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# The Influence of Display Characteristics on Visual Exploratory Search Behavior

CHRIS JANISZEWSKI \*

Visual information search is a combination of two distinct types of behavior. Goal-directed search behavior occurs when consumers use stored search routines to collect information in a deliberate manner. In contrast, exploratory search behavior occurs when consumers are confronted with multiple pieces of information but have little stored knowledge about how to proceed with the information gathering. This article reports on an investigation into exploratory search behavior and attempts to establish a connection between the layout of objects in a display and the amount of attention devoted to each of these objects. The research has implications for catalog page layout and visual merchandising.

Visual information search can be categorized into two broad types of behavior: goal-directed search and exploratory search. Goal-directed visual search occurs when consumers are motivated to use a stored search routine to gather information more efficiently. Goal-directed search impacts general information gathering activities (e.g., the number of product attributes considered) and specific information gathering activities (e.g., the assessment of product performance on selected attributes; Brucks 1985). In contrast, exploratory visual search occurs when consumers lack the motivation or experience needed to search efficiently. For example, the browsing behavior associated with paging through a catalog is often more stimulus driven than planned.

Most information search is a combination of these two activities: top-down decisions about where and how to find desired information and bottom-up decisions about how to visually explore a novel environment (Groner, Walder, and Groner 1984). Despite evidence that both processes are a fundamental part of any information gathering activity, the consumer research literature has virtually ignored exploratory search and has focused primarily on the volitional activities associated with goal-directed search (e.g., Wilkie and Dickson 1985). Although there has been research on how to interrupt a goal-directed search routine using executional factors (e.g., size or color), it is often assumed that such executional factors simply redirect the goal-directed search activity to the

new material (Hornik 1980; Valiente 1973). Thus, there has been no attempt to isolate the influence of exploratory search activities in the broader context of goal-directed search.

The objective of this research is to understand the processes that guide exploratory search behavior and to document the influence of exploratory search activities on information gathering, information retention, and choice. The article begins by contrasting goal-directed visual search and exploratory visual search in an effort to generate hypotheses about how these competing search routines are differentially sensitive to display characteristics. The discussion reviews evidence that goal-directed search becomes faster when the number of nonfocal (nonattended) items competing for attention is limited because it is easier to select the next area to receive attention. In contrast, it is predicted that exploratory search will become slower when the competition for attention from nonfocal items is low because there will be a limited incentive to shift attention. The literature review concludes with a discussion of how layout influences the degree to which nonfocal items compete for attention during the viewing of each object in a display.

Study 1 uses a layout manipulation to vary the degree to which nonattended items are competing for attention in a multi-item display and shows that people spend more time gathering information about an attended object when the competition for attention from nonfocal items is limited. Studies 2 and 3 show that the increased viewing time that objects receive when placed in noncompetitive environments results in increased memory for the objects. Study 4 uses catalog display stimuli to show that the increased attention to objects in visually noncompetitive environments can motivate the additional information gathering that encourages a purchase. The implication is that for any given set of items in a display, there is a

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subset of layouts that promote more intensive viewing of the items in the display.

## GOAL-DIRECTED SEARCH VERSUS EXPLORATORY SEARCH

### Goal-Directed Search

Goal-directed search is a broad-based term used to describe numerous activities. In the context of selective attention, goal-directed search refers to the planned acquisition of data using a search routine stored in memory (e.g., scanning from left-to-right) or generated for the current task (e.g., the feature “yellow” can be used to locate the mustard containers in a condiment aisle). The demands of the search task, organization of the information in the search environment, and the task-relevant experiences of the searcher determine the ease/difficulty of the search activity. This discussion will concentrate primarily on the factors that influence the complexity of the visual environment—salience and layout.

Salience influences search by making certain items easier to select for attention than other, competing items. Size and contrast are often used to increase the salience of an object and, thus, to increase the likelihood it will be selected for viewing. Size is the most important determinant of attention in advertising, in some cases accounting for over 25 percent of the variance in readership scores (Adams 1917; Strong 1914). Contrast occurs when a stimulus is unique on a distinctive feature, allowing it to be easily differentiated from other stimuli within the visual environment. For example, the advertising literature has documented the ability of color to make advertisements pop out in a black and white environment, as well as the declining effectiveness of this strategy when competing advertisements also use color (Hornik 1980; Schindler 1986; Valiente 1973).

Like salience, layout or stimulus organization can also make information search more efficient. To organize a visual environment by an important sorting feature allows the viewer to limit attention to a smaller subset of information, thus speeding search (Treisman 1988). Likewise, expectations about the content and organization of a scene that are developed as a consequence of past encounters with similar scenes can speed information search by making attention more selective (Biederman, Glass, and Stacy 1973).

In summary, viewers can use salience cues and layout knowledge to locate and attend to candidate objects more quickly, thus speeding the information search.

**H1:** In a goal-directed search task, making the information display easier to search will make information gathering more efficient (i.e., less time consuming).

### Exploratory Search

Exploratory search behavior is fundamentally different from goal-directed search behavior. Physiologically, goal-

directed search relies on an attention system localized in the anterior cingulate gyrus, whereas exploratory search behavior relies on an attention system localized in the posterior parietal lobe (Posner and Peterson 1990). Goal-directed search behavior is effortful and requires a pool of allocated resources. When a person is not engaged in goal-directed search, the visual system continues to gather information, using exploring search routines (Posner and Peterson 1990; Vecera and Farah 1994). In effect, exploratory search routines are used to monitor the environment when a person is not actively searching for a piece of information.

Exploratory search activity can operate as either a screening process that identifies candidates for goal-directed search or as an information gathering device when goal-directed search routines are inadequate. Exploratory search is a moment-by-moment activity, always ready to defer to goal-directed search routines, but always active as the baseline visual search system. Thus, an exploratory search routine is a process that can determine whether or not attention should shift and where attention should shift to when necessary.

Like goal-directed search routines, exploratory search routines must have procedures for determining how much attention will be devoted to each location in the display. Unlike goal-directed search, each decision to shift attention will involve an information value trade-off assessment. In effect, the search routine control mechanism must determine whether more information will be gathered by continuing to attend to the current area of focus or by shifting attention to a competing location. Thus, the system continuously compares the “demand” being generated by focal (i.e., currently attended) material to the demand being generated by nonfocal (i.e., currently unattended) material that is competing for attention. As the amount of time devoted to the focal material increases, more information is gathered, and the value of additional attention to this material declines. At some point, the demand for attention from nonfocal material surpasses the demand for attention from focal material, and attention shifts. Similarly, an increase in the amount of nonfocal material will increase the expected value of nonfocal material in total relative to focal material. In both cases, increased demand for attention from nonfocal material should result in less viewing of the focal material. Stated conversely:

**H2:** In an exploratory search task, making the material surrounding an object less visually demanding will lead to more leisurely (i.e., more time consuming) information gathering.

The next section discusses how display layout can influence the demand for attention created by nonfocal material and, thus, explains how layout can be used to influence the amount of attention devoted to specific material in the display.

## COMPETITION FOR ATTENTION FROM NONFOCAL MATERIAL

The physiology of the visual system is responsible for the relationship between the layout of information in a display and the competition for attention exerted by nonfocal material while viewing a specific object in the display. The visual system "sees" by recognizing differences in the intensity of signals generated by the boundaries of objects located in the visual field (Helmholtz 1866; Steinman and Levinson 1990). Receptors measure the differences in the intensity of signals from the visual environment, and the perceptual system coordinates and/or differentiates these signals in order to attribute meaning to the information. The visual receptors are located on the retina and are densest at the fovea (i.e., area of eye receiving information from the current area of focus; Polyak 1941). As a nonattended object is located further from the current point of focus, the image of the object is projected on a portion of the retina that has a lower density of receptor cones, and, consequently, the degraded signal does not allow the perceptual system to differentiate the signal associated with the nonattended object from the noise associated of the surrounding area. Therefore, as objects are located further away from the current point of focus, they become harder to see and are less likely to compete for attention (Polyak 1941).

Contrast and size can compensate for the degradation in the signal strength that occurs when an object is moved further from the current point of focus. As a nonattended object exhibits more contrast with the surrounding environment, receptor cones become more activated, and the signal strength associated with the nonattended object becomes stronger (Hering 1868; Steinman and Levinson 1990). Similarly, as a nonattended object becomes bigger, the projection of its image (boundaries) on the retina is dispersed over a larger number of receptor cones, and the signal generated by its borders becomes stronger (Anstis 1974). In each case, the object is interpreted as having more potential information value and hence exerts more competition for attention.

Anstis (1974) and others have shown that there is a linear relationship between the size of an object and its distance from the fovea when the objective is to maintain a constant signal strength (i.e., sustain visual acuity). For each degree an object is removed from the current point of focus, the object must increase by 0.2 degrees in size to sustain an equivalent level of acuity. Figure 1 shows this relationship between size and distance. Each object in the display has a constant signal strength when attention is directed at the middle point of the display (O). The reader should note that s/he can name any letter of any vector in the display when attending to the midpoint (O), but this ability is lost as attention is shifted to the left, right, up, or down. Figure 1 maintains this quality at varying distances from the eye, within certain bounds. An increase in the distance of the eye from the display will result in a decrease in the size of the nonattended letters, but this

will be offset by a decrease in the degree to which the letters are displaced from the foveal viewing area. In other words, as the distance between the eye and the display increases, the smaller, nonattended letters will be projected on an area of the retina that has a higher concentration of receptors.

The signal strength of each object surrounding a current point of focus is influential in determining the competition for attention being experienced by the visual system during the viewing of the focal object. For example, suppose a viewer attends to area A in Figure 2. Areas B, C, and D are the nonfocal objects that will compete for attention while the viewer attends to area A. To assess the demand exerted by these areas, a ratio of the size of the object to its distance from the current point of focus can be computed (see the Anstis discussion above).<sup>1</sup> In an  $8.5 \times 11$  inch display, each area would displace 7 cm, the square root of the amount of space occupied by the area.<sup>2</sup> Thus, when viewing area A, area B would generate the most demand (1.00), area C would generate half the demand of area B (0.50), and area D would generate the least demand (0.44). Calculations of the demand for attention created by nonfocal items during the viewing of areas B, C, and D can be made in a similar fashion.

The demand calculations can be used to compute a measure of the competition for attention experienced during the viewing of an area. The competition for attention can be measured as the summed demand for attention from the nonfocal areas. For example, area A is surrounded by 1.94 units of visual demand, 1.00 from area B, 0.50 from area C, and 0.44 from area D. Using a similar procedure, area B is surrounded by 2.70 units of visual demand, area C by 2.38 units of visual demand, and area D by 1.98 units of visual demand.

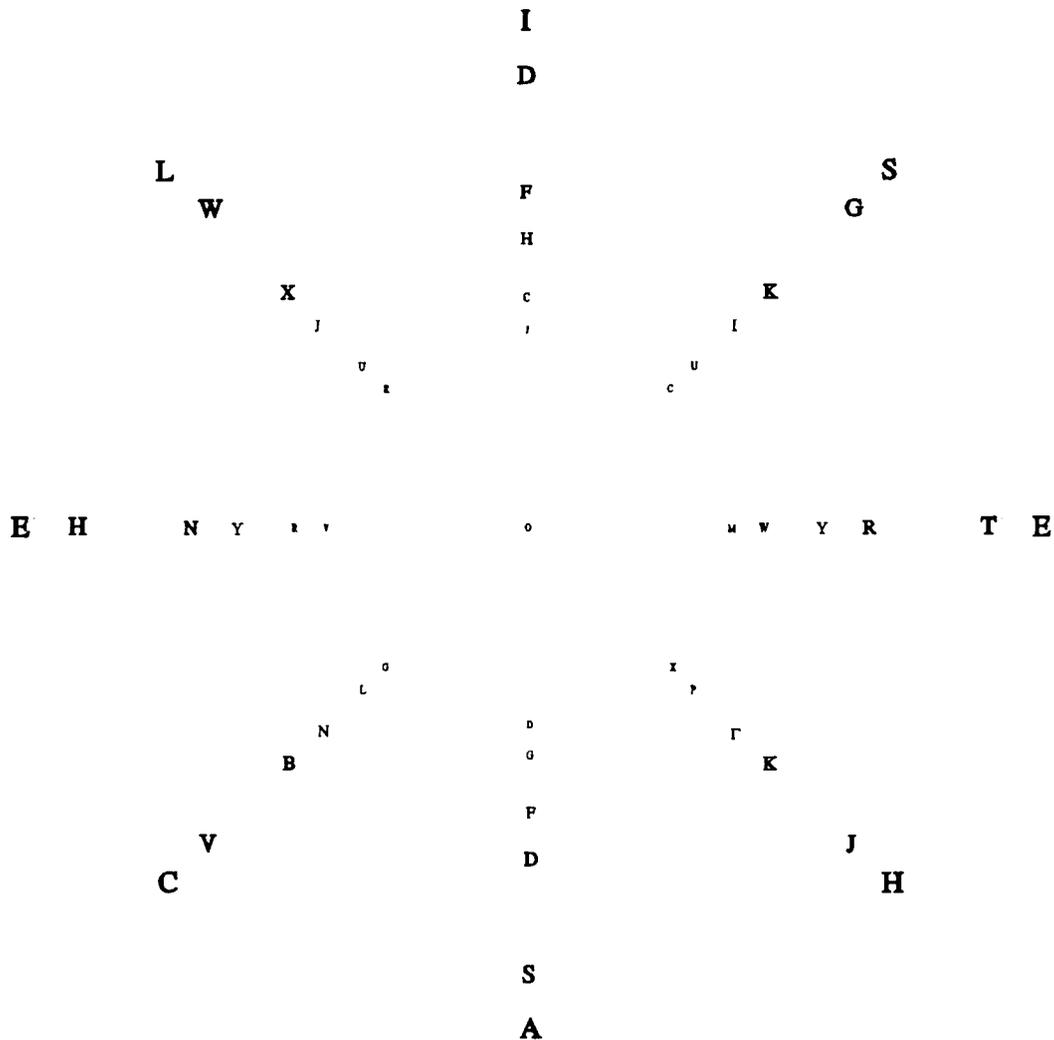
### STUDY 1

The demand calculations presented in Figure 2 can be used to illustrate the predictions associated with Hypotheses 1 and 2. Hypothesis 2 predicts that people engaged in an exploratory search routine should spend less time looking at target areas that are surrounded by material generating a strong demand for attention. In Figure 2, area B is surrounded by the most demanding material ( $\Sigma$  demand = 2.70), followed by area C ( $\Sigma$  demand = 2.38), area D ( $\Sigma$  demand = 1.98), and area A ( $\Sigma$  demand = 1.94). Thus, in an *exploratory* search routine, area B should receive the *least* attention, area C should receive a moderate amount of attention, and areas D and A should receive a relatively high amount of attention. In contrast, Hypothesis 1 predicts that people engaged in a goal-di-

<sup>1</sup>A tangent function could be used to calculate the actual number of degrees of visual space occupied by each object. This estimate would correlate perfectly with the area to size ratio.

<sup>2</sup>The degree of displacement must be reduced to a single dimension. The square root of the area occupied by the object is a weighted average of the height and width dimensions.

**FIGURE 1**  
THE RELATIONSHIP BETWEEN SIZE, DISTANCE, AND VISUAL ACUITY



NOTE.—All letters lie at the threshold for identification when attention is focused on the O at the center of the chart. The figure was developed from a display in Anstis (1974).

rected search routine will spend less time looking at areas that are surrounded by a configuration of material that allows for an easy shift in attention. In Figure 2, area A is surrounded by a single area, B, that is exerting a strong demand for attention (demand B = 1.0) and two areas, C and D, that are exerting a weak demand for attention (demand C = 0.50 and demand D = 0.44). In this situation, it is easy to select area B as the next location of attention. At the opposite end of the spectrum, area B is surrounded by two areas with an equally strong demand on attention (demand A = 1.0 and demand C = 1.0) and planning a shift in attention should be difficult. Thus, in a *goal-directed* search routine, area B should receive the *most* attention, area C a moderate amount of attention, and areas A and D a relatively small amount of attention.

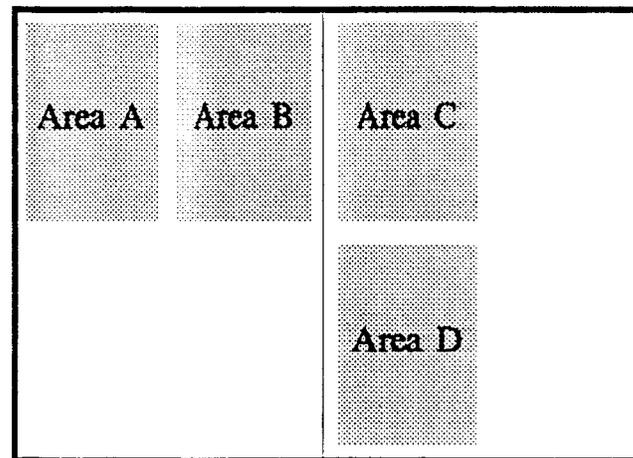
In sum, Hypotheses 1 and 2 predict opposite patterns of relative attention to the four areas displayed in Figure 2 based on the nature of the search routine.

### Method

*Stimuli.* The stimuli were 48 four-object displays. Each display was divided into eight equal-sized rectangular areas (see Fig. 3a). The stimulus displays had four of the rectangles filled with a color, the other four areas represented by lines (see Fig. 3b). Sixteen of the displays had three of the four rectangles on the left-side page, 16 of the displays had three of the four rectangles on the right-side page, and 16 of the displays had two of the rectangles on each page. Each of the eight locations in

FIGURE 2

THE COMPETITION FOR ATTENTION EXPERIENCED DURING THE VIEWING OF EACH AREA OF A DISPLAY



COMPETITION FOR ATTENTION WHILE VIEWING AREA A			
Area <sub>a</sub>	Size <sub>b</sub>	Dist. <sub>c</sub>	Demand <sub>d</sub>
B	7cm	7cm	1.00
C	7cm	14cm	0.50
D	7cm	16cm	0.44

COMPETITION FOR ATTENTION WHILE VIEWING AREA C			
Area	Size	Dist.	Demand
A	7cm	14cm	0.50
B	7cm	7cm	1.00
D	7cm	8cm	0.88

COMPETITION FOR ATTENTION WHILE VIEWING AREA B			
Area	Size	Dist	Demand
A	7cm	7cm	1.00
C	7cm	7cm	1.00
D	7cm	10cm	0.70

COMPETITION FOR ATTENTION WHILE VIEWING AREA D			
Area	Size	Dist	Demand
A	7cm	16cm	0.44
B	7cm	10cm	0.70
C	7cm	8cm	0.88

NOTE.—A = Area, a nonattended object that is competing for attention; B = Size, the square root of the area occupied by the nonattended object in the original display; C = Distance, distance from the center of the current point of focus to the center of the nonattended object in the original display; D = Demand, the size/distance ratio.

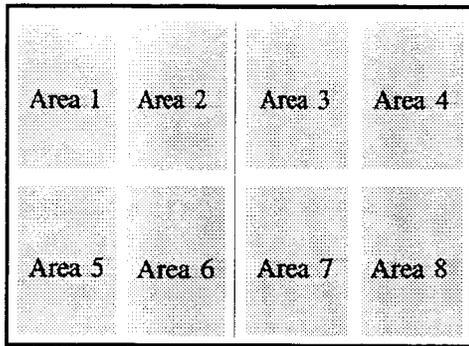
the display template were occupied by a rectangle in 24 of the 48 displays.

*Procedure.* Forty undergraduate male and female subjects viewed the stimuli while their eye movements were monitored. Stimuli were presented using a 20-inch Multi-Sync 5D monitor and Microsoft Corporation's Powerpoint software. Subjects were asked to look at the colored rectangles, letting their eye flow from box to box

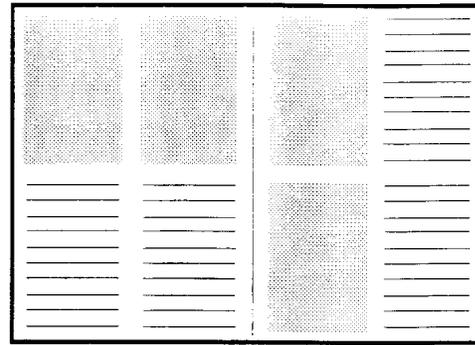
in a natural manner. The displays were presented for 4.4 seconds each, a time sufficient to see each rectangle at least once. A filler slide preceded each stimulus slide.

An Applied Science Laboratory Model 1996 corneal reflection monitoring system was used to measure each subject's eye movements during the viewing of the displays. The system reflects an infrared light off the surface of the eye while measuring the position of the pupil.

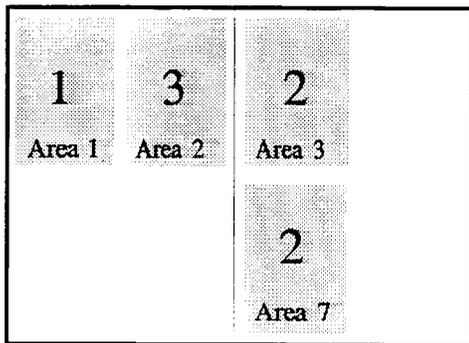
**FIGURE 3**  
ILLUSTRATIONS FOR STUDIES 1, 2, AND 3



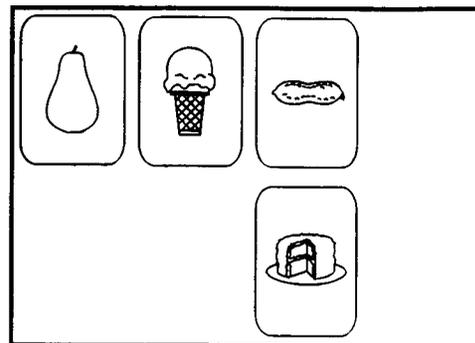
3a. Study 1: Eight Display Areas



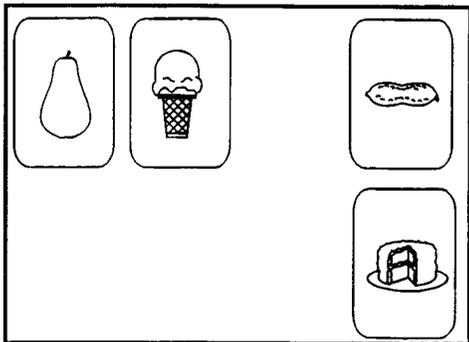
3b. Study 1: Sample Display



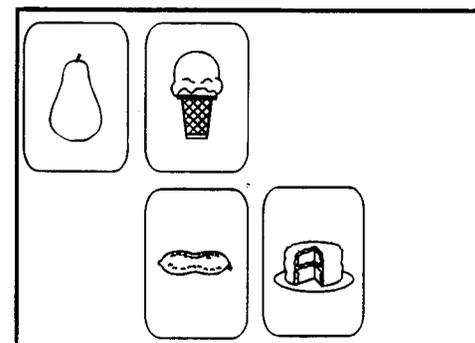
3c. Study 2: Visual Competition by Area



3d. Study 2: Sample Display



3e. Study 3: Low Visual Competition Display



3f. Study 3: High Visual Competition Display

During calibration, the distance and the angle between the infrared reflection and the center of the pupil can be measured while the subject looks at a grid of nine predefined areas. Thus, the distances between the subject's corneal reflection and pupil center can be directly related to X,Y locations in a scene. Corneal reflection eye-tracking procedures have an accuracy of 0.5 to 1.5 degrees (Young and Sheena 1975).

*Calculation of Viewing Times.* Each subject's raw

data were converted to fixations and then combined with information on the location of the colored rectangles.<sup>3</sup> Only the fixations from the first viewing of an area were analyzed, as these fixations were likely to be associated with exploratory search. In addition, because the viewing

<sup>3</sup>During recording, the eye-tracking system recorded the distance between the center of the pupil and the corneal reflection every sixtieth

time was forced to 4.4 seconds by the presentation software, using all fixations would have artificially increased the uniformity of the viewing times. To control for recording errors and finishing pauses (i.e., some subjects would simply stop and stare at an area while waiting for the display to change), viewing time data were truncated at two standard deviations.<sup>4</sup> This truncation resulted in the loss of 3.5 percent of the data and did not vary with the degree of visual competition created by the surrounding objects, hence it primarily served to reduce variance created by outliers.

### Test of the Exploratory Search Hypothesis

The exploratory search hypothesis (Hypothesis 2) predicted that people would spend less time viewing areas surrounded by items exerting a strong demand for attention. For each area, the competition for attention from nonfocal items was calculated by summing the demand of the surrounding items. Referring to Figure 2, area B would have a high level of competition for attention (2.70), whereas area A would have a low level of competition for attention (1.94). The amount of attention to an area was measured as the average viewing time of the 40 subjects that viewed the area. As predicted by Hypothesis 2, an increase in the competition for attention from the items surrounding a focal object resulted in less attention to the object ( $r(192) = -0.46, p < .01$ ).

### Test of the Goal-Directed Search Hypothesis

The goal-directed search hypothesis (Hypothesis 1) predicted that easy to navigate environments would be searched more quickly. In other words, if a goal-directed search routine is operating, attention should shift more quickly when it is easy to identify the next area for attention. The ease of identifying the next area for attention was calculated by creating a ratio of the demand from the nonfocal area exerting the strongest demand for attention to the demand of the nonfocal area exerting the second strongest demand for attention. Referring to Figure 2, area A would be an area where the planned shift in attention would be easy (ratio = 2.00) because it is surrounded by a single area, B, with a strong demand (1.00) with the next strongest area, C, having a weak demand (0.50). Shifting attention from area B would be more difficult (ratio = 1.00) because it is surrounded by two

areas with an equally strong demand for attention (area A demand = 1.00 and area C demand = 1.00).

Hypothesis 1 was not supported by the data. The prediction of a negative correlation between the ratio representing the expected ease of shifting attention and the amount of time spent looking at an area was not supported ( $r(192) = 0.18, p < .01$ ). In fact, wherein Hypothesis 1 predicted that an easier search would result in less viewing time, areas associated with an easier search were viewed for longer times. The implication is that viewers were not using a goal-directed search routine to view the displays.

### Discussion

The results of study 1 suggest the competition for attention exerted by nonfocal items can influence the amount of time a person initially spends looking at a focal item (Hypothesis 2). The greater the summed demand for attention exerted by the nonfocal items, the shorter the amount of time spent viewing the focal object. This evidence is consistent with the hypothesized behavior of an exploratory search routine.

## STUDY 2

Study 1 provided evidence that areas surrounded by objects generating less demand for attention were viewed for longer periods of time. This raises the question of what type of processing, if any, occurred during this additional viewing time. The exploratory search model predicts that the information processing system gathers additional information during this time. An alternative hypothesis is that increased viewing times signify less efficient processing. For example, it may be that when there is limited competition for attention from surrounding material, the visual system gathers information from the focal area in a more leisurely, less efficient manner. Study 2 tested these competing hypotheses using a cued-recall measure that should be sensitive to the amount of information gathered.

Sixteen display configurations similar to those used in study 1 were used as templates for study 2. Line drawings of easily named objects were placed into the areas formerly occupied by the colored rectangles. Instead of measuring the time spent looking at each display area, each subject's ability to recall the objects was measured.

### Method

**Stimuli.** A pretest was used to select stimuli. A sample of 20 subjects from a principles of marketing course subject pool was used to select 64 stimuli from a set of 220 common objects. Pretest subjects were asked to name each of 220 line drawings selected from the Arts and Letters ClipArt Library. Only objects that were given the same name by at least 90 percent of the subjects were eligible for use as stimuli. The stimuli selected were from

of a second, simultaneously converting this distance into an X,Y coordinate in the viewing area. These locations were reduced to a series of fixations using an algorithm that identified sequences of data points that represent less than 0.5 of a degree of movement within a 117 millisecond time period, less than 1 degree of movement in 234 milliseconds, or less than 1.5 degrees of movement in 351 milliseconds.

<sup>4</sup>The two-SD cutoff was approximately two seconds for each of the eight locations. This is approximately five times the commonly observed fixation length of about 300–400 milliseconds and is consistent with recommendations for truncating data (Searls 1966).

the following categories (number of items): animals (16), sports equipment (8), kitchen items (8), clothing (8), furniture (8), and food (16).

The stimuli were arranged four to a display using 16 unique layouts (see Fig. 3*d* for an example). Each of the 16 layouts had one area with a single adjacent display (see area 1 of Fig. 3*c*), two areas with two adjacent displays (see areas 3 and 7 of Fig. 3*c*), and one area with three adjacent displays (see area 2 in Fig. 3*c*). It was expected that areas with one adjacent display would be viewed while experiencing a low competition for attention, areas with two adjacent displays would be viewed while experiencing a moderate competition for attention, and areas with three adjacent displays would be viewed while experiencing a high competition for attention. Four counterbalanced versions of each page were created so that objects could be rotated through each of the four locations on the page (a between-subjects factor). All of the stimuli were printed in color.

The 16 single-page layouts were used to create a prototype of a children's sticker book (i.e., the experimental guise). The book had a title page, an introductory page, pages of scenes for pasting the stickers, and the 16 stimulus pages. The introductory page explained that the book would have a special feature called surprise stickers. A surprise sticker was a sticker under a sticker, the top sticker being blank. Kids simply had to peel off the top sticker to see the surprise sticker. The surprise sticker feature allowed the stimulus pages to have four of the eight locations on the page left blank, thus allowing for manipulations of competition for attention. The books were bound and looked professional.

*Experimental Guise and Procedure.* One hundred seventeen undergraduate subjects from a principles of marketing course subject pool participated in groups ranging from five to twelve members. Subjects entered the laboratory and read a scenario describing a book publisher's efforts to develop and market a line of sticker books targeted at the parents of two- to five-year-old children.

After paging through the book at their own pace, subjects completed a questionnaire that had been placed under their desks. The questionnaire began by asking subjects to comment on their impressions of the booklet, to hypothesize about how children might use the book, to suggest improvements, to list potential distribution outlets, and to provide demographic information. These questions took five minutes to complete and served as a filler task.

After completing the filler task, subjects were provided with a guise for the cued-recall task. Subjects were informed that the likelihood parents would buy additional books in the product line depended on the number of times parents observed their children playing with the book. Subjects were told that the major determinant of a child's repeated usage was his/her memory of the stickers. Subjects were asked to remember as many stickers as they could, their memory being an indicator of the

appeal of the book. Each product category was listed as was the first letter of the objects to be remembered.

## Results

*Manipulation Check.* There was no eye tracking of the subjects while they viewed the booklets, so data from study 1 were used to verify that low-competition areas were likely to receive more attention than moderate-competition areas, which were likely to receive more attention than high-competition areas. Twelve of the 16 displays used in study 2 were used in study 1. In study 1, the amount of attention paid to the areas having low, moderate, and high visual competition was 0.99 seconds, 0.94 seconds, and 0.88 seconds, respectively. The planned contrast test between the low-competition and moderate-competition areas was not significant ( $F(1, 38) = 1.87, p = .17, \omega^2 = 0.04$ ), whereas the test between the moderate-competition and high-competition areas was significant ( $F(1, 38) = 4.94, p < .05, \omega^2 = 0.10$ ).

*Analysis.* Recall that counterbalancing of the stimuli on each page resulted in four versions of the sticker booklets. A test for the interaction between booklet type and the planned contrast between low and moderate competition areas was insignificant ( $F(3, 113) = 2.06, p > .05$ ), as was the test for the interaction between book type and the planned contrast between moderate and high competition areas ( $F(3, 113) = 1.35, p > .05$ ). A test for a main effect of the book type was also insignificant ( $F(3, 113) = 0.83, p > .05$ ). A linear trend test assessing the influence of the number of nonfocal items competing for attention on memory was significant ( $F(1, 116) = 19.54, p < .05, \omega^2 = 0.10$ ). Planned contrast tests showed more memory for objects presented in the low-competition areas ( $\bar{X} = 5.35$  objects of 16 objects or 33 percent) than in the moderate-competition areas ( $\bar{X} = 9.73$  objects of 32 objects or 30 percent;  $F(1, 116) = 4.84, p < .05, \omega^2 = 0.03$ ), and more memory for objects presented in the moderate-competition areas ( $\bar{X} = 9.73$  objects of 32 objects or 30 percent) than the high-competition areas ( $\bar{X} = 4.37$  objects of 16 objects or 27 percent;  $F(1, 116) = 8.04, p < .05, \omega^2 = 0.05$ ).

## Discussion

The combined results of studies 1 and 2 suggest the competition for attention created by information surrounding an attended item can influence the amount of time a person spends looking at the item and the likelihood a person will recall information about the item. Study 1 showed that increasing the competition for attention exerted by surrounding information decreased the amount of time spent looking at a focal area. Study 2 showed that increasing the competition for attention from surrounding information decreased the memory for information in the focal area.

Although the first two studies provide evidence in support of an independent exploratory search routine, one

could argue the tests were biased in favor of demonstrating the existence of the exploratory search routine. Recall that exploratory search routines are moment-to-moment search routines, thus are best tested by measuring attention to individual items in a display. In contrast, goal-directed search routines are more global search plans, thus are best tested by measuring aggregate attention to all items in the display. The first two studies used measures of attention to single areas in a display, an orientation consistent with exploratory search. If an exploratory search routine could be shown to influence aggregate attention to all of the areas in a display, then confidence in its robustness would be enhanced.

### STUDY 3

Study 3 used a procedure identical to study 2 but with a modified set of stimuli. Two booklets were created. The first booklet consisted of displays that had all four of the items in visually noncompetitive environments (see Fig. 3e).<sup>5</sup> Each item in these displays had a single nonfocal object competing for attention. The second booklet consisted of displays that had all four of the items in visually competitive environments (see Fig. 3f).<sup>6</sup> Each item in these displays had two or three nonfocal objects competing for attention. The exploratory search model predicted memory for information from a display having four objects in visually noncompetitive environments (Fig. 3e) would be better than would memory for information from a display having four objects in visually competitive environments (Fig. 3f), whereas the goal-directed model search model predicted the opposite.

### Results and Discussion

Ninety-four subjects participated in a two-condition, between-subject design with a procedure identical to study 2. A test comparing the memory of the subjects that viewed the book with the noncompetitive displays ( $\bar{X} = 20.4$ ) to the memory of the subjects that viewed the book with the competitive displays ( $\bar{X} = 17.0$ ) was significant ( $F(1, 92) = 6.20, p < .05, \omega^2 = 0.05$ ). The results are consistent with the prediction of an exploratory search routine. A reduction in the competition for attention experienced when viewing each item in the visually noncompetitive booklet resulted in greater memory for its contents, supposedly because viewers spent more time viewing the information.

Across three studies, the objective has been to show that information-gathering activities incorporate exploratory search routines and that these routines are fundamentally

different from goal-directed search routines. One remaining criticism of the evidence provided thus far is as follows: although exploratory search routines may exist, their impact is likely to be minimal in most purchase situations. This criticism may be legitimate. It is difficult to provide evidence about the relative impact of a search routine using laboratory evidence. Thus, it would be informative to show that the construct most associated with an exploratory search model, the competition for attention created by nonfocal objects, can influence the amount of attention to an item and, subsequently, to sales of that item.

### STUDY 4

The objective of study 4 was to demonstrate that an exploratory search routine could have an impact on attention and sales above and beyond the impact of a goal-directed search routine. This investigation required both a shopping environment that was likely to encourage the use of both types of search routines and the identification of variables that were likely to impact attention and sales in the event a search routine was active. A catalog shopping environment was chosen as a context that would encourage the use of exploratory and goal-directed search routines. Product size was chosen as the variable most likely to influence attention and sales in a goal-directed search routine. Competition for attention was chosen as the variable most likely to influence attention and sales in an exploratory search routine.

The strategy for showing an independent influence of the exploratory search routine was as follows. First, the products on a set of catalog pages were scored for size (goal-directed search routine variable) and competition for attention (exploratory search routine variable). Then customers from the catalog retailer's target market were asked to view the catalog pages while their attention was monitored using eye-tracking machinery. Subsequently, the catalog retailer provided information on the sales of each item displayed. Thus, there was an opportunity to link the product display variables associated with each attentional search routine to sales behavior.

### Method

*Stimuli.* The stimuli were on 11 two-page women's apparel displays from the catalog of a major retailer. The 11 displays were selected from a larger set of 54 two-page displays because each display consisted of a set of areas in which a single product was presented, hence was quite similar to the displays investigated in studies 1–3. Displays that had areas consisting of multiple products on a single model (e.g., blouse and slacks) were avoided because some viewers were likely to see the products in the area as a single outfit, whereas other viewers were likely to see the products in the area as two individual products. This interpretation would influence the amount of attention to each product in the display, thus introducing error into the measurement of attention.

<sup>5</sup>Using the procedure discussed in Fig. 2, the average competition for attention for each of the four areas would be 1.71 (area 1 = 1.67, area 2 = 1.94, area 4 = 1.67, area 8 = 1.61).

<sup>6</sup>Using the procedure discussed in Fig. 2, the average competition for attention for each of the four areas would be 2.36 (area 1 = 2.14, area 2 = 2.58, area 6 = 2.58, area 7 = 2.14).

*Catalog Coding.* Two measures were computed for each of the 52 products in the 11 two-page spreads. The size of the area displaced by each product was expected to influence attention in a goal-directed search routine. The competition for attention (illustrated in Fig. 2) was expected to influence attention in an exploratory search routine.

*Subject Processing.* Fifty-four subjects were recruited from local women's organizations, schools, and the retail sales records of the sponsoring firm. Ninety-one percent of the subjects were familiar with the retailer and its past catalogs. Data were collected soon after the mailing of the catalog and none of the subjects expressed familiarity with the stimulus materials. Subjects were paid \$15 or had \$15 donated to a charity in their names.

After a short orientation, subjects were told that the experimenter was interested in exploring how women look at catalogs while at home and were asked to browse the pages and to gather attribute and pricing information when appropriate. The two-page catalog spreads had been mounted on 11 × 17 inch cards and placed in a three-ring binder mounted on a lighted display stand. Pages were flipped down at a pace determined by the subject.

*Data Collection and Preparation Procedure.* Data was collected in a manner similar to study 1. Each subject's data were converted into fixations and combined with a file containing the location of the products, faces, text, prices, and color options. After these files had been combined, statistics about how long a subject looked at each area were computed, then averaged across subjects for each product.

*Purchase Data.* Two measures related to purchase behavior were provided by the catalog retailer. First, the retailer provided estimates of expected unit sales. The estimates were inventory planning estimates made by experts within the retail organization. These sales estimates were the retailer's best guess of the appeal of the merchandise without factoring in knowledge of how the merchandise display or a changing retail environment might influence sales. The retailer also provided data on actual unit sales. The ratio of actual unit sales to estimated unit sales was used as an indicator of sales. Note that raw sales data would have incorporated the biases associated with using different categories of merchandise (e.g., blouses, dresses, coats).

## Analysis

The relationship between the size and the competition for attention display variables, the amount of attention to an area, and the sales of the product in the area was investigated using a test of mediation. Baron and Kenny (1986) recommend that a series of three regression equations be estimated: (1) the influence of the independent variables (product size and competition for attention) on the mediating variable (attention), (2) the influence of the independent variables (product size and competition for attention) on the dependent variable (sales), and (3)

the influence of the independent variables (size and competition for attention) and the mediating variable (attention) on the dependent variable (sales). To establish mediation, size, and competition for attention should predict attention (Eq. 1), size and the competition for attention should predict sales (Eq. 2), and attention should predict sales when size and competition for attention are also potential predictors (Eq. 3).

The goal was to test if an exploratory search routine could account for differences in attention and sales beyond that of the goal-directed search routine. In other words, the goal of the analysis was to test whether competition for attention predicted differences in attention and sales above and beyond the influence of the size of the product. For this reason multiple equations were estimated at each stage of the mediation analysis. Two equations were estimated to determine the influence of the size of the product and the competition for attention on attention. Equation 1A in Table 1 shows the results of regressing attention on the size of the product. The model is significant ( $F(1, 50) = 11.04, p < .01$ ). Equation 1B in Table 1 shows the influence of regressing attention on the size of the product and competition for attention. This model is also significant ( $F(2, 49) = 9.00, p < .01$ ). Significantly more variance was explained by adding the competition for attention variable to the equation ( $F(1, 49) = 5.86, p < .05$ ), hence Baron and Kenny's first criterion is met. As the competition for attention from the nonfocal products increased, attention to the focal product declined.

Two equations were estimated to determine whether competition for attention had an influence on sales above and beyond the influence of size. Equation 2A in Table 1 shows the results of regressing sales on the size of the product. The model approaches significance ( $F(1, 50) = 3.11, p < .10$ ). Equation 2B in Table 1 shows the influence of regressing sales on the size of the product and competition for attention. This model is significant ( $F(2, 49) = 3.98, p < .05$ ). Significantly more variance was explained by adding the competition for attention variable to the equation ( $F(1, 49) = 4.61, p < .05$ ), hence Baron and Kenny's second criterion is met. As the competition for attention from the nonfocal product increased, sales of the focal product declined.

The third part of the mediation test assessed the influence of the mediating variable (attention) on sales when size and competition for attention were in the regression equation. As shown in Table 1, the coefficient for attention was not significant when size and competition for attention were in the regression equation ( $\beta = .124, t(48) = .80$ ). An additional test regressed only competition for attention and attention on sales and estimated the indirect effect of competition for attention on sales via attention ( $t(49) = 1.60$ ; Sobel 1982).<sup>7</sup>

<sup>7</sup>The correlation ( $a$ ) between competition for attention and attention was .378 ( $SE = s_a = .131$ ). The correlation ( $b$ ) between attention and sales was .278 ( $s_a = .136$ ). Sobel's (1982) indirect test (as reported in

**TABLE 1**  
THE INFLUENCE OF NONFOCAL MATERIAL ON ATTENTION AND SALES

Equations	$\beta$	<i>t</i> -test	<i>p</i>	SS	MSE	<i>F</i>
1. Independent variable on mediator:						
A. Size on attention	.425	3.32	.002	.364	.032	11.04
B. Size and competition on attention	.362	2.90	.006			
Equation 1B – 1A	–.303	–2.42	.020	.540	.030	9.00
				.176	.030	5.86
2. Independent variable on dependent variable:						
A. Size on sales	.242	1.76	.084	1.568	.504	3.11
B. Size and competition on sales	.181	1.34	.187			
Equation 2B – 2A	–.291	–2.15	.037	3.736	.470	3.98
				2.168	.470	4.61
3. Independent variable and mediator on dependent variable:						
A. Size and competition and attention on sales	.136	.93	.359			
	–.253	–1.76	.084			
	.124	.80	.427	4.039	.473	2.85

NOTE.—SS = sum of squares; MSE = mean square error.

## Discussion

The conclusion of study 4 is that the competition for attention created by material surrounding a focal product explained variance in attention and sales in addition to the variance that was explained by the size of the product. Unfortunately, attention was not a significant mediator of the influence of the size of the product or the competition for attention on sales. Still, the implication is that the exploratory search model and the goal-directed search model are both operating during the viewing of the material and that a failure to consider the impact of the exploratory search model on viewing behavior could reduce the effectiveness of a display. Increases in the demand for attention created by nonfocal material can reduce attention to a focal item, and this consequence may have an adverse impact on sales.

## GENERAL DISCUSSION

Although there has been a considerable amount of research on goal-directed search processes, little attention has been paid to exploratory search routines. Exploratory search routines are interesting because they help explain some of the variability in the amount of attention people devote to a particular piece of information in a display. Whereas a goal-directed search model predicts that the amount of time spent viewing a piece of information is a function of its salience and/or relevance given a search goal, an exploratory search model predicts that attention is a function of the competition for attention created by nonfocal information. In study 1, a layout manipulation was used to vary the competition for attention experienced when viewing any one area in a display. Areas placed

in more visually competitive environments received less attention. In study 2, increasing the competition for attention generated by information surrounding an area was shown to decrease the likelihood that viewers would remember the information in an exploratory search task. Study 3 demonstrated that the relationship between the visual competition created by nonfocal information and memory for attended information persists even when all areas in a given display are visually competitive or noncompetitive. Study 4 provided evidence that an exploratory search model can explain differences in attention and sales of products on a catalog page in addition to that explained by a goal-directed search model.

The increased effectiveness of the noncompetitive displays relative to the competitive displays has one significant practical implication. There are optimal ways to display multi-item information. For example, suppose a cataloger wants to encourage viewers to maximize their attention to items in a display, thus increasing the likelihood they will to switch from an exploratory search routine to a goal-directed search mode. Currently, the most popular method of increasing attention to an item in a multi-product display is to increase the salience of the item by increasing its relative size or removing other items from the page. Each of these strategies benefits the featured product at the expense of the remaining items in the display. This method is suboptimal, especially if the goal is to maximize attention to all items in the display.

The studies presented in this article provide a framework for maximizing attention to all items in a display, without the complications associated with featuring selected items or removing items from the display. As shown in study 3, one booklet of four-item displays (i.e., the low-competition booklet) was 20 percent more effective at communicating information than a second booklet of four-item displays (i.e., the high-competition booklet). Noncompetitive displays were not created by removing

Baron and Kenny) is  $t = ab / (b^2 s_a^2 + a^2 s_b^2 + s_a^2 s_b^2)^{1/2}$  or  $(.378 \cdot .278) / (.278 \cdot .131 + .378 \cdot .136 + .131 \cdot .136)^{1/2} = 1.60$ .

items from a multi-item display but by rearranging these items. Assuming that retailers are not yet optimal in their arrangement of information in a display, the procedures discussed above provide a method for a cataloger to increase attention to each item in a display or to increase the number of items in a display while maintaining sufficient levels of attention to each item in the display. Given the high cost associated with producing and distributing each page of a catalog, the ability to display merchandise on a smaller number of pages would provide a significant economic benefit.

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