Do we need the red-green color channel in order to detect fruit?

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Color perception is an important ability in our everyday life. It facilitates object perception and improves memory of these objects. There is an ongoing controversy whether trichromatic primates take advantage of their ability to discriminate red and green colors in order to detect ripe fruit embedded in foliage. This issue is closely related to the question whether primate trichromacy evolved to detect this food source.

Humans and some non-human primates are trichromatic, i.e. their eyes contain three types of receptors, which respond to light of different wavelengths. The outputs of these receptors are transformed into two color-channels and one luminance-channel. Cells in the two color-channels respond to opponent colors (red-green, blue-yellow). The other primates are dichromatic, they possess only two types of color receptors in the retina. In humans, there are three types of genetically determined dichromacy. Some of the dichromatic humans and non-human dichromatic primates cannot discriminate between red and green as good as trichromats.

Previously, researchers observed non-human primates in Kibale rainforest (Uganda) for several months and recorded the color of their food with a spectrometer. They found that ripe fruits could be discriminated from unripe fruits using both opponent color-channels. This result suggests that there is no advantage of being trichromatic to solve this task.

In contrary to the studies conducted before, we did not look at the opponent color-channels themselves, but at the color-contrast in these channels. Color-contrast can be interpreted as a measure of how different colors in a certain region are. In the rainforest, fruits are normally surrounded by greenish leaves. This arrangement could produce a high color-contrast in opponent color-channels. In addition, we assessed the salience of the red-green and the blue-yellow color-contrast, i.e. their ability to influence eye-movements.

To this end, we recorded eye-movements of human subjects, while they were looking at images of Kibale rainforest. The images showed mainly foliage with embedded fruits. Since we wanted to make a statement about color-channels in primates, these images were taken with a color-calibrated digital camera, which models the responses of the color receptors in the human eye.

As a first step, we analyzed color-contrasts at the subjects' fixation locations (baseline). We found that red-green color-contrast is more salient than blue-yellow color-contrast, i.e. people tend to look more at regions of high red-green color-contrast. Then we defined regions of interest on fruit objects and selected only fixations out of these regions. For those selected fixations, the saliency-value for red-green color-contrast is more than twice the baseline value. There is only a small increase for blue-yellow color-contrast. This shows that red-green color-contrast is higher at fruit objects compared to the other parts of the scene. This result could seem trivial at first glance, but the color of fruit and foliage is strongly influenced by the blue-yellow color-channel.

In order to further analyze differences between the two opponent color-channels, we calculated the similarity of fixation locations between the different subjects. We changed the images in the following ways: we either removed the red-green or the blue-yellow color information. In unmodified images and images devoid of blue-yellow color information, similarity of fixation locations between subjects is significantly higher than in images devoid of red-green color information. This shows that different people looked at similar locations in the images, when red-green color information was present. However, when red-green color information was removed, people did not look at the same locations that often.

Our results suggest that red-green color-contrast is an important feature for the guidance of eye-movements and the detection of fruit on a background of foliage. Thus, dichromatic non-human primates should be less efficient in finding fruit by visual inspection. This prediction could also apply to some of the dichromatic humans.