The following article is the result of a formal study recently completed by senior graduate students at the Southern California College of Optometry and supervised by professor, Dr. Chase, a renowned authority on visual reception. The study was designed to determine scientifically if there is a difference in the detectability and visibility, by human observers, in clothing made from solid orange vs. camouflage pattern orange.

Detectability and Visibility of Solid Hunter Orange Vs. Camouflage Hunter Orange To Human Observers

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ABSTRACT: *Purpose*: The purpose of this investigation was to determine if there is a difference in the delectability and visibility, by human observers, of clothing made from solid orange vs. camouflage orange cloth. *Methods*: Subjects 53 adult subjects from 20 to 83 years of age volunteered as subjects. Setup The environment was a wooded area with a grassy clearing with pine trees as background on a clear summer evening. One target each of solid and camouflage Hunter Orange targets were hung on easel stands separated by 10 yards at a distance of 100 yards from the subjects. Targets were 216 inches square, the approximate size of an average male's torso. Procedure Subjects were instructed to identify the most detectable target of the two when abruptly revealed, and the most visible target on sustained viewing. Five to ten people were tested at one time for five trials each. *Results*: For detectability, 79% found solid orange more detectable that camouflage orange on the basis of having a count of 3 or more out of 5. For visibility, 91% selected the solid target 3 or more times out of 5. *Comments*: In this study which simulates a stationary hunter, the solid Hunter Orange cloth sample orange was significantly more detectable and visible than the camouflage pattern. It remains to be determined if this finding is true over a wide variety of hunting environments and situations.

Objective

The purpose of this study was to determine if there is a difference in the detectability and visibility, by human observers, of clothing made from solid orange vs. camouflage orange cloth. This study may provide valuable information that is important to hunting safety and to the legislation of hunting laws. It could have impact on the 17 million people who purchase hunting permits in the United States each year.[1] This project may also initiate other studies that ultimately result in safer hunting procedures and regulations that save lives.

Background

The use of "Hunter Orange" garments is a safety measure. It is worn by hunters to increase their visibility to other hunters so that they will not be mistaken for game. The

International Hunter Education Association (IHEA) and the Canadian Ministry of Natural Resources define “Hunter Orange” as “having a dominant wavelength between 595 and 605 nanometers, a luminance factor of not less than 40% and an excitation purity of not less than 85%.” [2,3]

According to a 1995 survey supported by the IHEA, forty states in the U.S.A. and five provinces in Canada require hunters to wear Hunter Orange for big game hunting.[2] All other states strongly encourage hunters to wear Hunter Orange. It should be noted, in those states requiring Hunter Orange, that the amount, specified in square inches, and the type of garment vary according to state regulations. Most states require a total of 400-500 square inches to be visible on the chest, back, and head. Sixteen states and three provinces specifically require “solid” Hunter Orange. The remaining states and provinces either allow or do not make specific reference to camouflage pattern Hunter Orange. Additionally, Maryland, Michigan, Minnesota and Wisconsin state laws require a camouflage orange pattern to consist of at least 50% Hunter Orange.[2]

Several studies have demonstrated that there is a lower proportion of hunting accidents among those hunters who wear Hunter Orange compared to those who do not wear Hunter Orange garments.[1] In New York State from 1989 to 1995, of the 125 incidents in which hunters were mistaken for game, only six (5%) were wearing hunter orange. North Carolina laws requiring hunters to wear orange clothing have significantly reduced the number of deaths and injuries resulting from people being mistaken for game.

A relevant side issue is “how do deer and other large game animals see Hunter Orange garments?” Hunters want to know if wearing bright orange garments will reduce

their hunting success. Historically, there are conflicting opinions about the ability of deer to see color. It has been stated that "these animals are completely color blind"[5]. This belief that deer are color blind, and therefore, cannot see Hunter Orange as humans do, may have helped promote acceptance for the use of Hunter Orange garments.

There is, however, a body of evidence that supports the belief that deer are capable of seeing color based on anatomy, electrophysiological function, and behavior. Both light and electron microscopy reveal the anatomic presence of both rods and cones in the retina of white-tailed deer.[6] Electroretinogram (ERG) photometry, conducted on two species of deer, has demonstrated the presence of rod and cone cells with maximum sensitivities at 497 nm and 450-460 nm respectively.[7] Behavioral studies have shown that deer can be trained to discriminate color stimuli, providing evidence for the presence of color vision[8,9]

Although humans have three types of cone cells to provide color vision, carnivores and ungulates, including deer, have a color vision that is based on only two types of cones cells.[10] This simplified type of color vision would result in a difficulty distinguishing colors of objects that reflect light in the middle to long wavelengths (green, yellow, orange, and red.) For a deer observing a hunter, this implies Hunter Orange would provide no contrast against the surrounding field environment. However, these animals have an excellent ability to detect blue and UV light that is filtered out by the human lens. A hunter who wears garments that are highly reflective of UV light may be more visible than one whose garments do not reflect UV.[10]

Among hunter education associations and state hunting agencies, the use of Hunter Orange clothing is broadly accepted as a means of making a hunter more visible

and detectable to other hunters. To our knowledge, however, there have been no studies, reports or surveys to date that specifically evaluate the visibility, and thus the safety, of solid verses camouflage pattern Hunter Orange garments. Nevertheless, manufactures of hunting garments are producing and marketing a vast selection of camouflage Hunter Orange garments and state agencies are implementing or perpetuating hunting garment regulations. This may lead to more accidents and injuries in the field, as hunters assume they are visible safe enough to other hunters. Therefore, a scientific study evaluating solid and camouflage Hunter Orange is needed.

Methods

Subjects: We recruited 53 adult subjects to voluntarily participate as subjects in this study. We used a sample of convenience for enrolling subjects who were individuals who had come to a wooded picnic area for their own relaxation. Subject ages ranged from 20 to 83 years with the mean being 38.7 years of age. There were 30 males, 20 females and 3 subjects who did not indicate their gender on their answer form. Subjects were not screened to determine visual acuity or color vision defects just as hunters are not screened when they purchase a hunting permit.

Setup: One target each of solid and camouflage Hunter Orange targets were hung on easel stands separated by 10 yards at a distance of 100 yards from the subjects. The cloth, donated by the IHEA, was consistent with the definition of "Hunter Orange" as previously stated. The camouflage target was approximately 50% hunter orange and 50% gray and green splotches. Each target measured 216 inches square, which is the approximate size of an average male's torso while wearing a coat. The study was

conducted on a grassy clearing with pine trees as the background on a clear summer evening.

Procedure: Each subject was shown the location of the targets and instructed to identify which target (right or left) was (1) most detectable immediately upon removal of a cardboard blind and (2) which was most visible upon sustained viewing. After the subjects had obstructed their view, the targets were switched in a predetermined sequence. The subject then uncovered his/her face, viewed the target, and recorded a response. This was repeated for five trials. For efficiency purposes, subjects were tested in groups of 5 to 10 people at one time.

Results

Figure 1 compares graphically the numbers of subjects who selected the solid target and the camouflaged target immediately after removal of the blind on each of the five trials. For each subject, the number of trials on which the solid target was first detected was determined. These counts range from 0 to 5, but the median is 4 with 79% (42/53) of the subjects having a count of 3 or more and 53% (28/53) having 4 or 5. If there were no bias toward the selection of the solid or camouflaged targets, the distribution of these counts would have been centered near 2.5. The observed median of 4 is significantly greater than 2.5 (Wilcoxon signed rank test, $W = 1181$, $P < .0005$). The median counts for male and female subjects were 3.5 and 4, respectively, which were not significantly different (Mann-Whitney test, $W = 541$, $P = .53$).

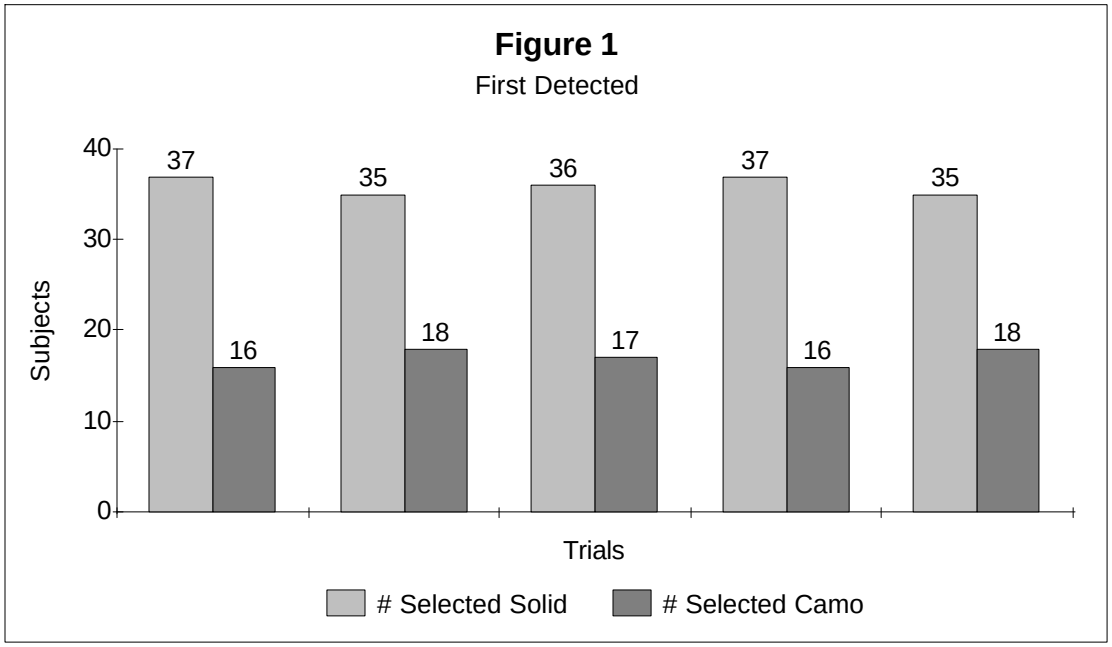
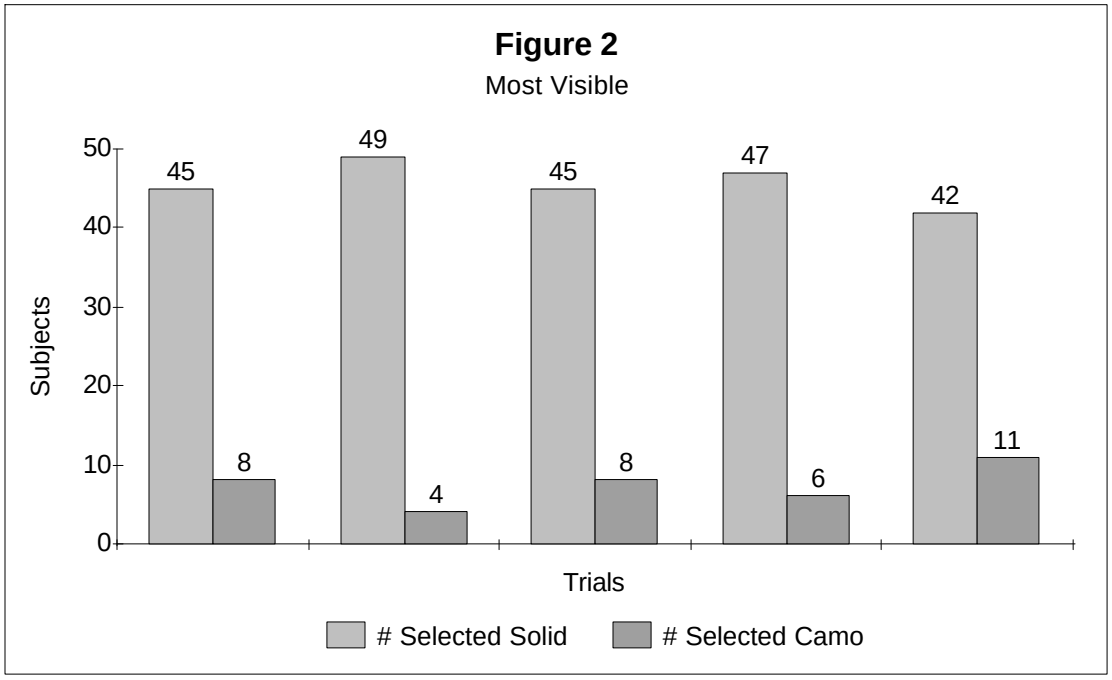


Figure 2 graphically summarizes the “most visible” data – that is, the numbers of subjects who selected the solid target and the camouflaged target after sustained viewing. For the 53 subjects, the median number of solid target selections on the five trials was 5 with 91% (48/53) selecting the solid target three or more times and 85% (45/53) having four or five solid target selections. The median of 5 was significantly greater than 2.5 ($W = 1399.5$, $P < .0005$), and the male and female medians, 4 and 5 respectively, were significantly different ($W = 626.0$, $P = .010$).



Comments

Analysis of our data shows a solid Hunter Orange cloth sample, which simulates a stationary hunter, is significantly more detectable and visible than a camouflage pattern Hunter Orange cloth. Further studies are necessary to determine if this remains true over a wide variety of hunting environments, weather conditions and times of day.

If deer and other game animals do indeed have a limited range of color vision, bright orange would not likely stand out to these animals as it does to humans. Rather, hunters should be more concerned with an animal's ability to see ultraviolet that is reflected from hunting garments.

It is difficult, if not impossible, to predict by how much safer a hunter would be using solid orange garments. It is our opinion, however, that any safety measures that reduce preventable injury and death outweigh the potential gains of acquiring more game through the use of camouflage pattern orange garments.

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