[accepted manuscript before copyediting]
Tomoyo Sasao, Shin'ichi Konomi, Vassilis Kostakos, Keisuke Kuribayashi, Jorge Goncalves (2017). Community Reminder: Participatory Contextual Reminder Environments for Local Communities. *International Journal of Human-Computer Studies,* Elsevier, Amsterdam. (in press) © 2017. http://dx.doi.org/10. 1016/j.ijhcs.2016.09.001. This manuscript version is made available under the CC-BY-NC-ND 4.0 license http://creativecommons.org/licenses/by-nc-nd/4.0/.

Community Reminder: Participatory Contextual Reminder Environments for Local Communities

Tomoyo Sasao[a] Shin'ichi Konomi[b] Vassilis Kostakos[c]
Keisuke Kuribayashi[a] Jorge Goncalves[c]

[a]Graduate School of Frontier Sciences, the University of Tokyo, Japan
[b]Center for Spatial Information Science, the University of Tokyo, Japan
[c]Center for Ubiquitous Computing, University of Oulu, Finland

Abstract
Many projects have looked at how communities can co-design shared online repositories, such as Wikimapia and Wikipedia. However, little work has examined how local communities can give advice and support to their members by creating context-aware reminders that may include advice, tips and small requests. We developed the Community Reminder environment, a smartphone-based platform that supports community members to design and use context-aware reminders. We have conducted a one-month field study of Community Reminder to crowdsource and deliver safety-relevant information in a local community. The results show the benefits of involving community members in reminder design and connecting different perspectives. We also show that the proposed approach can broaden participation in local communities.

1 Introduction
Improving local communities can require costs and efforts beyond the capacities of local governments or a small number of experts. Citizen participation has been a focal point of discussion as a way to overcome the limitations to traditional approaches for improving the quality of life in local communities. Conventional methods for citizen participation include various types of face-to-face meetings and activities, which can require substantial commitments to participate. Mobile crowdsourcing as a means of lightweight pervasive collaboration and communication has the potential to change the landscape of participatory tools in community settings.

Most of the conventional mobile crowdsourcing tools require users to "pull" tasks reminiscent of its desktop counterpart. However, many crowdsourcing tasks for local communities can be tied to specific locations and contexts. Making meaningful contributions to local communities would thus require participants to remember to "pull" tasks at the right contexts, which can be extremely cognitively demanding and consequently impractical. In this context, one may opt for active mechanisms to remind citizens of relevant tasks based on context-aware computing. Currently, there are no established tools, processes or practices for integrating active reminder-based mobile crowdsourcing in local community environments although they have significant potential to activate lightweight contributions in all kinds of indoor and outdoor environments, broaden participation to many people including passers-by, and connect different viewpoints, knowledge, and feelings within and across the boundaries of local communities.

In this paper we present and evaluate Community Reminder, a system designed to allow community members to create contextual reminders for other members in the community. While many projects have looked at how communities can design shared online repositories, such as Wikimapia (Wikimapia, n.d.) and Wikipedia (Wikipedia Foundation, n.d.), little work has examined how local communities can give advice and support to their members by creating context-aware reminders that may include advice, tips and small requests. For example, context-aware reminders can deliver messages such as *"it's raining and the road in this area gets flooded easily. Better to change your route"* or *"car stolen here last week. Did you see suspicious people lately?"*

The crucial characteristic for effective context-aware reminders is the ability to foresee relevant situations. Thus, we argue for a system that exploits a participatory approach to create and use contextual reminders. A key differentiation between our proposed idea and conventional systems for sharing information in the local community (e.g., LOCQL (LOCQL, n.d.) and Naver KiN 'here' (Park et al., 2014)) is that the latter require proactive searching and do not necessary react to users' context.

Existing context-aware reminders such as Nixle (Everbridge, n.d.) focus on the mechanisms to trigger reminders rather than the process to create reminders. In practice, a "curator" would have to define the contents and behaviors of reminders in many cases. This approach does not necessarily scale, as an expert is needed to create reminders. Also, these are usually one-way information channels (i.e., users just "consume" contents, and they cannot generate contents). Therefore, it is not easy to transfer a system to a different local community. Furthermore, a "curator" may not be aware of local information and knowledge that are critical to integrate context-aware reminders into community-centric mobile crowdsourcing environments. We thus take advantage of communities and discuss how people create and receive reminders in relation to collective concerns of a community.

The key research question we address is how communities can, through a participatory process, develop valuable contextual reminders for other members of the community so as to improve their living environments together. We iterated the design of a context-aware reminder system by maintaining frequent contact with the members of a local community, and developed the system by integrating a participatory design tool and mobile clients. Acknowledging the diversity of local community members in terms of the motivation to participate as well as the familiarity with information technologies, the system welcomes different types of participants, some of whom carry out small pieces of work using smartphones such as answering short questions or taking photos in response to contextual reminders while others collaboratively design reminders as active volunteers of the community. In addition, we developed an intuitive paper-based input technology so that community members can create reminders regardless of their levels of familiarity with information technologies. The system we describe allows members of a community to create reminders including advice, tips and crowdsourcing tasks through a participatory process, and in doing so strengthen the ties in communities, encourage members of the community to become active in local matters, and of course provide helpful advice to members of the community.

We evaluate the system based on design case studies and a one-month field study in a local community in Ibaraki prefecture, Japan. The first design case study utilized the participatory design tool to capture local knowledge from the members of the community while the second design case study exploited existing information on a website. The field study evaluated how the residents of the community used and experienced the two sets of reminders that were produced in the case studies.

The results show the benefits of using both sets of reminders. The reminders created by the community members can better fit particular local contexts and generate more empathy. The reminders that are based on existing information are more general and often easier to create, yet they were perceived as having the comparable potential to contribute to the local community, and may introduce external viewpoints that tend to be overlooked by locals. We thus argue for complementary uses of different design methods to integrate the different benefits and perspectives, thereby enabling the provision of meaningful advice, tips and mobile crowdsourcing requests in local communities. Moreover, we show that our system allows for broader participation than traditional approaches to community participation without context-aware mobile crowdsourcing.

2 Related Work

2.1. Participatory Data Collection and Sharing Tools

As existing systems and research projects have demonstrated, participatory computational tools can provide a number of benefits to local communities. FixMyStreet (FixMyStreet, n.d.) and SeeClickFix (SeeClickFix, n.d.) are websites for local citizens to report issues such as potholes and broken streetlights. These websites may connect citizens and the people who can help address their issues, including administrative authorities in the area (FixMyStreet, n.d.). Geowiki has allowed cyclists to share useful knowledge that is not available elsewhere (Priedhorsky and Terveen, 2008). Le Dantec et al. (2015) use the data collected by cyclists to inform urban planning processes. Gallacher et al. (2015) propose tangible questionnaire, which is a physical box and set-up in a specific place. In disaster situations, people increasingly use volunteered geographic information (Goodchild and Glennon, 2010), and crisis mapping platforms like Ushahidi (Ushahidi, n.d.), which allows citizens to share information about human and material support, road conditions, safety, and so on. In addition, many participatory platforms allow citizens to collect sensing data such as the data about air quality, watersheds, transportation environments, parks, university campuses, and urban safety (Aubry et al., 2014; Christin et al., 2013; Kim et al., 2013; Manzoor et al., 2014; Misra et al., 2014; Reddy et al., 2010; Willett et al., 2010). People can use mobile devices to share valuable data along with relevant location information as Burrell et al. (2002) have shown in the study of a mobile guide application for university campus tours. Although these participatory data collection and sharing tools have successfully demonstrated their usefulness, they focus on a simple mode of participation based on data collection, thereby leaving a wide range of opportunities unexplored without explicitly supporting local communities to participate in the processes to create tasks, triggers and tools.

It is crucial to incentivize users effectively in participatory data collection and sharing

environments based on crowdsourcing. Incentive mechanisms in crowdsourcing systems either use extrinsic or intrinsic motivators (Kaufmann et al., 2011). Extrinsic motivation is basically payment and is the *de facto* incentive mechanism for many crowdsourcing platforms including MTurk (Amazon, n.d.) and Upwork (Upwork Global, n.d.). However, while payment has been successful in crowdsourcing with local communities (Hosio et al., 2014), sustained user engagement is more likely to happen when using intrinsic motivators (Kaufmann et al., 2011). Some examples of intrinsic motivators that have been successfully leveraged by crowdsourcing deployments to elicit contributions from local communities include altruism (Goncalves et al., 2013a), psychological empowerment (Goncalves et al., 2014a), contextual cues (Goncalves et al., 2013b), gamification (Goncalves et al., 2014b), and other enjoyment-based and community-based factors (Kaufmann et al., 2011).

2.2. Designing Tasks, Triggers, and Tools in Context-Aware Applications

Existing projects have proposed models and systems to make context-aware applications useful and usable by supporting end-users to design different aspects of the environments. One of the earliest examples is the context-aware reminder environment called CybreMinder (Dey and Abowd, 2000). It is based on the Context Toolkit (Dey, Abowd, and Salber, 2001) and allows individual users to design and receive reminders. The Context Toolkit itself supports software developers to build context-aware applications easily. In a similar vein, Henricksen and Indulska (2006) propose a set of relevant models and techniques to support the development processes of context-aware applications. Alt et al. (2010) propose a location-aware mobile crowdsourcing platform in which individual users can design location-based crowdsourcing tasks. In this platform, crowdsourcing workers "pull" crowdsourcing tasks from a web server based on their locations. Location-based social Q&A services such as LOCQL (LOCQL, n.d.) and NaverKiN 'here' (Park et al., 2014) similarly allow individual users to design location-based requests. Curated City is a website that allows individuals to create a guide for exploring a city (Cranshaw et al., 2014).

There are systems that allow users to design more fundamental aspects of context-aware systems. For example, Sensr (Kim et al., 2013) is an authoring environment for citizen science that enables people without programming skills to build mobile data collection tools. IFTTT (IFTTT, n.d.) allows users to define personal triggers by themselves, and a similar trigger-action environment has been used in smart home environments as well (Woo and Lim, 2015). These models and systems support individual users to design tasks, triggers or tools, however, without explicitly supporting collaboration in local communities, which is crucial to cope with 'wickedness' of problems in cities and neighborhoods.

2.3. Participatory Approaches for Local Communities

Approaches to designing for the integration of computational and community environments include user-centered approach (i.e., "user as subject") and participatory approach (i.e., "user as partner"). The user-centered approach uses citizen participation for extracting vision for the community and design codes. Contextual Inquiry has been used to design an urban social navigation system (Bilandzic et al., 2008). Tang et al. (2011) have used rapid prototyping tools to find and correct design problems early. Taylor et al. (2014) have proposed insight journalism to provide insights and inspire new technology designs.

Participatory approaches have been exploited to develop software for local communities. Examples include community informatics projects (Carroll and Rosson, 2007; Carroll and Rosson, 2013; Han et al., 2014; Sabiescu et al., 2014), public service design (Bradwell and Marr, 2008; Cook, 2013), urban planning (Arias et al., 2000), as well as location-based games (Björgvinsson et al., 2010). In addition, participatory approaches have been used to design ubicomp-supported visitor experiences in a historic English country estate (Hornecker et al., 2006), and to design a participatory application in public transit environments (Yoo et al., 2010). Sasao and Konomi (2014) have proposed workshop-based environments to support participatory design of urban applications. Moreover, web-based creative crowdsourcing services such as Neighborland (Neighborland, n.d.) and OpenIDEO (OpenIDEO, n.d.) attempt to generate good solutions by exploiting the creativity of a large number of participants.

The participatory approaches can provide opportunities for informed participation and connect different stakeholders (Arias et al., 2000; Botero and Saad-Sulonen, 2010). Moreover, in the area of participatory design, the notion of co-design has been discussed in relation *to the creativity of designers and people not trained in design working together in the design development process* (Sanders and Stappers, 2008). This notion enables an approach in which community members play a large role in ubiquitous service design as experts of their experiences in the community. It has been used to design healthcare, telecom, and logistics services (Steen, Manschot, and De Koning, 2011). Sabiescu, et al. (2014) has used the approach to design communication tools for empowering minority groups as well as ICT solutions for tourists. Our work is inspired by these developments, and, as far as we know, a first major effort to explore participatory processes for contextual reminders in local communities, employing participatory workshops for designing contextual reminders.

3 Context of the Study

Our study took place in a suburban community in Ibaraki prefecture in Japan. We contacted this community through our acquaintance, and iterated the design of our system by maintaining frequent contact with the members of this community from January 2014 till September 2014. We collected information about the community through a comprehensive literature survey and interviews. We also conducted ethnographic observations as we focus on safety issues in this community, and organized two focus groups involving local anti-crime patrol members. Overall, we gathered information about the geographical, historical, and social context of this community, including the details about voluntary activities by citizen groups and their motivations.

3.1. Overview of the Local Community

The local community has the population of about 4,500 and the area less than 1km^2. A wide main road with few pedestrian crossings divides the community into eastern and western segments and there are rather frequent traffic accidents on this road.

The major regional development in the 1970's divided the residents into newcomers and long-term residents. The newcomers and the long-term residents are different demographically in terms of age, occupation, and family structures, and they have little

communication with each other.

This local community did not have its own residents association for some time. In 1991, a group of citizens who were concerned about the scarcity of community engagement in this area created a residents association. However, only 12.8% residents participate in the residents association as of 2015, and they do not have an efficient means of sharing information and relies on "circular notice" which is manually passed around from one household to another and face-to-face communications (e.g., at a local event). This leads to perceived insufficiency of communication and bonding, which is a continued concern to the community.

The recent opinion poll and our conversations with community members suggest that safety is an important concern in the community. It seems to be related with the relatively large number of car thefts reported in the region as well as the major earthquake that affected the community in 2011.

3.2. The Neighborhood Watch Group in the Community

The neighborhood watch group of this community is a relatively new organization. It was affiliated to the residents association of the community in 2013 to support newcomers by increasing their awareness about potential dangers in the local community. It has 27 members, who are aged 35-65, all male. Their main activity is to patrol their community on foot, paying attention to illegally parked bicycles and cars as well as any unusual events. In addition, they greet passers-by and sometimes provide them with safety tips. Their voluntary activities seem to complement the safety-enhancing services provided by the local government, such as email services to notify recent incidents of crimes, tips for avoiding dangers, and so on. However, they cannot patrol everyday because most of them have day jobs: they patrol the community for one hour only on weekends.

Another issue is that they don't have an easy means to connect with other local community members. Although they often share what they find during the patrol activities with other members of the neighborhood watch group (e.g., by using email), it is difficult for them to share the information with other citizens.

3.3. Motivating the Design of Participatory Tools for Local Communities

As we came to believe that safety is one of the most important issues in this community, we organized two focus groups involving the members of the neighborhood watch group. The topics of the focus groups centered around the potential of computing technologies such as smartphones in enhancing safety in the community.

We found that neighborhood watch members have expectations and concerns about the uses of computing technologies for the safety of the local community (see Table 1). One of their prominent expectations was to use mobile tools to share information with other citizens as well as within the members. There are also concerns around the sensitiveness of information that mobile tools may potentially capture.

	Topic	Description
Expectations	Collecting More Information	Checking the environment every day, reporting local news in a timely manner, and being more observant of the problems that elderly people may have in their domestic life
	Efficient Voluntary Work	Patrolling the community more efficiently by sharing patrol courses
	Increased Cooperation	Collecting information about the community in a cooperative manner, and helping other members of the community by notifying them of dangerous spots
	Crime Prevention	Analyzing causes of crimes, and visualizing dangerous spots in the community
Concerns	Misperception	Falsely perceiving someone as a suspicious individual
	Privacy	Collecting and sharing privacy-sensitive photos of people or houses without permissions
	Digital Divide	Excluding community members who do not have easy access to digital technologies, and collecting more and/or better information in one area than others

Table 1. Expectations and Concerns around the Use of Mobile Tools for the Safety of the Local Community

In relation to the concerns about misperception, we need to consider the questions about responsibility. What if the information shared with all local community members turns out to be wrong? Although these concerns may not be easy to address, we saw promising potential in participatory design environments to remedy these issues. In particular, a process of collaboration and negotiation within such environments can help citizens make informed decisions based on different viewpoints.

We additionally conducted expert interviews with 4 professionals who have experiences working on community development projects. The objectives of these interviews are to better understand conventional practices of participatory urban design, which may inform the design of participatory computing tools for communities, and to obtain their feedback about our ideas of participatory computing technologies for local communities. As we go along, we collected valuable feedback about the ideas and usage scenarios from experts as well as community members. Additionally, we identified issues around information reliability, citizens' privacy, and access control for different types of people. In particular, the results of the expert interviews suggested that reminders could be designed in workshop-like settings, possibly with facilitators who connect the perspectives of citizens and experts.

4 The Community Reminder System

Based on the focus groups and some pilots, we designed the Community Reminder system. Our general objective is to produce useful mobile tools for serving the community. To do so, we focus on safety issues in local communities. The decision to focus on safety issues is partly our response to the voices we heard at the focus groups and partly influenced by our belief that safety is one of the most important issues in the community in view of the historical context and the statistics related to this local community. We expect that the system's technical architecture itself is generic enough to be used for not only negative issues such as crimes and accidents but also positive issues such as attractiveness of local

communities.

Smartphone-based participatory sensing tools could facilitate various community members as well as the neighborhood watch group to collect geo-tagged safety relevant information easily during weekdays as well as weekends. Moreover, context-aware information delivery tools on smartphones could provide an easy means to share citizen-generated information in the community. Accordingly, such tools would potentially have positive impacts towards connecting the community better and improving citizen engagement.

Context-aware information can be either "pushed" to mobile users via notifications or made available for users to access (or "pulled") via a web service. We opted for the "push" mode of information delivery as it can reduce the chance that users miss important safety information such as a dangerous intersection in proximity. When systems "push" information to users, the timing and the content of information delivery should be designed carefully. As context sensing techniques advance and detailed contexts become detectable, it is crucial to design appropriate contents and behaviors around various detailed local contexts. We believe that this is where local community members as experts of their own local environments can play a significant role.

Many urban and community development projects exploit shared physical artifacts such as large paper maps in colocated settings. Existing research (Arias et al., 2000) suggests that colocated collaborative design tools can be highly useful when it comes to the design for local communities by bringing together different stakeholders. We build on such existing research and practices to develop an inclusive participatory tool for designing tips, advice and requests, which are to be "pushed" to the smartphones of local community members.

4.1. System Overview

We have developed Community Reminder that displays to users' smartphones reminders and questions appropriate to their context (Figure 1). The system acquires users' context such as their location and activity based on the data from smartphone sensors. Trusted members of the community can co-create reminders by specifying the content and context of each reminder using a participatory design environment. Reminders may be used to simply provide information, but they can also be used to request information or request performing physical activities. Currently, the user interface of the participatory design environment is tailored to support certain types of context, such as geofences, types of activities, time of day, and weather conditions, which have been selected based on the results of the two focus groups. The system can be enhanced to support other types of context by implementing corresponding user interface components. The overall architecture consists of three major components (Figure 2):

Figure 1. Smartphone client. Shown in (a), (b), and (c) are reminders to post a photo report and to answer questions about physical vicinity. Locations of reminders can be displayed along with their geofence circles as shown in (d).

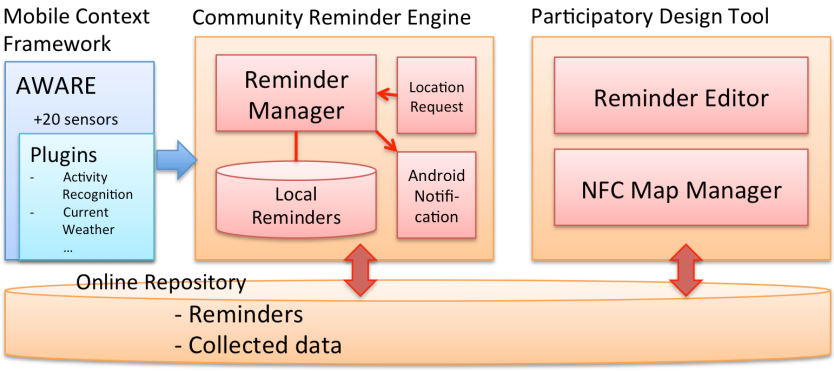


Figure 2. Overall architecture.

Mobile client: This Android-based software runs in the background and monitors users' context continuously. When the current context matches the context of certain reminders, a notification is issued to the user.

Online repository: This is the back-end of the system and stores all relevant information regarding the reminders and usage data from clients.

Participatory design environment: This is a tool with a tangible user interface that allows groups to design reminders for their community.

4.2. Mobile Client

The Mobile client continuously captures a user's context using Community Reminder Engine, which is based on AWARE framework (Ferreira, 2013). In our system, users' contexts can be detected based on multiple sensors and their combinations. For example, one could exploit users' locations and activities (e.g., being still, walking, biking, and moving in vehicle), environmental conditions such as presence of rain or darkness for delivering information related to safety or other goals of local communities.

Context matching is performed locally on the phone without disclosing contextual information to the server. The engine runs as a background service and initiates a context matching process every 30 seconds. We observed that the speed of battery drain with this context-matching frequency was acceptable if users change smartphones on a daily basis. The context collected on the phone is locally broadcast to the Reminder Manager. It first checks for entry events into geofences, as well as contextual changes in terms of time of day, activity, and weather condition. When any changes are detected, the engine accesses the local reminder database using the geofence's ID and the rest of the contextual information as keys. When the system matches a reminder to the current context, the reminder is then triggered via Android Notification Manager. The client makes users aware of reminders by showing small icons in the notification bar with sound and vibration (see Figure 1). The icons stay in the notification bar unless users delete them manually with a swipe gesture or by tapping on the "delete all" button. Therefore, users can also respond to reminders later (e.g., after driving).

4.3. Online Repository

The online repository stores all relevant information regarding the reminders including the contexts and contents of reminders. Therefore, new reminders can be pushed easily to all clients of the system. The repository also stores any data that are contributed by the users in response to reminders. These user-contributed data are stored along with location and timestamp information. Device IDs are hashed as a means of privacy protection.

4.4. Participatory Design Environment

Although citizens could use small personal devices to design reminders individually, we developed a large shared device for collaborative design since we mainly focus on reminders for the whole community. In particular, our participatory design environment consists of paper maps augmented with NFC markers, and mobile phones that are used as pointing devices to identify locations on the map.

As shown in Figure 3, participants use these devices based on a workshop-based process, which has the following three steps:

Figure 3. Workshop-based reminder design process.

(1) Participants discuss local issues and write down each problem along with its location on

a paper map.

(2) Participants discuss each problem and write down notification on sticky-notes.

(3) Participants use smartphones to capture notifications digitally.

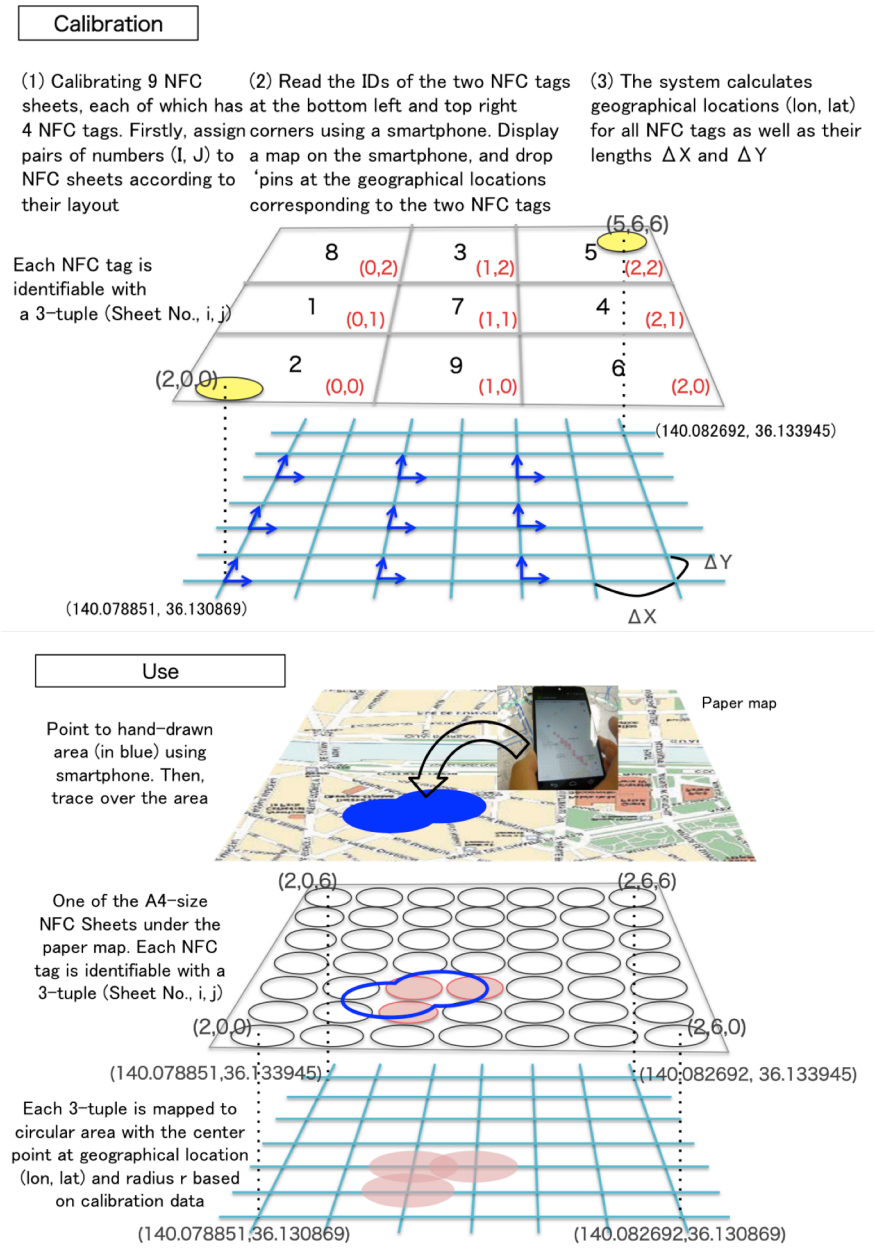


Figure 4. Calibration process and use of our tangible map interface. During the calibration process, one can easily assign a geo-location to a corresponding tag by tapping on a digital map and touching the tag with the smartphone.

The proposed paper-based tool is designed for inclusiveness to avoid intimidating community members with obtrusive technologies such as large tabletop computers. Figure 4 shows the calibration process and the usage of the tool. Using the phone, participants point

to a particular area on the map where they want to create a new reminder and trace over the area. When the phone detects the NFC markers behind the paper map, it marks the corresponding areas on a digital map to confirm or tweak the position of the markers. Once the area is confirmed, the user can specify the context (i.e., time of day, activity, if it is raining or not) that should trigger the reminder, as well as the content of the reminder (see Figure 5). The reminder itself can provide information (e.g., avoid this park after 8pm) or request information (e.g., has the abandoned car been collected? Yes/No).

There are 9 reminder types, including the ones that provide information, request information, or request performing physical activities. Recipients can provide information by answering yes/no, single-choice, multiple-choice, Likert-scale, number-entry and text entry questions, or taking photos. Examples of physical activities include picking up trash.

Figure 5. User interface to specify the context of reminders.

5 Reminder Design Case Studies

We conducted two case studies to explore different reminder design methods. The first case study exploits the proposed workshop-based reminder design process in which community members create reminders together in a colocated setting. The second case study is based on a systematic process to produce reminders by using existing information on a website.

5.1. Participatory Reminder Design by Local Community Members

To carry out the first case study, we recruited 4 members of the local neighborhood watch group (all male, age ranges from 30 to 60), and invited them to a workshop session. The participants knew one another and the workshop session lasted about 1 hour. Two researchers participated in the workshop as facilitators, and recorded the session by using a video camera and taking field notes. The facilitators first presented the paper-based participatory design tool and explained the purpose of the workshop. They then gave participants training until the participants felt comfortable enough to create reminders on their own. As shown in Figure 3, the workshop session itself consisted of three steps for identifying issues (Step 1), sketching reminders (Step 2), and creating reminders (Step 3). After the session, the researchers analyzed the results by transcribing the videotaped session and using affinity diagramming.

Step 1 lasted 20 minutes, and generated a map with a sketch of possible reminders, which

consists of handwritten texts and drawings made during discussions. They spent time sharing a variety of information about the community, and communicated with other participants verbally and non-verbally seeking agreements and consensuses.

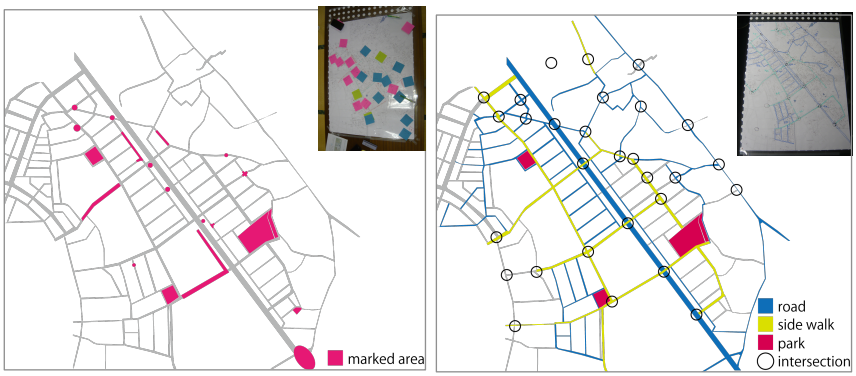
Importantly, our results show that the participants did not simply discuss locations and contents of reminders. They shared their knowledge and information relevant to their community and determined which information is important. Then, they recorded the information on the map. Face-to-face collaboration helped in this process. Firstly, it allowed for evaluation of ideas through nuanced verbal and non-verbal feedback from others. For example, one of the participants tended to talk loud about his ideas sometimes without getting any responses from others. Such communication can filter ideas and reminders in a nuanced way. Secondly, ideas can develop and expand quickly through face-to-face communication. Although this finding may not be entirely new, it came out as an important benefit in reminder design as a participant's description about the community reminds another participant of a relevant problem that could be notified to citizens, and also a participant's identification of a problem about a dark place causes others to mark the locations of other dark places thereby quickly producing a reminder that an individual person cannot create easily.

Step 2 lasted for 6 minutes, and generated a map with sticky notes that can be directly converted to actual contextual reminders (Figure 6a). Thanks to the division of labor, this step was finished quickly and participants did not have to talk much. The face-to-face setting however allowed participants to look at other participants' sticky notes to learn from one another.

Step 3 lasted for 35 minutes, and generated the 21 contextual reminders that are ready to use. This step was also completed quickly and participants did not talk much. We call the resulting reminders CDR (Collaboratively Designed Reminders). Figure 7a shows their geographical distribution, and Table 1 shows their samples. As shown in Figure 8a, CDR consists of 15 alert messages (*alert*), 3 single-choice question messages (*choice_1*), 2 yes/no question messages (*yn*), and 1 photo-taking request (*photo*). According to the distribution of CDR in Figure 8b, participants specified geofences for all reminders, activity types for 14 reminders, time of day for 7 reminders, and "rain or not" for 1 reminder. Seven reminders have been specified to be triggered only once per user.

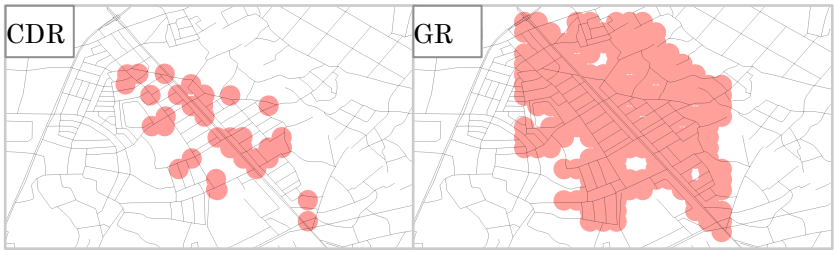
Title	Message	Context	Place
Watch Kids	Are there any kids playing?	Night	Park
Traffic accident warning	Traffic accidents happen frequently at this intersection.	Once	Intersection
Suspicious people?	A car was stolen.	On foot	The place at which a car was stolen

Table 2. Samples of CDR. Original text was in Japanese.



(a) Design by local community members **(b) Design based on existing information**

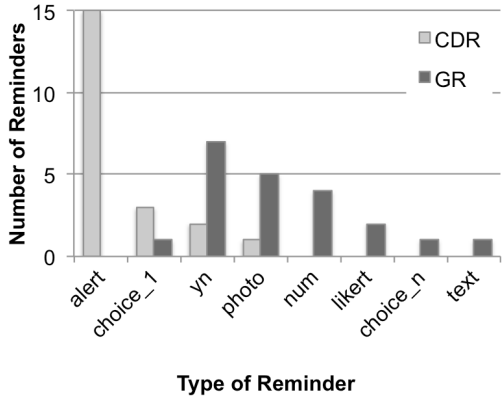
Figure 6. Depiction of the sketches drawn on paper maps.



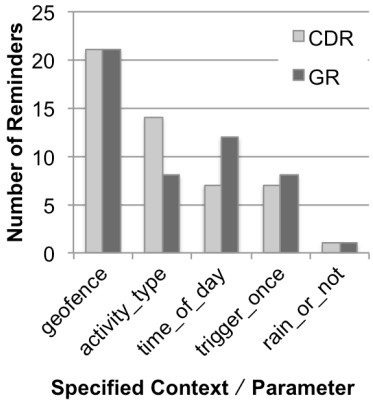
(a) Collaboratively Designed Reminders (CDR) by local community members

(b) General Reminders (GR) based on existing information

Figure 7. Geographical distribution of reminders.



(a) Distribution by type



(b) Distribution by context

Figure 8. Distribution of generated reminders by type and context.

5.2. Systematic Reminder Design Based on Existing Information

To carry out the second case study, we exploited existing information on a website that allows people to report problems related to living environments. The Japanese FixMyStreet website (FixMyStreet, n.d.) has a collection of reports describing problems such as broken

streetlamps, which are contributed by individual smartphone and/or PC users living in different areas of Japan. One of the motivations for people to report problems on this website can be the expectation that someone might potentially solve reported issues. For example, cities including Handa and Chiba are exploring programs to respond to issues reported on this website.

Two researchers examined all reports (n=806, as of July 2014) on the website independently, and jointly derived a list of 31 *location categories* (Cohen's kappa indicates substantial agreement with κ=0.752, $p<.005$). The same procedure was followed for jointly deriving a list of 20 *reminder categories* (Cohen's kappa indicates substantial agreement with κ=0.706, $p<.005$). We then constructed a matrix of these results (31 location categories by 20 issue categories) and selected the top 19 location-issue pairs with more than 8 reports (e.g., (*'park', 'graffiti'*), (*'sidewalk', 'danger'*), or (*'street', 'disturbing public peace'*)). We derived 21 general reminders based on these 19 pairs (see Table 2). To define the geofences of the reminders systematically without being influenced by designers' personal intentions, we color-coded the map of the community based on the 31 location categories (see Figure 6b), and assigned each reminder to the corresponding color-coded area. Figure 7b shows the resulting geofences of the 21 reminders. Alternatively, we could use coarse location categories that are available as category tags on the website, and derive the contents of reminders based on the titles of representative web reports for each location category. In doing so, we can exploit text summarization techniques. Subsequently, location categories can be converted to geofences by using open data including geocoded datasets of local parks, streetlamps, bus stops, etc. Producing reminders this way requires little manual effort although they may be more spatially coarser-grained and general than the ones we have produced manually.

It is apparent that the resulting reminders cover wider geographical area than CDR. This can be due to the difficulty to pinpoint the locations of reminders without local knowledge. Also, Figure 8a shows that this design method mainly produced reminders that ask questions rather than the ones that deliver information via alert messages. We could have potentially created alerts such as "roads have potholes," however, such reminders were judged to be of little relevance to the community and not considered. Consequently, all of the resulting reminders are requests to check problems (see Table 2). We call them General Reminders (GR) since they are designed by systematically generalizing and categorizing existing information resources.

Title	Message	Context	Place
Broken street lamp	How many street lamps are broken on this street?	Night	Road
Damaged street	Take a photo if there is a pothole.	Still	Road
Garbage check	If you see any garbage on sidewalk, indicate what kind of garbage it is.	Daytime	Sidewalk

Table 3. Samples of GR. Original text was in Japanese.

6 Field Study

We eventually conducted a field study of our software using CDR and GR as described in the preceding section on the design case studies. The field study sought to evaluate how participants perceived these reminders, and whether reminder changed participants' perceptions. We also sought to identify the key factors that must be considered in reminder design.

6.1. Experimental Design

We conducted a 28-day study of our system using both sets of reminders. After obtaining the approval from our institute's internal review board, we recruited 19 participants (see Table 3). We recruited them at the community's annual festival and through the social network of a member of the neighborhood watch group. Two participants dropped out of the study, and for all remaining participants we collected survey, diary and interview data. Two participants had technical problems that stopped us from collecting data from their phones.

	Gender		Age					Group	
	M	F	30s	40s	50s	60s	70s	G1	G2
Complete	3	12	5	6	1	3	0	8	7
No phone data	1	1	0	2	0	0	0	1	1
Dropped out	2	0	0	0	0	1	1	1	1
Total	6	13	5	8	1	4	1	10	9

Table 4. Overview of the participants.

Each participant used two sets of reminders: the collaboratively designed reminders (CDR) and the general reminders (GR). 10 participants were shown CDR for the first 2 weeks, and GR for the subsequent 2 weeks (Group G1). The remaining 9 participants were shown GR first, then CDR (Group G2).

We first explained the purpose and the general procedure of the study, and asked the participants to fill out the pre-study survey once they agreed to participate in the study. The pre-study survey was designed to collect demographic data as well as the data about their attitudes and knowledge related to the community and its safety.

We provided smartphones (15 Nexus 5's and 4 Galaxy S4's) so that participants who do not currently own smartphones can also join the study. We presented our tools and gave them training until they felt comfortable enough to receive and interact with all types of reminders and basic functions of smartphone. We informed them that there will be two different sets of reminders but did not tell which one was CDR or GR.

We handed a mid-point survey and a diary booklet to each participant, and explained how to complete them. The mid-point survey was designed to collect the data about the usability, usefulness and privacy concerns related to the reminders they received during the first two weeks. The diary booklet was designed to collect the data about the reminders they received on a daily basis. It also includes a 2-page cheat sheet for smartphone and system operations. At the 2-week point, we contacted all participants by phone or email to inform them that the reminder set would be switched, and asked them to fill out a mid-point survey about their

experiences during the first two weeks.

Finally, soon after the end of the 4th week we met the participants in person and collected the devices, mid-point surveys, and diary booklets. The data contributed in response to the reminders were made available as web reports and were shown to participants to ask them about the usefulness of each reminder. The devices' location data have been low-pass filtered before they are used. Then, we asked them to fill out the post study survey. The post study survey was identical to the mid-point survey, but covered their experiences during the final two weeks. Finally, we conducted informal short interviews.

Participants received 10,000 Japanese yen (approx. 100 US dollars) for compensation. They also received 50 Japanese yen (approx. 50 US cents) per day for making a diary entry.

6.2. Results

Seventeen participants received 4,475 reminders during the 4 weeks, and responded to 2,167 (48% response rate). About 31% responses were given within 5 minutes, and 80% within 3 hours. Overall, the response rate for collaboratively designed reminders (CDR) was 79%, and general reminders (GR) 46%. The movement of our 15 participants collectively covered 99% of the community's area in 4 weeks.

6.2.1. Perceptions of Reminders

Figure 9 shows participants perceptions of reminders. Over 70% recipients perceived reminders as useful for both CDR and GR. Generally, CDR seems somewhat better than GR although the differences are not statistically significant. CDR was perceived as emphatic more than GR, i.e., 44% and 30% recipients thought CDR and GR are empathic, respectively. This is a statistically significant difference ($U=61.00$, $p=.025$). One of the participants commented about CDR: *"I empathized [with this reminder] because I am always careful on this street."* Also, more than half of the participants perceived contextual reminders as closely related to the local community according to our quantitative results. This is echoed in participants' comments about the experience of receiving CDR such as *"It is good that I could be conscious of the local community."* Unlike GR, CDR delivered novel information about dangerous spots, hangout spots for kids, and improvements in the community such as a newly installed streetlamp. Relevance seems to influence participants' judgments about credibility of reminders. When asked about reasons for judging reminders as credible, many participants mentioned stronger relevance to the local community as well as timeliness of delivery. Reasons for judging reminders doubtful include vague messages and locations.

Participants noticed that GR misses important information such as school commuting routes that span outside the official boundary of the community. This suggests the limitations to the design process for GR, which does not provide an effective means to capture information about a specific place. However, interestingly, participants thought that almost half of GR contributes to a local community or society (see Figure 9). Thus, one can argue that exploiting existing information can be a useful approach to reminder design, and the participatory design process by local community members can complement it.

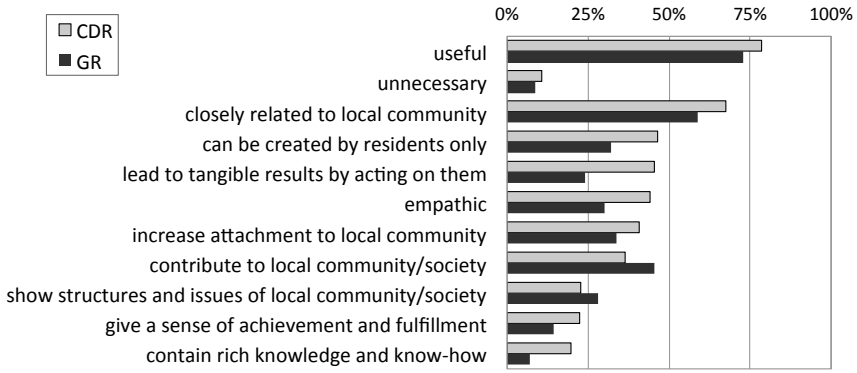


Figure 9. Participants' perceptions of the reminders.

Not surprisingly, participants disliked receiving reminders too often. Their diary comments suggest that they felt overloaded when they received more reminders than they can respond. Receiving a reminder every few minutes, for example, can be perceived as "too many" when driving a car but not when taking a walk. They also pointed out the need to collect more information from local community members via crowdsourcing. Although sending more reminders and requesting more crowdsourcing tasks could help collect more data, one must consider the tradeoff between "reminder overload" and scarcity of collected information. In our field study, CDR and GR position themselves differently in this tradeoff relationship, with CDR being more towards "less reminder overload and less collected information." Less reminder overload came at the expense of less collected information, thereby potentially leading to slightly lower ratings in terms of perceived contribution to the local community.

6.2.2. Perceived Benefits to the Community

Participants commented on the reasons why they think they can make meaningful contributions to the community by responding to reminders. The comments talk about increased amount of information about the community, which many perceived as beneficial to the community. There was also a comment that their acquired tendency to be attentive to the local environment is itself a benefit to the community. Moreover, such tendency can lead to discoveries that one may want to share with others. People who are willing to participate in the act of creating notifications said that they wanted to share what they have discovered in the community. On the contrary, people who are not willing to participate imagined that it would be difficult to design reminders and felt that they do not have sufficient time or knowledge.

6.2.3. Patterns of Participation

We have analyzed the correlations between the participants' attitudes towards community participation in the pre-study survey and their response rates to reminders. It is not surprising that the levels of interest in participating in community-improvement activities are moderately correlated with the actual frequency to participate in the activities of the local community ($r.=.557$, $p<.01$). However, the levels of such interest have no correlation with the response rates. We can thus expect similar response rates regardless of the initial levels of interest in community participation. This could be interpreted in two ways. One

interpretation is that our mobile tool has increased the levels of interest in community participation. The other interpretation is that the participation through our mobile tool is very easy and does not require high levels of interest in community participation. We also asked about the levels of interest in participating in reminder design in the post-study survey, and found that they are moderately correlated with the initial levels of interest in community participation ($r=.520$, $p<.01$). This suggests that participation in reminder design would require more commitments from citizens and be susceptible to the levels of interest in community participation.

7 Discussion

7.1. Designing Reminders for Local Communities

Our results suggest that people may perceive both CDR and GR as useful and closely related to local communities even though each type of reminders has its own strengths and weaknesses. CDR allows for development of reminders with detailed and concrete local contexts, and it may support empathic communication in communities better than GR. Existing research (Arias et al., 2000; Björgvinsson et al., 2010; Bradwell and Marr, 2008; Carroll and Rosson, 2007; Carroll and Rosson, 2013; Cook, 2013; Goodchild and Glennon, 2010; Sabiescu et al., 2014) also points to the benefits of involving citizens in design even though their approaches vary. Although an apparent issue with CDR is the cost to involve trusted local community members, GR is less costly to generate as it is based on existing user-generated contents rather than the collaborative efforts of local community members. Yet, our results show that GR shares many of the perceived benefits of CDR. Thus, our results suggest a complementary relationship between CDR and GR, and a potential of their combined uses. Locals can focus their efforts on the reminders that require local knowledge if GR can be used for general issues that recur at different locations in different communities. A major shortcoming of GR is that it is difficult to provide locally-relevant advice and tips, which can be complemented by CDR. Although many participatory systems focus on contributions by crowds, our results suggest a potential to build a more effective system by leveraging both crowds and trusted local experts.

We have used the face-to-face participatory tool to involve local residents in reminder design. Research suggests that choices of communication media are important in negotiation (Bandura, 1992). Co-located collaboration can facilitate group decision making by fostering development of rapport and reducing misunderstanding among people who may not already have a close relationship, although they may presuppose a smaller group of participants. Additional benefits of co-located collaboration relate to the integrated uses of physical and digital objects to support the development of shared context defined by task at hand (Arias et al., 2000). Such integration has been a prominent approach in the HCI and ubiquitous computing communities (e.g., (Ishii and Ullmer, 1997)), and we believe that co-located shared context can be useful for designing reminders that require consensus by different stakeholders.

We derived general reminders based on the existing information from various geographical areas other than the local community of interest. Yet the community members have perceived the generated reminders as beneficial. Although one might think that general reminders are simply a “cheap alternative” to CDR, our results show that general reminders

have their own strengths in terms of usefulness. Although locals may be experts of their own local contexts, it would be less likely that they are experts of everything that is needed to design effective reminders. A reminder for improving safety in a local community, for example, is a *nexus of different perspectives* ranging from geography and history of the community to public safety and computing. General reminders lead to the idea of connecting different viewpoints and know-hows in different local communities, thereby strengthening reminder environments by connecting relevant communities and supporting better practices beyond the boundaries of a local community. It can be useful to develop regional or even global repositories of general reminders, which various local communities can exploit. Community Reminder is not simply about increasing cohesion within local communities but also about creating continuities across their boundaries.

7.2. Making Contextual Reminders Part of a Community

One of the traditional approaches for residents to contribute to local communities is to join a residents association and collaborate with other members of the association. However, it often requires a major commitment to join such an association, and the percentage of people who participate in residents associations is decreasing in countries such as Japan. As we described earlier, residents can participate in the Community Reminder environment by co-designing reminders and/or by using the smartphone client. The latter mode of participation is more lightweight, requiring less time, effort and knowledge than the former. This *lightweight mode of participation* enabled people who do not participate in the neighborhood watch group or the residents association to contribute useful safety-related information in their daily lives. Thus, Community Reminder has provided novel *peripheral experiences* by exploiting mobile crowdsourcing in local communities. They are the kind of experiences that *"offer them various forms of casual but legitimate access to a practice without subjecting them to the demands of full membership*" (Wenger, 1998, p. 117).

In our study, some participants thought of the designers of reminders when their smartphones displayed notifications. Some participants even became willing to play a designer role that is more demanding than just receiving and responding to reminders. Generally speaking, there are different levels of participation (Arnstein, 1969; Fischer, 2011), and provision of migration paths towards more demanding levels are critical for having sufficient numbers of people at each level and thereby creating conditions in which cultures of participation are fostered (Fischer, 2011). Provision and awareness of such migration paths can be critical in improving participation and enabling meaningful collective action. It is then insufficient to merely provide citizens with easy-to-use mobile crowdsourcing tools. It can be critical that support mechanisms exist to facilitate migration and sustain participation. One of the key aspects that differentiate Community Reminder from existing crowdsourcing tools (FixMyStreet, n.d.; SeeClickFix, n.d.) is that it can connect users and citizen organizations such as a neighborhood watch group. Our experience with Community Reminder suggests that existing organizations and practices in local communities can facilitate and sustain participation around contextual reminders. In the long run, the Community Reminder environments may develop as the relationships are constantly negotiated between active volunteers and other community members such as end users of our mobile tool. Additionally, long-term usage generates historical data, which we can use to help designers create new reminders using statistical techniques (Sasao and

Konomi, 2016).

7.3. Incentive Design

Comments provided by the participants of our study suggest that the ease of smartphone-based inputs as well as the perception that collected information can benefit the community have positively impacted participation. We can support and strengthen such perception by providing quick feedback such as *"Thank you for your contribution. It will be used to make this intersection safer"* to increase awareness of the causal importance (Peterson, 1999). We also plan to incentivize participation by increasing awareness about self-efficacy (Bandura, 1992), sense of community (Wandersman and Florin, 2000), and thereby psychologically empowering users (Goncalves et al., 2014a).

Members of the local neighborhood watch group created the reminders in our study. They are the kind of people who have been and are motivated to collect and share safety relevant information in the community. What this highlights is the effectiveness of the strategy to connect with the right group of active community members who are intrinsically motivated to participate. Our study also suggests that end-users may become creators of reminders although they could feel hesitant to do so due to lack of experience and confidence. One approach to encourage their participation as creators is to provide social features, or to *go social* (Bellotti et al., 2015), for the support of learning and self-efficacy. For example, we could provide a social networking feature that creates an additional communication channel to share their experiences with reminders and recommending each other ways to create and use reminders in effective ways. This may increase social interactions that motivate peer learning and sustained collaborative activities among the users and creators of contextual reminders. Finally, we can also consider explicit monetary and social rewards for people who benefit the community by creating or responding to reminders although our study focused on a simpler environment without such rewards.

7.4. Privacy

Although the quantitative survey results show that most participants did not feel their privacy was invaded or they invaded others' privacy, participants' comments suggest that a few participants had concerns about their location privacy, and that 4 participants had concerns when they responded to reminders with questions about people or requests to take a photo of a car. These concerns must be considered in the next round of iterative improvements of the system.

7.5. Limitations

The study lasted for 4 weeks and we might face further issues in longitudinal deployments with larger numbers of users. They might include higher "reminder overload" and methods to update reminders. We are yet to develop methods to transfer the environment in one community to another and also invite various kinds of citizens to design sessions. Participants' comments also suggest other technical improvements that concern battery conservation as well as proactive reminding (e.g., reminding X seconds/meters before one reaches a dangerous intersection). Although our current method for deriving general reminders requires someone to handle information manually, machine learning and text summarization techniques (e.g., (Inouye and Kalita, 2011)) could be used to minimize such a

burden.

8 Conclusion

As a first step towards establishing tools, processes, and practices for reminder-based mobile crowdsourcing in local communities, we have proposed Community Reminder, a platform that allows community members to design and use contextual reminders. Our participatory tool provided a space for sharing local information, developing and judging ideas, and collaborating spontaneously to generate ready-to-use reminders. Community members perceived that co-designed reminders (CDR) fit local contexts and create more empathy. General reminders (GR) were perceived to contribute to the local community as well although they can be produced relatively easily without face-to-face meetings. We thus argue for complementary uses of different design methods to incorporate different viewpoints and provide meaningful advice, tips and mobile crowdsourcing requests in local communities.

We discussed the benefits of supporting different levels of participation using the participatory tool and the mobile clients. Mobile crowdsourcing with the client devices allowed for a lightweight mode of participation in which a wider variety of community members can perform small voluntary work in their daily lives. We thus argue that Community Reminder has broadened participation in local communities by providing novel peripheral experiences, which could potentially change the landscape of participation towards achieving shared goals in the local community.

Beyond addressing the limitations, we hope to iteratively improve the system in the long run. In particular, we intend to complement our participatory design environment with a mobile tool allowing for the creation of reminders on the go. We also intend to develop additional mechanisms to motivate participation and facilitate the usage of collected information by focusing on its quality, ownership, management, and ethical aspects. We believe that effective contextual reminders can be generated through an integrated design based on an emerging landscape of participation that our study suggests.

Acknowledgements

We thank all the participants who contributed to the study. This work was partially supported by MEXT under the Green Network of Excellence (GRENE) program, JSPS KAKENHI Grant No. 15J08542, and SS Avenue, Inc. The work only reflects the authors' views.

References

1. Alt, F., Shirazi, A.S., Schmidt, A., Kramer, U., Nawaz, Z., 2010. Location-based crowdsourcing: extending crowdsourcing to the real world. In: *Proceedings of the 6th Nordic Conference on Human-Computer Interaction: Extending Boundaries (NordiCHI '10)*. ACM, New York, pp. 13-22. http://doi.acm.org/10.1145/1868914.1868921
2. Amazon, n.d. Amazon Mechanical Turk – Welcome. https://www.mturk.com/ (accessed 16.07.05)
3. Arias, E., Eden, H., Fischer, G., Gorman, A., Scharff, E., 2000. Transcending the individual human mind—creating shared understanding through collaborative design. *ACM Trans. Comput.-Hum. Interact. 7*, 1, 84-113. http://doi.acm.org/10.1145/344949.345015

4. Arnstein, S.R., 1969. A ladder of citizen participation. *Journal of the American Institute of Planners 35*, 4, 216–224. http://doi.org/10.1080/01944366908977225

5. Ashbrook, D., Starner, T., 2003. Using GPS to learn significant locations and predict movement across multiple users. *Personal and Ubiquitous Comput. 7*, 5, 275–286. http://dx.doi.org/10.1007/s00779-003-0240-0

6. Aubry, E., Silverston, T., Lahmadi, A., Festor, O., 2014. CrowdOut: a mobile crowdsourcing service for road safety in digital cities. In: *Proceedings of 2014 International Conference on Pervasive Computing and Communications Workshops (PERCOM Workshops)*. IEEE, Piscataway, pp. 89-91. http://dx.doi.org/10.1109/PerComW.2014.6815170

7. Bandura, A., 1992. Exercise of personal agency through the self-efficacy mechanism. In: *Schwarzer, R. (Ed.), Self-Efficacy: Thought Control of Action.* Hemisphere Publishing Corp, Washington, DC, pp. 3–38.

8. Bazerman, M.H., Curhan, J.R., Moore, D.A., Valley, K.L., 2000. Negotiation. *Annual review of psychology 51*, 279–314. http://doi.org/10.1146/annurev.psych.51.1.279

9. Bellotti, V., Ambard, A., Turner, D., Gossmann, C., Demkova, K., Carroll, J.M., 2015. A muddle of models of motivation for using peer-to-peer economy systems. In: *Proceedings of the 2015 ACM Conference on Human Factors in Computing Systems (CHI '15)*. ACM, New York, pp. 1085–1094. http://dx.doi.org/10.1145/2702123.2702272

10. Bilandzic, M., Foth, M., De Luca, A., 2008. CityFlocks: designing social navigation for urban mobile information systems. In: *Proceedings of the 7th ACM conference on Designing interactive systems (DIS '08)*. ACM, New York, pp. 174-183. http://doi.acm.org/10.1145/1394445.1394464

11. Björgvinsson, E., Ehn, P., Hillgren, P.-A., 2010. Participatory design and "democratizing innovation". In: *Proceedings of the 11th Biennial Participatory Design Conference (PDC '10)*. ACM, New York, pp. 41-50. http://doi.acm.org/10.1145/1900441.1900448

12. Botero, A., Saad-Sulonen, J., 2010. Enhancing citizenship: the role of in-between infrastructures. In: *Proceedings of the 11th Biennial Participatory Design Conference (PDC '10)*. ACM, New York, pp. 81-90. http://doi.acm.org/10.1145/1900441.1900453

13. Bradwell, P., Marr, S., 2008. *Making the most of collaboration: an international survey of public service co-design.* DEMOS Report 23. http://www.demos.co.uk/files/CollabWeb.pdf (accessed 16.06.09).

14. Burrell, J., Gay, G.K., Kubo, K., Farina, N., 2002. Context-aware computing: a test case. In: *Borriello, G., Holmquist, L.E. (Eds.), Ubiquitous Computing, 4th International Conference, UbiComp 2002*. Springer-Verlag, Berlin, Heidelberg, pp. 1-15. http://dx.doi.org/10.1007/3-540-45809-3_1

15. Carroll, J.M., Rosson, M.B., 2007. Participatory design in community informatics. *Design Studies 28*, 3, 243–261. http://dx.doi.org/10.1016/j.destud.2007.02.007

16. Carroll, J.M., Rosson, M.B., 2013. Wild at Home: the neighborhood as a living laboratory for HCI. *ACM Transactions on Computer-Human Interaction 20*, 3, 1–28. http://dx.doi.org/10.1145/2491500.2491504

17. Christin, D., Roßkopf, C., Hollick, M., 2013. uSafe: a privacy-aware and participative mobile application for citizen safety in urban environments. *Pervasive and Mobile Computing 9*, 5, 695–707. http://dx.doi.org/10.1016/j.pmcj.2012.08.005

18. Cook, M.R., 2013. *The emergence and practice of co-design as a method for social sustainability under New Labour.* Ph.D Dissertation. University of East London. http://roar.uel.ac.uk/3014/ (accessed 16.06.09).

19. Cranshaw, J.B., Luther, K., Kelley, P.G., Sadeh, N., 2014. Curated city: capturing individual city guides through social curation. In: *Proceedings of the 2014 ACM Conference on Human Factors in Computing Systems (CHI '14).* ACM, New York, pp. 3249–3258. http://dx.doi.org/10.1145/2556288.2557401

20. Dey, A.K., Abowd, G.D., 2000. Cybreminder: a context-aware system for supporting reminders. In: *Thomas, P., Gellersen, H.-W. (Eds.), Handheld and Ubiquitous Computing, Second International Symposium, HUC 2000*. Springer-Verlag, Berlin, Heidelberg, pp. 172–186. http://doi.org/10.1007/3-540-39959-3_13

21. Dey, A.K., Abowd, G.D., Salber, D.A., 2001. Conceptual framework and a toolkit for supporting the rapid prototyping of context-aware applications. *Human-Computer Interaction 16*, 2, 97–166. http://doi.org/10.1207/S15327051HCI16234_02

22. Ferreira, D., 2013. *AWARE: A mobile context instrumentation middleware to collaboratively understand human behavior.* Ph.D Dissertation. University of Oulu. http://herkules.oulu.fi/isbn9789526201900/isbn9789526201900.pdf (accessed 16.06.09).

23. Everbridge, n.d. *Nixle | Building Stronger Communities Together.* http://www.nixle.com/ (accessed 16.06.09).

24. Fischer, G., 2011. Understanding, fostering, and supporting cultures of participation. *interactions 18*, 3, 42-53. http://dx.doi.org/10.1145/1962438.1962450

25. FixMyStreet, n.d. *FixMyStreet Japan.* http://www.fixmystreet.jp/ (accessed 16.06.09).

26. Gallacher, S., Golsteijn, C., Wall, L., Koeman, L., Andberg, S., Capra, L., Rogers, Y., 2015. Getting quizzical about physical: observing experiences with a tangible questionnaire. In: *Proceedings of the 2015 ACM International Joint Conference on Pervasive and Ubiquitous Computing (UbiComp '15)*. ACM, New York, pp. 263-273. http://doi.acm.org/10.1145/2750858.2807529

27. Goncalves, J., Ferreira, D., Hosio, S., Liu, Y., Rogstadius, J., Kukka, H., Kostakos, V., 2013a. Crowdsourcing on the spot: altruistic use of public displays, feasibility, performance, and behaviours. In: *Proceedings of the 2013 ACM International Joint Conference on Pervasive and Ubiquitous Computing (UbiComp'13).* ACM, New York, pp. 753-762. http://doi.acm.org/10.1145/2493432.2493481

28. Goncalves, J., Kostakos, V., Hosio, S., Karapanos, E., Lyra, O., 2013b. IncluCity: using contextual cues to raise awareness on environmental accessibility. In: *Proceedings of ACM SIGACCESS International Conference on Computers and Accessibility (ASSETS'13)*. ACM, New York, article 17. http://doi.acm.org/10.1145/2513383.2517030

29. Goncalves, J., Kostakos, V., Karapanos, E., Barreto, M., Camacho, T., Tomasic, A., Zimmerman, J., 2014a. Citizen motivation on the go: the role of psychological empowerment. *Interacting with Computers, 26,* 3, 196-207. http://dx.doi.org/10.1093/iwc/iwt035

30. Goncalves, J., Hosio, S., Ferreira, D., Kostakos, V., 2014b. Game of words: tagging places through crowdsourcing on public displays. In: *Proceedings of the ACM Conference on Designing Interactive Systems (DIS'14)*. ACM, New York, pp. 705-714. http://doi.acm.org/10.1145/2598510.2598514

31. Goodchild, M.F., Glennon, J.A., 2010. Crowdsourcing geographic information for disaster response: a research frontier. *International Journal of Digital Earth 3*, 3, 231–241. http://dx.doi.org/10.1080/17538941003759255

32. Han, K., Shih, P.C., Rosson, M.B., Carroll, J.M., 2014. Understanding local community attachment, engagement and social support networks mediated by mobile technology. *Interacting with Computers, 28,* 3, 220-237. http://dx.doi.org/10.1093/iwc/iwu040

33. Henricksen, K., Indulska, J., 2006. Developing context-aware pervasive computing applications: models and approach. *Pervasive and Mobile Computing 2,* 1, 37–64. http://doi.org/10.1016/j.pmcj.2005.07.003

34. Hornecker, E., Halloran, J., Fitzpatrick, G., Weal, M., Millard, D., Michaelides, D., Cruickshank, D., De Roure, D., 2006. UbiComp in opportunity spaces: challenges for participatory design. In: *Proceedings of the 9th Biennial Participatory Design Conference (PDC '06)*. ACM, New York, 47-56. http://doi.acm.org/10.1145/1147261.1147269

35. Hosio, S., Goncalves, J., Lehdonvirta, V., Ferreira, D., Kostakos, V., 2014. Situated crowdsourcing using a market model. In: *Proceedings of the 27th ACM User Interface, Software and Technology Symposium (UIST '14)*. ACM, New York, pp. 55-64. http://doi.acm.org/10.1145/2642918.2647362

36. IFTTT, n.d. *Learn how IFTTT works.* https://ifttt.com/ (accessed 16.06.09).

37. Inouye, D., Kalita, J.K., 2011. Comparing twitter summarization algorithms for multiple post summaries. In: *Proceedings of 2011 IEEE International Conference on Privacy, Security, Risk and Trust and IEEE International Conference on Social Computing (PASSAT/SocialCom 2011)*. IEEE, Piscataway, pp. 298–306. http://doi.org/10.1109/PASSAT/SocialCom.2011.31

38. Ishii, H., Ullmer, B., 1997. Tangible bits: towards seamless interfaces between people, bits and atoms. In: *Proceedings of the ACM SIGCHI Conference on Human Factors in Computing Systems (CHI '97)*. ACM, New York, pp. 234-241. http://doi.acm.org/10.1145/258549.258715

39. Kaufmann, N., Schulze, T., Veit, D., 2011. More than fun and money. worker motivation in crowdsourcing - a study on Mechanical Turk. In: *Proceedings of the Seventeenth Americas Conference on Information Systems (AMCIS)*. Paper 340. http://aisel.aisnet.org/amcis2011_submissions/340

40. Kim, S., Mankoff, J., Paulos, E., 2013. Sensr: evaluating a flexible framework for authoring mobile data-collection tools for citizen science. In: *Proceedings of the 2013 Conference on Computer Supported Cooperative Work (CSCW '13)*. ACM, New York, pp. 1453–1462. http://doi.org/10.1145/2441776.2441940

41. Le Dantec, C.A., Asad, M., Misra, A., Watkins, K.E., 2015. Planning with crowdsourced data: rhetoric and representation in transportation planning. In: *Proceedings of the 18th ACM Conference on Computer Supported Cooperative Work & Social Computing (CSCW '15)*. ACM, New York, pp. 1717-1727. http://doi.acm.org/10.1145/2675133.2675212

42. LOCQL, n.d. *Welcome to LOCQL: location based questions and answers*. http://www.locql.com/ (accessed 16.06.09).

43. Manzoor, A., Patsakis, C., Morris, A., McCarthy, J., Mullarkey, G., Pham, H., Clarke, S., Cahill, V., Bouroche, M., 2014. CityWatch: exploiting sensor data to manage cities better. *Transactions on Emerging Telecommunications Technologies 25*, 1, 64–80. http://doi.org/10.1002/ett.2786

44. McMillan, D.W., Chavis, D.M., 1986. Sense of community: a definition and theory. *Journal of Community Psychology 14*, 1, 6–23. http://doi.org/10.1002/1520-6629(198601)14:1<6::AID-JCOP2290140103>3.0.CO;2-I

45. Misra, A., Gooze, A., Watkins, K., Asad, M., Le Dantec, C., 2014. Crowdsourcing and its application to transportation data collection and management. *Transportation Research Record: Journal of the Transportation Research Board 2414*, 1–8. http://doi.org/10.3141/2414-01

46. Neighborland, n.d. *Neighborland.* https://neighborland.com (accessed 16.06.09).

47. OpenIDEO, n.d. *OpenIDEO*. https://openideo.com (accessed 16.06.09).

48. Park, S., Kim, Y., Lee, U., Ackerman, M., 2014. Understanding localness of knowledge sharing: a study of Naver KiN 'here'. In: *Proceedings of the 16th International Conference on Human-Computer Interaction with Mobile Devices & Services (MobileHCI '14)*. ACM, New York, 13-22. http://doi.acm.org/10.1145/2628363.2628407

49. Peterson, C., 1999. Personal control and well-being. In: *Kahneman, D., Diener, E., Schwarz, N. (Eds.), Well-being: The Foundations of Hedonic Psychology*. Russell Sage, New York, pp. 288–301.

50. Priedhorsky, R., Terveen, L., 2008. The computational geowiki: what, why, and how. In: *Proceedings of the 2008 ACM Conference on Computer Supported Cooperative Work (CSCW '08)*. ACM, New York, 267-276. http://doi.acm.org/10.1145/1460563.1460606

51. Reddy, S., Estrin, D., Srivastava, M., 2010. Recruitment framework for participatory sensing data collections. In: *Floréen, P., Krüger, A., Spasojevic, M. (Eds.), Pervasive Computing, 8th International Conference, Pervasive 2010.* Springer-Verlag, Berlin, Heidelberg, pp. 138–155. http://dx.doi.org/10.1007/978-3-642-12654-3_9

52. Sabiescu, A.G., David, S., Van Zyl, I., Cantoni, L., 2014. Emerging spaces in community-based participatory design: reflections from two case studies. In: *Proceedings of the 13th Participatory Design Conference (PDC '14)*. ACM, New York, pp. 1-10. http://doi.acm.org/10.1145/2661435.2661446

53. Sanders, E. B.-N., Stappers, P.J., 2008. Co-creation and the new landscapes of design. *CoDesign 4*, 1, 5–18. http://doi.org/10.1080/15710880701875068

54. Sasao, T., Konomi, S., 2014. U.App: an urban application design environment based on citizen workshops. In: *Streitz, N., Markopoulos, P. (Eds.), Distributed, Ambient, and Pervasive Interactions, Second International Conference, DAPI 2014*. Springer-Verlag, Berlin, Heidelberg, pp. 605–616. http://dx.doi.org/10.1007/978-3-319-07788-8_56

55. Sasao, T., Konomi, S., 2016. The use of historical information to support civic crowdsourcing. In: *Streitz, N., Markopoulos, P. (Eds.), Distributed, Ambient, and Pervasive Interactions, Fourth International Conference, DAPI 2016*. Springer-Verlag, Berlin, Heidelberg, pp.470–481. http://dx.doi.org/10.1007/978-3-319-39862-4_43

56. SeeClickFix, n.d. *Report non-emergency issues, receive alerts in your neighborhood - SeeClickFix - Web and Mobile Government 311.* http://seeclickfix.com (accessed 16.06.09).

57. Steen, M., Manschot, M., De Koning, N., 2011. Benefits of Co-design in Service Design Projects. International Journal of Design, 5, 2, 53–60.

58. Tang, L., Yu, Z., Zhou, X., Wang, H., Becker, C., 2011. Supporting rapid design and evaluation of pervasive applications: challenges and solutions. *Personal Ubiquitous Comput. 15*, 3, 253–269. http://dx.doi.org/10.1007/s00779-010-0332-6

59. Taylor, N., Frohlich, D.M., Egglestone, P., Marshall, J., Rogers, J., Blum-Ross, A., Mills, J., Shorter, M., Olivier, P., 2014. Utilising insight journalism for community technology design. In: *Proceedings of the 32nd annual ACM Conference on Human Factors in Computing Systems (CHI '14)*. ACM, New York, pp. 2995-3004. http://doi.acm.org/10.1145/2556288.2557054

60. Underkoffler, J., Ishii, H., 1999. Urp: a luminous-tangible workbench for urban planning and design. In: *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems (CHI '99)*. ACM, New York, pp. 386-393. http://doi.acm.org/10.1145/302979.303114

61. Upwork Global, n.d. Upwork - Hire Freelancers & Get Freelance Jobs Online. https://www.upwork.com/ (accessed 16.07.05)

62. Ushahidi, n.d. *Ushahidi*. http://www.ushahidi.com/ (accessed 16.06.09).

63. Wandersman, A., Florin, R., 2000. Citizen participation and community organizations. In: *Rappaport, J., Seidman, E. (Eds.), Handbook of Community Psychology*. Kluwer Academic/Plenum, New York, pp. 247–272. http://dx.doi.org/10.1007/978-1-4615-4193-6_11

64. Wenger, E., 1998. *Community of Practice.* Cambridge University Press.

65. Wikimapia, n.d. *Wikimapia - Let's describe the whole world!* http://wikimapia.org (accessed 16.06.09).

66. Wikipedia Foundation, n.d. *Wikipedia*. http://www.wikipedia.org (accessed 16.06.09).

67. Willett, W., Aoki, P., Kumar, N., Subramanian, S., Woodruff, A., 2010. Common sense community: scaffolding mobile sensing and analysis for novice users. In: *Floréen, P., Krüger, A., Spasojevic, M. (Eds.), Pervasive Computing, 8th International Conference, Pervasive 2010.* Springer-Verlag, Berlin, Heidelberg, pp. 301–318. http://doi.org/10.1007/978-3-642-12654-3_18

68. Woo, J.-B., Lim, Y.-K., 2015. User experience in do-it-yourself-style smart homes. In: *Proceedings of the 2015 ACM International Joint Conference on Pervasive and Ubiquitous Computing* (UbiComp '15). ACM, New York, pp. 779-790. http://doi.acm.org/10.1145/2750858.2806063

69. Yoo, D., Zimmerman, J., Steinfeld, A., Tomasic, A., 2010. Understanding the space for co-design in riders' interactions with a transit service. In: *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems* (CHI '10). ACM, New York, pp. 1797-1806. http://doi.acm.org/10.1145/1753326.1753596