A Case Study on Information Presentation to Increase Awareness of Walking Exercise in Everyday Life

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Abstract

The advancement of technologies has led people to a sedentary lifestyle with a lack of physical activity. Consequently, preventing lifestyle-related disease is now a social issue. In this article, we propose an augmented mirror to increase the awareness of daily walking. The augmented mirror is a two-way mirror that displays symbols representing the number of steps walked on a daily basis. The mirror is designed with four strategies to reflect daily walking: 1) pleasurable interaction with the system through daily walking, 2) avoiding negative feelings while providing negative feedback, 3) increasing self-reflection of each day's walking, and 4) facilitating encouragement among a group of participants. The results of an in-house experiment show that our proposed system has the potential to increase awareness of a person's daily walking. The positive effects of the four strategies were also found.

Keywords: *Augmented Mirror, Persuasive Interface, Walking awareness, Artificial Life.*

1. Introduction

Today, the advancement of technologies such as communications and automation has created environments where people do not have to leave their homes and, in general, do very little or no physical activity. Consequently, this lack of physical activity means more people are likely to suffer lifestyle-related diseases. The treatment and prevention of these diseases have now become a social problem [17,20]. A pedometer, which is a device that counts a person’s steps per day in an unobtrusive manner, is used in this study to increase not only the awareness of daily activity but also the level of physical activity [2,25].

Technologies have advanced applications of the pedometer along two paths: network connectivity [21,28] and integration into a mobile phone [19]. By connecting a pedometer into one's PC, mobile phone or portable gaming terminal with wired or wireless communication, data can be stored, shared, analyzed, and presented in more persuasive ways than mere numbers. For example, graphs of recent trends, diagnostic messages based on the data, or displays of other people’s activities can be used to support individuals or encourage the interaction of groups of users [21]. In a gaming system, people also run applications, transfer data, and interpret complex presentation [28]. However, when people are busy or in a low motivational period, it may become a barrier to *use* any of the above systems. We consider this is an issue of usability of the system.

Integration into a mobile phone can increase awareness of an activity due to its “always-with” characteristic, especially if data is presented on the background screen (e.g., [19]). As Consolvo et al. reported in [4], a *glanceable display* with a stylized, aesthetic representation of physical activities and goal attainment successfully keeps the user focused on self-monitoring and his or her commitment to fitness. Although such a mobile phone-based service may provide instant access to information, it is not effective for those who rarely use mobile phones or do not keep them nearby. Because we consider it important for users to be comfortable with the information, this information should be delivered without explicit acquisition by the user and without forcing the acquisition. The suitability in daily life should be taken into account.

The design principle to address the issues in usability and the lack of chance of reflection is to adopt an ambient display technology [29] by embedding awareness elements into the information to be presented in a way that a user can easily understand the meaning. An ambient display is an information provision method that offers information while accounting for peripheral awareness capabilities; people can focus on their main tasks while feeling the presence of information. People will become aware of current status without requiring any action from them.

Another design principle includes injecting information acquisition process into people's daily activities. Here, we leverage a daily object as a medium of realizing an ambient display to acquire the information. Although ambient displays are getting attention as a medium for persuasion [14-16], they have not fully leveraged the metaphor or familiarity of existing daily objects, rather a new type of an object has been created or the metaphor of presented image itself is subject to investigation. Generally, a daily object is fitted into daily life. If the information is presented automatically on detection of the utilization of a daily object, a user can obtain useful information without changing his/her lifestyle. As a case study, we utilized a mirror for this purpose, where the information was superimposed with the appearance of a person staying in front of a mirror.

In this study, we performed an empirical study on increasing self-awareness of daily walking, and thus increasing physical activity, through an augmented mirror. The augmented mirror is a two-way mirror that shows not only the participant's appearance but also a set of symbols that represent the daily amount and relative increase of steps walked. Participants were asked to walk 8,000 steps per day, as measured by the pedometer. The design rationale of the system and the result of in-house evaluations by the participants are presented. In the remainder of this article, Section 2 gives the reasons for augmenting a mirror. The design of the information presentation and a prototype implementation are described in Section 3. In-house experiments are presented in Section 4, followed by a discussion of the design and implications. Finally, Section 5 concludes the article.

2. Increasing awareness with an augmented mirror

Humans have utilized mirrors since prehistoric times [12]. By looking at a mirror, one can see his or her physical appearance. When a person positions himself in front of a mirror, he may decide to modify his behavior upon noticing and understanding an unwanted or unknown situation. This could be explained by the psychological notion of "objective self-awareness" [7]. Objective self-awareness is a state in which an individual's consciousness is directed toward the self, and the individual is able to evaluate his or her current self-conception against an internal standard of correctness; In this state, one feels tension and discomfort when there is a clear, negative discrepancy and tries to avoid self-focusing stimuli or to reduce the discrepancy through changing an attitude or action. Conversely, when perceiving a positive discrepancy, the individual feels pleasure and happiness and tries to pursue the stimuli.

In the physical world, the mirror acts as a self-focusing stimulus and facilitates objective self-awareness.

We believe that information presented on the mirror surface can enhance objective self-awareness. This conclusion came from an assertion made by Pinhanez et al. in the context of a frameless display, which states, "positioning information near an object causes immediate, strong associations between the two" [23]. Although their frameless display projected digital information on or near a physical object**,** we extend this idea to include information superimposed on the surface of a mirror because both the information that represents one's activity and the user's appearance would coexist on the same surface. People do not have to carry out any additional action to get information and do not have to change their patterns of mobile phone usage. Their daily activity is input to a mirror (or a system), and the mirror affects the activities of people through its presence augmented with awareness information.

3. Walking awareness system

3.1. Designing information presentation

We specified four strategies to increase the awareness of walking: 1) pleasurable interaction with information obtained through daily activity, 2) avoiding negative feelings while providing negative feedback, 3) increasing self-reflection of each day's walking, and 4) facilitating encouragement among a group of participants. In the following subsections, each strategy is explained in more detail.

3.1.1. Pleasurable interaction: People continue to interact with things if they find something pleasurable as well as effective for attaining the original purpose [18]. In our earlier work [11], we obtained feedback from a user of an augmented mirror that supports morning decision-making; the participant enjoyed predicting what image would appear the next day based on the image viewed on the present day. So, we consider an appropriate level of unpredictability as a source of pleasure. Unpredictability attracts people to the display and can become a trigger to increase awareness of their health. Additionally, we apply a life-like metaphor of presentation to allow a user to project his/her activity. Such a metaphor is a popular representation in persuasive technology, e.g., growing fish [15,16] or a tree [14], where a user is basically passively presented information. Furthermore, we introduced explicit interaction with the augmented mirror: the user can use a mouse click (or a touch if a touch-based interface is available) to interfere with the flock and observe the process of re-organization. This adds an element of fun while enabling the user to reflect on the daily achievements.

3.1.2. Positive and negative feedback: The second strategy implies that feedback is given regardless of the appropriateness of the current activity. We decided to apply both positive and negative reinforcement based on the theory of *objective self-awareness*, which suggests a negative discrepancy is also effective in changing an attitude or action, as described in Section 2. Drawing a realistic character, e.g., bird, might allow people to have intimate feelings and become more aware of the states; however, people with low motivation tend to refuse the system when characters do not grow or die, rather than watch their unhappy appearance [15]. To give feedback on daily walking, we decided to use an abstract symbol, which we chose to be a triangle, which changes its shape according to the data collected by the pedometer.

3.1.3. Increasing daily self-reflection: Existing work basically employs the persuasive feedback with instant and/or accumulated information of interest [14-16], and the potential of discrete history, e.g. day-by-day results, has not yet been explored. We consider that not only the accumulated history for a specific period of time but also the day-by-day history helps a person to increase awareness. Therefore, we present both. The accumulated history provides a clue to reflect on his/her longer-term past performance. However, the day-by-day history provides immediate feedback of the daily walking activity.

Here, three types of day-by-day history indicators are introduced: 1) the actual number of steps per day, 2) an accomplishment flag for a fixed number of steps and 3) a comparison between consecutive days. The first feedback is straightforward in that it just presents the day's achievement, whereas the second one indicates whether a user walked beyond the daily goal. In this study, we stress commitment to a goal and its attainability to maintain motivation. The number set for the daily goal was 8,000. Although more than 10,000 steps per day are recommended to maintain health, it is not easy to reach that number through routine daily activities [3]. With the third feedback, a user would feel satisfied at a minimal degree, even though the goal was not achieved, if the current day's result was better than that of the preceding day. In contrast, a bad result should make the participant recall that day's activity compared with the day before. We believe that the daily result helps the user to develop a strategy for achieving a better result on the upcoming day.

To realize the first and the third strategies, we used flocking symbols that represent the day-by-day history of walking for seven days or more. Here, the symbol corresponds to the achievement of a day and moves autonomously on the screen following Boids algorithm of flocking [24]. As a result of local decision-making based on the neighboring symbols, a wide variety of flock forms emerge; that is, unpredictable behavior can result.

3.1.4. Inter-personal engagementEncouragement among a group of people: Fogg states that a technology allowing other people to be virtually present is able to motivate its users to perform a target behavior [8], based on the social facilitation theory [30]. For such inter-personal encouragement, flocks for a group of users are presented in the same display, and members in different flocks try to avoid collisions if they come too close. In this study, a group is identified by color. Additionally, the concept that a mirror is basically a shared object facilitates another form of inter-personal encouragement. That is, people can then talk about the presented information in a face-to-face manner, which increases the awareness of daily walking exercise.

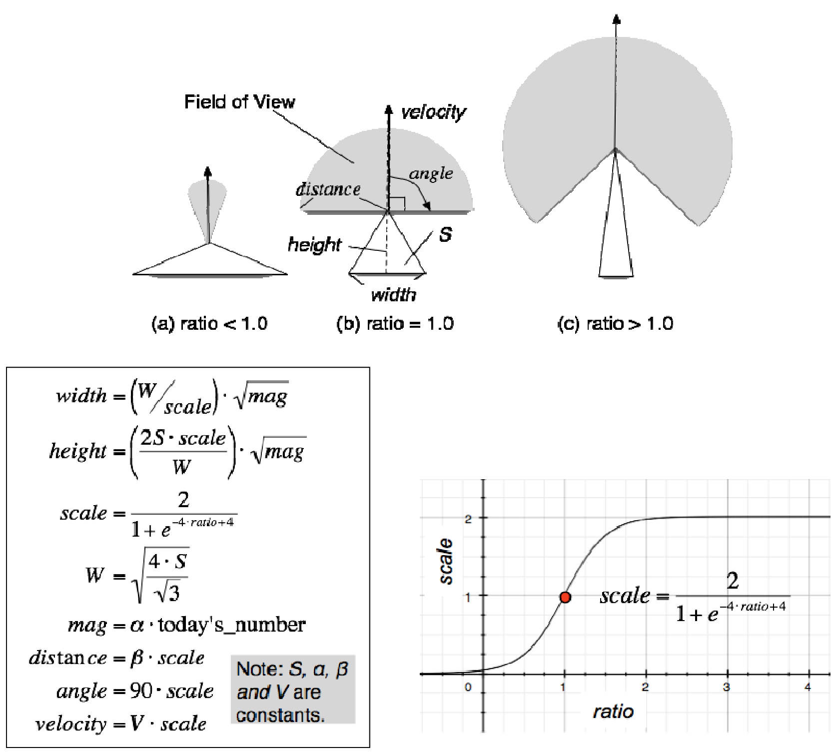
3.2. Mapping daily walkingthe activity into the appearance and behavior of a *poid*presentation

Mapping a person's level of activity of a day into a persuasive-boid (called "*poid*" in this study) is the most relevant task for making the information comprehensive, credible, and thus persuasive. However, we designed the presentation so that it does not allow a person to quickly understand it; instead, the presentation gives the person time to think seriously about it. Since this could pose multiple interpretations, this design sounds inconsistent with the previous requirement of *comprehension*. However, as Sengers et al. argue [26], posing ambiguity while supporting a space of interpretation around a topic, e.g., healthy lifestyle, encourages a person to relate the presentation to his or her life, which would support reflection.

We designed Tthe appearance, i.e., the shape, size, and behavior of an individual character, were designed to reflect the healthiness of one's body. The appearance is controlled by the ratio of the number of a specific day to the nearest preceding day. We tried to represent the appearance of a person who is doing more walking and thus is active: more walking makes a person thinner and allows that person to move more quickly. So, we considered size and speed as a mapping rule that is easy for users to accept.

A triangle shape was used to clearly indicate the moving direction, especially in comparison with a rectangle or a circle. The width of the triangle varies according to the ratio of a day to the preceding day. The more a person walks compared to the nearest preceding day, the sharper the shape becomes. Figure 1 illustrates three types of *poids* with a (a) lower, (b) equal and (c) higher ratio, where the field of view of a *poid* is also shown (the dark fan-like area). The definitions of the controlling parameters are shown in (d).

As can be seen in (d), the width and height of a triangle are actually controlled by the *scale* variable that is represented by a sigmoid function (e). The reason for applying a sigmoid function is that 1) it can specify the lower and the upper bounds by saturation with a single function, and 2) it can emphasize the difference around 1.0. The upper bound is especially required to avoid a too tall triangle that is difficult to draw in a limited display area. The emphasis around 1.0 is effective for giving noticeable feedback to those who did a little more or less walking than in the nearest preceding day. Especially, a person who walked more would feel happy with such a small but steady achievement.



(d) the definitions of controlling parameters (e) a sigmoid function to obtain 'scale' variable

Figure 1. The shape and the field of view of a *poid* with the controlling parameters.

The variable *mag* that appears in the definition of *width* and *height* indicates the magnification ratio of the body of a *poid*. This was introduced to meet users' requests at an early stage of an empirical study. Those users wanted to see the absolute result as well as the relative one because they had felt discouraged to see a flat triangle when they could not walk more than the day before, but the number of steps actually had been large, for example, 20,000. Hence, the number of steps is reflected by the size of the body: a large body represents a large number of steps.

Figure 2 shows an example snapshot of *poids* that represent a person's walking results for one week. Here, the date is put near the poid to help the person recall the activity of the day. The ratios of "yesterday" and "the day before yesterday" are presented in a relative manner, like "kinou" and "ototoi" (indicating the two dates in Japanese), rather than a direct date expression. This helps a person find the latest results quickly. The feedback for reaching the goal of a day is provided by a blinking color of the body (see *poids* for 23, 24 and 25 April in Figure 2). An example application of the *mag* variable is shown by shape of the *poid* for 24 April. This day is represented as an obtuse triangle, which means the number of steps on April 24 was less than that on 23 April (ratio < 1), but the actual number was large (10,000).

The field of view of a *poid* is also a function of the ratio. The behavior of a *poid* is determined by the perception of a small neighborhood. Here, the view defined by *distance* and range (*angle*) gets longer and wider when the ratio is high. So, a *poid* can find members in the same group that are advantageous to approach as well as obstacles, i.e., other group members to avoid (see *poids* for 20 to 23 and 25 April in Figure 2). Meanwhile, a *poid* with a short and narrow view tends to be isolated (see *poids* for 24 and 26 April). Finally, the *velocity* is proportional to the ratio, which allows a *poid* with a high exercise ratio to move faster.

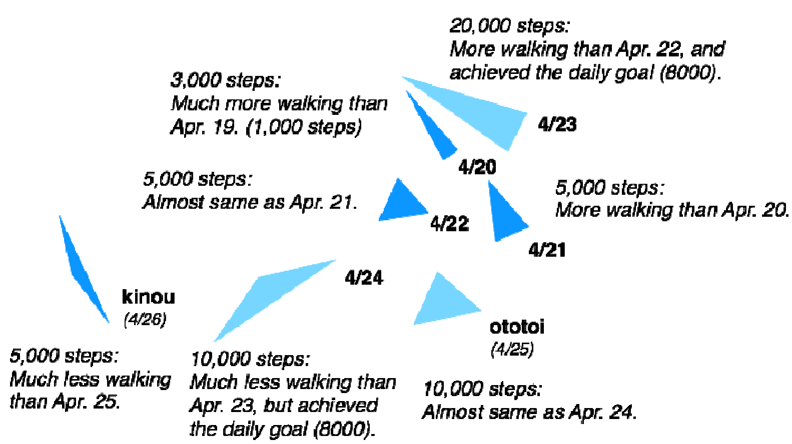


Figure 2. An example snapshot of poids for one person with interpretations. Only triangles and their date annotations are actually drawn.

3.3. Prototype system implementation

An augmented mirror was developed by attaching a glass two-way mirror board on an ordinary computer monitor, as was done in our previous project [10]. The image and/or text displayed behind the mirror can be seen through the panel, while physical objects (people in this study) in front of it are reflected, as in an ordinary mirror. The two-way mirror is a translucent panel that reflects light from the brighter side when the light intensity difference between the two sides of the panel is significant. Therefore, bright colors projected onto the panel from behind can be seen from the front, while the reflection of an object placed in front of the panel is seen in the dark areas behind the panel. Figure 3 shows the prototype system. A 17- or 19-inch ordinal LCD display is connected to the control PC. Attached to the PC is a glass two-way mirror board with an 8% light transmission ratio. The screen resolution is set to SXGA (1280 x 1024 pixels).

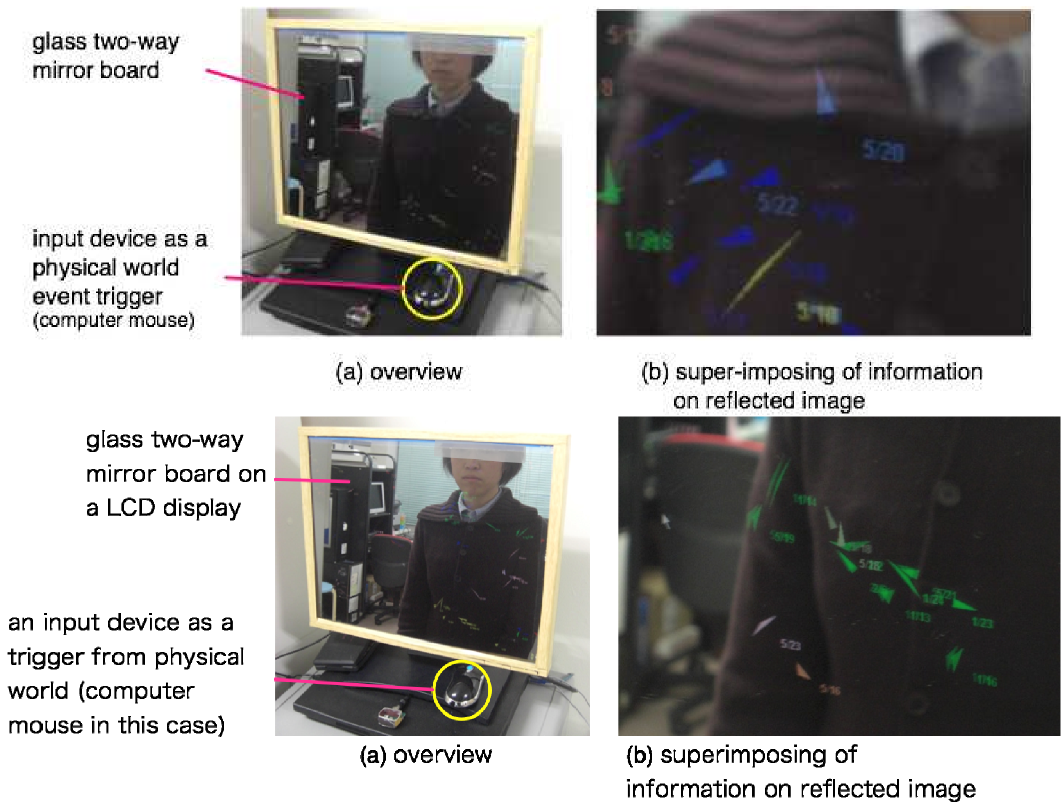


Figure 3. Appearance of the prototype system and superimposed image of reflected image with digital information.

A simulation using a video camera and image-processing techniques can also serve as an augmented mirror with superimposing [1,13]. The simulation allows flexible mixing of a person's image and processing of the captured image. However, when considering screen resolution and real-time image rendering, along with the need to make images of the observed world consistent with the viewer's position, making a "virtual" mirror that is realistic enough for actual use is difficult [9].

Figure 4 shows the architecture and processing flow of the prototype system. A user wears a commercially available pedometer and manually reports the number of steps of a day into an e-mail client. To reduce the user's burden of data registration, the data can be transferred electronically using wireless (e.g., Bluetooth) or wired (e.g., USB) communication. However, at the time of developing the system (January 2008), no product was known that provided a developer with an application programming interface (API) on the receiver's side. Also, a pedometer application running on a mobile phone was not popular. Therefore, we decided to take the manual registration approach.

The display system consists of three major components: user data management, calculation, and rendering components. The user data management component accesses a dedicated e-mail server (POP3 server) managed by an Internet Service Provider (ISP) and fetches messages from members in the same group every 5 minutes. Here, a group can include a user at a remote site. The reason for utilizing an e-mail infrastructure is that it is simple, common, and often freely available, and the network policy at a user's home does not need to change. Additionally, we do not need to operate a web service on our infrastructure. The user can also register the data using the e-mail service of a mobile phone. Once a new datum is found, the calculation component calculates the *poid*'s controlling parameters by using the data of the nearest preceding day. The controlling parameters include the distance and angle for controlling the field of view, the width and height of the triangle body, and the velocity of movement. Then, the calculation component requests the rendering component to generate a new *poid* on the screen. The rendering component controls the number of *poids* per user based on the maximum number and duration. If the number exceeds the maximum number, which was seven (one week) in this experiment, the oldest *poid* is removed. Even if the max number has not been reached, a *poid* that is older than seven days is also removed. The rendering component updates the *poids*' images at a specified time slice (10 [Hz] in this prototyping). Furthermore, the rendering component handles external stimuli. As mentioned in Section 3.1.1, we introduced an interaction mechanism with the augmented mirror of physical world events by using a computer mouse. Once a user clicks at any position on the screen, flocks of *poids* are broken and soon start organizing. Since the rendering component is separated from the application logic for walking awareness, a new information source and an external input devices, for examplee.g., blowing and tapping,, are easily adopted.

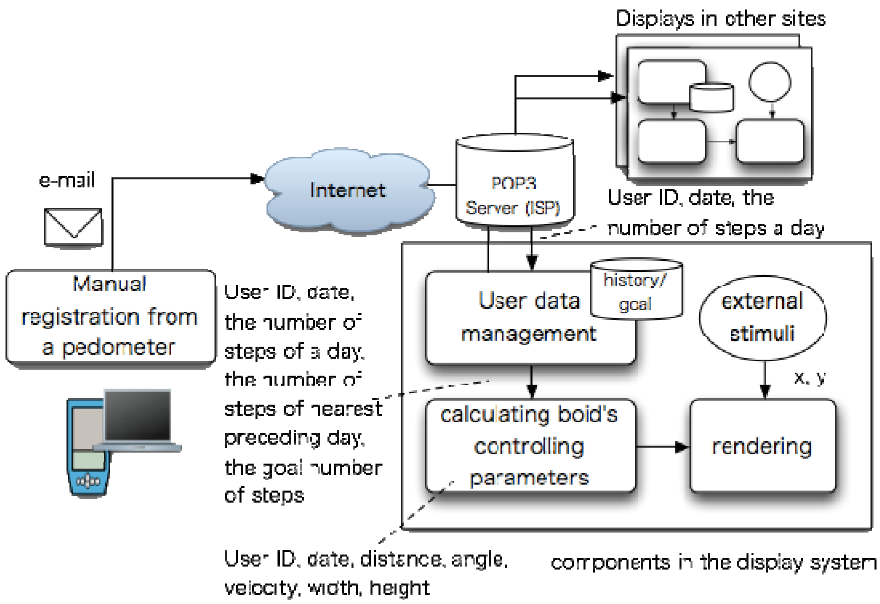


Figure 4. System architecture

4. Empirical study

In-house experiments were conducted to investigate the validity of the proposed approach.

4.1 Methodologies

The participants were asked to wear a pedometer (TANITA FB720 [27]) all day and to register the daily results manually. The daily goal was specified as more than 8,000 steps, based on the participant's preference. (To maintain health, the recommendation is more than 10,000 steps per day, but we found that this was not an easy goal for all of the participants.) The systems were deployed in two homes (H1 and H2) and in our laboratory. Eight people (four males and four females) participated. The ages ranged from 22 to 72 years old, but most were in their 30s. Seven participants used the system for approximately three months, although one person participated in the experiment for six months. One participant living in H2 is a member of the family living in H1. So, the systems were connected via the Internet for inter-personal encouragement.

The mirrors were installed outside the lavatory to avoid damaging machines by dew condensation. The alternative placement was decided based on the preferences of the participants. They were 1) on a cabinet in the living room (H1), 2) on the shoe cupboard in the entrance (H2), and 3) on the refrigerator in the laboratory. To let the participants get used to the pedometer and new mirror as well as to obtain a dataset for the control group, the participants were provided with a system with an ordinary mirror for one week before the receiving the fully functional version.

4.2 Quantitative results from pedometer data

Figure 5 shows the average number of steps for six of eight participants before and after using the system in the poid-based presentation. In a *t-test* examination, only the result of participant YS showed a statistically significant difference ($p=0.00000064<0.01$) in the number of steps after using the system. We consider that this result does not mean our approach failed. It is actually difficult to assess the net result of the approach only in a quantitative manner since various factors affect people's motivation, for example, TV advertisements, organizational dietary campaigns, etc. Further exploration of the evaluation methodology is the subject of future work.

4.3 Qualitative results from the participants' interview and reflection on design

The subjective comments obtained from interviews and hand-written memos are summarized in Table 1.

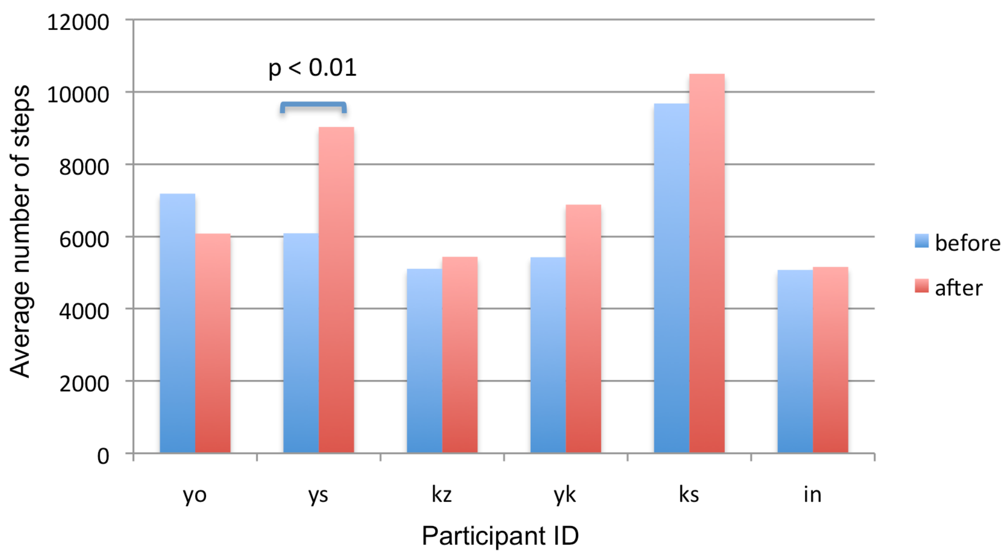


Figure 5. The average number of steps before and after the presentation (six of eight participants).

Table 1. Summary of subjective comments. Note that similar comments from different participants were merged into one

No.	Comments
C1	*I became aware of daily walking.*
C2	*I like to see the process of emerging and collapsing a flock. I had a feeling of growing them.*
C3	*I wanted to see the result soon when I realized that I had walked more than the day before.*
C4	*I hope I would be a person with prompt action. I don't like slow-moving. So, I paid attention to make my flock a "beautiful" one.*
C5	*I basically stay at home, and it is almost impossible to walk 8,000 steps a day. But, I was happy when I had walked more than the day before because I was aware of my shortage of exercise and the increase was progress for me.*
C6	*I enjoyed talking with others who shared the poids presentation since I could understand their hobbies, thoughts, and so on.*
C7	*I was sad to see a poid with a "bad appearance" when I had walked for a long period of time.*
C8	*I was frustrated with the fact that the actual number of steps was not small, e.g., 10000, but the shape of the poid was flat and might give an impression to others that I had been idle just because the number of steps of the day before was larger.*
C9	*I was disappointed with the result when I realized I had exercised enough by bicycling.*
C10	*It was hard to see the superimposed information and my appearance reflected on the surface of a mirror. It was also hard when the body of a poid and the background had a similar color.*
C11	*I could not follow poids when they were moving fast.*
C12	*Reflecting activities from the appearance and behavior of poids was messy.*
C13	*I did not have enough time to comprehend information through the mirror (installed at the entrance).*
C14	*I took care of avoiding snacks between meals since I realized there were many small poids.*

4.3.1. Supporting daily reflection: As shown in Table 1, all eight participants became aware of their walking activity level (C1), which agree with those reported in [25]. An interesting fact is that one participant (KS) was the most active participant, although she had not been interested in walking exercise at all before the experiment (but had already been walking a lot every day, as shown in Figure 5). According to her, she sometimes spent a long time with the mouse-clicking interaction, because she enjoyed destroying the flocks and watching the re-organization process many times (C2). Emergent behaviors of *poids* such as chasing and skirmishing (or chatting) pleased the participants, including KS; they actually named these patterns and looked forward to seeing new ones. Also, KS talked to herself in the mirror and checked her appearance against the movement of her flock. At the same time, she thought about her health as well as other things that were too embarrassing to tell other people. The participant of the C4 comment (KS) likes prompt action and self-organization. So, she disliked the disordered flock with flat and isolated *poids*, e.g., she did not like the *poid* labeled "4/24" in Figure 2. Consequently, she intentionally walked more than or equal to the day before in order to generate a "beautiful" flock. We consider these user feedbacks of superimposing digital information on the surface of the mirror to be pleasurable interactions with a life-like metaphor and presentation on a day-by-day basis. Only KS explicitly made the abovementioned reflection on her past activities; however, this does not imply the other participants did not do so. They might make reflections in an implicit manner, which was hard to capture by the interview.

4.3.2. Daily reflection: The majority of the participants wanted to know what a new *poid* and a corresponding flock would look like, which was true especially on a day that a participant realized he/she had walked a lot (C3). Some participants intentionally walked more to see changes. For example, the participants at H1 (YS, KZ and YK) went further when they took their dog for a walk. They were pleased when they saw a blinking *poid*, i.e., the daily goal was achieved, and even a sharp *poid* that was not blinking. Participant YS significantly increased the level of activity after using the fully functional system.

Additionally, even slight increases satisfied housewife participant (C5 from KZ). This suggests that a blinking *poid* and enhancing daily results worked as positive feedbacks from the system, as in Section 3.1.2. In contrast, we did not observe comments on negative feedback in terms of a *single poid*; however, comment C4 from KS could be the result of negative feedback presented by a *flock of poids*. Here, a "beautiful" flock consists of *poids* with regular or acute triangle bodies that have enough field of view to find companions and the velocity to follow them. To "spawn" such a *poid*, the participants needed to keep the daily number of steps at the same level or continue to walk more than the day before, i.e., ratio ≥ 1.0. We consider KS made sense of the relationship between the appearance of a flock and daily walking throughout the experiment. Then, she made an effort to prevent her flock from having an appearance that could let her imagine undesired characteristics of herself. This implies the effect of a negative discrepancy of objective self-awareness of the mirror introduced in Section 2: she tried to reduce the discrepancy by paying attention to the number of daily steps and keeping them at the same number at a minimum. We consider this is also the effect of inter-personal encouragement in a group of participants realized by sharing one's display with others.

4.3.3. Inter-personal encouragement: We did not observe a competition-like behavior among the participants regarding daily achievement, because they knew it was useless. Instead, some active participants, such as KS, attempted to improve by themselves. However, one participant (IN), who often forgot to report the daily number, preferred the idea of gaming: that is, the right to change the background of the screen is given to a *winner* who is determined in a particular way.

We received comments on talking with others for both better and worse achievement (C6). The appearances and behaviors of the *poids* served as a trigger to start conversations, such as the participants explained what made a *poid* so sharp (flat) and large (small). Through the explanations, they might remember past activities. These discussions should increase the awareness of walking. A participant would not asked if the presentation described too many details about a person's activities, which suggests multiple interpretations facilitates inter-personal encouragement. The sense-making process caused by ambiguity causes one to think more, as Sengers et al. mentioned in [26].

4.3.4. Credibility on sensing: Comments C7 and C8, which were obtained at an early stage of the experiment, imply that the participants needed adequate rewards for their achievement. That is why the parameter *mag* (Figure 1-(d)) was introduced. Furthermore, one participant tended to regard the output of a pedometer as the result of net exercise (C9). Participant IN made this point because he mainly used a bike as transportation; so the actual number differed from what he had perceived as activity since a pedometer counts steps, not pedal revolutions. Even though he rode a bike for five hours, the number of steps was not high. We consider this is also related to the fact that IN often forgot to report the result, which indicates he might lose credibility when using the monitoring device, the *pedometer*, along with his expectation of the system. This issue was also pointed out by Consolvo et al. [5] as a design strategy for increasing credibility; they addressed this issue because they adopted a manual entry (and edit and delete) mechanism. The advancement of an experience sampling method (ESM) [6] as well as activity-sensing technologies would address this issue.

4.3.5. Visibility of information: C10 to C13 are negative comments regarding the usability of the information presentation system. C10 refers to the "invisibility" of both information and appearance, which could be improved by drawing in bright colors as well as using a two-way mirror board with a high light transmission ratio. Although the ratio of the board utilized in the prototype system was only 8%, as described in Section 3.3, there is a commercial product with a light transmission ratio of almost 100% [22], which could address the invisibility issue.

We consider that C13 resulted from inappropriate installation of the display; the participant at H2 (YO) complained that the placement of the mirror-based display in the entrance did not provide sufficient time to reflect on herself. This happens when people do not stop at the entrance. The entrance is usually a passing point to the outside or inside, and they just do "final checking" of their appearance before going outside. This implies the presentation should take into account the characteristics of the place so that the system works persuasively.

4.3.6. Physicality of *poids*: Through the experiment, we found a need for considering the physical dimensions in the *poids* animation. The physical dimensions include the velocity of a *poid* [cm/sec], the size of a *poid*, text [cm^2], and screen area [cm^2]. As described in Section 3.2, the behavior (movement) of *poids* was designed to increase awareness of the daily exercise level of the user; however, this can cause a problem in identifying the *poid* of a particular day. This was reported by an older couple in H1 (YS and KZ), who have decreased eyesight due to age; they had difficulties in reading the date annotation and understanding the achievement of a day (C11). Therefore, the size of the body of a *poid* and text as well as the velocity of movement needs to be adapted to the characteristic of the users' eyes.

The screen area determines the maximum number of *poids* per user and that of users in one display, which allows the *poids* to form stable flocks. In a laboratory environment, we increased the number of *poids* per participant from 7 to 14 (two weeks) for four people. A total of 56 (=14x4) *poids* reduced the area that works as a mirror. Also, such a large number of *poids* increased the possibility of encountering *poids* in different groups and increased the frequency of avoidance behavior, which made it difficult to form a flock: the *poids* looked like moving randomly. Thus, it is important to take into account the physicality of *poids even though they live* in the cyber world.

4.3.7. Side effects of the presentation: An interesting feedback was C14. This participant took an action that made him totally healthy, e.g., avoiding sweets, even though he was too busy to walk more than the specific goal. This is because he noticed the small number of steps in a recent week at a glance of the display. Considering the final goal of walking exercise, *healthiness*, the system was successful for him.

Another curious effect is that the family at H1 bought a pedometer for their dog and presented its *poids* on the same surface. They enjoyed sharing time and space even in a cyber world, which could contribute to their *mental* health.

5. Conclusion

In this article, we described a case study on information presentation to increase awareness of daily walking exercises. The motivation of work is to provide people with an environment in which they are aware of their health state without explicit utilization of a system. We selected a mirror as a display to presentTherefore, we augmented a mirror with the history of daily walking results based on psychological phenomena. Also, to maintain the attention of people, we introduced an aspect of pleasure by presenting animated *poids* that display unexpected behavior. The design and implementation of a prototype system was presented.

We conducted experimentsAn empirical study was conducted to see if the concept is acceptable and to explore further requirements of the system. The experimental results were analyzed both quantitatively and qualitatively, which impliesy that the presentation could provide a person with an opportunity to notice his/her level of daily walking exercise. Especially, the reflective characteristic of the augmented mirror suggests the potential for a person to watch him/herself from a third-person perspective, which would help this person to notice his/her current habit of exercise and improve it if it is not appropriate. Additionally, some design issues were presented, which would be addressed in order to enhance the power of “awareness” of the system.

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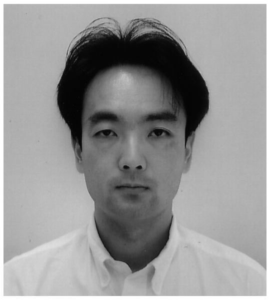

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