Product Fingerprints: Studying Mobile Visualizations In-Situ

Kevin Ta
University of Calgary
Calgary, Alberta, Canada
kta@ucalgary.ca

Jo Vermeulen[1,2]
[1] Aarhus University
Aarhus, Denmark
[2] University of Calgary
Calgary, Alberta, Canada
jo.vermeulen@cs.au.dk

Lora Oehlberg
University of Calgary
Calgary, Alberta, Canada
lora.oehlberg@ucalgary.ca

Sheelagh Carpendale
University of Calgary
Calgary, Alberta, Canada
sheelagh@ucalgary.ca

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Abstract
Mobile visualizations inherently need to be studied in-situ since mobile devices are used in a variety of different contexts. These studies are difficult to conduct, for instance, because the environments in which they take place can be complex; social awkwardness can impact study realism; and getting access to field sites is difficult. Furthermore, visualization researchers are also interested in evaluating the merits of their mobile visualizations in conjunction with its use in context. We discuss these challenges based on our experiences running an in-situ study to evaluate our mobile visualization Product Fingerprints at a local pharmacy.

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Information visualization, mobile visualization, methodology, in-situ, mobile HCI.

ACM Classification Keywords
H.5.2. Information interfaces and presentation (e.g., HCI): User Interfaces; *Mobile Interfaces*

Introduction
Marketing research suggests that consumers are increasingly using mobile devices to help browse product information while shopping [1]. Product information, such as ingredients, can be presented in different formats or use different measurement units

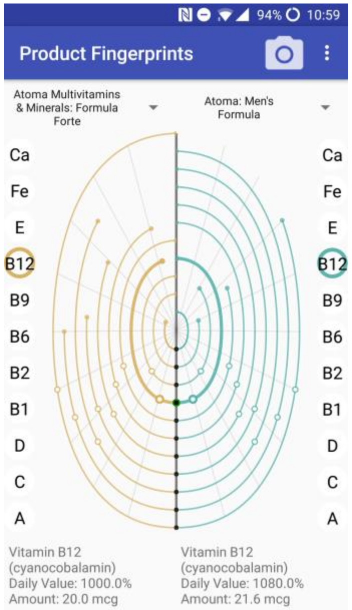

Figure 1: Product Fingerprints as shown on a mobile device after scanning two different product barcodes. The user has selected Vitamin B12 which boldens the curves and displays detailed vitamin content information.

which is tedious and prone to error. Mobile visualizations, due to their portability, can inherently become situated visualizations [10] where the user makes use of multiple sources of external information or influences. External factors such as the in-store environment, pricing, and product packaging is situated so that it may influence consumers' decisions or make product comparisons across brands more difficult. A mobile visualization can help translate and compare product information. However, a challenge remains: *How do we evaluate mobile visualizations in situations where participants draw upon multiple sources of information situated in the environment?*

We discuss the challenges of running an in-situ study to evaluate our mobile visualization *Product Fingerprints* at a local pharmacy. Product Fingerprints is a tool that allows consumers to physically scan in multivitamin products and compare their ingredients. We chose to focus on multivitamins as these products are particularly hard to compare because their ingredients are often presented differently and use different units. The goal of the study was to better understand how people used Product Fingerprints to explore multivitamin product information and how the visualization informs decision-making within the surrounding context. We discuss factors such as accessing field sites, performing using mobile research equipment, and dealing with uncertainty in realistic settings. We will then discuss methodological issues for the community to discuss.

Figure 2: A shopper (right) scanned a barcode of a multivitamin product and compares it to other products scanned earlier on the mobile visualization application. The shopper retains the product in their hand to refer to other details outside the visualization.

Product Fingerprints

Product Fingerprints is a mobile visualization that allows people to compare nutritional information between food products. The visualization looks like a fingerprint, hence its name. As shown in Figure 1, two products are represented side-by-side. Each arc represents a particular factor that is compared between the two products (e.g., Vitamin B12). An arc is drawn completely (touching the black vertical line in the center on both ends) when that product has a higher value for this vitamin than the other product. The other product's arc for this vitamin is then drawn relative to

Figure 3: A small selection of multivitamin products used in the study. Products in consideration for the study only fit in two shelves. More products used in the study to the left (not shown).

the value of the first product's vitamin. In other words, the longest arc represents the maximum value of a particular factor that one of the products has the most of, and the opposite arc's length is then drawn relatively (percentage-wise, with a full arc representing 100%) to the value of that factor in the first product. This produces gaps in the visualization that represent how similar or different the products are in terms of the quantities of the different vitamins or minerals. The recommended daily value of a vitamin or mineral is indicated by the small hollow circle on the arc.

The visualization was designed to support comparison of information embedded on products at a store. However, product packaging and store advertising introduces information external to the information presented in the visualization (i.e. vitamin content). Consumers may have multiple other goals to optimize for such as following a doctor's recommendations, avoiding allergic ingredients, and minimizing cost.

While we could have run a traditional controlled lab study with a mock store aisle, we would have lost some aspects of realism. We ran an in-situ study because realistically, the visualization may be used to communicate with staff members, its effectiveness can be influenced by in-store advertising, and may lack information that is present in the product's packaging.

Product Fingerprints was implemented as an Android app. Data for each product was manually programmed into the application and used the product's physical information label for consistency. We chose a fixed set of 11 vitamins that all products had in common.

Methodological Challenges

The research community has already discussed the value of field studies for evaluating mobile interfaces. Kjeldskov et al. [6] found little value evaluating their mobile application in-situ since their lab study yielded more usability problems than the field evaluation. Rogers et al. [9] argue that in some cases, in-situ is cheaper and more valuable when mobile apps depend on extracting information from the environment, as it reveals problems not yet considered in the lab. Kjeldskov et al. [5] conclude that with today's proficiency in developing with mobile displays, the new questions we should consider are *when* and *how* to do in-situ evaluation.

In-situ visualization research hints at how we should conduct field evaluations. Reilly and Inkpen [8] suggest that we ought to consider the social psychology of the study environment on the behavior of the participant. Jakobsen and Hornbæk [4] found value in observing actual daily tasks in think-aloud protocols of professional programmers (versus laboratory style tasks). They mention that while this revealed ad-hoc use of their visualization, a participant's busy workload may still be a barrier to use and long-term evaluation, even in a field study. A hybrid approach involving a semi-controlled setup with open-ended tasks in an in-situ environment may help balance attention to different factors in the study environment [3].

Whilst our discussion of these challenges is not new, we would like to bring attention to some of these challenges regarding field studies for mobile visualizations. We discuss several challenges we encountered specifically for our in-situ evaluation below and present them for the community to discuss.

Figure 5: A study investigator wearing an camera mounted hat. The hat depicted is similar to the one used in our study (including duct-tape) and illustrates the unusual appearance of running a study in public areas.

Transporting Participants. One logistical issue is transporting the participant to the study location. Research assistants (graduate students) may not have cars and transporting participants can be a liability concern for ethics protocols. Driving can be avoided by choosing a location with public transportation access but can be a limiting factor in the choices of store location. We were fortunate that our local pharmacy was an easy location to access and surrounding area was easy access to recruit participants. Furthermore, ethics approvals for on-campus studies are easier to obtain for than off-campus study sites.

Figure 4: The study aisle and shelf used in the study. Only a narrow section of the shelf was used in the study. Sale labels and coupons are all unanticipated artifacts of realism.

Environment Complexity. Public environments have a large variety of objects and people to interact with (Figure 3), each of which can distract from the research question. A set of objects that the participant should interact with or not interact with can create complexity when collecting data. Our pharmacy had over 35 multivitamin products of different pill counts, formulations (men's, women's, sports, and generic), and supplement types (pills, gummies, and powders). In our pilot studies, we discovered that participants would take up to 1-2 minutes browsing products. In the worst-case scenario, a participant could take up to 10 minutes to browse products before they could answer any questions. We decided to only include 19 products that were all of the pill type and their alternative capsule counts to minimize repetitively irrelevant interactions such as browsing products silently.

Social Awkwardness. Participants in a study can be subject to feelings of awkwardness consistent with findings for interactive public displays [2]. Ideally, participants and non-participants would be able to interact with each other with the study investigators being invisible. However, this often conflicts with study ethics protocols as non-consenting participants cannot be recorded. In our study, non-participants (staff and customers) are not to be recorded at all and must be removed from the data. Furthermore, study teams can create additional social awkwardness as we observed store staff avoiding interaction during the study. One participant commented on the study investigator's camera hat as a "funny looking hat" (Figure 5). The fact that a study is happening is an unusual event that people – out of courtesy – would rather not interrupt.

Respecting Store Owner's Requests. Property owners may negotiate requests so that studies do not interrupt their business. This could include restrictions about when and where the study can take place, compensation for time lost, or charges for supplies. We were asked to pause the study if a customer or staff needed access the aisle. The concern was that the study would prevent other customers from accessing the multivitamin aisle. While it is a reasonable request,

Figure 6: The two sample products used to train our participants on how to use the visualization. The boxes have barcodes that simulate how to scan a barcode with the visualization app. We intentionally made non-realistic packaging to avoid learning effects and avoid the appearance of shoplifting.

it also requires the study investigator to stay aware of non-participants who may be reluctant to request aisle usage. We were also prohibited from recruiting participants at the store by intercepting shoppers as it would be disruptive. Thus, we developed two fake sample products based on the real products (Figure 6) to train our participants on the visualization. Meeting, introducing, training, concluding, and any other study process that did not required access to the aisle were requested to be conducted outside the store.

Behavioral Realism. To make our study situation more realistic, we clarified to the owner and staff that their participation was not required and asked that they conducted their business normally. This includes staff needing to interrupt the study to access shelves, help customers, and even change available products. This was to prevent the study area from devolving into a controlled laboratory experiment where participants cannot interact with the environment. We did, however, run the study at non-peak hours (afternoon) to avoid customer traffic. But running an in-situ study also meant that participants might not ask for help from the staff as they would ordinarily.

Uncontrolled Environment. Field environments are expected to change and need to be accounted for in the study design. We anticipated the store updating pricing labels, and adding coupons, and restocking products. During the study, one of the products had been discontinued and was no longer stocked in the store, which affected three of twelve participants. This meant that these participants could not choose the product that most other participants had chosen earlier. While we could have asked the owner to temporarily restock the product or provided a fake product ahead of time, the uncertainty was more realistic. Our task questions did not require the correct answer since we were interested in external factors to our application. However, this makes data more difficult to analyze and compare between participants that experienced different situations.

Mobile Research Setup. A small team of investigators can help minimize social awkwardness during a study. In our study, a single investigator recorded data and took notes. They wore a hat mounted with a GoPro camera to record audio and video. The phone also captured usage data such as products compared and interface interaction logs. The study ran for at most 90 minutes, with the two phases typically lasting approximately 15-30 minutes each.

However, we noticed that a single experimenter will have far too many things to manage simultaneously. The camera needs to be focused on what the participant is doing but avoid capturing non-participants; notes should be taken as the participant completes the task; the next task needs to be prepared; the participant needs to be asked questions; etc. A team of researchers running the study can be difficult in the limited aisle space and the relatively obvious "paparazzi" in public could draw unwanted attention impacting the realism of the study.

Discussion

Realism vs Precision. Just like with all technology, people's response to visualizations can vary depending on the context. Mobile visualizations are particularly suited to being used on-the-go, in specific situations. That a visualization performs well in a controlled lab situation (*precision*) [7] does not inform us about how it will perform in-situ. An in-situ study will allow researchers to get data about how their mobile visualization is used in context (*realism*) [7]. While in-situ studies can be costly, they provide invaluable insights and uncover problems that may not be present in the lab [9]. In the future, researchers will likely employ novel mobile visualization designs and would like to evaluate their effectiveness as a specific visualization tool in its intended context.

Mobile Research Setups. As a community, we ought to consider ways to setup mobile research suites for in-situ studies. It can be challenging for a single study investigator to conduct an entire study. Designing a setup to help investigators offload tasks such as watching out for non-participants, monitoring changes in the study environment, aiming the camera, or taking notes can help. Different ways of replaying multiple sources of data (e.g. visualization interaction, body language, store-setup) may be of visualization design interest.

Questions for the Community

We pose the following open questions to the research community to address:

- How do we design studies to evaluate mobile visualizations in their intended contexts?
- How might we improve data collection and analysis to infer mental processes of our participants?
- When should we perform in-situ studies for mobile visualizations?
- How might we perform in-situ studies for mobile visualizations?
- Can we design ways to facilitate access to field sites more readily?

It would appear that the challenges of studying visualization in-situ are very similar to the challenges of studying any mobile app in-situ. We are curious as to whether any actual differences will emerge.

Authors

Kevin Ta is a Master of Computer Science Student at the University of Calgary, Interactions Lab. He is interested in tools for creativity and exploration with a focus on Augmented and Virtual Reality.

Jo Vermeulen is an Assistant Professor at the Department of Computer Science at Aarhus University. His research interests lie at the intersection of human-computer interaction, ubiquitous computing and information visualization. Previously, he was a Postdoctoral Fellow in the InnoVis group at the University of Calgary.

Lora Oehlberg is an Assistant Professor of Computer Science at the University of Calgary. She leads the Curio Research Group and co-directs the Interactions Lab. Her research focuses on tools to support creativity, curiosity, and collaboration, including fabricating data physicalizations and situated visualizations.

Sheelagh Carpendale is a Professor of Computer Science at the University of Calgary, where she holds a Canada Research Chair in Information Visualization and the NSERC/AITF/SMART Industrial Research Chair in Interactive Technologies. She leads the InnoVis Research Group and co-directs the Interactions Lab. Her research focuses on combining information visualization and human-computer interaction to better support everyday practices of people.

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