand, it draws a line in how much users could or should contribute. Users may only contribute to the interaction ability they are responsible for, but not perceive the activity itself as a whole. According to our study, this concern mostly valid between participants without prior or distant relationship, e.g., strangers and colleagues.

On methodological retrospect, the study only considered collocated dyadic users in a creative task. Further exploration is needed to understand asymmetry in involving more users or in a task that require more cognitive load (e.g., wayfinding or problem solving).

Asymmetry and Mobile Devices in General

As mentioned earlier, the personal nature and interaction capabilities of mobile devices are seen to hinder collocated collaboration. Lack of shared attention and awareness of others' actions across mobile devices is generally considered to be problematic [32]. Contradictory, we argue that the personal nature of mobile devices could also successfully support collaboration by utilizing asymmetry. Mobile devices and asymmetrical design actually complement each other when designing systems that aim to encourage collocated interaction. Asymmetry is based on difference in interaction abilities and information between users [27], and mobile devices allow the distribution of the abilities naturally due to their personal nature. Furthermore, asymmetrical design engenders interaction dependency that encourages direct interaction and communication between users. This study also suggests that the interaction asymmetry design could be successfully implemented to mobile activities and not limited users only to the screen, but also involve interacting with the surrounding physical environment—in other words, bursting the mobile bubble.

CONCLUSIONS

We explored photo taking with mobile phones as a collaborative activity by using three different photo taking methods. The collaboration in the typically solitary activity of photography was enforced by asymmetrical interaction abilities so that users have to carry out the task together. The goal of this study was to understand collaborative practices and user experience that asymmetry creates in mobile collocated interactions. The findings suggest that (1) a typical solitary activity such as mobile camera phone photography could be turned into an activity that benefits from collaboration; and (2) *enforced* collaboration could engender positive experiences without overly encumbering the task itself. The findings also suggest that interaction asymmetry encouraged interaction, negotiation and idea sharing, and helped maintain engagement in the activity and the other user. Overall, interaction asymmetry showed as a promising approach to "burst the mobile bubble" at least in a creative small task like photo taking. As a broader contribution, we present design implications for applying the approach of *interaction asymmetry* in other mobile activities.

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