Artifact: Journal of Design Practice
Volume 5 Number 2
 doi: 10.1386/art_00002_1

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Afforded exploration: An approach to novel yet understandable product experiences

ABSTRACT

A product's form and related affordances, together with interaction possibilities, have a significant influence on the user's emotional response. Although interaction influences the user's product experience, little is known of how product interaction may best provide opportunities for novel yet understandably familiar product-user experiences. The purpose of this study is to contribute to understanding the contradictory relationship between novelty and acceptability in product design, with a focus on product interaction. Adopting a research-through-design approach, four bottle designs were developed and prototyped. Two dichotomous theoretical constructs were applied to the four designs: Explanatory-Affordance, Exploratory-Affordance, Explanatory-DisAffordance and Exploratory-DisAffordance-Based designs. The four constructs broadly relate to the types of product interactions afforded through interaction with the four bottle designs. Affordance and DisAffordance-Based designs refer to the product's ability to afford an understanding of use through form and other signifiers. Explanatory-Exploratory-Based design suggests the extent to which a user may exploratively interact with the product. The four bottle designs were used as stimuli to collect participants' emotional response under controlled conditions. We confirmed the significant impact of an exploitive approach to product

KEYWORDS

product interaction
product design
research-through-design
design & emotion
design affordance
design novelty

interaction for increased positive response and stimulation of novelty in product appraisal. Moreover, affordance, while not stimulating positive emotion on its own, may provide opportunity for reassurance and acceptability during product interaction when combined with an explorative design approach.

1. INTRODUCTION

Much work has been undertaken to explore emotional response during product interaction. For example, Bornemann et al. (2015) examined relations between design-related, product aspects and the assessment of firm value to discuss aesthetic, ergonomic and symbolic value as positively or negatively influencing market reaction. Hung and Chen (2012) explored how novelty may influence product design preferences, highlighting a number of dimensions of aesthetic preference in product design. Khalaj and Pedgley (2014) examined the translation of the designer's intended impressions of a product in contrast to user impressions. Findings indicate how the translation of semantic intent may be dependent on the novelty of design. In other studies, Lee et al. (2016) investigate how novel product form may influence assessment of product innovation. Other research on innovation suggests a dichotomy between the need for, on the one hand, novelty and, on the other, acceptability, where the acceptable is described as a need for understandable typicality (Hekkert et al. 2003; Hung and Chen 2012; CMG Worldwide 2015). Notably, Hekkert et al. (2003) describe an interaction effect between novelty and typicality in deciding aesthetic preferences.

Norman (2002) describes the ways in which products may express how they can be used to achieve a functional purpose through the concept of affordance. The current study indicates how the absence of affordance in product interaction may stimulate exploration, in turn resulting in product interactions that better satisfy a contradictory need for both novel yet understandably typical product-user experiences. Our investigation thus also plays into the requirement for novel products to be both emotionally stimulating (novel) and practically understandable (typical). How can we design novel product experiences and at the same time satisfy a need for understanding based on a product's pragmatic function? This was the starting point and inspiration for our investigation.

Applying two dichotomous constructs (*Affordance-DisAffordance-Based* and *Explanatory-Explorative-Based* design; see Section 2) we designed and prototyped four design stimuli. The four stimuli (see Section 5.1) were then used to gather participant responses to indicate the nature of the product-user experience in its ability to provide novel product experiences, while at the same time meeting a contradictory need for typicality.

2. AFFORDANCE AND DISAFFORDANCE-BASED DESIGN

Products may express how they are to be used through their physical form, material and colour choices. For example, a handle on a coffee cup may afford holding; a button or slider may indicate the necessity of a physical interaction (pushing or sliding).

In this way, and adopting Gibson's original work on a theory of *affordance* (1979), Norman (2002) uses the term *product affordance* to refer to action

Figure 1: Affordance in design. The Norman door (Norman 2002).

possibilities that are readily perceivable by a user prior to product use. Norman (2002) further describes the concept as dependent on both the physical and cognitive capabilities of the user, resulting from interaction between user and product, its forms, materials and characteristics as offering certain opportunities for how interactions may lead to a goal state of use. Norman's (2002) focus on physical affordance presupposes interaction as dependent on past experiences. People recognize the affordance through past experience of how the product works and is to be used. The often-used example of affordance in design is the Norman door (Figure 1).

The door handle illustrated in Figure 1 affords pushing. However, the sign plate on the door instructs the user to pull. The door is an example of a miss-match or perceptual gap between the physical affordances of the handle design and the way the door must be used to allow entry. However, due to the current study's aim of exploring product design interactions that may best satisfy the need for both novel and typical product experiences, we introduce the term *DisAffordance-Based* design to describe the extent to which a product's design does not provide obvious physical affordances to indicate use. Thus, we investigate if physical *DisAffordance-Based* design can lead to explorative product interaction to provide users with more novel product experiences.

3. EXPLOITATIVE AND EXPLANATORY-BASED DESIGN

Together with Norman's (2002) affordance construct, Buur and Stienstra (2007) described *explorative interaction* design in contrast to explanatory interaction design. Here the focus is on the activity of the interaction, in contrast to any affordances evident prior to use. In this sense, an explorative interaction may be described as requiring a level of search and identify to achieve the required goal state. This contrasts with an explanatory interaction, whereby the user is provided a clear understanding of how interaction will result in reaching a goal state of product use and so use will proceed with full understanding and predictable results (Figure 2).

As indicated in Figure 2, a standard bottle top design for a carbonated beverage is clearly explanatory in the kind of interaction required to achieve the goal state (open bottle). The user will engage an activity where no explorative interaction is required or engaged. However, the Cubis design (Steeman 2009)

Figure 2: Standard carbonated bottle top design, left. Cubis bottle design, right (Steeman 2009).

requires a degree of exploration before the relation between interaction and goal is comprehended. The explanatory nature of the bottle top, and so its comprehensibility, is of course dependent on the extent to which the user's past experience of similar products and their use may map onto a product interaction. However, the current study does not examine this question. Instead we make the assumption that the interaction pictured (Figure 2, left) is an example of product interaction that exemplifies affordance (Norman 2002), and so allowing a purely explanatory interaction (Buur and Stienstra 2007).

Studies of product interaction have shown that physical interaction affects emotional response to the product (Demir et al. 2009; Desmet and Hekkert 2007; Desmet et al. 2008). For example, in the study by Demir et al. (2009), product interaction is described as dependent on physical manipulation of the product, together with other sensory modalities (visual, smell, auditory). Thus, the Desmet et al. (2008) study indicates the important role of affordance and interaction in stimulating emotional response during product interaction.

The nature of emotional response to product use as dependent on novelty has also been described through Verganti's (2008) design-driven innovation model. According to the model, product novelty can lead to radical change in meaning. Here Verganti (2008) describes meaning as related to the meaning of a product experience: playful verses practical for example. Thus Verganti (2008) presupposes that radical changes in meaning can lead to new and exciting product experience. The Nintendo Wii is offered as an example in the gaming space through the introduction of a novel interaction type and associated, more inclusive game playing.

However, as stated by Lowry's (CMG Worldwide 2015) MAYA maxim of most advanced yet acceptable, for products to succeed in terms of elicitation of positive emotion through experience of the novel, they must at the same time be acceptable. Hekkert et al. (2003), in an earlier work, describe a tension between novelty and a human desire for typicality. Here typicality is described as a contradictory desire for certainty and expectability related to a need for understandable familiarity.

As such the current study examines how the contradictor requirements of product novelty and understandable typicality in user–product experience may best be achieved when experience is described through affordance, or the lack thereof, and the resulting level of exploration required to achieve product function.

To achieve this we manipulate the two dichotomous constructs *Affordance-vs. DisAffordance-Based* design. The current study uses these terms to describe the product's features (form[s], materials), their ability to express how the product may be used to achieve its function. This affordance precedes the

actual use of the product during the initial product experience. We employ the construct of *Explanatory vs. Explorative* design to describe a connectedness to the goal state, and level of exploration required to achieve it *during product interaction*. This relates to Buur and Stienstra (2007) notion of the extent of mapping between interaction and objective. The extent to which interaction proceeds with a clear mapping between interaction and objective.

4. RESEARCH AIMS

Exploring variations in product interaction, we aimed to examine the influence of interaction methods on emotional response during user–product interaction and to then consider the results in terms need for both novelty and understandable typicality in design. With these research aims in mind we addressed the following research question:

- What is the potential for affordance and/or explorative interaction design to satisfy both novelty and understandable typicality in user–product experiences?

5. METHODS

5.1 Research-through-design

A *research-through-design* (RtD) approach was adopted to examine the influence of interaction type (defined by the two dichotomous constructs *Affordance-DisAffordance-* and *Explanatory-Exploratory-Based* design) on response to the user–product experience (Figure 3). Our RtD approach provided an opportunity to better isolate and examine how the interaction types affected the participants' emotional response to the product interaction (Frens 2007). We then compared these results to examine implications for providing both product novelty and typicality in user–product experiences.

The RtD approach drove the design and development of four products that attempted to embed the constructs: *Affordance-DisAffordance-* and *Explanatory-Exploratory-Based* design. These were then used as stimuli to gather participant response to product interaction through the PreMo self-report tool (SusanGroup 2017). Following this, an evaluation of the products themselves was performed through semantic differential scales. The act of opening a disposable bottle was chosen as product interaction, with the RtD process resulting in the design and development of four bottle-top interaction types (Figure 3).

At top-right (Figure 3), the *Screw* design simulated a standard bottle-top design and is described as an *Affordance-Explanatory-Based* design. The *Explanatory-Affordance* Screw design was used as a baseline control.

In contrast, the *Push* design (Figure 3, bottom-left) embeds a *DisAffordance-Exploratory* approach to achieve opening, with the user required to turn and push the bottle top, resulting in a nozzle spout emerging from the cap. In this sense it is unclear how the physical properties of the design may achieve the interaction goal (*DisAffordance*), with interaction requiring a level of exploration (*Exploratory*) to achieve the required goal state.

The *Push and Screw* design (Figure 3, top-left) requires the user to push down on the cap to engage the screw-thread before unscrewing, thus embedding *Explanatory-DisAffordance-Based* design. It is explanatory because no exploration is required during interaction (it is clear how the lid must be turned to

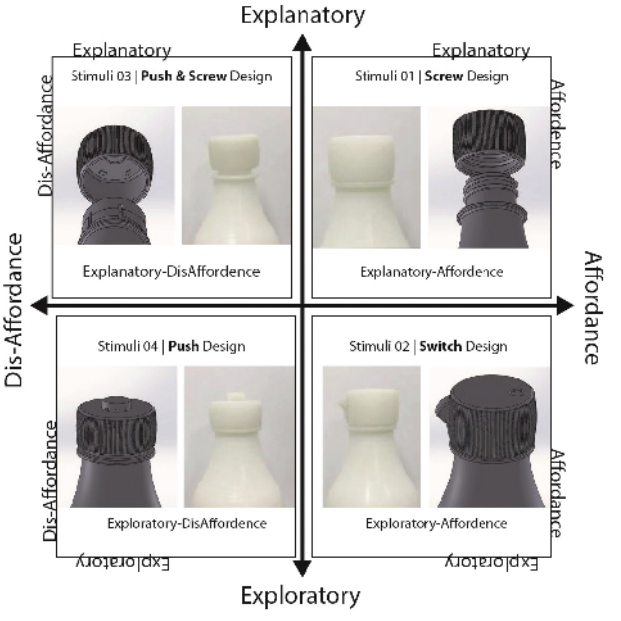

Figure 3: Four bottle lid designs and relation to interaction types.

achieve the goal state, as with the standard screw design). *DisAffordance* is due to the lack of any indication of the opening mechanism from the design's form (a standard screw-top cap does not provide indication of the push-down action required to open the bottle).

Finally, the design illustrated on the bottom right (Figure 3, switch) provides a switch that, upon pushing, opens a flow hole in the top of the cap. This design we position as exemplifying affordance (a switch affords pushing) and exploration (it is unclear what will happen once the switch is pushed). The final four design prototype stimuli are further illustrated in Figure 4.

Figure 4: Final four design stimuli embedding and expressing two conceptual constructs: affordance and exploration.

The use of each of the four design stimuli is further illustrated in Figure 5.

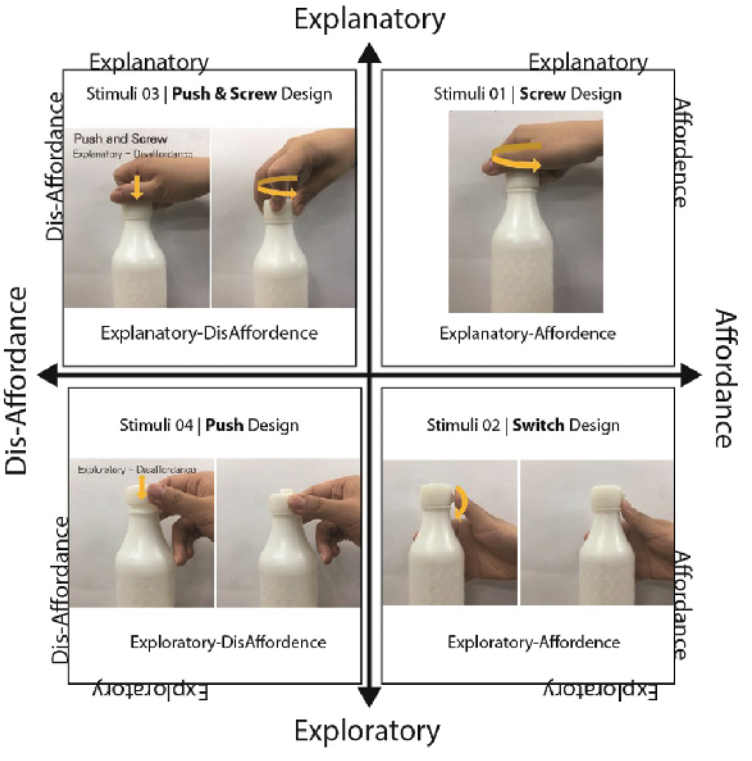

Figure 5: Four bottle-top design stimuli in use.

In the design of the four stimuli we have attempted to embed interactions representative of the four interaction types. However, we admit that the four designs were not subjected to a validation study, that may have provided evidence of their reliability as representative of the four interaction types. This notwithstanding, we do consider the current study an important step in contributing to a discussion of how different interactions, defined through the two dichotomous constructs, may implicate response to the product experience.

5.2 Participants

We recruited a total of twenty participants (n = 20). All were full-time under- or post-graduate students studying for degrees at the researchers' home institution. The sample group consisted of twelve males and eight females, with an age range of 19–32 years. The participants self-volunteered for the study through a university-wide online platform. Although a relatively small sample with a wide age range was used, we position the results as an initial attempt to explore the implications for the product experience in terms of the four interaction types. Further studies may wish to control for the many other variables that can influence response during product interaction (i.e. age, gender, personality traits, etc.). All participants were in

good health at the time of the study. Sessions were conducted during office hours (9:00–18:00). No instructions were provided to participants prior to their session.

5.3 Research instruments

PrEmo (SusanGroup 2017) was used to gather participants' emotional response to the four designed stimuli (Figure 5). Because respondents do not express their feelings in words using the Premio tool, it can be used cross-culturally to measure the apparent emotion. It can also be used to measure one or more emotions that are experienced at the same time, achieved through fourteen measured emotions, depicted as animations of moving motion and voice expressions, respectively.

Using the PrEmo interface, each icon is activated by clicking on the image. The icon then expresses a specific emotion through a short animation and participants can record responses dependent on the degree to which they feel the emotion. As such we anticipated the use of PrEmo as providing response data to address the study's research aims of exploring novelty and typicality of product experience through more or less affordance and/or exploration.

Following the PrEmo study, semantic differential scales (SDs) were used to further measure subject responses (Figure 7).

The SD scales were taken from Khalaj and Pedgley's (2014) validated set of *Product Personality* semantic scales. Thus, although the validated scales did not map directly onto the current study's research aims, they were used as a validated set to provide further indication of participant responses to the four designs.

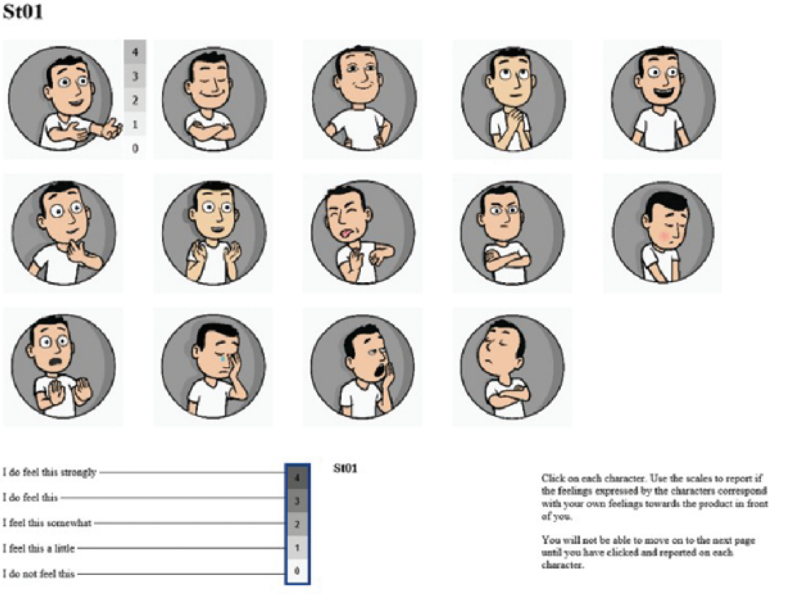

Figure 6: The PrEmo interface (SusanGroup 2017).

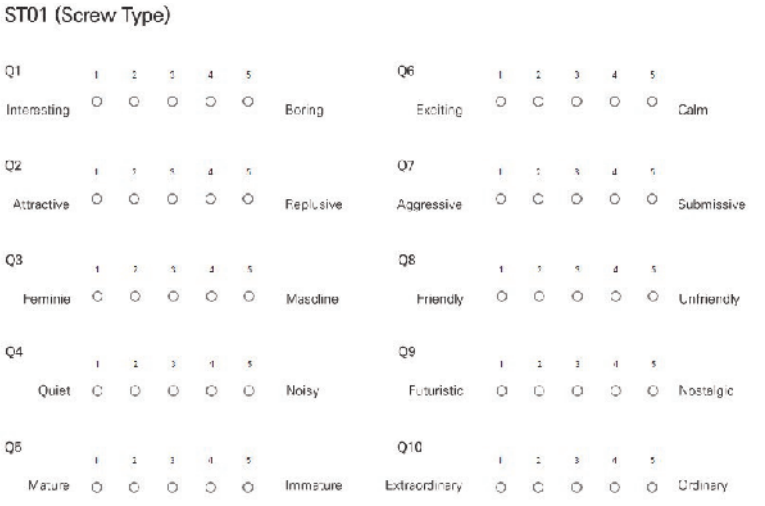

Figure 7: Self-report response sheet consisting of ten semantic differential scales (Khalaj and Pedgley 2014).

5.4 Experimental design

The experiment was conducted in three stages. First, a description of the PrEmo tool was provided and participants were asked to pour water into a cup. In a repeated-measures design, each of the four stimuli was introduced in turn, randomized to reduce order effect (Figure 8).

Subsequent to each pouring, subjects were asked to record their response through the PrEmo tool. Next, the ten SD-scales (Figure 7) were introduced and participants were requested to record their response across each of the four stimuli through four sets of the ten SD questions, with the four stimuli evaluated together, rather than in turn, and responses recorded through the four SD-scale sets. Finally, participants were asked the following open questions.

- Which bottle did you like the most? Why do you think this?
- Which bottle did you like the least? Why do you think this?

The results for the final open questions above are not reported in the current article. The experiment sessions were video recorded and recordings were archived for later analysis.

Figure 8: Experimental session in progress. Participant interacting with screw-type design.

6. RESULTS

6.1 Emotional response to physical interaction

A one-way between-subjects ANOVA analysis was run to compare the effect of the four stimuli expressing the interaction types (*Explanatory-Affordance Screw-*, *Exploratory-Affordance Switch-*, *Explanatory-DisAffordance Push and Screw-* and *Exploratory-DisAffordance-Based Push* design). Table 1 illustrates the results for five (of fourteen) PrEmo response items that showed statistically significant differences in the mean ($\bar{x}$) response.

Figure 9 graphically illustrates data presented in Table 1 for each of the five statistically different responses across the four stimuli designs. The graph highlights stimuli that resulted in significantly different response from the standard screw design (*Explanatory-Affordance*) according to post-hoc tests (Tukey HSD).

As indicated in Figure 9, a significant difference between the four stimuli in terms admiration (Figure 9, left, $F[2,76]=6.479$, $p= 0.001$) was identified, with a post-hoc comparison indicating response scores for the *Exploratory-Affordance-Based Switch* design (Figure 9, *admiration*, green-bar) and *Push* design (red bar) as significantly different from the standard, *Explanatory-Affordance Screw*

	Screw type	Switch type	Push and screw type	Push type	*F*	Sig.
Admiration	0.9500	2.2500	1.6000	2.4500	6.479	**0.001
Fascination	1.4000	2.9500	1.6500	2.7000	8.835	**0.000
Hope	0.8000	1.9500	1.5000	1.6500	3.232	*0.027
Joy	1.3000	2.8000	1.3500	2.5000	6.972	**0.000
Boredom	2.1000	0.3500	1.1000	0.2000	20.751	**0.000

Notes: *p<0.05; **p<0.001.

Table 1: Emotional ANOVA.

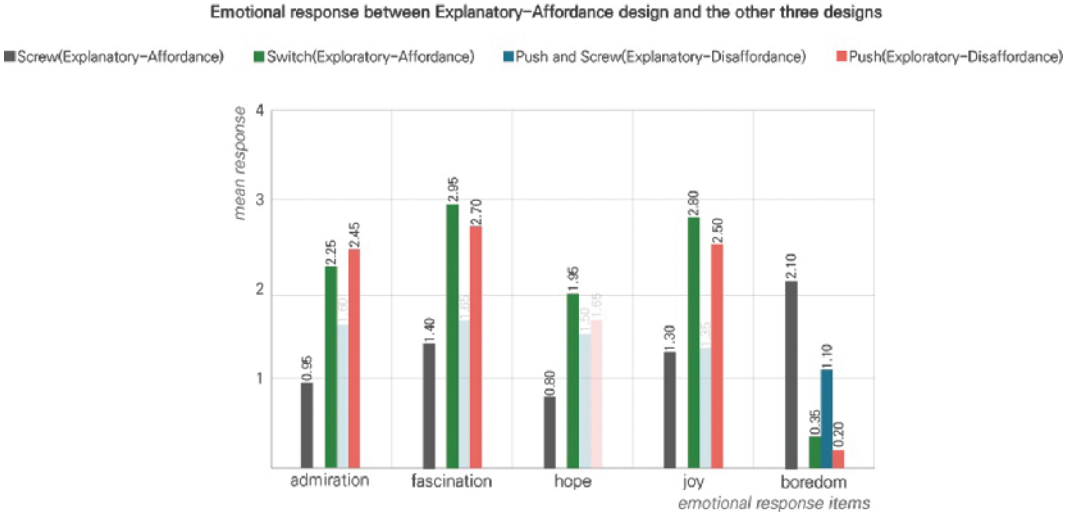

Figure 9: Comparison of significant difference in emotional response between four designs.

design (grey-bar). This result suggested that an explorative interaction (what will the switch do?) was admired by participants. In contrast, the *Explanatory-DisAffordance Push and Screw* design (Figure 9, *admiration*, blue-bar) showed no significant difference in admiration response from the standard *Explanatory-Affordance Screw* design, indicating a combination of a lack of affordance and no exploration in interaction as suppressing feelings of admiration. Taken together, these results indicated that the explorative interactions (*Switch* and *Push* designs), irrespective of affordance, resulted in significantly increased feelings of *admiration* towards product interaction compared to the standard *Screw*-type design.

Response in terms *fascination* (Figure 9, second from left) also showed significant differences between the four design stimuli ($F[3,76]=8.83$, $p=0.000$). The post-hoc test revealed a significant difference between the standard *Explanatory-Affordance-Based Screw* design and the *Exploratory-Affordance Switch* design (Figure 9, green-bars), indicating, together with stimulating feelings of *admiration*, that the *Switch* design also significantly increased *fascination*. Interestingly, a significant difference was also found in responses towards *Hope*, although at a lower level of significant ($F[3,76]=3.232$, $p=0.027$). Subjects showed significant differences in emotional responses between the *Explanatory-Affordance-Based Switch* design (Figure 9, green-bar), with its combination of explorative, but afforded interaction, and the standard *Exploratory-Affordance Screw*, indicating the *Switch* design as a driver for an increased *hope* response.

Responses to the *Joy* response item were also found to be significantly different across the four design stimuli ($F[3,76]=6.972$, $p=0.000$). According to the post-hoc test, participant response to the standard *Explanatory-Affordance Screw* design (Figure 9, *joy*, grey-bar) was significantly different to responses towards both the *Exploratory-Affordance-Based Switch* design (green-bar, *joy*) and the *Exploratory-DisAffordace Push* design (red-bar). These results again indicated explorative interactions, irrespective of affordance, as drivers for significantly increased positive responses.

Between the seven PrEmo-negative response items only *Boredom* was found to have reached statistically significant difference across the four stimuli ($F[2,76] = 20.751$, $p = 0.000$). The *Exploratory-Affordance Switch* design (Figure 9, *boredom*, green-bar, far-right) was found to have a significantly lower response score compared to the standard *Explanatory-Affordance Screw* (grey-bar). Similarly, the *Explanatory-DisAffordance Push and Screw* design (blue-bar) and the *Exploratory-DisAffordance Push* design (red-bar) were also significantly lower than the *Screw* design.

Taken together, the results suggested that the physical interaction method, which was already familiar to the subjects (i.e. *Explanatory-Affordance, Screw*), induced significantly reduced positive emotional responses (*admiration, fascination, hope, joy*) compared to the more exploratory interaction designs (i.e. *Switch* and *Push*). In addition, emotional response towards the *Exploratory-Affordance-Based Switch* design reached significance against the standard *Explanatory-Affordance Screw* design across the four positive response items. Similarly, it was rated as significantly less boring compared to the standard *Screw* design. The same result was found for the *Exploratory-DisAffordance Push* design, but to a lesser extent. These results thus suggested the explorative interactions as drivers for significantly increased positive response, but that *affordance juxtaposed with exploration* increased the participants' positive response for some emotions.

6.2 Positive and negative response towards four design stimuli

An overview of positive (green) and negative (red) responses towards the four stimuli designs is provided in Figure 10.

Both the standard *Exploratory-Affordance-Based Screw* (top-left, Figure 10) and the *Explanatory-DisAffordance Push and Screw* design (Figure 10, bottom-left), received increased negative response scores (in red) compared to both the *Exploratory-Affordance Switch* design (top-right) and the *Exploratory-DisAffordance-Based Push* design (bottom-right). This result indicated that the explanatory lid designs stimulated greater negative response compared to the explorative stimuli.

It is unclear why the explorative interactions of the *Switch* (Figure 10, top-right) and *Push* (bottom-right) designs resulted in increased positive response (green-bars) and reduced negative reactions (red-bars). It may be that, in the more exploitive interactions, a clear difference between the standard design and the new design was important. However, the interactions ability to reveal the goal state (i.e. open the bottle) appeared as important as an explorative approach. In this the *Switch* design appeared to stimulate more positive responses, indicating that some combination of affordance (i.e. press here and something will happen) and exploration (what *will* happen when I push?) may be best placed to satisfy both novelty and understandability.

6.3 Product characteristics' evaluation

A second section of the study employed a set of ten SD (semantic differential) scales to explore participants' attitude towards the characteristics of the four designs. A one-way ANOVA analysis of mean (x) responses revealed a significant difference for nine of the ten SD-scales (Table 2).

A post-hoc test revealed which of the four stimuli caused the significant differences across the nine SD scale response questions presented in Table 2.

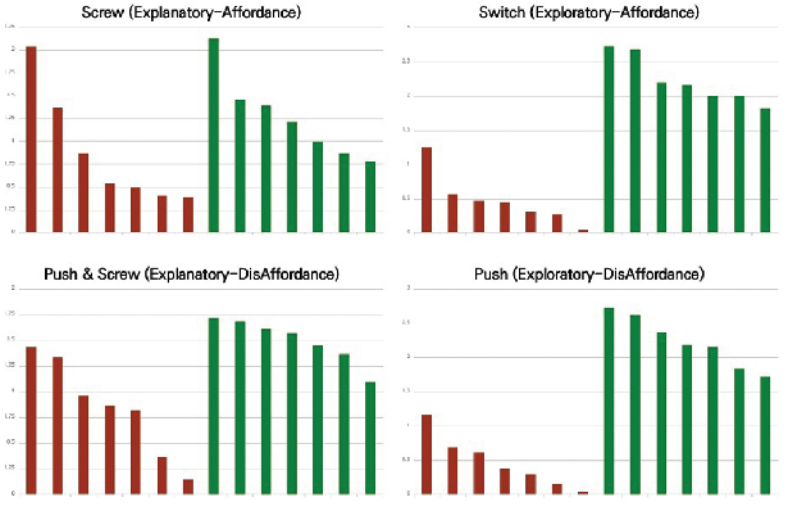

Figure 10: Overview of emotional responses towards four design stimuli.

	Screw type	Switch type	Push and screw type	Push type	*F*	Sig.
Boring > Interesting	4.3000	1.2000	3.3000	1.7500	27.401	**0.000
Repulsive > Attractive	3.4500	2.2500	3.4000	2.3000	4.947	**0.003
Noisy > Quite	2.3500	2.7500	3.4000	2.8500	2.747	*0.049
Immature > Mature	1.9500	3.4500	2.9000	2.8500	5.612	0.002
Calm > Exciting	4.3500	2.1000	3.3000	2.0000	26.622	**0.000
Submissive > Aggressive	3.9500	2.8000	2.8500	3.0000	4.155	**0.009
Unfriendly > Friendly	1.3000	3.3500	3.3000	2.9000	11.673	**0.000
Nostalgic > Futuristic	4.4000	2.1000	3.3500	2.9000	19.723	**0.000
Ordinary > Extraordinary	4.8500	1.7000	3.5500	2.3000	53.159	**0.000

Notes: *p<0.05; **p<0.001.

Table 2: ANOVA result of product appraisal through the SD-scale response.

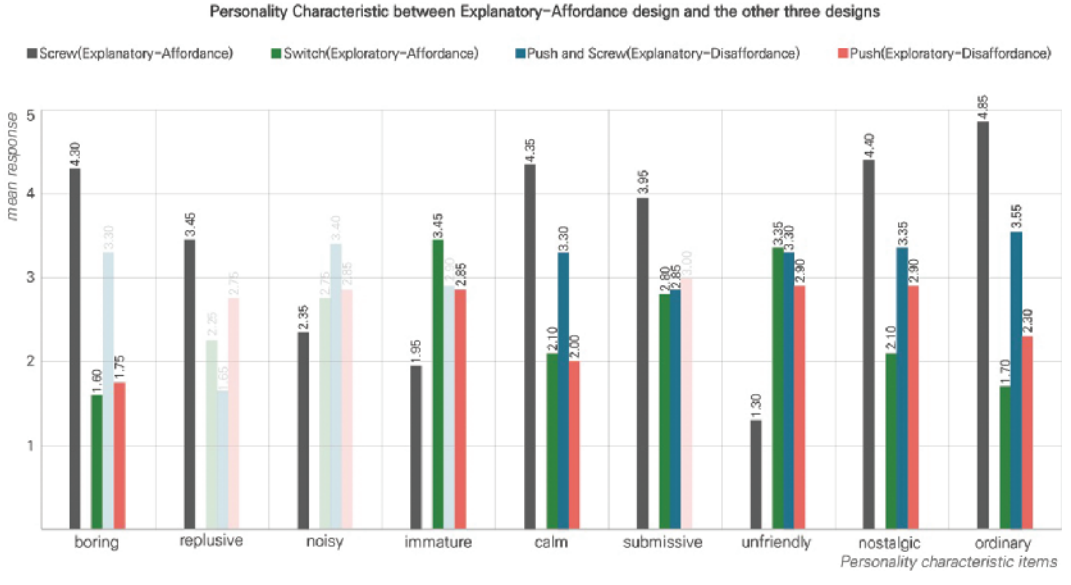

Figure 11: Graphically illustrates the differences between design stimuli.

In response to the *Interesting-Boring* SD-scale (Figure 11, far-left, *boring*) we identified a significant difference between the *Exploratory-Affordance-Based Switch* (Figure 11, green-bar) and the *Exploratory-DisAffordance Push* design (red-bar) compared to the standard *Explanatory-Affordance Screw* design (grey-bar). However, differences between the standard *Screw* design and the *Explanatory-DisAffordance-Based Push and Screw* design (Figure 11, blue-bar) were not found to be significant. These results indicated the standard *Explanatory Screw* design as significantly less interesting than the *Exploratory-Affordance-Based Switch* and *Exploratory-DisAffordance-Based Push* designs, suggesting that the explorative interaction design was more interesting compared to the two designs that required no exploration.

A significant difference was also found in response to the SD-scale *Attractive-Repulsive* (Figure 11, *repulsive*, $F[3,76] = 4.947$, $p = 0.003$), with a *post-hoc* test indicating the *Exploratory-Affordance Screw* design (Figure 11, grey-bar) to be significantly more *repulsive* compared to the *Explanatory-DisAfffordance Push and Screw* design (blue-bar). Participant responses were also found to differ significantly in the evaluation of *Mature-Immature* ($F[3,76] = 5.612$, $p = 0.002$, Figure 11, *immature*). Comparing results for the standard *Explanatory-Affordance Screw* design (grey-bar, *immature*) with the *Exploratory-Affordance Switch* design (green-bar) and *Explanatory-DisAffordance Push* design (red-bar), the latter two were again found to lead to a significant difference in response, indicating that participants found the designs more *immature* than the standard screw-top design. Similarly, participant responses indicated the standard *Screw* (*Explanatory-Affordance*) design as significantly less *friendly* (Figure 11, *unfriendly*), but more *nostalgic* and *ordinary* (Figure 11, far-right, *ordinary*, grey-bar).

Both the *Exploratory-Affordance-Based Switch* design (Figure 11, green-bar) and, to a lesser extent, the *Exploratory-DisAffordance Push* design (red-bar) were also found to attract responses indicative of their evaluation as significantly less *nostalgic* compared to the standard *Explanatory-Affordance Screw* design (grey-bar, nostalgic). Similarly, the standard *Explanatory-Affordance Screw* design received a statistically significant increase in score for ordinary (Figure 11, *ordinary*). In contrast both the *Exploratory-Affordance-Based Switch* (green-bar) and, to a lesser extent, *Exploratory-DisAffordance Push* designs (red-bar) received statistically significantly lower scores for *nostalgic* and *ordinary*.

We suggest that these results support those derived from the PreMo study (see Section 6.1 'Emotional response to physical interaction'), to indicate that a combination of affordance and exploration supported through the *Switch*-type design was optimal in its ability to stimulate positive response because it was able to satisfy the contradictory requirements of novelty (explore) and acceptability (afforded). In this sense, our results provide evidence to suggest an *Exploratory-Affordance-Based* design approach as best placed to address the contradictory needs of novel, yet typical user–product experiences through providing elements of exploration compounded with clear indicators of how to proceed towards the functional goal of product use.

7. DISCUSSION

The current study has adopted a research-through-design (RtD) approach to the design and development of four stimuli. In their design we have attempted to embed the concepts of affordance (Norman 2002; Gibson 1979) and explorative (vs. explanatory) product interactions (Buur et al. 2007). Participants then evaluated the four design stimuli through two sets of self-report: one to gather emotional response to the user–product experience (SusanGroup 2017) and the other to examine response to the four design stimuli themselves. We discuss the results in terms of our original research question, before reflecting upon broader implications, including the limitation of our study.

Results indicated that both *Exploratory-Affordance-Based Switch* and *Exploratory-DisAffordance Push* designs were found to provide a more positive product experience compared to the standard *Explanatory-Affordance-Based Screw* design. In particular, a statistically significant difference in emotional response was found between the *Explanatory-Affordance-Based Screw* design

and both the *Switch* and *Push* designs for emotional response items: *admiration*, *fascination*, *hope*, *joy* and *boredom* (*Screw* design). In this sense the results indicated that the application of exploratory interactions resulted in an increasingly positive emotional response during product use compared to the standard, explanatory design (i.e. the *Screw* design stimuli). Moreover, the *Explanatory-DisAffordance-Based Push and Screw* design did not result in the level of significant difference in emotional response compared to the standard *Explanatory-Affordance Screw* design achieved by the *Switch* design.

Moreover, the standard *Explanatory-Affordance-Based Screw design* received a significantly increased mean (x) score in terms the SD response *boring*. These results suggested the explorative interaction as a driver for increased novelty. As above, the findings also indicated the *Switch design*, with its combination of *affordance* and *exploration*, to be stimulating more positive response across all dimensions compared to the other three designs (if only marginally so against the *Explorative-DisAffordance-Based Push* design).

These results suggested greater product affordance, or understanding how a goal state may be achieved through evaluation of the products characteristics prior to use (Norman 2002), combined with explorative interaction (Buur et al. 2007), as best placed to stimulate more positive user–product experiences. We speculate that our results indicate how an *afforded-exploration* design approach may address the contradictory challenge of novelty and understandable typicality, as indicated by Hekkert et al. (2003), during product interaction. The explorative may provide novelty, with affordance able to ground the novel in the more familiar through indication of use and/or how function may be achieved.

In terms of design implications, product designers may wish to consider the kinds of affordances intuitively appropriate to the target user. These then have the potential to act as points of understanding in interaction. At the same time, designers may also wish to consider a certain level of novelty in providing exploration opportunities through uncertainty towards the result of an interaction. Thus, a product design may leverage affordance to satisfy the user's need for understanding, while in parallel stimulate a more engaging use experience through a level of guided (through affordance) exploration. This may be best achieved through first identifying how product characteristics (forms, materials, interaction details) may express affordance in terms the target user(s), to then consider how novelty (through exploration) may be embedded within a directed (afforded) interaction.

8. CONCLUSIONS

The current study has provided evidence to indicate how exploratory interaction can stimulate positive emotional response. We speculate that these more positive responses are evidence of stimulation of novelty during the user–product experience. Moreover, our results indicated exploration combined with affordance as best placed to stimulate more novel yet understandable, product interactions. We speculate that exploitive interaction offers opportunities for novelty, while affordance may stimulate feelings of reassurance. If interaction possibilities are made *clear* (*afforded*) prior to use, an explorative interaction approach is more reassuring, thus providing increased opportunity for stimulation of *acceptably novel* product experiences.

The current study has contributed to existing work on user–product experience through our attempt to identify actionable constructs (i.e. explorative/

afforded) to satisfy the contradictory requirement of the product experience to be novel but also understandably typical as indicated by Hekkert et al. (2003). However, we see limitations in our methods, theoretical approach and generalization of the results.

First, we have attempted to embed Buur et al.'s (2007) concepts of explorative interaction and Norman's (2002) ideas towards affordance within the design of four stimuli. In making the move from theoretical construct to application in design, we did not validate our four designs to provide evidence of the extent to which they represent a true reflection of the four combinations of the theoretical constructs that they purport to represent. This is then problematic in the interpretation of results as truly derived from product interactions that are valid in their representation of afforded and/or explorative interaction. Future works may wish to validate the reliability of the constructs themselves by, for example, embedding them as stimuli for investigating the product experience through the research-through-design approach.

Second, our experimental approach was lab-based, involving user interaction with a relatively simple product, of the type the participants were clearly familiar with (i.e. a drinks container and lid). Thus, we decontextualized the product experience to control and focus our analysis. However, further studies are required to examine the influence of, for example, context-of-use upon emotional response to affordance and/or explorative interactions. The simplicity of the product, and the interaction it provided, also makes it challenging to generalize our results. For example, how emotional response to affordance and/or explorative interaction change in interaction with products of increased complexity and use functions (i.e. smart products and devices). Moreover, individual participant interpretation of what may or may not constitute an explanatory/exploratory and/or afforded/disafforded interaction-based design was not considered in the current study. This is problematic because the extent to which a product experience is interpreted as explanatory and/or afforded can differ from user to user dependent on experience, attitudes, culture and other idiosyncratic variables not considered in the current study. Future studies may wish profile users to explore, for example, how episodic and/or procedural knowledge and experience may influence response in terms of the four interaction types.

These limitations notwithstanding, we feel that the current study reveals insights into how *Afforded Exploration* may satisfy the contradiction between novelty and more understandable typicality to drive delightful user–product experiences.

ACKNOWLEDGMENT

This work was supported by the Ministry of Education of the Republic of Korea and the National Research Foundation of Korea (NRF-2015S1A5A8015329) and the Promotion of Special Design-Technology Convergence Graduate School of Korea Institute of Design Promotion (N0001436) with a grant from Ministry of Trade, Industry & Energy of the Republic of Korea.

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SUGGESTED CITATION

Lee, S. and Self, J. A. (2018), 'Afforded exploration: An approach to novel yet understandable product experiences', *Artifact: Journal of Design Practice*, 5:2, pp. 2.1–2.18, doi: 10.1386/art_00002_1

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