Vertoid: Exploring the persuasive potential of location-aware mobile cues

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***Abstract*—This paper presents the design, implementation and user study of *Vertoid* — a mobile system for providing context-aware cues that help users limit domestic greenhouse-gas emissions. We have designed an Android-based mobile application that provides user with tips on simple eco-friendly actions in relevant locations. We then conducted a medium-term field study to evaluate the system. Our study shows that while context-aware cues have the potential to be a useful way to deliver customised content, they may as well provide unnecessary distractions. Based on the results of our study, we discuss how location awareness can be used to support persuasive systems and outline several design considerations for providing context-aware cues.**

I. Introduction

MANY researchers share the belief that technology can be effectively used as means to persuade users to change their habits and alter current behaviours [1]. Emerging technologies will try to persuade us to enjoy a healthier lifestyle and buy products from preferred suppliers. In our work, we aimed to investigate if this kind of potential can be used to support a more social cause where direct impact is harder to observe. Inspired by many social campaigns by those battling for reducing greenhouse gas emissions, we investigated that problem in detail. A unique feature of this particular case is the fact that only a large collective of users over a long period of time may make an impact. We have decided to explore possible answers to that challenge by designing a mobile system that provides information on how to limit greenhouse gas emissions only in locations where users can affect the emission levels.

In the remainder of this paper, we discuss related research and describe *Vertoid*'s design process. We then provide details on how the system was implemented and evaluated in a user study. The main contributions of our work include: the design and implementation of a persuasive mobile application for limiting greenhouse gas emissions, an exploratory user study of the application and a set of design notes that can be used with future systems.

II. Related work

Several past projects have explored the use of mobile devices in persuasive systems. Consolvo *et al.* [2] pointed to the unexplored potential of mobile phone displays for persuasive use. They investigated a system called *UbiFit* that facilitated physical activity self-monitoring. Their results show that a personal mobile display can increase awareness and support positive lifestyle changes. Contrary to *UbiFit*, in *Vertoid* we aim to avoid introducing additional devices to be carried, but try to cater to users already carrying a smart phone on a daily basis. In a similar vein, Gasser *et al.* [3] compared mobile and web-based activity and nutrition monitoring systems. While the study found no significant differences in the effectiveness of the systems, a significant advantage of an enhanced user experience was observed in favour of the mobile application. We aim to build on that potential and explore the mobile setting as a change enabler.

A critical design perspective on designing for self-reflection on the go was presented in *Fit4Life* by Purpura *et al.* [4]. Similarly to *Vertoid*, this project aims at promoting social change through small, individual steps. *Fit4Life* aims at supporting individual healthy behaviours to stop the spreading of obesity in the population. Similarly, *Vertoid* employs a system of persuasive messages to stimulate the user and provide guidelines on proper behaviours. As *Fit4Life* is mostly a conceptual prototype it uses a wide range of sensing technologies to provide context-aware cues. As *Vertoid* uses everyday smart phones, its sensing capabilities are limited, but it follows a similar design pattern. However, it is significantly different from *Fit4Life* as it addresses a problem where positive actions are harder to observe. An analysis of the literature available shows that most persuasive mobile applications have focused on improving health and fitness. Several other examples worth noting include: Exergaming [5] where a mobile app encouraged youngsters to exercise; MONARCA [6] which was used for helping patients with bipolar disorder; and CAMMInA [7] which promoted physcial activity among elders.

Gabrielli *et al.* [8] conducted design studies for a mobile application aimed at supporting sustainable transportation solutions. Their investigation included users that are not motivated by environmantal factors. *Vertoid* is aimed at users that are aware of the global warming problem and attempts to improve overall attitudes and promote principles rather than focusing on specific point-to-point transport tasks.

Creating user engagement is also an emerging theme in recent research. As Rogers [9] suggests, sometimes designers should sacrifice seamless usage to create excitement and cause

change. in *Vertoid*, we try to build on that notion and determine if messages provided in between everyday actions can be an effective persuading factor and, potentially, produce a long-term effect. This is also in line with an emerging trend for promoting engagement through mass-scale easy prototyping with high participation of the user base [10].

III. Design

We have endeavoured to design a system that would help the users make environmentally-conscious decisions when performing everyday tasks. We have decided to utilise the smart phone as the tool to achieve our goal as many users already carry these devices at all times. Recent analyses have proven that smart phones have the potential to create new habits consisting of brief usage sessions [11]. In principle, our goal was to capitalise on that potential by establishing a set of triggering contexts (in our case driven mainly by location) that would promote the desired behaviours. We have conducted semi-structured interviews with potential users and constructed severla user journeys and personas to aid the design.

To engage the user in environmental activities, Vertoid uses a set of environmental challenges that suggest possible actions that might help reduce greenhouse-gas emissions. Location tagging assures the challenges are posted at appropriate locations. The tasks may range from simple ones, like replacing a light bulb, to more complicated, like replacing the furnace filter. Whenever possible, a specific amount of carbon dioxide that can be saved by completing the challenge is indicated. Some challenges concern changing habits and others are designed to incline the user to make a single contribution. Each task is associated with a specific location type. Our aim was to increase the chances for an immediate completion of the tasks by asking the user to manipulate objects in their direct physical proximity.

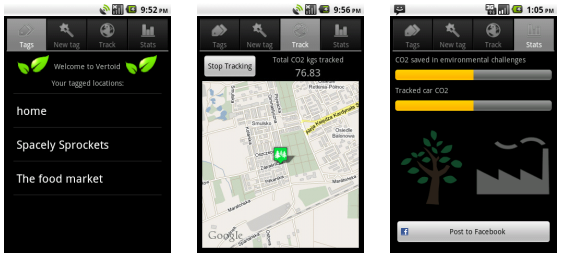
The application keeps track of the declared contributions and can always provide an overview of the current progress of the user. The users can also use the phone to track the carbon dioxide produced during car travel by activating *Vertoid* while driving. The personal statistics are also easy to share on social networks.

IV. Implementation

In order to evaluate the *Vertoid* concept, a high-fidelity prototype was implemented on the Android mobile platform. Here, we present the key features of *Vertoid*.

The tag list (Figure 1(a)) — Technical limitations require the users to declare their home and work locations as well as public places they frequent. This is needed only once. The main purpose of the list is to enable the user to verify which locations have already been tagged. There is a possibility to delete a given tag by using the context menu.

The map view (Figure 1(b)) — this screen enables recording carbon dioxide emissions while driving. The current position of the user is displayed on a map and tracking can be toggled on and off.



(a) The tag list screen (b) The map view during car tracking (c) The statistics screen

Fig. 1. Screen shots showing the most used screens in *Vertoid*

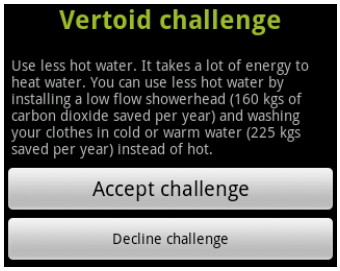


Fig. 2. The challenge prompt. *Vertoid* triggers environmental challenges based on user location

The statistics screen (Figure 1(c)) contains a visualisation of all the data accumulated during the usage of *Vertoid*. The user's status as to saving and generating carbon dioxide is presented as progress bars and waning pictures of a factory and a tree. A Facebook share button is provided.

Environmental challenges are *Vertoid*'s core feature. Whenever a user enters a location defined previously, a *Vertoid* notification appears in the Android notification panel. When reviewed, the notification scales up to a challenge prompt (an example is provided in Figure 2). The user can accept or reject a given challenge. The appearance of a new challenge is signalled by a vibration and challenges appear only once per visit to a location.

V. Evaluation

A. Methodology

We have conducted a limited-scope field study with 16 (9 male and 7 female) participants who were asked to try using the application in their everyday lives. Study subjects were recruited on a voluntary basis and consisted mainly of students. We looked for regular smart phone users already familiar with the Android operating system who expressed interest in actions against global warming. A detailed demographic profile of the participants is presented in Table I. The first user evaluation activity was conducting semi-structured interviews with all the participants to ensure their prior familiarity with smart phones and the intent to pursue environmental activities to some extent. The inteviews included a section where we discussed everyday actions and their impact on global warming. While the participants were quite enthusiastic about helping the

TABLE I
BASIC INFORMATION ON THE PARTICIPANTS AND THE STUDY. WE ASKED THE PARTICIPANTS TO SUBJECTIVELY RATE THEIR SMART PHONE USAGE FROM 1 — VERY SELDOM TO 5 — MORE THAN 10 TASKS PER DAY

Property	max	min	$mean$
Age [years]	33	19	24.73
Usage duration [weeks]	8	4	5.27
Smart phone usage [see caption]	5	3	4.10

common cause of reducing greenhouse gas emissions, their awareness to what one can do to help was rather limited. This created an opportunity for exploring *Vertoid*. We also recorded basic demographic data on the participants. We have then installed the application on the users' personal Android phones and provided a brief overview of the functionality with a practical walk through. Our initial concern was that the usability of the program might have affected its persuasive potential. We used expert evaluation from the start of the development, but a simple user test was required. Consequently, each user was asked to complete a simple questionnaire based on Nielsen's usability heuristics [12] after two weeks of use. We asked the users to rank the qualities of the application on a 1 to 5 scale. Short descriptions of the qualities were provided. We concluded that the usability of the application did not affect its possible impact as the users rated Vertoid (on average) 4.10 for clarity, 3.82 for appearance and 4.28 for error handling. We believe that these ratings are satisfactory for a prototype application. The participants had the opportunity to use *Vertoid* on their phones for periods from 4 to 8 weeks (the varying period lengths are a result of limiting the intrusiveness of the study by avoiding scheduling conflicts).

After the unsupervised usage period, the participants were invited for an interview once again. As our investigation was largely exploratory, we looked mainly for qualitative feedback. However, we gathered input on the frequency of use. In our preliminary talks, we have determined that some of the participants were reluctant to share their logged data as it contained their frequented location. This is the motivation behind relying on reported usage accounts rather than logging.

In order to evaluate the environmental awareness change caused by Vertoid, we included questions about green living in the interviews both before and after using the application. In the initial talk, we included both straightforward questions (*e.g.* "Do you try to maintain a sustainable lifestyle?") and indirect measures of green living ("How many incandescent light bulbs are there in your house?"). We asked similar indirect questions in the post-usage interview.

B. Results

Overall usage frequency varied significantly among participants. On average participants reported using *Vertoid* $\mu = 4.18$ times in a week with $SD = 2.36$. Such a discrepancy prompted us to investigate why some of the users refused to use *Vertoid* regularly. In Figure 3 we show usage frequency distribution among the participants.

Those of the participants who reported using the application

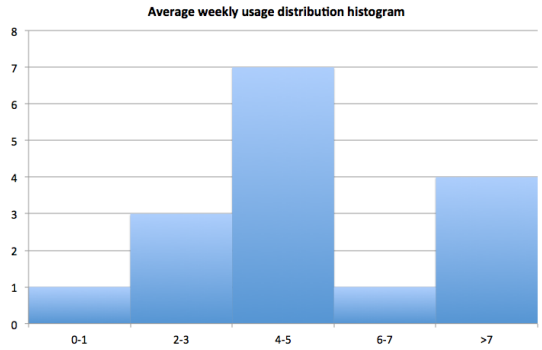


Fig. 3. The histogram shows participant counts and usage frequency intervals in times used per week for the field study.

only sporadically described the experience as interesting, but lacking the impact potential. *"A few lines of text cannot convince me to do additional housework."* remarked one participant. Two participants did not tag their frequented locations citing privacy issues, so they only received notifications in a predefined set of locations shipped with the installation. Even though 7 (33%) of the users explicitly stated that they did not use the application more than once a week, they still claimed that they wanted to improve their daily routines to make their lives more sustainable. On the other hand, those who reported using *Vertoid* regularly noted that the number of challenges was quite high (*"I never realised you could have so many tips on green living"*). All of the users who read at least one of the challenges (95%) reported learning new facts through the challenges. Those who used location tagging reported that it worked properly and the triggered challenges were relevant to the space. Accounts of the shopping experience with *Vertoid* provided us with additional insights. It surfaced that the coarse positioning was inadequate in the shopping areas while it worked at home and at work. For example, users were annoyed to receive suggestions about buying local produce once they have passed the vegetable section, but they did not mind being reminded to change to fluorescent light bulbs while not within reach of a lamp. Generally, we can conclude that the cues were quite successful when they concerned short, immediate actions performed with objects close to the user, *e.g.* choosing nationally locally meat.

We have observed a difference between declared environmental engagement and real actions taken everyday. Users often overestimated their efforts in living a green lifestyle despite being unaware of the simple actions that help. In the post-usage interview, we noted a slight increase in the knowledge of easy ways to reduce greenhouse gas consumptions. Figure 4 illustrates the subjective and objective pre-study awareness level as measured by our questionnaires and the results of a similar objective test after using *Vertoid*. We believe that the observed increase in awareness may suggest that mobile contextualised cues have cause a long-term effect.

VI. DISCUSSION

Overall, we believe that our exploratory field study confirmed the persuasive potential of location-aware mobile cues

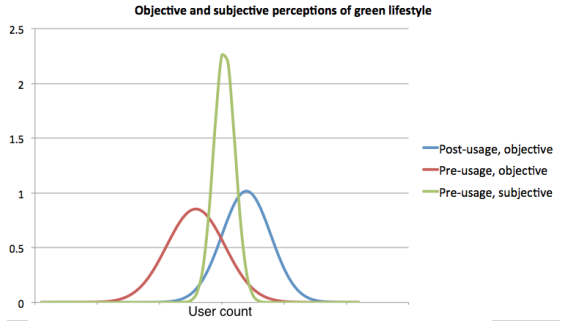


Fig. 4. User environmental awareness levels as measured by our questionnaire. The plot contains values declared by the participants and pre- and post-study results obtained with our questionnaire.

for stimulating environmental awareness. Those of the participants who decided to use *Vertoid* regularly reported positive experiences and were inclined to put some of the suggestions into practice. This was not the case for those using the application only sporadically. We can attribute this difference to the fact that *Vertoid* may constitute a significant intrusion to everyday life that must be consciously accepted by the user. As a consequence, we may speculate that context-aware mobile cues may affect everyday acrtion to a degree that requires conscious acceptance of the intrusion prior to delivering the cues, *i.e.* they are effective for users who want to change, but seek the means to achieve the goal. In a way, the field study differentiated between those who spoke of environmental matters as this was "a good thing to say" and those who were ready to take action.

We have consciously employed a user-driven design approach in creating *Vertoid* in order to embrace the practicality of everyday lives and focus on user accounts. This is supported by the fact that most known theory-driven methods revolve around health and well-being (discussed to a large extent in [13]). Using a design-oriented approach affects our insights as to the long-term effect of the application. The long-term experience of using *Vertoid* is a complex research question due to the mobile field setting and we cannot use theoretical means for modelling the answer. We have completed an exploratory study that clearly confirms the potential of mobile cues to become an effective behavioural change technology. Qualitative feedback from the participants seems to confirm that some of them learnt new ways to lead a more environmentally-friendly life and integrate some of the suggestions into everyday habits. Thus, we see an emerging need for studying this research context further to clearly determine if providing contextualised suggestion can lead to real changes in patterns of daily life. Long-term field studies are required, but these will only be possible if sensing techniques that will enable more accurate context recognition are made available. Recent advances in embedding information in physical objects like near field communication can be explored for opportunities to provide more relevant suggestions.

VII. Conclusions

In this paper we have presented the design, implementation and an exploratory field study of a mobile application that investigates the potential of contextualised mobile cues for persuading users to lead a more environmentally-friendly lifestyle. We have implemented a high-fidelity prototype and ran a field study that resulted in a better understanding of the persuasive effect of the application. *Vertoid* received positive feedback from most of the 16 study participants. Usage intensity varied significantly, but those participants who reported using the application on a everyday basis concluded that it was a useful addition to their everyday routines and created new opportunities for a greener lifestyle. We have observed that the location-based challenges functioned satisfactorily at home and at work. We see new potential emerging from increased accuracy at shopping places for an enhanced experience. We hope to explore the potential of context-awareness for persuasion further by employing more advanced sensing methods and long-term studies.

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