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How Do Semantic Clues Affect People's Perceptions of Products with Multiple Meanings

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Abstract

A psychological experiment was conducted to explore the relationship between design features of physical controllers and perceived multiple meanings or possible operations by users. In particular, we focused on affordances and informatives, two semantic clues derived from product semantics, to find out how these clues affect users' perceptions. The results indicated that both desired shapes, text, and icon could encourage and discourage the perception of specific operations. Those empirical data could be useful for product designers in communicating effectively with users through their products.

Keywords: product design, user experience, evaluation

1. Introduction

Operational experiences with things are most common in daily life (Krippendorff, 1989). With the improving of information-based technology, more and more multi-functional electronic products with simple interfaces, are being introduced to our daily life. However, it has been found that usability issues persist, and that older adults are often neglected in the design of electronic products (Taha et al., 2013; Czaja, 2019). Recently, the complexity of a microwave oven was revealed by comparing designers' conceptual models and users' mental models in a usability testing (Zhong et al., 2020). Such devices often require users to select (e.g., choose one item from the menu) and execute (e.g., confirm the selection) by appropriate operations from a number of possibilities. Several interface types were considered to afford "select and execute", among which knobs are normal, particularly for home appliances with simple interfaces. However, it was observed that older adults had a difficult time understanding a knob with multiple operations, i.e., press-ability and turn-ability (Zhong et al., 2020). This issue prompted us to investigate how we could convey complex usage more effectively through the object.

Krippendorff and Butter (1984) posited that users create meanings whilst interacting with an artifact, which is mainly determined by product features like shapes, colors, textures etc. These meanings are generally referred to as product semantics. So how can designers ensure appropriate usage and prevent undesired meanings from being conveyed? As Krippendorff and Butter (2008) noted, designers mainly have two ways to afford or discourage meanings: the semantic way (e.g., by choosing forms unlikely to encourage undesirable usage) and the physical way (e.g., by introducing constraints preventing undesirable contexts from arising). Under their view, affordances and informatives are critical components of the meaning of artifacts in use (Krippendorff, 2006).

The concept of affordances was coined by Gibson (1979) in his theory of direct perception (i.e., ecological approach), which explains animal perception from an ecological point of view. When it comes to design, the notion of affordances drew wide discussion led by Donald Norman. Norman's perceived affordances, referring to the design features such as forms, colors, materials, etc. perceived by users, which indicate the ways that the users could interact with the object (Norman, 1999). Frens (2006) argued that affordances explain how humans acquire information-for-use from their natural environment. When affordances are applied to product design, a desired action can be guided by making desired affordances achievable and perceptible (Parmentier, 2021). Sheridan et al. (2003) investigated the behavior of participants in response to various characteristics (size, texture, color/pattern, weight, sound) of a cube and suggested possible requirements for designing graspable cube-shaped physical interfaces. Murakami et al. (2009) tried to formulate the relationship between geometrical attributes of objects and affordance for operations as affordance features, suggesting that intended affordances could be strengthened by formulating affordance features well. Maier and Fadel (2009) proposed a systematic design method called Affordance-Based Design (ABD) to address the user needs and capabilities. On the other hand, Frens (2006) argued that even though an affordance itself cannot be designed, the idea that human can interact with artifacts meaningfully based on their perception instead of their memory alone is inspirational for designers. Regardless of how researchers interpret this difficult concept, its significance in product design is undeniable.

Meanwhile, informatives are more like clues with capability of informing users of what can be done (Krippendorff, 2006). Krippendorff (2006) proposed ten informatives available to designers for considering whether their designs provide sufficient support to users for exploring what they are doing with an artifact, in which the affordings indicate the state of readiness of the artifact or parts thereof to be acted upon. Affordings include what users can understand the artifacts logically from clues, icons, shapes, and patterns. Usecues, described by Boess & Kanis (2008), resemble the notion of affordings as "any characteristic that people use to attribute functional meaning to a product." For example, arrows are commonly recognized as a directional clue. Frens' study (2006) also told the fact that labels (text and icons) could be used to guide an intended operation. The fact that designers heavily rely on convention understood by the user to apply icons, symbols, or metaphors in product design is indisputable (You & Chen, 2007).

This study is an extension of exploring the relation between form and interaction, as Frens (2006) pointed out that it is one of areas need to be investigated if interactive products are to be designed. To our knowledge, however, there are very few empirical works that examined the relationship between semantic clues and people's perception. Many studies related to product semantics considered the effect of form on emotional level, or tended to be qualitative analysis. Furthermore, many of them mainly focused on one-to-one matched relationship between the characteristics of an object and its operation, for example, the operation of “push” could be perceived better in the objects with lower height (Murakami, 2009). Only a few studies elucidate one-to-many matched relation. Last but not least, a more organized and controlled method such as psychological experiment is needed to verify such relationships.

The purpose of this study is to experimentally elucidate the relationship between design features and perceived meanings of products in use, especially for physical controllers. To be specific, we conducted a psychological experiment in which participants were shown stimuli and asked to respond to questions about how to operate the object. Three types of semantic clues were used in this study: shapes (variations of cylinders), text, and icon (i.e., arrow).

2. Methods

2.1. Stimuli

In this experiment, we tried to investigate the perceptible meanings of operations in relation to four semantic clues. We collected 82 microwave ovens and 7 toasters of several Japanese home appliance brands, and extracted basic shapes from the controllers (See Figure 1A). Based on this, we made 48 samples of physical controllers with four parameters: Text (without, with), Arrow (without, with), the Heigh of Flat Surface (0mm, 1mm, -1mm), and the Design of Curved Surface (d = 0mm, -4mm, handle, 4mm), of which some examples are shown in Figure 1B. Those design factors were treated as within-participant factors. For text, we chose “Start” in Japanese since all participants are Japanese and it is also one of the most common words used in electronic products. Two sets of 48 stimuli were presented, including image and video set. All stimuli were modelled in Rhinoceros 3D and rendered in

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Keyshot7. Sauer et al. (2008) have proved that a 2D prototype can be used in a pure decision-making task. More importantly, we presented 2D renderings of design instead of showing them 3D physical models in order to record participants' reaction times. Though we made both an image and a video set, we will only discuss the data from the image set here.

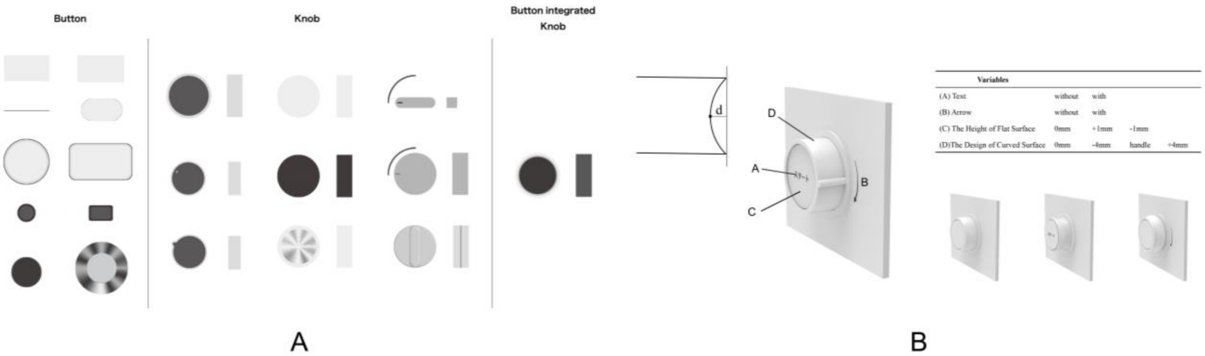

Figure 1. Stimuli and four dimensions of experimental manipulation

2.2. Participants

Participants included 18 younger adults (M = 22.39, SD = 1.64; 8 males) and 16 older participants (M = 71.56, SD = 3.10; 9 males). All of them self-reported having normal or corrected-to-normal vision. Before participating in the experiment, each participant signed an informed consent. In addition, they were paid according to the regulations.

2.3. Procedure

All participants saw all stimuli twice[1]. Time course within a trial is as shown in Figure 2. There was a constant interstimulus interval of 1000ms, then a fixation cross appeared on the screen for 1500ms, and a randomly selected image stimulus or two-second video stimulus was presented. Meanwhile, the first question ("Which operation do you think is possible?") and its options were also presented. After the participant finished the choose, the second question ("Which operation else do you think is possible?") and its options appeared. As the standard operations on electronic products, "Press," "Turn," "Pull," "Slide," "None" were set up as options. A stimulus with two questions can be seen as one trial. Therefore, there were 192 trials in total. A brief interview on their criterions was also conducted at the end. Audio and video were recorded during the experiment.

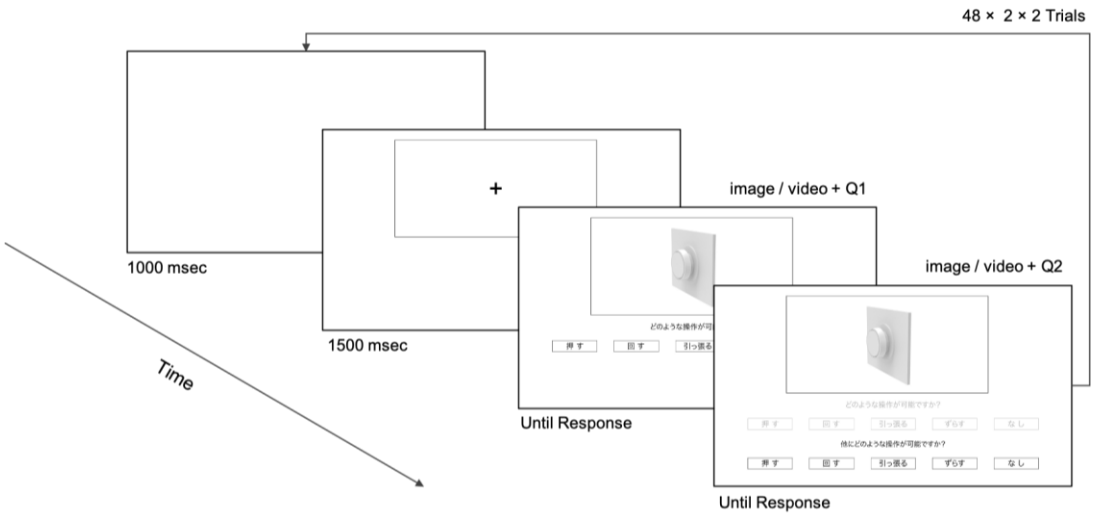

Figure 2. Time course within in each trial

[1] Participants were randomly assigned to either the image-go-first or video-go-first group.

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2.4. Data analysis

We treated selection ratio within individuals as a dependent variable since all participants saw each stimulus twice during the experiment. Therefore, if one chooses "Press" and "Turn" for the same stimulus in Q1, then the selection ratio of "Press", "Turn", "Pull", "Slide", and "None" is 50%, 50%, 0%, 0%, 0%, respectively. An arcsine transformation was performed on the selection ratio to make the distribution normal.

For Q1, using four parameters in Figure 1, an ANOVA of 2 (text) × 2 (arrow) × 3 (the heigh of flat surface) × 4 (the design of curved surface) × 5 (possible operations of Q1) was conducted to examine how participants perceived the meanings of different forms intuitively.

In order to examine participants' perception of multiple operations, we analyzed the conditional selection ratio of press, turn and none in Q2 based on the selection of Q1 (press and turn) individually. Therefore, a 2 (text) × 2 (arrow) × 3 (the heigh of flat surface) × 4 (the design of curved surface) × 4 (possible operations of Q2) ANOVA was conducted to examine how participants who chose press or turn in Q1 perceived the meanings of different forms subsequently. The analyses were carried out using R version 4.1.0 and the R function "anovakun" version 4.8.5.

3. Results and discussion

3.1. Selection ratio of possible operation in Question 1

For the dependent variable of selection ratio of possible operations (PO), we analyzed four within-participant factors, i.e., Text, Arrow, The Height of Flat Surface, and The Design of Curved Surface. Since our purpose is to elucidate the factors related to the selection of PO, results of main effects and interactions with PO were summarized in Table 1. Result revealed a significant main effect of PO (F (4, 132) = 97.93, $p < .001$, $\eta_p^2 = 0.75$; Figure 3A). Based on the results, a main effects analysis of the height of flat surface and a three-factor (Text × Arrow × The Design of Curved Surface) ANOVA were run for each possible operation.

Table 1. Summary of ANOVA Results with Interactions of Q1

Source	*SS*	*df1*	*df2*	*MS*	*F-ratio*	*p-value*		*partial η^2*
PO	945.5705	4	132	236.3926	97.9318	0.0000	***	0.7480
Tx × PO	77.8494	4	132	19.4623	30.9447	0.0000	***	0.4839
Ar × PO	444.2645	4	132	111.0661	135.1729	0.0000	***	0.8038
Hf × PO	7.4219	8	264	0.9277	7.3799	0.0000	***	0.1828
Dc × PO	106.7688	12	396	8.8974	21.1652	0.0000	***	0.3908
Tx × Ar × PO	3.5628	4	132	0.8907	2.7550	0.0306	*	0.0771
Tx × Hf × PO	0.4203	8	264	0.0525	0.8852	0.5294	-	0.0261
Tx × Dc × PO	2.5528	12	396	0.2127	2.1205	0.0150	*	0.0604
Ar × Hf × PO	0.7363	8	264	0.0920	1.6150	0.1205	-	0.0467
Ar × Dc × PO	59.8836	12	396	4.9903	21.2802	0.0000	***	0.3920
Hf × Dc × PO	1.9760	24	792	0.0823	1.3647	0.1142	-	0.0397
Tx × Ar × Hf × PO	0.7529	8	264	0.0941	1.5524	0.1394	-	0.0449
Tx × Ar × Dc × PO	3.5552	12	396	0.2963	4.2955	0.0000	***	0.1152
Tx × Hf × Dc × PO	1.2367	24	792	0.0515	0.9308	0.5593	-	0.0274
Ar × Hf × Dc × PO	1.5497	24	792	0.0646	1.1093	0.3260	-	0.0325
Tx × Ar × Hf × Dc ×PO	1.1097	24	792	0.0462	0.7559	0.7939	-	0.0224

PO, possible operations; Tx, text; Ar, arrow; Hf, the height of flat surface; Dc, the design of curved surface.
-: p > .05, *: p < .05, **: p < .01, ***: p < .001

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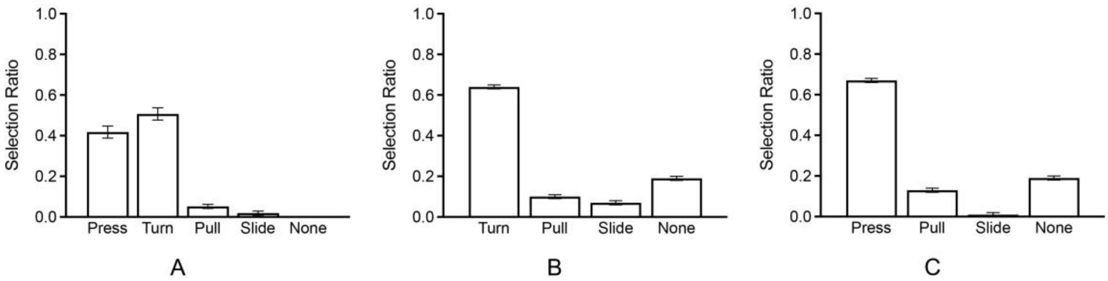

Figure 3. The main effect of possible operations; A: Q1, B: Q2 (when the answer of Q1 was press), C: Q2 (when the answer of Q1 was turn)

3.1.1. Press

The results revealed a significant main effect of text ($F(1,33) = 37.14$, $p < .001$, $\eta_p^2 = 0.53$), arrow ($F(1,33) = 132.84$, $p < .001$, $\eta_p^2 = 0.80$), the height of flat surface ($F(2,66) = 9.21$, $p < .001$, $\eta_p^2 = 0.22$), and the design of curved surface ($F(3,99) = 39.40$, $p < .001$, $\eta_p^2 = 0.54$), as shown in Figure 4A. Multiple comparisons indicated that press was perceived significantly higher when the height of flat surface is 1mm, compared to 0mm and -1mm. Also, press was perceived significantly higher when the design of curved surface is 0mm, followed by 4mm, -4mm, and handle.

In addition to those main effects, the Arrow × The Design of Curved Surface interaction ($F(3,99) = 22.47$, $p < .001$, $\eta_p^2 = 0.41$; Figure 4B) was significant. Planned comparisons revealed that press was perceived significantly higher when the design of curved surface is 0mm, followed by 4mm, 4mm, and handle in without-arrow condition ($F(3, 99) = 37.08$, $p < .001$, $\eta_p^2 = 0.53$). On the other hand, no significant difference was found within 0mm, -4mm and 4mm in with-arrow condition ($F(3, 99) = 5.29$, $p < .01$, $\eta_p^2 = 0.14$). Results explicitly showed that arrow's existence weakens user's perception of press-ability regardless of the shapes, at least at the first sight.

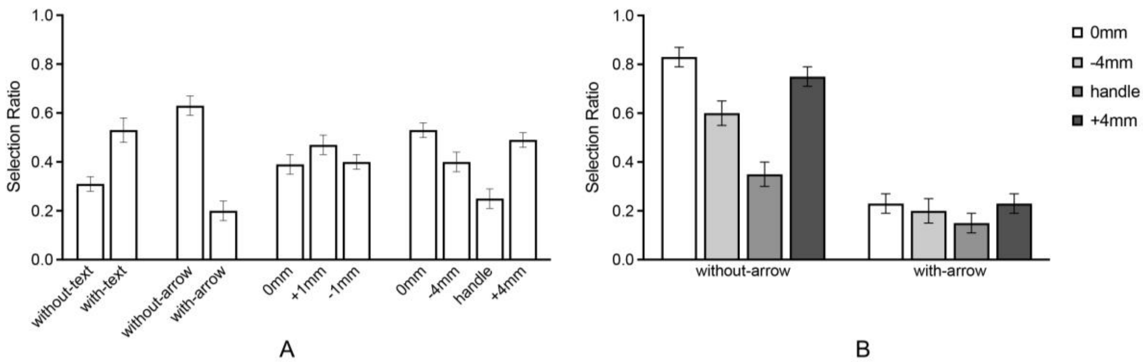

Figure 4. Probability of press (Q1); A: The main effects of four parameters; B: The interaction between arrow and the design of curved surface

3.1.2. Turn

The results revealed a significant main effect of text ($F(1,33) = 26.15$, $p < .001$, $\eta_p^2 = 0.44$), arrow ($F(1,33) = 153.05$, $p < .001$, $\eta_p^2 = 0.82$), the height of flat surface ($F(2,66) = 5.69$, $p < .01$, $\eta_p^2 = 0.15$), and the design of curved surface ($F(3,99) = 19.75$, $p < .001$, $\eta_p^2 = 0.37$), as shown in Figure 5A. Multiple comparisons showed that turn was perceived significantly lower when the height of flat surface is 1mm, compared to 0mm and -1mm. Also, turn was perceived significantly higher when the design of curved surface is with handle ($M = 0.69$), compared to other conditions.

The interaction between Text × Arrow ($F(1, 33) = 4.53$, $p < .05$, $\eta_p^2 = 0.12$; Figure 5B), Arrow × The Design of Curved Surface ($F(3, 99) = 24.83$, $p < .001$, $\eta_p^2 = 0.43$; Figure 5C), and a three-way interaction between Text × Arrow × The Design of Curved Surface ($F(3, 99) = 5.49$, $p < .01$, $\eta_p^2 = 0.14$; Figure 5D) were significant. Planned comparisons showed a significant difference in the

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without-text condition (with-arrow > without-arrow, p < .0001, η_p^2 = 0.86), the with-text condition (with-arrow > without-arrow, p < .001, η_p^2 = 0.69), the without-arrow condition (without-text > with-text, p < .001, η_p^2 = 0.46) and the with-arrow condition (without-text > with-text, p < .001, η_p^2 = 0.35), indicating that the existence of text might weaken the role of arrow. No significance was found among the designs of curved surface in with-arrow condition. When it comes to text, planned comparisons showed a significant difference among the designs of curved surface in the without-text condition with the without-arrow condition (F (3, 99) = 27.43, p < .001, η_p^2 = 0.45), and the with-text condition with the without-arrow condition (F (3, 99) = 24.18, p < .001, η_p^2 = 0.42), suggesting that the existence of text might weaken the role of desired shape design.

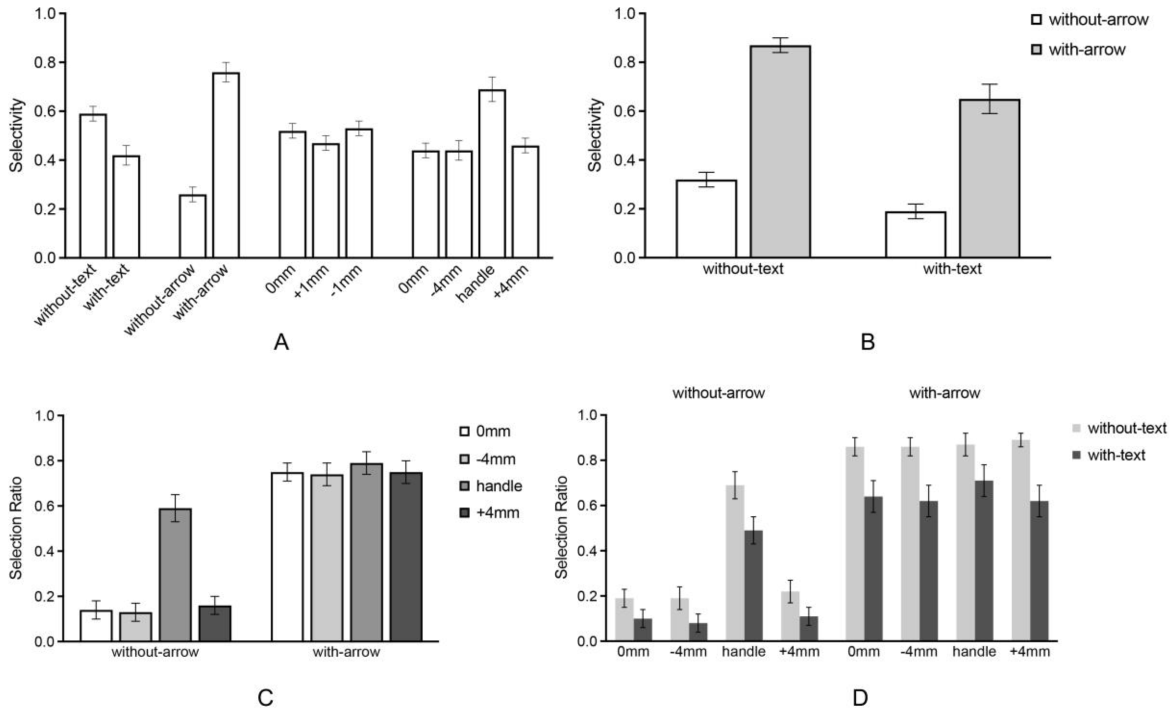

Figure 5. Probability of Turn (Q1); A: The main effects of four parameters; B: The interaction between text and arrow; C: The interaction between arrow and the design of curved surface; D: The interaction between text, arrow, and the design of curved surface

3.2. Selection ratio of possible operation in Question 2

3.2.1. The results of participants who chose press in Q1

As conditional selection ratio of each possible operation was an independent variable, Text, Arrow, The Height of Flat Surface, The Design of Curved Surface, and Possible Operations (PO) were treated as between-participant factors in this ANOVA analysis. Results were summarized in Table 2. There was a significant main effect of PO (F (3, 3100) = 320.84, p < .001, η_p^2 = 0.24; Figure 3B). Then 2 two-way (Text × Arrow, and Arrow × The Design of Curved Surface) ANOVAs were run for each possible operation.

For turn, the results revealed a significant main effect of arrow (F (1, 775) = 134.04, p < .001, η_p^2 = 0.15) and the design of curved surface (F (3, 775) = 2.90, p < .05, η_p^2 = 0.01), as shown in Figure 6A. The Text × Arrow interaction (F (1, 775) = 4.50, p < .05, η_p^2 = 0.01, Figure 6B) was significant. Simple effects analysis indicated a marginally higher selection ratio on the with-text design than without-text design in the with-arrow condition (p = 0.05), which means that the combination of text and arrow may afford press-ability and turn-ability. The Arrow × The Design of Curved Surface interaction (F (3, 99) = 13.44, p < .001, η_p^2 = 0.29, Figure 6C) was significant. Simple effects analysis

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revealed that turn was perceived significantly higher when the design of curved surface is handled, compared to 0mm, 4mm, and -4mm in without-arrow condition ($p < .001$). However, the selection ratio of 4mm was significantly higher than handle in with-arrow condition ($p < .05$), and a likely reason for this difference is that some participants chose slide in Q2 after press, as shown in Figure 6D.

For none, the results revealed a significant main effect of text ($F (1, 775) = 104.04$, $p < .001$, $\eta_p^2 = 0.12$) and the design of curved surface ($F (3, 775) = 5.85$, $p < .001$, $\eta_p^2 = 0.02$), as shown in Figure 7A. The Arrow × The Design of Curved Surface interaction ($F (3, 775) = 8.20$, $p < .001$, $\eta_p^2 = 0.03$, Figure 7B) was significant. Simple effects analysis revealed that the selection ratio was higher when the design of curved surface was 0mm than 4mm, -4mm, and handle in the without-arrow condition ($p < .001$). Results showed an important role of arrow and handle in proving secondary operation (i.e., turn) after selecting press.

Table 2. Summary of ANOVA results with Interactions of Q2 (Q1: Press)

Source	*SS*	*df*	*MS*	*F-ratio*	*p-value*		*partial η^2*
PO	246.3350	3	82.1117	320.8438	0.0000	***	0.2369
Tx × PO	1.4624	3	0.4875	1.9048	0.1266	-	0.0018
Ar × PO	96.5094	3	32.1698	125.7005	0.0000	***	0.1085
Hf × PO	1.8993	6	0.3165	1.2369	0.2840	-	0.0024
Dc × PO	27.8595	9	3.0955	12.0954	0.0000	***	0.0339
Tx × Ar × PO	2.6910	3	0.8970	3.5049	0.0148	*	0.0034
Tx × Hf × PO	1.4061	6	0.2344	0.9157	0.4823	-	0.0018
Tx × Dc × PO	2.5408	9	0.2823	1.1031	0.3567	-	0.0032
Ar × Hf × PO	2.8931	6	0.4822	1.8841	0.0798	-	0.0036
Ar × Dc × PO	30.1488	9	3.3499	13.0893	0.0000	***	0.0366
Hf × Dc × PO	1.3461	18	0.0748	0.2922	0.9984	-	0.0017
Tx × Ar × Hf × PO	1.8598	6	0.3100	1.2111	0.2972	-	0.0023
Tx × Ar × Dc × PO	1.9319	9	0.2147	0.8388	0.5802	-	0.0024
Tx × Hf × Dc × PO	1.8179	18	0.1010	0.3946	0.9891	-	0.0023
Ar × Hf × Dc × PO	2.2070	18	0.1226	0.4791	0.9676	-	0.0028
Tx × Ar × Hf × Dc × PO	1.2063	18	0.0670	0.2619	0.9992	-	0.0015

PO, possible operations; Tx, text; Ar, arrow; Hf, the height of flat surface; Dc, the design of curved surface.
-: p > .05, *: p < .05, **: p < .01, ***: p < .001

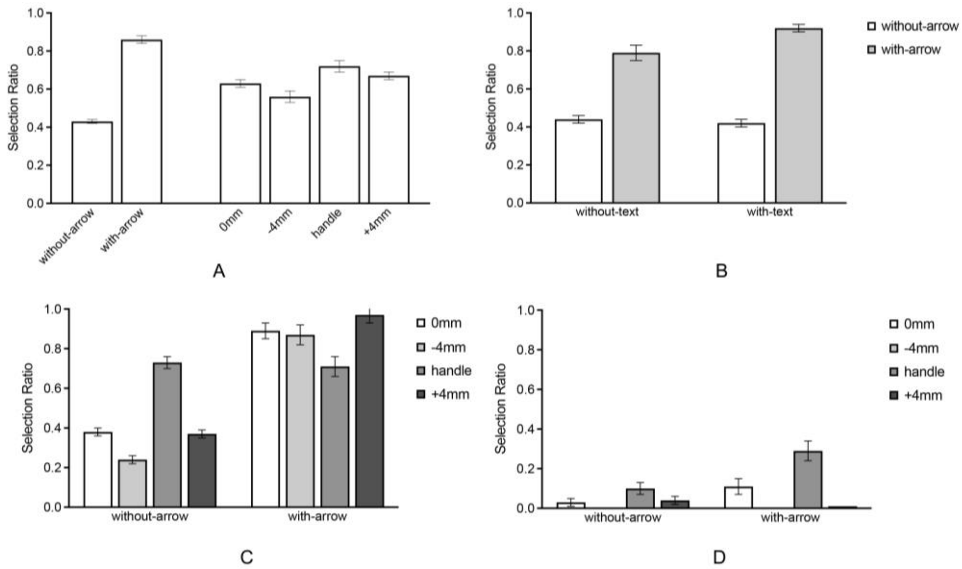

Figure 6. A: The main effects of arrow and the design of curved surface on turn (Q2); B: The interaction between text and arrow on turn (Q2); C: The interaction between arrow and the design of curved surface on turn (Q2); D: The interaction between arrow and the design of curved surface on slide (Q2)

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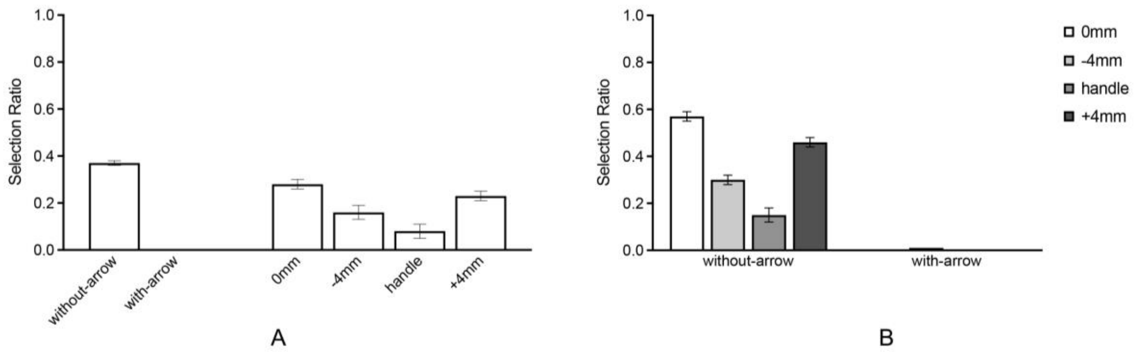

Figure 7. Probability of none (Q2); A: The main effects of arrow and the design of curved surface; B: The interaction between arrow and the design of curved surface

3.2.2. The results of participants who chose turn in Question 1

The dependent variable was selection ratio of each possible operation and between-subject factors were Text, Arrow, The Height of Flat Surface, The Design of Curved Surface, and Possible Operations. Results were summarized in Table 3. There was a significant main effect of PO ($F(3, 3100) = 495.67$, $p < .001$, $\eta_p^2 = 0.29$; Figure 3C). Then a simple effect analysis of the height of flat surface, the design of curved surface, and a two-way (Text × Arrow) ANOVAs were run for each possible operation.

Table 3. Summary of repeated measures ANOVA results with Interactions of Q2 (Q1: Turn)

Source	*SS*	*df*	*MS*	*F-ratio*	*p-value*		*partial* η^2
PO	346.0875	3	115.3625	495.6710	0.0000	***	0.2891
Tx × PO	41.4732	3	13.8244	59.3984	0.0000	***	0.0465
Ar × PO	1.7681	3	0.5894	2.5324	0.0553	-	0.0021
Hf × PO	10.3797	6	1.7300	7.4330	0.0000	***	0.0121
Dc × PO	26.8043	9	2.9783	12.7965	0.0000	***	0.0305
Tx × Ar × PO	2.2206	3	0.7402	3.1804	0.0230	*	0.0026
Tx × Hf × PO	1.2036	6	0.2006	0.8619	0.5221	-	0.0014
Tx × Dc × PO	2.1044	9	0.2338	1.0047	0.4336	-	0.0025
Ar × Hf × PO	2.5685	6	0.4281	1.8393	0.0876	-	0.0030
Ar × Dc × PO	3.1791	9	0.3532	1.5177	0.1355	-	0.0037
Hf × Dc × PO	2.8461	18	0.1581	0.6794	0.8349	-	0.0033
Tx × Ar × Hf × PO	2.8868	6	0.4811	2.0672	0.0538	-	0.0034
Tx × Ar × Dc × PO	0.6970	9	0.0774	0.3328	0.9644	-	0.0008
Tx × Hf × Dc × PO	4.2200	18	0.2344	1.0073	0.4474	-	0.0049
Ar × Hf × Dc × PO	2.2140	18	0.1230	0.5285	0.9464	-	0.0026
Tx × Ar × Hf × Dc × PO	2.9804	18	0.1656	0.7114	0.8026	-	0.0035

PO, possible operations; Tx, text; Ar, arrow; Hf, the height of flat surface; Dc, the design of curved surface.
-: $p > .05$, *: $p < .05$, **: $p < .01$, ***: $p < .001$

For press, the results revealed a significant main effect of text ($F(1, 914) = 64.90$, $p < .001$, $\eta_p^2 = 0.15$), the height of flat surface ($F(2, 914) = 7.10$, $p < .001$, $\eta_p^2 = 0.02$), and the design of curved surface ($F(3, 914) = 3.72$, $p < .05$, $\eta_p^2 = 0.01$), as shown in Figure 8A. Multiple comparisons showed that press was perceived significantly higher when the height of flat surface is 1mm, compared to 0mm. Also, press was perceived significantly higher when the design of curved surface is 0mm or handle, compared to -4mm.

For none, the results revealed a significant main effect of text ($F(1, 914) = 36.15$, $p < .001$, $\eta_p^2 = 0.04$), the height of flat surface ($F(2, 914) = 6.14$, $p < .01$, $\eta_p^2 = 0.01$), and the design of curved surface ($F(3, 914) = 4.57$, $p < .01$, $\eta_p^2 = 0.01$), as shown in Figure 8B. The Text × Arrow interaction ($F(1, 914) = 4.62$, $p < .05$, $\eta_p^2 = 0.01$, Figure 8C) was significant. Multiple comparisons indicated a significant difference in the without-text condition (with-arrow > without-arrow, $p < .05$, $\eta_p^2 = 0.01$).

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However, there is no significant difference in the with-text condition. Results suggest that a single clue might work on a certain operation.

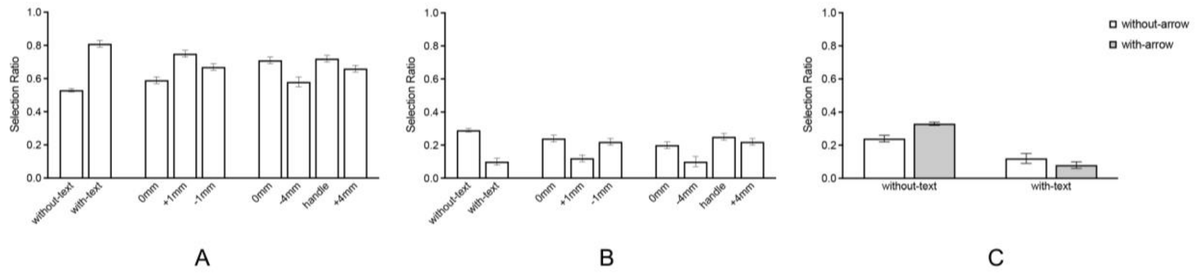

Figure 8. A: The main effects of text, the height of flat surface, and the design of curved surface on press (Q2); B: The simple effect of text, the height of flat surface, and the design of curved surface on none (Q2); C: The interaction between text and arrow on none (Q2)

4. General discussion

In this study, we examined the effects of semantic clues on users' perception of possible operations. Overall, the results indicated that both desired shapes and signs (whether text or icons) could enhance perception to some degree.

In general, users can perceive a slight change in an object, such as a variation in height or arc, so that they can understand the designer's intention and make a judgment based on that information. For example, people tend to press the object when the height of its flat surface is 1mm, and the design of its curved surface is 0mm; meanwhile, people tend to turn the object when the height of its flat surface is 0mm or -1mm, and the design of its curved surface is a handle. The results show that users are more likely to respond to signs in this study than to shapes, which means that signs are regarded as more effective than shapes. However, it has been observed that whatever the design of its curved surface was, people tend not to press / tend to turn the object initially once the arrow appears. Thus, our findings support the viewpoint that semantic clues, especially signs, could encourage or discourage the meanings (Krippendorff & Butter, 2008).

When designers want to afford a simple actionable possibility, using one sign can be more effective. In addition, we found that icons (arrows) may affect more than text, which is consistent with the previous finding on user interface design (Panagopoulos, 2019). As Panagopoulos' study focuses on older adults, a further analysis of the results by age groups should be conducted in order to verify this finding.

In terms of multiple operations, using two simultaneous signs (i.e., text and icon) could afford multiple possible operations basically. Shape and sign (e.g., handle and text) can be combined to strengthen a specific combination of operations (press-ability and turn-ability). On the other hand, the combination of shape (handle) and sign (arrow) may lead to a different interpretation (press-ability and turn-ability / press-ability and slide-ability). One possible explanation may be the subtle similarities and differences between the Japanese words "turn (mawasu)" and "slide (zurasu)". Consequently, a further study of three-dimensional prototypes is required in order to facilitate interaction between participants in the real world.

This paper is a first attempt at studying the effect of semantic clues on the perception of possible operations by users. Two important aspects of product semantics, affordances and informative, are covered in this paper, which can effectively assist designers in conveying their messages through products. In this study, we presented empirical data regarding the relationship between design features and perceived operations, which could be useful for product designers in communicating effectively with users through their products, especially when designing products with multiple operations.

Despite the contribution, we acknowledge the limitations of our work. In order to know the user's reaction time upon recognizing the object, we presented all stimuli on screen this time. Indeed, this is found anomalous when investigating user-product interaction. Furthermore, a larger sample size could give more reliable results with greater power. Accordingly, the author's future work will focus

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primarily on: 1. Analyzing the data in order to determine whether other factors (such as age, presentation style) affect the users' perceptions of the meaning of the operations; 2. Conducting a further study in more practical scenarios since the physical controllers of electronic products are basically considered as a manipulable part; 3. Considering a larger sample size for further research.

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