Simplicity by Metaphor

: How to apply metaphor to achieve simplicity of interaction design.

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Abstract: Simplicity has always been a core design objective to make human-product interaction more intuitive and efficient. Simplicity has always been a primary demand from users. In our preconceived assumption, minimalism seems to be the one right answer to tackle the problem. However, with the increasing number of artifacts and their advanced features, our life and daily tasks had become more and more complex. Users need products with more functions to deal with the variety of challenges they encounter everyday. When every feature seems to be necessary, reduction of workflows might have opposite affect in simplicity and instead result in confusion. What needs to be achieved in regard to simplicity in interaction design is a combination of simple and multi-functioned product that is easy to use while making users feel empowered. When carrying out simplicity in design, designers` challenge now is to find the perfect balance between the interface`s representation and operation. In this paper, the concept of simplicity in its multi-faceted meaning is explained. Two aspects: perceptual and operational simplicity is discussed as well as their relationship and conflicts (Norman, 2011). Among all the design methods that achieve simplicity, this paper focuses on exploring the impact of design metaphor in creation of simplicity. Metaphor is a way for designers to create attraction, pleasure experience, and better communication for users. Metaphor has been used to design a new function in a familiar appearance. However, there has not much of study about how to apply metaphors to design. In this study, based on the analysis of existing products where metaphor is applied. We divided the application of metaphor into 2 variables: representation (*descriptive* vs. *abstract*) and application method (*graphical* vs. *physical*). Paper prototypes were made to illustrate different approaches of using metaphor. We compared each approach by evaluating the perception of prototypes. 24 students were tested with 13 different models. The study results were analyzed both quantitatively and qualitatively, followed by discussion on the affects of metaphor on simplicity of interaction.

Key words: Perceived simplicity, Operational simplicity, Design metaphor

1. Introduction: what do we mean by simplicity?

Simplicity has always been a core design objective to make human-product interaction more intuitive and efficient. In our preconceived assumption, minimalism seems to be the one right answer to tackle the problem. However, with the increasing number of artifacts and their advanced features, our life and daily tasks had become more and more complex. When every feature seems to be necessary, reduction of workflows might have opposite affect on simplicity and instead result in confusion. Simplicity could be interpreted as different values depending on design contexts. This paper aims to conceptualize simplicity to specify actionable design approaches to achieve simplicity.

1.1 Simplicity in design: perceived simplicity vs. operational simplicity

Simplicity is defined as *the quality or condition of being easy to understand or do*, specifically as *the quality or condition of being plain or uncomplicated in form or design*, according to Oxford dictionary. In designing an interactive product, a plain or uncomplicated form indicates a minimal number of interface elements, and a common approach to achieve simplicity is to reduce the number of interfaces of a product. However, simplicity in appearance sometimes contradicts to simplicity in usage (Norman, 2011). According to Larry Tester's law of conservation of complexity (mid-1980s), when designers try to make the product's appearance clean and simple, there will almost always be inevitable sacrifices in the operational experience of the product. By reducing the number of interfaces, the steps or modes of operation could increase with more complicated hierarchies of navigation underneath the surface. In this vein, the conceptualization of perceived simplicity and operational simplicity is a useful framework to investigate design approaches to achieve simplicity in interaction (Norman, 2011). Perceived simplicity indicates the simplicity of the look or surface of product's interface: the fewer buttons displayed on the interface and a cleaner look, the better. Operational simplicity means the actual experiential simplicity of the interaction: the fewer steps needed to accomplish a task, the better.

The two aspects of simplicity have equal importance in creating fluent user experience but they seem to be often in conflict with each other (Wroblewski, 2006). For example, if we compare a traditional remote control with the Apple remote control (figure 1), most of us would think that the Apple remote control is the simpler design and definitely creates a simpler user experience. However, as the Apple remote control's interface has only six control buttons, in order to access the network of all the channels on a modern television, users need to repetitively press directional buttons and the menu button. The simple design of the Apple remote control is actually an elegant cover of the complicated television service interface. On the other hand, if we take a closer look at the traditional remote control, dozens of buttons and features are displayed on the surface all at once. Each button represents its own function, the operational workflow is quite clear to the user (Norman, 2011, p. 47). All of the complexity is in plain sight of its layout on the surface of the device. Because of the information interference, it takes a while for users to sort through the functions of the button groups and keep on track of their tasks. However, once they get accustomed to the position of the buttons, they could tune in to their favorite shows within seconds by just clicking one or two buttons. They do not need to make any effort diving into layers and layers of advanced hidden menus.

Figure 1. Workflow comparison of Apple remote control and traditional remote control

1.2 Simplicity in use: novice vs. expert

The two kinds of simplicity—perceived simplicity and operational simplicity—satisfy users' needs during different stages of their interaction. According to their familiarity and knowledge of the product, users are categorized into three different classes: novice users, intermediate users, and expert users (Cooper, Reimann, Cronin, 2007, p. 41). For beginner users, a basic understanding of the link between each button and its function would guide them smoothly into understanding the basic concept of the interaction. The labels and layout of the functions has primary impact on their experience. Next, the intermediate users who have had previous experience with the product may still need to read the labels aside the buttons constantly; they need reminders and reset buttons to help them restart the workflow once they make a mistake. The design of the interaction needs to be error-proof and displayed on-demand (Cooper et al., 2007, p. 42). Finally, expert users are the ones that not only require the access to basic function of a product, but also desire to use more advanced features. They need shortcuts to powerful and relatively more complicated features and demand for shortcuts and customization. They want to tailor the interface to their own specific needs. (Cooper et al., 2007, p.42; Wroblewski, 2006).

To sum up, products with a simple look with features distributed into complicate hierarchies, which exhibits more perceived simplicity, may be attractive to first-time users. The interaction tunnels the multi-stepped workflow into one fluent process. There is no need to memorize or rationalize the workflow; the only thing users need to know is how to read the labels on the interface. On the contrary, the traditional remote control, which possesses more operational simplicity, provides users with all of the multi-features on the surface. Its design makes the more powerful features handy for advanced users (Wroblewski, 2006). Operational shortcuts would create more delightful user experiences once users gained more knowledge about their product. It is critical to construct to consider these different aspects of simplicity, as design strategies to achieve simplicity would vary according to different target user groups.

1.3 Dilemma of simplicity: function vs. appearance

A big challenge in achieving simplicity is to leverage the balance of perceived simplicity and operational simplicity, which has been a frequent dilemma in the market. Psychological experiments (Reber, Schwarz, Winkielman, 2004) show that objects that are perceived to be simple—which contains less elements to be perceived—creates cognitive fluency in users' aesthetic judgment and decision making process (Roller, 2011).

That is to say, products with a simple looking surface could bias people when they judge the simplicity of the workflow. Users tend to make the presumption of linking perceived simplicity with its operational simplicity: it looks simple, so it must be simple to use. On the other hand, products with a complex look usually intimidate users before they even touch it (Wroblewski, 2006). It seems that in order to acquire a larger customer pool, a product needs to address perceived simplicity implemented with only the core features demanded by mainstream users. However, the situation in the real market is contradictory. Our daily life is composed of complex technologies and challenges, customers require more and more features to assist them with all of the complexities in their daily life. Complexity has become a part of modern life, which cannot be satisfied with limited features of simplicity (Norman, 2011). Users do have requirement and desire for an elegant and simple-looking product, but they are more likely to select the one with its multi-featured functionality displayed above the surface, the one with low perceived simplicity. Here, complexity equals empowerment, satisfying user need for control, often making them to purchase features that they would rarely use (Norman, 2011, p. 55).

As briefly introduced above, simplicity as it turns out is actually a very complicated concept, which cannot be approached from one simple solution of minimizing features. The challenge to design simplicity lies in finding the balance between perceived simplicity and operational simplicity in consideration of their conflict in design and dilemma in use. In what follows, we will review psychological foundations and design principles that provide guides to achieve simplicity in design practice.

2. Approaches for Simplicity

2.1 Theoretical Foundations

As the perception of simplicity is closely related with human cognitive process, it is critical to understand relevant theoretical foundations. Pattern recognition is a basic theory to describe human perception process of matching information stimulant with existing knowledge or experience stored in memory. An object containing fewer elements is perceived to be simple because it takes less time and effort to understand the pattern of information. Organization by grouping and applying hierarchy are common design approaches to achieve simplicity of perception as well as operation. Furthermore, a familiar stimulant that a user had former experience with reduces even more time and effort to process presented information (Reber et al., 2004). The relationship between how information is presented and users' existing experience plays a critical role in the process of cognition.

Another concept in cognitive psychology that impact user's understanding and decision-making profoundly is *cognitive fluency*. Cognitive fluency or processing fluency refers to the ease with which information is processed. Objects with fluent cognition process create familiarity and a positive feeling in users. For example, when presented with the same task written in different fonts, task written with an illiterate font were considered harder to accomplish than task written in an easily readable font (Figure 2) (Wroblewski, 2006). With fluent stimulant, people tend to make decisions based on intuition and first impression. On the other hand, inconsistency in stimulants would make people spend more time analyzing the information and thus utilizing a more rational analytical decision-making strategy (Wroblewski, 2006).

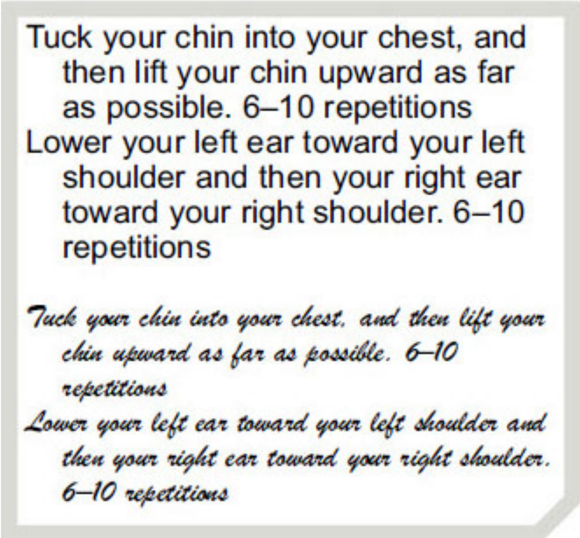


Figure 2. Psychological experiment on cognitive fluency

2.2 Design Principles

Principles of interaction design are closely related to human cognitive process. Designers can utilize several principals to approach simplicity. Commonly used methods include reduction, hiding, and Gestalt psychology. Reduction refers to the design process when designers analyze the workflow and eliminate redundancies and only keeping core functions in the interaction. Once functions and features become irreplaceable, another method we use is to separate functions onto different layers of interaction, hiding feature underneath the surface. Creating hierarchy may eliminate complexity on perception, but it risks lowering operational simplicity of the product. Because advanced functions were hidden and out of reach of surface interface. When designers reduce, organize and hierarchy function modules, we apply the Gestalt principles to all elements of the design including lay-out, color, shape, texture, and form.

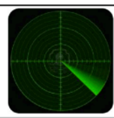
All of the above principles had been utilized to simplify information digestion for users. The methods create fewer elements and facilitate the cognitive process of users, but the other aspect – familiarity – had not been fully cultivated. A primary approach to raise familiarity in user is through metaphor. Metaphor had been adopted from linguistics and utilized in design to create better communication in various aspects. But its connection to simplifying product interaction had not been discussed before. In this paper, we propose that design metaphor could be used as a principle to address simplicity in interaction. We will conduct an experiment to test the impact of metaphor on creating perceptional simplicity as well as operational simplicity.

2.3 Simplicity by Metaphor

The concept of metaphor was drawn from linguistics (Lakoff, Johnson, 1980). The links between metaphor and design now are mostly on a literacy and verbal level. Metaphors have a positive effect on making interaction simpler by presenting new features in familiar forms and behaviors. In this paper we aim to explore how to apply metaphors in consideration of the balance of perceived and operational simplicity, specifically in terms of how a source of metaphor is selected, applied to a design in terms of specific attributes, and influence the simplicity of interaction.

First we surveyed various examples of products that utilized metaphor from design websites, and analyzed the relationships between the sources of metaphor and the designs that metaphor is applied to (Table 1).

Table 1. Samples of the survey

Product Metaphors	Graphical Metaphor			Physical Metaphor				Metaphoric Relationship			Product Description	Metaphoric Concept	Metaphoric Image
	Texture & Color	Shape	Digital display	Texture	Shape & Size	Oper-ation	Physical Feed-back	Abstract	Neutral	Descrip-tive			
	√	√	√					■			Digital watch	Radar	
					√	√	√			■	Timer	Exersice pull ring	

Based on the analysis, we identified two dimensions that respectively categorize the use of metaphor: *manipulation* and *representation* (Table 2). The dimension of manipulation is about how a metaphoric concept is carried out onto a design—either as a verb (*physically*) or as a noun (*graphically*) (Turner, Walle, 2006). When a metaphor is applied physically (as a verb), meanings and forms of the source of a metaphor are applied to three-dimensional elements of a design object: physical shape, operation, feedback, etc. When a metaphor is applied graphically (as a noun), meanings and forms of the source object are applied to two-dimensional elements of design: graphic icons and feedback on screen-based display. The other dimension to consider is how directly the elements of a metaphor are represented. The link could be either *abstract* or *descriptive*. For example, as seen in the examples (Ziiro digital watch), the details of the metaphor could be abstracted when applied to specific design elements, while in another example (the timer with a pull ring), the detail elements could be represented descriptively in full details.

As specified above, the two dimensions provide a useful framework to understand different approaches of how a metaphor could be applied to a design. Furthermore the quadrants of the framework serve as criteria to compare how different approaches could result in simplicity of interaction, different affects in facilitating product communication. In what follows, we compare the metaphoric approaches from each quadrant of the framework by conducting a set of user studies.

Table 2. Framework of metaphor applications

		Representation of Metaphor	
		Abstract	Descriptive
Manipulation of Metaphor	Graphic		
	Physical		

3. Case Study: applying metaphors to alarm clock interaction design

3.1. Objectives and Methods

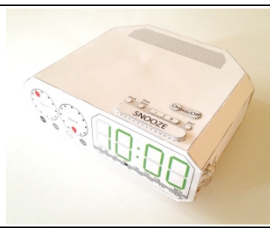
The general assumption is that metaphor contributes achieving simplicity of interaction by presenting a set of functional elements in a familiar pattern. In this study we further investigate *how* different approaches of applying metaphor would affect perception and operation of simplicity in interaction, specifically by comparing the affects of metaphor when it is applied *physically* vs. *graphically* as well *abstractly* vs. *descriptively* as defined with the framework above.

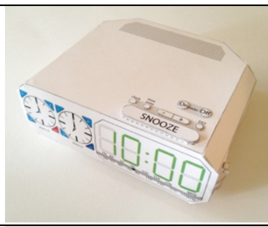
The four different design approaches—by combining physical and graphic manipulations and abstract and descriptive representations—were applied to the selected functionality of an interactive product. An alarm clock was selected as the object as it is a familiar everyday product with complicated enough interface elements and steps of operation. The scope of functionality was defined as 1) alarm setting, 2) time setting, and 3) radio tuning, and the number of corresponding interfaces was kept the same in 12 prototypes with different manipulations and representations designed according to the four strategies from each quadrant of the framework (Table 3).

Three different concepts of metaphor were assigned to each group of prototypes in order to avoid any influence of a particular metaphor. The metaphor concepts assigned to graphical manipulation include face, analogue clock, and dial phone. The concepts for physical manipulation include: bottle cap, seesaw, and zipper. In graphical application group, the forms and meanings of the metaphors were applied to the screen-based interface elements, while in the physical groups metaphors were applied to the tangible interface elements in physical application group; In the abstract group, elements were represented with basic concepts and shapes, while elements represented in the descriptive group were more detailed and precise.

Total 13 models were designed as three-dimensional paper prototypes: 3 for graphic abstract group (GA), 3 for graphic descriptive group (GD), 3 for physical abstract group (PA), 3 for physical descriptive group (PD), and one without any metaphor designed to be the control group. All of the models contain a similar number of interface elements representing the same set of operations: 1) press alarm buttons, and 2) set alarm times. The 13 models were grouped into 6 sets in order to present different models in random order during the experiment. Each set consists of three models: control model (CG), one from the abstract groups (GA and PA), and the other from the descriptive groups (GD and PD). The purpose of the prototypes was to provide an impression of the interface layout and the expected operation, not to actually test their usability in use. In order to eliminate variables including physical feedbacks and human factors, participants were asked not to touch the models and rate answer the questionnaire only based on their perception and expectation from the presented interfaces.

Table 3. Different models for the test

CG Control Group			
GA Graphic Abstract			

GD Graphic Descriptive			
PA Physical Abstract			
PD Physical Descriptive			

During the experiment, individual participants were provided with a set of three prototypes (grouped as described) and a questionnaire. They were first asked to observe the interfaces of the prototype models and to compare their perceived impressions by rating the questionnaire. The questionnaire covers qualitative criteria to estimate simplicity of interaction: overall perceptual simplicity, representational efficiency (the distinctiveness of alarm setting control), engaging appearance of model, perceived learnability, perceived predictability, the alarm clock control's perceptual simplicity, accuracy in predicting interactive workflow, confidence of predicted workflow, operational simplicity by perception, and metaphoric implication (Table 4). Participants were asked to rate each question on a scale of 1 to 5.

3.2. Results

24 graduate students from the design program participated in individual sessions of the study. Their rating for different questions and groups are averaged and converted to a percentage scale in Table 4. In order to get a clear view of differences between different groups, we converted the average score to percentage scale. All of the scores from the testers were added up together and divided by 5 times the number of testers, then transferred to percentage. For example, the scores for question 1 of the Abstract Graphical group were 5, 5, 4, 4, 2, 4, 4, 4, 4, 3, 4, 4, the percentage scale of the question = SUM of scores/(5*12)*100%=78.3%

Table 4. Questionnaire and results

Questionnaire	GA Graphic Abstract	GD Graphic Descriptive	PA Physical Abstract	PD Physical Descriptive	CG Control Group
1. Overall simplicity: The model looks simple to use.	78%	77%	82%	65%	72%
2. Perceived simplicity: The interaction of the alarm clock looks simple.	77%	77%	87%	72%	69%
3. Operational simplicity by perception: How do you rate the simplicity of the workflow?	78%	78%	85%	80%	66%

4. Perceived learnability: The alarm clock's interface looks easy to learn.	82%	78%	83%	75%	79%
5. Perceived predictability: I know how to interact with the alarm by observing it.	75%	80%	77%	73%	73%
6. Accuracy of elaborated workflow: Set alarm A to 9 am and read the time set for alarm B.	81%	80%	80%	82%	73%
7. Confidence in prediction of workflow: I am confident of the workflow as answered above.	70%	73%	82%	72%	70%
8. Representational efficiency: The functional controls of the alarm are obvious.	78%	72%	85%	73%	74%
9. Engaging appearance: The alarm clock's interface looks inviting.	75%	75%	87%	72%	60%

As seen in the table above, the PA (Physical Abstract) group was perceived the most positively in terms of overall simplicity while PD (Physical Descriptive) group was mostly negatively perceived with the lowest ratings of all four metaphoric groups, even lower than the Control Group. The graphic application groups (GA and GD) were rated slightly higher than the Control Group. We had not expected the low score from the Descriptive Physical group. The results show that the expressiveness and preciseness of the metaphor actually affects interaction simplicity negatively. Instead, it may cause more user confusion.

In the results, the descriptive groups were rated relatively low compared to the abstract groups, while the control group was the lowest in most cases. The results show a clear difference between the descriptive groups and the abstract groups, reinforcing the finding discussed above. It was observed from the ratings to both questions that *abstract* representations of metaphoric concepts have a positive effect on the perceived simplicity of interaction. While on the other hand, *descriptive* representation has negative influence on the perception of simplicity. This is because too many details of metaphor can create more information and interferes with the rest of the other functional elements, thus bringing confusion to participants. As is shown in the result of question 7 (representational efficiency): testers couldn't tell which part was for alarm control and which part was for time setting.

Regarding specific operations, participants were also asked to write down their expected workflows for a given task based on the presented interfaces of each model, without actually operating them. Investigators then rated the accuracy of elaborated workflows (question 6). The scores of accuracy were similar in the four groups – all higher than the control group. After this task, participants were asked to rate their confidence about operational simplicity by perception (question 7). It is interesting that their confidence in their ability to predict the workflow significantly changed before (question 5) and after (question 7) actually elaborating the workflows (question 6) regarding to different groups. Participants became more confident about their prediction for the Physical Abstract group (PA: 77% in question 5 -> 82% in question 7), while their confidence dropped in the other groups. Referring to the psychological experiment in cognitive fluency as we mentioned in Chapter 2, we deduct the reason of the difference is that participants become more analytical and critical in ratings compared to their first impressions after scrutinizing the workflows.

Here in most cases, significant differences were observed between the ratings for abstract groups (GA and PA) and descriptive groups (GD and PD), implying that abstract applications of metaphor contribute to perceptual simplicity while descriptive application may have negative effects on simplicity. We conducted t-test to validate any statistical significance between the ratings among different groups, which is shown in Table 5 below. We conducted the t-tests with the original average scores instead of percentages. In the results, the difference between scores from Physical Abstract group and Physical Descriptive group is statistically significant. But the difference between Graphical Abstract group and Graphical Descriptive group is not significant and the scores could be considered similar. The P value between Graphical Abstract group and the Control Group is considered very statistically significant, and yet the Physical Abstract group got even higher score than group GA. This could be an indication that metaphor have bigger influence on creating simplicity in interaction than utilizing reduction and Gestalt Principles, since metaphor addresses users' former knowledge or experiences and is more engaging in appearance. However, this is not an indication for users' preference. We could not say that users would prefer models with metaphors or models that possesses perceptual simplicity as well as operational simplicity, but the results did show a relatively positive feedback on the physical abstract groups in question 9 where we asked if the model looked inviting to them, in which the results reads GA: 75%, GD: 75%, PA: 87%, and PD: 72%. The abstract physical models did give testers a positive impression on its engaging appearance.

Table 5. T-test results

Significant P Value	PA vs. PD Physical Abstract & Physical Descriptive	GA vs. PA Graphical Abstract & Physical Abstract	GA & CG Graphical Abstract & Control Group
	0.002	0.012	0.0043
Insignificant P Value	GA vs. GD Graphical Abstract & Graphical Descriptive	PD vs. CG Physical Descriptive & Control Group	
	0.6953	0.3073	

Overall, we can argue from the results that metaphor helps achieve perceived simplicity of interaction, although it does not change operational simplicity, only when it is applied at an abstract level. Applying every detail of the forms and concepts of a metaphor could actually confuse user with more information to process. We see this finding as a critical foundation to guide the use of metaphor in interaction design.

4. Summary

Below is the summary of the study results as analyzed above:

- In most cases except for the physical descriptive (PD) group, metaphor contributes to increasing perceived simplicity of interaction with a given scope of operational steps, showing higher ratings than the control group. The findings imply that metaphor helps develop a familiar pattern among individual interface elements. However, too much detail-oriented application by mimicking the source of metaphor could result in negative effect with information interference. The information interference created by the redundancy details of the metaphor may have a counter-effect on conveying their operational workflow.
- Metaphors applied for physical manipulation (as a verb) display more positive effects than the ones applied for graphic manipulation (as a noun). The physical application involves more diverse modes of user interactions as well as kinetic behaviors of the metaphor object compared to the graphic application where only graphic representations of the metaphor object are used. Again, too much descriptive application of metaphoric concepts could make a design more complicated, and this could be a more

significant issue in case of physical application than graphic application due to rich modes of interactions involved in physical manipulation.

In this study we have compared different approaches of applying metaphor to interaction design and compared their effects on perceived simplicity of interaction. It has been statistically proven that abstract representation of a metaphor is more efficient in achieving simplicity than its descriptive presentation. The finding has also been supported by the qualitative analysis of the study results. Although it is hard to make a generalized comparison among different strategies of applying metaphor—whether a certain approach is more efficient in achieving simplicity than the others, we still consider the identification of the four approaches (physical vs. graphic manipulations and abstract vs. descriptive representations) is a meaningful contribution to guide *what to consider* in applying metaphor to interaction design. The framework also implies the approaches corresponding to each quadrant would result in different affects in perceived simplicity of interaction. This underscores more critical ideation in selecting and applying a metaphor to interaction design instead of mechanically mimicking all the details of a metaphoric concept. As future work, we hope to continue our study by applying the framework to various design subjects and types of tasks.

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