Pedestrian Navigation through Pictograms and Landmark Photos on Smart Glasses: a Pilot Study

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ABSTRACT
Wayfinding is the process through which a person moves from one location to another. The means however that each person utilizes to complete a wayfinding task are different depending on the person's preferences, habits and characteristics. For a large number of people, using turn-by-turn directions with metric reference (in 30 meters turn left) is a natural way of navigation. However, people with intellectual deficiencies (ID) are less likely to use them. Instead, they rely on visible, distinct landmarks to orient themselves during a wayfinding task. In our efforts to provide a novel pedestrian navigation system for such users, our first step was to conduct preliminary studies with non ID participants to understand user behavior when using pictures of landmarks. The study presented in this paper is a preliminary step to validate the testing protocol in a controlled indoor environment before deploying it on a larger scale. We asked 14 participants to navigate from a starting point to an end point while guided by pictograms. They had the possibility to take pictures of interesting landmarks on their path. On their way back, they were not guided but could rely on the previously taken photos to trace back their path. We observed a number of user tendencies in taking pictures of landmarks as well as their use by the participants to orient themselves. The results will help us gain insight on the use of pictures for navigation by a general population as well as to inform the design of further research with persons with intellectual deficiencies.

Author Keywords
Wayfinding; navigation; landmarks; pictograms; HCI; smart glasses.

ACM Classification Keywords
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General Terms
Human Factors; Measurement.

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INTRODUCTION

The availability and the affordability of navigation assistance systems made them a staple of everyday navigation tasks. They can be useful for calculating the shortest route, as well as locating oneself during day-to-day navigation tasks. The user interface built into these systems communicates navigational information and instructions to the user. In these systems, turn-by-turn navigation is heavily used by to convey instructions to the user such as "in 30 meters, turn right". The route to be taken is then broken into segments linked by decision points. Around each decision point, a new instruction is given to the user at a frequency and an anticipatory distance that is appropriate to the context of use. Although this format of instruction can be considered as natural, a person with intellectual deficiencies (ID) may find it difficult to reason in the same way. According to the literature and several interviews with guides, an ID person relies more on navigation by landmarks [1, 2, 3]. For example, instead of reasoning like "after 30 meters, I turn right", an ID person is better off with the instruction "when I reach the pharmacy, I turn right". In our daily life, this mode of recognition [4] can also be useful in the absence of precise localization tools. Their saliency prompts us to focus on them during the wayfinding task [4]. In addition, some ID people do not have the lateralization skill. In this case, the instruction to turn right will not help them. Finally, from our experience in the field, people with ID are not all readers, so text instruction may not be suitable.

The SAMDI (*Système d'Aide à la Mobilité pour personnes Déficientes Intellectuelles*) project aims at developing a navigation aid for people with intellectual deficiencies that can adapt to the context of use. It needs to be reactive and able to handle impromptus changes in the environment. With the constraints that are mentioned above, it needs to rely on either signals that are visually simple to understand (adapted pictograms) to indicate directions or photos of landmarks.

A number of studies investigated the use of landmark photos during navigation. However, changes to the environment, for example, can make the landmark hardly recognizable based on the provided picture if not updated properly. The angle of the photo may also be confusing if not closely related to the actual point of view of the person, especially if the user has intellectual deficiencies. For these reasons, we would like to get more insight on useful parameters that influence the use and the usefulness of landmark pictures during a wayfinding task. Before starting experiments with people with ID, we first conducted a preliminary study with able bodied participants in a controlled indoor environment.

In this study, we asked 14 participants to go from a starting point to an end point while guided with pictogram based instructions. Simultaneously, they could take pictures of interesting sights. On their way back to the starting point, they would not be guided but can, if needed, rely on the photos they have taken previously to back track their path. The main goal of this study is to observe whether or not participants would feel the need to take any pictures and use them or they would rather remember the path by themselves. In addition, whether or not the fact that the pictures would be used to back track would influence the angle of the picture is also important to note. Lastly, we wanted to investigate whether or not participants' characteristics such as their sense of direction, navigation habits or type of memory could have an effect on them taking the pictures or not. We present the results of this study and outline directions for future improvements and research based on our observations and participants' feedback.

The rest of the paper is organized as follows: we first present prior works in the literature that motivated the current study. Then we present a user scenario in which the proposed system could come as a help for a person with ID. After that, we present the current study and analyze both the quantitative and qualitative results. Finally, we present future directions of our research based on the observations from the current study.

RELATED WORK

In this section, we present a number of past studies in the literature that motivated the current study.

In [5], the authors proposed a model for wayfinding that represents the user's state at each step of this task as well as the types of wayfinding tasks. These can range from directed navigation to a destination in a known place to free exploration in an unfamiliar environment. At each step of wayfinding, the system needs to know the position of the user in space (and along the route) and the orientation so that the movement instructions and/or information about the explored environment are accurate and useful.

Regardless of the technology used to acquire these parameters, their resolution, accuracy and precision affect greatly the wayfinding decisions. Thus, the user needs to be aware, to one degree or another of these parameters for an optimal decision-making. [6] and [7] proposed a framework where the representation of the navigation instructions can change format depending on the resolution and estimated accuracy of the location and direction of the user. The framework also supports the display of information on different devices to accommodate for the changing environment and resource limitations. In addition, the change in information representation can also be heavily influenced by the limitations in perception or cognition of the user. More precisely, when presenting navigation information to a user with intellectual deficiencies, information pieces like precise distance are much less relevant than information about prominent landmarks along the way. The framework links these two parameters in stating that the less precise the position and orientation of the user are, the more the navigation instructions have to emphasize on more global landmarks instead of smaller, more local ones. This is further backed up by [4] where the authors state that the prominence of these landmarks grab the attention of the users the most in the landscape. In the same paper, the authors infer landmarks from the feed of the person's eye gaze data. Consequently, they then state that it is possible to extract landmarks relative to a certain person by matching almost a third of all image data, inferred by the user's gaze.

Other researchers have also investigated the use of landmark navigation like in [1] where photos, taken from available databases, were shown to the users on a smartphone interface and proved helpful for navigation. Furthermore, [9] pushed the idea even further by allowing the users to add annotations to the photos. The author found that adding annotations can be helpful to better put the picture of the landmark into context and facilitate the decision making once the users gets to it. However, the users may be tempted to add too much information in the annotation that they become more confusing than helpful.

Lastly, in a preliminary study [10], the authors explored the use of landmarks beyond the simple task of wayfinding. They used recall tests after the navigation task. They observed that while mobile pedestrian navigation systems based on landmarks could convey well landmark knowledge, they failed to convey survey knowledge.

All these past studies show the importance of adaptation of information representation as well as the promising potential of landmark based mobile navigation systems. Carrying on the works in [5], we propose to study user navigation on smartglasses, based on photos of landmarks they have taken. Here, there is no constraints on the type nor on the number of landmarks chosen by the user.

PICTOGRAMS VERSUS LANDMARK PHOTOS

In this section, we present the current study conducted to better understand user behavior while taking pictures of landmarks to be used later. We aims to analyze strategies to propose them to ID people in the future.

The use of smart glasses for navigation

One of the most common ways to navigate from point A to point B is using a smartphone's GPS. Depending on the user interface of the application used, the route can be drawn on the application for an overview, the user receives visual turn-by-turn movement instructions. The user can also choose to have auditory instructions so that they do not have to look at the smartphone and not be distracted. The problem arises when the person is in a noisy environment and the sound instructions are no longer easy to hear. Another more dangerous situation is when the audio instructions are played at a volume high enough to be audible but while obscuring possible sounds, such as an approaching vehicle. This can endanger the user.

In order to mitigate these constraints, a system developed by [3, 5] uses smart glasses (Figure 1). On the right lens of the glasses, the direction instructions (Figure 2) are displayed using a pictogram.

Figure 1: Vuzix Blade Smartglasses

In the same study, the system is compared to smartphone used for a population of non-ID users and appears to show promising results. This can have the advantage of giving visual instructions to the person without obscuring their field of vision and distracting them from their environment.

Figure 2: Pictogram direction instruction shown on the smartglasses' screen

Hypothetical user scenario

We introduce a hypothetical user John who has an intellectual deficiency. He is semi-independent in the sense that he does not have a problem taking routes that he is familiar with but requires assistance with new routes. John goes to work every day at the packaging plant that is located about two kilometers from where he lives. He goes through the main avenue for half a kilometer, then at the grocery store, he turns left to continue for 800 meters until the pharmacy. After that, he turns right and continues 700 meters until he reaches the bike repair shop then he turns left again and walks 500 meters to his work. All these landmarks are salient and have been operating for as long as John has been working at the packaging plant. In addition, he is provided with a hotline he can call during his journey to and from work in case of emergency. On a Tuesday morning, the road between the pharmacy and the bike repair shop was closed for works for both cars and pedestrians. According to his caregivers, in normal circumstances, he would simply return home and call in saying that the road was closed and he could not make it to the plant. He does not have the cognitive capabilities to plan on the fly and follow the road signals that indicate an alternative route that will get him to his work location. However, that Tuesday was an exception since he was wearing smart glasses with a special software. He called the hotline and the assistant gave him direction instructions based on pictures of landmarks that are along the new deviation. As no one was able to predict how long the road works were going to last, the pictures and the direction instructions were saved to the glasses in order for John to use them for the come back and also for the following days on his way to and from work.

This scenario is imaginary but could depict a realistic episode and the help that the system on the glasses could provide would be in fact very helpful according to our interviews with caregivers in the field.

Pilot study with non-ID users

Before providing real ID users with such a system, we wanted to understand first what characteristics of both the user and the landmark pictures would influence the use and usefulness of these pictures. We also wanted to refine the testing protocol with participants not having any type of disability before testing with ID participants. To this end, we devised a study where participants are guided from one location to another with pictograms that show the direction to take. The participants can simultaneously take pictures of interesting sights on the path. Then, on their way back, the participants are not guided but rather have to find their way while having the possibility to scroll through the pictures they have taken. We first wanted to see whether or not participants would feel the need to take any pictures and use them or they would rather remember the path by themselves. We wanted also to see whether or not the fact that the pictures would be used to back track would influence the angle of the picture. Lastly, we wanted to see whether or not participants' characteristics such as their sense of direction, navigation habits or type of memory could have an effect on them taking the pictures or not.

Apparatus

The study was conducted using smart glasses as a wearable device for giving direction instruction to the users based on the work of [5]. The users can then receive direction instructions without losing focus of the environment. In order to avoid any issues with indoor localization, we conducted the experiment in a wizard of Oz paradigm. The glasses, Vuzix blade running on Vuzix operating system based on Android, were connected through Bluetooth to a smartphone operated by the experimenter (see Figures 1 and 2). The latter sends navigation instructions to the participants when needed and they are directly displayed on the screen (as for example pictogram on Figure 3).

Experiment setting and design

The experiment was conducted in three different locations. Participants 1, 2 and 3 tried the system within the facilities of our laboratory. Then, during a conference on Human-computer interaction, the other participants were able to test the system. Participant 4 through 12 tested the system in a first building of the conference during a demonstration session and participants 13 and 14 inside a second building of the conference, both in the campus of the University of Namur, in Belgium.

In all three settings, the chosen path was selected with similar length. According to [10], the level of complexity is dependent on the number of intersection-based decision points. Thus, the different paths were chosen with similar level of complexity.

The experiment was run as follows: We first collected the consent forms and a number of demographic information such as the primary ways the participants find their way in day-to-day wayfinding tasks. We also asked self-reported questions about the type of memory. The participants were asked whether they tended to link a memory to an image, a sound or other types of stimuli as well as how they thought of their memory as a series of images, sounds or other types of recollections. Then, we asked the participants to fill in the Santa Barbara Sense of direction Scale (SBSDS) [11] which is a standardized test for the sense of direction. For concerns about standardization all questionnaires were asked in French except the SBSDS as no known certified French translation existed at the time of the experiment.

After that, the experimenter installed the pair of smartglasses to the participant and showed them how to interact with the navigation system as well as how to take pictures of interesting sights during the first part of the experiment. The experimenter also showed them how to navigate the photos they have taken on their way back. The experimenter tells the participant that they are going to move around the building. The participant must follow the instructions which are displayed by pictograms on the glasses. At any time, when they want, the participant can take pictures. Then the participant must return to the starting point by the same path.

During the first part of the experiment, one experimenter accompanied the participant to handle the pictogram based instructions that appear on the smartglasses' screen (Figure 4). When the end of the path was reached, the participant was asked to fill in the System Usability Scale (SUS) form for this part of the experiment. Then they were asked to go back to the starting point through the same path. Once the initial starting point is reached, the experimenter asked the participant to fill in the SUS form as well as two questionnaires, one concerning the first part, and the other one concerning the second. The questions were concerning the use as well as the usefulness of the system as a whole, and more specifically taking the pictures and using them to find their way back. An example of the questions (in the form of statements on a 7 point Likert scale) was "knowing that the pictures were going to be used to get back to the starting point influenced the angle with which I took the pictures". The last question was an open one to elicit free commentary on the use of the system as well as the whole experiment.

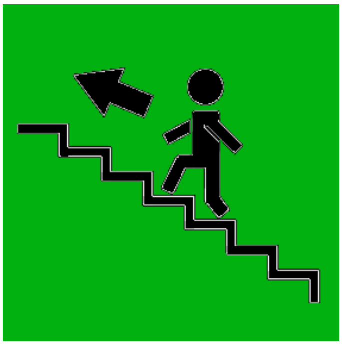

Figure 3: An example of pictogram based direction instruction (take the stairs up)

Consequently, the dependent variables were: the number of photos taken, SUS Score part 1, SUS Score part 2, photos taken at decision points*, pictures taken at intersections*, photos used*, photos useful* and the impression that the participant made a mistake tracking back the same path*. The latter variables with an asterisk were statements on a 7 point Likert scale and were self-reported. In the analysis, we compared these variables according to the following criteria: SBSDS score, the level of familiarity with the path, whether the participant took photos or not, whether they have an image oriented memory or not, whether they orient themselves in terms of relative positioning (in front of, behind…), cardinal directions (N,S,E,W) or in terms of landmarks.

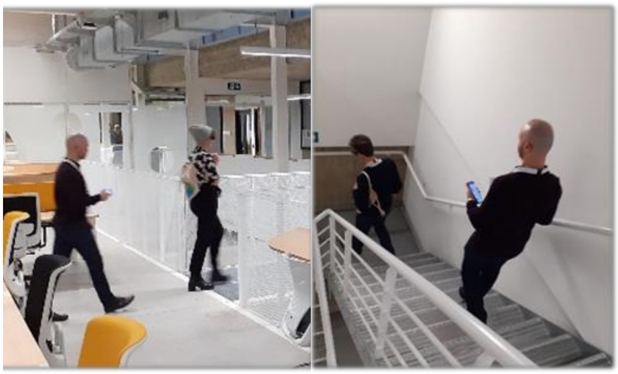

Figure 4: Photos of two participants during the tests followed by the experimenter directing the navigation instructions

Participants' characteristics

The participants were all adults, 6 males and 8 females, with either a graduate or postgraduate degree, aged between 21 and 65 (mean = 38 years old). They all work or study in a HCI related field. They used various means of navigation in their everyday life, although GPS navigation systems were predominantly the first choice. The SBSDS score followed a normal distribution with a mean = 4.39 over 7 and a standard deviation of 0.95. According to the test's website, the higher the score, the better the sense of direction of the person is. On average, they were moderately familiar with the path (mean 3.64 over 7, with standard deviation = 2.56). 11 participants tended to link a memory to an image (as a first choice) and 3 participants linked it to another stimulus like a sound or an affordance (or a manual manipulation of an object). Then 6 participants expressed that their memory is a collection of images (as a first choice) and 8 expressed other choices like sounds, a collection of experiences or manual manipulations of objects.

Concerning the way the participants thought of their environment (three items on a 7 point Likert scale), the participants mostly thought of it in terms of landmarks (mean = 5.86, sd = 0.66), then relative positions (mean= 5.5, sd =0.76) and last in terms of cardinal directions (mean=2.93, sd= 1.77).

Quantitative results

To take pictures or not

During the test, 10 participants took pictures and 4 did not. Between the two groups, there was no significant difference in SBSDS scores (means were 4.39 and 4.47 respectively), neither was there in familiarity of the path and they were equally confident about making or not mistakes during the second part of the experiment (2.21 vs 2.75 over 7 respectively). Neither were there any differences between the way they thought of their environment (relative positioning, cardinal directions and landmarks). The only notable remark was that all four participants who did not take any picture tended to link a memory to an image and had their memory constituted of a series of images and/or a series of experiences. The inverse logic was not verified in the sense that participants who did take pictures had visual and non-visual memory. Lastly, the group that did not take any photos gave an SUS score of 86.25 to the pictogram guidance system versus an average of 82 for the group that took photos. The latter also gave an average SUS score of 74 to the image based guidance system, this score was not asked from those who did not take any photos. The rest of the analysis is based on the group of participants who took photos during the experiment.

Photo based memory

For this subsection we will describe how the nature of the person's memory influenced the participants' experience using the system between the group that has a predominantly visual memory (memory constituted of a series of pictures group I) and other participants group I'.

First, there was no significant difference in the number of photos taken (although slightly higher for I'). There was however a significant difference in terms of the SUS scores each group gave. The I group rated both the pictogram based guidance and the photos based one as below the usability standard (76.43 and 66.78 respectively). I' however rated both guidance methods as usable with 95 and 90.83 respectively.

Although no significant difference, the group I' tended to take photos more on direction changes and use the photos more to help guide themselves on their way back. On the utilization of the photos, I' rated 5 over 7 while I rated 2.86, although no significant difference. However, the tendency is inverted in terms of utility of photos with I rating 3.71 over 7 and I' rating 2.33 over 7 with no significant difference. No significant difference was found either in the impression of taking the wrong route on their way back both 2 over 7. This may indicate a tendency by the I' group to take more pictures than needed in the end while the I group were more confident in their image based memory, so they took only pictures that were useful to them.

Correlation tests did not show any significance between the impression of having made a mistake and either SBSDS score or familiarity of the trajectory. When we asked the participants, on a Likert scale, if they took photos in intersections as well as direction changes, we noticed a nearly significant positive correlation. This means that the more the participants knew the environment, the more they tended to take pictures in intersections and direction changes. This result seems counter intuitive and needs to be investigated in depth during further experimentation.

There was also a positive correlation between familiarity of the route and the use as well as the usefulness of the photos on the way back (Figure 5). This also seems counter intuitive since we would have guessed that the less the person knew the environment, the more they will rely on the pictures. One explanation might be that when the environment is less familiar, the person may tend to engage more their own (natural) memorization abilities rather than rely on an external aid which in turn builds a more robust mental image of the route. In future studies, we may include a recall test at the end in order to verify this hypothesis.

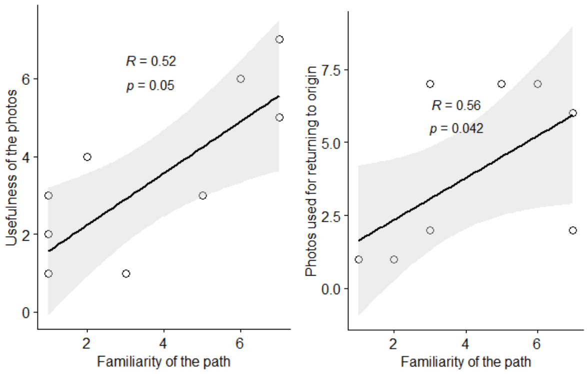

Figure 5: Graphs of correlation between familiarity of path and use and usefulness of photos to retrace the route

This is backed up by some participants' remarks that they wished they took more pictures in some key locations to register for example the level number on the elevator. Not having done so, they were not able to use them and were slightly more hesitant when they were at a decision point. Figure 6 shows the photo taken by one participant at the door of the elevator without capturing the whole context. This example shows the difficulty to people with no intellectual deficiency to choose pertinent photo in order to be reused in another time.

Figure 6: Photo taken by a participant at the door of the elevator (The black rectangle covering the reflection of the participant for anonymity)

Qualitative results

Participants' remarks

The first set of remarks concerns the usability of the system. Some participants, not being used to the smart glasses, found them a little cumbersome and for one participant too heavy. Furthermore, some participants needed to wear their own correction glasses. Having the smartglasses on top of them made the wear experience less enjoyable for these participants. In real life scenarios this would not be an issue as one can get adapted lenses for the smartglasses so they use them with the required correction. One of the goals of the use of smartglasses is to be able to navigate, get directions while not distracted by the screen of a smartphone for example and being able to look at the entire environment. However, as some participants were not used to smartglass screen, they shifted focus constantly between near field of view (FOV) to focus on the screen and far FOV to focus on the environment which is counterproductive. Finally, one participant said that the photo resolution was too small which made the pictures unclear to be fully useful. Another participant had a similar photo clarity issue, but after looking at the pictures post-hoc, she may not have taken the time to stabilize her movement before taking the picture which in turn gave way to somewhat blurry photos. In future tests, we can add a smartphone condition to the tests as well as give the participants more time to get used to taking stable photos with the glasses. This being said, the participants on average, found the interaction seamless and natural.

Second, as far as the pictogram instructions are concerned, one participant expressed that she would have liked them to appear in a smaller size and not occupy the entirety of the glasses' screen as this did not help her pick up more on orientation clues from the environment. One other suggestion that we found interesting is to add animation to the pictograms to explain more the meaning of specific ones. For example, rotate right (and to what degree) would be animated in a different way than simply take a right hand turn and continue straight.

Then, concerning the experiment setup, most participants found the system useful but expressed that the photo guidance system would have been more so if the route was more complex. In future tests, we will choose more complex routes, in a visually more or less stimulating environment and see how the participants judge the usefulness of the system. Furthermore, the participants expressed that the pictogram instruction were overall helpful and of intuitive meaning. The noticeable exception was the elevator pictogram where the indication up/down was not very clear for a couple of participants. Yet, at times, the pictograms' timing was not optimal as they appeared right when the person was about to take a photo. This implies that we will have to adjust more for the timing of the direction instructions with the photo capture.

Photos taken

In this subsection, we shift gears to focus on participants' remarks concerning the specific tasks of taking the pictures and using them for navigation. Except one participant who took photos simply to test the system, most users who took photos expressed that the angle of capture was important. In fact, some needed to make a 180° turn to take the photo from roughly the same point of view that they would have on their way back so the picture of the landmark and their actual point of view would match. One participant had an interesting suggestion to take 360° photos, then depending on the direction of the user, show a point of view that matches his/hers. Figure 7 shows a photo containing an arrow drawn on the ground (originally drawn for other purposes) that coincides with the way the user needed to orient himself on his way back.

Figure 7: A photo taken by one of the participants of arrows on the ground

Other participants also expressed the desire to have text or audio annotations and location tags added to the photos to give more context. Three main comments however seemed especially interesting. First, some participants, even among those who did not take any photos, expressed that they should have done so to capture the context in some key decision points, especially (as mentioned above) the floor number on the elevator. Figure 6 shows the photo taken by one participant who in fact took the photo. Even though all participants did not make mistakes, we could observe some clear hesitation when they wanted to take the elevator if they had not previously taken the picture of the floor when they got in and when they got out. This can indicate that the need or not to use the pictures depends in part on the complexity of the decision point and the likelihood of similar yet different choices.

Second, one participant in particular who took the photos and used them during her way back expressed that they acted more as a reassurance that she was on the right path more than an indication to follow. This brings up a pertinent point especially when expanding this system to users with intellectual deficiencies. Through our observations in different specialized work plants, we noticed their need for frequent reassuring indicators that they are doing the right task, doing it the right way and/or they are on the right path (literally or figuratively).

Lastly, one participant did in fact take the photos but did not use them for navigation. When asked about that, she hinted that taking the photos was in a way a means to further pay attention to the landmark and the details of the environment and helped her memorize the route even more. As stated in the related works section, in [9], the authors suggest that using photos of landmarks can improve the process of wayfinding but does not necessarily help build survey knowledge of the route. The authors mostly use photos that are given to the users. It can be possible that photos taken by the users themselves may help build a better survey knowledge either because they are more personalized to the user or because they help the users take more time and be more attentive to the landmarks and to the environment. We would need to include this comparison in future tests to verify this hypothesis.

Overall, we did not emphasize on when, where and how the photos need to be taken as well as the necessity or not to use them to retrace the way back. On reason is that we did not want to influence the participants in their choices. Say a person who did not need to use photos, they might feel obligated to use them if we insisted on them during the presentation of the experimentation protocol.

A second reason was that we wanted to see what information was captured by the participant's photos when left to their own devices. Normally, they were supposed to capture all the pieces of information that seemed relevant. Yet, with some participants' remarks and hesitation seem to indicate otherwise. As an example, the picture in Figure 6 does not convey more information than "I took the elevator". Information about whether the participant was going up or down, what as the starting/exit floor are obviously missing and might add more confusion.

In future iteration of the experimentation protocol, we may add more explanation on the function of the photos and what important information needs to be captured. This will be especially the case for participants with intellectual deficiencies as they require much more guidance in decision-making and choice selection. As a direction example, we could tell the person: when you get into an elevator, take a photo of the direction you are going in, as well as the starting floor and exit floor.

CONCLUSION AND FUTURE WORK

In this paper, we presented the results of a pilot study where we looked at landmark based navigation through photos taken by the users themselves. It serves both to gain insight on the use of photos for navigation by a general population as well as to prepare the ground to conducting similar experiment with participants having intellectual deficiencies. We tried to link user characteristics (such as SBSDS score and memory) to user behavior in first whether or not they would take and use those photos. Although many of the correlation tests were not conclusive, we were still able to get some insight.

First, all users who did not feel the need to take photos and rather decided to rely on their memory had visually dominant memory. Second, we could not find a correlation between SBSDS scores and the number of photos taken. As the participants' sample was more homogeneous in terms of SBSDS scores, we still would like in later experimentation stages to have a more varying sample in order to better explore this matter.

Also, we could see that the level of familiarity with the track had an effect on the use and the usefulness of the landmark photos. With a path that is relatively simple, many participants did not feel the need or the usefulness of taking pictures throughout the experiment. Perhaps, the takeaway lesson for further experimentation would be to vary the complexity of the path in a sufficient manner and observe whether this can yield to more distinctive or homogeneous user behavior.

Lastly, we will add the option to annotate the photos as it was suggested by many participants and to compare this process with the previous literature.

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