Preattentive Visual Processing Applied to Website Analysis
Lydia Sankey
Bentley University
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There are many ways in which the mind takes in information – through sight, sound, touch, etc. The visual processes provide the richest input and information for humans, but it is impossible for the mind to process everything in the visual field simultaneously (Wolfe, 1994). There are two ways that the mind works to be able to process the amount of data – discard input and process information selectively (Wolfe, 1994). However, there are some “low-level” and “fast-acting” (Healey & Enns, 2011, p. 2) visual processes that can be accomplished simultaneously and automatically (Treisman, 1986). When presented with an image, the mind attempts to organize, combine, and segregate data in order to make it more efficient for further, detailed processing, and Treisman (1986) states that “meaningful wholes seem to precede parts and properties, as the Gestalt psychologists emphasized many years ago” (p. 114B). Ulric Neisser called this early-stage visual processing “preattentive” to distinguish it from a subsequent, attentive level that would start to identify the details of the objects (Treisman, 1986).

Tasks are considered preattentive if performed in less than 250 milliseconds (ms). In that amount of time eye movements are not possible and the task is completed in a single glance (Bergen & Julesz, 1983 and Healey & Enns, 2011). In the early visual processing levels, the neurons in the retina of the eye are particularly sensitive to basic features, such as “orientation, color, and direction of motion” (Houtkamp & Roelfsema, 2010, p. 1443). In the bottom-up vs. top-down processing model, preattentive vision is part of the bottom-up operation – it is automatic and biological. Because this biological ability of the mind to organize information in specific, repeatable ways is common across the majority of people, it can be predicted and used advantageously.

When presented with a new source of information (e.g. a website), it should be possible to start to organize the information at first glance, and designers can take advantage of the principles that have been proven through research. Since it is known how humans will perceive items such as grouping, proximity, and similarity in color and size, the designer can guide the viewer’s eye to the appropriate location on the website. Alternatively, if designers do not align their design with preattentive principles, the viewer will not be able to make sense of the situation; she may not be able to understand what information should be grouped with others, what is the relevant data, or where to look first. At first glance, the website will just be a jumble of shapes, color, and words. In the virtually endless world of the internet, this first glance is crucial to establish the validity of the website, give the viewer confidence that she will be able to find the appropriate information, and not overload her with trivial distractors. Often, 250 ms is all that is needed for a viewer to move on to the next website.

In this paper, I will briefly discuss Gestalt theory and how these psychological principles
are being proven and redefined with modern research. I will then discuss five theories of preattentive vision and how they contribute to the visual features and patterns that are important to the human mind. Based on these concepts, I will present an analysis and recommendations of an ecommerce website, Campmor.com, taking into account spatial grouping (proximity, connectedness, closure), similarity (color, shape, size), and figure-ground segmentation.

**Theories of Preattentive Vision**

Gestalt psychology has been influential in discussions of perception since 1886 and has taken on “renewed significance” as more modern researchers attempt to “characterize neural mechanisms of cognition” (Westheimer, 1999, p. 5). The Gestaltists, such as Wertheimer and Koffka, presented a list of rules for perceptual grouping, but the only justification for these rules was their “evident plausibility” (Grossberg & Mingolla, 1985, p. 142) and the only basis was “perceived (rather than retinal) relations” (Palmer & Rock, 1994, p. 29). Many researchers have worked to find a scientific foundation for the organization, grouping, and structuring that the mind does preattentively, and Healey and Enns (2011) describe five well-known models of preattentive vision that have been developed: feature integration, textons, similarity, guided search, and boolean maps.

**Feature Integration Theory**

Treisman and Gelade (1980) propose the feature integration theory of attention, in which “features are registered early, automatically, and in parallel” (p. 98), while objects are identified later. These features (e.g. red and vertical) are registered on individual feature maps, which are processed in parallel, and the locations of these features are on a master map, which is processed serially (Treisman & Gormican, 1988). Because of this, a target stimulus can be preattentively identified if it differs in only one feature from the distractors, but when there are conjunctions of more than one feature in the objects, serial attention to each stimulus is required (Treisman & Gelade, 1980). However, it is possible to preattentively group objects, which would then allow focus on the “homogeneous groups that share one target feature” (Treisman, 1982, p. 198).

**Texton Theory**

The texton theory proposed by Julesz also differentiates between parallel (preattentive) and serial (focused attention) search; variations in patterns of “textons” can be preattentively processed if the textons differ in certain “local features” (Bergen & Julesz, 1983, p. 696). Julesz categorized textons into three categories – elongated blobs, terminators, and crossings of line segments – which can be preattentively detected only if there is a difference in textons or their density (Healey & Enns, 2011).

**Similarity Theory**

Duncan and Humphreys (1989) disagree with Treisman, Julesz, and others; they do not
make a distinction between serial and parallel search. The similarity theory proposes that there is a “continuum of search efficiency” which depends purely on the similarity (or dissimilarity) of target and distractors (Duncan & Humphreys, 1989, p. 433) and varies according to the difficulty of the search (Quinlan & Humphreys, 1987).

**Guided Search Theory**

Wolfe (1994) attempts to build upon the models of Treisman and Julesz, and the guided search theory also relies on feature maps and parallel and serial processes. However, this model does not hold that serial search is required for conjunctions of two features; “the parallel processes guide the ‘spotlight of attention’ toward likely targets” (Wolfe, Cave, & Franzel, 1989, p. 420). This was also the first model to incorporate the viewer goals into the search (Healey & Enns, 2011).

**Boolean Map Theory**

A more recent theory proposes that the visual system creates boolean maps, which separates a scene into two regions – one that is selected and one that is not (Huang & Pashler, 2007). Only one feature – but including its location – can be selected at a time, and the spatial pattern created by multiple locations does not compete with a feature, but two features compete with each other (Huang, Treisman, & Pashler, 2007).

**Case Review**

There are, of course, other theories, principles, and variations than the ones mentioned above, and these models, while not always consistent in their approach, provide guidance for how to design a display that takes advantage of the natural preattentive processing of the mind. The models differ in why and how they were developed, but they mostly agree on which visual features can be processed (Healey & Enns, 2011). There are many examples of grouping and organizing principles on any website, including the one analyzed here (Campmor.com), which is an ecommerce website for outdoor gear and supplies. I will focus on reviewing several of the main features of this site by looking at spatial grouping (proximity, connectedness, closure), similarity (color, shape, size), and figure-ground segmentation.

**Spatial Grouping**

Pomerantz and Portillo (2011) have identified proximity to be a preattentive “emergent feature” by performing trials with two dots located close together. The Campmor website could use proximity more effectively in the “Featured Products” section in Figure 1. Because the spacing between the groups of objects – photos of merchandise and text descriptions – is uniform, it is not obvious at first glance what photo is associated with what text. By clustering the photo closer to the associated text, this association could be made preattentively. Another alternative is to provide a closure around associated elements. However, both remedial methods are not
necessary, and effort should be taken to keep the design simple in order to reduce the distractions (noise) to the viewer.

Figure 1. This is a screen shot of the top section of the Campmor.com ecommerce website.

Palmer and Rock’s (1994) principle of uniform connectedness states that a single unit is perceived if there is a “connected region of uniform visual properties”. These properties, such as luminance, color, or texture, create a connectedness even when challenged by other grouping principles such as similarity and proximity (Palmer & Rock, 1994). In Figure 1, there is a light grey rectangular region, which goes horizontally across the page (starting with “Sweaters & Sweatshirts”). This area is preattentively processed as a single unit, overriding the proximity of the text to the photos and even the dark blue lines enclosing the photo/text groups. This grey is probably meant to highlight the text categories and could be improved by either truncating it before it touches the blue closure lines or possibly removing it all together.
By performing trials with circles in the midst of incomplete circles, Treisman (1986) found closure to be a feature that is preattentively detectable. Campmor uses closure and boundaries very frequently, sometimes quite well and sometimes unnecessarily. In Figure 3, the five boxes at the bottom (starting with the “More Ways To Shop” heading) are closed very effectively. They have a thin black border on the right and bottom, a white border on the left, and the edge of the green (or yellow) band at the top. Another example of closure is the heavy dark lines around the second row of brand logos in Figure 2. However, the logos are easily recognized as objects against the white background due to their color and size, and the closure lines are unnecessary. The top row of logos illustrates that they are easily seen as separate objects, and the thin black rectangle bordering all the logos clearly groups the logos together.

Figure 2. This is a screen shot of the middle section of the Campmor.com ecommerce website.
Figure 3. This is a screen shot of the bottom section of the Campmor.com ecommerce website.

**Similarity / Patterns**

Most, if not all, researchers recognize color (hue and brightness) as a basic preattentive feature (Wolfe, 1994 and Callaghan, 1984). However, Duncan and Humphreys (1989) believe that the perceptual group is strong when the same-colored elements are in close proximity, but when there are differently colored elements in between these elements the grouping is less strong. On the Campmor website, the three red arrows on top of the large picture in Figure 1 are in close proximity to each other and are thus preattentively processed as a group. The fact that they have the same shape also adds to the strength of this grouping. Further below, some of the prices are listed in red. Because of the distance and other elements between the red arrows and the red prices, no preattentive grouping is made, which is as it should be. In fact, because of the distractor elements between the prices themselves, they are not even preattentively grouped.

Although Palmer and Rock (1994) do not believe that shape is a preattentive feature and that shapes are initially processed as “blobs” (p. 39), Treisman and Gelade (1980) state that the feature integration model applies to shape. In Figure 3, there are five long, thin rectangles (which are the “headers” for the individual boxes) that can be preattentively grouped together. In later visual processing, they can be separated into green and yellow rectangles.

Healey, Booth, and Enns (1993) include size in their list of preattentive features. The small photos in the “Featured Products” section of Figure 1 are of similar size and will be
preattentively grouped together, even though they are not adjacent to one another. This is a reasonable grouping since they are all individual clickable products and thus similar. While the size will be preattentive, the fact that they are photos – and not blobs – will be perceived only in later processing stages.

**Figure/Ground**

Figure-ground segmentation is predicted by boolean map theory since only one region (figure or ground) can be preattentively processed at a time (Huang & Pashler, 2007). In the first part of the Campmor website (Figure 1), it appears as though white is the background color. Since the region that is surrounded is perceived as the figure (Palmer & Rock, 1994), the merchandise photos and text are seen as the figures here. But if one scrolls down (Figures 2 and 3), the background is a light tan color. Upon closer inspection, the white boxes on the upper part of the page are actually the figure on the tan background. Since only one (preferably the figure) can be preattentively processed, the white area could possible be removed from the boxes in Figure 1, since they are already enclosed by the light black line around them.

**Conclusion**

We started with perceptual grouping of Gestalt psychology, discussed some of the major scientific theories of visual preattentive processing, and applied those theories and others to an analysis of the Campmor.com ecommerce website. In doing so, I have not taken into account all preattentive features and have concentrated on the ones more relevant to the case. Two major ones excluded are motion and stereoscopic depth. The number of models, theories, and principles shows that there is much research that has been done in this field over the past 30 years, and almost every cited researcher proposed future work in their papers, indicating that the trend of discoveries and refinements will continue.

Most researchers agree that the human mind tries to make sense of what it perceives in an efficient way that does not create cognitive overload and that it does so by seeking patterns and clumping like features with each other. Treisman and Gormican (1988) believe that recognition and labeling of objects are done in a later processing stage and are “not essential to vision” (p. 15). Within the 250 ms of preattentive vision, the human visual system cannot “change its focus of attention” (Healey, Booth, & Enns, 1993, p. 110). However, a website designer’s misalignment of preattentive principles may cause a viewer to quickly change her focus of attention and move on to the next site, especially with something as seemingly ubiquitous as an ecommerce website.
References


