Unique Object Characteristics Differentially Affect Visual Attention During Viewing of Dynamic Stimuli: The Influence of Location and Luminosity

Brooke E. Wooley[1(✉)] and David S. March[2]

[1] MediaScience, Chicago, IL, USA
b.wooley@mediasciencelabs.com
[2] University of Tennessee, Knoxville, TN, USA
dmarch@vols.utk.edu

Abstract. Understanding which characteristics of dynamic stimuli affect visual attention is crucial to usability research. We explored how *object location* and *object luminosity* differentially affect visual attention. Thirty-seven American participants viewed 34 Australian commercials, which were broken down by scene ($N = 606$) to identify all pertinent Areas of Interest ($N_{AOIs} = 2{,}695$). Each AOI was subsequently coded for location and median luminosity. Luminosity was positively associated with attention capture ($\beta = .12$, $p < .001$), but negatively associated with sustaining attention ($\beta = -.06$, $p < .000$). Higher ($\beta = .04$, $p < .000$) or lower contrast with the immediate background ($\beta = .03$, $p < .000$) led to longer fixations, and central location drew visual attention ($\beta = .49$, $p < .001$) and sustained it ($\beta = .19$, $p < .001$) more than other locations. Our results show that object location and luminosity affect visual attention during dynamic stimuli, and likely influence subsequent cognitive or behavioral interaction with those objects.

Keywords: Design for all best practice · Evaluation of accessibility, usability and user experience · Visual attention · Eye tracking

1 Introduction

Eye-movement research has informed a number of technological and practical applications and has helped guide visual design improvements, which serve to enhance the usability of certain platforms and influence the behavior of the user. Due to advancements in eye-tracking technology, gaze tracking has become a very useful tool in the study of human computer interaction [1], human factors research [2], media and marketing research [3, 4], human development research [5, 24], and reading behavior [6]. For example, recent research has shown that the number and duration of fixations can explain 45 % of variance in the actual in-market sales performance of television commercials [7], and that fixations become more dispersed prior to viewers pressing the skip button to avoid online video commercials [8].

Like other automatic processes (e.g., heartbeat), it is very difficult to consciously suppress eye-movements [5, 9, 10]. Thus, the ability to track these movements can yield meaningful insights into unconscious cognitive activity and behavioral motivations.

M. Antona and C. Stephanidis (Eds.): UAHCI 2016, Part I, LNCS 9737, pp. 481–492, 2016.
DOI: 10.1007/978-3-319-40250-5_46

Because eye movements have a systematic means of expression, those movements can be measured consistently and reliably [11, 12] making eye tracking a very useful tool to usability researchers.

However, much of this research has been limited to the study of static images and static situations [13], in large part due to the difficulty in analyzing eye movement data in dynamic stimuli. The main difficulty preventing the expansion of eye-tracking research from the static to the dynamic domain has been that Areas of Interest (AOIs) in dynamic stimuli move around the frame 24 or 25 frames a second. Researchers have used laborious hand coding methods to identify when a viewer's gaze point enters and leaves a dynamically moving AOI. But now, eye-tracking software offers intelligent bounding boxes for AOIs that move with a scene, and if necessary, grow or shrink in size.

Given that many situations people come into contact with are dynamic in nature, it is necessary that usability researchers understand how people visually process dynamic stimuli. Thus, this study further explores which elements of dynamic images garner visual attention. Specifically, we identify how the location, luminosity, and contrast of an object with its background affect the visual attention it received and discuss how that visual behavior can inform dynamic stimuli design.

1.1 Influence of Object Location and Object Luminosity

Basic characteristics of static stimuli such as size, color, and luminosity can affect visual attention, as well as viewer goals and motivations [14].

Previous research on website usability has shown that viewers tend to allocate eye movements to the top and upper right corners of websites to facilitate in navigation and directed tasks (i.e., web search tasks) [15]. Eye movements during newspaper and magazine viewing also exhibit learned visual patterns in that readers tend to fixate on headlines and pictures first and then flow to the body text [16]. However, a central bias has been documented in natural static scene viewing, suggesting that the most important areas of visual media content should be centered in the frame [17]. Tatler [17] found that regardless of the features contained within images (e.g., chairs, buildings), viewers tend to fixate the center of the image more often than other areas, even during search tasks.

Brasel and Gips found similar patterns using dynamic stimuli, showing that viewers have a general tendency to fixate on the center of the screen during television programming [18]. It has been proposed that central bias during dynamic stimuli viewing may reflect viewers attending to multiple moving objects at once [19]. Thus, viewers would tend to fixate the center of the screen more often and for longer in order to allow the tracking of multiple moving objects within the visual field.

Similar to object location, object luminosity represents a highly salient visual characteristic to which the human eye is drawn. Eye-tracking studies have taken advantage of the fact that our eyes are well adept at identifying areas of contrast to explore the influence of luminosity on attention to visual objects [11]. Within the realm of media, researchers have shown that visual characteristics such as the brightness of products or text influence visual attention [3]. Advertisements from the yellow pages that exhibit bright colors or that contrast more with advertisements around them garner more visual attention [3]. Thus, it may not be simply that luminosity drives attention, but that contrast (i.e., luminosity of object minus background luminosity) is actually what draws viewer attention. This remains an empirical question that we will address herein.

Certainly, visual attention to areas and objects of interest is influenced by both location and the luminosity/contrast and the static or dynamic nature of the stimuli. There remains a need to investigate the conditions under which that visual attention varies in order to better inform the design of stimuli in media and other applications. Ultimately, identifying situations in which luminosity or contrast affect visual attention can inform design efforts to enhance interactions with visual stimuli.

1.2 The Current Study

The present study expands on previous eye-movement research by exploring how object location and object luminosity of visual elements affect visual attention toward those objects presented as dynamic stimuli. We collected eye-movement data from participants as they viewed dynamic visual content, specifically, television commercials. Televised advertisements served as a proxy for other dynamic stimuli humans encounter in that they present a variety of visual elements (e.g., animals, graphics, text, humans, objects) and visual situations, and they generally convey an entire idea within a relatively short period of time.

In order to evaluate the impact of object location and luminosity on visual attention, relevant areas of interest had to be first identified in every commercial. Each commercial was broken down into scenes and those scenes were content analyzed for their elements of interest. A scene began when either the camera cut to a new set of elements of interest or a new area of interest was introduced into the existing scene. The Area of Interest (AOI) identification process was informed by previous research in which content analysis was used to identify important factors in visual stimuli and advertisements [20]. Once scenes and relevant AOIs were identified, the location and luminance of each AOI was coded.

We hypothesized that areas of interest that were centrally located would receive more visual attention due to previous research concerning central tendency bias [17, 18]. We further expected that objects of high versus low luminosity and objects contrasting more with their background would draw visual attention, as previous research suggests these bottom-up factors attract visual attention.

Eye-movement data reveal cognitive processes on an implicit and continuous basis [11]. Using eye-tracking technology to identify which visual characteristics grab visual attention and sustain it in a scene can offer valuable insights into the fundamental design of a stimulus and how it could affect subsequent behavior. Designing visual content around what actually captures visual attention can allow for more streamlined and informative interactions.

2 Commercial Selection and Coding

2.1 Commercial Selection

The average amount of advertisements viewed during a 1-h long television program is roughly equivalent to 18-min on U.S. network television. Thus, thirty-five 30-s randomly selected Australian produced commercials were chosen from the top three Australian free-to-air commercial television networks. These commercials were embedded during pre-recorded Australian programming. This ensured a high level of attention to all the commercials and ensured that any effects revealed by the analysis could be attributed to the commercials' visual execution factors and not to individual differences in ad exposure and familiarity.

2.2 Commercial Coding

Scene Identification. As a first step, we completed content analysis of each commercial to catalogue important non-visual elements. This first step ensured that the correct visual elements could then be selected for further coding. The components coded during content analysis of the non-visual components of each advertisement were primarily derived from Stewart and Furse (e.g., information content, commercial tone, commercial setting) [20]. All of the non-visual execution factors were coded by watching and reviewing transcriptions of each commercial multiple times to identify the presence or absence of each variable.

We then coded visual execution factors, which were based on previous research investigating visual attention to different elements in a stimulus (e.g., size in pixels, type, movement, location, luminosity). The strategic-level coding revealed insights such as the number of scenes, main characters, product presence, graphical or animated components and more. Each of these categories had its own sub-variables for which each commercial was coded. Once these visual and non-visual execution factors were completely coded for any one commercial, scenes were then identified.

Each of the 35 commercials was broken down by scene. A scene was deemed to begin when either (1) the camera cut to a new set of AOIs, or (2) a new AOI was introduced into an existing scene. If a scene lasted less than 200 ms, they could not be well explored by the eye since the eyes take about 100–200 ms to re-orient after a scene change [21]; thus, the shot was deemed to be too short to warrant coding. All scenes had an area of 589,824 pixels (1024×576 pixels). Once a scene was created, it was then further broken down into AOIs.

Area of Interest Identification. Given that people are generally able to store around seven or fewer items at a time in working memory [22], it was decided that each shot would be broken down into no more than seven areas of interest (AOIs). This number also includes the "background" (i.e., all non-AOI pixels) of a snapshot as one of the seven AOIs. AOIs in a scene ranged from seven to a minimum of two (including the background).

AOIs were determined using several rules. Factors that have been shown to attract visual attention [6, 11] and thus, increased a visual element's likelihood of being chosen for AOI coding were: motion (if the AOI was moving), size (if the AOI took up a substantial part of the shot), location (if the AOI appeared near the center of the shot), and luminosity (if the AOI was especially bright).

Semantic factors that render an AOI important regardless of its size, location, or motion also affected whether an AOI was coded. For instance, objects such as human faces or eyes were almost always coded if they appeared in a scene. The AOIs relation to the product being advertised also increased an AOI's importance (i.e., if it was the product or product packaging).

The progression of the commercial was one the most important factors in determining AOIs for coding. Although the snapshots are static in nature, they represent dynamic moments in time possibly lasting from 500 ms to a few seconds in length. Thus, the coding scheme relied heavily on the objective of the commercial as a whole, as well as on auditory cues and the progression of visual elements throughout the commercial. For instance, a snapshot might include multiple faces, but unless the face was that of a main character or a speaking character, it may not have been coded as one of the seven AOIs. This was especially true for commercials with 'background casts.'

Once important AOIs were defined, each AOI was broken down further depending on the length of the scene. Scene length was coded and used to account for how visual attention allocation might differ in a scene that is 800 ms long versus a scene that is 3.5 s long. Scenes that lasted longer required a more detailed breakdown of important AOIs. However, the breakdown of AOIs was ultimately constrained by the maximum number of AOIs that could be defined within a snapshot (≤ 7).

AOI Location Coding. As it was hypothesized that the location of a visual object might have an influence on visual attention to it, we developed a way in which the location of an AOI could be systematically coded. We wanted to provide more than general location (i.e., "left" or "right"), since visual element location is often chosen very intentionally. By dividing the 1024 × 576-pixel snapshot into thirds, both horizontally and vertically, a grid was created so that each AOI could be coded as having occupied a specific location or set of locations. The location of an AOI was determined using the grid in Fig. 1 overlaid onto each snapshot. If an AOI existed in the middle of a snapshot, it would be coded as having a location of five (Location 5 = 1, all other Locations = 0). If an AOI existed in more than one rectangle, then all the rectangles occupied by the AOI were coded as its location.

1	2	3
4	5	6
7	8	9

576 pixels

1024 pixels

Fig. 1. Location grid with numbering scheme used during coding. This grid was overlaid onto each snapshot in order to code the location of each AOI appearing in the snapshot.

AOI Luminosity Coding. Luminosity was coded using the luminosity histogram in the Photoshop Elements program. Luminosity values disregard color information and represent the tonal intensity of an object on a scale from 0 (black) to 255 (white). Median luminosity value for each AOI was used as a measure of central tendency for luminosity, as it was robust to outliers, such as the presence of a few dark pixels. We also thought it important to explore how the brightness (or darkness) of an AOI against its background might affect visual attention to the AOI. Two foreground/background contrast variables were created from the luminosity (median) scores ("light on dark" and "dark on light" contrasts) by comparing the luminosity value of an AOI in a scene to the background AOI's luminosity value.

Coding Reliability. To check the reliability of the coding scheme, a subset of the commercials (15 %) was coded independently by a different coder. Intercoder reliability was tested using Krippendorf's alpha, confirming that both the location and luminosity codes were reliable (>0.67; range = 0. 70 to 1.00).

3 Methodology

3.1 Sample

Our original sample consisted of 49 participants (35 females). Data from 12 participants in the sample were excluded due to eye-tracking calibrations below the required accuracy threshold of "good" or "excellent" as reported by the Attention Tool 5.1 software plus hitting ten out of 12 targets in the validation stage. The final sample used in analysis was made up of 26 females (M_{age} = 39.4 years, SD = 8.64) and 11 males (M_{age} = 36.9 years, SD = 6.52).

Participants were recruited from the MediaScience® participant panel in Austin, Texas, USA and were screened for normal or corrected-to-normal vision. Over 20,000 panel members make up the MediaScience® panel in Austin embodying a wide range of demographics that closely represent that of the general U.S. population. Participants received a $30 American Express gift card for participating.

3.2 Apparatus

Participants' eye movements were recorded using Attention Tool 5.1 (iMotions Global) and tracked via a Tobii T60 eye tracker (60 Hz sampling rate, tracking accuracy of 0.5°) integrated just below a 573 × 579 mm stimulus presentation monitor. Participants were seated 60–70 cm eyes-to-monitor. Stimuli were presented via the Attention Tool program as well, which allowed for the rotation of stimuli, custom settings to present that stimuli, and screen recordings of what the participant sees.

3.3 Stimuli

The 35 commercials were presented during program content to simulate a normal TV viewing experience. We integrated the commercials into an episode of the Australian comedy documentary series, Caravan of Courage. The program was of Australian production to match the country-of-origin of the commercials. Because the episode was a one-hour program, five commercial breaks could be embedded in the program, each containing seven 30-s ads (i.e., a total of 35 ads). These five commercial breaks were labeled A through E and ad positions within those commercial pods were labeled one through seven.

Seven different presentation orders for the 35 commercials were created. These rotations were created by randomizing the entire list of 35 commercials into ad positions A1 (first ad in the first ad break) through E7 (last ad in the last ad break) such that (1) no one commercial could appear in the A1 (very first) or E7 (very last) position more than once, and (2) no ad could appear in any ad position more than once across rotations.

3.4 Procedure

A research assistant escorted a single participant to one of two identical viewing laboratories (each simulating a typical home living room) where the participant was seated at a desk equipped with a Tobii T60 monitor and computer speakers. Participants were told what they would be watching an episode of the comedy show, Hamish & Andy's Caravan of Courage and that their program would last approximately 1 h. The research assistant then adjusted the tracker to capture the participant's eyes and proceeded with a 9-point calibration. Once participants reached a successful calibration, they watched a video clip presenting a second set of 12 visual targets that served as a calibration validation. Once the participant was calibrated with the eye-gaze equipment and instructions were provided, the program content began and the research assistant left the room.

3.5 Analysis Strategy

Once data were collected, the dynamic AOI drawing tool in Attention Tool 5.1 was used to break down scenes into their respective dynamic AOIs. Once AOIs were coded, fixation metrics (fixation = eye-gaze duration > 100 ms), including if an AOI was fixated and for how long it was fixated, were automatically calculated for each AOI.

Mixed model methods were used in all analyses as this approach accommodates the non-independence of observations inherent in eye-movement data. Thus, Participant and Commercial were entered into the model as random intercept effects, and the visual execution factors served as the other independent variables. Two dependent variables were used: fixation, which was a binary (1/0) variable, and fixation duration, which was a continuous variable. The same predictor variables were used in each regression model.

A separate regression model was estimated for each of the two dependent variables: (1) the binary (1/0) dependent variable fixation, and (2) the continuous dependent variable percentage of total fixation time (fixation duration). In both models, the intercept term can be interpreted as the expected value of the dependent variable when the nine screen location variables and luminosity median are zero.

4 Results

4.1 Fixation Model Results[1]

Effect of Object Location on Attention Capture. AOI Location revealed significant predictors associated with a likelihood of acquiring fixation and a likelihood of not acquiring fixation. Screen locations in the center, center-top, and center-left (Locations 2, 4, and 5) were positively associated with fixation, while screen locations in the corners of the screen, or bottom-center (Locations 1, 3, 7, 8, and 9) were negatively associated with fixation (see Fig. 2). Thus, AOIs appearing into locations 2, 4, and 5 were significantly more likely to receive a fixation, and AOIs appearing in Locations 1, 3, 7, 8, or 9 were significantly less likely to acquire fixation.

Location 1 -.24***	Location 2 .13***	Location 3 -.07***
Location 4 .04*	Location 5 .49***	Location 6
Location 7 -.21***	Location 8 -.09***	Location 9 -.22***

Fig. 2. GLM results for the predictor variable Location displayed within the location grid. Standardized estimates are reported in each location. Red shading represents those locations associated with a lesser likelihood of predicting fixation; green shading represents those locations associated with a higher likelihood of predicting fixation. Location 6 was not a significant predictor. *p < 0.05, **p < 0.01, ***p < .001. (Color figure online)

Effect of Object Luminance and Contrast on Attention Capture. The overall *Luminosity* of an AOI was also positively associated with predicting fixation, such that the higher AOI luminosity values predicted fixation ($\beta = .12$, $p < .001$). Furthermore, the contrast variable, *Dark AOI on Light Background*, was significantly negatively associated with predicting fixation ($\beta = -.02$, $p < .001$), meaning that those AOIs having a lower luminosity value than the background on which they appeared were less likely to receive fixation. *Light AOIs on Dark Backgrounds* did not significantly affect attention capture.

4.2 Fixation Duration Model Results

Sustained attention was measured by the continuous dependent variable fixation duration. One of the main differences between this second regression model and the previous GLMM analysis is the dependent variable here did not include zeros. Any AOI that was

[1] Because predictors in the current model are measured on different scales, the regression coefficients have been standardized. These standardized beta estimates can be interpreted in terms of standard deviation units, and as such can be compared in terms of effect sizes, small = .1, medium = .2, and large = .5 (Cohen 1988).

not fixated on had fixation duration = 0 and therefore was not included in this analysis; if an AOI was not fixated on, it could not predict sustained attention.

Fixation durations on the AOIs in each commercial were collected in units of milliseconds. Fixation duration was converted into a standardized percentage by dividing the fixation duration of an AOI by the length in milliseconds of its associated scene. The transformed dependent variable represented the percentage of time an AOI was fixated on out of the time it was on screen.

Effect of Object Location on Sustained Visual Attention. Similar to fixation, the center and center-top of the screen (Locations 5 and 2) were significant predictors of longer fixation duration (see Fig. 3). The top-right corner of the screen (Location 3) was also associated with longer fixation duration. The other corners of the screen, the center-left, center-right, and the bottom-center (Locations 1, 4, 6, 7, 8, and 9) were all either significant predictors of shorter fixation durations (Locations 1, 4, 8, and 9), or non-significant predictors of fixation duration (Locations 6 and 7). Thus, AOIs appearing in Locations 2, 3, and 5 received longer fixation durations, while those in Locations 1, 4, 8, and 9 received shorter fixation durations.

Location 1 -.10***	Location 2 .07***	Location 3 .04*
Location 4 -.06***	Location 5 .19***	Location 6
Location 7	Location 8 -.07***	Location 9 -.11***

Fig. 3. LMM results for the predictor variable Location displayed within the location grid. Standardized beta estimates are reported. Red shading represents those locations associated with a lesser likelihood of predicting fixation duration; green shading represents those locations associated with a higher likelihood of predicting fixation duration. Locations 6 and 7 were not significant predictors. *p < 0.05, **p < 0.01,***p < .001. (Color figure online)

Effect of Object Luminance and Contrast on Sustained Visual Attention. The overall Luminosity of an AOI was positively associated with fixation but negatively associated with fixation duration ($\beta = -.06$, $p < .000$), such that AOIs with greater luminosity than the median were less likely to capture longer fixation durations. Furthermore, the contrast variables *Dark AOI on Light Background* ($\beta = .03$, $p < .000$) and *Light AOI on Dark Background* ($\beta = .04$, $p < .000$) were significantly positively associated with predicting with fixation duration. Thus, contrast between the foreground and background increased fixation duration, regardless of which AOI was lighter or darker.

5 Discussion

We found that AOI location was an important variable in visual attention to dynamic AOIs. Figure 4 displays the location grids from both regression models in order to facilitate comparison.

Attention Capture

Location 1	Location 2	Location 3
Location 4	Location 5	Location 6
Location 7	Location 8	Location 9

Attention Sustaining

Location 1	Location 2	Location 3
Location 4	Location 5	Location 6
Location 7	Location 8	Location 9

Fig. 4. The figure on the left indicates locations that were related to fixation capture while the figure on the right indicates locations that were related to fixation duration. Red shading represents those locations associated with a lesser likelihood of predicting fixation or fixation duration; green shading represents those locations associated with a higher likelihood of prediction fixation or fixation duration, gray indicates areas that were not significantly related to either. (Color figure online)

In both models, AOIs appearing in Locations 2 and 5 were significantly more likely to receive fixations and receive longer fixation durations. This result corresponds with previous research identifying viewers' central tendency bias, where most visual attention during dynamic content is focused towards the middle of the screen [18].

Location 4 was more likely to receive fixation but was less likely to receive longer fixation durations. This effect might be influenced by our participants' left to right reading behavior that biases visual attention towards items appearing at the left of a stimulus. Viewers from a culture that read right to left might reveal the inverse effect. This might also be why Location 6 was not a significant predictor of attention capture or sustaining attention, as many AOIs would make their exit from the scene through this location.

The bottom third of the location grid was mostly negatively associated with both fixation and fixation duration. This result indicates the presence of either an innate central tendency bias or possibly that the most important or relevant objects are centered in the frame during the creation of the stimuli, leaving less relevant things (e.g., small print or negative space) to appear in the lower locations. It is likely the interaction of the two; viewers tend to direct visual attention toward the center of the screen, even in the absence of accompanying audio [23], and realizing this tendency, creative decisions are made to place the most important objects in centralized locations, further reinforcing the central tendency bias.

The overall Luminosity of an AOI positively predicted fixation (attention capture) but negatively predicted fixation duration (sustaining attention). Dark AOIs on a Light Background captured fixation and both the Dark AOI on Light Background and Light AOI on Dark Background variables significantly predicted longer fixation durations. These results indicate that the salience of a bright (luminous) AOI contributed to capturing fixation, however, it seemed that the contrast of an AOI with its background was more important in sustaining visual attention. AOIs having a higher or lower luminosity than the background on which they appeared tended to receive longer fixations, suggesting that the degree to which an AOI contrasts with its background is more influential in visual attention than luminosity alone. Taken together, these results suggest that visual objects of high importance should be centrally located and contrast with the background on which they appear in order to garner more visual attention.

Because real commercials were used as stimuli in this study, the ecological validity of our results is greater, but there is also an unavoidable lack of control in the variables of interest. It may be the case that certain features in a scene (e.g., faces) would garner more attention regardless of their location. We cannot say for certain that it was an innate central tendency driving our results, but that perhaps advertisers put the most informationally salient features of an ad in the center of the screen. In future studies, dynamic stimuli created to manipulate the presence or absence and location of each variable would further clarify their impact on visual attention.

Previous research has shown that studying eye movements provides valuable insights into the ways users visually and behaviorally interact with stimuli. It is necessary to first understand how the user engages with and is influenced by the basic visual components of the display. These understandings can guide the people that design and create dynamic interfaces and content to best serve the user interacting with them. Using insights from studies such as this on visual attention, designers can create strategies to increase visual attention to items of interest, or perhaps to encourage *when* visual attention is lent to important objects, further enhancing, streamlining, and improving interactions with the content.

References

1. Jacob, R.J.K., Karn, K.S.: Eye tracking in human-computer interaction and usability research: ready to deliver the promises. In: Hyona, J., Radach, R., Duebel, H. (eds.) The Mind's Eye: Cognitive and Applied Aspects of Eye Movement Research, pp. 573–605. Elsevier Science, Amsterdam (2003)
2. Egeth, H.E., Yantis, S.: Visual attention: control, representation, and time course. Annu. Rev. Psychol. **48**(1), 269–297 (1997)
3. Lohse, G.L.: Consumer eye movement patterns on Yellow Pages advertising. J. Advert. **26**(1), 61–73 (1997)
4. Schiessl, M., Duda, S., Tholke, A., Fischer, R.: Eye tracking and its application in usability and media research. MMI-Interaktiv **6**, 41–50 (2003)
5. Gregory, R.L.: Eye and Brain: The Psychology of Seeing, 5th edn. Princeton University Press, Princeton (1997)
6. Rayner, K.: Eye movements in reading and information processing: 20 years of research. Psychol. Bull. **124**(3), 372–422 (1998)
7. Venkatraman, V., Dimoka, A., Pavlou, P.A., Vo, K., Hampton, W., Bollinger, B., Hershfield, H.E., Ishihara, M., Winer, R.S.: Predicting advertising success beyond traditional measures: new insights from neurophysiological methods and market response modeling. J. Mark. Res. **52**(4), 436–452 (2015)
8. Teixeira, T.S., Wedel, M., Pieters, R.: Moment-to-moment optimal branding in TV commercials: preventing avoidance by pulsing. Mark. Sci. **29**(5), 783–804 (2010)
9. Hillstrom, A.P., Yantis, S.: Visual motion and attentional capture. Percept. Psychophys. **55**(4), 399–411 (1994)
10. Loftus, G.R., Mackworth, N.H.: Cognitive determinants of fixation location during picture viewing. J. Exp. Psychol. Hum. Percept. Perform. **4**(4), 565–572 (1978)

11. Duchowski, A.T.: Eye Tracking Methodology: Theory and Practice, 2nd edn. Springer, London (2007)
12. Hammoud, R.I. (ed.): Passive Eye Monitoring: Algorithms, Applications and Experiments. Springer, Germany (2008)
13. Anderson, D.R., Burns, J.: Paying attention to television. In: Bryant, J., Zillmann, D. (eds.) Responding to the Screen: Reception and Reaction Processes, pp. 3–25. Routledge, New York (1991)
14. Rayner, K., Castelhano, M.S.: Eye movements during reading, scene perception, visual search, and while looking at print advertisements. In: Wedel, M., Pieters, R. (eds.) Visual Marketing: From Attention to Action, pp. 9–42. Taylor & Francis Group, New York (2008)
15. Roth, S.P., Tuch, A.N., Mekler, E.D., Bargas-Avila, J.A., Opwis, K.: Location matters, especially for non-salient features–an eye-tracking study on the effects of web object placement on different types of websites. Int. J. Hum.-Comput. Stud. **71**(3), 228–235 (2013)
16. Holmqvist, K., Wartenberg, C.: The role of local design factors for newspaper reading behaviour - an eye-tracking perspective. Lund Univ. Cogn. Stud. **127**, 1–21 (2005)
17. Tatler, B.W.: The central fixation bias in scene viewing: selecting an optimal viewing position independently of motor biases and image feature distributions. J. Vis. **7**(14), 1–17 (2007)
18. Brasel, A.S., Gips, J.: Points of view: where do we look when we watch TV? Perception **37**, 1890–1894 (2008)
19. Fehd, H.M., Seiffert, A.E.: Eye movements during multiple object tracking: where do participants look? Cognition **108**(1), 201–209 (2008)
20. Stewart, D.W., Furse, D.H.: Effective Television Advertising: A Study of 1000 Commercials. Lexington Books, Lexington (1986)
21. Le Meur, O., Le Callet, P., Barba, D.: Predicting visual fixations on video based on low-level visual features. Vis. Res. **47**, 2483–2498 (2007)
22. Miller, G.: The magical number seven, plus or minus two: some limits on our capacity for processing information. Psychol. Rev. **101**(2), 343–352 (1955)
23. Wooley, B.E., March, D.S.: Exploring the influence of audio in directing visual attention during dynamic content. In: Proceedings of Symposium on Eye Tracking Research and Applications, pp. 187–190. ACM Press, New York (2014)
24. Bergstrom, J.C.R., Olmsted-Hawala, E.L., Bergstrom, H.C.: Older adults fail to see the periphery in a web site task. In: Universal Access in the Information Society, pp. 1–10. Springer, Heidelberg (2014)