

Understanding Mobile Notification Management in Collocated Groups

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Abstract. We present an observational study of how notifications are handled by collocated groups, in the context of a collaborative mobile photo-taking exercise. Interaction analysis of video recordings is used to uncover the methodical ways in which participants manage notifications, establishing and sustaining co-oriented interaction to coordinate action, such as sharing notification contents and deciding on courses of action. Findings highlight how embodied and technological resources are collectively drawn upon in situationally nuanced ways to achieve the management of notifications delivered to cohorts. The insights can be used to develop an understanding of how interruptions are dealt with in other settings, and to reflect on how to support notification management within collocated groups by design.

Introduction

Notifications play a key role in our communications and social media. They alert us that an email or text message has arrived, that a friend has tagged us on a photo or mentioned us in a post, or that a follower has retweeted us. Importantly, notifications may not just announce the arrival of a message – they may act as a *summons* (Schegloff, 1968) that prompt the receiver to engage in a subsequent activity.

Particularly relevant to the CSCW community, notifications have been deployed to encourage user engagement in collaborative mobile systems for collocated groups; for example to support photo sharing and collective souvenir creation whilst in a theme park (Durrant et al., 2011), spectating at an on-going sports event (Jacucci et al., 2007; Salovaara et al., 2006), visiting a city (Patel et al., 2009), or to support

the social fabric of a student group (Van House et al., 2005). This paper addresses the question of how these notifications are dealt with in the context of such group-oriented activities through a field trial of a collaborative mobile photo system.

We accept notifications as a ‘fact of life’, this paper examines the social process that follows on the delivery of the notification. Accounts in the literature of how this is accomplished hint that *social* management of notifications is commonplace. For example, Tolmie et al. (2008) reveal complex ways in which mobile interruptions make the recipient accountable to other members of the shared setting. Harr and Kaptelinin (2007) have talked about the “rippling effect” an interruption may have on others nearby.

We present a study of the ways in which groups of people organise their interaction around notifications delivered through a system designed to support a collaborative mobile photo-taking exercise. Based on video recordings triangulated with usage logs we provide an in-depth analysis that unpacks the methodical ways in which groups employ *interactional resources* to deal with notifications. Explicating the interactional resources in face-to-face settings (e.g., talk, gaze, body orientation) is common in the literature that seeks to provide insights to support the design of collaborative technologies (e.g., Luff and Jirotko, 1998).

Findings from the trial reveal the embodied and technological resources employed to manage notifications within the unfolding interaction. Drawing upon observations from our field trial, we contribute a detailed account of the social ways in which people accomplish *notification management within groups*, and implications for the design of notifications for collaborative systems. In particular, we identify a repertoire of interactional resources for notification management that can be used as a framework to inform the research and design of technology that employs notifications to support collocated group activities.

Notifications and interruptions

We review literature that reflects the prevalent orientation towards interruptions in related work to motivate why notification management within groups is a common, yet understudied phenomenon. We then revisit previous uses of notifications in collaborative systems and highlight some group-specific issues.

Studies of workplaces have shown that interruptions are part of everyday life (e.g., Mark et al., 2005). The literature tends to emphasize the detrimental effects of the change in attention interruptions can instigate; for example that they cause frequent task switches (Czerwinski et al., 2004) that can lead to stress (Su and Mark, 2008), and failure to resume prior tasks (O’Conaill and Frohlich, 1995).

Adjacent research in interruption management often aims at minimising the cost of interruptions by deferring interruptions to more opportune moments (Adamczyk and Bailey, 2004; Ho and Intille, 2005; Iqbal and Bailey, 2007), or by adapting the way the interruption is presented (Avrahami and Hudson, 2004). This strand of work often proposes technical solutions that predict the cost of the interruption

based on sensing salient characteristics of the interruption context, such as the environment (Avrahami et al., 2007), the activity (Iqbal and Bailey, 2007; Avrahami et al., 2007; Adamczyk and Bailey, 2004) and attention of the interrupted person (Altosaar et al., 2006), as well as interruption content (Avrahami et al., 2007), and modality (Ho and Intille, 2005).

However, Rogers (2006) notes that efforts of constructing such automated systems have failed to meet the expectations evoked by labels such as ‘context awareness’. This is perhaps due to the unpredictable and dynamic nature of context (Greenberg, 2001). Dourish (2004) argues that context is a “slippery notion” that is “continually renegotiated and defined in the course of action”. In their ethnographic study of interruptions, Tolmie et al. emphasise the high local specificity with which interruptions are handled, that “pretty well precludes any principle judgment regarding its positive or negative character” (2008, p. 264); instead, they suggest that there are opportunities to support people’s management of interruptions that arise from the identifiable and methodical characteristics of how people handle interruptions. The question this paper seeks address is, what exactly are these methodical characteristics employed locally to handle notifications?

Notifications in collaborative systems

The role of notifications in collaborative systems at large has been introduced as a feature to support awareness in distributed groupware (Dourish and Bellotti, 1992), such as group editing (Shen and Sun, 2002). Mark et al. (2005) highlighted their role in alerting users to the interdependencies within cooperative work, a feature we adopt for our own work presented here. Work on mobile photo sharing in collocated groups has shown how people use these systems as a site of self-expression within social groups (Van House et al., 2005) and to support an on-going real-world experience (Jacucci et al., 2007). It has further emphasised the importance of a ‘common space’ to enable group access and use of resources to support collective creative practices (Salovaara et al., 2006), and social discourse around the shared artefacts (Patel et al., 2009). Our focus in this paper is to study how collocated groups handle and situate notifications within their ongoing interaction.

Rogers notes that notifications may contribute to people engaging in experiences: “A constant but ‘nagging’ mechanism may also be effective at persuading people to do something they might not otherwise done” (2006, p. 416). To that end, in our prior field study of a collaborative mobile photo-souvenir system, we revealed how notifications interfered with social group interaction, to the point that one participant described accepting them “all of the time would seem anti-social” (Durrant et al., 2011, p. 1772). Furthermore, the notifications of new shared photos in the photo pool often told the groups something that they could already physically see for themselves, being collocated. Redundancy and overload with notifications in mobile collaborative systems has also been reported by Streefkerk et al. (2008).

The literature indicates strategies employed within group management of notifications, such as ignoring (Durrant et al., 2011) and making interruptions account-

able to various cohorts, is commonplace (Tolmie et al., 2008). However, it appears there is little discussion of how notifications are dealt with in situ and how this process might be supported by design, particularly for settings with collocated groups. The study we present in this paper aims at addressing this gap in the literature.

Application areas that may benefit from understanding and supporting notification management within groups include locally distributed work settings with high temporal demands, such as policing (Streefkerk et al., 2008), fire-fighting (Jiang et al., 2004), and disaster response. Moreover, technology support of leisure activities are relevant, such as cultural visiting (Brown et al., 2005; Bellotti et al., 2008), spectating at outdoor sports events (Jacucci et al., 2007; Salovaara et al., 2006), location-based games (Bell et al., 2006), and learning (Benford et al., 2005).

Exploring notification management within groups

The field trial was based on a collaborative photo-taking exercise to create orientation guides of a university campus for new students and staff. As part of the exercise, a group (four to six people) was split into two teams to collectively take photos around the campus to be used in the orientation guide. We designed the trial and system with a view to encourage the management of notifications by the groups. To realise this, we deployed audio-visual system notifications to support the interdependencies within the exercise.

Before we turn to the study, we briefly describe the photo-taking exercise, the application used in the study and its underlying notification mechanics.

Collaborative photo-taking in INSTACAMPUS

To provide a realistic collaborative scenario, we devised a photo-taking exercise with interdependencies. Interdependencies were introduced by telling participants that a balanced amount of photos were to be taken of four different aspects of the campus: nature, building, wildlife, key services and information points. Notifications alerted group members to newly available photos, and also had the function of highlighting interdependencies between teams in the photo-taking exercise.

The notifications were implemented in a mobile app for Android called INSTACAMPUS that participants used to take, access and browse photos. Newly taken photos are automatically shared across the group by being added to a shared photo pool integrated locally with the application's gallery.

Standard Android notifications were used (chime, vibrate, and icon + text in the 'notification drawer'). There are two types of notifications in INSTACAMPUS.

- One teammate in the collocated team is notified when the remote team has 'shared' a photo (for the entire duration of the trial). When opening this type of notification, the app takes the viewer to the remote team's most recently shared image in the photo pool on the device. 'Shared photo' notifications are intended to provide a sense of awareness of the remote team's actions. To

avoid notification overload, the rate at which shared photo notifications were delivered was limited by aggregating the notifications generated within three minutes after the delivery of a notification.

- Another teammate is notified when they ‘found’ a nearby photo (stock photos associated with a geofence; likewise for the entire duration). Opening a photo displays what was ‘found’ with the option to add it to their photo pool or to dismiss it. Notifications of ‘photos found nearby’ are designed to encourage team decision-making. Any notification overrides an unopened existing one.

Participants and procedure

Four groups of four to six people were recruited for the trial, and consisted of colleagues and students in their twenties and early thirties who were familiar with the university campus. Upon gaining informed consent, each group was split into two teams of two to three people, with two phones assigned to each team to take photos through INSTACAMPUS: one configured to receive location-based notifications, and the other configured to receive shared photo notifications. In groups with more than four people a phone was shared and the carrier was swapped when the teams met up for a halftime re-group after 15 minutes. We varied the group member-to-phone ratio to trial different naturalistic configurations.

The groups were briefed on their objective to take a balanced amount of photos of different aspects of the campus, focusing on nature, buildings, key services and information points. It was explained to each person that the pictures they take would be automatically shared amongst them. In addition, they would either receive notifications about the arrival of new, shared photos or notifications regarding images that were previously taken nearby, which they could choose to add to their collective photo pool. These instructions were also given to them on a print out.

During the trial, a researcher shadowed each team with a camcorder, and each individual’s usage of the app was logged. The trial lasted for approximately 45 minutes (2 sessions of 15 minutes with a re-group discussion at halftime). The first group was used as a pilot study to refine the trial and was excluded from the analysis. Group 2 had 6 participants (3 female); Group 3 had 5 (all male), and Group 4 had 4 participants (1 female).

Method

This paper examines the ways notifications were dealt with whilst interactions within collocated groups unfolded. The findings are based on an analysis of video recordings of the trials, focusing on the way participants accountably organised their group interactions around the technology (cf. Crabtree et al., 2006). We draw on a framework to guide our analysis that “prioritises the situated and interactional accomplishment of practical action” (Heath et al., 2010, p. 1).

We catalogued the data corpus consisting of log files triangulated with the video recordings in a preliminary review that helped us to identify sequences of inter-

est. The 74 location-based and 109 shared photo notifications generated for the three groups served to index the *fragments* in the data corpus (Heath et al., 2010), temporally framing (sometimes overlapping) distinct units of interaction. We then transcribed both the verbal and visual conduct in sequences of particular interest for an in-depth analysis of the accomplishment of interaction that makes the socially organised work of dealing with notifications observable and reportable.

Findings

We present relevant sequences from our data (fragments) that show key aspects of notification management. Occurrences of notifications mark the beginnings of the sequences we analyse (indicated in seconds by 0:00). We describe visual conduct and `transcribe talk` using a widely used orthographic notation (cf. Heath et al., 2010) as evidence for our analysis. All participant names are fictional.

Ignoring notifications

Notifications were frequently ignored. For the purpose of this analysis, ‘ignoring’ a notification is defined by an observable absence of ‘opening’ a notification, i.e., the interaction required to ‘open’ a notification. 20% of the ‘images found nearby’ notifications were not opened (16), and 62% of the ‘shared photo’ notifications were equally not opened (68). The fact that the device was seen being carried in hand nearly all the time makes it less likely that notifications were unintentionally missed. Some/many of the notifications may have been overridden by the next notification despite the receiver possibly having the intention to open and examine it. However, for most of the unopened notifications our observations suggest that they have been deliberately ignored. For example, in a fragment about 7 minutes into the trial (not pictured) Charlie and Dom are planning what kind of photos to take as they are walking towards a fountain. C: I’ll take it from this side. If you want to ((points the other way)) D: Yeah (0.2) ((turns the other way)). As C is preparing to take a photo, he then receives his third ‘shared photo’ notification that he ‘ignores’; i.e., C continues with his ongoing course of action without appearing to attend to the notification bodily or in his talk, and he does not subsequently attend to it in any way having taking his photo.

Ignoring frequently occurred when the handling of arising contingencies was prioritized over opening new notifications. Examples of actions that were prioritized over opening notifications were taking photos, negotiating physical environment, talking to teammates, being on time for the halftime or the endtime of the trial, or witnessing events such as a ‘fish fight’ in the lake on campus.

Notification management within groups

When notifications were not managed through ignoring them, they were dealt with in a range of ways, one is through sharing its contents with one’s teammates. Frag-

ment 1 joins Simon, Pete and Oli (left to right) close to the end of the first half of the trial. Pete receives his sixth notification of an ‘image found nearby’ as the team of three is walking on a narrow pavement along a quiet campus road. Simon, to Pete’s left, is not currently carrying a phone. Oli, who carries the other phone is walking slightly ahead of them.

Fragment 1: The content of a notification is shared with team members.

a) (0:04): Simon appears to have overheard the notification. He leans towards Pete and looks down at Pete’s phone as he is opening the notification and they slow down. At this point, Oli carries on walking while Simon and Pete slow down to a standstill.



b) (0:07): Pete reviews the notification’s content, while Simon leans in more, his gaze fixed on Pete’s screen.



c) (0:09): Pete then slightly turns towards Simon, and lifts the phone up so it is easier to see, while simultaneously looking up at Simon. At the same time, Oli turns around towards the others.



d) (0:11): Oli is walking back towards them, as Pete briefly tilts the phone back to glance at it himself, with the screen showing the photo:

P: ? think it’s worthy (0.8)



e) (0:13): He then tilts it in a circular motion back past Simon to show the screen to Oli whilst saying:

P: or not.

Whilst Oli is looking at the screen, Simon replies:

S: ? to keep (0.2) no!



f) (0:15): Followed by Oli’s agreement expressed by shaking his head. Pete turns the phone back to himself, and says:

P: OK. (0.8)

He then presses the “dismiss” button and, whilst lowering the phone he looks back at Simon and says:

P: Somebody else took that one.

Oli turns back the same way the others are facing and they continue walking in the direction they were heading before the interruption.



The described sequence exemplifies the interaction through which the notification is socially shared within the group. On reception of the notification Simon signals interest in its contents through his bodily orientation towards his device and Pete. This indicates that this is a ‘good moment’ for the notification to be dealt with. Despite that there is no talk between the two as Pete shares the screen with Simon, Oli senses that they have stopped, turns around and approaches them, indicating his willingness to participate in handling the notification. P’s question (? think its worthy) is heard as a request for S and O to share their opinion. S and O’s agreement not to keep the photo is reciprocated by P’s response both by dismissing the photo on screen as well as verbally by stating that somebody else took the photo.

The sequence illustrates how the decision on whether to add the photo ‘found nearby’ is made collectively within 15 seconds of receiving the notification. More generally we found that coordinate resources drawn upon within this process of notification management within groups usually included signalling readiness or receptiveness to the notification on side of the receiver, and at least a willingness and ability to share the notification on side of the sender. The above sequence presents an unproblematic instance of social notification. At the same time, it demonstrates the interactional resources drawn upon to achieve agreement and align their action: making visible that one has heard the notification sound, responding through slowing down and stopping (having paid attention to others stopping), turning one’s body, turning the phone and making it visible and available for a recipient gaze etc.

Although groups in all trials employ interactional resources to manage notifications, it is important to note that this management is accomplished in nuanced, situationally, and individually distinct ways. For example in a different fragment (not pictured), Eva requests that Frank shares the contents of the ‘new shared photos’ notification he has just received, as he can be observed browsing photos. E: What have you got there then? He replies, without sharing the screen with her, F: They are (2) ((browses pictures)) Colin Campbell building. This fragment demonstrates that sharing the contents of a notification may be both requested explicitly, as well as performed verbally as opposed to visually as in fragment 1.

In the same team with Eva and Frank, Gerald receives the ‘image found nearby’ notifications on his phone. He frequently shares the contents, and he has a penchant to initiate sharing immediately after receiving a notification by stopping abruptly and announcing Oh I’ve got a notification!, or Oh I’m off again!, or, Oh hang on! – demonstrating that ‘bringing to attention’ and topicalising of a notification may be driven by by a single individual rather than achieved in a more symmetrically co-oriented fashion observed in fragment 1. Overall, we have identified 51 fragments that feature visual or verbal sharing of notification contents among the collocated team.

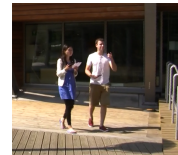
However, reaching an agreement regarding how to deal with a notification is not always this swift. In the following, we provide an account of a second instance of how reaching agreement can be more complex.

Managing concurrent activities

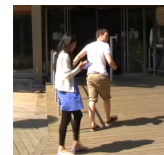
The sequence depicted in fragment 2 shows how agreement to dismiss the content of the notification is reached whilst the teammates negotiate their ongoing photowork. This sequence begins about 4 minutes after the start of the trial.

Fragment 2: Negotiation of agreement is started in (d), pending during ongoing photowork in (e) and (f) and completed in (g).

a) (-0:04): As we join the action, Ben is preparing to take a photo of the opposite “Exchange” building. He points while saying:
B: Yeah maybe from this side



b) (0:00): Angela receives her second ‘image found nearby’ notification on her device as Ben walks around the handrail in his way of getting a shot with more of the building on it, with his gaze still directed at the building.



c) (0:07): Angela follows him, positions herself to his side and then opens the notification as he prepares to take a photo by of the opposite “Exchange” building.



d) (0:10): Angela proceeds to lift and tilt the phone towards whilst pointing and saying:
A: Got this one in a notification (1.0)
same building



Ben glances at the photo to be added or dismissed briefly (showing a photo of the same building he is attempting to capture), but then refocuses on his phone whilst saying:

B: Yeah, you can't get a lot of it in.

He lifts his phone higher and brings it closer to his face, framing the photo. She lowers the phone, points towards the building and says:

A: ? Shall we try to capture exchange and the student shop.

e) (0:13): He proceeds to take the photo, she glances back at her screen, still showing the photo to be added or dismissed. He then lowers the phone to a more comfortable viewing position for both, and then review the photo he has just taken.



continued on next page

Fragment 2 continued.

B: °It didn't (2.0) I don't know is it [()°
A: [Can't really see
what's that [just about (.) that it's Exchange (0.6)
B: [no
A: maybe like (.) ((tuts)) ah::m (1.0) what would be really
good to capture would be like (.) shop ((points)) and
ah::m=
B: =yeah=
A: =and cafe.
B: Yeah

f) (0:22): They start walking towards the Exchange building he just took a photo of, which has the mentioned shop and cafe in it. As they are walking she is carrying her phone upright near her face while he points towards the entrance.



He looks at the paper with the instructions and reads out:

B: services (0.4) timetables n maps

They then stop in front of the entrance, she points towards the shop on their left:

A: the shop there

B: Ah OK.

They then take a few steps towards the shop until he abruptly stops:

B: Let's get the shop from the inside.

They turn back towards the buildings main entrance (shown in fragment 2(f)), as they enter the atrium he points at the shop:

B: You do the shop I'll do ((points the other way))

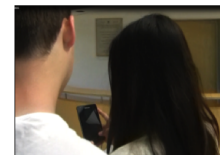
g) (1:21): Angela then lifts the phone up hovering her finger over the dismiss button, saying:

A: °dismiss:°

To which Ben orients by leaning towards her device, glancing at her phone.

B: °Yeah.°

She then presses the dismiss button, after which she immediately turns her phone into landscape mode and proceeds to take photos of the shop, while Ben turns away from her to take photos on the other side of the atrium.



The first feature of the interaction we wish to draw attention to is the focused way in which Ben accomplishes the photowork required to complete the overall task of the trial. Indicative of this are his remark at the beginning of the sequence (*maybe from this side*) that reveals his current objective to take a photo of the opposite building to his teammate. Further, his lack of engagement with Angela's attempted sharing of the notification that she has just 'found' a photo of the selfsame building shows his overriding concern with the framing of the photograph, causing 'trouble' for her concern to come to an agreement on her notification.

Most importantly, the sequence highlights the work Angela does to finally elicit her teammate's opinion on whether to add the photo to their shared pool, whilst also engaging in the concurrent and conflicting photowork Ben is focused on. Angela's more or less immediate opening up of the notification shows that she is receptive to the notification at this point. She shares the content of the notification (frag. 2d), but perhaps due to a lack of Ben's expression of opinion she can be observed 'deferring' the decision whether to add or dismiss the photo. All the while keeping the device lifted close to her face or shoulder, glancing at it several times, perhaps to remind herself of the pending decision (frag. 2e).

As they have entered the building and Ben suggests they split up to take photos separately, she seizes the moment to get his agreement on her suggestion to dismiss the photo. She immediately turns the device into landscape format in preparation to take the next photo. The immediacy and fluency with which she switches modes suggests that she probably planned this switch. In turn, this suggests she may have perceived the moment as the proverbial 'last chance' at which she can elicit his opinion without having to try switching back to the notifications view *later on*.

Contrasting this sequence of interaction with the one previously presented, features of the interaction emerge that make it remarkably different – most prominently the work to reach agreement and coordinate action (i.e., adding or dismissing a photo) in negotiation with a concurrently ongoing other activity. Angela employs a range of interactional resources to support the 'pending' state, including holding the phone up and keeping it there even when walking (e.g., frag. 2f), repeated 'bringing to attention' through talk and bodily conduct (e.g., frag. 2g), finally seizing the moment to share just-in-time. The previous fragment contrasted with this one in that the 'good moment' emerged *in and through* participants observably demonstrating a (physical) orientation to the moment as an appropriate one for managing the notification. Through Angela's conduct she demonstrates a similar orientation, but also develops a strategy of momentarily deferring the decision to an appropriate moment whilst there exists the sense of the group's engagement in ongoing photowork (demonstrated through Ben's focus on his screen, limited attending to Angela's screen and relative silence in response to her requests).

We have identified several more fragments in which groups reach an agreement in negotiation with ongoing activity. For example, after Angela receives an 'image found nearby' during the halftime discussion with the other team, in preparation she opens but then defers sharing her phone screen with Ben while in conversation. In another group, Dom receives an 'image found nearby', a notification he opens as he is walking beside Charlie. Charlie himself then receives a 'shared images' notification a few seconds after. Dom 'defers' sharing his screen contents for a few seconds while Charlie is opening and reviewing his notification. In yet another group, Gerald has already shown his teammates the photo 'found nearby', as Eva receives a notification which leads to the team briefly discussing her photo before Gerald goes back to his phone, remarking, *I'm not gonna add that one*.

Overall, we have identified 8 fragments that feature a 'pending' decision and/or delayed content sharing as situational contingencies are dealt with between opening

the notification and handling it in some way.

Distinctly different, the following sequence illustrates that participants exhibit alternative ways of dealing with notifications without sharing their contents with their collocated teammates.

Managing notifications ‘individually’

The following fragment joins Charlie and Dom about 12 minutes into the second half of the trial.

Fragment 3: The decision to dismiss is taken without seeking agreement with the teammate.

a) (0:00): Dom (wearing a black T-Shirt) receives his 12th notification of an ‘image found nearby’ (the notification chime is inaudible on the video). He crosses in front of Charlie and stops, looking down at his phone.



b) (0:05): Whilst shielding the screen from sunlight and opening the notification, Dom turns slightly towards Charlie who is approaching from behind. However, Charlie continues straight past him without stopping.



c) (0:10): As Dom reviews the notification contents (a photo of a student hall to their left) he continues to turn to face Charlie, who is walking towards and preparing to take a photo of a large information sign showing a Campus map.



d) (0:13): With the decision whether to add or dismiss the recent photo on screen pending, Dom follows Charlie and just looks up from his screen as he is about to take the photo of the sign.



e) (0:14): Charlie is taking the picture, while Dom engages animatedly, pointing at the sign, saying:

D: Ah yes!



f) (0:21): After the two briefly stand next to each other quietly, looking at the sign, Charlie turns away and walks off to take more pictures. Dom once again looks at his phone, and presses the ‘dismiss’ button.



Most notably, the decision to dismiss the photo is made by Dom without seeking the agreement of Charlie, or even bringing the notification contents to his attention. However, Dom demonstrates awareness of Charlie as he positions himself out of his way and turns towards him, and then turns with him as he is opening the notification (frag. 3b-c). Yet Charlie does not even glance at Dom's activity while he is walking past him – perhaps he is already concerned with taking the photo. When Dom realises Charlie's action, his outburst suggests his approval and sudden co-orientation to his photo-taking. His teammate's activity appears to have 'overridden' any (potential) prior endeavour to share his notification's contents. Another moment of 'standing still' together passes (without Dom seizing the opportunity), upon which Charlie turns and walks off.

The sequence shows the importance of a) the exhibiting of receptiveness on the side of the (potential) receiver (Charlie), or lack thereof; and b) the seizing of a moment to 'bring to attention' an outstanding decision (Dom), or lack thereof. Taken together, the absence of employing interactional resources to that effect results in a lack of co-ordinated agreement. This is not to say that the team has 'failed', simply that the decision is being made 'individually' as opposed to collectively.

We observed 21 instances where an individual dealt with a notifications without sharing its contents. In another team, for example, as Max and Linus are walking back to the meeting point for halftime, Max suggests where to go after the break. Linus does not engage in dialogue, and he never looks up from his phone on which he is browsing photos. This does not change when Max receives a notification a few seconds later, which he proceeds to deal with quietly as both continue. In a different group, Gerald and Frank are lamenting what kind of pictures to take next, as Eva receives, opens and reviews a 'shared photo' without comment. These examples show that more than willingness to share notification content is required; they emphasise that the sensitivity to interpret their teammates' actions as exhibiting (un-)availability plays a key role in deciding whether content is 'brought to attention'.

Limitations

The observed behaviours were occasioned by the nature of the task, which was the subject of the trial. Behaviours such as consulting team member(s) for decision making, commenting on the other team's location and reviewing their photos to inform what kinds of photos to take next are contingent to the nature of the photo-taking task the participants were instructed to carry out.

Further, the contents of the notification appears to have been critical in people's judgement of the value of the notification and whether it is worth a transforming the notification into a group concern, perhaps echoed in the frequency that participants opened notifications without sharing their contents. The content of location-based notifications presented a task that prompted a decision whether to add or dismiss a photo 'found nearby'. In contrast, the value of the shared photo notifications may 'only' be informational. Hence, the observations made in this study may not generalize to other settings. However, as the discussion will show, the findings

support and echo the wider literature on interaction in face-to-face settings, which suggests that our study may have merit, particularly when considering the design of collaborative interactive notification systems.

Discussion

We now reflect on a) the ways participants employ interactional resources to different effects and relate these to the literature on face-to-face interaction, and b) the sequentiality of notification management within groups. Finally, we relate our findings to previous work on interruption management and ask design questions to support the collaborative management of notifications.

Interactional resources for notification management in groups

The introduced fragments have illustrated the nuanced, situationally and individually distinct ways in which notification management was achieved in practice within our field trial. Participants have displayed remarkably smoothly co-ordinated, shared agreement (fragment 1), skilful management of a ‘pending’ decision in negotiation with ongoing work (fragment 2), and the absence of content sharing and seeking agreement altogether (fragment 3). However, in spite of these different effects, the interactional resources participants employed to manage notifications were drawn from the same repertoire. Table I summarises the embodied and technological resources and (some of) the effects to which they were deployed to manage notifications. A key insight is that in spite of a relatively limited repertoire of coordinate resources, participants employ them in ways and configurations to drastically different effects. For example, body orientation and movement can be equally employed to make visible availability and interest (‘turning towards’, ‘leaning in’) as well as to exhibit unavailability (‘turning away’, ‘walking past’).

Unpacking the interactional resources in face-to-face settings can be applied to provide insights into the support of collaborative technologies (e.g., Luff and Jirotko, 1998). Our findings echo aspects of some of these accounts of interaction in the literature. For example, Hindmarsh and Heath (2000) describe how objects are brought to the attention of a colleague by another in the context of shared activities at work. Then the object is ‘constituted’, i.e., a mutual understanding or appreciation is achieved through talk, gestures and bodily co-orientation. Similarly, our study has shown that

- initiation (bringing to attention) is often accompanied by additional embodied resources such as gaze by the co-participant (e.g., frag. 1a),
- co-orientation and understanding is displayed through body orientation (e.g., frag. 1e).

The bodily co-orientation our participants exhibited speak to previous findings in nonverbal communication, e.g., Kendon’s F-Formation (1990) is assembled as a ‘transactional space’ in which, for example, agreement is reached (frag. 1); and

Goffman’s “body gloss” (1963) features, in that overall ‘body gestures’ may be applied to make facts ‘gleanable’.

Table I: Interactional resources for notification management within groups.

Interactional resource	Interactional achievement	
	Sender	Recipient
Body orientation	‘turning towards’ to signal willingness to engage (frag. 3b,c)	‘leaning in’ (frag. 1a), or ‘turning towards’ (frag. 1c, 2g) to signal receptivity; ‘turning away’ signals unavailability (frag. 3f)
Body motion	walking together side-by-side, slowing down together facilitates glancing of screen, making visible screen interaction (frag. 1a,b)	‘walking past’ signals unavailability (frag. 3b)
Gestures	Making phone screen available for gaze to topicalise content (frag. 1c,e, 2d,g); ‘holding up’ phone close to face to support ‘pending’ decision (frag. 2e,f,g), ‘hovering finger’ to make action visible and accountable (frag. 2g)	
Gaze & Glance	repeated glancing at phone to sustain ‘pending’ decision (frag. 2e,f); monitor recipient availability (frag. 3d) and reaction (frag. 1c)	gaze to view screen contents (frag. 1c,e, 2d,g), to co-engage in screen activity (frag. 1b)
Talk	Request teammate opinion (frag. 1d); (repeated) bringing to attention ‘pending’ decision (frag. 2d,g)	Express opinion (frag. 1e); agreement (frag. 2g) and co-engagement (frag. 3e)
Audio	Chime affords co-orientation of participants to notification arrival (frag. 1a)	
Visual	Performing visible touch screen interaction makes actions accountable to teammate (frag. 2b)	Observing/glancing interaction gestures affords awareness of teammates actions; phone display is easily made available for glancing through simple ‘sharing screen’ gesture (frag. 1,2)

Sequentiality of notification management

We can now chart the sequential orderliness of the work accomplished by collocated participants. In the same way in which turn at talk is both *context shaped* and *context shaping* (Heritage, 1984), the sequentiality of preceding and successive actions shape the social organisation of notification management. The sequentiality shapes

when and whether a notification is opened or ignored, how it is brought to attention ('topicalised') and the matter resolved, and whether this happens immediately after arrival (frag. 1), or in a delayed fashion (frag. 2), or not at all (frag. 3).

Our analysis focused on the actions through which the notification is dealt with once opened, within the course of ongoing interaction. The analysis of the 183 instances of notification management made apparent the sequential and interactional ways in which these were organised as a concerted activity between the co-participants in the setting.

On ignoring. In contrast to face-to-face interactions, the 'object' at first is not brought to attention by the other, it announces itself through audible notification. Hence, there is no social obligation *per se* for the recipient to deal with a notification, 'ignoring' at this point is understood as a socially legitimate practice by the co-participants. In the same way that tending to a phone call displays to the collocated its relevance to the here and now (cf. Hindmarsh and Heath, 2000), nonresponse ('ignoring') displays that the self-announcing 'object' is deemed irrelevant. In contrast, once the notification ('object') is brought to attention (e.g., through a question) by a co-participant in the face-to-face setting, there is a moral impediment to nonresponse (cf. Goffman, 1963). We have pointed out interactional sequences in which the other held the recipient of the notification accountable and demanded to be informed of its contents. It is by virtue of the chime being an audible signal to those within earshot that co-orientation to its arrival can be established, which, together with the notification's relevance to the shared task at hand justifies this holding accountable of the other.

On content sharing. The notification content is topicalised for example when the recipient signals receptivity, and the sender is willing and able to share the contents. Once topicalised, the sender (the person who carries the phone) is accountable to perform an adequate presentation in a visual (e.g., by making the screen available for glancing) or verbal fashion (e.g., by commenting on the other team's shared photos). Of note here is that the small and light form factor of the mobile device affords the visual 'shareability' of the screen. Depending on the notification type the 'sharing' may support awareness of the remote team, or instigate team co-ordination on whether to add or dismiss the photo 'found nearby'. Body orientation and talk sustains the co-orientation and understanding until mutual agreement is achieved.

On filtering. In cases where notification contents was not shared with the group, the potential recipient of the notification can be observed producing actions that exhibit unavailability (e.g., being 'engrossed' in one's device) (cf. Sudnow, 1972). As Sudnow argues, timing of glances, and more importantly, the other's "production of appearances under an orientation to their timing" (1972, p. 261) is a key issue to establish a co-orientation of participants in coordinating availability for social exchanges such as a greeting. The importance and sensitivity of this issue can be seen when contrasting fragment 2 and 3. In the former, B. finally signals availability, which allows for unanimous completion of the task. Contrastingly, in the latter, C. never signals availability, amounting in D.'s 'filtering' (never performing) of the (social) notification.

On negotiating concurrent activity. The case in fragment 2 illustrates that reaching an agreement on the notification sometimes requires careful negotiation with a concurrent activity. On part of the sender, assigning priority to ongoing activity was pivotal, alongside an ability to sustain the ‘pending’ state of the decision displayed through repeated glances and bringing to attention. Finally, detecting and seizing the opportune moment and adequate presentation (sharing screen and ‘hovering finger’) to come to an agreement is critical. In contrast, not seizing a potentially opportune moment resulted in ‘filtering’ of the (social) notification.

Supporting human interruption management

By conducting the trial of a notification system designed for the collaborative task (photo-taking), we have examined how people readily exhibit social ways of managing notifications. Strategies that have featured prominently in the technical interruption management literature speak of attempts to mimic the human strategies we have observed. Technical strategies include “defer-to-breakpoint” (Iqbal and Bailey, 2007; Adamczyk and Bailey, 2004), “filtering” of relevant information (Sawhney and Schmandt, 2000) and the adaptation of presentation (Altosaar et al., 2006). Our participants readily employed interactional resources to manage notifications in ways that amount to ‘deferring’, ‘filtering’ and ‘adapting the presentation’.

However, the situationally sensitive and nuanced ways in which notification management is collaboratively achieved within groups raises the concern that automated systems that simply aim to replicate these strategies may not be appropriate. As previous work has suggested, this may be very difficult to do even for relatively controlled settings of desktop (Iqbal and Bailey, 2007; Adamczyk and Bailey, 2004) and office work (Avrahami et al., 2007). Our study highlighted how much more complex these difficulties could be when moving to mobile settings.

Instead, the account we offered echoes Tolmie’s conclusion (2008) that people are already expert in how they handle interruptions. So instead of trying to replace human expertise with inadequate automated solutions, a challenge this insight poses for the CSCW community is how to support people’s expert strategies in managing interruptions. Moreover, where is the design line between supporting expert strategies and attempting to automate or replace them? Our study attempts to chart the contours of that line. Concrete design proposals have to be left for future work. Rather, we ask designers to reflect on how might notifications be designed

- to ensure important content is not ignored;
- to maximise the interactional resources co-participants can employ to initiate and perform ‘content sharing’;
- to support the resources to ‘keep alive’ a ‘pending’ notification in negotiation with concurrent activity;
- to ensure important content is not lost when a participant ‘filters’ contents.

Conclusions

This paper has presented a detailed account of how notifications are dealt with during ongoing group interaction around a collaborative mobile photo-taking exercise. The account has broader relevance to the use of notifications in social and collaborative media in collocated settings, in that it unpacks how members manage notifications with sensitivity to the ongoing accomplishment of social order.

Our study has revealed the methodical ways in which participants organise the management of notifications with their collocated teammates. We had created a setting in which notifications are relevant because of task interdependence; and notification types are delivered to a different member of the collocated team to encourage social interaction. Our account pays particular attention to the interactional resources participants employ in situationally distinct ways to different effects, and to the sequential organisation of notification management. The study reveals that notification management within groups routinely features ignoring, content sharing, negotiating concurrent activity and filtering; we suggest that instead of attempting to replicate these sorts of strategies as part of an interactive system, technology design should aim to *provide support for these existing strategies themselves*. To that end, this paper has identified a repertoire of interactional resources that can be used as a framework to inform the research and design of technology that employs notifications to support collocated group activities.

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