Reveal: Investigating Proactive Location-Based Reminiscing with Personal Digital Photo Repositories

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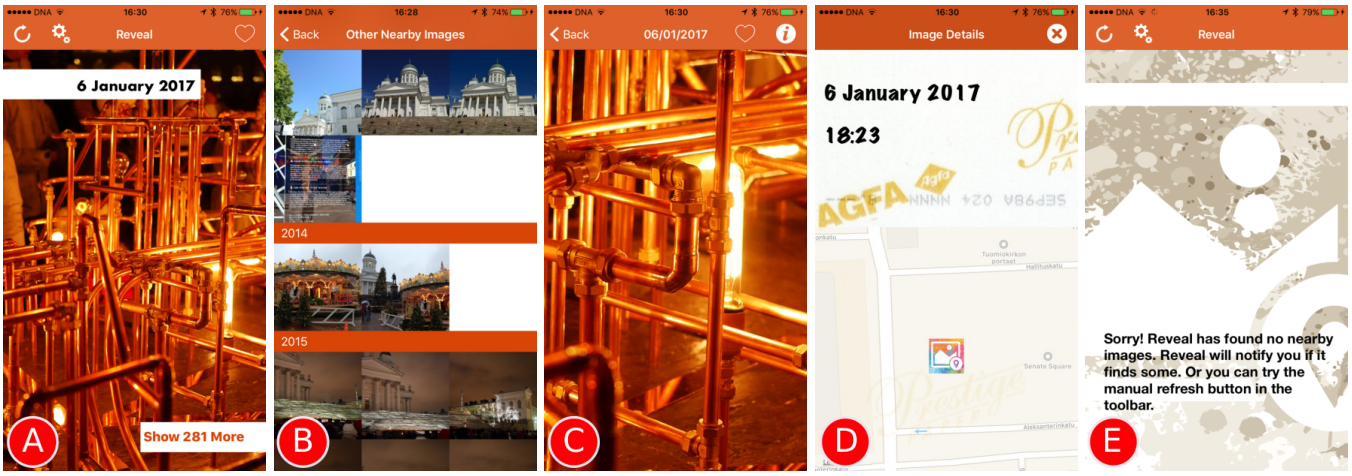

Figure 1: A: When images were found, one was selected as primary and viewable as soon as the app was opened. If more than one image was found, the 'show more' button presented additional images in a year sorted grid view (B). C: Tapping any image loaded a zoomable high res version. From this view, further metadata about the image could be loaded (D). If no images were found in the current area a standard view was presented (E).

ABSTRACT

Recording experiences and memories is an important role for digital photography, with smartphone cameras leading to individuals taking increasing numbers of pictures of everyday experiences. Increasingly, these are automatically stored in personal, cloud-backed, photo repositories. However, such experiences can be forgotten quickly, with images 'lost' within the user's library, loosing their role in supporting reminiscing. We investigate how users might be provoked to view these images and the benefits they bring through the development and evaluation of a proactive, location-based reminiscing tool, called Reveal. We outline how a location-based approach allowed participants to reflect more widely on their photo practice, and the potential of such reminiscing tools to support effective management and curation of individual's increasingly large personal photo collections.

CCS CONCEPTS

• **Human-centered computing** → **Human computer interaction (HCI)**; **User studies**; **Field studies**; **Empirical studies in HCI**.

KEYWORDS

Reminiscence; Personal Digital Photography; Location-Based Systems

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1 INTRODUCTION

The ubiquity of smartphone cameras has significantly changed what individuals take pictures of. Instead of documenting only events that would be known to be important *a-priori* (such as weddings or holidays), smartphones have allowed more everyday and 'mundane' aspects of life to be captured [14], leading to many more images being taken. An important role however remains to record and later reminisce on events and experiences. Reminiscing has been found to improve mental wellbeing [16], and is something people wish they did more often [14].

Van House argues [36] that such use is threatened in part by the retrievability of images, with increasingly larger collections being created making it more likely individuals will forget they have taken an image, and be less likely spend time manually searching for it. Services, such as Apple's iCloud Photo Library [2] and Google's Photo services [12], automatically upload, store and tag images (using AI labels) in personal, cloud-backed repositories. Whilst beneficial, these reduce touchpoints where individuals might view and curate their image collections [9]. Images may be taken and then quickly 'buried' as more are taken. Many may never be viewed [18]. Whilst 'important' events are likely to be remembered, the increasing 'everyday-ness' of photography means that everyday events (e.g. a walk in the park), that overlap in the same environment will be quickly forgotten.

Existing work has shown how resurfacing previous email [13], social media [24], as well as encouraging people to record and later reflect on their experiences [16], can support reminiscing. Some of these approaches have been incorporated into commercial platforms. For example, Facebook's 'On this Day' feature, that resurfaces an individual's posts from the same day in previous years (see Figure 2 (left)). Although such work includes images, there is relatively little understanding of how to support reminiscing over personal digital photo collections. Prior work has largely focused on images already shared on social media [24]. Whilst representing events that individuals wanted to share, and therefore saw as important, individuals curate their online self to provide a specific impression to others [10], and may not share many images that would be valuable to support reminiscing. Cloud backed personal photo repositories make all images a user took available ubiquitously, yet no work has yet been carried out to understand how reminiscing can be supported there, particularly with the 'everyday' events being recorded.

We argue effective solutions to support reminiscing on personal digital photo collections are important to avoid being overwhelmed by increasingly large personal image collections that are taken, but never reflected on. Through the development of a location-based mobile reminiscing tool we contribute a first step towards investigating this.

2 RELATED WORK

To develop our argument, we will first discuss practices around how and why individuals take personal photographs, existing work supporting reminiscing on digital media (including images) and finally, work on mobile photo browsing that has inspired our mobile probe, Reveal.

Photo Practice

Individuals take photographs for a variety of reasons, including to record and support reminding of individual and shared experiences [14]. As cameras have become ubiquitous through smartphones, this has led to additional new reasons, increasing the situations deemed photo worthy, leading to individuals documenting more 'everydayness' [14].

However, existing work has also found that many of these images may never actually be viewed [18], but simply stored. Smartphone providers are increasingly removing the 'work' [9] of image management (e.g. copying files from SD cards or creating albums), providing cloud-backed photo repositories (such as Apple's iCloud Photos library [2] and Google Photos [12]) that automatically take care of photo management and allow individuals to have ubiquitous availability to their entire photo collection. Whilst individuals may intend to sort and organise their images [26], sorting large numbers of digital images is seen as onerous and a chore, and is often not done [36]. Individuals also often underestimate the personal value that digital media have and such value often takes time to develop [26]. Whilst 'best images' may be displayed or presented around the home, acting as both a curated sense of self and as a ticket to support individual and social reminiscing [27, 38], or more recently on social media to support the same goals [10], most become lost and forgotten, requiring both effort and a deliberate decision to find [15]. Whilst consideration has been give to how digital images can be made more visible, such as 'attaching' them to physical souvenirs from holiday trips [22, 34], these approaches favour notable events, with an obvious relevance of images needed to a tangible object to associate them with. Everyday images are unlikely to have such an association, or have been seen as important enough when taken.

However, such everyday images are valuable to reflect on, particularly about everyday events that might not have been see as important at the time, but gain importance later. In co-review sessions, Van House [14] noted how images of forgotten events elicited surprise and pleasure. In particular, images that were not necessarily 'good' (and which would not be shared or displayed in the home [27, 38], or uploaded via social media), acted as "evocative tokens" that triggered memories and discussion. The value of such images may only emerge over time, yet Whittaker *et al.* found that individuals were unable to retrieve around 40% of personal images over a

year old [39]. By the time individuals might see the potential value in such images, they may have already forgotten about them [26]. Such images can often bring surprise and pleasure [14], but on current smartphones are lost in a 'digital pile'.

Reminiscing over Personal Digital Media

The pleasure and surprise that Van House reports participants found in the rediscovery of photographs is an example of Reminiscing. Reminiscing is an informal, situated activity, woven into everyday life [24]. The use and benefits of which have been found to exist for multiple age groups [6]. However, it is something individuals don't do as much as they would like [8]. The HCI community has given a great deal of focus on digital reminiscing, identifying that both generic media and personal media can support positive reminiscing [1, 11, 16, 23]. Work supporting reminiscing over personal media, which often includes digital images, often draws from existing social media accounts and services as a source. Pensieve [24], for example, prompted users with emails containing previously posted social media content (including images stored on the flickr.com photo sharing site), asking users to reminisce by writing a diary entry on the content. Peesapati *et al.* identified that individuals must be prompted to reminisce, and will either do so immediately, 'in the moment', or not at all. Contextual links with the media also elicited more personalised reminiscing. Whilst only studying temporal contextual links (e.g. the same day last year) between images and 'now', Peesapati *et al.* hypothesised that exploiting a location-based context may also be valuable [24]. Isaacs *et al.* [16] developed Echo to study how perception of events changed over time. Echo asked people to record events and rate their happiness about them. They were later prompted (between 1 day and 2 years later - although their study ran for only 4 weeks) to reminisce and rate the happiness of the memory. They identified an increase in subjective wellbeing, with time altering the perception of events, with participants identifying positive aspects of (at the time) negative events [16].

Such approaches have been incorporated into mainstream social-media services. Facebook's "On this Day" feature (see Figure 2 (left)) displays a previous post from the same day one or more years ago. Users can comment and re-share these posts. Similarly, Time-Hop (www.timehop.com) (see Figure 2 (right)) allows uses to explore their activity on the same day in previous years. This can include personal images stored on the user's phone, as well as other social media services. Apple's Photos app (see Figure 2 (middle)) uses algorithms to periodically create topical slideshows. These can include places or photos taken on a specific date. However, Photos does not prompt users to view images, and doesn't support contextual links between images and now, as Peesapati *et al.* [24] suggest as important. Evaluations of these mainstream

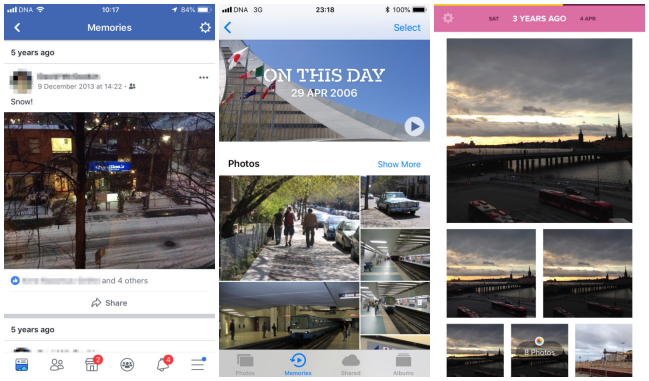

Figure 2: Mainstream applications to support reminiscing. Left: Facebook's "On this Day" highlights a previous post from the same day in a previous year. Middle: An auto-created Apple Photos 'memories' album. These can be generated based on date or location. Right: Timehop can use both Facebook memories and on-device photos. None have been formally studied.

services have not yet been carried out. As existing research uses images uploaded to social media services, they are also likely to highlight images that were seen as important at the time they were taken. As noted by Petrelli and Whittaker [26], this excludes images whose value may only become clear months or years later, and may not have been seen as important enough to share on social media when taken.

Outwith of work focusing on personal photography, Sellen and Whittaker [32] have considered the role and use of life-logging data - where images, video and other sensor data are automatically and effortlessly recorded - to support recall and reminiscing. Whilst Sellen and Whittaker explicitly note the difference between the effortless collection of data with life-logging and the more effortful and selective capture of digital images that we discuss here, their work does provide a more nuanced consideration of how images may support and augment memory. They define five different activities that media may support. Recollecting is defined as supporting episodic experiences [33], allowing the 're-living' of them for largely practical purposes (e.g. relocating a lost of object or if someone was present at an event). Reminiscing is defined as a refinement of recollecting, exhibiting a more emotional or sentimental component. Sellen and Whittaker note 'flipping through photo albums' either alone or together as an example, and this most closely fits with the definitions previously discussed [24]. Beyond an individual event, reflection is defined as understanding patterns in past behaviour, supporting understanding of self. Remembering intention is defined as a prospective memory aid, focusing on what should happen rather than recalling what has happened (e.g. a reminder to run an errand or take medication). Finally, retrieving fits with standard Information Retrieval

approaches of locating a given document or email using remembered information (name, date, etc.) to uniquely locate some recorded media. Although Sellen and Whittaker's definition of reminiscing [32] closely fits that of previous work [24], it is likely that the other activities that they describe, excluding retrieving, may also be present existing work and provides a more nuanced consideration of the potential value and role of personal digital photo repositories we focus on.

Location-Based Interaction

The work above uses a temporal contextual link between 'now' and the content presented. However, it is not the only possibility. In a diary study to identify external cues that caused individuals to reminisce, van Gennip, van de Hoven and Markopoulos [35] found that after physical objects, location was the most common cue that provoked reminiscing. However, Petrelli and Whittaker [26] found that individuals were often not able to remember where and when events occurred when looking at images [26]. Van House [36] notes how photography is situated in a place, and images increasingly have GPS coordinates attached that allow them to be relocated. As everyday events are likely linked to everyday environments that users will be present in often, an *in-situ*, location-based approach to support reminiscing is worth consideration. Whilst location-based reminiscing has not yet been applied to personal digital photo collections, it has shown value in other domains. Bentley, Basapur and Chowdhury [5] developed an inter-generational story sharing system that allowed older adults to record stories and associate them with a location, these being triggered by younger family members when in the same location. They found this supported intergenerational interaction. Existing work shows there is potential in using a location-based context. However, the role and impact of this as a contextual cue to support reminiscing over personal photo repositories is understudied.

Outwith reminiscing work, other researchers have found presenting digital content in the physical location of it's relevance can help to provoke consideration of both [4, 7, 19, 25]. Karapanos *et al.* [17] found presenting location-based narratives (including images) in the physical place they referred to (as opposed to a similar environment) helped immerse and enhance the experience of users. Rost, Cramer and Holmquist [30] developed Columbus, that allowed individuals to unlock and view other's images as they walked around a city centre. The images used had been publicly shared on flickr.com, and were not taken by the participants. However, Rost, Cramer and Holmquist noted how finding unexpected images in familiar locations could support new serendipitous understanding of those places. Naaman, Nair and Kaplun [20] developed Zurfer. Zurfer acted as a client to the flickr.com photo sharing platform, and was intended to identify the needs of mobile photo browsing. Users could browse their own images and view images taken nearby. Although not their focus, Naaman, Nair and Kaplun [20] found that during empty moments, participants would browse through their images and reminisce. Whilst this shows the value of a location-based approach in supporting reminiscence, they do not elaborate on reminiscing use. As with existing reminiscence work, the images uploaded on flickr.com were likely to reflect 'best' images, that a user would wish to share, rather than all images taken.

3 RESEARCH QUESTIONS

Based on our related work, there is a clear value in considering reminiscing both from a location-centric perspective as well as doing so over a user's entire photo collection, rather than a curated subset. We codify our objectives through the following three research questions:

RQ1: What is the impact of a location-based contextual relationship to support supporting reminiscing over personal digital photography collections?
RQ2: What is the value of supporting reminiscing beyond only images previously uploaded to social media accounts?
RQ3: How do users fit location-based reminiscing into their day-to-day life and what issues does it bring?

4 REVEAL

To address our research questions we developed and built a mobile location-based app called Reveal. Reveal (see Figure 1) ran on Apple's iOS platform, using significant changes in user location to trigger a search of his or her iCloud photo library for images taken in the immediate vicinity. By default this was defined as 150m from the user's current location, representing the immediate environment nearby. If one or more images were found, then a standard iOS notification was fired with a vibration and custom notification sound (See Figure 3). This worked, and could be interacted with in the same way as other notifications on iOS (and comparable to notifications on the Android platform). To ensure that images related to the current location, the notification (and display of the results in Reveal - see Figure 1 (A & E)) were automatically cleared after the user had moved 160m away (10m beyond the search radius). Reveal had a maximum number of notifications that could be issued in a 24 hour period, and an earliest (07.00 hours) and latest (22.00 hours) time, outwith which no notification would be issued. These could be adjusted by the user as a preference. A weighted random function was used to determine (given valid search results) if a notification should be fired. This was designed to both avoid overloading users with notifications, so they wouldn't get a notification each time they moved 150m, and

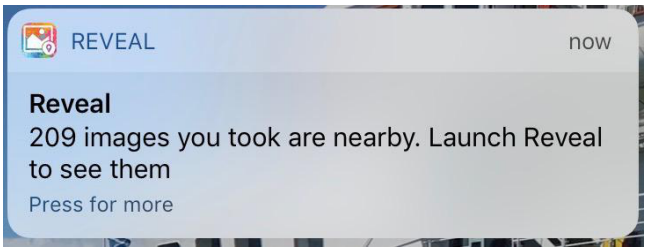

Figure 3: Users were notified of images in the current area by a standard iOS notification.

spread the number available out evenly over the day. I.e. avoid all notifications being used early in the morning.

Reveal used the Apple iCloud Photos service to access the user's iCloud photo library. This provided full access to images both on the device and stored 'in the cloud', including images taken on previous devices or cameras the user has imported. Reveal therefore had access to the user's private photo repository, rather than just a public facing subset (as has been necessary in prior work with flickr.com [20]).

When images were found and a notification fired, one image was randomly selected as the 'primary' image, and was presented in the main view of the app (see Figure 1 (A)). This provided an instant glance to an image the participant had taken in the current area as soon as the app was opened. If there was more than one image in that area, a button on the lower right of the screen presented the number of additional images in the area. Tapping it provided a grid view of all other images in the area organised by year (see Figure 1 (B)). An image was only selected as the primary image once, ensuring each time a notification was responded to a different image was seen (although images would still appear in the grid view if found on subsequent searches). If all images in a search had previously been seen as a primary image (e.g. over multiple visits), the result was discarded and no notification issued.

Tapping any image provided a full-screen, full resolution image, allowing the user to zoom and scroll (see Figure 1 (C)). From this view the user could also display the exact date, time and location the image was taken (see Figure 1 (D)). If the user opened the app when there were no valid image results, a placeholder screen was shown (see Figure 1 (E)). The user could also manually force Reveal to carry out a search, but in practice this was not used and we do not discuss it further.

5 STUDY OUTLINE

14 participants took part in the study (8 female, 6 male, aged 19-60, with a range of occupations). Participants were recruited from flyers placed around campus, email lists and social media posts. As reminiscing is valuable at all ages [6, 24], we did not use age as an exclusion criteria. We did pre-screen participants to ensure they used an iPhone, used the iCloud photo library, and geo-tagged their images. Participants also had to have lived in their current location (all lived in the same medium sized city) for at least the last 2 years. This ensured participants had a good number of images that they would be likely to encounter during the study period, and were likely not to be familiar with all of them.

Participants first completed a consent form and demographic questionnaire. Participants were then introduced to Reveal and it was installed on their personal iPhone. Participants were then asked to use Reveal as and when they wanted over the following 14 days, including not at all. Participants were told they could respond (or not) to as many (or few) notifications as they wanted. We chose 14 days as being similar to other work studying how individuals reminisce [1], which has shown good understanding of reminiscing activity over such periods (e.g. van Gennip, van den Hoven and Markopoulos' diary study lasted 10 days [35]). Whilst studies have used a longer period (e.g. Issacs *et al.* [16] used four weeks), these have also required users to create the media they will later reminisce over. This reduces the time between the media being created and when a participant might be asked to reminisce about it, whilst existing work indicates a longer time is valuable [14]. With Reveal, participants had already taken the images we asked them to reminisce over months or years earlier (see Table 1).

After 14 days we met with each participant and undertook a semi-structured interview on their use of Reveal. These complemented on-device logging. Due to ethical concerns we did not store participants' images, but provided a 'favourite' button (see Figure 1 (A) and (C)). This added the image to the favourites album on the iPhone photos app, so participants could discuss these images in the interview. Each was compensated with two movie tickets (18 €).

6 RESULTS

Interviews were transcribed and coded using a framework approach [29], with initial codes derived from research questions. Further codes emerged through iteration of the coding. All participant interactions with Reveal were logged on device. Logs also recorded meta-data about the user's iCloud photo library (e.g. total number of images, number of geocoded images, etc.) (see Table 1). Log data provided an overview of use, as well as contextualising coded interviews.

Existing Photography Practice

Participants had owned a smartphone for an average of 5 years (S.D.=1.7). For all, it served as their primary camera for around the same period of time. Participants reported that they took between 5 and 50 new images a week (M=17.7, S.D.=14). The large standard deviation illustrated that some participants were more active photographers than others.

Those with larger photo collections took more photographs per week. Participants took photographs for a variety of reasons, with recording memories, acting as notes or reminders and sharing on social media as being most important. Although participants reported viewing images on average 3-4 times a week (M=3.5, S.D.=1.8), this was mostly driven by referencing very recent images, such as notes, or sharing an image on social media. Only a minority of participants reported they engaged in undirected browsing of images, often when they were 'bored' or had nothing else to do. This fits with behaviour described by Naaman, Nair and Kaplun's study of Zurfer [20] described earlier.

Although Reveal did not store images, it did store metadata about the iCloud photo library, including its overall size, how many photographs were geo-tagged and the date of the earliest geo-tagged image. An overview is shown in Table 1. Apart from P8 (who had only recently started geo-tagging her images, but still met the criteria for our study), the majority of each participant's images were geo-tagged. As geo-tagging is a default once activated, geo-tagged images will become a more significant proportion of each user's library over time. Most had been geo-tagging for the past 1-2 years (P1, 3 and 8 being outliers). Hence participants were regularly exposed to images taken 1-2 years ago or longer during the study.

Table 1: Overview of participants' iCloud Photo Libraries at the start of their participation in the study. Note P9 & P7 dropped out of the study mid-way, so are excluded.

Participant	No. Photos	GeoPhotos	Oldest GeoPhoto
P1	2003	1290	November 2013
P2	5309	4465	April 2015
P3	812	556	June 2016
P4	495	432	April 2015
P5	1558	1230	April 2016
P6	4535	2647	November 2011
P8	3416	46	April 2017
P10	1331	977	August 2016
P11	2505	1860	January 2015
P12	1150	1142	May 2016
P13	700	668	April 2016
P14	2782	1759	August 2014
P15	403	289	June 2015
P16	1249	657	February 2013

Logged Use of Reveal

From analysis of the log files, an average of 69 (S.D.=36) notifications were presented to each participant during the study (Median 69). Notifications were evenly spread over the two week period, with an average of 5 notifications being presented each day. The median number of images associated with each notification was 15.5, but this obviously varied widely (M=29, S.D.=30) on the location where the images were searched for. Participants responded to a minority of notifications (Median = 8, Mean = 12, S.D.= 9). Whilst notifications were responded to throughout the two weeks, the majority of responses were clustered towards the start of each participant's use of Reveal. Interviews revealed there were multiple, diverse reasons why participants chose not to respond to every notification, which we discuss in the next section. However, the choice to respond to notifications was largely driven by having enough time to engage more deeply with the images. Participants did not often just glance at the primary image and move on with their day. P6: *"when I was alone and I didn't have anything better to do, I was curious to open it."*. Participants accessed the additional images screen (see Figure 1 (B)) on average 12 times (S.D.=8.1, Median = 11), and accessed large scrollable versions of images (see Figure 1 (C)) on average 13 times (S.D.=15.3, Median=12). These are similar to the number of notifications responded to, indicating that when they did respond, this acted as a trigger to explore other images (if any) taken in the area. However, the 'more details' view for each image (see Figure 1 (D)), showing exact image date, time and a map with location, was not accessed. (M=0.7, S.D.=1.0, Median=0). That the image was taken nearby was 'good enough' for participants.

Responding to Reveal

As participants wished to engage with Reveal for at least a few minutes when they responded to notifications, lack of available time was a large driver in deciding when not to respond. For example, being engaged in another activity or with others at the same time. P3: *"... if I was in the middle of chatting with someone, I didn't pull it up because I was in the middle of a conversation. Or, for example, I play Pokemòn GO ... I wouldn't pull up the notifications. If I was in the middle of something else."*. This also extended to driving or walking somewhere. P8 *"If I'm on my way, then I just ignored it, I would still look at it when I arrived at a place."*.

However, participants discussed a number of other reasons why they chose to respond (or not) to Reveal, beyond simply having time available. One factor was the familiarity of the place where the notification was received. Participants reported they would be more likely to ignore notifications in recently visited places (a day or two before), or where they had previously gotten a number of notifications. This developed over time, and evolved during the study. P6: *"...in the beginning when I got the notification near my home, I opened it up, but later on when I got the notification at home I was like, 'Yeah, okay, I know what this is."*. Initial places to ignore notifications were at home and work, but also included places regularly visited with a 'lots of images'. Although Reveal would only set an image as the primary image once, other

images in the area could be seen in the 'more images' view (see Figure 1 (B)). On subsequent notifications in that area, those images could be set as the primary image. This could lead to participants quickly learning what images were taken in an area, and on subsequent notifications already felt they were familiar with images and could ignore the notification. P3: *"I responded to them in the beginning, but after a while, I learned which pictures were going to show up and after that, I didn't feel that it was necessary to bring out the same pictures all the time."*. This did however lead to participants building up an overview of where they took images and were able to reflect upon this. P3 continued: *"I noticed that I've mostly just taken pictures at my school which is also my current workplace, and then at home."*. We discuss later how Reveal caused participants to reflect on their photo taking.

Conversely, participants described the unexpectedness of receiving a notification as a driver to attend to it. If participants did not remember being in a place before, or couldn't remember taking photographs there, they were more motivated to respond to Reveal. P6: *"...if I didn't remember when I was here before, so I wanted to check, 'Okay, what's the picture now?'"*. This also extended to places a participant did not go to very often, being more curious about what was there. P1: *"every time that I've had a notification that I've noticed, in a place that I haven't yet had a notification in, I've been interested to check out what the photos are."*. Participants were more likely to respond in places where few images were taken, and relatively quickly stopped attending to notifications in places where many were taken. Whilst a location-based reminiscing approach has potential, the images available are determined by where the user goes. Understanding what influences participants to respond, or not, can support tailoring notifications to avoid over-notification in places with many images, making them seem too familiar.

Photographs taken as Notes

In discussing the images viewed with Reveal, participants drew a distinction between the intended role of the image when taken and how interesting they found it. A key distinction was between images intended as notes or reminders, and other images (such as those identified by Van House *et al.* [37]). Although notes may only be useful for a short period, they are still stored in the user's library, who may forget to delete them. P8 compared the experience of getting notes to other images Reveal had shown: *"probably the first set of pictures that I got a notification about were all about memories and good, nice memories. In contrast, when I got those notifications, then I found it really funny"*. The majority of participants found such notes to be boring, or uninteresting. P8: *"I find it sometimes pointless why I am getting notifications of the pictures I took just as a temporary note. I wouldn't need it anywhere in the future. I probably should have deleted those photos, ..."*. Such examples reflect that notes fitted into the remembering intention use of Sellen and Whittaker [32]. Once they had served this purpose notes were simply clutter. Whilst it may be better to automatically exclude such images from being viewed, a minority of participants found that some notes could still support recall of information, and beyond that, potentially useful reminiscing: *"I think that the chance aspect was interesting because even if it's not an interesting photo it is a memory or some recall happens"*. As discussed later, adding editing and curation tools to support taking action on the images shown may be an effective solution to support this issue.

'Other' images were often seen as interesting. P12: *"anniversary pictures that I took, and also there were pictures I took when I was with somebody. For instance, it was a reunion or with friends. Then there are other pictures where I took them at a really beautiful place or at a time"*. However as P2 noted: *I think that the chance aspect was interesting because even if it's not an interesting photo it is a memory or some recall happens*. How individually interesting these images were seen to be was influenced by a number of contextual factors around the image and the situated nature of its viewing.

Issues Around Image Age

As Reveal picked a random (previously unseen) image from the images found in an area, this could mean the image was taken recently. Such images were found to be uninteresting, and offered little value, P13: *"most recent ones I find less interesting, at least in my opinion, because I probably still remember exactly why and when I took it and I still have a really fresh memory about it."*. Older images were often described as more interesting. As P2 noted: *"No, I think the older ones are more interesting. ... Well because they're more about forgotten memories or like, not so immediate recalling."*. Although important events were remembered and found interesting, such as with P3 who noted she still liked getting photographs of the day her fiancé proposed, even though this was an obviously remembered event: *".. I still brought them up at home, for example, because some of those pictures were pictures of my fiancé, so those were nice memories, for example, of the day he proposed to me. So I looked at those.."*, many of the older images discussed reflected smaller events, or were not particularly significant. Yet the photograph allowed them to be brought back. For example P1, in showing us the photographs he favourited through Reveal, described how a photograph of a sunset taken through a bus window had reminded him of commuting on his previous job: *"A few years back, I used to travel a lot through Länsiväylä in the bus and I used to enjoy the sunset a lot, and there were more often than not, very beautiful scenery there. I took a few photos, I hadn't really thought about that, or remembered it in a long time, but it was nice to see colour photos I took."*. Although

such experiences were less significant and easily forgotten over time, participants still found them valuable and important. As P1 described: *"...it's not like there is this overarching theme of my life that's important, but all the little experiences are important as well, and very interesting too, to see and get reminded of what happened and what I've experienced."*

Participants also discussed how the increasing number of photos they took with smartphones increased the inertia that needed to be overcome to view older images. Existing practice when viewing images was described as scrolling back through images from the present day. Participants would go back only so far, meaning that very old photographs are not accessed. P11 described how Reveal supported overcoming this. P11: *"I have a lot of pictures, but if I start to scroll back to look, I wouldn't probably go to the very beginning. This (Reveal) brings back a lot of really, really old pictures that I have on my phone, so it's interesting because I haven't seen them for a really long time."*.

Participants also highlighted how the interpretation of images they saw with Reveal changed since being taken. Images that perhaps were seen as important when taken, and shared on social media sites, were not seen as so interesting in the future, whilst others raised memories or thoughts. P14: *"... after a long time you look at the pictures differently... some pictures wouldn't stand out as really important photos. If I ever lost them I would really feel, 'Okay, it's a shame that I lost them.' There are pictures that I took which are nice and if I look at them again it would bring me back to those really nice memories..."*. Whilst this highlights that importance of images will develop over time [26], it also highlights that importance can reduce as well as increase. Images posted on social media cannot be assumed to reflect what will be important to reminisce about over the longer term.

Although Reveal showed the date the primary image was taken (see Figure 1 (A)), this was often not accessed, with participants using other images taken in the same place (via the more images button) to help contextualise the memory that the primary photograph stimulated, helping the participant put events 'in order'. P2: *"... I was checking the 'show me more' and like it shows you 2015, 2016 pictures. So, I could say 'Ah, this has happened in that year, or that happened on the next year.' It was actually a nice grid of some images."*. In this way Reveal supported extending individual reminiscing through providing other contextual images related to the main image shown. Such use was also reflected in the use of the 'more images' to help reflect on how a place had changed over time (as discussed in the following section).

Situated Viewing Of Images

That images were viewed nearby where they were taken had a strong impact on how participants considered them. The situated viewing of the images in part contributed to the depth of reminiscing that participants discussed. In particular, the notion of feeling, or reliving, the experience was enhanced by being in the same place. The previous example of P1's sunset photograph on the bus, for example, was described in this way, with being on a bus when viewing the image helping to take the participant back. P14 described how viewing a relatively uninteresting image *in-situ* increased the interestingness of it, and supported her reminiscing about how she felt when the image was taken: *"It was actually my path going back home. And then there was this day when it was very snowy and strange and it was very late... It was just like the bus stop but still the memory was kind of activated again because of that. ...it was a strange feeling of like the darkness, and then being late and cold but still I was sort of satisfied of being in that place. Probably because I was happy with work or had been doing something."*. P14 continued: *"...you think based on the location and so on. Like we did this then you reflect more about life in the sense because you see what changes like in a particular boring space.."*. The use of situated viewing allowed participants to go beyond simply the recall of events, but encouraged more reminiscing and reflecting of experiences [32]. Such images reflect the value of using the user's 'unfiltered' photo library, rather than the curated subset posted on social media. Images not seen as valuable to share, did support useful reminiscing when presented *in-situ*.

Environmental Changes Over Time. A clear consideration in viewing images was how the environment had changed over time. Often, as with the previous quote of P14, there was a seasonal element. As our participants were based in a Nordic country, these changes were dramatic, and often stimulated more general reflections. P12: *"I found it very interesting that like... we have like it was summer and then it was winter photos. I can image that in winter I will be recalling the summer photos and cry and say, 'Oh you were so nice'. I was recalling and thinking about this period. When I was thinking it was interesting for that."*.

That Reveal would show all photos in a location also allowed participants to consider changes over a longer time. In places participants visited often, these images reflected their visiting patterns, supporting reflection [32] on when and how often they visited. P8 discussed how she often took landscape photographs, and how Reveal helped her reflect on her image taking when visiting a regular lakeside bird-watching tower. *"When I got the notifications of several photos that I took in the past in different seasons it was really interesting just to see. They also remind me. 'Okay, I have been here more frequently in the summertime, but in contrast, I haven't been here so often in the winter. Probably I should come here more often.' In the wintertime it's also really beautiful"*.

Changes could, of course, also reflect more permanent physical changes in the environment (such as removed or

renewed buildings, etc.). 'Now and then' photographs, juxtaposing contemporary and historical locations, are a common technique used in cultural heritage applications to support considerations on how a place has changed [21]. Although the time between the image and current day is shorter for participants in our study, reflecting months or years rather than decades or centuries, participants still reminisced on those differences. P3: *"...if I was somewhere here in Helsinki and then I looked around, I realised, yes, this place has changed... ...maybe it made me feel a little bit nostalgic about some things"*. However, this also extended to environments that participants themselves had changed. In a similar way to P8, P13 discussed how she reflected on photographs of her apartment over time, from moving in to the present day: *"I took a lot of pictures when I was doing home decor improvements, so along time I can see that. It was, first, really empty. Then I got a lot more plants, I got a lot more things to hang on the walls and all that. I can see actually the progress over time. ...it made me thing, 'Okay, I've stayed here for a really long time and it has been really nice. This place is becoming more and more homely to me.'"*. In this way, Reveal highlighted gradual changes over time, and supported reflection [32] on them.

Supporting Reminiscing

Viewing the photographs was discussed by all participants as a 'trigger' to support reminiscing. In this, it was found to be effective and valuable in resurfacing more everyday, forgotten memories that participants would have been unlikely to think of again. As P8 put it: *"sometimes when you are really busy you don't tend to think so much about the past or those moments which are not so important, but still, for instance like friends' reunions or just some regular gathering with friends, I don't think I would really think about those."*.

Participants discussed reminiscing at different depths. Although some reflections were at a surface level, fitting with the definition of recall by Sellen and Whittaker [32], such as reminding a participant of something they had forgotten, it was more common for participants to discuss 'around' the image more widely on what was happening around the time the image was taken, and showing the clearly more emotional or sentimental aspect that Sellen and Whittaker [32] distinguish reminiscing from recall. P1 for example, discussed how the image of a sketch he drew as part of a freshman class (originally taken as an image 'note' to support recall [32]) led to reminiscing around the task that the sketch came from. P1: *"...it showed this photo which looks like a mess but if you look closely this is from my first year of studies... We had to make a mask for a group of students... ...at the same time, while I was drawing this, a few people had to go to the store, they didn't know what they were buying but they had 5 euro or something to buy stuff. Then when they came back we had to create a 3D model..."*. P1's example, as the sketch was originally photographed as a note to share with others, also highlights that although participants generally found notes as uninteresting, they could still stimulate valuable reminiscing on past events.

Beyond activities taking place, participants also discussed how the images helped them recover more emotions or feelings they felt during the event of the photograph. P9 described how Reveal allowed him to remember the feelings when taking a photograph, beyond just what it looked like: *"...the feelings are something that I find interesting, because I quite rarely think I remember feeling something. Mostly I remember how I see things... I rarely remember, that much feeling, usually they just blur into the background and I forget about that kind of experience. So, this helped me in a way, remember the feelings of those things that I took photos of, or things that I had seen."*. P15, for example, discussed images taken at an outdoor light festival and an art museum, and how this not only reminded her of the images, but also the people she was with and the 'feeling' of the place: *"It's hard to describe but, anyway, I remember the friends we went with and that moment and how it was snowy there."*.

Reveal also provoked reflections of self [32], that in addition to simply recalling and reminiscing about the experience depicted, led to participants more widely reflecting on their personal situation and how it differed from when the photograph was taken. For example, P6 discussed how viewing photographs of her boyfriend supported reflection on how her relationship situation had changed since it was taken: *"...because we used to live very far from each other, in two different countries. I was thinking something like, yes, I'm happy that I'm not travelling once in a month anymore and it has changed my life a lot... Because I saw a lot of pictures of us in Germany and not here. I mean here, when he was here, but not living together."*. This was also discussed as an active process, reflecting Baber *et al's.* [3] argument, that photographing is a sense making process. Reveal contributed to this sense making activity by reflecting changes in life. P2: *"I was always trying to remember how I was feeling or how I was perceiving that time..."*.

Such reflections could also lead to actions. P6 discussed how reflecting on images encouraged her to re-connect with people in the images, if they had not been seen for some time. Although this was described as maybe being once or twice through the study, and was reflected by only a minority of participants, it does illustrate the practical value in supporting everyday reminiscence. Identifying the actions individuals take because of reminiscing has also been understudied and may be a valuable future research direction.

Co-Viewing Images

A particularly valuable form of reminiscing was discussed when the photo was being viewed in the presence of others,

and provided the opportunity to tell a story to the other person. For instance, the sketch example of P1, previously discussed, occurred when the participant was walking with his wife, with Reveal providing an opportunity to tell the story. P1: *"...this just gave me an opportunity to tell something about what happened, which I thought was funny. I was proud of the drawing that I made, yes very artistic. ...this was just a very cool reminder of a very cool experience.."*. Such use illustrates Van House's [38] discussion of social reminiscing, telling stories as a way to reminisce about past events. However, we identified relatively few instances of this. Largely as participants had to be with someone when Reveal provided a notification and they viewed the image, and as already discussed, participants would largely avoid checking notifications when in the presence of others. Participants did not often show images to others later. However, the notification sound we used (being unique to Reveal) sometimes acted as a 'ticket' [31], encouraging questions on what the sound was by others that could lead to co-viewing and discussion.

Reflections on Everyday Photo Taking Practice

Beyond the direct reflections [32] of the images participants saw, Reveal also provoked participants to reflect on their photo taking practice. The overall pattern of notifications (the geographical areas where more or less notifications were generated) allowed participants to build up a mental map of where they took everyday photographs, and reflect on this. P8: *"...it makes me reflect on my habits. When I walk I would realise, 'Okay, I always walk there.' I don't walk in the other direction for instance. It gives you an idea of patterns in your life in the way that happens"*.

Awareness of their photo taking practice led to some participants considering how they might want to change it. P3 described how he noticed that he didn't have a habit of taking pictures with friends, with most notifications at either work or home. Later he described how he reflected on this, saying: *"I realise that I should commemorate more of what actually happens in my life. Not just stuff I want to remember but, for example, like in 20 years, I will probably want pictures from what my life was like right now. ...it will maybe make me more take a few more pictures of happy memories - moments I share with friends. I take pictures of things, but I feel like I should take pictures of people"*. Such deep consideration extended to P6, who questioned why she took many of her photos. Noting that she didn't look at pictures after taking them, and described many Reveal showed as 'boring'. P6: *"I started to think about the kinds of things I actually photograph. Should I take different kinds of pictures? And I take these kind of pictures. And I'm not looking at them after I take them... I still feel they're boring, so why did I take these pictures?"*. We do not know if use of Reveal actually changed photo taking practice in our participants, only that it caused reflection, but it does indicate that many participants were unaware of the kinds of photographs they took, and may not have looked at many of them before.

Enhancements in Reveal

Use of Reveal was discussed as an overall positive experience by participants, providing them insight into their personal photo libraries, resurfacing forgotten events and images, and supporting reminiscing over them. However, participants did raise future enhancements to improve their experience.

Participants wanted Reveal to support more actions on images. Whilst it supported viewing, within the app participants could not do much with those images (apart from favouriting/unfavouriting images). Participants wanted to delete 'boring' images, save results to view later and support sharing images (such as via social media or email). In this, Reveal was discussed not only as a tool to support reminiscing, but also to provoke curation of a photo library. Given time has passed since the image was taken, allowing the time necessary to reflect on its value, and that participants chose to view images when they had 'free time', this would provide a natural opportunity to help curate the user's photo library. In this sense, interaction with Reveal was described by participants as a point to reintroduce useful manual 'work'.

Although our focus was on *in-situ* reminiscence in everyday environments, participants did discuss that they also wanted to have reminiscence support for images taken outwith their everyday environment. P1: *"we have some pictures from Singapore and we're not going to Singapore in a while at least, so this app wouldn't remind us of those."*. Such issues also extend to places when people move, such as to a new city, where everyday memories from where they previously lived would also be valuable for reminiscing. Our current version of Reveal does not support such images. However, the location-based approach to reminiscing has shown valuable, and there is scope to consider how such images might be incorporated. We discuss this in future work.

7 DISCUSSION

Our goal was to consider the value of location-based reminiscing over the increasingly large and ubiquitously available personal photography repositories that individuals are now creating. This is in contrast to existing work on temporal reminiscing that exploits only a subset of images individuals have previously shared on social media services (e.g. [24]), and which represent a curated presentation of self [10]. Reveal has uncovered significant new knowledge, providing new insight into future reminiscing over digital images. We frame the discussion around our three research questions.

RQ1: What is the impact of a location-based contextual relationship to support supporting reminiscing over personal digital

photography collections? That users were collocated with the location where they took the image was found to provide similar benefits for reminiscing over photographs that a temporal context provides, providing a link between 'now' and the image that helped deepen reminiscing. We identified three main benefits of exploiting a location-based context. Firstly, was the way in which it illustrated how the environment changed. Whilst this could fit physical changes in the environment, participants also talked about how physical changes reflected changes in their life, such as the transformation of an apartment into a home, or the way in which seasonal changes were reflected in the environment. Although a single image could provoke these considerations, there was often a temporal component. The use of a location-based context helping to filter down the user's full image repository to just those images that were nearby and could be viewed through the more images button to see images taken of the same place over time. For example, P13's discussion of the gradual changes in her apartment over time. Whilst the juxtaposition of the place and image was a primary contextual link, this demonstrates that combining both place and temporal relationships, where possible, in reminiscing applications may be the most powerful approach. Secondly, finding themselves in the same location when viewing an image prompted reflections around what participants did in that place when the image was taken. This often went beyond what was depicted in the image. For example, P1, who found himself viewing an image taken when on a bus he used to commute to work on. As discussed in the next section, these images were often 'bad' or unclear, and the co-location with where they were taken helped to better identify and reminisce on them. As individuals often find difficulty in identifying where an event took place [26], but find locations to be an important trigger to remembering [35], many of these images may not have provoked memories if presented using a temporal relationship. The opposite is also likely true, with Reveal not supporting reminiscing that would be temporally based (e.g. 'what did you do one year ago today?'). However, a location-based context is largely driven by where participants go, and may exclude images that were taken in different places or countries until the user visits them again. We discuss potential solutions to deal with this in future work. However, it is likely that temporal and location-based contexts each support different photographs better, and as already discussed, there is benefit in combining both approaches. Deeper comparison between both is an area ripe for future study.

Thirdly, a location-based approach also provided wider benefits. We identified examples of not only recall and reminiscing, but also reflecting [32]. Participants gained new insight into their photo-taking practice, where and when they took photographs, as well as their daily patterns. Some, like P3, discussed how they would like to change their photographic practice, photographing more people as a way to store more memories to support better reminiscing in 10 or 20 years time. Others discussed how the provocations of Reveal to view a small subset of images could help to support curation of their library. A subset making curation a pleasurable experience, rather that a chore with thousands of images. Similar to Petrelli and Whittakers' [26] note on how sorting through a small collection of physical mementos was a pleasurable experience, compared to the off-putting nature of browsing through large digital collections.

RQ2: What is the value of supporting reminiscing beyond only images previously uploaded to social media accounts? By drawing images from a user's iCloud photo repository, Reveal was able to work over all the images a user took, rather than just those previously shared on social media (e.g. flickr.com or Facebook) that prior work has focused on [24] and where an individual chooses images that seek to portray a particular impression of Self [10]. Whilst images that were previously shared on social media were discussed as provoking reminiscing, it was often more mundane, everyday images that were discussed. Our findings paralleling the co-viewing studies of physical images by Van House [14], where images that were not good and were left in a box still provoked valuable reminiscing. Our participants discussed mundane images and even images taken as notes as helping to provoke consideration about past experiences and events. As already discussed, a benefit of being co-located with where the image was taken was the physical environment helped individuals to better understand what the image was of. The key predictor in how interesting an image was to participants was largely that it must be 'forgotten', this overriding most other image attributes, such as quality. Images taken recently, or those that had been previously shown by Reveal (e.g. showing a primary image that had previously been seen via the more images grid view (see Figure 1 (B)), were often described as less interesting. Whilst not all such images would become valuable over the longer term, some did. Highlighting that the value of digital images often changes over time. Whilst it has mostly been argued that value increases over time [26], participants also noted that images shared on social media could become less valuable or important over time. There is value therefore in considering a users' entire digital photography collection to provoke reminiscing, rather than a more curated, limited subset, presented via social media. As digital repositories of images continue to grow as more are taken, and images become buried faster, location-based approaches offer a way of re-contextualising more mundane images and supporting their use as reminiscing aids.

RQ3: How do users fit location-based reminiscing into their day-to-day life and what issues does it bring? As with Peesapati *et al.* [24], participants had to be provoked to consider reminiscing. No participants used the manual refresh button to search for images, only responding to some notifications. Participants responded to 1-2 notifications per day, and this is similar to temporal contextual work that may send one email or provocation per day (e.g. Facebook's 'on this day' feature). When participants did choose to engage they wanted time to be able to do so deeply, such as looking at all the images in an area. However, as Reveal was driven by where photographs were taken, this could mean that it was not always suitable or convenient to attend to the notification (e.g. if driving or walking). As notifications were cleared automatically when the participant moved away from the search area, to ensure sure individuals looked at images very close to where they were taken, they may be removed by the time the participant attended to the device. That participants also quickly understood their photography practice also influenced if they would respond to notifications, either ignoring or attending them. Our findings here provide good understanding how individuals would react to a proactive location-based approach, and notes the importance of trying to target users with notifications when they have both the desire and time to respond. Recent work by Pielot *et al.* [28] has looked at detecting user boredom via mobile phone sensors, using this to target notifications when individuals are most open to reminiscing may be a promising approach to achieve this.

8 DESIGN IMPLICATIONS

From our study we can begin to distil key issues future designers should consider when using location-based relationships to prompt reminiscing on personal photo collections.

Support Users to Defer or Save Reminiscing: Whilst Peesapati *et al.* argue that temporal linked reminiscing is either responded to immediately or not at all [24], with location-based cues individuals may not be able to respond immediately, or wish to share the results later with others. Supporting individuals to save and revisit previous prompts may have value, particularly for collective reminiscing.

Consider the Relationship Between Images: Whilst participants gained value from considering the change between the location they were in and a single image, having multiple images from the same location allowed participants to reflect on changes in that place over time. For example, P13 was able to reminisce about how she had made her apartment into a home. There is value in surfacing these gradual changes between images.

Older Images Support more Reflection: Images that are likely to have been 'forgotten' were most valuable. Older images which have not been recently viewed are more likely to have been forgotten and should be prioritised as a 'primary' notification image.

Limit Prompts to Very Regularly Visited Places: Places that are very frequently visited, and which have a large number of images (such as home), might benefit from having the number and frequency of notifications in those places limited. It may also be beneficial to limit the maximum number of images that are presented in one notification to ensure users are not overwhelmed by a large number of images to review. Without constraining in such a way users quickly stop responding to prompts in those areas.

Prioritise Prompts to New Places: Individuals quickly learned where most images were taken and further notifications in these areas were ignored. Areas with fewer images, or where individuals may have forgotten they took images, were more interesting. When the user is in such an area a notification should always be presented.

Think Beyond Reminiscing: Participants wanted to have practical outcomes of their reminiscing. Participants identified opportunities in the use of Reveal to support micro-curation tasks such as editing, deleting or sorting important images into albums. The smaller subset of images that a location-based approach presents reduces the burden of large photo collection management previously identified [26]. Support users to take action on the reminiscing directly.

9 LIMITATIONS AND FUTURE WORK

Viewing images *in-situ* supported deep reflection on everyday events participants had forgotten. However, it does not currently include everyday events outside the area where participants live. Whilst all participants had lived in the current place for the last 2 years, some had lived in other cities or countries before, and wanted these images to be included. A geographical association excludes these. We are therefore considering how semantic, rather than geographical, location might be used. For example, a participant out for drinks with friends in a bar may get a notification of images from outside the current geographic region but which occurred in the same semantic location (e.g. when out at a bar with friends). AI classification techniques employed to tag images in commercial solutions (e.g. in Apple Photos [2]) make this a potential approach to employ location based approaches without excluding content not generated geographically in that area. It is also important to more directly compare location-based contextual cues to other types (e.g. temporal cues [24]). Whilst we have shown location-based approaches can work well, and there is scope to overcome their obvious limitation with semantic locations, we do not know how they compare with other approaches, or when they are more and less suitable. It is unlikely that any contextual cue is a universal solution to supporting reminiscing, and further studies comparing Reveal to a more temporal

system will allow the benefits and limitations of each to be more easily compared.

We also want to consider the actions on reminiscing more, both within and outside of Reveal. To our knowledge, existing work has not considered what the outcomes of reminiscing are, beyond resharing content on social media with a new comment (e.g. Facebook's 'on this day'), and there is value in doing so. We are currently developing a new version of Reveal to focus on these issues, using semantic location and further editing and sharing tools within the app. By doing so we will be able to further expand our understanding of location-based tools to support reminiscing over personal digital photo repositories.

10 CONCLUSIONS

In conclusion, our study of Reveal represents an important first step to begin to support effective ways to resurface, browse and reminisce over the increasingly large, often unsorted, personal digital photo repositories that individuals are creating. In considering a location-based approach, rather than a temporal based relevance, Reveal has supported valuable reminiscing of everyday events that are increasingly part of personal digital photography. Our work allows future developments to better support individuals engaging with images of everyday events, helping them understand how the threads of their experience weave through the increasingly large photo repositories they are creating.

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