Objects for Change: A Case Study of a Tangible User Interface for Behavior Change

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TEI '15, Jan 16-19 2015, Stanford, CA, USA
ACM 978-1-4503-3305-4/15/01.
http://dx.doi.org/10.1145/2677199.2687906

Abstract
We present Objects for Change (OFC), a set of design considerations based on established behavior change techniques that can serve designers of Tangible User Interfaces (TUI). We highlight empirical findings from behavior change literature, and show how to apply them to inherent TUI properties: (1) visibility and persistency, (2) locality, (3) tangible representation, and (4) affordances. We demonstrate how we applied OFC in the design of a TUI prototype aimed to promote behavior change in planning and organization tasks among youth diagnosed with ADHD.

Author Keywords
Tangible user interfaces; persuasive technologies; behavior change; design guidelines.

ACM Classification Keywords
H.5.2. User Interfaces: Interaction styles, Theory and methods.

Introduction
Our work strives to highlight best practices from the behavior change research community in a way that will aid the TUI community in the design of effective tangible technologies for changing behavior. We review relevant findings from behavior change literature, and

provide a practical set of design considerations for Tangible User Interface (TUI) design. We demonstrate how we utilize these design considerations in the design process of TangiPlan [17], a TUI designed to assist youth diagnosed with Attention Deficit Hyperactivity Disorder (ADHD) in their daily planning and organization tasks.

Related Work

Recent large-scale systematic reviews identified three techniques as particularly effective for achieving behavior change: goal-setting, providing feedback on performance, and self-monitoring [1, 8].

- Goal-setting: Setting a specific goal results in greater effort and performance, compared to not setting a goal or generally urging people to "do their best" [7].
- Providing feedback on performance: This technique involves providing individuals with data about their own behavior or commenting on their behavioral performance, for example identifying a discrepancy between performance and a set goal [9].
- Self-monitoring: This technique refers to keeping a record of a specified behavior to increase awareness of this behavior and the circumstances that precipitate or surround it [2]. Self-monitoring is effective because it encourages the individual to develop a sense of accountability and heightens self-awareness. Even though the accuracy of reporting is often poor, accuracy does not appear to be as important as focusing attention on the behavior [15]. Heightened attention leads the individual to reconsider, and possibly change the monitored behavior [13].

Persuasive technologies are technologies designed to support behavior change in everyday life, and are often based on general behavior change theories and findings. Researchers have been developing frameworks and guidelines to adapt effective behavior change techniques to match computing specificities [12, 13].

The Objects for Change Design Considerations

In this section we apply the key findings from the behavior change literature to TUI design, based on four TUI properties.

Visibility and persistency

Tangible interfaces are physical objects, persistent and visible, and as such become an integrated part of our environment, a constant entity in our daily rituals. They are usually single-purpose, and are constantly visible even when turned off or inactive. Therefore, they can serve as a constant reminder of the task they represent. Prior findings from behavior change literature showed that reminders have positive behavioral outcomes [3]. Usually, reminders are textual in nature. Users must specifically attend to them, which could potentially interrupt ongoing activities. In contrast, TUIs serve as non-textual reminders, constantly present in the visual field. This type of reminders was found to be effective as well [6]. TUI's properties of visibility and persistency should be enhanced by design, leveraging their potential to seamlessly integrate into daily rituals and act as constant reminders of behavior change tasks.

Locality
Tangible objects are associated with a specific physical location, and that location has a certain context, to the task itself and to the user's daily rituals. This could potentially facilitate behavior change, because location has been shown to enhance cognitive processes. Memory is known to be location-dependent, it is easier to recall information in the same location where it was first learned than in a different location [16]. Similarly, learning can be specific to the location in which it occurred [10]. Thus, the object's location can serve a purpose, and may increase relevancy and awareness. Indeed, initial evaluations of location-based persuasive technologies found location to be a valuable addition to the system. For example, Vertoid [18] is a mobile application that investigates the potential of contextualized mobile cues for persuading users to lead a more environmentally-friendly lifestyle. A user study revealed that cues were quite successful when they concerned short, immediate actions performed with objects close to the user. TUI's location-dependent property should be leveraged by designers, creating context and purpose by connecting the TUI location with task location, and promoting short, immediate interactions.

Tangible representation
Persuasive technologies implementing feedback on performance were found to facilitate a desired behavioral change [19]. TUI by definition provides tangible representation to digital information [5]. Thus, TUI can leverage various mediums to provide feedback to users, including physical form, physical movement, light-based visual feedback, and sound, to name a few. TUIs tangible representation could be leveraged to present real-time feedback on performance and progress towards a set goal. The tangible representation could leverage multisensory communication channels, and can help present abstract concepts related to certain behavior change goals in a concrete way.

Affordances
As previously discussed in the review of behavior change literature, self-monitoring is effective because it encourages the individual to develop a sense of accountability and heightens self-awareness [2, 9]. Intuitive TUI affordances could contribute to accountability and self-awareness. However, affordances do not guarantee intuitive interaction. Gaver [4] argues that affordance of an object refers to attributes of both the object and the actor. When affordances are perceptible, they offer a direct link between perception and action. On the other hand, hidden affordances and false affordances lead to mistakes. Gaver emphasizes that affordances are not passively perceived but actively explored.

Affordances are only the first step; leading users towards reflection is the main goal when behavior change is concerned. Reflection leads the individual to reconsider and possibly change behaviors [13]. Norman has differentiated between experiential cognition and reflective cognition [11]. In the experiential cognition mode we perceive and react efficiently and effortlessly, the mode of skilled activity that is conducted fluently without thinking. The reflective mode is a process of comparison and contrast; it requires thought, effort, time, and decision-making. Rogers and Muller [14] introduced the concept of transforms, how a user's experience shifts from perceiving to understanding to reflecting. They suggest two techniques, uncertainty

Figure 1. The TangiPlan prototype consists of a set of objects that represent routine morning tasks, which are spread around the house in locations relevant to a target task. Each object communicates with a central server and offers a visual representation of the time allocated to the corresponding task. Each object also gives real-time feedback of the gradual count-down of time left to complete the task.

and unexpectedness, that can trigger high levels of perception, understanding, and reflection.

TUI affordances could be leveraged to lead users in a gradual way from perception to reflection, in a mixed process of experiential and reflective modes of cognition. Designers must remember that mere usage is not the goal. When behavior change is concerned, the goal is reflection that leads to accountability and self-awareness; which eventually leads to behavior change.

In sum, in order to utilize best practices from behavior change research, we recommend on the following considerations for designers of persuasive TUIs:

1. Leverage TUI's visibility and persistency properties as a constant reminder of the desired change in behavior. Keep the TUI single-purpose and not multi-purpose, design it to be meaningful also when inactive, design it to become an integrated part of daily rituals.

2. Leverage TUI's locality property to enhance context and purpose of the desired change in behavior. Design the TUI to be associated with a daily task that is relevant to the target behavior in order to increase relevancy and awareness. Design the TUI to leverage people's location-dependent memory for easier learning and recall. Take advantage of the TUI integration to daily rituals and design short and immediate interactions that do not require prolong attention or complex cognitive processes.

3. Leverage TUI's property of tangible representation to provide feedback-on-performance and progress towards a goal. Design the TUI to provide real time and meaningful feedback of the goal and the progress towards the goal. Strive to present abstract behavior change concepts in a more concrete and relevant way.

4. Leverage the potential in TUI's affordances. Design effective and sequential affordances, mix experiential and reflective cognition, design transforms that shift a user's experience from perception to reflection. Leverage the effectiveness of self-monitoring and design the TUI to lead users to increased self-awareness and accountability that will hopefully lead to behavior change.

The TangiPlan Prototype Design

TangiPlan [17] is a TUI prototype designed as an assistive technology to help youth with ADHD in planning and organization tasks, specifically during their morning routine (see Figure 1). The design process included interviews with clinicians treating children with ADHD, parents, and children diagnosed with ADHD (see Side Bar on the next page).

OFC design considerations in TangiPlan

Visibility and persistency: TangiPlan objects serve as physical reminders for teen users to perform morning tasks and to keep time in mind. The objects are visible to the user during the morning routine and in various occasions during the day, and become a constant reminder of the desired change in behavior. The objects are single-purpose, each representing one sub-task during the overall morning routine. TangiPlan objects are visible even when not active, constantly reminding the user about the task they represent.

Interview insights from TangiPlan design process

Interviews with clinicians treating children with ADHD [17] revealed a challenge concerning lack of efficiency in maintaining daily routines. The intervention strategies experts offer are: (1) Plan a daily schedule and allocate time for each activity. (2) Separate complicated tasks into smaller ones. (3) Write to-do lists and reminders. (4) Ask for assistance from caregivers. (5) Use a stop-watch to track completion time.

Interviews with parents revealed lack of efficiency in children's ability to follow daily routines, especially in the morning routine.

Interviews with children [17] revealed they tried writing notes but found it tedious, and they tried setting reminders and timers but perceived those smartphone-based techniques as annoying or as a potential distraction due to smartphones multi-purpose nature.

Locality: Each TangiPlan object is placed by the user at a specific location associated with a specific task. Context and purpose are formed by the user's decision where exactly to place the TUI, for example during a paper prototype evaluation a user placed an object representing the "brushing teeth" task near the sink in the bathroom [17]. The specific location and association with the task increases relevancy and awareness. The repetitive process users go through of associating tasks with objects and then with specific locations enhances task-location coupling and leverages location-dependent memory.

Tangible Representation: The abstract concept of time is represented based on an hourglass metaphor, using a vertical column of LED lights that gradually dim off in a sequential process. The user sets the target goal for each task, and the goal is represented using the number of LEDs that are lit in a specific object, before the user activates the object (the "allocated time per task"). Feedback on performance towards the goal is represented after the user activates the object, using the gradual vertical "countdown" of the lights. Real time feedback is provided using LEDs, and the feedback is in context of the task completion process itself (e.g., brushing teeth) but does not require focused attention by the user, peripheral attention is enough to notice the performance level compared with the desired goal.

Affordances: a TangiPlan object is designed with sequential and perceptible affordances [4]. The object's shape is of a truncated square pyramid, directing attention towards the vertical line of LEDs at the front side of the object. The real-time "countdown" of the lights leverages vertical motion as an additional mean to enhance focus on task completion. The design promotes a shift from experiential to reflective mode of cognition using the light's progress towards the goal, as the user has to assess her current rate of progress with the time left to complete a task. A transform is leveraged using the unexpectedness technique [14], when a goal has not been reached the lights are starting to progress upwards as red-colored light instead of the standard downward movement of green-colored light. Self-monitoring is utilized using the real-time feedback on performance and the on-going tracking of one's performance. Accountability is utilized by allowing the user to choose her own tasks and her own goals. Self-awareness is addressed using the overall integration of TangiPlan objects into the daily ritual of morning organization.

Conclusion and Future Work

We presented the Objects for Change design considerations in an effort to aid the TUI community in the design of effective tangible technologies for changing behavior. We showed how we applied those guidelines in the design of the TangiPlan prototype. Further work is needed to evaluate the effectiveness of the OFC design considerations and the TangiPlan prototype as an assistive technology.

Acknowledgements

We would like to thank Ayelet Gal-Oz and the TangiPlan team for their valuable insights regarding this work. This research was supported by the I-CORE Program of the Planning and Budgeting Committee and The Israel Science Foundation (grant no. 1716/12).

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