Provoking Imagination and Emotion with a Lively Mobile Phone: A User Experience Study

Abstract:

Grounded in cognitive semantics in cognitive science and the psychology of emotion, this paper first theoretically articulates the imaginative and affective user experiences of lively interactive artifacts. It then introduces an exemplar of lively interactive products, the mobile phone NEC FOMA N702iS with an intriguing water-level screen interface. Built upon the concept of a glass of water, the design of the phone can provoke users' imagination and emotion regarding resource consumption and conservation, persuading one to take action. To collect empirical data as cross-references to the theoretical framework, user experience tests on an implementation of the interface have been conducted. The qualitative findings show how the interactions at different moments provoke participants via conceptual blends, desires, and appraisals. This demonstrates the application of the proposed framework for interpreting users' meaning-making and emotion elicitation processes.

Research Highlights:

- Review relevant literature including notions of conceptual blending, desire-based emotion, appraisal theory, and others
- Theoretical framework of the interwoven imagination and emotion provoked by lively interactive artifacts at multiple cognitive levels during different moments
- Collect qualitative data from user experience tests on a lively mobile phone interface
- Map qualitative findings to the theoretical framework to articulate what users think and feel in response to the artifact at different levels and moments

1. Introduction

When a user of the OS X system runs fingers over the trackpad and sees pages scrolling along in a window as a result, the user feels like directly moving the pages. If the scroll direction is set in reverse, one might unconsciously imagine the scrolling process as panning a camera over the document instead. In either case, the user's action and perception are cognitively coupled up in a sensorimotor feedback loop, constituting an immediate interpretation of the interaction. In addition, some intriguingly designed interactive artifacts exhibit further changes and provoke user imagination and emotion at higher cognitive levels. Examples can be found in many interactive live wallpaper widgets available on the Android platform, which turn the screen into a window looking out at some natural environments or imaginary landscapes. These widgets usually allow a user to swipe to pan the view, while automatically updating the scene according to the current time of day or the location-specific weather. The user sees the screen not only as a camera in control, but also like a live feed from another place.

Another intriguing example is the mobile phone NEC FOMA N702iS (designed by Oki Sato and Takaya Fukumoto). It features a "water-level" battery meter, which is displayed on the phone's screen as an image looking like water. The subtle movement of the water in the interface prompts the user to tilt the phone, resulting in animation of reactive water graphics (see Figure 1). During these reactive moments, the user has an impulsive desire to tilt and immediately appraises the realistic reaction of the water

graphics. The coupling of action and perception makes the user feel like holding a phone filled with liquid. This sense of illusion supported by the reactive animation comes about pre-reflectively. Meanwhile, the water level descends gradually because it actually indicates the battery level. Noticing the descending water level during these contingent moments, the user literally "sees" and realizes how much battery power is consumed and starts to worry or becomes nervous. It is like he or she would not have enough drinking water for the following daily activities. This feeling emerges from the metaphorical projection between water and electricity, which is a higher cognitive operation.

Drawing upon insights from cognitive semantics in cognitive science, phenomenology in philosophy, and the psychology of emotion, the first author has articulated in length the phenomena of how users perceive, act upon, and respond affectively and imaginatively to "lively" interactive artifacts like the one mentioned above (Author 1, 2013, 2014). Following the humanistic approaches, the earlier work consisted of interpretive analyses, which offered possible meanings from the researcher's perspective about the phenomena, just like critiques in the humanities about a work of art, a film, or an event. Since the interpretations were based on cognitive models and phenomenological notions, the analyses were both cognitive and interpretive. In order to collect empirical data as cross-references to the theoretical framework, the research team are currently working on a funded evaluation study (RGC PolyU 5412/13H) of the user experiences of selected artifacts. It started with an implementation of the water-level interface built by the team on iPhone. User experience tests on the interface have been conducted to collect qualitative data of how imagination and emotion are provoked at different moments via conceptual blends (from cognitive semantics), desires (from phenomenology), and appraisals (from the psychology of emotion). This paper first introduces the above theoretical framework. It then articulates the research design of the user experience study, followed by interpretation of the user responses.

2. Theoretical Framework

2.1 Lively Interactive Artifacts

When interacting with a lively interactive artifact, the user makes meaning through simultaneous engagement of sensory and motor apparatuses. By liveliness, we mean that the artifact provides the possibility of, in J. J. Gibson's words, "affords" (Gibson, 1977), the interactions that are reminiscent of everyday life experience, and the user is able to elaborate imaginations with emotional responses at multiple cognitive levels during different moments.

Reactive moments
First, the artifact allows the user to perform motor input and presents instant sensory feedback or feedforward for the user to perceive. The action and perception are cognitively coupled up in a continuous sensorimotor feedback loop (Figure 2(a)) in the user during these reactive moments. This loop is reminiscent of a slice of life (e.g., panning a camera in the cases of many interactive live wallpaper widgets, holding and tilting a bottle of liquid in the case of N702iS, etc.). The user unconsciously blends the current experience with the past, generating an embodied imaginary concept (e.g.,

a movable panoramic view on the phone, a water-filled phone, etc.) at the immediate, pre-reflective level.

Contingent moments
Secondly, the user is able to perceive extended changes, which are apparently not dependent on the user input. The input to the above loop is temporarily faded in the user's mind (Figure 2(b)). The changes seem to be contingent upon other variables such as time or location (e.g., the background color of a live wallpaper depends on the current time of day, the descending water level depends on the phone usage, etc.). During these contingent moments, the user can invoke an interpretive frame accounting for similar changes (e.g., why it rains both here and there, why water is gone so quick in the bottle, etc.) in a familiar scenario (e.g., it rains everywhere, much water has been consumed, etc.). One can imaginatively elaborate a narrative from the current experience at the metaphorical, reflective level. When noticing the water level descending, the user may elaborate an imagined narrative of consuming too much. Further emotional responses, like anxiety, may result. When seeing the rain on the other side of the screen, one may feel the resonance.

The overall changes demonstrate a kind of "enduring interaction" in which a user is able to make imaginative meaning with emotional responses (Author 1, 2012; Author 1 & Author 2, 2011). The above framework of liveliness is built upon the conceptual blending theory and the appraisal theory.

2.2 Conceptual blends and material-based imagination

When the sensorimotor feedback loop in Figure 2(a) evokes a slice of life, a pervasive cognitive operation called "conceptual blending" takes place. Building upon the earlier concepts of mental spaces (Fauconnier, 1985) and conceptual metaphors (Lakoff & Johnson, 1980), Gilles Fauconnier and Mark Turner (2002) argue that conceptual blending is a basic mental operation that generates new meanings by integrating concepts, forming emergent networks. They analytically point out many cases in common sense meaning making, from understanding a relationship of particular persons in a typical family structure (p. 121), imagining and comparing the records of two runners from different periods on the same trail (p. 41), interpreting a boxing metaphor of the business competition between two CEOs (p. 128), to the integration network emerged from the computer desktop interface (p. 131). Blending is pervasive in many embodied actions like throwing crumbled paper into a trashcan as if playing basketball (Coulson & Fauconnier, 1999), using the desktop interface on a screen like on a table (Imaz & Benyon, 2007), and experiencing augmented reality in games as blended space between the physical and the virtual (Benyon, 2012).

Some blends can be so commonly exercised in everyday life that they become automatic and unnoticed. Fauconnier has cited the computer interface phenomenon as an example of this kind of immediate blend (Fauconnier, 2001, pp. 264-265). For instance, a user dragging a window on a computer desktop slides the mouse on a real horizontal desk. Meanwhile, the user's eyes track the vertically-oriented movement of the graphics on the screen. There are a set of mappings between the physical space and the screen space, including from the mouse to the window, from the mouse click to the act of "picking-up" the window, from forward to up, from backward to down, and so on. Most users, however, feel that they are directly manipulating the window

and unaware of the immediate blend between the computer interface and the experience of sliding a sheet of paper or a physical book on a desk.

During reactive moments, the continuous feedback loop enabled by lively artifacts is analogical to certain sensorimotor experience in everyday life. They have similarities but also subtle differences (e.g., tilting and seeing water waves inside the phone differs from doing so on a bottle of water in weight and force feedback). It is because of these nuances an immediate blend takes place. The similarities are compressed to relations in the blend (e.g., tilting and seeing waves), while the differences are selectively projected to the blend (e.g., the phone is selected but force feedback is left out). The output is an embodied imaginary concept (e.g., a water-filled phone).

During contingent moments, lively artifacts continue to show changes apparently unrelated to user input. A user needs to invoke an interpretive frame (Fillmore, p.232) to account for the changes (e.g., the water level drops due to consumption, the changing background color reflects the current time of day, etc.), followed by recalling a scenario (e.g., finishing a bottle of water, it has been raining everywhere, etc.) comparable to the current experience and blending them to form imagined narratives (e.g., I am consuming the water "inside" the phone) at higher cognitive levels, which Author 1 and 2 call metaphorical blends.

And the overall meaning-making processes, which emerge from users' sensorimotor experiences of the artifacts via conceptual blends, is called "material-based imagination" (Author 1 & Author 2, 2009, 2012).

2.3 Desire, appraisal, and the laws of emotion

Apart from imagination, lively artifacts also elicit emotions from users. During reactive moments, motor action in the feedback loop embodies a user's intention, desire, and so emotion. The phenomenologist Maurice Merleau-Ponty believes that through repeated practice, our body can "absorb" motor knowledge from the environment we inhabit and turn it into situated motor habits (Merleau-Ponty, 1962, pp. 146-147). He called this the "intentional arc," which is the "power of laying out a past in order to move toward a future" (Merleau-Ponty, 1962, pp. 135-136). The intentional arc forms the repertoire that directs bodily action beneath the level of reflective thought. In other words, bodily action embodies one's pre-reflective intention toward a desirable future state. Some thinkers have further argued that pre-reflective bodily action is closely tied to emotion as well. To Roberta De Monticelli, emotions are "vectors of (impulsive) action and of immediate action" (Monticelli, 2006, p. 74). Michelle Maiese points out that emotion is based on one's impulsive, spontaneous, and pre-reflective desire to move the body self-expressively (Maiese, 2011, pp. 62-63). This impulse is our first-order desire of "wanting or not wanting things to be a certain way." For instance, a user of N702iS feeling annoyed by the ring of an incoming call might immediately shake the phone without second thought. This is because the act of shaking fits the intentional arc of starting over something. After repeated use one acquires the habit of shaking away undesirable calls and going back to standby mode. When one feels a need or want, the body spontaneously performs the corresponding movements that constitute embodiment of the desire.

During both reactive and contingent moments, a user assesses the current change against the desired state through perception. In addition to desire, assessment or appraisal constitutes the core of our affect. James A. Russell (2003) believes that "core affect is a continuous assessment of one's current state." This kind of assessment is often done via perception. As De Monticelli puts it, "feeling is essentially the perception of values" of things, and it can be positive or negative (Monticelli, 2006, pp. 65-66). Hence, continuous assessment via perception constitutes our raw feelings. Paul Ekman has also described appraisal of a current event as one of the characteristics of emotion (Ekman, 1992, 1994). He points out that the appraisal mechanism can operate automatically at the primary level or sometimes take place more reflectively at higher cognitive levels. The two mechanisms, namely automatic and extended as Ekman calls it, suggest appraisals of the enduring changes of lively artifacts during reactive and contingent moments respectively. Seeing the reactive animation on the water-level interface, the user automatically appraises if it looks familiar (e.g., a bottle of water or juice). Noticing the water level dropping, one performs extended appraisal to assess if the battery is enough for the rest of the day, and might be worried or at ease.

Lastly, Nico H. Frijda's two particular laws of emotion (1988) among others also add to the emotional appraisal of lively artifacts. First, the law of change specifies that emotions are elicited by "actual or expected changes in favorable or unfavorable conditions." It is the change with respect to the current state that affects how a person feels. The enduring change over both reactive and contingent moments readily provokes users' emotional responses. Second, the law of apparent reality states that emotions are elicited by events that seem to be real. Images, pictures, photographs, sounds or voices, are taken to be more vivid and serious than words. Lively artifacts feature dynamic perceptual images (or other sensory data) and trigger imaginative blends, yielding immersive mental imagery. It follows from the above two laws that users appraise the changes in the imagined situation (e.g., less and less water in the phone, weather in virtual landscape changing with the real, etc.) as vividly real and have emotions (e.g., anxiety, amaze, etc.) elicited.

Table 1 and 2 summarize the theoretical framework.

Table 1 Mapping experiences during reactive moments

Table 2 Mapping experiences during contingent moments

3. The User Experience Study of the Water-level Interface

3.1 Methods and Participants

User experience tests on the water-level interface were conducted in order to collect empirical data of how and what the artifact provokes at different moments in terms of immediate blend (e.g., a slice of life evoked, an embodied imaginary concept yielded, etc.), impulsive desire and automatic appraisal (e.g., emotions elicited), contingent change (e.g., the interpretive frame invoked, a scenario recalled, etc.), metaphorical blend (e.g., an imagined narrative yielded), and extended appraisal (e.g., emotions elicited).

Each test was conducted with one participant at a time. It consisted of a questionnaire session, a laboratory experiment, followed by an in-depth semi-structured interview. The questionnaire was designed to identify the participant's adoption of digital and mobile technologies (e.g., how often one installs new apps, how many gadgets, whether one plays games or listens to music on the smartphone, etc.) and the prior experience of similar kinds of products (e.g., the objects one found most useful versus those most meaningful). It aims to identify their assumptions about technology between functionality and meaning.

The tests took place in our usability study room. The whole process was videotaped, and the researchers observed the participant behind the one-way mirror. The participant was first asked to stay alone in a comfortable sitting room environment set up in the room for about 20 minutes. During the period, the participant had to put aside his or her own phone and was given an iPhone with something to listen. The audio content was an interview of Mark Zuckerberg, which was intended to engage the participant. Meanwhile, the phone came with a simulated implementation of the water-level interface. It displayed reactive animation of water graphics resembling that on N702iS. The graphics included a blue line looking like the water surface, a gradation below the blue line showing the fluid substance, and occasionally a few varied circles representing water bubbles. When the participant tilted the phone, the water surface moved accordingly (Figure 3(a)). When a call came in, the water surface got rough like water ripples, and a message box popped up displaying the caller name, the call number, or just "Unknown caller" (Figure 3 (b)). On shaking, water bubbles showed up and faded out in a few seconds. The participant was told that the principal investigator would call via the phone after a while. If it showed that the caller is the principal investigator, the participant had to answer with a tap. If the call was from others, one had to shook the phone to cancel it. The participant was also reminded to "pay attention to the interface, which showed the battery level" (in exact wordings). Due to the deteriorating battery condition, the water surface started at a level of 70% on the screen and continuingly descended to the bottom in only 16 minutes. When the water level descended to only 20% and 10%, a warning message "Very few water" showed up on the screen (Figure 3 (c)).

During the process, the participant was free to browse through the magazines, look out the window, or just lay back. The researchers photographed every time a participant looking at the interface and jotted down what the participant did with it. The notes included whether the participant tilted the phone aimlessly, shook it quickly, put it aside, or just had a glance at it. The notes taken could be immediately referred by the researchers during interview. For example, if a participant did not tilt the phone until the first call came, the researchers would ask about this. The videotaped footage was kept for retrospective reference.

The in-depth interview was semi-structured in that an outline of questions was prepared but re-arrangement and partial elaboration were possible. The outline roughly reflected the timeline of the expected user experience based on the theoretical framework, that is, from reactive moments to contingent moments. The questions for the reactive moments include those related to immediate blends, impulsive desires, and automatic appraisals. Regarding emotions probing, emoticons are used to cross-check verbal descriptions. The questions for the contingent moments start with those about contingent changes, imagined narratives, metaphorical blends, and extended

appraisals. Sometimes, more elaborate questions need to be raised to invoke different interpretive frames for further discussion. Table 3 summarizes the questions according to the proposed framework.

Table 3. Questions asked during interviews refer to the theoretical framework

Twenty participants, six females and fourteen males, have taken the test. Six of them are at the age between 18 and 25, nine are at the age between 25 and 35, and the remaining five are above 35. They are all educated at least the tertiary level and from various disciplines, including six in Design, four in Business and Management, four in Language and Humanities, one in Cognitive Science, two in Information Engineering, two in Multimedia, and one in Statistics. Their cultural backgrounds are diverse with 13 participants influenced by Chinese cultures (Hong Kong or Mainland China), two from the Philippines, two Canadians, one Australian, one Indian, and one Columbian. The questionnaire results show that they all use smartphones, with good exposure and accessibility to digital and mobile technologies.

3.2 Qualitative Findings

This study concentrates on qualitative data such as participants' bodily action and gestures during the experiments, and their quotes during the interviews, which reveal their thoughts and feelings.

Initial exploration with the interface
10 out of 20 participants started with exploring the interface at the very beginning. They tilted the phone arbitrarily to different directions and looked at the reactive animation on the screen. Note that none of them were told of the reactive animation during the introduction. They just saw the subtle movement of the on-screen graphics (e.g., the blue line) seemingly responding to the phone orientation. The other eight participants were caught by the audio content right after the start of the test and only paid more attention to the interface after the first call. The remaining two participants focused on browsing magazines and ignored the interface most of the time unless there was a call. No participant had tried to shake or rotate the phone vigorously before the first call came in.

Listening to the audio content
Nearly all participants were interested in the given audio content (the talk). Some said that they even forgot there would be incoming calls, and so felt annoyed, distracted, or uncomfortable when the phone rang at the first time.

Reaction to incoming calls
All participants said they felt slightly shocked with the first ring because it interrupted the talk. They wanted to get rid of it. All participants could see the message about an incoming call, but just four of them did mention the rough water ripples during ring. Their attention was mostly drawn to the message box.

All participants seemed hesitant for a second about the first ring and then tested with the way and magnitude of shaking in order to cancel it. After the first call, all participants then reacted very quickly to other following calls by shaking the phone. This was in contrast to the gentle exploration with the interface at the beginning of the

test. They all found the action of shaking to cancel a call became easy and straightforward to do. At least eight of them mentioned in the interviews that they saw "bubbles" when shaking the phone.

Immediate blends and embodied imaginary concepts

- Liquid containers

When being asked about the first impression of the interface, participants initially mentioned some kinds of liquid containers, including very mundane examples like "glass/cup/bottle of water" (4/3/2 participants), "juice box" (1 participant), "fish tank/bowl or aquarium" (6 participants), and "swimming pool" (2 participants).

For instance, Participant AL said, "it moves like water trapped in the cell." On the other hand, Participant XC mentioned "gel or pudding in a plastic bag", and Participant WL said "oil in a bottle", largely due to the perceived lower fluidity of the animated graphics compared with real water.

- With hand movements

In addition to glass/cup/bottle of water and juice box, more cases imply hand movements, including "spirit level" (4 participants), "water inside goggles when swimming" (1 participant), "glass ball toys with water and maybe snowflakes inside" (2 participants). These cases were informative as they showed participants' unconscious cognitive mappings with the motor action of moving or even shaking container filled with liquid.

- Without hand movements

On the other hand, two participants (AN and KW) recalled "lava lamp", which revealed their focus more on sensory perception of emergent fluid movement than their own motor action. The bias toward the sensory side was even more obvious when two participants (CA and AL) pointed out that the waves of calls reminded of the cardiograph instruments in hospitals.

Noticing the change in water level

All participants became aware of the descending water level at certain moments, but at least two of them (LL and EL) said that they only noticed it until the warning message popped up. They were much engaged in the talk and had paid less attention to the interface.

Contingent changes and interpretive frames

- Leaking or draining

A few participants unconsciously attributed the descending water level to some kinds of leaking or draining, revealed by their sayings. For instance:

"The line drained, …" (AL)
"Like a bottle of water with a hole in the bottom and water is leaking out." (LL)
"Toilet, as you can flush the water away." (SH)
"Because the phone was kept flat, the water may have flowed out?" (CL)
"Pulling the plug of the sink and water drains." (WL)

- Passage of time

Among various kinds of draining, four participants (JU, SZ, EL, and WL) mentioned about “hourglass” during interviews. This was informative. First, the substance was not liquid. Secondly, the artifact related the sense of directional change (descending) to time, which was distinct from other kinds of draining. The four participants saw the gradual change in water level as passage of time, and the interface as a timer.

Two other participants (GY, AN) explicitly said the water level is about time. Some related the change to the timeline of the talk, or saw it as approaching deadlines. For instance, Participant EL said, “Deadlines, time is less and less, and one still has a lot of things to do.”

- Consumption of limited resources

On the other hand, many participants assumed it was a result of consumption. Those mentioning deadlines or schedules actually saw not only the passage of time but also the consumption of it, because there is a time limit. Others recalled scenarios of various forms of consumption, including drinking water or juice (JA, JU, XC, XX, OL), using everyday commodities (KW, XC), eating candies (KW), spending money (EL), and even consuming game character energy (SZ, HE). The materials varied from fluid to solid, the intangible, and the virtual. The following are their quotes grouped according to the kinds of materials.

Fluid:

“I’m consuming the water.” (JA)

“Water dispenser, at certain duration you need to change the next bottle.” (JU)

“Looks like the water machine, after you use it, it becomes empty.” (XC)

“I recalled the juice box, only very little left in the corner.” (XX)

“Drinking a glass of juice using straw.” (OL)

“Oil container in kitchen, shampoo in bathroom - visually we don’t see the gradual change.” (KW)

“Fuels in cars.” (SH)

Solid:

“Rice in the bag, and we cook every day. Or oil in the bottle.” (XC)

“Similar to a jar with lots of candies, and as you pick the candies, it gets empty.” (KW)

“When you eat or drink something, it gets less in the process.” (CA)

Intangible:

“Money becomes less and less with everyday shopping and eating.” (EL)

Virtual:

“Fighting games - energy bar to show how much energy the player got.” (SZ)

“In games, life level of character tends to drop very fast.” (HE)

Metaphorical blends

- Replenishment of resources

Some participants in addition thought of replenishment after consumption, like the above saying by JU about changing bottles for the water dispenser. Some mentioned refilling cars with gasoline. Some further imagined ways of replenishment of the battery power.

"Cars need gasoline and has a meter." (SZ)
"Putting gasoline in the car engine." (OL)
"How to gain back the water level or recharge." (SH)
"Like hourglass, it's been empty out; I think if we flip it over, it will refill." (JU)
"Had I shake the phone longer, it'd have filled up the water!" (JO)

The above imaginative thoughts are in fact very inspirational for next generation of the design. For example, the idea of shaking to power up can be a good initiative toward human-powered design. This can be regarded as a demonstration of co-design.

When being asked about the relations between water and energy, some participants spoke of the physical connection (e.g., "use water to generate electricity"). On the other hand, many could tell the analogical connection that both are limited, non-renewable, scarce resources, although they are in different and even contrasting forms.

"Water is liquid but electricity is fire. Similarities like going through channels or passing through some pipes." (JU)
"Battery is solid, but in the mind, the small battery icon with some container and some level going down, which looks like solid, but metaphorically it's a container and fluid going down." (MO)

From implicitly invoking interpretive frames to explicitly talking about the analogical connection, participants were aware of the limited resource in their phones.

Extended appraisals of enduring changes
Four participants seemed to be indifferent to the dramatic drop in the water level, because they saw just a test, and it was not their phones. All other participants had certain degrees of anxiety. As said above, two of them (JU and JO) did come up with imaginative ways of replenishment ("flip it over" and "shake it longer"). Some of them tried to save the battery. For example, Participant OL put the phone horizontal to save the battery as this turned the screen off. Two participants (XC and EL) turned down the volume "to stop the water from leaking".

4. Interpretive Analyses

4.1 During reactive moments

All participants were initially appealed to the reactive animated graphics on the interface. They had a quick desire to tilt the phone and checked the resulting movement. The feedback then invited further motor action from each participant, mobilizing the sensorimotor feedback loop in each of them. This feedback loop lasted for a while until a participant lost the interest. Some participants saw the interface as a glass, bottle, plastic bag (as one could see it through) of water (because of the bluish

color) or oil (due to the fluidity), or a spirit level (because one tilted it left and right). The sensorimotor experience of tilting the phone and checking the graphics on the interface was analogical to that of moving a container with liquid inside. The compression of the analogical mapping resulted in immediate imaginative blends, which were “water trapped in the cell” or “oil in a plastic bag” as said by participants.

Later when a call came, participants felt annoyed because it interrupted the talk. One had an impulsive desire to get rid of it and so shook the phone quickly. Some participants saw the bubbles and rough waves. During these reactive moments, they recalled those glass ball toys with water and other little flakes inside. The reactive graphics on the interface resembled the little flakes scrambled inside the glass ball. The resulting immediate blends in this case included shaking to start over, go back or jump to something desirable (e.g., the standby mode). Participant JO was particularly familiar with this gesture, because he did it often to shuffle or jump to next song in his music player. He even imagined if different types of shake could send different messages to the caller, like a severe one representing “go away” or a gentle one meaning “not available now, please call later”.

We illustrate the affective and cognitive processes based on Fauconnier and Turner’s integration diagrams (Fauconnier & Turner, 2002). An integration diagram consists of circles representing mental spaces, each of which contains conceptual elements of a scenario, such as actors, objects, actions, or relations. The two horizontal spaces are input for the blend, while the one below is the output. The horizontal solid lines between the two input spaces are links connecting the counterparts respectively. These outer-space links are compressed into inner-space relations inside the blend. Other elements are only selectively projected from either input to the blend. Figure 4(a) shows the reactive moments. What we add to the integration diagram includes the sensorimotor feedback loop, which envelops motor action and sensory perception in the space. The left input is the current experience provided by a lively interactive object featuring a loop mobilized by impulsive desire and automatic appraisal, which is analogical to a past experience denoted by the right input. The result is an immediate blend. The texts in red represent the imaginary thoughts (e.g., “water trapped in the cell”) and feelings (e.g., interested) of the user.

4.2 During contingent moments

Participants started to notice the descending water after some time. Based on the things they recalled, some of them seemed to attribute the change to a time limit (e.g., hourglass, a bottle with a hole, deadlines, etc.). As said, it can be regarded as consumption of time. Some others thought of more tangible resource consumption (e.g., water, oil, fuel, food, etc.). The consumption frame was invoked in their minds. A past experience came to one’s mind (e.g., flipping the hourglass over when playing the word game Boggle, emptying out a water machine, picking candies from a jar, etc.). Metaphorical blends of these past experiences with the phone interface yielded imagined narratives in apparent reality. One literally saw how much was consumed.

Four participants (JO, JU, XC, EL) went further to the conservation frame. They imagined different ways to save the juice or to refill the water based on some past experiences (e.g., turning down the volume, flipping the phone over, shaking the phone longer, etc.). They knew water or juice has very different physical materiality

than electricity, but all need our conservation. They tried to or actually took action to save the limited resource during the tests. To them, the interface was a visible, evocative, and persuasive reminder of energy conservation. Since the experiments were done in laboratory, some participants did not see the phone as their own phones. If the interface were to be used in real life, more users would be triggered. Figure 4(b) illustrates a possible blend during the contingent moments. The loop is partly faded in the user's mind, but perceivable changes continue in the lively interactive object. An interpretation frame (in red) is invoked by the user, and a metaphorical blend is resulted. This gives rise to an imagined narrative (in red, e.g., "I'm consuming") and elicits emotions (in red, e.g., anxious).

Just like most of the battery indicators, the water-level interface was able to elicit emotions like anxiety when the power was running low. In addition, the novel "water" metaphor triggered some imaginative thoughts in the participants, associating with their mundane past experiences like flipping an hourglass. Whether this kind of provocation would lead to behavior change in users' everyday lives, such as reducing unnecessary usage of gadgets in order to save energy, is still largely uncertain. With current promising findings in the laboratory environment, we believe if a user continuingly and intermittently interacts with this interface on the phone in real everyday life, more frequent resonating thoughts will be incited. For example, when one is picking up a bottle of beverage in a grocery store, he or she might remember the "water" in the own phone, recalling the message "save the power, save the juice!" And this requires more experiments of deploying a working prototype of the interface on a participant's own phone and testing it "in the wild" for a period of time.

5. Limitations and Future Work

Based on a rigorous theoretical framework and earlier cognitive and interpretive analyses from the researcher perspective, we conduct user experience study of the water-level interface in order to collect empirical data as cross-references. The findings from the user perspective provide informative samples for our interpretive analyses in terms of possible impulsive desires, automatic appraisals, immediate blends, interpretive frames invoked, extended appraisals of the overall experience, and metaphorical blends. With 20 participants, from young adults to the early middle-aged, of diverse educational and professional backgrounds, and all using smartphones, the samples represent how a group of urban population is provoked by a lively mobile phone. The results show that they might see the phone as a liquid container and then invoke interpretive frames like consumption to account for the drain of liquid.

The study has been conducted in a controlled laboratory environment. In pilot study of the research design process, we have explored different arrangements, such as the choice of the audio content and descending rate of the water level, in order to maintain participants' attention to the interface and also minimize intervention. The advantage of this is to have a set of comparable samples from different users. Yet, the downside is that the results are isolated from any real-life context. Participants did not use their own phones, and they experienced the interface in an environment detached from their daily lives. Future work will be installing the interface in a participant's own phone and let one use it in real life for a period of time (e.g., 3 days). In addition to retrospective interviews, prospective experience sampling will be needed, which will be a challenge too.

This paper focuses on discussing the possible blends and interpretive frames triggered in users. Since interpretation and imagination can be dependent on a wide array of factors, including both intrinsic (e.g., personality traits, memories, past experiences, moods, etc.) and extrinsic (e.g., current physical and mental status) ones, the research results, instead of capturing universal or typical patterns, actually bring us representative samples for convincing interpretative analyses that balance the views of the researcher and the user. The approach is qualitative.

In fact, the participants have been surveyed in the questionnaires on their individual attachment to digital media (e.g., what kinds of apps installed on their smartphones, how often they play mobile games, etc.), daily engagement in thinking (e.g., what kinds of movies they like, how often they read books, etc.), and attribution of meaning to objects (e.g., the most meaningful, compared with functional, objects to them). Further analyses can be performed to identify any correlation between the above parameters and individual outcomes of material-based imagination, for example, the levels of blends.

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Figure Captions:

Figure 1. The mobile phone N702iS whose battery level is indicated via the illusion of water inside the phone.

Figure 2(a) An immediate feedback loop between a user and a lively interactive object during reactive moments

Figure 2(b) Extended changes apparently not dependent on user action during contingent moments

Figure 3 (a-c) The implementation of the water-level interface on iPhone reacts to user tilt, shows rough waves on incoming calls, and displays warning messages when the level is low.

Figure 4(a) Impulsive desire, automatic appraisal, and immediate blend triggered by the water-level interface during reactive moments.

Figure 4(b) Metaphorical blend and extended appraisal enabled by the water-level interface during contingent moments.