Measuring the Impact of Affordance-Based Clickability Cues

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1 ABSTRACT

In order for a user to successfully navigate around a website, they must be able to find and click on interface buttons. However, recent design trends have emphasized minimalism and a reduction in cues that users rely on to find and click buttons. An alternative design approach relies on affordances, or users' action capabilities in the real world, to indicate what actions are possible in a technological interface. The present study tested the impacts of two affordance-based clickability cues ? depth and color contrast ? on a user's ability to find and click an interface button. Twenty participants were asked to find and click a call-to-action button on various websites while their gaze was tracked with an eye tracker. In a 2X2 design, each participant saw buttons with either depth present or depth absent, and color contrast present or color contrast absent. Results showed no significant effect of depth or color contrast on the overall time it took to click the button. However, the condition in which neither depth nor color contrast were presented on the button resulted in significantly diminished visual search performance (more total fixations before task completion and longer time to the first fixation on the button) compared to conditions in which either one or both cues were present. We discuss the importance of clickability cues for visual search performance and website usability, and caution designers who utilize minimalistic 'flat' design.

2 INTRODUCTION

Websites utilize call-to-action (CTA) buttons to encourage and guide users to complete a task (e.g, to purchase a product or sign up for a service). Typically, the call-to-action button represents the ultimate goal of the website, which makes its design and implementation crucial to the success of the site. Users rely on clickability cues to know where on the page they can click and how they can interact with the site; common clickability cues include strategic use of color, depth, underlining, and arrows [Loranger 2015]. Thus, if the goal of the website is for users to click the CTA button, multiple clickability cues should be utilized.

Despite this, the past decade has seen the rise of flat design in technological interfaces. Flat design is a minimalistic design approach which utilizes open space, lines, and two-dimensional illustrations to reduce interface clutter and improve usability [Meyer 2017a]. However, the absence of depth, and in some instances, color contrast, leads to a decrease in the clickability cues that users rely on to interact with the system [Meyer 2017b].

One technique to improve the clickability of a CTA is to use affordance-based clickability cues. An affordance is a property of the environment that makes possible some action [Gibson 1979]. For example, a chair affords sitting on, a handle affords grasping and pulling, and a button affords pressing. Perhaps affordance-based clickability cues will be effective at eliciting the appropriate action from the user because they introduce additional perceptual cues that match the action capabilities of items in the real world. For example, buttons in the real world afford pressing because they protrude outward from their surrounding surface (indicating depth). Additionally, disturbances in an opaque and constant surface texture (most easily created through changes in color from the surface) indicate objects that are separate from the surface. As such, depth and color contrast are two strong indicators of affordances in the physical world that can be implemented into the design of CTA buttons. The purpose of this study is to assess the impact of two affordance-based clickability cues — depth and color contrast — on the effectiveness of call-to-action buttons.

It is important to note that affordances exist whether or not they are perceived. A specified section of a webpage affords clicking based on the underlying code that designates the page; The affordance exists regardless of a user's ability to perceive the clickability. One approach to designing usable systems is to ensure that the affordances of the system are perceptible [Gaver 1991]. Indeed, intuitive interaction with a system can be obtained when users directly experience the environmental perception [McGrenere and Ho 2000], and desired user behavior is easily evoked when the user ability corresponds to the object's affordance [Drewitz and Brandenburg 2010]. Flat design and "ghost buttons" (clickable areas on a webpage that are transparent and empty) remove cues to the affordance of clickability. In contrast, an affordance-based design [Maier and Fadel 2008] provides sufficient cues to ensure perception of the affordances of the interface. In the same vein, skeuomorphic design uses visual metaphors to create objects in the interface that resemble real world objects and their functions [Jung et al. 2017]. An example of skeuomorphic design would be the use of GUI buttons and switches: buttons in the interface afford the same action (pressing) as buttons in the real world, just as switches in the interface afford the same action (toggling) as switches in the real world.

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Incorporating depth and color contrast into buttons on an interface should improve the resemblance of the button metaphor and increase the perceptible cues that indicate the clickability of the button. Additionally, depth and color cues have been found to improve visual search performance [Pashler 1998]. Enns and Rensink [1990] showed that efficient visual search is possible when the target stimuli has a 3-D appearance. Efficient searches can also be based on depth cues due to shading [Aks and Enns 1992; Braun 1993], as well as the presence of shadows [Rensink and Cavanagh 1993]. Similarly, using color differences is one of the easiest ways to make a stimulus pop out from its surroundings to promote efficient visual search and texture segmentation [Van Orden 1993]. This effect is robust in that any number of colors that differ from the distractors can be used successfully; D'Zmura [1991] suggests that efficient search is possible whenever the target and distractors lie on opposite sides of a line drawn through color space.

The present study will test the individual and combined effects of depth and color contrast on the effectiveness of call-to-action buttons on various webpages, and will also measure gaze fixation patterns using an eye-tracker. In a 2X2 design, participants will view webpages that have CTA buttons with depth present or absent and color contrast present or absent. They will be asked to complete specific tasks on the webpage, each of which will require clicking on the CTA button. Time to complete the task will be used to measure overall effectiveness of the button. The total number of fixations before task completion will be used as an index of visual search efficiency [Goldberg and Kotval 1999]. Lastly, time to the first fixation on the button will be used as an index of the attention-getting properties of the button [Byrne et al. 1999].

We expect to see a main effect of color contrast across all dependent variables, such that participants who view buttons with color contrast will have faster task times, fewer fixations, and faster times to first fixation on the button compared to those who viewed buttons with no color contrast. Secondly, we expect to see a main effect of depth across all dependent variables, such that participants who view buttons with depth will have faster task times, fewer fixations, and faster times to the first fixation on the button compared to those who viewed buttons with no depth. Lastly, we expect the effect of depth to be moderated by color contrast, such that depth will have a larger impact on all variables when color contrast is absent compared to when color contrast is present.

2.1 Background

Due to the competitive nature of corporate businesses and the fact that company success and profit are closely tied to the success of the website, most companies who conduct empirical research on web usability choose not to publish or share their findings with their competitors. The Nielson Norman Group, a leading consultant for user experience research, reported an unpublished eye tracking study in which 70 users engaged with websites that had either traditional, weak, or absent (e.g flat) clickability cues for every interactive element on the webpage [Meyer 2017b]. The results of this study found that users who saw websites with strong signifiers completed tasks faster and required fewer fixations than those who saw websites with weak or absent signifiers.

The Nielson Norman study found significant improvement in task performance when clickability cues were present, but the study did not differentiate between different clickability cues to see which (if any) were more impactful. The current study will expand upon the Nielson Norman study by assessing the individual and collective effects of two main clickability cues — depth and color contrast — to determine the relative effect of each on a call-to-action button.

3 METHOD

3.1 Participants

Twenty undergraduate and graduate students at Clemson University (15 males; Age M = 21.5, SD = 1.67) volunteered to participate. All participants had normal vision with no visual impairments, and all read an informational letter of consent prior to participating.

3.2 Materials

For each trial, participants were presented with a screenshot of a webpage. Webpages were selected from current ecommerce, travel, technology, and financing websites. Each webpage included at least one text element, at least one picture element, and a call-to-action button. The text of the call-to-action button was edited so that each button read "Get Started." Other criteria for webpage selection required that the size, location, and configuration of the text, picture, and button elements varied across webpages. Webpages also varied in their background color/color scheme and the amount of visual clutter.

Four identical copies of each webpage screenshot were made. Each copy was then edited using standard photo editing software (Sketch3) to display a different level of Depth (present vs absent) and Color Contrast (present vs absent) for the "Get Started" button. The depth and color contrast of the button were the only changes; all else remained the same across each set of copies.

When depth was present, a box shadow was added to the CTA button. When depth was absent, no shadow or other depth cues were used; This represents the conventional use of 'flat design.' When color contrast was present, the color of the button was changed so that the color contrast ratio of the button color to the background color was 10:1. A contrast ratio of 10:1 was chosen because it exceeds the guidelines set by the Web Content Accessibility Guidelines [Caldwell 2008] for contrast at the strongest level of conformance. When color contrast was absent, the color of the button exactly matched the color of the webpage background, resulting in a contrast ratio of 1:1. The absence of color contrast represents the conventional use of 'ghost buttons.' See Figures 1-4 for examples of stimuli at each level.

3.3 Apparatus

Stimuli were displayed on a 22-inch Dell 22FP monitor at a resolution of 1680 x 1050. Participants sat approximately 60 cm from the display. Eye gaze was tracked using a Gaze Point GP3 Eye Tracker mounted beneath the monitor. The Gaze Point GP3 is a pupil center corneal reflection (PCCR) eye tracker which emits infrared light towards the eye and tracks the corneal reflection in order to measure eye position. The device offers an accuracy of 1 degree of visual angle and collects data at a sampling rate of 60 Hz.

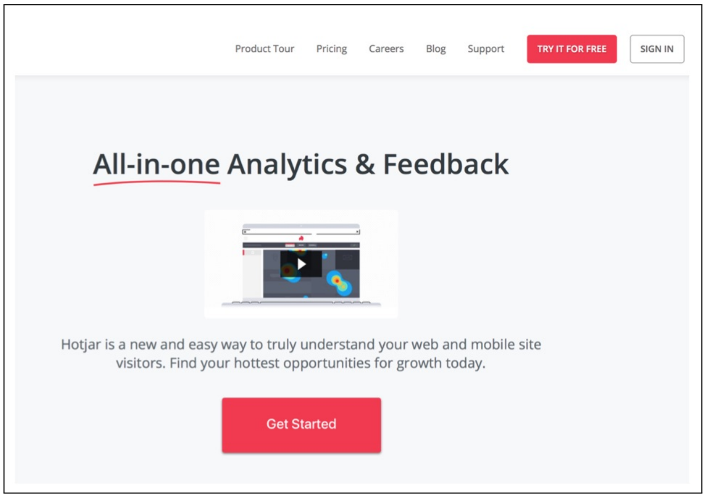

Figure 1: Depth present, Color Contrast present

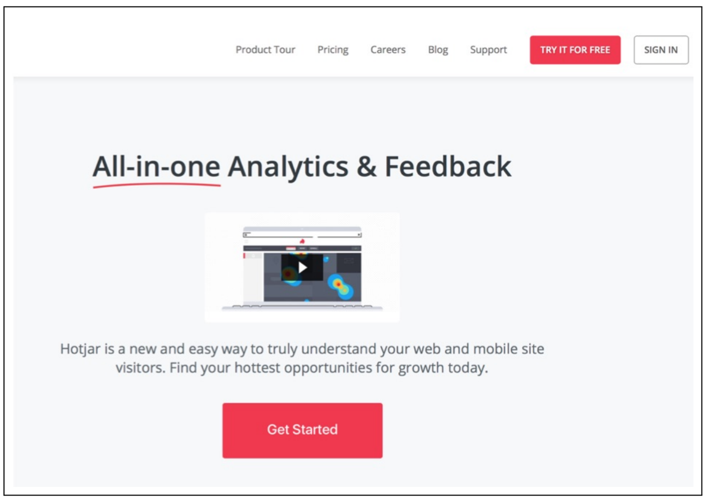

Figure 2: Depth absent; Color Contrast present

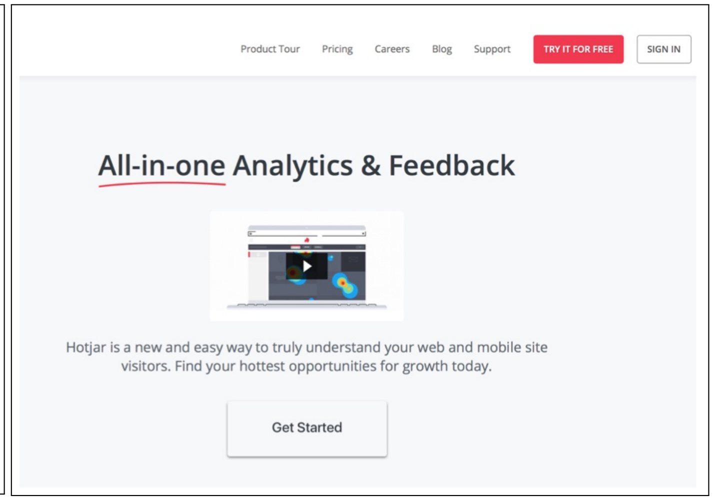

Figure 3: Depth present; Color Contrast absent

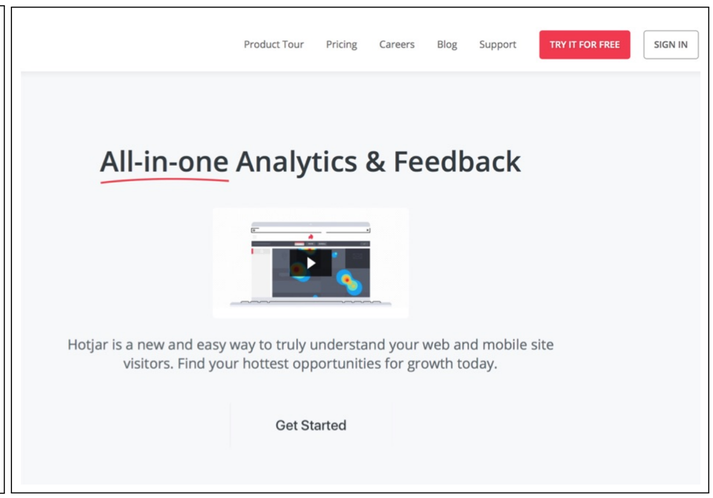

Figure 4: Depth absent; Color Contrast absent

3.4 Procedure

Participants were greeted by the researchers and escorted to a computer lab. After reading the informational letter of consent, each participant was seated in front of a computer and completed a pre-experimental demographic questionnaire in which they noted their age, gender, and any visual impairments. Upon completion of the questionnaire, participants completed a 9-point calibration task that was built into the Gaze Point software. An experimenter then validated the calibration by asking participants to look at specific locations on the screen while their estimated gaze was displayed in real time on the screen. If the software's estimated gaze was inaccurate, the 9-point calibration was repeated and retested.

An experimenter verbally presented a brief overview of the experiment, followed by instructions. Participants were told that they would view a series of webpages, and that each webpage contained a button with the words "Get Started" written on it. They were instructed to find and click on the "Get Started" button as quickly as possible. Once they clicked on the button, a blank grey screen with a black fixation cross in the upper left corner was presented for 4 seconds. Participants were asked to stare at the fixation cross and move their mouse so that the cursor was on top of the cross in between each trial. After the fixation screen, the next webpage was presented. Participants completed this task for a total of 12 webpages, and were then thanked, debriefed, and dismissed. The experiment lasted approximately 15 minutes.

3.5 Design

This experiment utilized a 2 (Depth: present vs absent) X 2 (Color Contrast: present vs absent) between-subjects design. Each participant was randomly assigned to one of four groups. Each group was presented with one of the following configurations of the call-to-action button: depth present/color contrast present, depth present/color contrast absent, depth absent/color contrast present, and depth absent/color contrast absent. The main dependent variables were time to complete the task, total number of fixations before task completion, and time to the first fixation on the button.

3.6 Data Extraction

For each trial, task time, number of fixations, and time to the first fixation on the button were extracted from the raw data. Task time was extracted from a program that gathers mouse click data, and was calculated as the time from the presentation of the webpage to the time of the first click. The total number of fixations was calculated via the GazePoint software, and was calculated as the number of fixations from the presentation of the webpage to the time of the first click. Areas of Interest (AOIs) were manually drawn around the CTA button on each screenshot, and time to first fixation on the button was calculated as the time from presentation of the webpage to time of first fixation falling partially or fully within the AOI.

4 RESULTS

In order to reduce the likelihood of family wise error due to multiple univariate tests, a 2X2 multivariate ANOVA was run to test the effects of depth and color contrast on task time, number of fixations, and time to the first fixation on the button. The Wilke's Lambda F test showed a nonsignificant effect of depth (F(3,14) = 1.25, p = 0.341), a significant effect of color contrast (F(3,14) = 4.03, p = 0.029), and a significant interaction effect (F(3,14) = 3.40, p = 0.048). The significant omnibus test suggests that across all dependent variables, there are significant effects of color contrast and depth*color contrast. Additionally, it provides justification for performing univariate analyses for each dependent variable.

To assess the effects of depth and color contrast on time to complete the task (seconds), a 2X2 ANOVA was performed. Results showed a marginally significant main effect of depth (F(1, 16) = 3.474, p = 0.081, *partial eta squared* = 0.178). A post-hoc pairwise comparison showed that participants completed their tasks faster when depth was present (M = 2.21, SD = 0.182) than when depth was absent (M = 2.69, SD = 0.182). There was not a significant main effect of color contrast (F(1,16) = 2.28, p = 0.151) or a significant depth*color contrast interaction (F(1,16) = 2.49, p = 0.134) for overall task time.

To assess the effects of depth and color contrast on the number of fixations required before task completion, a 2X2 ANOVA was performed. Results showed a marginally significant main effect of depth (F(1, 16) = 3.54, p = 0.078, *partial eta squared* = 0.181). A post-hoc pairwise comparison showed that participants had fewer total fixations when depth was present (M = 6.03, SD = 0.382) than when depth was absent (M = 7.05, SD = 0.382). Additionally, there was a significant main effect of color contrast (F(1, 16) = 4.66, p = 0.046, *partial eta squared* = 0.226). A post-hoc pairwise comparison showed that participants had fewer total fixations when color contrast was present (M = 5.96, SD = 0.382) than when color contrast was absent (M = 7.125, SD = 0.382). Lastly, there was a significant interaction between depth and color contrast (F(1, 16) = 4.15, p = 0.05, *partial eta squared* = 0.206). Post-hoc independent samples t-tests revealed that when contrast was present, there was no difference in the

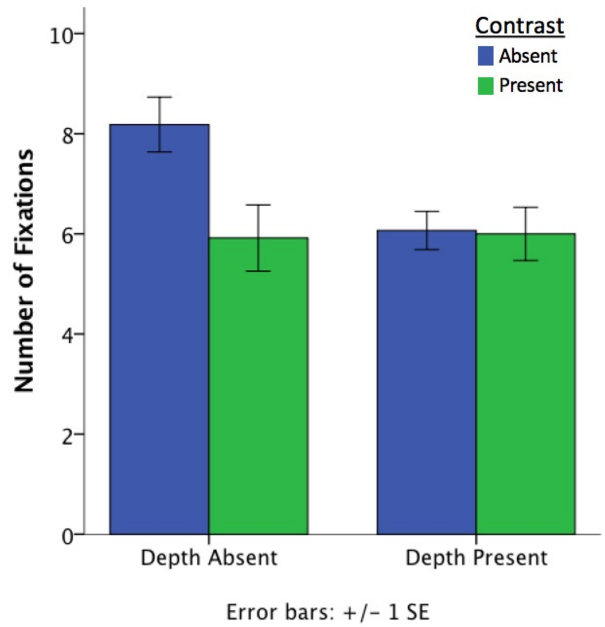

Figure 5: Bar graph showing the effects of depth and color contrast on the number of fixations.

number of fixations between the depth present condition (M = 6.0, SD = 1.18) and depth absent condition (M = 5.92, SD = 1.48, t(8) = -0.098, p = 0.924). However, when contrast was absent, participants had significantly fewer fixations when depth was present (M = 6.07, SD = 0.85) than when depth was absent (M = 8.18, SD = 1.23, t(8) = 3.17, p = 0.013, see Figure 5).

To assess the effects of depth and contrast on the time to the first fixation on the button (seconds), a 2X2 ANOVA was performed. Results showed a significant main effect of color contrast (F(1,16) = 10.76, p = 0.005, *partial eta squared* = 0.402). A post-hoc pairwise comparison showed that participants fixated on the button significantly faster when contrast was present (M = 1.01, SD = 0.081) than when contrast was absent (M = 1.39, SD = 0.081). Additionally, there was a significant interaction between depth and contrast (F(1,16) = 10.01, p = 0.006, *partial eta squared* = 0.385). A post-hoc independent samples t-test revealed that when contrast was present, there was no difference in the time to first fixation on the AOI when depth was present (M = 1.1, SD = 0.21) than when depth was absent (M = 0.97, SD = 0.14, t(8) = -1.09, p = 0.311). However, when contrast was absent, participants fixated on the AOI faster when depth was present (M = 1.17, SD = 0.13) than when depth was absent (M = 1.66, SD = 0.39, t(8) = 2.65, p = 0.029, see Figure 6). There was no significant main effect of depth on time to the first fixation on the button (F(1,16) = 2.68, p = 0.121).

5 DISCUSSION

The results for each dependent variable (task time, number of fixations, and time to the first fixation on the button) followed similar patterns, but these patterns varied in significance. First, we expected

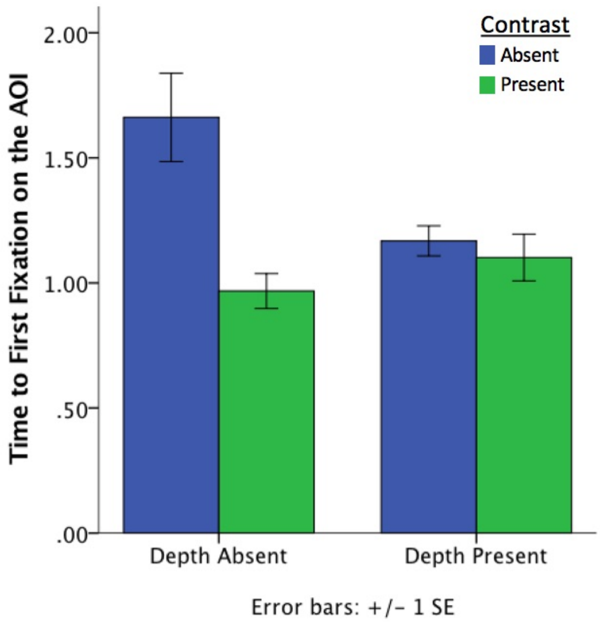

Figure 6: Bar graph showing the effects of depth and color contrast on time to the first fixation on the button.

a main effect of color contrast across all DVs. This hypothesis was partially supported: the presence of contrast on the button reduced the total number of fixations and the time to the first fixation on the button, but it did not have an effect on overall task time. Second, we expected a main effect of depth across all DVs. This hypothesis was not supported: we saw only a marginal decrease in task time and number of fixations when depth was present on the button. Lastly, we expected a significant depth*contrast interaction. This hypothesis was also partially supported: the interaction effect was significant for time to the first fixation on the button, and was marginally significant for number of fixations, but was not significant for overall task time. The interaction showed that when contrast was present, there was no significant difference in performance between the depth present and depth absent conditions. Additionally, there was no significant difference between the depth present/contrast absent condition and either of the contrast present conditions. Thus, the only condition that significantly harmed performance was the condition in which both depth and contrast were absent from the button.

Overall, the results suggest that the presence of either depth or contrast on the CTA button is sufficient to elicit peak performance, but the absence of both depth and contrast results in a diminished ability to find and click the button. This depth absent/contrast absent condition represents what is conventionally known as a "ghost button." The increase in total fixations and time to the first fixation on the button indicates that ghost buttons have fewer attention-getting properties and that users engage in less efficient visual search processes when trying to find them.

Figure 7 displays the gaze pattern from a single participant on one trial in the depth absent/contrast absent condition. Each red circle represents a single fixation, and the size of the circle indicates the relative length of the fixation (larger circles represent longer fixations). Fixations are numbered sequentially. The opaque purple box represents the area of interest, which was manually drawn around the CTA button. For the depth absent/contrast absent condition, fixations moved across the middle of the page from left to right, skipping over the button participants were searching for. Comparatively, Figure 8 displays the gaze pattern from a single participant on one trial in the depth present/contrast present condition. Fixations in this condition moved almost directly toward the call-to-action button. Since participants' gaze did not have to sweep across the entire webpage, this suggests far better visual search efficiency compared to the depth absent/contrast absent condition.

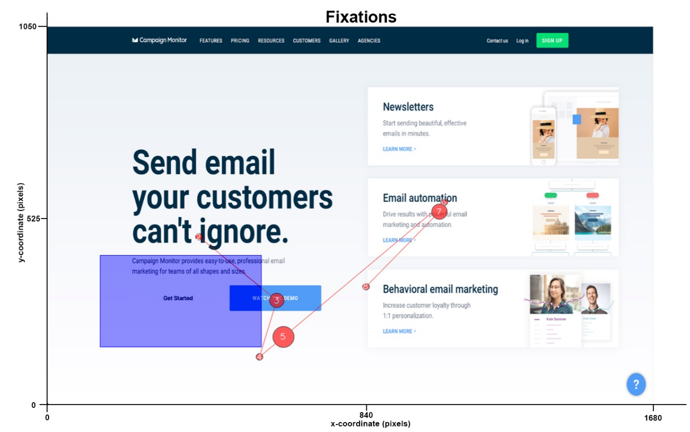

Figure 7: Fixation pattern for one participant in the depth absent/contrast absent condition.

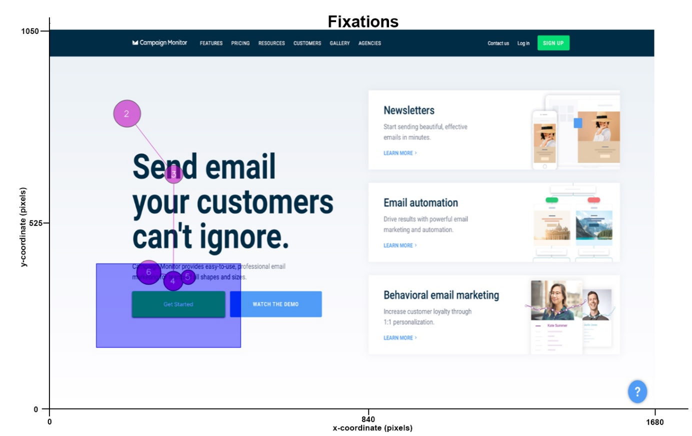

Figure 8: Fixation pattern for one participant in the depth present/contrast present condition.

Since all of our dependent variables were highly related to each other, it was expected that each DV follow a similar pattern of results. This was the case for the DVs that were collected from the eye tracker (number of fixations and time to the first fixation on the button), but not for overall task time. This suggests that while depth and contrast have an effect on the user's visual search performance, other factors (e.g, reaction time, motor capabilities, etc) play a role in determining the overall time it takes for the user to click on the button.

Again, the results for each DV followed a similar pattern, but only some expected effects were significant, while others were marginal. This may be due to the lack of statistical power in our study. With a total of 20 participants (5 per condition), this between-subjects experiment may have produced stronger results with a larger sample size.

An additional limitation of this study was that the controlled nature of the task reduced its ecological validity. Since each webpage had a standardized "Get Started" button, they were less realistic than those with an actual call-to-action button. CTA buttons vary in their text (e.g, "Sign Up Now," "See More," "Buy Now," etc), which means that users don't always have a specific phrase they are searching for before they arrive at the website. Unlike our experimental task, users typically explore the page in a less task-oriented manner prior to clicking on the CTA button. We designed our experiment with this limitation in mind because we wanted to ensure enough experimental control to draw comparable and interpretable conclusions about the effects of depth and color contrast on the speed with which a button was found and clicked. Since our participants were given a specific task to find and click the CTA button, the results of this study only indicate the effects of clickability cues on their visual search of the button. It is important to note that this study does not make any conclusions about the discoverability of CTA buttons, but rather their findability.

While this study determined that the presence of even one clickability cue (either depth or contrast) greatly improved the user's efficiency of finding and clicking a CTA button, future work could assess the effectiveness of other signifiers. A larger assessment of additional clickability cues (e.g, button size and shape) could produce stronger guidelines for web designers to ensure that their CTA buttons are easy to find and click.

6 CONCLUSIONS

In this experiment, we asked participants to find and click a call-to-action button with varying levels of depth and color contrast while we measured overall task time, number of fixations, and time to the first fixation on the button. The results of this study indicate that the absence of all affordance-based clickability cues results in a decreased ability to find and click a call-to-action button on a webpage. However, the presence of either depth or color contrast on the button (or both) drastically improve the visual search performance. Ghost buttons – a new trend in website design in which clickable areas of the webpage are transparent and empty – reduce the user's ability to find and click on the button because they remove all cues that the button affords clicking. We recommend that web designers incorporate as many affordance-based clickability cues as possible into their design in order to improve the user's interaction with the site.

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