

Examining the Visual Processing System: A Look at Vision and its Limitations

(with a case study of Lenovo Blogs)

Kyle Bedell

Bentley College

Examining the Visual Processing System: A Look at Vision and its Limitations

The human visual system is arguably the most important of the five senses. It plays a vital role in allowing us to perceive and respond to our environment; without it, we are left at a major disadvantage. However, our visual systems have their own strengths and weaknesses.

For example, as Ware (2004) states, “the nerves that transmit information from the eyes to the brain...signal the *relative* amount of light; how a patch differs from a neighboring patch” (p.69). Our eyes are not absolute value receptors, they measure change. When detecting elements like contrast, brightness, color, and the contours of an object, everything is relative. The environment we are in can “cause substantial errors” (Ware, 2004, p.69) in the way we perceive something.

To create an effective design, be it the labeling of the buttons on a car dashboard or the navigational structure of a website, we must take these issues into account. As Ware (2004) notes, the lesson to be learned is that the visual system is best suited for detecting “patterns of differences or changes over time” (p.70).

Elements of Visual Perception

Contrast and Brightness

Contrast is literally the difference between two things. In the visual system, it is the difference between “a lighter and darker spacial area” (Wickens et al, 2004, p.69). *Brightness*, or the “perceived amount of light coming from a source” (Ware, 2004, p.80), hence determines the amount of contrast in a given image. Contrast is an important element, as every individual has what Wickens et al (2004) refer to as a *contrast*

threshold, a point where we can no longer distinguish between two points of brightness. This is also known as the *just noticeable difference*. This is an important concept, as changes to our environment that are smaller than the JND are not perceived. Wyszecki and Stiles (1982) explain that the value of the JND is actually a constant, known as Weber's Law. Ware (2004) notes that under "optimal viewing conditions" this equivocates to about a 0.5% change in brightness (p.89).

Objects with high brightness can be especially detrimental in nighttime conditions. While driving, for example, high-intensity beams of light from oncoming traffic can cause *discomfort glare*, the "subjective sensation of discomfort," and *disability glare*, which results in reduced contrast sensitivity as the rods of the eye are overstimulated to the point of losing their sensitivity to the lower frequencies of light (Theeuwes et. al., 2002, pp. 1-3). This makes it more difficult to view not only the road, but also other vehicles and pedestrians on it (increasing the chances of an accident).

The brightness of an element in our environment is not the only thing that affects our perception of contrast. Wickens et al. (2004) note that environmental and age-related conditions also play a role. In environments where our eyes have "due to blurred or degraded conditions...poor sensor resolution...and low light conditions" our contrast threshold is reduced. In addition, "lower contrasts are less easily discerned." As we age, a "reduced amount of light passes through the cornea, reducing sensitivity" (p.71). This results in a substantial "loss of visual acuity...and perceptual flexibility" (Czaja, 1990, pp. 4-5). In designing for those with degraded visual acuity, working with larger elements at an increased contrast can go a long way in improving their experiences.

In essence:

- Low contrast leads to decreased visibility of visual elements
- Low-light environment leads to decreased contrast sensitivity (this is made worse by the presence of intermittent sources of high brightness)
- The older we are, the lower our contrast sensitivity is
- And, most importantly, contrast is *relative*, not absolute

Color

Color is a core property of our vision, the perception of which is determined by three elements: the *brightness* (perceived amount of light striking the eye), the *hue* (position along the visual light spectrum), and the *saturation* (how free of other impurities a color is).

Strengths

Color can help us differentiate things in our surroundings that would otherwise be extremely difficult to detect. If we could only see in monochromatic vision, any two (or more) objects with equal brightness (and hence, contrast) would be indistinguishable.

The fact that the colors we can see lie along a particular spectrum can be utilized to our advantage, as they can easily be differentiated by most in conditions of good contrast. In a study of an interactive battlefield mapping system, Yeh & Wickens (2001) discovered that “color coding...significantly facilitated performance ($p < .05$) relative to the monochrome” versions of the maps when users were asked to locate specific entities and objectives. User accuracy increased by roughly 4% with the colored interface (red, blue, and green) over the grayscale (5 shades) (p.551).

However, color comes with its own set of limitations, two of which are severe enough that they should be at the forefront of one's mind whenever designing something in anything but black, white, and shades of gray.

Weaknesses

As Ware (2004) notes, color is "irrelevant to much of normal vision...it does not help us determine the layout of objects in a space, how they are moving, or what their shapes are" (p.97). Despite its usefulness in distinguishing between objects, Wickens et al (2004) note that in "poorly illuminated conditions," our ability to distinguish color decreases (p.71). The cones (a type of light receptor cell) in our eyes that help us distinguish colors become inactive in low-light conditions, and the rods that enable us to see in these situations "cannot discriminate different wavelengths of light" (Wickens et al., 2004, p.68).

In addition Wickens et al (2004) note that "approximately 7% of the male population is *color-deficient*" (p.73), unable to distinguish hues of certain colors (most commonly red and green). As a result, if one relies on color alone to indicate important elements in a design, you may be setting a significant percentage of your users up for failure. As a result, Shneiderman (1987) suggests that we should "design for monochrome first...the primary goal of a display designer should be to lay out the contents in a logical pattern" (p.400). He indicates that color is best used "to group related items...indicate status changes...[and] improve information density on graphic displays" as opposed to just "brighten up the display" (pp. 10-12). Using color purely for 'brightening' is detrimental; as Horton (1991) states "a long exposure to broad areas of color can prove fatiguing. Red causes the greatest fatigue, blue the least" (p.164).

For older adults, the use of color can be an issue as well. Ellis and Kurniawan (2000), during a study of participatory design involving elderly participants, noted that “caution must be exercised with respect to the use of color coding, because there is some decline in color discrimination abilities with age, particularly in shorter wavelengths such as blues and greens” (p.267).

The ideas to take away about color and the way we perceive it are:

- It can be useful in coding and organizing information, but only if used sparingly
- Certain user groups are insensitive to or otherwise unable to differentiate between certain colors and color pairings; keep elderly and color-blind users in mind
- Avoid using color in low-light conditions; the rods of the eye that we use to see in these conditions cannot differentiate between various wavelengths of light
- The use of color (particularly red) causes visual fatigue; the more fatigue someone is experiencing, the more difficult it is for them to focus.

Contour Enhancement

The Gestalt law of continuity states that “we are more likely to construct visual entities out of visual elements that are smooth and continuous” (Ware, 2004, p.191).

This implies that we identify objects and items in our environment not through their

details (as one might expect), but primarily from their edges, contours, and shapes.

Notice how when presented with the silhouette of a bicycle, for example, that, despite its lack of color, texture, or other identifying details, that one can still recognize the object?

Fields et al. (1993) surmise that our perception of continuity must be “derived from a process that integrates [visual elements] along the length of a [perceived] path.”

Further investigation done by Kovács (2000) notes that this contour detection is actually

a “specialized subsystem” of vision (p.1306), implying that we have dedicated cognitive functions to handle the processing of edges.

What can we take from this as far a design goes? That the human visual system is drawn to items with well-defined contours. Areas of a website, for example, that are clearly differentiated by their shape and visible edges are the ones we notice first. To draw attention and differentiate different sections of content, navigation, etc., we can encapsulate them in shapes.

Now that we have some background on the human vision system and how it handles things like brightness, contrast, and color, let us examine Lenovo Corporation’s blog site (<http://lenovoblogs.com/>) from a purely visual-processing angle and show where its strengths and weaknesses are.

Case Study: Lenovo Blogs

Strengths

The individual blogs are distinguished by their icons at the center of the screen, and the “active” blog icon (whose author, comments, and latest post are displayed in a section underneath) has been colorized to indicate it is selected. Other blogs in the list have their icons fade to very light, muted tones to indicate that they are not currently active. This contrast difference focuses the user’s attention on the active selection. Also, note the use of contours around each blog’s icon to help differentiate them from each other. Because of their shape and slight spacing away from each other, the visual system picks up seven distinct units that are easily distinguishable from each other. In

addition, this use of contours divides the site into distinct, identifiable sections, making it easier to visually discriminate between different content areas.

Weaknesses

The use of low-contrast light gray colors on the white and light blue backgrounds (the blog subtitles and the section headings) make that text difficult to read, as there is not much signal differentiation between the foreground and the background. The same applies to the gray-on-gray titles in the right-hand “Recent Comments” and “LenovoFlickr” sections.

The body text on the page also poses a number of issues. While there is adequate color contrast (black on light gray) for some of the body text, this is hampered by the small font sizes. Of particular noteworthiness is the use of the light blue on light gray body text; as Horton (1991) notes, “most people cannot focus on blue objects” (p.164) as blue offers the poorest visual clarity/acuity of all of the colors in the spectrum. This makes the blue text particularly difficult to read. The situation is not improved by the use of a low-contrast gray background, making it even more difficult to focus on the blue text.

The gradual fading from gray to white on each of the content columns doesn’t serve to guide one’s vision in a particular order, like from most important element to least important element, as one might assume it does. Because of this, it only contributes to generating additional fatigue for the viewer. On the issue of color-coding, there also appears to be no consistent scheme for colorizing information on the page. Major headings, subheadings, and body text are colored seemingly haphazardly instead of following a natural organization scheme (via saturation, etc.) This is directly against

the suggestions of Shneiderman (1987), who indicated that color could be best used “to group related items” (p.10).

Suggestions for Improvement

- Improve the contrast between the title, subtitle, and body text on the site and the white/gray backgrounds. Consider using black to provide maximum visual difference between the foreground and background. This not only makes the text easier to read, but it reduces overall fatigue generated by the blue elements.
- Replace the gray-to-white transitioning backgrounds with solid white or solid gray, unless some meaningful content organization scheme can be built around the transition. It currently adds nothing to the experience except additional visual fatigue.
- Increase the overall size of all of the fonts (while maintaining the proportions that draw people to the titles first, subheadings second, body text third, etc.). The current selections are far too small for comfortable reading over long periods of time, and may pose problems for users with less-than-perfect visual acuity.

The human visual system, at heart, is a detector of change. It does not measure in absolutes, but instead by what differences elements have compared to their environments and other elements around them. Building a good design is about managing this change detection. Signals and elements that need attention should be prominent enough to draw attention without overwhelming, and elements that should be detectable without getting in the way should be subdued (just enough) accordingly. The needs of the elderly and less visually-acute (colorblind or vision-impaired individuals) should also be taken into account; ensure that elements are large enough to be seen

comfortably and only use color in situations where it helps with information coding and management. By adhering to some basic principles and armed with a reasonable understanding of the visual system, we can produce designs that are more usable for everyone.

References

- Czaja, S. J. (1990). Human Factors Research Needs for an Aging Population. National Academies Press.
- Ellis, R. D., & Kurniawan, S. H. (2000). Increasing the Usability of Online Information for Older Users: A Case Study in Participatory Design. *International Journal of Human-Computer Interaction*, 12(2), 263-276.
- Field, D. J., Hayes, A., & Hess, R. F. (1993). Contour integration by the human visual system: evidence for a local "association field". *VISION RESEARCH-OXFORD-*, 33, 173-173.
- Horton, W. (1991). Overcoming chromophobia: a guide to the confident and appropriate use of color. *Professional Communication, IEEE Transactions on*, 34(3), 160-171. doi: 10.1109/47.84110.
- Kovács, I. (2000). Human development of perceptual organization. *Vision Research*, 40(10-12), 1301-1310.
- Shneiderman, B. (1997). *Designing the User Interface: Strategies for Effective Human-Computer Interaction* (p. 639). Addison-Wesley Longman Publishing Co., Inc.
- Theeuwes, J., WAMAlferdinck, J., & Perel, M. (2002). Relation between glare and driving performance. *Human Factors*, 44(1), 95.
- Ware, C. (2004). *Information visualization: perception for design*, 486. Morgan Kaufmann.
- Wickens, C. D., Lee, J. D., Liu, Y., and Gordon-Becker, S. (2004). *Introduction to Human Factors Engineering* (2nd Edition). Prentice Hall.
- Wyszecki, G., & Stiles, W. S. *Color Science: Concepts and Methods. Quantitative Data and Formulae* (Wiley, New York, 1982), 1.
- Yeh, M., & Wickens, C. D. (2001). Attentional Filtering in the Design of Electronic Map Displays: A Comparison of Color Coding, Intensity Coding, and Decluttering Techniques. *Human Factors: The Journal of the Human Factors and Ergonomics Society*, 43(4), 543-562.

Appendix A: LenovoBlogs.com Screen Captures

