Flat-Design Icon Sets: A Case for Universal Meanings?

Andrea M. Legleiter[1] and Nicholas Caporusso[2]

[1] Department of Informatics, Fort Hays State University,
600 Park Street, 67601 Hays, United States
[2] Department of Computer Science, Northern Kentucky University,
Louie B Nunn Dr, 41099 Highland Heights, United States
amlegleiter@mail.fhsu.edu, caporusson1@nku.edu

Abstract. Nowadays, the Internet has reached a level of maturity that enables categorizing the main types of websites, the most common actions that the end-user can engage in, and the recurring patterns that characterize interactions. As users have become more accustomed to the shared features of websites and web applications (e.g., sign in, access cart, download file), pictographic icons have been increasingly used to replace text labels. Flat design is among the most recent developments in this abstraction climax. However, removing traits, affordances, and attributes increases the ambiguity of symbols, affects their recognition, and impairs the ability to associate them with their intended meaning. In this paper, we focus on open-source typographic icon sets for the web (e.g., Font Awesome). Specifically, we investigate to what extent flat-design icons have acquired a universal meaning and we analyze human factors and design aspects that play a key role in icon recognition.

Keywords: Flat design · Icon ambiguity · Typographic icon sets · Font Awesome · Human Factors

1 Introduction

In recent years, visual canons in web, application, and product design transitioned from skeuomorphism, that is, representing objects as close as possible to their real-world counterparts, to flat design, which describes a minimalistic approach that utilizes two-dimensional styling with an emphasis on function over form, vector elements, simple typography, and bold-color schemes [1][2]. Initial examples of flat design principles were first observed in the user interface (UI) of Microsoft Operating Systems and themes, such as Windows 7 and the Metro mobile OS. Subsequently, major software providers, such as Google and Apple, adopted its principles in their icons and themes (e.g., material design) in mobile and web-based applications [1][2]. Furthermore, as flat design has become popular so has open-source icon toolkits and typographic sets (e.g., Font Awesome and Icomoon), where both are especially beneficial to interactions on mobile devices, where simplicity improves page scalability and load time, and in responsive contexts, where it is necessary to adjust graphics to different screen sizes. Moreover, as they introduce a standard, flat icon sets can facili-

tate timely recognition of webpage interactions and provide a platform for universal translation, while enhancing the visual appeal of website design.

Nevertheless, the adoption of flat design has been contended by Human-Computer Interaction and usability experts. One of the main sources of criticism is its two-dimensional nature, which removes some of the visual cues and key affordances that help recognize the meaning of symbolic icons [1][2]. Moreover, despite the increased popularity of flat icons, a degree of perplexity specifically exists with icons and with the transition from a form-centered approach emphasizing the features of an object, to an opportunistic, function-centered design that focuses on the intent associated with the icon. Currently, there is a lack of understanding of the semantic gap between sign and signified. Also, as universal meanings remain atypical, the degree of icon ambiguity, that is, when an icon acquires different meanings depending upon end-user interpretation [3], remains unknown. As a result, despite icons being distributed as a unique package, different symbols in the same set might significantly vary in terms of recognition and ambiguity levels. Moreover, the issue might be aggravated as icon sets become larger with the addition of new glyphs.

2 Related Work

Although the relationship between the design features of icons and their perceived meaning has been studied extensively, over the last ten years, socio-technical changes determined a paradigm shift, particularly regarding web design; from arbitrary symbols associated with cognitive representation, icons have become signs that replicate structural characteristics of their semantic targets [4]. As a result, they have become more abstract and the objects represented in their images refer to their respective user goal. Moreover, several groups aimed at classifying icons and defining ontologies based on their functionality [5], and they discussed the limitations and challenges of their approach due to dynamics, such as overlapping meanings. Studies focused on evaluating the relationship between icon traits, such as background color, shape, contrast, icon composition, and user attention, measured based on quantitative features, such as fixation and subjective evaluation [6]. Conversely, others focused on aesthetic components: despite its significant impact on user interaction [7], ambiguity, uniqueness, and dominance are the three fundamental aspects in the design of icon sets [8]. Nevertheless, in the absence of a text label, the concept of ambiguity [2] has a key role in determining the ability to understand the meaning of icons: [9] evaluated whether intrinsic and extrinsic human factors (e.g., familiarity with the internet) affect the recognition rate of icons and they demonstrated that e-literacy facilitates users in understanding the meaning of symbols despite other factors, such as familiarity, concreteness, and semantic distance, having a stronger influence.

3 Research Study

Although several groups explored user interaction with icons and symbols in the last decades, the maturity of the Internet and the subsequent consolidation of a dictionary of actions and functions, combined with the recent introduction of typographic font

sets and their widespread use in websites and applications, create the demand for new analyses on the concept of universal icon meaning. Therefore, the objective of our preliminary study is two-fold: (1) evaluate whether there is a case for universal icon meaning for flat icon sets and (2) gain insight on the factors that affect recognition of typographic icons. As for the latter, our interest was to analyze the intrinsic/extrinsic human dimensions (e.g., age, education level, proficiency with the web, and familiarity) and design aspects (e.g., poor design or visually evasive), and their impact on recognition rates.

Specifically, our study explored the following hypotheses: (H1) a general deficit exists in recognizing icons utilized in web-based applications, (H2) age is a factor in icon recognition, (H3) the amount of time spent using web-based applications impacts recognition rates, and (H4) level of education impacts recognition rates.

All the material discussed in this paper, including data collection tools, additional figures, and more detailed charts, is available for further review at https://github.com/littleapple27/case-for-universal-meanings.

3.1 Materials

In our study, we selected 17 icons from the Font Awesome set (see Figure 1). To this end, we selected a list of the top 10 websites in the United States [11], all of which use simple flat icons in their user interface; we realized a census of the icons and then a ranking of the most common symbols. The selected icons were cross-referenced with the second and third most popular icon sets on GitHub, that is, Google Material Design (38,900 star rating) and Feather (16,500 star rating). Additionally, the icons were classified under the categories of resemblance, reference, and arbitrary for consistency with prior research [12]. Two data collection tools (Survey A and Survey B) were developed in the form of a questionnaire with multiple-choice questions. Each had 17 questions (excluding demographic information) and every correct answer increased participant's total score by 1. No points were deducted for incorrect responses.

Survey A: Icon Meaning. The objective of this questionnaire was to evaluate icon recognition in the absence of context. Participants were asked to select the meaning of the pictured icon from a predetermined list of choices with one being the target or "correct" choice. Also, an option to "write-in" a meaning was made available.

Survey B: Icon Contextual. In this questionnaire, we aimed at evaluating icon recognition in the presence of context. To this end, participants were asked to choose which icon among the four available options best represented the function described in the question, considering web-based interaction.

3.2 Protocol

Surveys were circulated via social media and participants completed them individually without any supervision. At the beginning of each questionnaire, subjects were asked to answer demographic questions regarding their age group, gender, level of education, and average hour-per-day use of web-based applications for personal and

work-related reasons. After completing the section about icon meanings, participants were asked to answer a set of questions about their degree of familiarity with the symbols, preceding interactions with the icons, and confidence levels in their responses. A Likert scale was utilized to collect the participants' subjective evaluations.

FA Icon	FAName	Classification	Target Icon Meaning
	bars	Arbitrary	Used to hide/access navigation/menu item
	bell	Reference	Used to represent notifications
	camera	Resemblance	Used to represent images / photo (take or upload)
	cog	Reference	Used to access application settings
	comment-alt	Resemblance	Used for comments and/or feedback
	download	Arbitrary	Used to indicate a file download
	ellipsis	Resemblance	Used to indicate more items available
	globe	Reference	Used to indicate language settings
	heart	Reference	Used to mark/save a favorite item
	sign-in-alt	Arbitrary	Used to indicate where to sign in to account
	map-marker-alt	Arbitrary	Used to indicate location
	pencil-alt	Reference	Used to indicate the ability to edit
	search	Reference	Used to indicate search capability
	share-alt	Arbitrary	Used to share information
	shopping-cart	Resemblance	Used to represent shopping cart for online retail
	star	Reference	Used for rankings or reviews
	user	Reference	Used to indicate user account

Fig. 1. The 17 Font Awesome icons used in the study and their respective target meaning.

3.3 Participants

A total of 72 individuals participated in the research study. All completed Survey A, whereas only 45 of them responded to survey B. The group consisted of a total of 45 females (62%) and 27 males (37%). 15 individuals (21%) aged 18-24, 10 (14%) were in the 25-34 bracket, 20 (28%) were in the 35-44 group, 10 (14%) were 45-54, 12 (17%) aged 55-64, and 5 (7%) 65 or older. Their average daily Internet use for personal reasons was less than 1 hour for 8 individuals (11%), 1-2 hours for 33 subjects (46%), 3-5 hours for 26 people (36%), 2 people (3%) used the web for 6-8 hours, and the remaining 3 (4%) reported more than 8 hours of Internet use. As per their daily Internet use for work-related purposes, 8 participants (11%) reported that they did not make any use of it, 10 subjects (14%) utilized the web for less than 1 hour, 22 (31%) 1-2 hours, 18 (25%) 3-5 hours, 9 (12.5%) 6-8 hours, and 5 (7%) used the Internet for more than 8 hours for work. Their education was as follows: 24 (33%) had a high school diploma or equivalent (e.g. GED), 4 (5%) graduated from a trade school, 12

(17%) had an Associate degree, 23 (32%) had a Bachelor's degree, and 9 (13%) had graduate degree or higher.

Of the 45 participants who completed survey B, 32 were females (71%) and 13 males (29%), showing a gender distribution similar to Survey A. As for age, 4 (9%) were 18-24, 4 (9%) were 25-34, 19 (42%) were 35-44, 7 (16%) were 45-54, 9 (20%) were 55-64, and 2 (5%) were 65+. Participant average daily Internet use for personal reasons was recorded as follows: 2 (4%) used it for less than 1 hour, 25 (56%) 1-2 hours, 12 (27%) 3-5 hours, 5 (11%) 6-8 hours, and 1 (2%) more than 8 hours. Participant average daily Internet use for work-related reasons was the following: 4 (9%) did not use it, 6 (13%) less than 1 hour, 13 (29%) 1-2 hours, 14 (31%) 3-5 hours, 5 (11%) 6-8 hours, and 3 individuals (7%) used the Internet for more than 8 hours per day. 11 participants (24%) had a high school diploma or equivalent (e.g. GED), 1 (2%) were trade school graduates, 5 (11%) had an Associate degree, 21 (47%) had a Bachelor's degree, and 7 (16%) had a graduate degree or higher.

4 Results and Discussion

It was hypothesized that a general user deficit existed in icon recognition rates due to ambiguity in typographic sets. However, most participants were able to correctly identify the target meaning of the icons. Specifically, the responses in Survey A resulted in an average recognition rate of 82% ± 12%. The overall score improved in Survey B: as icons were presented in the context and paired with their function, participants' average recognition rate was 88% ± 12% (+6%). Although the data offer limited support for the first hypothesis, our results might indicate that specific icons are becoming more universally recognized because of their widespread use across websites and applications.

Our second hypothesis, that is, age plays a role in icon recognition rate, was supported by the data. To this end, we analyzed two age groupings: 18-44 and 45+. We found statistically significant differences in Survey A (P=0.017) and Survey B (P=0.003). Specifically, participants aged 18-44 scored 82% ± 9% (i.e., 14 ± 1.5 points) and had a better recognition rate than participants aged 45+, who scored 76% ± 13% (i.e. 13 ± 2.3 points). For Survey B, those between the ages of 18-44 scored 88% ± 7.5% (i.e., 15 ± 1.3 points) which is higher than participants 45+ who had scores of 82% ± 7.6% (i.e., 14 ± 1.6 points). With all age groups considered separately, the inverse correlation (r=-0.247 in Survey A and r=-0.364 in Survey B) demonstrates that recognition rate does decrease linearly with age, however, it reveals a weak to moderate relationship.

The average daily use of web-based applications for personal and work reasons (hypothesis 3) was not found to impact the rate of recognition at a statistically significant level. Although, the sample size might be a factor, when considered in perspective it may be that the amount of time spent using websites is not indicative of how well users understand the intended meaning of an icon. Users' habituation to the symbols may result in effective interactions thus enabling them to accomplish their goal.

As for hypothesis 4, the data collected in Survey A demonstrated a strong impact on the level of education on the recognition rate of icons (P=.004). Participants who have achieved a graduate-level degree or higher were more likely to accurately select

the target meaning for the icon. On the contrary, the results of Survey B were not statistically significant, despite participants with a bachelor's degree or higher performing best. However, as mentioned earlier, this might be caused by the data collection protocol and by the limited sample size.

5 Conclusions and Future Work

In this paper, we presented the results of a research study aimed at investigating different types of icons to evaluate their ambiguity and, particularly, to understand whether icon sets, with specific regard to flat design, make a case for universal icon meanings. To this end, we conducted a qualitative and quantitative analysis based on one of the most widespread typographic sets on the web, that is, Font Awesome, and we investigated both the human factors and the inherent design features that affect recognition rate. From our findings, we can conclude that although several icons might support the case of universal meaning, most symbols representing common functions might be ambiguous, especially for specific categories of users.

Moreover, the results of our study show that the ability to recognize icons is correlated with intrinsic and extrinsic human factors, specifically, age and education level. Surprisingly, technical background and proficiency with web and mobile technology do not influence individuals' ability to recognize the meaning of icons. Also, we found significant differences between the symbols in the same set in terms of ambiguity, which we will explore more extensively in a follow-up study.

References

1. Page, T., 2014. Skeuomorphism or flat design: future directions in mobile device User Interface (UI) design education. IJMLO, 8(2), pp.130-142.
2. Burmistrov, I., Zlokazova, T., Izmalkova, A. and Leonova, A., 2015, September. Flat design vs traditional design: Comparative experimental study. In IFIP Conference on Human-Computer Interaction (pp. 106-114). Springer, Cham.
3. Gatsou, C., Politis, A. and Zevgolis, D., 2012. The Importance of Mobile Interface Icons on User Interaction. IJCSA, 9(3), pp.92-107.
4. Williams, D. and Colling, L., 2018. From symbols to icons: The return of resemblance in the cognitive neuroscience revolution. Synthese, 195(5), pp.1941-1967.
5. Islam, M.N. and Islam, A.N., 2016. Ontology mapping and semantics of web interface signs. Human-centric Computing and Information Sciences, 6(1), p.20.
6. Lin, H., Hsieh, Y.-C., Wu, F.-G.: A study on the relationships between different presentation modes of graphical icons and users' attention. Comput. Hum. Behav. 63, 218–228 (2016)
7. Wang, M. and Li, X., 2017. Effects of the aesthetic design of icons on app downloads: evidence from an android market. Electronic Commerce Research, 17(1), pp.83-102.
8. Goonetilleke, R.S., Shih, H.M. and FRITSCH, J., 2001. Effects of training and representational characteristics in icon design. International Journal of Human-Computer Studies, 55(5), pp.741-760.
9. Batra, R. and Memon, Z.A., 2016. Effect of Icon Concreteness, Semantic Distance and Familiarity on recognition level of mobile phone icons among E-literate and Non E-literates. IJWA, 8(2), pp.55-64.
10. Alexa - Top Sites in United States, https://www.alexa.com/topsites/countries/US
11. Nielsen Norman Group, https://www.nngroup.com/articles/classifying-icons/