Crafting Animated Parables: An Embodied Approach to Representing Lifestyle Behaviors for Reflection

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Kenny K. N. Chow is an Associate Professor in the School of Design at The Hong Kong Polytechnic University. Chow received a Ph.D. in Digital Media from Georgia Institute of Technology U.S.A., an M.F.A. from the City University of Hong Kong, an M.Sc. and a B.Sc. from the University of Hong Kong. He is interested in "Animation as Experience" - the influences of "lively" artifacts, interfaces, or environments enabled by technology on individuals' imagination, emotion, reflection, and behaviors. He is the author of *Animation, Embodiment, and Digital Media: Human Experience of Technological Liveliness* published by Palgrave Macmillan. It integrates embodied cognition ideas from cognitive science with interpretative approaches to digital media, discussing how today's animated interface phenomena transform the ways we think, feel, and play. Before joining the academia, Chow had extensive work experience in film, animation, broadcast, and multimedia productions.

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Related work in personal informatics, gamification, and feedback suggests that visualizing behavioral data for daily reflection should consider dynamic representations in metaphorical visual narratives with positively or negatively valued outcomes blended in daily life. The causal link between a behavior and its virtual outcomes should be easy to understand. Grounded in embodied cognition, this article proposes a framework guiding the generation of animated parables to meet the above criteria. The guidelines include metaphorical mapping and blending the behavior with a direct cause-effect scenario with similarities in embodied experiences. Application of the guidelines in a series of design workshops generates 47 parables. To evaluate the parables, metrics include naturalness of integrating with life routines, aesthetics of blending into environments, and ease of interpreting the causality. Evaluation results show that more embodied mapping and blending are more likely to result in understandable behavior-outcome links. Designers can follow the guidelines and metrics to generate and compare ideas. Recommendations for crafting better parables are also provided.

Keywords: personal informatics; data visualization; gamification for behavior change; conceptual metaphor; conceptual blending

1. Introduction

As technologies have been increasingly integrated into every facet of daily life, more data are generated, extracted, and aggregated around individuals' behaviors via various sources, such as electronic payment systems, IoT (Internet of Things) products, surveillance cameras, and the so-called "data exhaust" (Zuboff, 2015). Some of these systems present aggregated information back to individual users in typical data visualization, such as various bar charts shown in the latest iOS on the iPhone about the user's daily and weekly screen time (in hours and minutes) spent on different mobile applications (apps). Such visualizations require deliberate reading and are not effective

for daily review, because people do not always act like rational data analysts (Rooksby, Rost, Morrison, & Chalmers, 2014), not to mention those who are not data-savvy (Wilson, Bhamra, & Lilley, 2015). General users prefer an "emotional link" to the data and an "impressionistic image" of the information, in other words, a representation of one's lifestyle in an intuitive metaphor (Rapp & Cena, 2016). Early HCI studies have explored representing lifestyle behavioral data in a figurative way for users' reflection, such as *Fish'n'Steps* (Lin, Mamykina, Lindtner, Delajoux, & Strub, 2006), *UbiFit* (Consolvo et al., 2008), *UbiGreen* (Froehlich et al., 2009), *Playful Bottle* (Chiu et al., 2009), and *Eco-island* (Shiraishi et al., 2009). These representations typically map values of tracked data to states of on-screen virtual items like fish, flowers, trees, a garden, or an island. Findings from these studies with longitudinal field trials (from 3 weeks to 3 months) support positive correlation between virtual outcomes and participants' emotional attachment. Using virtual environments and items to show "metaphorical" outcomes of behaviors is commonly regarded as a means to complement typical data visualization (Chow, Leong, & Lee, 2018; Consolvo, Klasnja, McDonald, & Landay, 2014; Froehlich et al., 2012; Lane et al., 2014; Pinske, Weyers, Luther, & Stevens, 2012; Reitberger, Spreicer, & Fitzpatrick, 2014).

Using virtual outcomes in motivating behaviors needs to consider causality. If the causality between a behavior and its virtual outcome is difficult to understand, users see the virtual items like typical game elements (e.g., badges, rewards), which can be too extrinsic (He, Greenberg, & Huang, 2014; Laschke & Hassenzahl, 2011; Rapp, 2017a; Zuckerman & Gal-Oz, 2014). For instance, why do the fish (in Fish'n'Steps) grow when the user walks more? There are probably some cause-effect links (e.g., maybe walking to collect food for the fish), yet they are too indirect to users. The indirectness separates the virtual outcome from the behavior, rendering it like

"externally imposed," which undermines intrinsic motivation (Ryan & Deci, 2000). Conversely, if the behavior is experientially similar to the cause of the virtual outcome, the embodied cognition thesis (Lakoff & Johnson, 1999) holds that regular co-occurrence helps conceptualize the virtual outcome as part of the behavioral consequence. As informed by behavioral theories (Ajzen, 1991; Fishbein & Ajzen, 1975), favorable (or unfavorable) evaluation of the virtual outcome enhances (or reduces) the behavioral intention. Hence, virtual outcomes (positive or negative) should have their causes comparable to the behaviors based in embodied experiences.

Embodied cognition theories, including conceptual metaphor and blending, have been inspiring HCI research (Antle, Corness, & Droumeva, 2009; Benyon, 2012; Bødker & Klokmose; Chow & Harrell, 2012; Hurtienne & Israel, 2007; Imaz & Benyon, 2007; Jetter, Reiterer, & Geyer, 2014; Markussen & Krogh, 2008; Tan & Chow, 2017). To design appropriate virtual outcomes, a behavior can be blended with a direct cause-effect scenario into a mini narrative. The cause should be experientially comparable to the behavior, with the similarities highlighted, the differences aligned or suppressed, and then the effect presented virtually. For example, in order to motivate saving paper after washing hands in the restroom, shaking off water to the basin for a few more seconds results in virtual plants growing on the mirror, which is reminiscent of watering real plants (Tan & Chow, 2017). Shaking off water from hands is felt like watering plants. The basin can be designed to align the shape of a plant pot. The growth of virtual plants is a result of a compression of several direct cause-effect links (shaking off more water, thus using less paper to dry hands, cutting fewer trees, and finally seeing more trees) into what is called "blended causality" (Chow, 2019). One can immediately "grasp the essential whole" (Fauconnier & Turner, 2002, p. 76) that shaking off water brings more trees.

This article argues and proposes a framework for creating "animated parables," a kind of data-driven interactive narrative (Rapp & Tirassa, 2017) blended in daily life (Nakajima, Lehdonvirta, Tokunaga, & Kimura, 2008) including personal routines and environments (Huang et al., 2015). It first provides the theoretical background that underpins the characteristics and design guidelines of animated parables. The guidelines include comparing a behavior to a cause-effect scenario in terms of similarities in embodied experiences and blending them into a parable with different possible outcomes. Application of the guidelines in a series of design workshops generates an array of parables. The parables are ranked according to the number of matches in embodied experiences, and then further evaluated with suggested metrics regarding the ease of fitting into daily life and interpreting the causality. Results show that the extent of embodied mapping in parables promises understandable blended causality between behaviors and virtual outcomes, which also informs recommendations for enhancing embodied mapping. This work overall contributes an approach that designers can follow to generate and compare ideas before moving to more costly prototyping.

2. Theoretical Background

The idea of animated parables is situated in a context of personal informatics, gamification, and feedback for behavior change. Meanwhile, the approach is informed by behavioral models from social psychology and embodied cognition theories.

2.1 Personal Informatics and Gamification for Behavior Change

Animated parables are dynamic representations of information. Information systems that help people collect and reflect on "personally relevant information", such as step counts and digital screen time, are called "personal informatics" systems (I. Li, Dey, & Forlizzi, 2010). Many personal informatics systems present the information in typical

visual forms like bar charts. Rapp and Cena (2016), based on a diary study of novice users, uncover problems of personal informatics in various facets including data visualization. Numbers and bar charts are "too abstract" and "cold" to users, who actually want an "emotional link" to the data and prefer an "impressionistic image" providing at-a-glance information of what one has done and how one is or will be affected. In other words, images should be used to show behavioral outcomes related to users. Rapp and Cena suggest, for example, an avatar mirrors the user's image in past, present, and even future states, such as body shape, if the system aims to motivate physical activity. Some might see this kind of system like a game anchored to real life behavioral data. Yet, the avatar state is more than a simple badge, once the user identifies with it (Kao & Harrell, 2018; Kim & Sundar, 2012; B. J. Li & Lwin, 2016). Rapp and Tirassa (2017) even pictures that this form of data-driven avatar can visualize different possible futures for one to explore, forming interactive narratives (Murray, 1997; Wardrip-Fruin & Harrigan, 2004) of future projections. Extending from avatars to other virtual items, once users value them, they can play a motivating role in the interactive narratives, which also underpins the idea of animated parables.

Gamification is "the use of game design elements in non-game context" (Deterding, Dixon, Khaled, & Nacke, 2011, p. 10), such as lifestyle behaviors. In fact, many well recognized design principles of behavior change support systems (Oinas-Kukkonen & Harjumaa, 2008) involve game design elements like rewards (cf. virtual badges) and recognition (cf. player levels). Although gamification is shown to be effective in some health interventions (King, Greaves, Exeter, & Darzi, 2013), simply adding game elements (e.g., points, badges, leaderboards) to an activity sometimes reduces performance or intrinsic motivation (Mekler, Brühlmann, Tuch, & Opwis, 2017; Zuckerman & Gal-Oz, 2014). He et al. (2014), when reviewing energy feedback

technologies, raise concern on figurative representations, like UbiGreen, that if a user sees different states of virtual items like different game levels and just want to win, intrinsic motivation in the original goal is undermined. Nunes et al. (2015) raise similar concern that over-engagement in game competition can distract attention on the target health treatment. In fact, Deci et al. (1981) empirically shows that direct competition (i.e., the fastest the winner) has a significant negative effect on intrinsic motivation in solving interesting puzzles.

Laschke & Hassenzhal (2011) argues that more intrinsic approach should give meaningful stories to badges, which otherwise are just extrinsic rewards. Rapp (2017b) provides a thorough review on gamification for behavior change and suggests design strategies for better utilizing game elements. In addition to rewards, the strategies include exploiting penalties but allowing users to "repair the damages", enveloping goals and tasks in a "narrative framework" (i.e., a story world). In short, gamification should incorporate meaningful stories with foreseeable, reversible paths for users to navigate, beyond using basic game elements.

Insight: An animated parable combines a story world with the context of a behavior into an interactive narrative with multiple, reversible paths for users to "act out" their journeys. Each journey is meaningful to the user in that virtual outcomes are either valued negatively, like penalties, or positively, like rewards.

2.2 Ambient Feedback on Lifestyle Behaviors

Animated parables present virtual outcomes as feedback, and the presentation is a design issue. Consolvo et al. (2014), based on their previous work on personal informatics, discuss the use of what they call "glance-able displays" in providing additional feedback outside an application, for example, the mobile phone wallpaper.

The glance-able display is a concept emerged from ambient displays, which can be frequently seen by a user even though one is not explicitly engaged with the system. Nakajima et al. (2008) also explore the potential of ambient feedback in encouraging daily activities. They define "ambient lifestyle feedback system" in terms of three design principles, namely (1) integrating into daily activities and passively observing behavior, (2) provoking emotional responses in penalties and rewards, and (3) blending into environments and leveraging peripheral perception. Their proof-of-concept prototypes capitalize on everyday objects like wall-mounted paintings, fish tanks, and bookshelves, situated in common environments. Integration of positive or negative feedback into surroundings is recommended for behavior tracking.

Integrating feedback with people's life contexts is crucial. Huang et al. (2015) defines "personal visualization" as the design of interactive visual data representations for personal contexts, which include both routines and environments in daily life. Among different clusters of related work, the one most relevant to ambient feedback is to support continuous awareness (low attentional demand), enable at-a-glance lookup (low explorability), and provide in-the-moment feedback for immediate action (high actionability). Huang et al. suggest metrics of evaluating personal visualization, including naturalness of integrating with personal routines, aesthetics of blending into environments, and ease of interpreting the representation. These are also metrics of evaluating animated parables. First, integrating with life routines is time-sensitive. Sensing should be always on, and feedback should be presented continuously. Second, life routines involve objects (e.g., cushion) and environments (e.g., shower room). Blending into them is form-dependent. Sensing hardware should be encased or embedded (Hartman, Luginbuhl, Shao, & Correia, 2020). Feedback should be perceivable at a glance meanwhile matching the aesthetics of the place (e.g., virtual

items rendered in scale). Third, ease of interpreting will be discussed in the next two sections.

Insight: An animated parable is a story blended in daily life including personal routines and environments. Designers have to consider how to embed or encase sensing technologies in the surroundings, including objects, bodies, and environments, that people encounters in their daily routines. Feedback should be presented continuously, perceivable at a glance, and matching the aesthetics of the settings.

2.3 Behavioral Outcomes and Feedback Intervention

Animated parables present virtual outcomes, which should be linked back to behaviors. Theory of planned behavior (TPB), based on the theory of reasoned action (Fishbein & Ajzen, 1975), posits that one determinant of individuals' intention to perform a behavior is behavioral beliefs, which link a behavior to its outcomes that are valued positively or negatively by the individual, resulting in attitude toward the behavior (Ajzen, 1991). In other words, a consciously valued behavior-outcome link influences one's attitude toward a behavior. Figure 1 illustrates a cognitive processing on a behavior-outcome link according to TPB. B^A refers to the causal action in a behavior, and B_O is the outcome of B^A. After evaluation, they are either positive ($+B^A$ and $+B_O$) or negative ($-B^A$ and $-B_O$). The causal link between B^A and B_O is represented by a curved arrow graphic, because behavioral outcomes can be distant or abstract (e.g., expensive monthly bills come well after overuse of domestic energy, not to mention the impact on the environments; negative effects of smoking on family relationship cannot be measured). In fact, delayed or unnoticeable feedback reduces behavioral intention even though the outcomes are consciously known.

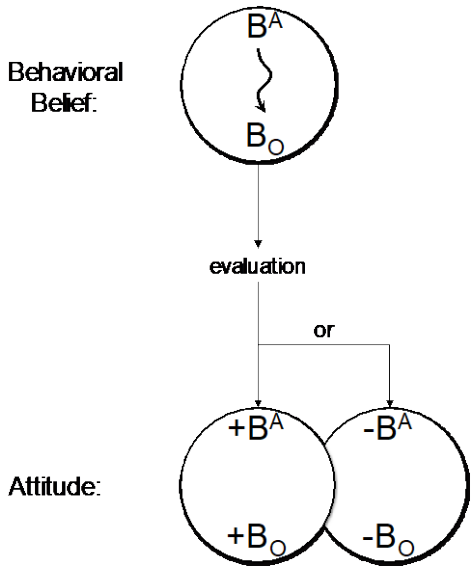


Figure 1. A cognitive processing on a behavior-outcome link according to TPB.

Feedback intervention theory (FIT) holds that feedback on an individual's task performance can direct one's attention (Kluger & DeNisi, 1996). For effective interventions, feedback should (1) show changes in performance over time, with a rapid rate of change better than a delayed one; (2) contain information of how to improve. Figure 2 illustrates two levels of attention directed by a feedback intervention. At the task performance level exists a rapid feedback loop mobilized by automatic thinking. At times, negative changes shift attention to the task details level, which require conscious thinking of how to improve.

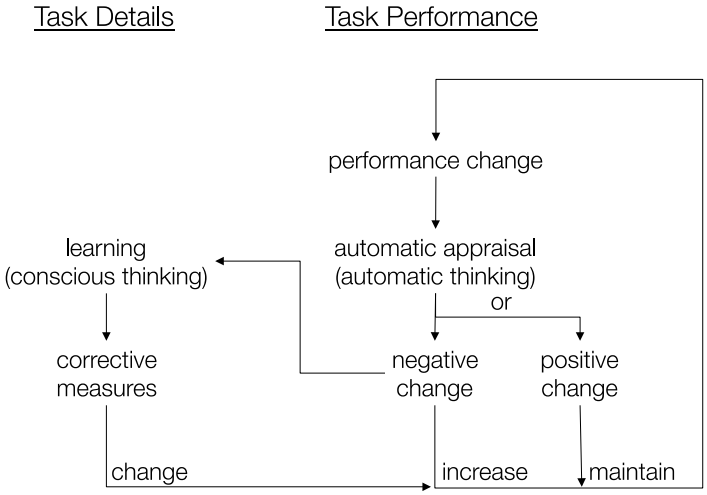


Figure 2. Two possible levels of attention directed by a feedback intervention according to FIT.

Insight: Behavioral outcomes in reality can be too indirect or abstract to be effective feedback. Animated parables transform changes in behavioral data into changes in virtual outcomes, which should be immediate feedback to users' performance. The narrative frame also links the virtual outcomes back to the behavior. One sees the outcomes as an integral part of the behavior, and the evaluation affects the behavioral intention.

2.4 Linking Behaviors and Virtual Outcomes

As feedback, virtual outcomes can be more immediate than actual behavioral outcomes. Yet, virtual outcomes are designed and may not be cognitively linked to corresponding behaviors in users' minds. One may see virtual outcomes as "externally imposed" rewards or penalties, which undermine motivation (Ryan & Deci, 2000). To increase behavioral intention, animated parables should link behaviors and virtual outcomes for users. In cognitive science, a link between two entities is a kind of image schema, which refers to recurrent patterns of sensory images (Johnson, 1987) (e.g., we see two linked objects often move together). According to embodied cognition, schemas are primitive cognitive structures (Lakoff, 2012) that can be found across many physical experiences and metaphorical thoughts. Examples include spatial relations like Up-Down (e.g., physically higher winner stairs; metaphorically higher quality), Containment (e.g., physically in the pocket; metaphorically in my mind), Contact-Noncontact (e.g., the plane physically touches the ground; his act metaphorically touches the bottom line), and Near-Far (e.g., geographically they live far apart; metaphorically their hearts are close). The Link schema is unidirectional or bidirectional dependency between two

entities, even though not in direct contact (Mandler, 1992) (e.g., smoke comes out of fire; let's never negotiate out of fear). Causality is a kind of link. Figure 3 illustrates a causal link between a causal action C^A and its effect C_E in the form of a straight arrow graphic indicating the directness. In Figure 1, the curved arrow graphic indicates the indirectness.

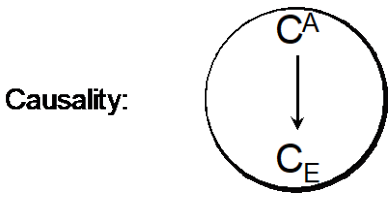


Figure 3. A direct causal link between a causal action and its effect.

The pervasion of image schemas suggests that we often conceptualize subjective experiences (e.g., affection) and abstract ideas (e.g., relationship) in terms of physical experiences including the sensorimotor (e.g., warmth) or the spatiotemporal (e.g., proximity). Initially informed by cognitive linguistics and then supported by evidence from experimental psychology and neuroscience research (Lakoff, 2012), the embodied cognition thesis (Lakoff & Johnson, 1999) holds that many of our basic concepts are primary metaphors that are learned pre-linguistically from regularly co-occurring experiences. For example, Good Is Up because we often go up (spatiotemporal experience) to higher places for something better (abstract idea) such as more spectacular views or quieter environments; Happy Is Up because of the usual upright body posture (sensorimotor experience) when we feel happy (subjective experience). The Up-Down schema structures the metaphorical mappings in these cases.

Two existing concepts structured by the same schema can be linked, combined, and compressed, or "blended" into new, emergent ideas when the corresponding experiences co-occur (Fauconnier & Turner, 2002). Good Is Up can be blended with

Happy Is Up if we climb stairs to higher places and see a spectacular view with excitement. We may link and compress Good, Up, and Happy, because their mappings are coherently structured by the Up-Down schema. In short, metaphors are structure mappings between two regularly co-occurring experiences, which are more universal. Blends are combinations and compressions of these structure mappings in more particular cases. A behavior, including its indirect actual outcomes, and a direct cause-effect scenario can be compressed for immediate understanding (Fauconnier & Turner, 2002, p. 76), if they share similar schemas and co-occur regularly. The behavior becomes the cause, whose direct effect can be rendered as virtual outcomes.

Insight. Animated parables should link behaviors and virtual outcomes via metaphorical mapping between a behavior and a direct cause-effect scenario. The cause should be comparable to the behavior in terms of similarities in physical experiences. After blending, the behavior becomes the cause, and the effect can be rendered as virtual outcomes.

3. Animated Parables

The above insights underpin the idea of animated parables. Animated parables are interactive metaphorical stories blended in daily life with positively or negatively changing virtual outcomes mapped with behavioral data. To be effective feedback, causal links between behaviors and virtual outcomes should be built on metaphorical mapping and blending between behaviors and direct cause-effect scenarios with similarities in physical experiences.

3.1 Characteristics

This section characterizes animated parables in three aspects, namely stories blended in

daily life, interactive and reversible outcomes, and understandable causality. First, animated parables are interactive narratives blended in daily life. Parables are metaphorical stories that unfold cause-effect relations (causality) (Chatman, 1978) in some domains that are seemingly unrelated yet comparable to the audience's situation. For example, the classic parable "The Tortoise and the Hare" prompts comparison of one's own scenario with the journey of the tortoise linking perseverance to final success, or comparison with that of the hare linking arrogance to losers. Animated parables take comparison further to combination and compression of parables with users' scenarios. Users can "act out" and perceive virtual outcomes in first-person perspective. Performing a behavior in daily life reminds of the causal action in the parable. Any objects that one acts upon "become" objects in the parable too.

Second, animated parables are interactive and reversible. Parables typically tell more than one journey of cause-effect links. Different choices or conditions lead to different outcomes. For example, in the classic "The Three Little Pigs", using different materials to build the house results in different outcomes when hit by the wolf. An animated parable not only links different actions to different virtual outcomes, but also allows one to alter the current outcome in the parable by changing the behavior at any moments. One knows that change is possible and remains hopeful.

Third, causal relations between behaviors and virtual outcomes are directly understandable. According to embodied cognition, when a user regularly performs a behavior similar to a causal action and sees its effect virtually, one cognitively compresses the behavior, and the cause and effect into a direct causal relation. One can intuitively alter the behavior for adjusting the virtual outcome. One can also review the causal relation and re-consider the necessary actions for major changes.

3.2 Crafting Animated Parables via Mapping and Blending

Animated parables are built on metaphorical mapping and blending between behaviors and cause-effect scenarios in terms of physical experiences. To craft an animated parable for a behavior, one needs to start with looking for a cause-effect scenario as the target of the mapping. For understandable causality in the parable, the cause-effect relation in the scenario has to be direct. The behavior and the causal action should have similarities in physical experiences, including sensory images and image schemas, because embodied cognition informs that coherent and recurrent bodily experiences can build mental links. Similarities in physical experiences facilitate cognitive mapping and then blending of the behavior and the cause and effect into a direct blended causal link.

Figure 4 illustrates the mapping and then the blending. The behavioral action B^A has to be mapped with the causal action C^A in the comparable scenario in terms of similarities in physical experiences (represented in thicker dotted lines), and then both compressed with the effect C_E in the comparable scenario into a direct causal relation in the parable. The new blended causality contains action P^A (projected from matches between B^A and C^A) and effect P_E (projected from C_E and virtually presented by technology). Blending mentally builds the causal link. It functions in two modes of thinking (cf. FIT). Figure 5 illustrates the two threads of thinking. With blended causality, one can rapidly appraise changes in P_E as positive or negative and adjust actions. At times, negative P_E triggers re-consideration. With understanding of the causality in the parable, one can review different behaviors and their outcomes, and then find the necessary action if improvement is wanted.

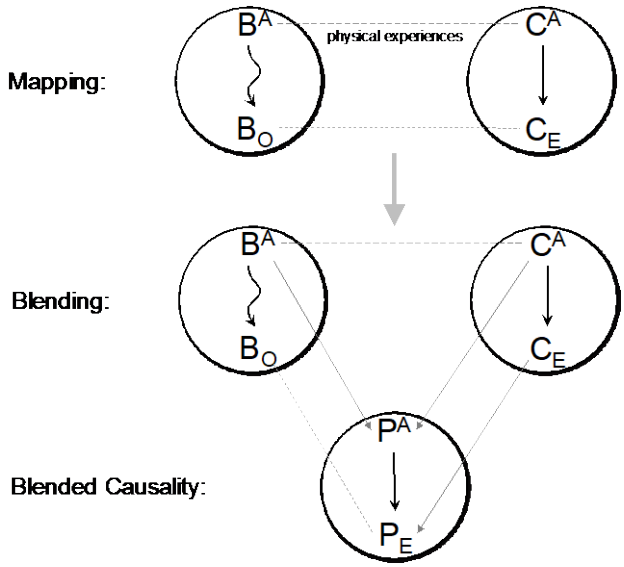


Figure 4. Mapping and blending between a behavior and a cause-effect scenario.

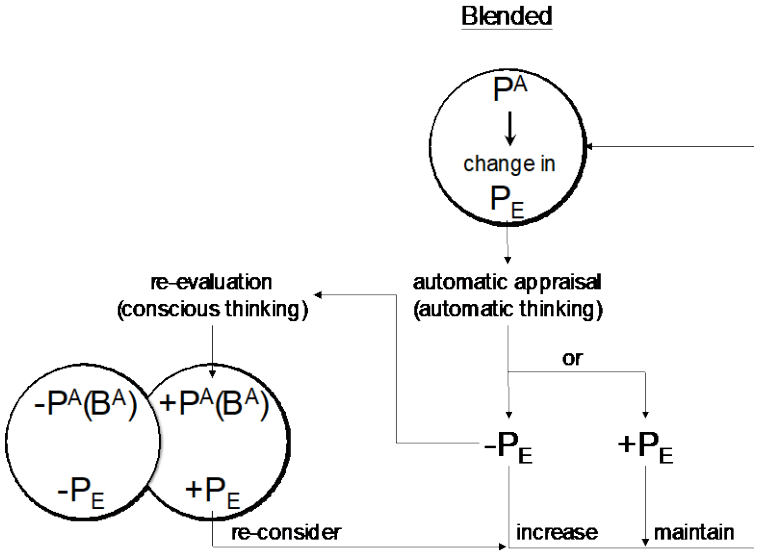


Figure 5. Two threads of thinking with the blended causality.

3.3 Initial Design Guidelines

To sum up, the crafting of animated parables includes several steps.

Step 1: Identify comparable scenarios. Designers look for mundane cause-effect scenarios from different domains. The cause-effect relation in the scenario should be direct and the effect can be valued positively or negatively.

Step 2: Construct mapping. The causal actions should be comparable to the behavior in terms of physical experiences. Designers first list out different aspects of sensorimotor and spatiotemporal experiences, including visual, auditory, tactile, kinaesthetic, motion path, physical contact, containment, and duration, in each side. Similar sensory images and common spatial or temporal relations are marked. The result is a mapping diagram.

Step 3: Perform blends. Designers combine the behavior and the comparable scenario into an interactive narrative wherein different actions lead to different virtual outcomes. The virtual outcomes are projected from the effect in the comparable scenario and blended into environments that people encounters in daily routines. The result is a blending diagram. Differences in physical experiences between the behavior and the cause-effect scenario may be aligned by using design and technology to simulate.

Step 4: Prototype and evaluate. Changes in behavioral data are mapped with changes in the virtual outcomes. Designers build prototypes, from physical mock-ups, interface wireframes, videos, to digital prototypes, which visualize the virtual outcomes for evaluation and iteration.

3.4 Evaluation Metrics

Based in Huang et al.'s metrics of evaluating personal visualization (Huang et al., 2015), evaluation of animated parables includes (1) how natural the system is integrated with daily routines; (2) how well the system aesthetically matches the place context; and (3) how easy the user understands the blended causality.

To evaluate naturalness of integrating with life routines, one examines how always-on hardware sensors (or digital devices) are placed in the user's surroundings without interrupting the routines. If the sensors are embedded in the physical settings (e.g., mounted on the wall, built in the chair), they can be non-obtrusive. If the sensors

are encased in some tools (e.g., toothbrush) or wearables (e.g., shoes), weight and size of the hardware modules including battery should be in a scale that would easily go unnoticed.

To assess aesthetics of blending into environments, one looks at the presentation and content of feedback. The feedback has to be presented continuously, and so it should appear as part of the daily context (e.g., a picture frame mounted on the wall, a cushion on the chair). When the feedback is intended to draw peripheral attention, it should be rendered in proportion (e.g., size of virtual cracks displayed on the mirror, magnitude of vibration simulating hatched chicks) to the surroundings.

To evaluate the ease of understanding the causality, one look for cues in environments (physical and virtual) that links the behavior (e.g., smoking) and the comparable scenario (e.g., incinerating). Chow (2018) proposes a protocol of cognitive processes of how interactive artifacts stimulate users' imaginative blends in which perceived changes should prompts an interpretive frame for the blending. It follows that the perceived virtual outcomes (e.g., dirt appearing on the digital picture) co-occurring with the behavior should consist of elements (e.g., smoke, dirt) that are reminiscent of counterparts in the comparable scenario. These coupled elements are in relation to the behavioral action (e.g., burning cigarette) and the causal action (e.g., burning waste) respectively, which lead to the effect in the comparable scenario. One can easily build the direct causal link between the behavior and the virtual outcomes.

4. The Study

4.1 Method

This is an exploratory study. Based on the above theoretical underpinning, an embodied approach to designing meaningful representations of tracked behaviors is proposed,

including the above step-by-step design guidelines and evaluation metrics. The guidelines are applied in a series of design workshops, and the generated animated parables are evaluated by the metrics.

The Interaction Design Research Triangle (Fallman, 2008) posits that (1) design studies, as science of design, aims to understand universal patterns; (2) design practice, as an opposition, deals with particular cases; and (3) design exploration, as the third way, attempts to suggest possibilities. The three extremes span a triangular spectrum of design research. This exploratory study, started with theoretically grounded design guidelines, is positioned near the design exploration corner, and then through application of the guidelines in design workshops to generate ideas the study moves toward the design practice corner. With analyses and evaluation of the generated ideas, we aim to identify patterns or correlations that send feedback to the theory and guidelines. In other words, the research agenda navigates among the three corners of the Interaction Design Research Triangle.

The well-known Research through Design methodology in HCI (Zimmerman & Forlizzi, 2008) consolidates a kind of design research approach that proposes design theory or model, which is the design studies corner, through construction of artifacts, which is a movement toward the other two corners. Yet, if the number of artifacts constructed according to the theory or model is too few, the feedback sent to the proposition is also limited in developing the theory. To enhance the potential contribution, this exploratory study seeks to generate more design ideas as data based on the proposed guidelines and targets to identify patterns or correlations that may inform design recommendations and update the guidelines.

4.2 Sample

The guidelines were applied in four courses conducted by the author at a design school

in Asia from 2017 to 2018. The project theme of the courses was designing representations of behavioral data that stimulate people to change or perform a behavior for wellbeing. Each course consisted of 18 to 30 students, with every two students forming a group (few groups have three students because of the odd number of students in the course). In the first week, each group was free to propose a behavior and then conducted preliminary research to understand the contexts of use, including the environments or objects for virtual outcomes to blend in, and possible behavioral data to be tracked by technology. Students then followed the guidelines, generated initial ideas, and presented the mapping and blending diagrams (see Figure 6 & 7 for example). The ideas went through one or two rounds of critiques in the following two weeks, before construction of mock-ups and scenario videos showing positive and negative outcomes. Overall, 47 parables were generated.

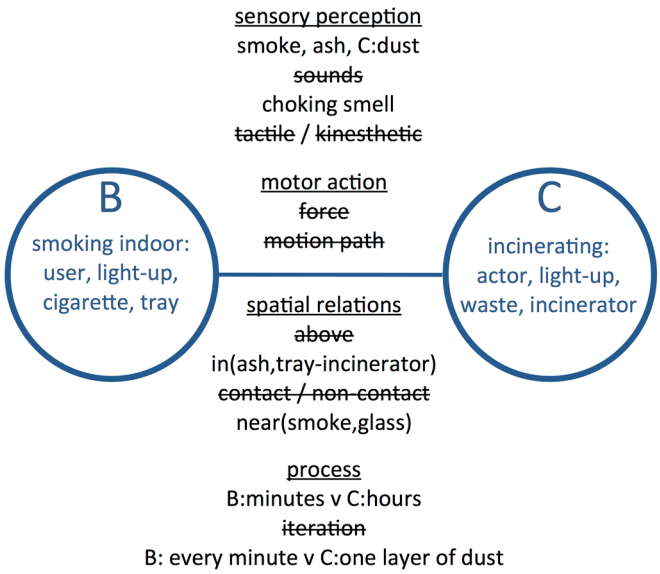


Figure 6. A mapping diagram of a parable idea combining smoking and incinerating. Students are given a diagram template guiding the comparison of sensorimotor and spatiotemporal experiences between the behavior and the cause-effect scenario.

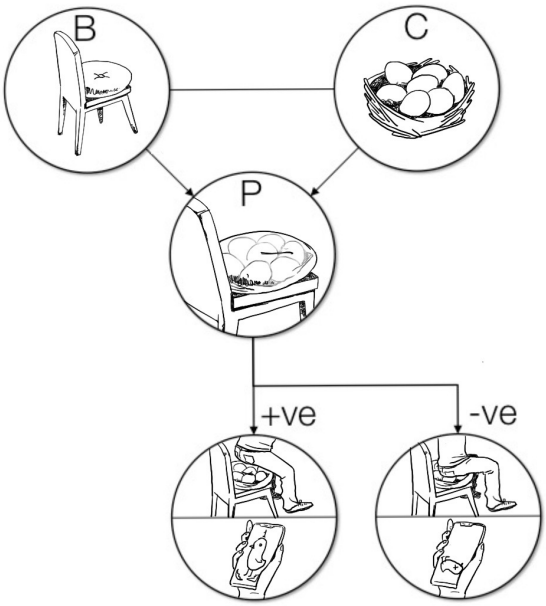


Figure 7. A blending diagram with positive and negative outcomes of a parable idea combining sitting and hatching eggs. Students imagine and visualize the negative outcome of sitting too long and the positive outcome if the user stands up regularly.

4.3 Analysis of Physical Experiences

4.3.1 Sensory Images and Image Schemas

With the 47 parables, the authors started the analysis by arranging them in a table. Every row is a parable, and every column corresponds to an aspect of physical experiences. According to embodied cognition (Lakoff, 2012), higher levels of human cognition, such as affective states (e.g., anger) and abstract concepts (e.g., city), are built upon physical experiences (e.g., heat, proximity, containment) and become "embodied" via conceptual metaphors (e.g., anger is heat; a city is a container). The source domains of conceptual metaphors can be multimodal sensory images (e.g., visual, sound, smell, tactile, kinesthetic) or their recurrent patterns or structures (e.g., source-path-goal, orientation, containment, proximity, iteration), that is, image schemas. Sensory images and image schemas provide the table columns of this analysis. Sensory

images cover typical modalities of perception. For instance, tactile images come from the sense of touch, like warmth or pain; kinaesthetic images refer to the internal sense of posture or bodily movement, such as holding something in hand, stretching arms, or blowing air. The analysis in terms of image schema can be more exploratory, because there is a long list of recognized image schemas (Johnson, 1987). This study starts with those commonly observed in the set of parables that span the spatiotemporal dimension. Spatial image schemas include source-path-goal (e.g., from one tooth to another), above/on (e.g., one pan above the other; the blanket on the bed), containment (e.g, ash in the ashtray; water coming out the tank), contact (e.g., direct contact between a needle and the body), and proximity (e.g., smoke near the window). Temporal image schemas include duration (i.e., at the magnitude of seconds, minutes, or hours) and iteration (e.g., daily, weekly).

4.3.2 Parable by Parable

For each parable (row), the Visual cell was marked with any color, shape, or identified object, which a user would see through the eyes; the Tactile cell with temperature, texture, or vibration, which one would sense through touch; the Kinesthetic cell with the posture or bodily movement; the Proximity cell with the closeness of two things, one of which can be the body. The scenario video of each parable, which visualized the user journeys after blending the behavior (B) and the comparable (C), provided important references here. If the behavior (B) and the comparable (C) featured similarity in the focused aspect, like having colors as seen by the user, a temporary code “color” was marked in the table cell. If the behavior (B) and the comparable (C) featured dissimilarity, or just one of them had the aspect (e.g., B coming with the smell of mint, while C with the smell of coffee; B having the mouth and the bottle in contact, but not for C; B coming about intermittently, but C occurring every day), the code was marked

with a prefix “B:” or “C:” as differentiation, and the cell was colored red. For those aspects with dissimilarity, re-examination was performed on whether the disparity could be reconciled by design and technology. For instance, “B: cushion” was visually different from “C: nest with eggs”, but that could be resolved by artificial prints of the latter on the former; blowing “C: flute” was different from blowing “B: peak flow meter” in terms of audio, but the sounds of flute could be simulated by technology; one pan could be “above” or “below” the other in a twin-pan balance, and a pair of photo frames on wall could be moved in the same way by simple mechatronics. For these aspects, the cell was re-colored green to indicate “augmented similarity”, as differentiated from “inherent similarity” (not colored) and “dissimilarity” (colored red).

4.3.3 Aspect by Aspect

The analysis then continued with examination of physical experiences aspect by aspect across all 47 parables, in other words, isolating column by column in the table. All temporary codes were compared and united in wording in order to formalize and condense the coding scheme. The intermediate results included the coding for shape (e.g., pipe-shaped, stick-shaped), for object (e.g., cushion, nest, ashtray, incinerator, scale, ice, blanket, egg), for kinesthetic (e.g., hold, pour, blow, turn-open, press-on). For spatial image schemas, a function-like notation, from (item1) to (item2), in (item1, item2), or contact (item1, item2) was used to describe the relations of items from other aspects, for instance, “from (pocket) to (dock-slot)” referring to a similar path from the pocket to the dock or slot, and “contact (feet, scale-ice)” meaning the feet are in contact with something like scale and ice.

After all aspects were examined and marked, the 47 parables were sorted according to the number of marked aspects with inherent similarity or augmented similarity (but not dissimilarity) in descending order. Every parable (row) was then

examined again to check for subtleties within aspects or to revise interconnections between marked aspects. For example, in Tactile, there could be inherent similarity in "warm" as well as augmented similarity in "C: vibration"; in Visual, "B: phone" and "C: drink" could be initially different but then simulated similarity, which are recurrent in "contact (hand, phone-drink)" in the Contact aspect. The examination of aspect-by-aspect (column-by-column) was then repeated to further revise the coding scheme.

The above processes of row-centric and then column-centric examination were iterated for three rounds. Appendix I shows all 47 parable ideas with marked similarities (augmented similarity colored green) and dissimilarities (colored red) in the table after sorting. Those ranked higher in the table have more similarities (cells without color or colored green) in physical experiences between the behavior and the comparable scenario. In other words, their mapping and blending are more embodied.

4.4 Metric Evaluation Results

This section reports the evaluation of the 47 parable ideas based on the aforementioned metrics in Section 3.4.

4.4.1 Naturalness of Integrating with Routines

The first metric is how natural the system of each parable is integrated with life routines. For each parable, the necessary hardware modules for sensing and feedback were identified and examined whether they could be embedded in relevant physical settings, built in the tools, or encased in some wearables. After examination, it was found that weight and size of the hardware modules including battery of all parables were in appropriate scale that would not be too obtrusive. Appendix II lists all 47 parable ideas with the potential hardware modules in the same order of Appendix I.

4.4.2 Aesthetics of Blending into Environments

The second metric is how well the system of each parable matches the aesthetics of the place context. For each parable, relevant objects where feedback could be presented were examined. And the content of feedback was checked if the virtual items were rendered in proportion to the context. It was found that all parables presented feedback in relevant objects (e.g., chair, toothbrush, mirror) and 34 out of 47 (about two thirds) parables could have feedback in scale. Those have feedback not in scale include visualizing virtual items (e.g., clouds, waves, campfire) on screen smaller than life-size, or on physical objects of a different size (e.g., a fried egg printed on a blanket, a fridge as a cassette player). Appendix II also lists all 47 parable ideas with the relevant objects with their scale (those not in scale colored red) in the same order of Appendix I.

4.4.3 Ease of Interpreting Causality

The third metric is how easy a user understands the blended causality. For each parable, the user's cognitive processes were delineated, from performed behavior and perceived changes (as sensory cues) in surroundings, to any elements that are reminiscent of counterparts in the comparable scenario. With sufficient coupled elements identified, the behavioral action was linked to the comparable causal action. If the causal action had the direct effect visualized virtually, the chain from the performed behavior, via the causal action, to the virtual outcome was compressed with ease into a direct behavior-outcome link, when they regularly co-occurred. If there was any missing link, for example, insufficient or no coupled elements, or uncertain causal action in the comparable scenario, the compression into direct behavior-outcome link became difficult, because they seemed separate.

It was found that 11 out of 47 parables had missing links that hindered users' interpretation of the blended causality, and they were clustered near the tail of the ranking. Among the missing links, three of them had coupled elements but insufficient, and two out of the three were ranked higher in the list. For example in Fridge Engine, "fridge door" was coupled with "car door" in appearance, yet "green food" was hardly reminiscent of "green fuel", making the chain to engine ignition (an indicator of condition) broken. Three other parables had uncertain coupled elements, because the sensory cues were too vague. In Daily Eye Usage, the performed "blink" behavior was hardly linked to "manual power generation", because the element "movement" was not obvious. In Take a Breath, the breathing behavior might have the element "air", but that was not visually linked to campfire. The final four parables even had uncertain cause in the comparable scenario that made coupled elements hard to be confirmed. In Weather Bottle, even though one might try to couple "water in bottle" with "water in clouds", but the indirect source of the water in clouds broke the link between the behavior and the comparable cause. In CAFFLOG, the similar question was "what causes the high waves?" Appendix III lists all 47 parable ideas with the chain of interpreting causality (only the negative outcome for demonstration) from performed behavior, perceived changes, coupled elements, comparable cause, to virtual outcome, and finally compressed behavior-outcome in the same order of Appendix I. Those with missing links were colored red.

4.5 Comparison of Evaluation Results with Embodied Mapping

According to the number of marked similarities in physical experiences, the 47 parable ideas are sorted in descending order (Appendix I). Those ranked higher in the table are more embodied in the mapping and blending between the behavior and the comparable scenario. On the other hand, metric evaluation shows that all parable ideas, with the

weight and size of potential hardware modules, can be naturally integrated into life routines. About one-third of them have feedback rendered not in scale. Only 11 of them have causal links difficult to be interpreted due to missing links. When the parable ideas are listed in the order according to the extent of embodied mapping, those with feedback not in scale mostly appear in the lower half (Appendix II), and those with missing links are even more clustered near the end of the list (Appendix III). The comparison shows that animated parables with more embodied mapping and blending are more likely to result in easy-to-understand behavior-outcome links, facilitating one to intuitively adjust action for intended outcomes.

To illustrate the usefulness of the embodied approach, seven parables ranked high in the table, with feedback rendered in scale and no missing links, are selected to be representatives of this corpus. These representatives cover three types of behavior change as suggested by Oinas-Kukkonen (2013), namely forming a new pattern (e.g., choosing more colorful meals), altering the frequency, intensity, or duration of an existing pattern (e.g., reducing the amount of smoking), and reinforcing an existing pattern, making it more resistant to change (e.g., brushing teeth properly). The seven parables proportionally represent the distribution of the three types in the corpus (forming: 5, altering: 23, reinforcing: 19). Table 1 lists the seven representatives, with snapshots from the scenario videos, showing the positive and negative outcomes.

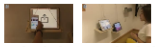
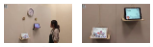
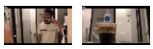
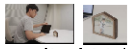
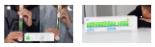
Parable	Technical description	Positive state	Negative state	Cluster
Hatcher	a smart cushion with embedded weight sensors (e.g., FSR) and vibrator, connected with a smartphone application via BLE	 sitting for an hour, a chick hatched out	 sitting over an hour, hatched chicks fainted	altering
COLOR	a smartphone app with built-in cameras	 balanced diet, colorful mandala	 unbalanced diet, dull mandala	forming
Accompany	a smart photo frame set with strings attached from constant torque motors and pulleys	 upload photos to both, balanced	 upload photos to one side, unbalanced	reinforcing
Tooth Barista	a smart toothbrush with embedded IMU or accelerometer, connected with a cup with a display on its side.	 brushing steadily, foam goes up	 brushing hastily, not enough foam	reinforcing
Smoked House / Incingarette	a smart ashtray case with embedded weight sensors (e.g., FSR), connected with a digital photo frame via BLE.	 no smoking, photo is clear	 smoking, photo gets dirty	altering
SHREDDER	a smart reminder-printer with a digital display, connected to an online bank account	 no overspending, no shred on printed reminder note	 overspending, more shreds on printed reminder note	altering
The Peak Flow Flute	a smart peak flow meter with embedded pressure sensors, connected with a speaker with a built-in amplifier via BLE.	 blowing regularly, complete music played	 blowing intermittently, broken music played	reinforcing

Table 1. The seven representative parables and their multiple paths.

4.6 Recommendations for Crafting Parables

After analysis of physical experiences and metric evaluation, recommendations for enhancing the embodied mapping in animated parables are drawn. They can be regarded as notes in parallel to the step-by-step design guidelines for crafting better parables.

4.6.1 Highlighting similarities, aligning differences

Mapping a behavior with a comparable scenario should explore all aspects of physical experiences, not only the more accessible sensory images like visuals and sounds, but also the less noticeable image schemas like containment or iteration. Marking more aspects with similarity (e.g., foam can be seen from toothpaste and from milk in Tooth Barista, warmth generated from sitting and from hatching in Hatcher, ash in the ashtray and in the incinerator in Incingarette) creates more embodied experiences of the parable. Designers are reminded of highlighting the similarities for users to experience (e.g., a voice message about the temperature under the lap when the user sitting too long) while prototyping, which are reminiscent of the comparable scenario.

Conversely, aspects existing on one side but missing on the other (e.g., the sound of flute in The Peak Flow Flute, visible dirt on windows resulting from incinerating in Incingarette, vibration of hatched eggs in Hatcher) can be simulated by design and technology, giving a sense of "being" in the parable world. The simulation details, such as size of a newly hatched chick, volume of a flute, and movement of raindrops, should be rendered in scale to create an embodied experience.

4.6.2 Mapping objects, giving them new forms

In animated parables, virtual outcomes are blended in everyday things and surroundings. Designers should scan the surroundings that one usually encounters in the routine and consider objects that have counterparts in the comparable scenario. The corresponding objects are acted upon by similar actions at both sides. Performing a location scout before making the video prototypes and watching documentary videos related to the comparable scenario may shed light here. For instance, visiting an office may find that many office workers have a cushion on the task chair; many people put the toothbrush in a cup after brushing; visiting your friend's apartment may see a printer next to the wallet holder. The identified object related to the behavior can then be designed to look like the counterpart in the comparable scenario. For example, in The Peak Flow Flute the peak flow meter used in lung capacity monitoring appears to be a flute by design; in Hatcher the cushion on the chair has prints of eggs on its surface; in Incingarette the picture frame is designed to look like a window frame; in Accompany the photo frame set is given the form of a twin-pan balance.

4.6.3 Mapping rate of change between behavior and virtual outcomes

Behaviors are tracked in terms of number (e.g., a quantity of weight, distance, time, speed, or transaction), which can be counted as an act or state (e.g., a change in weight

sensor reading as the start of a smoking session). The counts over a period of time become a pattern (e.g., number of minutes in a smoking session as the amount of cigarettes smoked). Patterns determine changes in virtual outcomes. Designers need to determine how to count and how many counts correspond to a unit of change. This is the rate of change between behavioral data and virtual outcomes. The positive and negative changes can have different rates.

For example, the parable Incingarette has been developed into a digital prototype. It includes a box containing a platform with embedded force sensitive resistors (FSRs) and hardware modules (WIFI-enabled microcontroller) for placing an ashtray. When the user picks out the ashtray for smoking, the significant change in FSR readings about weight marks the start. When smoking is done, one puts the ashtray back into the box. The increase in readings marks the end of the session of smoking. The length of a smoking session is regarded as the amount of cigarettes smoked. Figure 6 shows the box (with or without an ashtray) and the embedded sensors.

Figure 8. The box (with or without an ashtray) and the embedded sensors of Incingarette.

Incingarrette provides feedback through a digital photo frame, which is a tablet computer running an application. For every minute of a smoking session, the hardware modules notify the tablet application to change the displayed image, which comes from

a sequence of images of the same photo with increasingly more layers of dirt on it. After a smoking session, the hardware modules notify the tablet application to change the image to show the cleaning-up. To follow the metaphor of dust on windows, the virtual dirt is gradually washed out by virtual rains, again in a sequence of images. Figure 7 shows the digital photo frame and the sample sequences of getting dirty versus cleaning up. Every image in the dirty sequence (upper row) can switch to the corresponding one in the cleaning sequence (lower row). The rate of change of virtual outcomes relative to time during and after smoking depends on the number of minutes set for each image in the sequence. One can set one minute to each image in the dirty sequence and three minutes to each image in the cleaning sequence, resulting in the experience that smoking causes dirt fast, while cleaning up is slow.

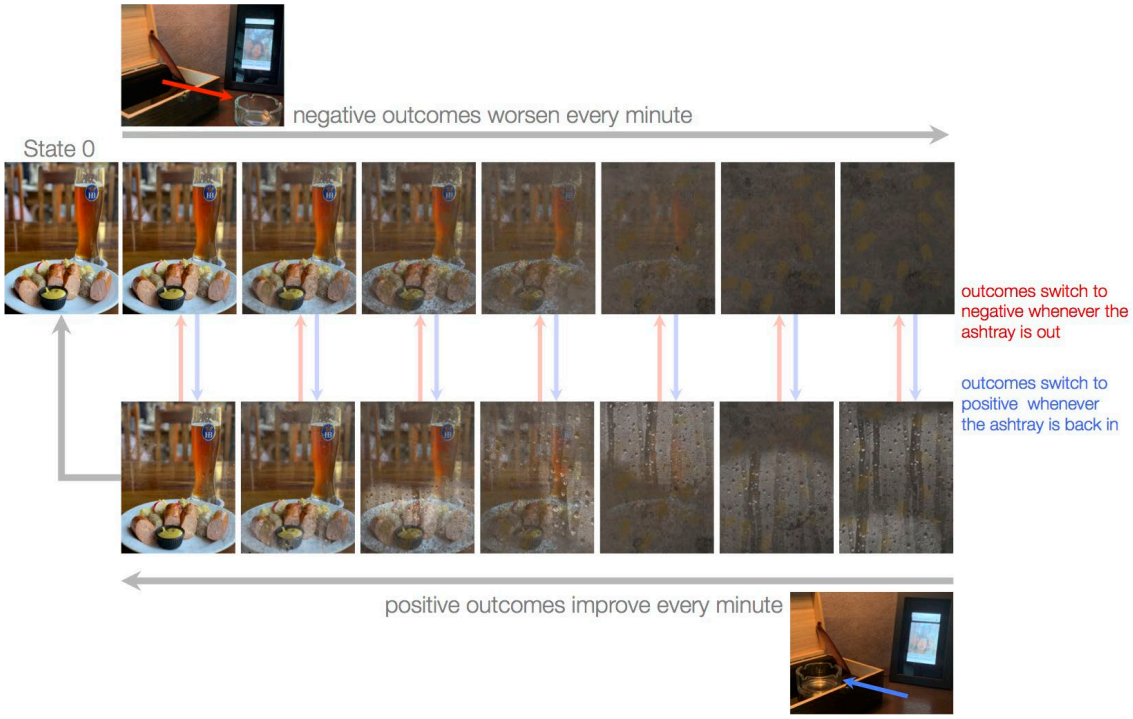


Figure 9. The sequence of images displayed on the photo frame of Incingarette. The upper row is negative outcomes. The lower row is positive outcomes. The blue arrows represent positive changes, while the red arrows represent negative changes.

5. Limitations and Future Work

In this study we derived theoretically grounded framework including design guidelines, which have been applied to generate design ideas as data. The design data is thick in that qualitative variables are well structured. Yet, the data generated from only a single design school can be biased. Although the participating students have different cultural backgrounds, including Chinese, Thai, Indonesian, Indian, and Europeans, the majority is still Asian-centric, and the school atmosphere is also imbued with particular styles. These factors may lead to bias in choosing the comparable scenarios and identifying the positive or negative outcomes.

Due to the potential bias resulted from only one single design school, future work includes applying the framework in a variety of contexts to generate more animated parables for the corpus. The more design data is generated, the clearer the patterns or correlations of the design variables are. Some unnoticed design variables, such as those related to physical experiences, might be uncovered too. It will then inform more boundary conditions for design guidelines and recommendations. More representative parables in the corpus will be considered for developing minimum viable prototypes and evaluating in the field.

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