Visual Aesthetic Appeal Speeds Processing of Complex but not Simple Icons

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Over the last decade there has been a shift in emphasis from interface usability to interface appeal. Very few studies, however, have examined the link between the two. The current study examined the possibility that aesthetic appeal may affect user performance. In a visual search task designed to mimic user searches of interface displays, participants were asked to search for a target icon in an array of distractors. Target icons were varied orthogonally along two dimensions, complexity (which is known to affect visual search for icons in displays) and aesthetic appeal. The results showed that visually simple icons were found faster than visually complex icons, replicating previous findings. More importantly, aesthetic appeal interacted with icon complexity, significantly reducing search times for complex but not simple icons. These findings provide empirical evidence to support the idea that aesthetic appeal can influence performance.

In recent years considerable emphasis has been given to the aesthetic appeal of user interfaces in the hope that aesthetic appeal will bolster interface usability. Studies to date suggest that our perceptions of appeal affect the effort we are likely to make in learning how to use an interface (e.g., Kurosu & Kashimura, 1995; Lingaard & Dudek, 2003; Tractinsky, 1997; Tractinsky, Katz, & Ikar, 2000; Wiedenbeck, 1999). Although a general relationship between appeal and performance has been identified, and research suggests that perceptions of appeal can influence user performance, no research has examined the precise nature of the appeal-performance relationship or the mechanisms which may underpin it. The study reported here examines one such relationship: the relationship between aesthetic appeal and attention.

Two prior strands of research suggest that aesthetic appeal could have a direct influence on behaviour. The first strand relates to the existence of brain regions that are active during evaluative judgments, such as judgments of aesthetic appeal. For example, Jacobsen and colleagues (e.g., Jacobsen & Hofel, 2002; Jacobsen, Schubotz, Hofel & Cramon, 2006) showed that aesthetic judgments elicit activation in brain regions which have been previously implicated in social or moral evaluative judgments (i.e., good vs. bad) related to persons and actions (e.g., Cunningham, Johnson, Gatenby, Gore & Banaji, 2003). The second strand of research involves studies showing that stimulus dimensions related to arousal (i.e., anger or fear) can influence performance in perception and attention tasks. For example, stimuli with evolutionarily threatening meanings, such as snakes, spiders, or angry faces, attract attention to themselves and hold it for longer, compared to non-threatening stimuli, such as flowers, or happy faces (e.g., Fox, Russo, Bowles, & Dutton, 2001; LeDoux, 1996; Pratto & John, 1991).

On the basis of the above research, we hypothesized that aesthetic appeal may have a similar, biasing effect on perception, due to its potential to elicit an emotional response. Such increased arousal may benefit any task in which the perceiver is engaged. This hypothesis fits with recent brain-imaging results demonstrating that the neural correlates of aesthetic appeal overlap with those of the emotion and arousal systems in the brain (e.g., the amygdala and parts of the orbito-frontal cortex; Kawabata & Zeki, 2004).

The current study examined the nature of the relationship between visual complexity, aesthetic appeal and user performance. Visual complexity is a stimulus characteristic that has been shown to influence not only performance in perception tasks such as visual search, but also subjective appraisals of appeal. We used a visual search task to examine the effect of complexity and appeal on performance, hypothesizing that aesthetically appealing stimuli ought to receive benefits due to higher arousal and attention associated with them. Visual search tasks are frequently used to examine attention (see Quinlan, 2003, for a review) and visual search is an important component of interacting with computer interfaces. Examples include finding icons in cluttered computer desktop displays, selecting icons in software packages (Philipsen, 1993; Smith & Peck, 1990), working with head-up and other displays while piloting aircraft (Kopp & Liebig, 1990; Wickens, 2002) and scanning radar displays in air traffic control (Remington, Johnston, Ruthruff, Gold, & Romera, 2000). Icons were used as visual search stimuli because the effects of icons' visual complexity on visual search performance are already well documented and icons are commonly used in interfaces to convey information.

ICON COMPLEXITY, USER PERFORMANCE AND AESTHETIC APPEAL

A number of studies have found that simple icons enhance performance because they can be discriminated more easily in arrays and are located more easily in visual search (Byrne, 1993; McDougall, de Bruijn & Curry, 2000; McDougall, Tyrer, & Folkard, 2006; Scott, 1993). Furthermore, in a visual search task, where participants had to find a target icon amongst a set of distracters, McDougall et al. (2000) found that simple target icons were found faster compared to complex target icons.

Apart from its role in performance during visual search, stimulus complexity is also a significant contributor to subjective appraisals of appeal (e.g., Berlyne, 1974; Jacobsen & Hofel, 2002). When Jacobsen & Hofel (2002) presented participants with novel graphic patterns, for example, visual complexity was second only to visual symmetry in predicting judgments of appeal. Recent work we have carried out also suggests that after icon familiarity, visual complexity is the most important determinant of icon appeal (McDougall & Reppa, 2008).

In the current study we contrasted two hypotheses:

(i) Complexity and appeal are independent

According to this hypothesis there will be no interaction between complexity and appeal but their effects are likely to be additive (i.e. we would expect optimal performance when icons are both simple and appealing).

(ii) The effect of appeal is contingent on complexity

Previous research has consistently shown that complexity affects performance but, as we have already noted, research showing a possible link between aesthetic appeal and performance is less specific. According to this hypothesis, the beneficial effect of appeal on performance is limited to either complex or simple icons, thereby creating an interaction between icon complexity and appeal.

With few exceptions, research has examined the role of icon characteristics when users are first presented with a new set of icons (but see Green & Barnard, 1990; McDougall et al., 2000). Although this is clearly relevant for newly created icon sets, it does not take account of the fact that icon sets are often used frequently. This experiment therefore explored the effects of complexity and appeal on user performance as users gained experience with the icon set over four blocks of experimental trials. This manipulation allowed us to examine whether the relationship between appeal and performance might change as the icon set is learned.

METHOD

Participants

A total of fifteen participants, who were undergraduate and postgraduate students at the University of Wales Swansea, took part in this study in exchange for course credit. The mean age of the participants was 26.5 years (SD=12.0 years; 12 females and 3 males).

Materials

A set of forty icons was drawn from the corpus of 239 icons gathered by McDougall, Curry & de Bruijn (1999). Icons were chosen that were varied orthogonally on aesthetic appeal and visual complexity (McDougall et al., 1999). Aesthetic appeal was determined in a previous pilot study, by asking 40 participants, who did not take part in the current study, to rate the corpus of icons on a Likert-scale ranging from 1-5 – 1 being very unappealing and 5 being very appealing. The icons, examples of which are shown in Figure 1, were split into four categories on the basis of their aesthetic appeal and visual complexity: appealing-complex, appealing-simple, non-appealing-complex and non-appealing-simple. Table 1 shows the mean rating values for each type of icon for aesthetic appeal and complexity. The icons chosen for this study varied orthogonally in aesthetic appeal and complexity but ratings of concreteness and familiarity were held constant. Differences in ratings between each icon type were examined by carrying out one-way analyses of variance followed by Newman-Keuls comparisons. Ratings of aesthetic appeal differed between icon types [$F(3,36)=40.03$, $p<.001$] and Newman-Keuls comparisons showed that complex and simple appealing icons differed in appeal from those which were not appealing (AC, AS>>NAC, NAS). Complexity ratings also differed reliably between icon types [$F(3,36)=48.48$, $p<.001$; AC, NAC>>AS, NAS]. No differences were found between icon types for concreteness ratings [$F<1$, $p>.05$; AC=AS=NAC=AC] or for familiarity ratings [$F(3,36)=2.17$; $p>.05$)].

Table 1: Mean ratings (*standard deviations)* for aesthetic appeal, visual complexity, concreteness and familiarity for each type of icon presented

Icon Type	Aesthetic rating	Complex rating	Concrete rating	Familiar rating
Appealing Complex	3.50 *(.10)*	3.49 *(.15)*	3.85 *(1.11)*	3.19 *(.62)*
Appealing Simple	3.49 *(.53)*	1.68 *(.80)*	3.61 *(.88)*	3.59 *(.94)*
Non-appealing Complex	2.45 *(.15)*	3.69 *(.26)*	3.26 *(.90)*	2.68 *(.87)*
Non-appealing Simple	2.61 *(.10)*	1.82 *(.23)*	3.27 *(.84)*	2.96 *(.85)*

Design & Procedure

The experiment used a repeated measures factorial design. Complexity (complex vs. simple), Aesthetic appeal (appealing vs. non-appealing) and Block (1-4) were within-subjects factors. Response time (RT) measured in milliseconds was the dependent measure.

Participants performed a computerised visual search task (see Panel B, Figure 1). The icons were presented in a 3 x 3 array. To start each trial, participants clicked the mouse on the OK button on the screen. The target icon was then presented alone for 2 seconds at the top left of the screen. Once the target icon disappeared, the participant was required to click once again on the OK button. This signaled that the participant was ready to be presented with a search array and ensured that every participant started every search with the mouse pointer in the same place. Following depression of the mouse button, a set of nine icons was presented on the screen. Each participant was required to identify the target from the array by placing the mouse pointer and clicking on the location of the target icon. Once the response was made the screen cleared and a new trial commenced. Each icon appeared as a target in each of the nine possible locations in the array, resulting in a total of 360 experimental trials per participant. Each block consisted of 90 trials where each of the 40 icons was presented in each of the nine array locations once. There was a five-minute rest break between the blocks and the entire experimental session lasted approximately one hour.

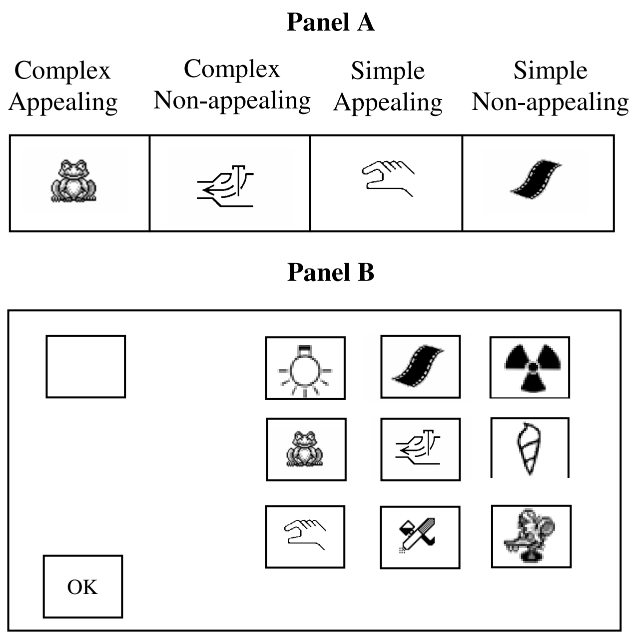

Figure 1: Examples of stimuli (panel A) and the procedure (panel B)

RESULTS

Trials with response times (RTs) that deviated by more than +/- 2 SDs from the mean in each condition were removed from the data. These accounted for 1.49% of all responses. Error trials, where participants gave an incorrect response, were also discarded (0.66% of responses). Means and standard deviations were calculated by experimental condition, and are presented in Figure 2. The figure shows that RTs were higher for complex as opposed to simple icons, and that RTs gradually reduced over blocks of experimental trials.

Data from the correct responses were entered into a 2x2x4 repeated measures ANOVA to examine the effect of Complexity (complex or simple), Appeal (appealing or non-appealing) and Blocks of trials (blocks 1-4) on RT. The main effect of Complexity was significant, $F(1, 14)=95.05$, $p<.001$, $\eta^2_{partial}=.872$, and so was the main effect of Block, $F(3, 42)=8.02$, $p<.001$, $\eta^2_{partial}=.364$. There was no significant main effect of Appeal, $F(1, 14)=2.50$, $p>.05$, $\eta^2_{partial}=.152$. However, there was significant Complexity x Appeal interaction, $F(1, 14)=8.05$, $p<.01$, $\eta^2_{partial}=.365$. The two-way interactions between Appeal and Block, $F(3, 42) = .64$, $p>.05$, $\eta^2_{partial}=.04$ and between Complexity and Block, $F(3, 42)=.96$, $p>.05$, $\eta^2_{partial}=.06$, were not significant and neither was the three-way interaction, $F(3, 42)=.46$, $p>.05$, $\eta^2_{partial}=.05$.

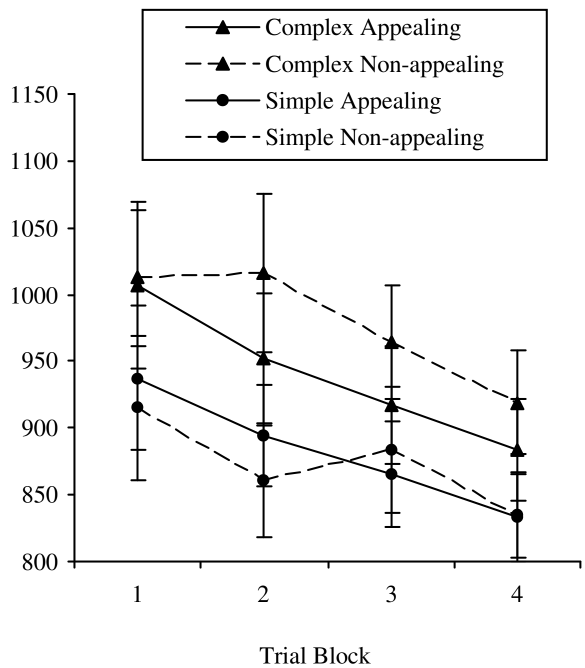

Figure 2: Mean response times for each icon condition across the four blocks of trials. Error bars show standard error.

Planned comparisons were carried out to investigate the Complexity x Appeal interaction. There was no difference in RT between appealing simple icons (M=882.5, SD=143.88) and non-appealing simple icons (M=873.3, SD=155.98), $t(14)<1$, $p>.05$ (1-tailed). However, the difference between appealing complex icons (M=940.10, SD =170.49) and non-appealing complex icons was significant (M=977.9, SD=173.86), $t(14)=-3.26$, $p<.001$ (1-tailed), with complex appealing icons leading to faster search times compared to complex non-appealing icons. Furthermore, participants were faster to respond to simple than to complex appealing icons, $t(14) = 5.50$, $p<.001$, and to simple than to complex non-appealing icons, $t(14) = 8.04$, $p<.001$.

DISCUSSION

The results showed that both complexity and aesthetic appeal influenced performance in a visual search task. Simple icons were identified faster than complex icons in all blocks of trials, suggesting that the effect of complexity did not diminish with increased experience with the icons and the task.

Similarly, there were no significant interactions between block and complexity, or between block and appeal, suggesting that the effects of complexity and appeal remained constant even when task demands decreased as the icon set was learned. Most importantly, the effect of icon appeal was *contingent* on the complexity of the icon: complex icons were found faster when they were appealing than when they were unappealing, whilst simple icons were found equally fast regardless of aesthetic appeal.

The effect of visual complexity on visual search performance replicated previous studies (e.g., Byrne, 1993; McDougall et al., 2000; McDougall et al., 2006; Scott, 1993). The finding that complexity influences performance is particularly relevant in HCI, as it reflects the time it takes for users to search a display for the desired icon. Our results suggest that simple icons will be more effective in tasks where fast responding is critical. Furthermore, the finding that these effects did not diminish over time indicates that extra training is not likely to reduce the effects of complexity.

The interaction between aesthetic appeal and complexity is a crucial finding and suggests that the effect of aesthetic appeal is contingent upon the effect of complexity. This is not entirely surprising, as visual complexity is an important determinant of performance. In visual search arrays, simple icons are more likely to 'pop-out' in a visual display, as they are easier to process (i.e., due to fewer features present in the stimulus). In this case any effect of aesthetic appeal is likely to be overridden by the 'pop-out' effect. In contrast, complex icons are less likely to 'pop-out' in a search array (i.e., due to greater number of visual features present in the stimulus). It is only in this case that aesthetic appeal has an effect on search performance, reducing search times for complex icons with high aesthetic appeal. This finding suggests that if complex icons are necessary, for example in some cockpit displays, one way to mitigate the increased search time for complex icons is to maximize aesthetic appeal.

The current findings support previous research showing that aesthetic appeal and performance are interrelated (Kurosu & Kashimura, 1995; Tractinsky, 1997; Tractinsky et al., 2000). More importantly, the current study extends previous research by showing that aesthetic appeal can, under certain circumstances, bias attentional and perceptual systems in such a way as to give processing priority to aesthetically appealing stimuli. In this light, the current findings are relevant to research showing that emotionally threatening stimuli (e.g., angry faces or snakes) bias attention and performance (Fox et al., 2001), by demonstrating that aesthetically pleasing stimuli may also bias attention by eliciting positive emotional responses. This is particularly pertinent in the context of the recent shift in the field of HCI from instrumental factors that contribute to usability (e.g., ease of learning an interface) to non-instrumental factors that emphasize the role of beauty and its affective consequences on performance (e.g., Hassenzahl & Tractinsky, 2006).

It is also important to discuss the role of other latent variables that may account for our findings. One such variable is familiarity, which is an important determinant of aesthetic appeal of icons (McDougall & Reppa, 2008) and novel stimuli (e.g., Zajonc, 1968). One may argue that it was familiarity, and not aesthetic appeal per se, that constrained performance in the visual search task. There are at least two reasons why familiarity alone cannot account for our findings. First, familiarity and concreteness were controlled for in this study, and therefore are unlikely to account for the observed differences between appealing and non-appealing complex icons. Second, although familiarity is an important determinant of aesthetic appeal it is not the sole determinant (McDougall & Reppa, 2008). The current finding that aesthetic appeal interacts with visual complexity endorses the view that aesthetic appeal is a complex multi-dimensional construct that can affect performance regardless of its contributing attributes.

Finally, it is important to acknowledge the fact that aesthetic appeal is also linked and influenced by social, cultural and moral evaluative systems. Regardless of the domain of influence, however, to the extent that the aesthetic value of a stimulus has the potential to elicit an emotional response, then it might be considered a stimulus attribute that can bias perception and influence performance.

In conclusion, our results support previous research that proposes that aesthetic appeal and performance are interrelated. In this study, we examined the nature of this relationship and showed, for the first time, that aesthetic appeal can influence performance. Furthermore, we propose that aesthetic appeal may have the potential to influence performance by possibly eliciting an emotional response. This is an interesting but yet unexplored issue that is worth pursuing in future research. The current findings also have implications in the field of HCI research. Our results suggest that, in tasks that require speeded responses, keeping icons visually simple is important for efficient performance. However, when icons need to be complex, possibly in order to convey more complex, or a greater amount of information, it may help user performance to endeavour to make them as appealing as possible.

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The 'airbrush' icon (Panel B, 2nd left, 3rd row of icons) comes from *The icon book: Visual symbols for computer systems and documentation*, W. Horton, 1994, New York and is reprinted with permission from John Wiley & Sons, Inc. The 'gastropods' icon (Panel B, 3rd left, 2nd row of icons) comes from *The Symbol Sourcebook,* H. Dreyfuss, 1972, and is reprinted with permission from McGraw-Hill Education. All the other icons are in the public domain.

REFERENCES

Berlyne, D.E. (1974). *Studies in the new experimental aesthetics*. Washington, DC: Hemisphere.

Byrne, M. D. (1993). Using icons to find documents: Simplicity is critical. *Proceedings of INTERCHI '93,* 446 – 453.

Cunningham, W.A., Johnson, M.K., Gatenby, J.C., Gore, J.C. & Banaji, M.R. (2003). Neural components of social evaluation. *Journal of Personality and Social Psychology, 85*, 639-649.

Fox, E., Russo, R., & Bowles, R.J., & Dutton, K. (2001). Do threatening stimuli draw or hold visual attention in sub-clinical anxiety?" *Journal of Experimental Psychology: General, 130,* 681-700.

Green, A. J. K., & Barnard, P. J. (1990). Iconic interfacing: The role of icon distinctiveness and fixed or variable screen locations. In D. Diaper, D. Gilmore, G. Cockton, & B. Shackel (Eds.), *Human computer interaction – Interact '90*, 457–462. Amsterdam: Elsevier Science Publishers.

Hassenzahl, M. & Tractinsky, N. (2006). User experience – a research agenda. *Behaviour & Information Technology*, *25*, 91-97.

Jacobsen T. & Höfel L. (2002). Aesthetic judgments of novel graphic patterns: Analysis of individual judgments. *Perceptual & Motor Skills, 95*, 755-766.

Jacobsen T., Schubotz, R.I., Höfel L. & Cramon, D.Y. (2006). Brain correlates of aesthetic judgment of beauty. *NeuroImage*, *29*, 276-285.

Kawabata, H. & Zeki, S. (2004). Neural correlates of beauty. *Journal of Neurophysiology, 91,* 1699-1705.

Kopp, U., & Liebig, T. (1990). Computer simulation and analysis of pilots' scanning behaviour during complex aircraft guidance and control tasks. In D. Brogan (Ed.), *Visual search*, 311–318. Philadelphia: Taylor & Francis.

Kurosu, M. & Kashimura, K. (1995). Apparent usability vs. inherent usability. *CHI 95 Conference Companion*, 292-293.

LeDoux, J.E. (1996). *The Emotional Brain*. New York, Simon and Schuster.

Lindgaard, G. & Dudek, C. (2003). What is this evasive beast we call user satisfaction? *Interacting with Computers, 15,* 429-452.

McDougall, S., Curry, M.B. & de Bruijn, O. (1999). Measuring symbol and icon characteristics: Norms for concreteness, complexity, meaningfulness, familiarity and semantic distance for 239 symbols. *Behavior Research Methods, Instruments & Computers*, *31*, 487-519.

McDougall, S., de Bruijn, O. & Curry, M. (2000). Exploring the effects of icon characteristics on user performance: The role of concreteness, complexity and distinctiveness. *Journal of Experimental Psychology: Applied*, *6*, 291-306.

McDougall, S. & Reppa, I. (2008). Why do I like it? The relationships between icon characteristics, user performance and aesthetic appeal. *Proceedings of the Human Factors and Ergonomic Society Meeting*.

McDougall, S., Tyrer, V. & Folkard, S. (2006). Searching for signs, symbols and icons: Effects of time of day, visual complexity, and group. *Journal of Experimental Psychology: Applied, 12*, 118-128.

Philipsen, G. (1993). Half valid colour highlighting and visual search in menu options. In D. Brogan, A. Gale, & K. Carr (Eds.), *Visual search 2*,. 359–370. Philadelphia: Taylor & Francis.

Pratto, F. & John, O.P. (1991). Automatic vigilance: The attention-grabbing power of negative social information. *Journal of Personality and Social Psychology, 61*, 380-391.

Quinlan, P. T. (2003). Visual feature integration theory: Past, present, and future. *Psychological Bulletin, 129,* 643–673.

Remington, R. W., Johnston, J. C., Ruthruff, E., Gold, M., & Romera, M. (2000). Visual search in complex displays: Factors affecting conflict detection by air traffic controllers. *Human Factors, 42,* 349–366.

Scott, D. (1993). Visual search in modern human-computer interfaces. *Behaviour and Information Technology, 12*, 174 – 189.

Smith, A., & Peck, D. (1990). The influence of time of day and cognitive failure on the effects of working at a visual display unit. In D. Brogan (Ed.), *Visual search*, 345–352. Philadelphia: Taylor & Francis.

Tractinsky, N. (1997). Aesthetics and apparent usability: Empirically assessing cultural and methodological issues. *Proceedings of the CHI 97 Conference on Human Factors in Computing Systems*. New York: ACM.

Tractinsky, N., Katz, A.S. & Ikar, D. (2000). What is beautiful is usable. *Interacting with Computers, 13*, 127-145.

Wickens, C. D. (2002). Situation awareness and workload in aviation. *Current Directions in Psychological Science, 11,* 128–133.

Wiedenbeck, S. (1999). The use of icons and labels in an end user application program: an empirical study of learning and retention. *Behaviour Information Technology, 18*, 68-82.

Zajonc, R.B. (1968). Attitudinal effects of mere exposure. *Journal of Personality & Social Psychology Monographs*, *9*, 1-27.