The Interactive Effects of Colors on Visual Attention and Working Memory: In Case of Images of Tourist Attractions

THE INTERACTIVE EFFECTS OF COLORS ON VISUAL ATTENTION AND WORKING MEMORY: IN CASE OF IMAGES OF TOURIST ATTRACTIONS

Dae-Young Kim
University of Missouri
Columbia, MO, USA

ABSTRACT

The paper explores the role that color can influence people's visual attention and working memory through a computer-based experiment. With the assumption that there are trade-offs between attention/ memory, and loading tasks which create distractions (e.g., tasking/working people cannot afford to pay attention to other objects, and no tasking people would more pay attention to the objects), the study examines the effects of colors on people's visual attention and the relevance of attention to retention of working memory by performing a dual-task experiment called the box shooting test. The results show that the color effect shows significant differences on working memory indicating that color would more significantly play a role for forming people's memory rather than holding attention. The possible implications are also discussed.

Keywords: Attention, memory, color effect, box shooting

INTRODUCTION

People are exposed to a tremendous amount of commercial or non-commercial information every day. The average person would be exposed to over 1,500 advertising a day, aware of less than 70 of them, and remember only 5 to 10 ads (Kotler, Bowen, & Makens, 2010). This screening-out process can be explained by the concept of selective attention which reduces the load on limited-capacity cognitive systems by filtering irrelevant information from the stimulus stream (Downing, 2000). The consumer's selective attention implies how hard it is for marketers to successfully hold consumers' initial attentions through advertising materials. In the marketing and consumer behavior field, many studies suggest the importance of attentions as predictors of consumers' attitude toward an object or advertisement (e.g., MacKenzie & Lutz, 1989). However, it has been noted that an important limitation of existing research in marketing, consumer behavior and social psychology is that there are relatively less efforts to empirically examine the role of attention in persuasion (Eagly & Chaiken, 1993).

Psychologists focused on cognitive research have been interested in how what is currently on our minds affects what we currently look at (e.g., Desimone & Duncan, 1995; Sreenivasan, Katz, & Jah, 2007). Recent research on the interactions between visual working memory and visual attention fits in the research question (Oh & Kim, 2004; Soto & Humphreys, 2006). The underlying assumption is that visual attention and visual working memory share important processes as well as content representations. Working memory is defined as the active maintenance of a representation after the stimulus that produced it is no longer present (Downing, 2000). It is generally assumed that working memory and attention appear very similar, in that both dimensions postulate the activation and prioritization of information relevant to the task at hand over information that is currently irrelevant (Olivers, 2009).

Understanding color effects on people's attention and working memory has been an important research area in cognitive psychology. Despite inconclusive arguments across time and settings (Madden, Hewett, & Roth, 2000), there are few general consensus in regard to color effects. First, full color generally holds more attention than black and white (Schaie & Heiss, 1964), and second warm colors (e.g., red) generate more arousal and attention than cool colors (e.g., blue) (Birren, 1978). In addition, it is reported that cool colors elicit greater relaxation and pleasure than warm colors (Jabocs & Seuss, 1975). Additional color and advertising studies suggest that background color effects

are qualified by the contrast between the background color and the color of the text or content (Fernandez & Rosen, 2000; Hall & Hanna, 2004; Moore, Stammerjohan, & Coulter, 2005). In contradiction, Popper and Murray (1989) examined the effectiveness of high versus low contrasting background color on the message, but found no significant differences between the contrast conditions.

Many researchers have examined the basic link between attention and working memory considering color effect. However, there has been little research endeavor on the issue of attention and memory in the hospitality and tourism industry. It is logically presumed that the constructs would be more important in the field, in that most products and services in the hospitality and tourism are symbolic and image-oriented which requires more attention and memory. Thus, the purpose of this study is to explore color effect on people's visual attention and working memory by employing the images of tourist attractions as stimuli. To achieve the goal, the computerized experiment manipulated memory load in a primary task and measured its attentional cost on a secondary task across sequential positions. More specifically, this study examines how different colors affect people's attentions and memory by requiring participants to do a dual task (i.e., box shooting and seeing different types of photos).

The Effects of Color on Attention and Memory

With the realization of the importance of attention in decision-making process in consumer behavior, advertisers and marketers devote considerable time and effort to designing attention-getting appeals. Many scholars examining consumer behavior from an information-processing perspective argue that the attention step in message processing controls a substantial portion of the variability in consumer decisions (e.g., Bettman, 1979). Attention has been explored extensively by cognitive psychologist, and if broadly defined to include people's perceptual areas such as selective attention, distortion, and retention, it is clear that there is a great deal of relevant social psychological research on these topics (Fiske & Taylor, 1991).

Due to several decades of intense research on understanding attention, there is now broad agreement that attention may play a special role in integrating elementary visual features (Treisman, 1991; Treisman & Gelade, 1980). In regard to attention studies in marketing and persuasion, research on color effect examines a certain degree of interest in how attentional processes affect persuasion. It has been noted that vivid information and color presumably attract and hold people's attention because it is concrete, imagery-provoking, or proximal in a sensory, temporal, or spatial way (Nisbett & Ross, 1980). Despite some contradictory arguments that vividness effects are primarily illusory (e.g., Collins, Taylor, Wood, & Thompson, 1988), vividness logic has been applied with some success to issues such as the persuasive impact of pictorial information (Kisielius & Sternthal, 1984), and eyewitness testimony (Bell & Loftus, 1989).

In regard with the effects of color on memory, it has been reported that color has been found to increase a person's arousal (Birren, 1978), and the arousal increases memory (Roozendaal, 2002). Wolters and Goudsmit (2005) studied the effects of arousing events on memory revealing that subjects show a high level of recall for details of messages when seeing vivid colored stimuli. According to Spence at al. (2006), if color can increase arousal, and arousal can increase memory, then it is possible to assume that we could find that color can increase memory. More specifically they found that color increased the recognition of the natural scenes by approximately 5%.

METHODS

It is hypothesized in the study that there are trade-offs between attention/ memory and processing tasks (e.g., work loading). In other words, working (busy) people can hardly pay attention to other objects that are irrelevant to their tasks, and less busy people can more afford to pay attention to other objects. By manipulating the conditions that create the trade-offs, the study examine what type of color more efficiently catch people's attention and effectively influences working memory. To test the hypothesis, the study requires subjects to do a dual task; see

a series of photos that randomly show up in computer monitor while playing a box shooting game. In terms of research stimuli, the study employed typical vividness manipulations in order to examine the effects of three types of color images on individuals' attention and memory. It is assumed that a certain type of color (e.g., black & white vs. partial color vs. full color) makes images more vivid and furthermore the colors would differently influence people's attention and memory.

The fundamental logic derived from the trade-offs between attention/ memory and processing tasks is that if subjects more pay attention to a photo, they are more likely to make an error on box shooting. On the other hand, if they less pay attention to a photo, they would more accurately play the box shooting game. After all, what is measured in the study is the number of errors in box shooting for three types of colors. For example, more errors in black and white photos than full color photos can be understood that participants more pay attention to black and white photos, and as a result, make more errors.

Subjects: A total of 36 undergraduates (18 females and 18 males; 33 right-handers and 3 left-handers) participated in the experiment in exchange for course credit. They were native speakers of English with normal hearing and vision.

Selection of landmark images: This study consists of two tasks, which used 75 image stimuli, including 25 black & white images, 25 partial color images, and 25 full color images for landmarks of tourism destinations in the same pictures. Initially, a total of 35 images for each color type of destination landmarks were selected through internet search. In regard to the selection of the landmark images, three conditions were considered to control respondents' biased feelings and pre-disposed perceptions, including (1) the images should be related to tourism attractions, (2) the presentations of the photo images are equivalent (e.g., all photos are not too complicated or not to simple to see), and (3) the level of awareness of the landmark images is similar among participants. A total of twenty five images were selected by graduate students and researchers who specialize in tourism and hospitality.

Process of the experiment: Participants went through a two-stage computerized test, individually in an image-attenuated booth. The two stages were 1) a speeded distraction task under full attention, and 2) a dual task combining image list recall and the speeded distraction task.

Speeded distraction task stage: This stage included 33 trials of a speeded distraction task. At the beginning of a trial, the participant saw a fixation sign of font size 30 at the center of the screen. Around the center popped up three boxes (15mm X 12mm) with their sides parallel to the edges of the screen. One of them was centered 60 mm above the fixation sign, and the other boxes were also centered 60 mm above the fixation sign, and the other boxes were also centered at the distance of 75 mm from the fixation sign on its both sides. A box was randomly selected out of the three as the target and was shown in red, whereas the other two were in white. The task was to shoot the target box by pressing the arrow key that mirrored the location of the target box (upper, left, or right arrow). If a key press response was absent or executed too late, a red rectangle frame around the fixation sign flashed; and if a wrong key was pressed, no change occurred to the display. This instruction in the monitor is as follows:
"You are to play a game called "Box Shooting." You will see a red box at one of three possible locations around a fixation sign. Your task is to press a corresponding arrow key to shoot it before it disappears. If your shooting is accurate and fast, the red box will be framed in blue.
However, if your reaction is not fast enough, a big red rectangle will pop up at the center of the screen instead. Press DOWN ARROW key to start when ready."

The display duration for the boxes was initially set as 500 millisecond (msec), but underwent continuous adjustment. It would be reduced by 10 msec every time the participant made 3 successful responses in a row; otherwise increased by 10 msec. Participants were instructed to rest their middle three fingers of their right hand on the three arrow response keys in a comfortable manner and to initiate the task by pressing the down arrow key with the middle finger when they were ready. Ninety-three trials were then automatically delivered in a row with no break.

At the end of this stage, the average of the shortest and the last display durations determined the single display duration to be used for each participant in the dual task in stage 2.

Dual-task stage: This stage included 30 trials that integrated the list memory task with the speeded distraction task episodes carried out during the list maintenance intervals, These 30 trials included a block of 75-image lists for each color type (i.e., black & white, partial color, and full color) and a block of 4-image recall lists, each with 10 trials, randomly mixed (see Figure 1). Participants should recall the 4 image list randomly selected from the 12 or 15 images shown in the speeded distraction test at the outset of each trial (see Figure 2). In this stage, both the correct number of image list recall and the speeded distraction were automatically counted.

More specifically, participants were instructed to do their best on both the memory and the speeded distraction tasks. Participants had their fingers in a ready position for the speeded distraction task before they pressed the down arrow key to start the dual task. Each trial started with a 500-msec display of a image and a 300-msec pause, which should be sufficient for stimulus encoding in the visual (Turvey, 1973) modalities, and then three speeded distraction trials with no break for a period expected to be about 1200 msec according to pilot data.

Figure 1
Illustration of the Speed Distraction Test

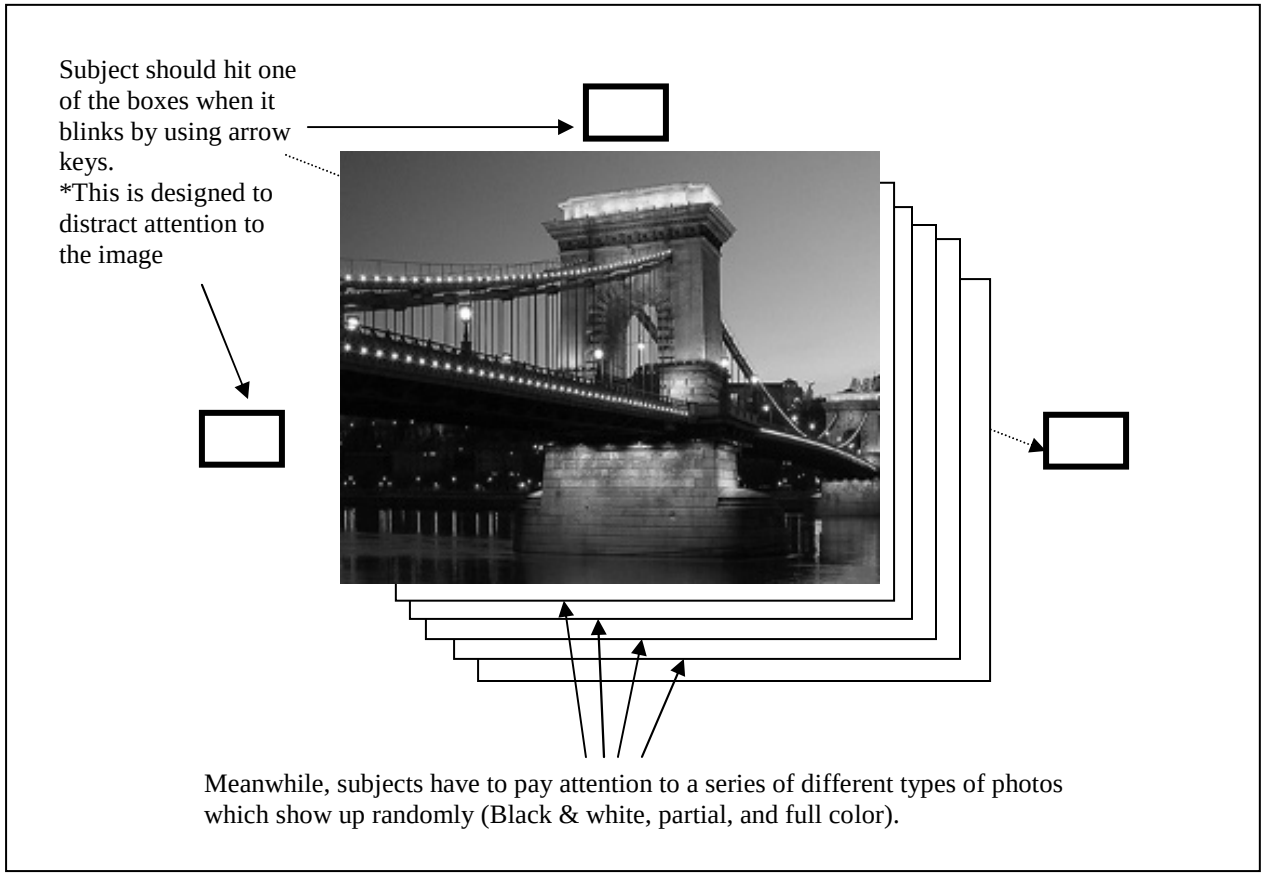
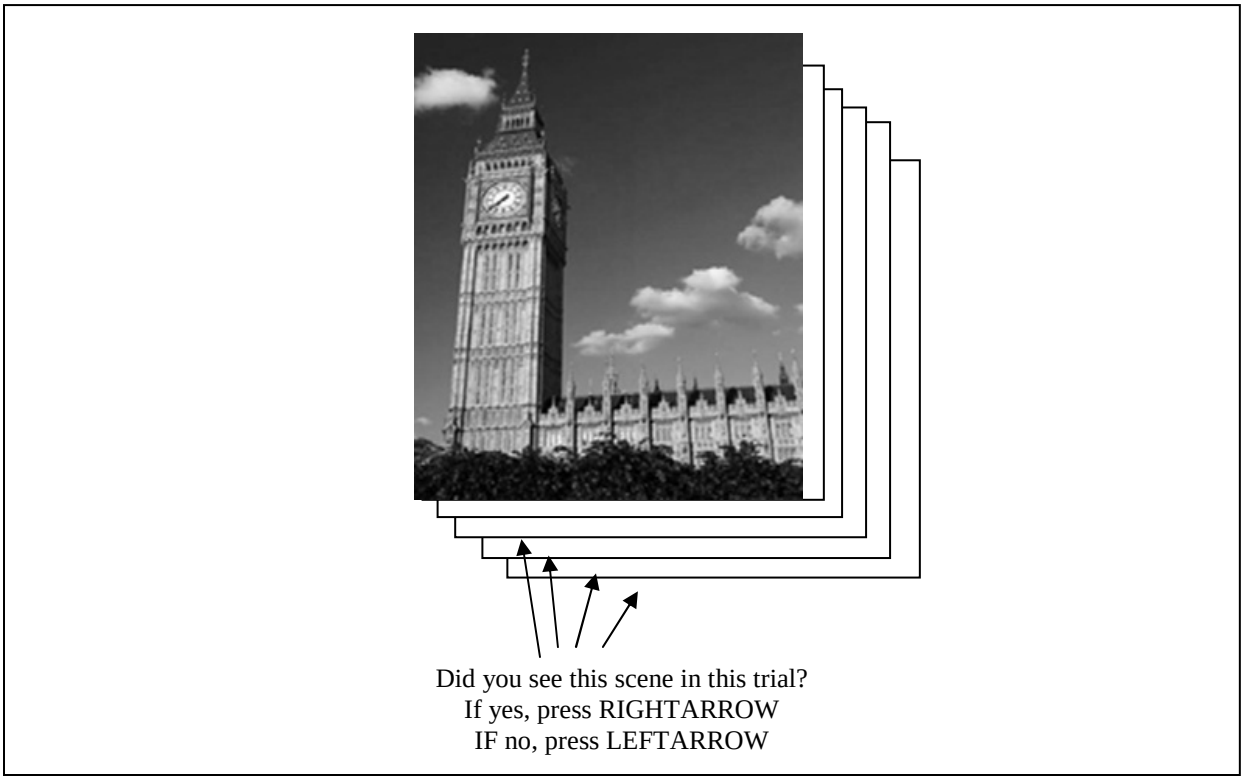


Figure 2
Illustration of the Working Memory Test

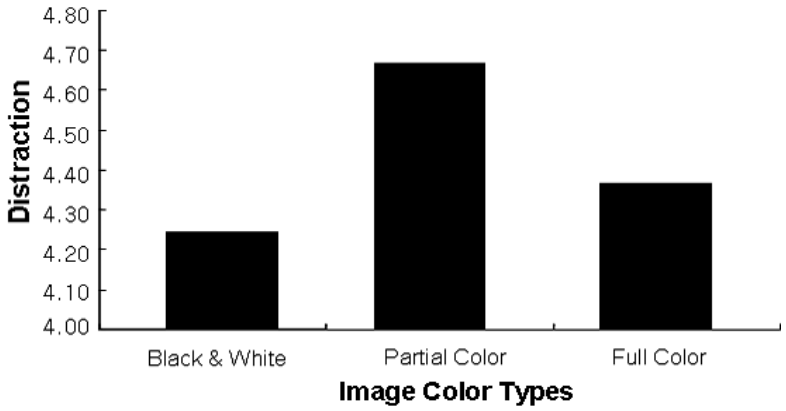


RESULTS

A primary interest of this study was to examine the color effects toward images of destination landmarks.

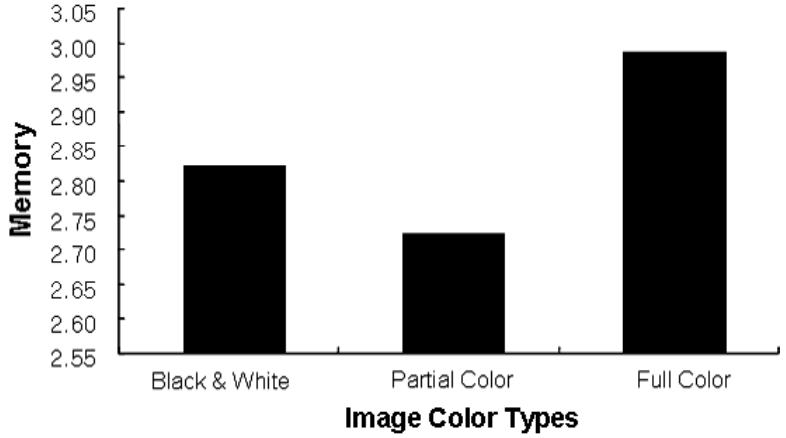
Differences between Distraction and Image Color Types: Distraction (i.e., the number of errors in the box shooting game) was measured using the number of correct distraction shooting. ANOVA test was conducted to examine the differences between distraction and image color types (i.e., black & white, partial color, and full color). The results indicate that there are not statistically significant mean differences between the number of distractions and image color types $F(2, 107)=0.758$, $p=.471$ (See Figure 3).

Figure 3
Differences of Distractions between and Image Color Types



Differences between Memory and Image Color Types: ANOVA test was conducted to identify the interaction between memory and the three different image color types (i.e., black & white, partial color, and full color), there are statistically significant difference of memory between the different types of images, F(2, 107)=3,841, p=.025 (see Figure 4), indicating that memory varies depending on the different color types in same images.

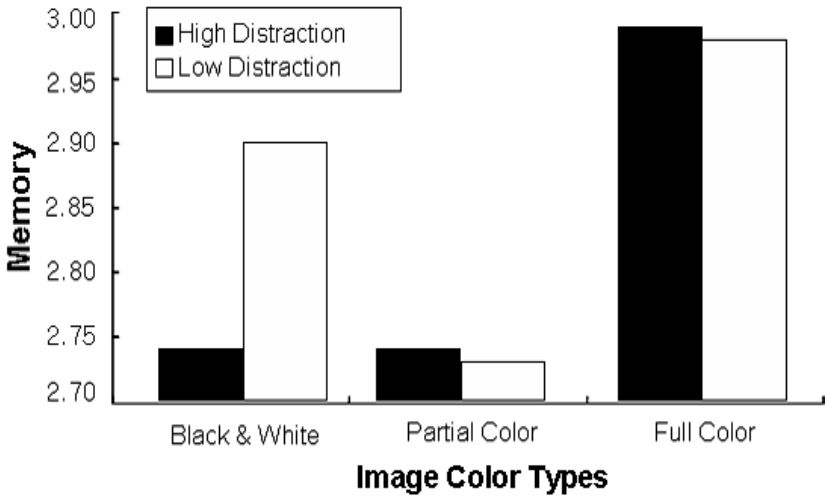
Figure 4
Memory Differences between Image Color Types



Interaction between image color types and distraction on memory: 3 x 2 ANOVA test was conducted to examine the interaction between image color types (i.e., black & white, partial color, and full color) and distraction (high vs. low) on memory. The result shows that there is not a statistically significant interaction between image color types (i.e., black & white, partial color, and full color) and distraction on memory, F(1, 108)=1.762, p=.127

(See Figure 5), indicating that although the color types cause the formation of positive memory in a certain situation, memory would not vary depending on the distractions in different color types.

Figure 5
Interaction between image color types and distraction on memory



CONCLUSIONS AND DISCUSSIONS

Marketers and advertisers face real struggles getting consumers to pay attention to their advertisements and messages. As marketers and advertisers consider various advertising alternatives, it is essential to understand more about the role of color in advertisements. Based upon salient color theory and research (e.g., Birren, 1978), it was anticipated that the different types of colors would impact consumers' visual attention to the contents and their working memory. In contrast to the expectations, but consistent with the results by Gorn et al. (1997), the color type has a limited role as a visual cue in this study. The results of the study reveal color effects on working memory indicating that full color images more significantly remains in people's working memory than the other two color types. The color effects, however, has not found in visual attention. The results from the experiment provide information regarding the use of colors, and attracting consumers' attention and generating working memory.

The research is anticipated to make a contribution to our understanding of effects of color in the hospitality and tourism research field. In all, this study provides some insights to hospitality and tourism research by providing theoretical and methodological contributions. First, this study shed light on the role of color in attracting attention and generating memory within the context of the hospitality and tourism Second, this research is anticipated to contribute to the realm of hospitality and tourism study by proposing an alternative approach to measure consumers' attention and memory through a computerized experimental design. As seen, survey methods predominate in the hospitality and tourism research area, and as a result, there is a paucity of experimental research endeavor that examine consumers' cognitive psychology. Third, the findings draw attention to the need to understand human-computer interactions and how aspects on digitalized color influence attention and memory since this study employ the personal computer for presenting the contents. Future studies might examine the effects of other characteristics, such as the font size, the modality of presentations, use of animation and video clip, and the rate of presentation on consumers' attention to the message (Moore at al., 2005). Obviously, there are many challenges and research questions that we have not explored yet particularly in the hospitality and tourism field.

REFERENCES

Bell, B. E., & Loftus, E. F. (1989). Trivial persuasion in the courtroom: The power of minor details. *Journal of Personality and Social Psychology*, 56, 669-679.

Bettman, J. R. (1979). *An information processing theory of consumer choice*. Reading, MA: Addison-Wesley.

Chaudhuri, A. (1990). Modulation of the motion after-effect by selective attention. *Nature, 344*, 60-62.

Collins, R. L., Taylor, S. E., Wood, J. V., & Thompson, S. C. (1988). The vividness effect: Elusive or illusory? *Journal of Experimental Social Psychology*, 24, 1-18.

Desimone, R., & Duncan, J. (1995). Neural mechanisms of selective visual attention. *Annual Review of Neuroscience, 18*, 193–222.

Downing, P. E. (2000). Interactions between visual working memory and selective attention. *Psychological Science*, 11(6), 467-473.

Eagly, A. H., & Chaiken, S. (1993). *The psychology of attitudes*. Belmont, CA: Thompson Learning.

Fernandez, K. V., & Rosen, D. L. (2000). The effectiveness of information and color in yellow pages advertising. *Journal of Advertising*, 29(2), 59-72.

Fiske, S. T., & Taylor, S. E. (1991). *Social cognition* (2nd ed.). New York: McGraw-Hill.

Gorn, G. J., Chattopadhyay, A., Yi, T., & Dahl, D. (1997). Effects of color as executional cue in advertising: They're in the shade. *Management Science*, 43(10), 1387-1400.

Hall, R. H., & Hanna, R. (2004). The impact of web page text-background color combinations on readability, retention aesthetics and behavioral intention. *Behaviour and Information Technology*, 23, 183-195.

Jacobs, K. W., & Seuss, J. F. (1975). Effects of four psychological primary colors on anxiety state. *Perceptual and Motor Skills*, 41(1), 207-210.

Kisielius, J., & Sternthal, B. (1984). Detecting and explaining vividness effects in attitudinal judgments. *Journal of Marketing Research*, 21, 54-64.

Kotler, P., Bowen, J. T., & Makens, J. C. (2010). Marketing for Hospitality and Tourism (5th ed.). Upper Saddle River, NJ: Prentice Hall.

Luck, S. J., & Vogel, E. K. (1997). The capacity of visual working memory for features and conjunctions. *Nature*, 390, 279-281.

MacKenzie, S. B., & Lutz, R. J. (1989). An empirical examination of the structural antecedents of attitude toward the ad in an advertising pre-testing context. *Journal of Marketing*, 53(21), 48-65.

Madden, T. J., Hewett, K., & Roth, M. S. (2000). Managing images in different cultures. *Journal of International Marketing*, 8(4), 90-107.

Nisbett, R. E., & Ross, L. (1980). *Human inference: Strategies and shortcomings of social judgment*. Englewood Cliffs, NJ: Prentice-Hall.

Oh, S.-H., & Kim, M.-S. (2004). The role of spatial working memory in visual search efficiency. *Psychonomic Bulletin & Review, 11*, 275–281.

Olivers, C. (2009). What drives memory-driven attentional capture? The effects of memory type, display type, and search type. *Journal of Experimental Psychology: Human Perception and Performance*, 35(5), 1275-1291.

Popper, E. T., & Murray, K. B. (1989). Communication effectiveness and formt effects on in-ad disclosure of health warnings. *Journal of Public Policy and Marketing*, 8(1), 109-123.

Prinzmetal, W., Presti, D., & Posner, M. I. (1986). Does attention affect feature integration? *Journal of Experimental Psychology: Human Perception and Performance, 12*, 361-369.

Roozendaal, B. (2002). Stress and memory: opposing effects of glucocorticoids on memory consolidation and memory retrieval. *Neurobiology of Learning and Memory, 78*, 578-596.

Schaie, K. W., & Heiss, R. (1964). Color and contrast in magazine advertising. *Psychology and Marketing*, 3(2), 69-78.

Spence, I., Wong, P., Rusan, M., & Rastegar, N. (2006). How color enhances visual memory for natural scenes. *Psychological Science*, 17, 1-16.

Sperling, G. (1960). The information available in brief visual presentations. *Psychology Monographs: General and Applied*, 74(11), 1-29.

Soto, D., Humphreys, G. W., & Heinke, D. (2006a). Dividing the mind: The necessary role of the frontal lobes in separating memory from search. *Neuropsychologia, 44,* 1282–1289.
Sreenivasan, K. K., Katz, J., & Jha, A. P. (2007). Temporal characteristics of top-down modulations during working memory maintenance: An ERP study of the N170 component. *Journal of Cognitive Neuroscience, 19,* 1836–1844.
Treisman, A. (1991). Search, similarity, and integration of features between and within dimensions. *Journal of Experimental Psychology: Human Perception and Performance, 17,* 652-676.
Treisman, A. (1991). Search, similarity, and integration of features between and within dimensions. *Journal of Experimental Psychology: Human Perception and Performance,17,* 652-676.
Treisman, A., & Gelade, G. (1980). A feature-integration theory of attention. *Cognitive Psychology, 12,* 97-136.
Turvey, M. T. (1973). On peripheral and central processes in vision: inferences from an information processing analysis of masking with patterned stimuli. *Psychological Review,* 80, 1-52.
Wolters, G., & Goudsmit, J. J. (2005) Flashbulb and event memory of September 11, 2001: Consistency, confidence and age effects. *Psychological Reports,* 96, 605-619.