

The Effect of Mobile App Icon Design on Satisfaction and Usability

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ABSTRACT

Currently there are many user interface design styles using a variety of app icon designs. The earliest style was skeuomorph which imitates the design of real-world objects. Flat and material design have emerged more recently and all of them are still currently in use. The purpose of this study is to examine the effects of different styles of app icon design among different Thai age groups in terms of satisfaction and usability. This paper observed 15 basic app icons from five mobile phone brands representing different icon styles; skeuomorph, skeuominimalist, flat, material design, and broken line. Young and senior adult participants were recruited into this study to examine their satisfaction with app icon styles. A visual search task was employed to measure the designs' efficiency and effectiveness. The results show that both age groups are most satisfied with skeuomorph and skeuominimalist. Seniors prefer flat rather than material design or broken line, and vice versa for young adults. In the visual search task, both age groups took the longest time for flat design and also made the most errors. In visual search, the skeuomorph icon design was the fastest for young adults, while material design was the fastest for senior adults. There were also some significant interactions between age, styles, and app icons.

Keywords: icon styles, app icon, visual cognition, mobile interaction

INTRODUCTION

The first computer developed using Graphic User Interface (GUI) was produced at Xerox PARC in 1973, so-called, Xerox Alto. The GUI was a human-computer interface that made it easier for users to communicate with electronic devices. The WIMP-based system was designed for creating the GUI of personal computers consisting of Windows, Icons, Menus, and Pointers. Icons in digital product design are created to represent among other things, a command, a program, data file, window, option, or a concept (Rushan, 2011). They are visual language that conveys meaning through an illustration. Digital product designers use them for making presentations more memorable and engaging and also to help users navigate the system. A good icon design should be universal; everyone in the world should be able to understand it clearly and easily. Using metaphors in icon design helps us to recognise their functions affecting the way we categorize experiences, organize our thoughts, and how people perceive the world (Hernan, 2007). However, some

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icons can express more than one meaning, such as, a globe icon; it can indicate world-wide, language setting, internet, etc. A/B testing is mostly used to measure which design users find more understandable and satisfying. Gordon (2020) stated that an optimized icon has the potential to increase the percentage of users' interaction up to 30%. He also summaries 5 principles for an app icon design; scalability, recognisability, consistency, uniqueness, No words.

Icons are grouped into three different types (Mills, 2013): Pictograms: they are symbols that convey the meaning through its pictorial resemblance to a physical object. They represent data, such as, a car to represent "car insurance". Ideograms: they are graphical symbols that represent a concept or an idea that is more general than a pictogram. For example, using a magnifying glass to represent a search function. Arbitrary: icons are designed to be more abstract creations. These icons are not real world objects. The association between an icon and a concept must be learned. Two main user interface guidelines used for UI design are Human Interface Guidelines for Apple's iOS and Material Design and for Android platforms. Icon size is one of the rules designers need to know for any device. From the Human Interface Guidelines, iPhone app icon size is 180 x180 pixels (px) while Android suggests 152 x 152 density-independent pixels (dp) for square icon keyline shape. UI design trends have been evolving since the 1980s. These concepts in design are used in both website and mobile designs. One of the earliest UI trends is Skeuomorphism, a design concept that describes interface elements that mimic their real-world counterparts (Interaction Design Foundation, 2021). It uses an interface metaphor design to help users recognise how to interact with the digital interface, for instance, designing an icon based on a picture of a microphone for the "Record" action. In 2007, Apple used skeuomorphism in visual design for iPhone (Spiliotopoulos et al., 2018) and this design style is still used for iPhone app icons. In 2011, when Microsoft released Windows 8, the interface was particularly influential in the development of Flat Design. Flat design became popular and is used in UI design by many companies such as Google, eBay, Twitter, etc. They use flat design principles to display their logos, icons, and all interface elements (Morson, 2013). In 2014, the UI design trend called Material Design was launched by Google and is now used across the Android platform. In late 2019, Neumorphism became the hottest trend in that year, also called soft UI. The design combines aspects of flat design and skeuomorphism. Neumorphism primarily plays with shadows and uses monochromatic color palettes for both the background and the interactable elements such as buttons (Tempest House, 2021). The newest trend to emerge is Glassmorphism and is mostly used by Apple and Microsoft. Transparency and blurred backgrounds are the main features of this new interface in combination with colorful images and a variety of shapes.

Previous studies on icon design across different age groups found that older adults had better performance with skeuomorph interfaces than flat. Flat design imposes a higher cognitive load in both age groups (Zhang et al., 2017; Burmistrov et al., 2015; Cansino et al., 2013). Urbano, Guerreiro, and Nicolau (2020) found that younger and older participants have preferences for skeuominimalist and

skeuomorph designs, respectively. Young adults perceive skeuomorph designs as fast and easy to use, while recognising skeuomorph design as complex. Moreover, the study showing that older adults have mostly different views, regarding skeuomorph interfaces as beautiful, trustworthy, interesting, fast and easy to use.

In 2021 many icon styles are used for mobile applications. The purpose of this paper is to study the effects of different styles of app icon design among two Thai age groups. The findings of this research help us to understand how those users perceive icon design with different design approaches through investigation of preferences, effectiveness, and efficiency so that we can design a better user interface. Qualitative and quantitative data were collected. A survey was used to explore participants' app icon satisfaction. A visual search task was employed to examine effectiveness and efficiency for two age groups across five design approaches (i.e. skeuomorph, skeuomorph, flat, material design, and broken line).

LITERATURE REVIEW

Icon styles can vary widely, from simple shapes and lines to full-color icons. Some use shadows and geometry to create distinct icons, while some use lines and color to represent. Previous studies have focused on icon design, the effect of icon styles on usability, and also the study of icon characteristics comparing between young and elderly users.

Styles of the Icons

Isometric style: this is a style of design which uses a technique called isometric projection. It represents three-dimensional objects in two dimensions with hard shadows and uniform line thickness. The concept of isometric icons is based on the "office metaphor" adding the illusion of depth and dimension to the GUI (Stefan, 2017).

Glyphs style: glyphs or filled/solid icons are usually displayed in one color and with a solid shape. The design is based on simple shapes and smooth curves for quick and easy object recognition. The style can be very effective, especially when used for smaller sizes. This style of icons is commonly used on a navigation bar of mobile applications.

Line style: line or outline icons have become more popular in recent years. The design is simple and clean, mostly using two colors that work together. Each icon is easy to see and understand at practically any size and uses a consistent line thickness. Designers may add a gradient to a line icon. A broken line style is a subset of a line style that puts dots or spaces between the line breaks; this is also referred to as an incomplete icon style.

Skeuomorphic style: skeuomorphic icons design uses shadows, shading and gradients. They must look as similar as possible to their real-life equivalents so that users understand the icon function easily.

Flat style: these can be seen as a descendant of glyph icons. This icon style became popular around 2012 when first used by Microsoft. The style displays a simple design with a flat two-dimensional graphic layout, simple elements, and bright colours. The design does not represent depth, gradients, textures, and has no added effects. Flat design represents simplicity and minimalism.

Skeuominimalist style: this icon design is mixed between skeuomorphism and flat design.

Material design style: material design was launched by Google in 2014. This style represents components that look like real-world objects that use shadow and element layers to make them look simpler than skeuomorphism. This style is mostly used in the Android interface.

Glassmorphism style: Glassmorphism is a new design trend launched at the beginning of 2011. The style is similar to the glass style that implements a transparent effect for an element and background. It also uses gradient colours for objects.

Related studies

User perception and interpretation of icons are the main factors in their effective use. How users interpret what they experience is the domain of cognitive psychology, which involves the study of the function of the human visual system. However, the interpretation of the sign will depend on the user's mental model (Gatsou et al., 2012). In 2014, Arledge studied the impact of icon style on usability in single color icons with flat design comparing filled-in and outline icons. The result showed that users could recognise more quickly and accurately when the icons are in a filled-in style or an outline style, however, there was a statistically significant interaction effect of the icon styles on task time. The task times of outline icons shown in white against a black background are slower than the other style-color variations and the form of an icon has a greater impact on its usability than its style or color. Recently, a few studies investigated the comparison of skeuomorphic and flat design. Spiliotopoulos, Rigou, and Sirmakessis (2018) investigated the level of icon design across the exact same functional options; recognizability, recall and effectiveness, comparing skeuomorphism and flat design. The data were collected using a Tobii T120 eye tracker. The aesthetic aspect of those two design approaches was also examined. The findings showed that there is no clear winner statistically. However, skeuomorphic icons are easily recognizable affordances while flat icons are minimalistic, abstract, and homogeneous. There is no significant effect of design approach on the perceived aesthetic result, but users tend to perceive flat design as more usable. The usability and design evaluated by using the SUS questionnaire (Brooke, 1995) awarded flat design a much higher score than skeuomorphic. Data from the eye tracker represented that in flat icon sets scan paths are longer and fixations more scattered. Older people are more positive towards skeuomorphism in website icon design. According to Urbana, Guerreiro, and Nicolau (2020), three design approaches: skeuomorph, skeuominimalist, and flat design were examined across different age users. The results indicated that there was a statistically significant interaction between age group and design on completion time. In visual search task, older adults were slower with flat design

while the younger adult group had no statistical difference in completion time across design approaches. In perceived aesthetics, the younger group perceived skeuomorph design significantly more complex compared to the older group. Skeuominimalist interfaces were not statistically easier or faster to use than flat interfaces. Younger users perceived skeuomorph interfaces as complex while perceiving skeuominimalist designs as fast and easy to use. Younger adults prefer skeuominimalist icon design while older adults prefer skeuomorphism. Moreover, flat design is either slower or less accurate than skeuomorph interfaces across three tasks: visual search, clicking objects, and multiple page navigation.

Few icon studies have been carried out in Thailand. Most of them used survey questions to investigate users' satisfaction with icon design. Srisuwan (2009) collected survey responses from 400 Thai participants about factors affecting the usability of icons on mobile phones. The study focused on speed, recognisability, communicativeness, resolution, and sharpness. The results indicated that participants who often use a smartphone for browsing the internet considered the size of the app icons more important than other groups. The most important factor in icon design is designing the icon to convey its meaning precisely. Spacing between icons affected usability, especially on a touch screen. In 2015, Supaphonthorn examined Thai elderly perception and usability on four styles of icons: skeuomorph, outline, filled-in with black and white colors, and skeuominimalist with colors. The findings demonstrated that colors help the elderly to recognise icons and the icon size that is suitable for them should be between 72x72 pixels (HDPI) and 96x96 pixels (XHDPI). In addition, app icons based on skeuomorph and skeuominimalist design with colors took less time to be recognised. Filled-in (black and white colors) and outline designs were less attractive for the elderly participants and were harder to understand and recognise.

METHODOLOGY

The study for this paper explored five different mobile brands that most Thai people currently use. Each brand represents different styles of icon design; skeuomorph, skeuominimalist, flat, material design, and broken line icon. The study consisted of two parts; a survey and a visual search task. The aim of this study was to examine three main metrics of app icon styles: 1. Satisfaction 2. Efficiency 3. Effectiveness. These metrics are based on the ISO 9241-11 standard for usability measures.

Participants

For the survey, 170 participants did a survey using Google Forms. They were aged between 18 and 70 (79 females and 91 males). For the visual search task, 33 adults aged from 18 to 44 (young group; 16 females and 17 males) and 36 adults aged from 45 to 70 (senior group; 19 females and 17 males) were recruited for the experiment. All younger adults used a smartphone in their daily life and most used social media, but some senior adults did not have a smartphone and were not familiar with social media. The young adults represented users in the millennial generation who were familiar with technology while the senior adults represented

users from middle age upwards who might have to struggle with technology and who might also be impaired through a decline in visual and/or cognitive abilities. All participants were in good health and had normal or corrected-to-normal vision, with no color blindness, color weakness, or other characteristics.

Apparatus

The survey was collected using a Google Form. The visual search task was run on a laptop (Lenovo, Windows 10). The laptop had a 14-inch display, which was set to a resolution of 1920×1080 , and the experiment was conducted using software for creating experiments for psychology, neuroscience, and experimental economics (OpenSesame version 3.2.5).

Materials and Procedure

There are five popular mobile phone brands in Thailand; iPhone, Huawei, Wiko, Oppo, and Sumsung. Different app icon designs were selected for quantitative and qualitative exploratory studies. Five app icon styles were selected: skeuomorph, skeuominimalist, flat, material design, and broken line. Fifteen basic app icons from each brand were also used.

App icons/Brand	iPhone/ skeuomorph	Huawei/ skeuominimalist	Wiko/ flat	Oppo/ material design	Sumsung/ broken line
Setting					
Message					
Calendar					
Photos					
Email					
Voice record					
Calculator					
Clock					
File					
Phone book					
Video					
Camera					
Phone call					
Music					
Note					

Figure 1 Basic app icons with different styles.

Figure 1. represents fifteen basic app icons with five different icon styles. Those icons were used in a survey and a visual search task. Participants aged between 18 and 70 did the survey. The survey was used to explore users' satisfaction on the app icon design of each brand. A five-point Likert scale was used to measure users' satisfaction. Seventy-five app icons were rated as shown in Fig 1.

The content of materials was evaluated by three experts and the Indexes of Item-Objective Congruence (IOC) values ranged from 0.95-1.00.

For the app icon search task, the purpose of this experiment was to examine the effectiveness and the efficiency of those five icon styles. The experiment was conducted using OpenSesame, which can record time and accuracy. A practice session with six trials was presented before the actual experiment; there was no recording in this part. This was followed by the visual search task involving 75 trials. Time and accuracy data were collected in this session. This task investigates how fast and accurate participants can recognise the app icons compared among different icon styles.

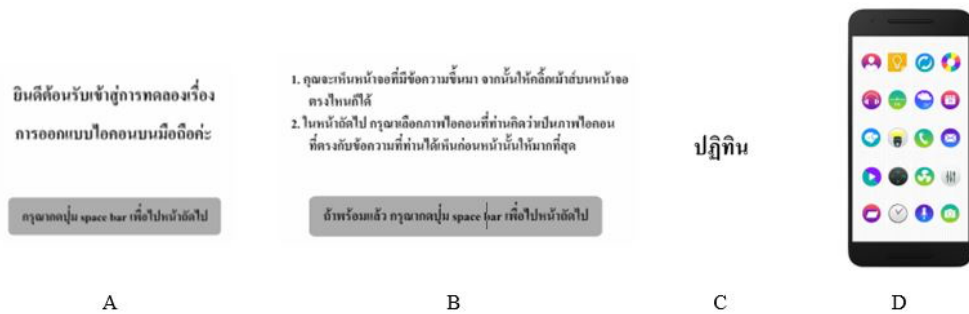


Figure 2 The app icon visual search task.

Figure 2. shows the steps of the app icon visual search task. Figure 2A. is a welcome message and if a participant is ready, press a space bar to the next screen. Figure 2B. is an instruction stating there is an app icon name, such as, photos, clock, etc., showing on the screen as shown in Figure 2C, a user must remember the app icon word in order to find the icon on the screen as shown in Figure 2D and if a participant is ready, press a spacebar. Then Figure 2C shows an app icon word and when a user is ready, she/he must click anywhere on the screen. The next screen displays app icons as shown in Figure 2D. Participants must click on the icon named on the previous screen. Once a user clicks to go to the next step, she/he cannot go back to the previous screen.



Figure 3 User interface of each app icon style.

The visual search task involves 75 trials. Participants were asked to choose all app icons presented in Figure 1 across the five icon styles. The trials were randomized across styles. All app icons were located randomly so that a user would not be familiar with the icon location of each icon style. Figure 3A displays a skeuomorph design. Figure 3B is skeuomorph. Figure 3C represents flat design. Figure 3D is material design. Figure 3E contains icons with broken line style. The whole experiment lasted about 10-15 minutes.

RESULTS

The analysis of the experimental data was done using R (R Core Team, 2020). Focusing on the visual search task in terms of speed and error rate, there were differences between age groups, app icon design styles, and individual app icons as well as interactions between those factors.

Satisfaction of app icon survey

Table 1: Overall satisfaction of young and senior adults with different icon styles.

Icon styles	Average	Std. Deviation	Median
Skeuomorph			
Young	3.85	0.31	3.77
Senior	4.02	0.27	3.96
Skeuomorph			
Young	3.15	0.32	3.09
Senior	3.84	0.33	3.94
Flat			
Young	2.80	0.47	2.86
Senior	3.65	0.33	3.64
Material design			
Young	3.00	0.54	2.84
Senior	3.57	0.36	3.45
Broken line			
Young	2.99	0.41	3.09
Senior	3.59	0.26	3.61

Table 1. represents a comparison of the satisfaction of young and senior adults with different app icon styles. The result from the survey shows that both groups are satisfied app icons with skeuomorph design the most, then skeuominimalist. However, senior adults prefer flat icon design to material design and broken line. In contrast, young adults satisfy material design and broken line than flat design.

Efficiency of visual search task

In the visual search task, participants were asked to search for 15 app icons of each icon style. The average search time for different icon styles between young and senior adults is represented in Figure. 4. The graph shows that in general senior adults spent longer times than younger adults for each app icon style. Flat design took the longest search time for both groups. Skeuomorph is fastest for young adults, while senior participants had the fastest search times for material design.

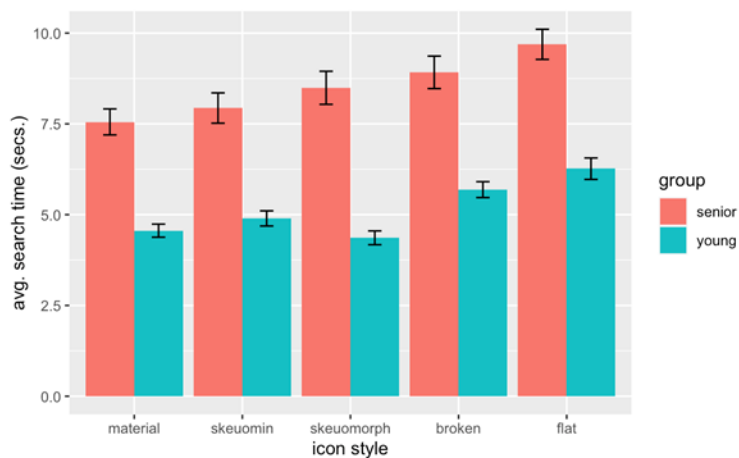


Figure 4 Average search time for different icon styles between age groups.

As shown in Figure 4., the average visual search time on app icon is increased for material design, skeuominimalist, skeuomorph, broken line, and flat in senior participants. While young participants took the least time on skeuomorph, then material design, skeuominimalist, broken line, and flat.

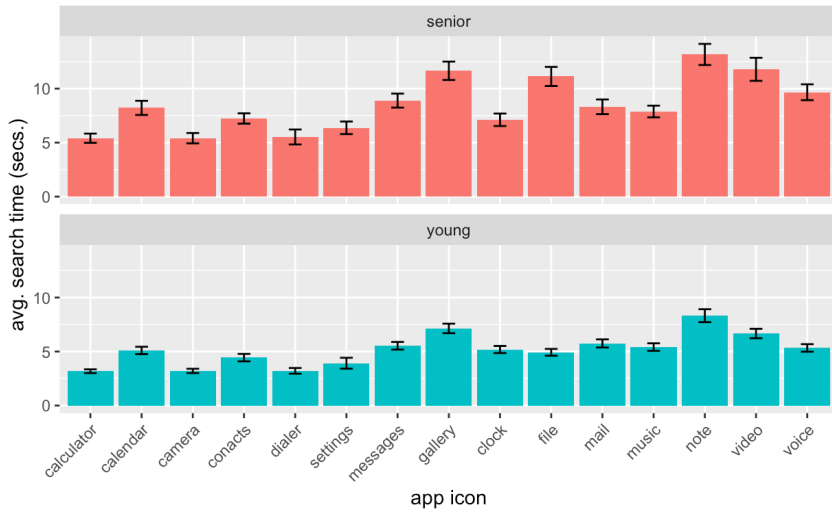


Figure 5 Average search time for app icons between young and senior adults.

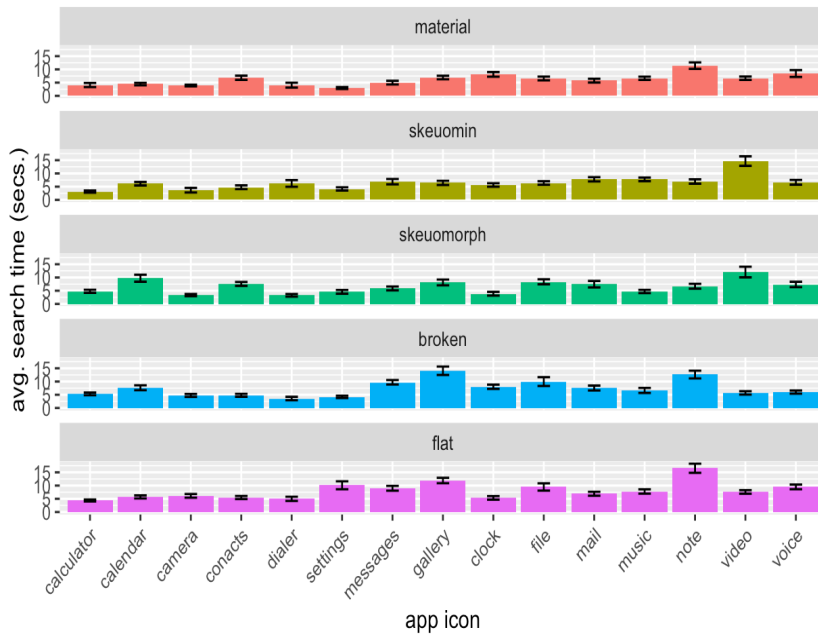


Figure 6 Average search time for different icon styles of each app icon.

Table 2: Analysis of variance of search time as a function of age, icon style, and icon object.

Variables	Df	Sum Sq	Mean Sq	F value	Significance
Age	1	14614	14614	266.284	p << 0.001
Style	4	2567	642	11.692	p << 0.001
Icon	14	18683	1335	24.317	p << 0.001
Age:Style	4	220	55	1.001	n.s.
Age:Icon	14	2068	148	2.692	p < 0.001
Style:Icon	56	17926	320	5.833	P << 0.001
Age:Style:Icon	56	2945	53	0.958	n.s.
Residuals	5025	275778	55		

Table 2 shows the results of an analysis of variance of search time with independent variables of age group, icon style, and app icon. The main effects of age, style, and icon were all highly significant (p << 0.001). There was a significant interaction between age and icon (p < 0.001), suggesting that some icons were harder to identify for different age groups as shown in Figure 5., for instance, file icon was harder among the seniors to find the icon than the younger ones. In addition, there was a significant interaction between style and icon (p << 0.001), suggesting that icons in some styles were easier to identify in one style rather than the other as shown in Figure 6., for instance, participants spent longer time to search for video icon with skeuominimalist and skeuomorph than the other styles. Interestingly, no style advantaged one age group over the other as evidenced by the lack of a significant age-by-style interaction. As would be expected, the analysis of error rates as a dependent measure gives a similar pattern of results to search time. In addition, the main effect of style in search time indicated by the adjusted p-values shows the differences are between flat and material (p << 0.001), flat and skeuomorph (p < 0.001), flat and skeuominimalist (p < 0.001).

Effectiveness of visual search task

An analysis of variance was carried out on the number of errors made by the study participants as a function of age, icon style, and app icon. The summary of the analysis is given in Table 3, below.

Table 3: Analysis of variance of the number of errors as a function of age, icon style, and icon object.

Variables	Df	Sum Sq	Mean Sq	F value	Significance
Age	1	228	228.08	75.653	p << 0.001
Style	4	41	10.24	3.395	p < 0.01
Icon	14	554	39.59	13.133	p << 0.001
Age:Style	4	8	1.90	0.632	n.s.
Age:Icon	14	186	13.29	4.407	p << 0.001
Style:Icon	56	412	7.36	2.441	P << 0.001
Age:Style:Icon	56	150	2.67	0.887	n.s.
Residuals	5025	15149	3.01		

There was a large main effect due to participant age, with the older participants making significantly more errors than the younger ones. The pattern of differences is clearly seen in Figure 7., below.

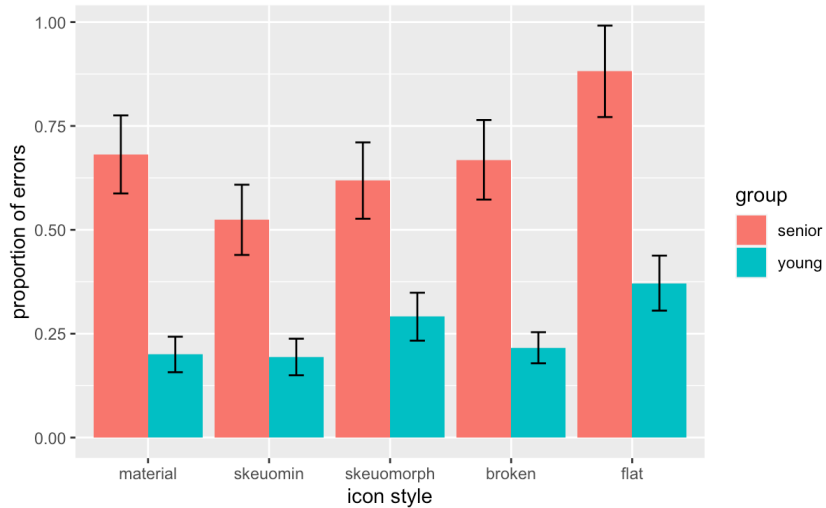


Figure 7 Average number of errors for different icon styles between age groups.

Although some of the styles seemed particularly challenging to the older group (e.g., flat), there was no significant age by style interaction. Interestingly, there was an age by icon interaction, with older participants finding some icon representations particularly hard to identify correctly (e.g., gallery, note) as shown in Figure 8., below.

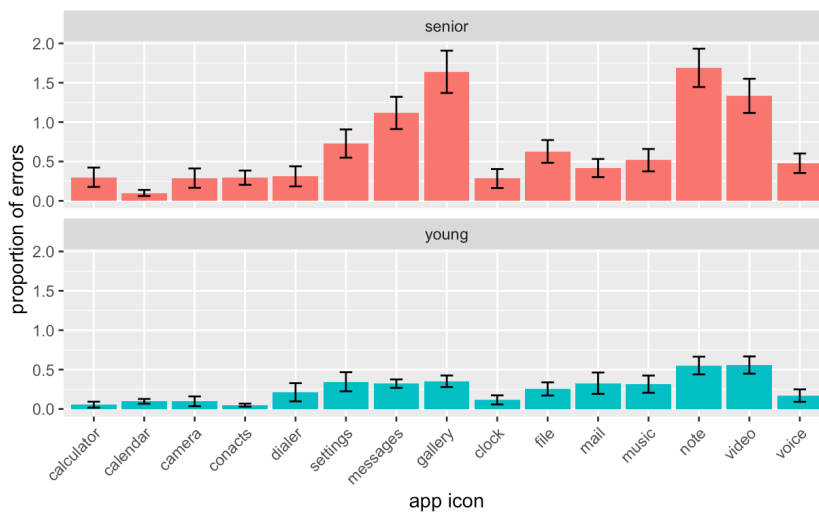


Figure 8 Average number of errors for app icons between young and senior adults.

There was also a significant interaction between object and style, suggesting that objects in some styles were plainly harder to recognize by everyone (e.g., the gallery in the broken style, video in the skeuomorph style) as shown in Figure 9., below.

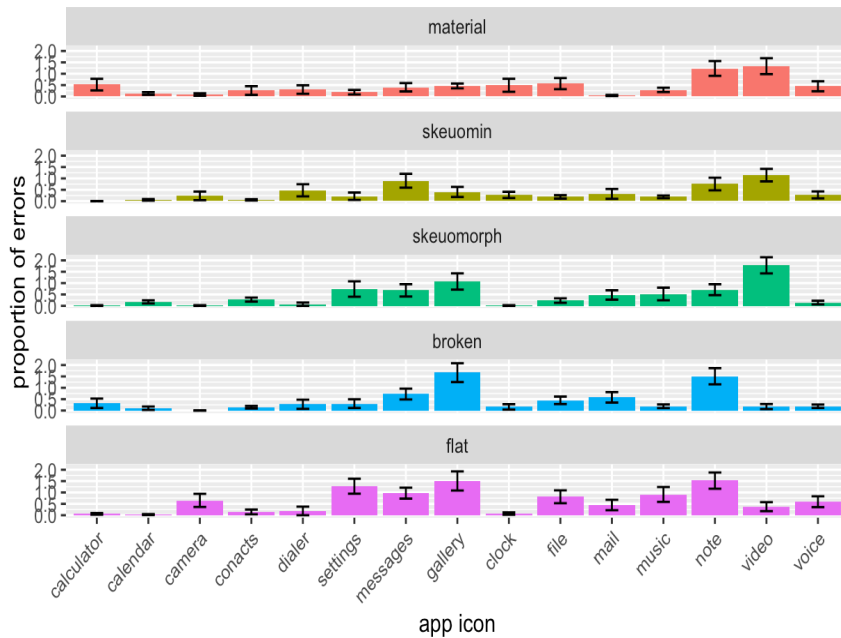


Figure 9 Average number of errors for different icon styles of each app icon.

CONCLUSIONS

Five main app icon styles used by different mobile phone brands were examined in this study. The three metrics used to measure the usability of the app icons are satisfaction, efficiency, and effectiveness. Participants were separated into two age groups; young and senior adults. The quantitative data were collected via Google Forms to survey the satisfaction of different types of icon design among Thai users' age group. A visual search task was conducted to evaluate the app icon among five icon styles; skeuomorph, skeuominimalist, flat, material design, and broken line. The findings show that users' preference for icon design is inconsistent with their icon search performance, especially in the senior group. Both groups, senior and younger, satisfy skeuomorph and skeuominimalist approaches the most which the finding is corresponding to Urbano, Guerreiro, and Nicolau (2020). Nevertheless, skeuomorph facilitates search only in young adults, while senior adults spent the least time searching material design. In the senior group, even though they prefer flat design over material design and broken line, the results of the visual search task indicate that they have worse performance on flat design compared to material design and broken line. This shows that what they like does not correlate with what they find useful. The statistical analysis also indicates some interaction between age, style, and icon type. There are significant differences in

performance between age groups as found in previous studies (e.g., Gatsou, Politis, & Dimitrios, 2012; Urbano, Guerreiro, & Nicolau, 2020). In general, participants in both age groups have the most difficulty in the visual search task with flat design having the longest duration and the most errors. It can be interpreted that flat design places a higher cognitive load required on participants. Icons were easier to identify in one style rather than another. Some objects were harder to identify for different age groups; these might be because they use symbolic or abstract representation and less concrete imagery as found in Gatsou, Politis, & Dimitrios's study (2012). Our results provide baseline against which future interfaces can be compared. Eye tracking might be useful to help infer users' cognitive behaviour. It would also be interesting to examine users' performance using the different design styles on different platforms, such as, websites, mobile, tablet etc.

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