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Heatmap analysis of profile facial images

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Introduction

Facial images are a very common element on the World Wide Web and in mobile applications. With the widespread use of eye-tracking systems, research in the field of viewing and memorizing facial images has greatly expanded. The main issue in analyzing facial images is to understand the way of viewing, memorizing and recognizing. Most of the research is done for the frontal facial images, but we focused on profile facial images. One of the most widely used methods for determining memorization and recognition of facial images is the internal facial feature method. However, in our research we have focused on the new heatmap method.

Problem Description

Heatmap method is the new method where the results of area, perimeter and circularity of heatmaps are analyzed. For the whole research we used a standardized memory test comprising two phases: an observation test and a recognition test. To analyze the influence of time on recognition success, we set four display times of facial images in observation test (1s, 2s, 4s, 8s). The results show that the recognition success increases with increasing display time of the facial images in the observation test. The turning point occurs at a display time of 4 seconds, as the recognition performance in the 8s test is almost the same as in the 4s test. The heatmap analysis method shows an increase in the area and perimeter of the heatmap areas up to the 4s test, after which both values remain practically the same. After that, both values remain practically the same. At this point, the circularity of the viewing areas also no longer decreases and is the same in the 8s test as in the 4s test. The results of the heatmap analysis are therefore in good correlation with the results of the facial recognition and proved the usefulness of heatmap analysis for research into the observation and recognition of facial images.

Methods

We took the images from the Minear and Park Face Database (Minear & Park, 2000). The facial images were prepared according to the conditions of natural observation (Kealey et.al, 2008, Henderson et.al, 2000). The conditions of natural observation mean that we look at a real face at a distance of one meter. The set of 20 facial images was equally selected by gender (10 male and 10 female). For the recognition test we added 20 new faces to these faces (also 10 male and 10 female).
As mentioned above, we conducted 4 tests for each observation time. Every test was done for 6 participants, so all together we recruited 24 participants (7 male and 17 female). They were our students and had normal vision. Average age was 20,3 years (SD = 0,96).
We have conducted a memory test according to the previously mentioned YES/NO principle. We performed two tests, an observation test, and a recognition test. The procedure observation test is shown in Figure 1.

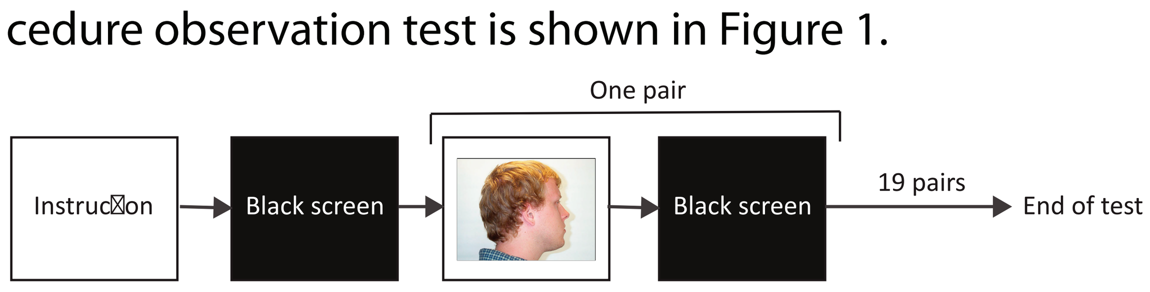

Figure 1
Procedure of the observation test

The observation test was followed by the recognition test (Figure 2).

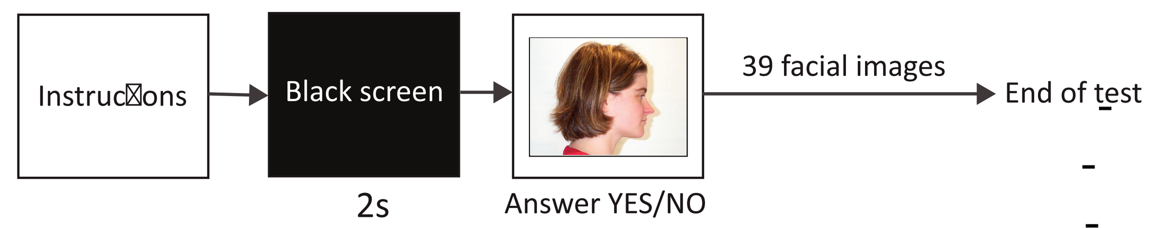

Figure 2
Procedure of the recognition test

The first part of the study provided us with the results of the average time of correct answers (CA) and incorrect answers (FA – False alarm) for each of the 4 tests. Those two data are then used to calculate recognition success (discrimination index A'). For the second study, we first set the eye-tracking system to create heat maps in grayscale instead of colour. So instead of red, yellow and green, we set black (R = G = B = 0), dark grey (R = G = B = 85) and light grey (R = G = B = 170). These greyscale images were then converted into black and white images using the ImageJ program. The process is shown in Figure 3.

Figure 3
Converting color heatmaps to grayscale heatmaps to a black and white image

We then used the ImageJ program to calculate the area size, perimeter and circularity of the black and white heatmaps.

Results

Figure 4 shows recognition success and incorrect recognition (false alarm) as a function of the observation time.

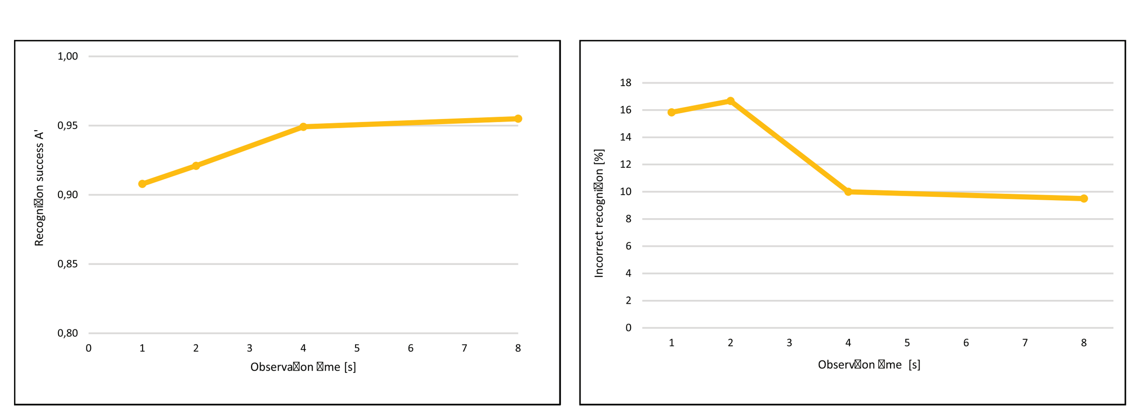

Figure 4
Recognition success and incorrect recognition (false alarm)

Figure 5 shows area size, perimeter and circularity of heatmaps as a function of the observation time.

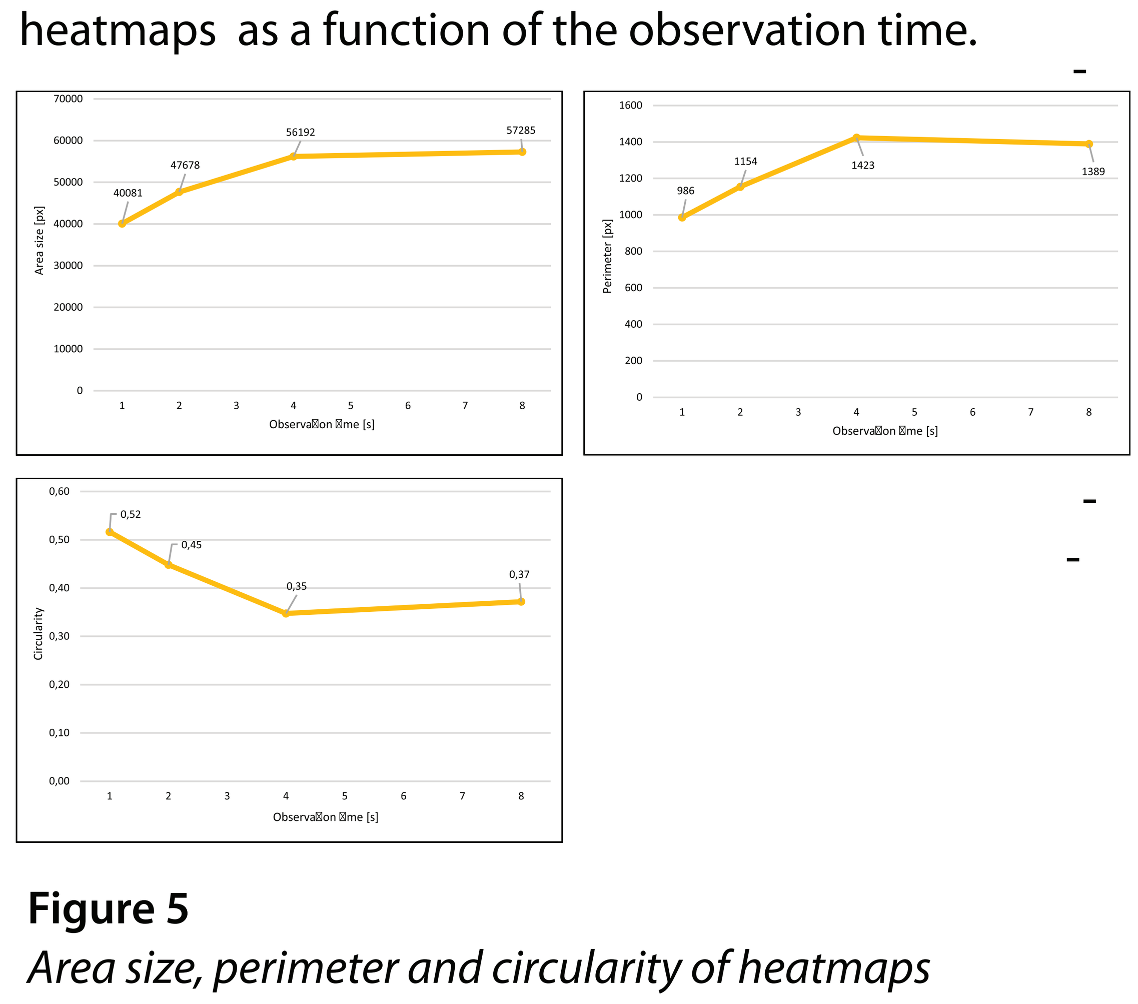

Figure 5
Area size, perimeter and circularity of heatmaps

Discussion / Conclusion

As we suspected, the recognition success increases with a longer observation time of the facial images in the observation test (Figure 4). This increase takes place up to an observation time of 4 seconds. In the 8-second observation test, the recognition performance is almost the same as in the 4-second test. The same applies to the result of incorrect recognition. With short observation times of facial images, the memorization ability is naturally poorer and thus the incorrect recognition is higher (15.8 % in the 1-second test and 16.7 % in the 2-second test). At the same time, memorization of facial images is much better in the 4-second test and incorrect recognition falls to 10.0%, and it remains at approximately the same level in the 8-second test (9.5%).
When analysing the Heatmaps, it can be seen in Figure 5 that their area is smallest when the observation time of facial images is 1 second, which is of course to be expected. With a longer observation time of facial images, users saw a larger part of the face, which also means a larger area of the Heatmaps. 4-second test and 8-second test had the same area size of the Heatmaps, which indicates that between 4 and 8 seconds, participants mostly looked at previously observed parts of the face. The same thing happens when measuring the perimeter of the Heatmaps. It increased until 4-second test, but for the 8- second test it even decreased a little (from 1423 to 1389 px). The reason for this is that there are certain cases where we obtained two separate Heatmaps in the 4-second test, for example, whereas in the 8-second test the participants observed a larger part of the facial image and these two Heatmaps merged into one. The results of the circularity shows that it is highest in the 1-second test and then decreases towards the 4-second test. This is because with longer observation time the participants observe larger part of the facial images, the views are more scattered and the Heatmaps have more varied shapes. There is practically no difference between the 4-second and 8-second test, which we have already seen from the results of the area and perimeter of the Heatmaps.
All results showed a similarity between the measured values. Thus, we found that a turning point occured everywhere at the observation time of 4 seconds. Up to this point, as the time observation increased, the recognition success (A') increased, the false recognition decreased, the area and perimeter of the Heatmaps increased and the circularity decreased. All these values remained almost the same for the 4-second and 8-second tests. With these results, we can explain the nature of observing facial images, which is such that the participants' gaze first land on the eyes, then in 4 seconds they observe the remaining parts of the face image, and between 4 and 8 seconds, participants observe parts of the faces in the facial images that they had already seen before. With our study, we have demonstrated the usefulness of measuring Heatmaps.

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