Effects of Vibrancy and Eye Size in Animals on Human Preference

Nathan Shipley
Clemson University
Clemson, SC
nshiple@clemson.edu

Scott Betza
Clemson University
Clemson, SC
sbetza@clemson.edu

Timothy Campbell
Clemson University
Clemson, SC
tcampb2@g.clemson.edu

ABSTRACT
Understanding how human visual perception of animals is influenced by vibrancy and eye contact with the animal is important for envirmental educators who attempt to promote positive human interactions with animals by instilling a positive first impression of potentially unfavorable creatures. We conducted a study that used eye tracking to explore the participant's ability to identify an unmodified butterfly image when presented with images of the same butterfly where vibrancy or eye size was reduced or increased. Seventeen participants were tested with a 2 x 5 non-repeated measures factor design. We found no significant relationships between butterfly modification type or intensity level with selection, but we found a relationship between choice and fixation, in that duration was significantly different between selection and non-selection, while the number of fixations was not significant. Our findings suggest that there may be a natural tendency for people to fixate upon the top row of targets when shown images in sets.

Author Keywords
Eye tracking, user studies, color, eye size, wildlife, ANOVA

ACM Classification Keywords
H5.m. Information interfaces and presentation (e.g., HCI): Miscellaneous.

INTRODUCTION
Humanity's diminishing relationship with the natural environment has been a focus of study over the last few decades, exemplified with the identification and creation of non-clinical diagnosis such as nature deficit disorder (NDD) [19] and other general negative trends such as an overall decline in reported nature-based play for children in relation to other activities [17]. As the connection between man and nature decreases, understanding how people engage with the natural environment is of critical importance in determining the preservation of natural areas for future generations. Of what little interest does exist for natural and wildland areas, much is directed towards the large, distant, and exotic animals (e.g., lions, penguins, etc.), offering few resources to animals deemed unimportant or unattractive by society (e.g., insects, snakes, etc.) [1,26]. Kellert [15] identified different perceived variables that influence human perceptions of animals, such as animal size, shape, and color. However, little research has been conducted to examine the specific influence that different external characteristics of animals have on human perceptions of animals.

Our research will examine how human visual perception of animals is influenced by the color and amount of available eye contact with the animal. We aim to understand how various degrees of animal color vibrancy (saturation of color) and eye size will impact human visual search patterns of different animals. We hypothesize that people will indicate a preference for images of animals where color vibrancy or eye size has been increased, while people will indicate minimal preference for images of animals where color vibrancy or eye size has been decreased. We will utilize eye tracking to calculate the amount of time spent in visual search between animals with increased and decreased vibrancy and eye size, allowing us to infer human preference. Findings will provide a more robust understanding of what traits of animals should be displayed to increase people's attention of the animal. Following a detailed summary of the available literature we then outline our proposed research methodology.

BACKGROUND
Much of the natural resource and tourism literature has focused on "flagship species" (often large, charismatic, and common vertebrates) as an important function in encouraging conservation efforts and human engagement with the natural environment [4,6,27,28]. However the concept and use of flagship species has been argued against from a management perspective [24]. Recent examination of the literature has revealed that even the scientific community has invested a disproportionate amount of research effort on relatively few species, often focusing on large and threatened mammals [26]. Estren [9] addresses the human evolutionary bias to favor animals which exhibit morphological neotenic traits (i.e., juvenile traits such as a larger head, larger eyes, reduced appendages, etc.). Estren argues that the "neoteny barrier" has decreased public attitudes towards non-cute animals and concludes by urging a new perspective to increase awareness of animals that may not be inherently cute.

Historic work conducted by Kellert [15] identified twelve variables that predicted human interest in different animals. Notable variables from Kellert's work include animal size, perceived animal intelligence, and perceived danger to humans. More recent work has suggested that the average person finds animals as a more salient unit of the environment while often disregarding other common aspects such as plants (i.e., plant blindness) [23]. Many large, charismatic, mammals are endeared by people (e.g., dogs, cats, rabbits, horses) while animals that express few mammalian traits are commonly disliked by people (e.g., snakes, spiders) [3,11]. Conversely, a study by Bixler, Crosby, Howell, & Tucker [2] found that spiders which exhibited neotenic traits (e.g., jumping spiders) were perceived as "less scary" than other spiders, suggesting that reduced body size and larger eyes may be an important factor in positively influencing human perceptions of animals, including those species innately disliked by humans. Of other perceptually available animal traits, color has been empirically suggested as an important moderator for positive human perceptions of animals [5,25]. While animal color and eye size are important in influencing human perceptions of animals, there exist few studies that have examined the effect of these variables on human preference for animals from a cognitive human visual attention and perception paradigm and methodology.

To better understand the influence of animal color and eye size in human perception of animals, it is important to first understand what people like and how that motivates human behavior. Hidi and Baird [12] argued that the "interestingness" of an object is related to motivation and memorability of that object, suggesting that stimuli can be inherently interesting to a person, which ultimately motivates behavior. When an object is interesting, people tend to invest more effort in the visual processing of the stimulus [18]. By measuring human visual search patterns of different animals, it may be possible to better understand the external morphological traits of animals that people find more interesting relative to other traits, revealing the traits of animals that people like.

Loftus and Mackworth [18] suggest that the fundamental psychological function of visual attention may be useful in revealing specific characteristics of attention, suggesting that a measurement of visual attention can reveal characteristics of animals that people finding interesting. Modern advancements in eye tracking technology has greatly expanded the ability for scientists to measure foveal gaze and human visual search patterns, providing a point of inference for mental attention [8]. A growing body of literature suggests that measuring foveal gaze through eye tracking technology is an ecologically valid measure of visually attentive traits [10] and that eye tracking can be useful in identifying preferences towards stimuli [14]. When measuring foveal gaze, increased duration and number of fixations on a target stimuli can be correlated with general positive evaluations of the stimulus [20,21]. Utilizing eye tracking could reveal patterns of human visual search and foveal gaze that could produce additional information about the influence of animal color and eye size in human perceptions of animals.

We hypothesized that color and available eye contact of an animal will influence human preference for animals and that an increase in animal color vibrancy and an increase in eye size will increase human preference. Specifically, we hypothesized the following:

1. An increase in animal color vibrancy will result in an increased amount of human visual search time spent on the vibrant animal compared to same animal with decreased color vibrancy.

2. An increase in animal eye size will result in an increased amount of human visual search time spent on the large eyed animal compared to same animal with decreased eye size.

METHOD

We presented participants (n=17) with a series of eight different images of butterflies. Participants viewed a single digital image that consisted of a quadrant of four modifications of the same animal, manipulated systematically along one of two variables, either color vibrancy or eye size. Participants were asked to identify which of the four images was the unmodified image. During the procedure, the experimenter manually recorded participant's verbal identification responses via a pen and paper survey. Visual search patterns and dwell time were recorded via a Gaze Point GP3 eye tracker.

Participants

Seventeen participants participated in the study (12 male, 5 female), with ages ranging from 19 to 29 (Mean = 22.7). All participants were university students. There were no major reported problems with any participant's vision, aside from one participant reporting their eyes as being "more dilated than normal". Nine reported wearing glasses, four reported wearing contacts, and four reported having no corrective lenses. Participants were not compensated for their participation and participation was strictly voluntary.

Apparatus

Stimuli were displayed on Dell Professional P2213t 22" LED monitor with 60Hz refresh rate. The screen resolution was 1680 x 1050 pixels. A Gaze Point GP3 pupil corneal reflection eye tracker was used with 0.5 – 1 degree of visual angle accuracy, 60 Hz sampling rate, 9-point calibration, with 25 cm of horizontal and 11 cm of vertical movement allowed, and with a ±15 cm range of depth movement. The tracker was calibrated using Gazepoint Control Software v3.1.0 and controlled by Gazepoint Analysis v3.1.0.

The display was driven by a Dell Optiplex 9020 PC with an Intel Core I7-4790 3.6GHz / 8MB cache processor, 16GB (2 x 8GB) 1600 MHz DDR3 Non-ECC Ram, a 3.5in 500GB 7200 RPM hard drive, and a nVIDIA GeForce GTX 745 4GB DDR3 video card. See Figure 1 for the study setup configuration.

Figure 1. Workstation configuration

Stimulus

Butterflies were selected as the target stimulus as they are generally liked by most people, while at the same time are diverse in color, shape, and size. Additionally, people are familiar with butterflies, however may be generally unaware of specific types/species. By using only butterflies, we were able to focus our study without controlling for additional animal types, while also allowing us to present uniquely different stimuli due to the diversity of butterflies. Lastly, because butterflies are the subject of much photography, there are numerous public domain images of high quality butterfly images. In total, eight unique butterflies were selected as stimuli.

All images used in this study were manipulated in Adobe Photoshop CC 2015. Every image was initially manipulated to remove background noise, displaying the animal on a solid white background. All images were manipulated so that the head of the animal was facing to the left of the image. The quadrant of four images were formatted to the same pixel dimensions of the monitor at 1680 x 1050 pixels. Color vibrancy was manipulated by increasing color saturation in image adjustments. For examples of the modifications made to animal color vibrancy see Figure 2. Eye size was manipulated by selecting the eye and application of a Gaussian blur to reduce pixilation. The image was finalized by transforming the eye to the desired eye size percentage. For an example of eye size manipulation see Figure 3.

Figure 2. Changes in color vibrancy of butterfly (top to bottom: normal and +40%)

Figure 3. Changes in eye size of butterfly (top to bottom: normal and +40%)

Experimental Design

The task consisted of eight trials. Each trial consisted of a unique butterfly, therefore each participant observed the same eight butterflies. During each trial, the animal image displayed consisted of four images of the same animal, with three modified, presented in a 2 x 2 quadrant. The modified animal image had an increased or decreased color vibrancy or eye size. During each trial, only the vibrancy or the eye size was modified. For vibrancy and eye size manipulation, half of the possible trials were modified and weighted negatively (-40%, -20%, 0%, +20%) and the other half weighted positively (-20%, 0%, +20%, +40%).

This produced a 2 x 5 non-repeated measures between subjects factor design, where either eye size or color was modified along the five weight categories. The seventeen participants were split into two groups, A and B. For group A, the color vibrancy of even numbered stimuli were manipulated while eye size was manipulated for odd numbered stimuli. Stimuli shown to group B received the counter treatment. The dual separation between eye size and color among stimuli resulted in a between-groups effect. This design permitted each participant to view every stimulus rather than one participant viewing the same animal more than once, thereby reducing repeated exposure effects.

Within each group, the ratio of the manipulated variable was counterbalanced between a positive weighting or negative weighting. Additionally, the respective quadrants in each trial was randomized. Counterbalancing the ratio of the manipulated variable and the rotation of the stimuli within the quadrants produced within group effects. To reduce ordering effects and other potential sources of error, each participant observed the eight stimuli in complete random order.

Procedures

Participants were verbally approached by a researcher and asked if they would be willing to participate in a short research study. Upon acceptance, the participants were escorted to the lab where they were instructed to sit down in a chair and to silence their cell phones. An overview of the experiment was described and then each participant was handed an informed consent document and given time to review the information and to ask any questions. Following verbal consent, the researcher asked each participant demographic and general questions related to the participant's vision and recorded the responses. Next, an explanation of the task and instructions on responding were given.

The participant was then moved to another seat, where calibration instructions were given and then proceeded to complete a nine-point calibration with the eye tracker. Following calibration, each participant was shown a blank white screen, the participant was then shown a white screen with a crosshair as to center the participant's visual gaze and attention. The participants focused on the crosshair for three seconds and then the computer automatically progressed to the target image. This was done to control for the origin for the first fixation. When the computer proceeded to the target stimulus, the target was displayed for a total of seven seconds. Upon the completion of the seven second interval, each participant was shown an image which displayed clear choices of A, B, C, or D which overlaid the previous locations of the target stimuli. The participant then vocalized their selection of the unmodified image to the researcher within seven seconds. This followed recommendations from Hout & Goldinger [13], which was done to control the total exposure to each target stimuli while also allowing for an accurate and appropriate response time. See Figure 4 for an example of the procedure. This process was repeated for a total of eight trials. After the experiment, each participant was thanked and dismissed.

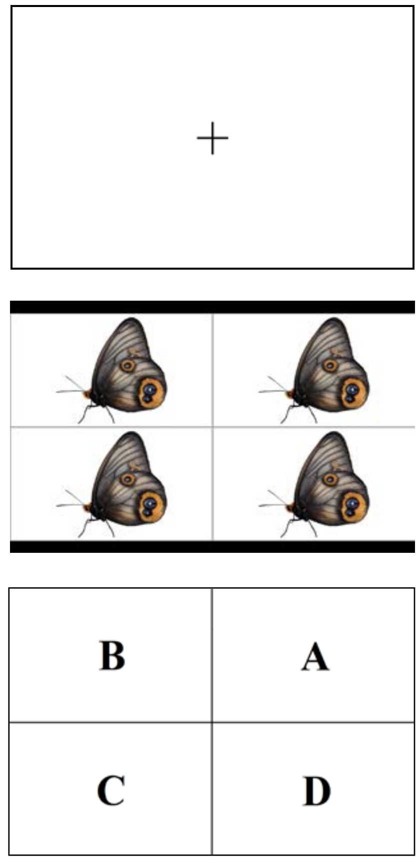

Figure 4. Experimental procedure (top to bottom: procedural order)

RESULTS

Data Summary

In order to classify fixations, we utilized a third-order Savitzky-Golay (SG) differential filter with width 5 to smooth the gaze points at a sampling rate of 60 Hz. The velocity threshold for the SG filter was set to 30°/s. Of the seventeen participants, fixation data was not analyzed for one participant due to equipment error. Additionally, all data from three participants were removed prior to analysis due to error that was identified after the data was processed. Of the thirteen usable participants, data was processed so that total fixations and total duration would be calculated for each image quadrant used in the study, resulting in 416 data cells for both total fixations and total fixation duration. Data was then cleaned by removing outliers beyond three standard deviations, leaving 408 data points for total fixations and 406 data points for total fixation duration. Average number of fixations per image in each quadrant was 4.12 (SD = 1.86) and average fixation duration was 1.29 seconds (SD = 0.59 seconds).

Eye Size and Color Manipulation

We used a MANOVA to test our original hypothesis that an increase in eye size and color vibrancy would result in increased total fixations and total fixation duration. We found no significant effect for either eye size or color in predicting total fixations or fixation duration. We then ran a two-way ANOVA using eye size and color to predict participant choice and found no significant effect. After finding no significant relationship between eye size and color manipulation, we then ran a MANOVA for butterfly type, modification type, modification amount, and image location to predict fixations and found that only location was significant in predicting total fixations (($F_{(3, 331)} = 13.40$, $p < .001$) and total fixation duration (($F_{(3, 331)} = 11.16$, $p < .001$). Following this finding, we ran a MANOVA using participant ID, choice, and image location to predict number of fixations and total fixation durations. There was a significant effect for the number of fixations in the corrected model ($F_{(105, 298)} = 3.17$, $p < .001$, adjusted $R^2 = .361$). There was also a significant effect for total fixation duration in the corrected model ($F_{(105, 298)} = 3.463$, $p < .001$, adjusted $R^2 = .391$).

Participant Differences

The main effect of participant ID was significant in predicting total fixations ($F_{(13, 298)} = 3.90$, $p < .001$) and total fixation duration ($F_{(13, 298)} = 2.26$, $p = .007$). The interaction between participant ID and image location was significant in predicting total fixations ($F_{(39, 298)} = 2.68$, $p < .001$) and total fixation duration ($F_{(39, 298)} = 2.75$, $p < .001$). The interaction between participant ID and image selection was not significant for either total fixation or duration. The interaction between participant ID, location, and choice was not significant for either total fixation or duration.

Choice

The main effect of choice was significant in predicting total fixation duration ($F_{(1, 298)} = 24.44$, $p < .001$) but not significant in predicting total fixations. The interaction between choice and location was significant in predicting fixation duration ($F_{(3, 298)} = 6.65$, $p < .001$) but not total fixations. Figure 5 displays the interaction between choice and quadrant location for fixation duration, notably fixation duration is longer for images which are selected when the image was located on the top row of the 2 x 2 quadrant. A post-hoc test revealed that fixation duration was longer on targets that were selected by the participant (M = 1.45 seconds, SD = 0.61 seconds for selected targets and M = 1.25 seconds, SD = 0.58 seconds for targets that were not selected). Additionally, we conducted a one-way ANOVA and found there to be no significant difference between the location of the correct (unmodified) butterfly image and choice. Lastly, of the 128 total selections made by the participants, only 23 were correct (18% correct).

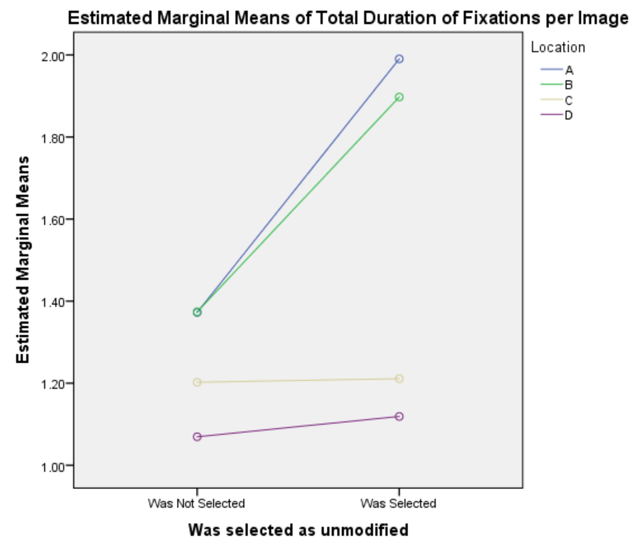

Figure 5. Choice x quadrant interaction for fixation duraiton.

Quadrant Location

The main effect of location was significant in predicting total fixations ($F_{(3, 298)} = 36.53$, $p < .001$) and total fixation duration ($F_{(3, 298)} = 5.52$, $p < .001$). A post-hoc test revealed that fixation was significantly different between target stimuli on the top row of the target quadrant image compared to the bottom row ($p < .001$ for both). Participants on average fixated on the top row 4.64 times (SD = 1.8), which is on average one fixation more than spent on the bottom row (M = 3.6 fixations, SD = 1.76). A similar pattern is reflected in fixation duration, where participants spent more time on the top row than on the bottom (M = 1.44 seconds, SD = .62 and M = 1.15 seconds, SD = .53, respectively). For an example of fixations per quadrant see Figure 6 and Figure 7 below.

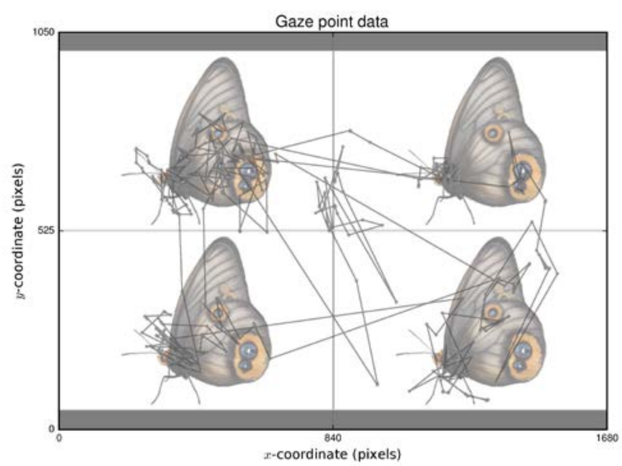

Figure 6. Gaze fixation visulaizaiton (gaze map).

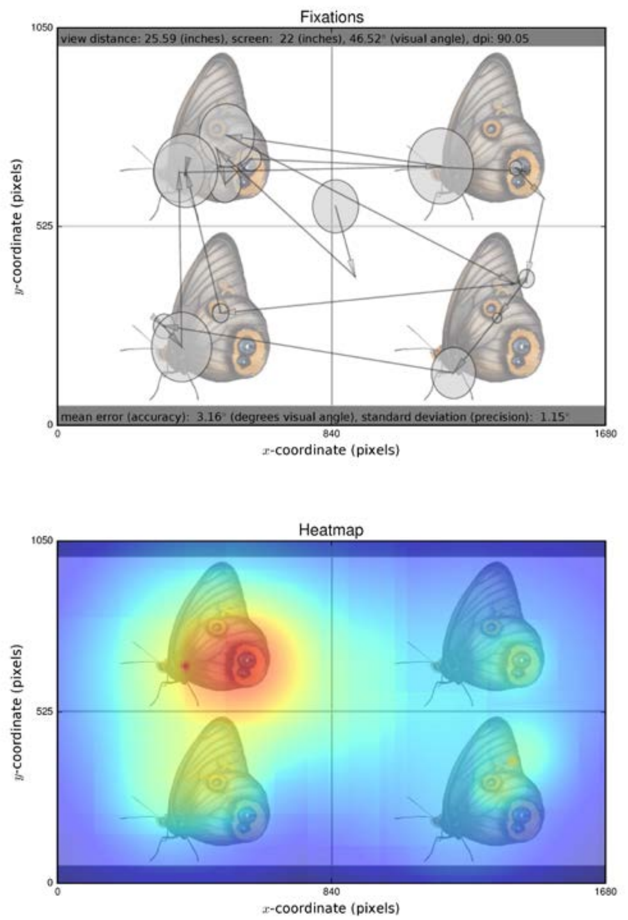

Figure 7. Gaze fixation visulaizaitons (top to bottom: fixation map and heat map)

DISCUSSION

Findings from our study did not support our original hypothesis as we found no significant relationships between butterfly modification type or intensity level with selection. The lack of any significant relationship between eye size and color in participant selection could be a result of there being no effect. However, we did find significant relationships within our data set that we did not initially expect. Of our findings, the most interesting was the effect of location and choice in visual fixation.

The observed relationship between choice and fixation is peculiar, in that duration was significantly different between selection and non-selection, while the number of fixations was not significant. That being said, long fixation times in relation to choice selection may be more indicative of more general human behavior. This notion is supported by other studies [7] which suggest that indeed longer duration times are usually related to choice. Furthermore, the same article suggests that the last object fixated on is also related to choice. Further analysis of our own data may reveal a similar relationship.

More peculiar was the relationship between fixations and the target locations. Unlike choice, location was significantly related with both number of fixations and total duration. We again believe this finding to be representative of general human behavior, particularly our assumption is that an increased fixation upon the top row is reflective of cultural differences which is supported in the literature [16,22]. We theorize that fixating longer on the top row reflects how western society reads from top left to bottom right.

CONCLUSION

Our data did not support our hypothesis that animals with bigger eyes and brighter colors would be fixated upon longer than animals with smaller eyes and dimmer colors. While our hypothesis was not supported, we did find evidence for broader characteristics of human behavior that may underlie visual fixations.

We conclude by addressing our additional findings involving choice and location effects on visual fixations. We theorize that these results may actually reveal further insight into our initial hypothesis. Specifically, our findings suggest that there may be a tendency for people in western society to fixate upon the top row of targets when shown images in sets of four. This suggests that our experimental design of having four target images may have biased or limited our findings in relation to our hypothesis.

Furthermore, the equal distribution of participant selection across the four quadrants suggest that choice may have been random. Paired with this knowledge, we theorize that the differences between the target stimuli may not have been unique enough to identify differences in the amount of time given to the participants. Lastly, there were no differences between the eight butterflies used. We theorize that had we implemented a more diverse selection of animal images, beyond butterflies, we may have found additional relationships. With this in mind, we suggest that future studies concerning human perceptions of animals should improve upon our study design and learn from our findings concerning more general human behavior.

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