Informative effect through changing the color attributes of smartphone application icons

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Abstract: This study investigates the informative effect on user's intuitive perception when the color attributes of smartphone application icons are presented in unusual way. As the color attributes, hue, saturation, lightness, and opacity were taken into consideration. An empirical study was carried out that involved two user studies. In User Study I, the focus was on what kind of change would draw the eye attention more efficiently. In User Test II, the focus was to observe whether participants could perceive any specific status change of the application by viewing the color manipulation. Throughout the empirical study, we observed four overruling tendencies: First, in case of hue and lightness, the changes made to icons were most noticeable, however their changes sent less specific message to users compared to other attributes; Second, decrease in both saturation and opacity of an icon was perceived as being less used; Third, increasing or decreasing the lightness of an icon implied that a user should take an action; Last, excluding hue, all the other attributes should have a dramatic change in order to let users be aware of the both change and informative effect.

Key words: color evaluation, icons, smart phone GUI, transparent interface, app icons

1. Introduction

Since the concept of graphic user interface (GUI hereinandafter) emerged, people have been operating electric devices in an easy and intuitive way. One of the most distinct characteristics of GUIs is that they always use icons. To activate or control a program in GUI, different input types have been considered, such as a mouse, fingertips, or more recently, body gesture. With the icons, users click, or touch them to execute commands. That same formula is applied in all mainstream smartphones. Although programs are now called applications, or apps, they are still represented by icons, and people touch them to use these apps. However, due to smartphones having relatively small display sizes, these icons are much more densely clustered, and are organized in a very rigid tile-like way. The image of aligned icons are all what the home screen can manage, and there are so many apps for users to choose and download, that their smart phone screens soon gets filled with endless icons. In this very confined space, it is rather difficult to add any additional information other than the list of app icons.

Unless users actually click, or touch the icons to execute the apps, all they know are the apps' names, and graphical icons that represent what the apps are. Other than going into separate application management screen, the method most app icons use to display additional information to, is a simple display of *notice numbers* (figure 1). As the relationship between the Apps/programs and users get more complicated, and their usage behaviors get more varied [1], More versatile method to intuitively send users informative messages is needed. In case of changing opacity, the transparent layers' ability to create focus and divided attention in GUI is explored [2], and implicational

research of changing opacity of layers was done by Ishack and Finer, which gave transparency to part of GUI that doesn't have crucial information [3]. These researches show the possibility of changing single attributes of already existing elements of GUI to provide additional information and function to users.

On the other hand, research done by Shin [4] propose a system that analyzes users' smart phone app usage patterns to recommend the next most probable app the user will use by showing the icons on top of the home screen. Such method is effective on paper, but the constant changing of icons' positions can bring confusion to users, providing useful, but distracting function that limits users' choice. Another less intrusive way to give information is changing the appearance, not the position of icons. However, researches or interface designs that explore such method are yet to be done. Changing the whole appearance will not be useful if users can't even identify which app is which. Changing only the color attribute, not the physical shape of icons is more suitable. That way, users can still identify the apps, while noticing the change. If such data on this matter is provided, designers and developers can find various ways to send users more functional messages by simply changing the appearance of the app icons. Thus, we intend to evaluate the informative effect on users through changed color attributes of smart phone app icons to provide designers and developers the data pool of users' response to such changes.

Figure.1 Current method of utilizing icons to send message to users

2. Objectives

In this study, we aim to evaluate the informative effect on users through changed color attributes of smart phone app icons. The objectives of this research are as follows:

1. To investigate the informative effect to users by changing color attributes of smart phone app icons in order to provide useful reference data to designers.
2. To demonstrate a design process that utilizes the empirical findings.

3. Plan for User Study

Participants

30 Smartphone users comprised of 15 male students and 15 female college students in their 20s were recruited. 18 were Android-based device users, and 12 were iOS-based device users. All 30 participants were familiar with app icons used in the user studies, and although the stimuli was created based on Android smartphones, iOS users were able to identify the apps easily.

Table 1. The list of 16 color attribute changes

Color Attribute	Change Level	Color Attribute	Change Level
Hue	+ 45˚	Opacity	75%
	-45˚		50%
	+90˚		25%
	-90˚	Lightness	+35
	+180˚		-35
Saturation	-33		+70
	-66		-70
	-100	Default	No change

Table 2. The list of 16 Apps used to create stimuli

Icon								
Name	Facebook	CutTheRope	KaKaoTalk	Camera	Gmail	Call	Instagram	Internet
Service	SNS	Game	Messenger	Camera	E-mail	Call	Photo Service	Browser
Icon								
Name	AngryBird	Twitter	Skype	Naver	Weather	Map	Google	Gallery
Service	Game	SNS	Video Chat/Phone	Search Engine	Weather Service	Map	Search Engine	Photo album

Stimuli

To investigate the informative effect of changed color attributes of Smartphone app icons, 4 images of generic smartphone screen based on Samsung Galaxy S3 were made with 16 app icons placed appropriately. For the change of color attributes, 16 variations were made (Table 1, Table2). There are 5 variations for hue, 3 for saturation (-100: grayscale; 0: default), 3 for opacity (100%: Completely Opaque; 0%: Completely transparent), 4 for lightness (+100: completely white; -100: completely black), and 1 for the default case. In case of lightness, for easier control of the parameter, we simulated the effect by overlaying white color with α % opacity value for + α lightness, and black color with β % opacity value for – β lightness. The position of each app icons and the changed color attributes were placed in random for each 4 images as shown in Figure 2

Procedure

The images were shown to participants using Samsung Galaxy S3, thereby simulating smartphone using situation. The experiment was comprised of 2 parts, and each participant went through 2 sessions using 1 image per session. 16 participants used 1st and 2nd image, and 14 participants used 3rd and 4th image. Participants weren't shown the original versions of app icons, and were to use their memory, or common sense to evaluate the change.

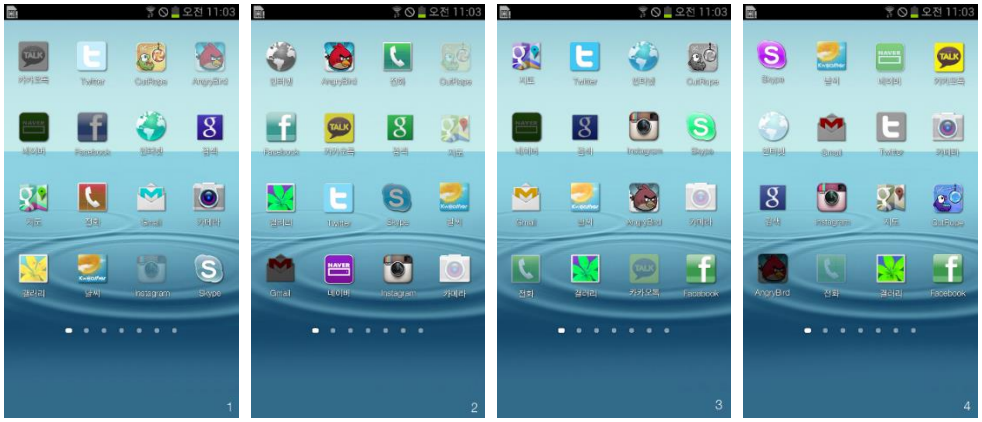

Figure.2 Four test images shown to participants

4. User Study I: Evaluation of attention grabbing ability of stimuli

The goal of User Study I is to investigate which stimulus draws more attention than others; thereby identifying which color attribute change will be noticed by users easily. The users' ability to notice the change made to icons differed greatly based on which attribute was changed. By average, as shown in Table.3, icons with changed lightness, and hue were most noticed by participants with average of 8.25% for individual lightness-changed icons, and average of 6.60% for icons with hue-changed icons. Looking into individual icons, the most noticed icons are the icons with opacity level of 25%, and icons with saturation removed all the way (-100: grayscale). Also, in case of opacity and saturation, the parameter had to be greatly lowered in order for people to take notice.

Table 3. The Result from user study I

Attributes	Change level	Chosen times		Percent (%)	Average (%)
Hue 0°~360 °	+90	34	99	11.33	6.6
	-45	19		6.00	
	+-180	18		6.00	
	-90	14		4.67	
	+45	14		4.67	
Lightness (-100~+100),	-70	45	99	15.00	8.25
	+70	27		9.00	
	-35	25		8.33	
	+35	2		0.67	
Opacity (0%~100%)	25	0	52	12.33	5.78
	50	15		5.00	
	75	37		0.00	
Saturation (-100~+100),	-100	36	48	12.00	5.33
	-66	10		3.33	
	-33	2		0.67	
Original		2		0.67	0.67

5. User Study II: Evaluation of informative message-sending ability of stimuli

The goal of User Study II is to evaluate the users' expectation of function followed by color attribute change of app icons, and the change of emotional feelings towards the apps. Participants were asked to choose app icons that they could make a rough guess on what the change meant. Participants were asked not to care too much on how noticeable the changes were, so if they couldn't guess the meaning, the icons weren't chosen even though they could clearly see the change. After writing the expected meanings, they evaluated how sure their guess was, usefulness of the guessed function, and the aesthetic appeal of the change based on 5-point scale (-2: not at all; 0: neutral; +2: very much so).

The answers with less than +1 of sureness were ignored, leaving total of 147 answers, and the written answers with basically the same meanings were grouped as shown in Table 5. After grouping the answers, they were scored based on the changed emotion towards the app (positive: +1, negative: -1), and if the answer is passive information or active information that require actions (passive: 0; active: +1).

As shown in Table 4, the top 3 chosen stimuli were saturation -100, opacity 25%, and lightness -70, showing the stimuli's ability of to represent certain functional message. The only stimulus with average score of aesthetic appeal that is lower than 0.00 was lightness-70 (Table 4). Even though the average aesthetic score of opacity75% was -2.00, the score was neglected due to there were only 1 answer written for the stimulus.

Table 4. Chosen times and percentage of stimuli

Attributes	Changed level	Chosen times	Percentage (%)	Aesthetic score
Saturation -100~+100, (0 = default)	-33	0	0.00	-
	-66	4	2.72	0.22
	-100	32	21.77	0.75
Lightness -100~+100, (0 = default)	+70	13	8.84	0.46
	+35	0	0.00	-
	-35	6	4.08	0.83
	-70	27	18.37	-0.15
Opacity 0%~100% (100 = opaque)	75	1	0.68	-2.00
	50	4	2.72	1.25
	25	28	19.05	0.36
Hue 0°~360 °	+-180	5	3.40	0.40
	+90	17	11.56	0.06
	+45	1	0.68	1.00
	-45	4	2.72	1.50
	-90	5	3.40	0.25
Original		0	0.00	-

Table 5. Raw data for opacity 25% (Phone app) and their grouped result

Original	Shown Stimulus	Written answer	Grouped result	Sureness	Usefulness	Aesthetic appeal
		This is not used often	This app is used less	2	1	0
		Probably won't use this		0	0	2
		It is being forgotten by not using		2	2	2
		fire is beginning to flicker		1	2	1

The details on top5 chosen stimuli are shown in Table 6. The test result in User Study II showed strong relation between the changed attribute of icons and the expected meaning of the change. The most written answer for both saturation -100, and opacity 25% is "This app is used less", with considerable gap of quantity between 2nd most written answers. For the top 3 most chosen stimuli (saturation-100, opacity25%, and lightness-70%), the average score of emotional change towards apps were all mostly negative (saturation-100: -0.85, opacity25%: -0.96, lightness-70%: -0.81). In case of hue +90, the answers were evenly mixed between negative/positive, as the average score was -0.11.Also, all stimuli's average score on active/passive rate was lower than 0.50. For lightness -70 and +70, it was relatively higher, each having average score of 0.33 and 0.38, meaning that the associated functions with lightness change required clear actions rather than simply giving information.

Table 6. Top 5 manipulation methods and the most commonly associated functions

Stimuli	Written answer	Percentage of answer within the stimuli (%)
Saturation -100	This app is used less	31.25
	Deactivated	25.00
	Unable to use	12.50
Opacity 25%	This app is used less	46.43
	The app is hiding	14.29
	The app was deleted	10.71
Lightness -70	Use this app less	18.52
	Deactivated	18.52
	Broken	18.52
Hue +90	Broken	29.41
	Notice	23.53
	This app is used often	11.76
Lightness +70	Need update	15.38
	Etc	7.69

For designers, it will also be useful to be able to see the data organized starting from the message/function, considering that designers might want to start the ideation from message/function already decided. Top 5 mentioned message/function, and the percentage of according attribute change is reorganized, and shown in Table 7. Lowering saturation, opacity and lightness seems suitable to send usage related message to users. Within those 3 attributes, lowering saturation and opacity is more suitable to show the apps that are not used, and lowering lightness is more suitable to prevent users from using the apps. Lowering saturation also seems to show that the app is deactivated. To show the app is broken, changing hue seems most effective, and also affective to give simple notice to users.

Table 7. Percentage of related attributes within the top 5 written message/function

Written answer	Lowering Saturation (%)	Lowering opacity (%)	Lowering lightness (%)	Raising lightness (%)	Changing Hue (%)	Number of answers
This app is used less	34.29	45.71	17.14	0.00	2.86	35
Broken	11.11	11.11	27.78	5.56	44.44	18
Deactivated	50.00	12.50	37.50	0.00	0.00	16
Use this app less	16.67	16.67	58.33	8.33	0.00	12
Notice	9.09	0.00	18.18	9.09	63.64	11

6. General Discussion

This study evaluated the effect of color attribute change of application icons. Through the result, we were able to evaluate each parameter change based on attention grabbing ability, and the general expectation of users on what the changes meant on functionality aspect. Though many participants noticed hue level change, the expected function/message of the change was a mixed result, being hard to be conclusive on any aspect. But if the intended message/function is just a simple notice, changing hue can be effective. Lowering lightness also caught participants' attention, written answers for lightness -70 were equally divided (all top 3 being equally 18.52%), and the average score of 5-point analysis on aesthetic appeal was -0.15, being the only stimulus to have negative aesthetic appeal. All things considered, it is not recommend to lower the lightness of icons in the design field.

The written answers were scored based on the changed emotion towards the app (positive: +1, negative: -1), and based on if the answer is about passive information or information that requires users to take actions (passive: 0, active: +1). All changes excluding lightness +70 lead participants to feel negative towards the apps. In case of lightness +70, the average emotional score of the written answers was 0.08, which is too low to be conclusive that it has emotionally positive effect. The most recommendable attribute change to be used in design field is lowering saturation, and lowering opacity. The high percentage of participants expected the stimuli to mean that the app was used less. But combined with the result from User Study I, the change must be significant enough in order to actually deliver this message to users.

Despite meaningful results, there were some limitations in this study. First, to use app icons that were familiar with participants was necessary, but the individual participant's perception on some of these apps could have affected the result. Even though participants were asked not to be affected by the type of the apps (game, SNS, news, etc.) for this specific research, it could have been interesting if each type of apps were fully considered, and to analyze

their effect on the result. Second, the participants were limited to Korean students. Even though students in their 20s are the active smartphone users in most countries, there may be some differences from country to country, or between different ages. Hence, conducting experiments with subjects from various cultural groups and observing the differences between them can serve to be meaningful.

7. Conclusion

In this study, we evaluated the informative effect on users by changing color attributes of smart phone app icons. The experiment to achieve the objective is as follows. First, we evaluated the attention grabbing ability of different color attributes such as hue, saturation, lightness, and opacity to identify how one attribute change is more eye-catching compared to others. Participants could easily detect the change of hue and compared to other changes. Second, we evaluated the users' expectation of function followed by color attribute change of app icons, and the change of emotional feelings towards the changed app icons. Decreasing Opacity and saturation was found to give participants the impression the apps are not used for a long time. Also, even though lowering lightness didn't seem to give one specific message to participants, the messages were stronger, requiring users to take actions rather than simply just informing them. Regardless of which attribute was changed, most changes give emotionally negative impression on the changed apps. Through our research, we hope to give designers the necessary data for them to create various implementations that overcome the limit of screen size with intuitiveness.

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