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Eye tracking study of frontal and profile face image observation and

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Introduction

We see faces in nature when we communicate with other people in different representations. We talk about different angles in the representation of facial images and also about the representation of faces in different emotional states. In our study, we limited ourselves to a neutral facial expression and defined two different angles of representation of the facial image (frontal and profile representation). Some previous studies (1) have shown a better memory for facial images in frontal view. In our research we combined different representations of facial images in the observation and recognition process. We measured the fixations duration and the saccades length from which they can determine memory performance of facial images (2). In our study, we also used a new method of heatmap analysis, in which we measure the area, perimeter and circularity of the viewing areas (3). To obtain these results, we used eye tracking technology.

Problem Description

We were interested in which combination of observation and recognition of facial images was better: observation of the frontal view and recognition of the profile representation or the inverse combination of observation of the profile representation and recognition of the frontal view.

Methods

Our tests were attended by 22 test participants, 6 men and 17 women (average age of 20.6, SD = 1.02). They were our students, all of whom had normal vision. For testing purposes we took 40 male and 40 female facial images from the Minear and Park database (4). We selected 20 faces for both genders, as well as a frontal and a profile image for each face. The dimensions of the facial images were 800 x 800 and were displayed at a distance of 60 cm from the screen. We performed the test with Tobii X-120 eye tracking system. We had two main tests, and both were divided into observation and recognition test. This is commonly referred as a memory test. Procedure of tests are presented in Figure1.

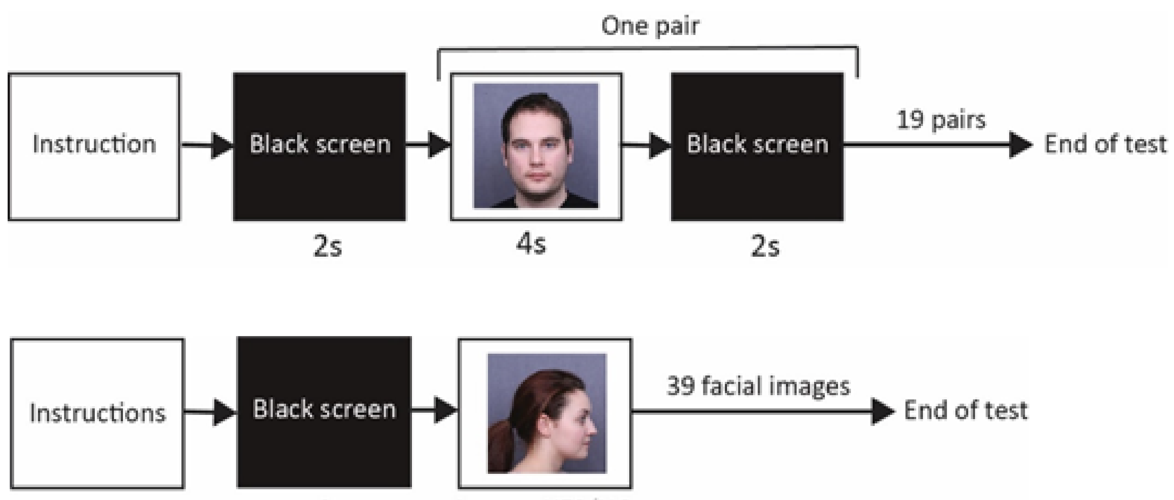

Figure 1

Procedure of observation and recognition test

The recognition results were presented as correct and incorrect recognition. Another group of results was measuring the fixation duration and saccade length. The fixation duration was obtained directly from Tobii Studio, and saccade length was calculated by as a distance between two consecutive fixations, as shown in Equation 1.

$$F_1F_2 = \sqrt{(x_1 - x_2)^2 + (y_1 - y_2)^2} \quad (1)$$

The saccade length then had to be converted from px to angular degrees ° using Equation 2.

$$\alpha = \arctan \frac{F_1F_2}{60\,R} \quad (2)$$

where R is the screen resolution. In our case we set 27.5 px / cm.

The third group of results was the heatmap analysis, where we analysed their area, perimeter and circularity. The procedure was as follows: colour heatmaps were converted to grayscale (in Tobii Studio) and grayscale were then converted to black and white in ImageJ. In this program, we also calculated the parameters of these heatmaps described above. The procedure is shown in Figure 2.

Figure 2

Colour, grey and BW heatmap

Results

We compared the test results of two different conditions (frontal observation, profile recognition and opposite). Table 1 shows the correct and the incorrect recognition.

Table 1

Results of correct and incorrect recognition for both tests

Test combination	Correct recognition	Incorrect recognition
Frontal observation, profile recognition	72,9 %	10,7 %
Profile observation, frontal recognition	69,2 %	25,4 %

Further results were fixation duration and saccade length (Table 2). In the controlled observation tests (4-second image display) they were more comparable than in the recognition test, in which the image display times were controlled by the participants themselves.

Table 2

Results of fixation duration in saccade length for both tests

	Fixation duration (ms)		Saccade length (°)	
Test combination	Observation	Recognition	Observation	Recognition
Frontal observation, profile recognition	320	308	3,79	4,97
Profile observation, frontal recognition	349	266	4,72	4,14

We analysed heatmaps for both cross-tests, but only for the observation process, since we had controlled conditions (observation time 4 seconds). The results of the area, perimeter and circularity of heatmaps and are shown in Table 3.

Table 3

Results of area, perimeter and circularity of heatmaps in the observation test

Test combination	Area (px)	Perimeter (px)	circularity
Frontal facial images	46029	888	0,739
Profile facial images	39269	784	0,805

Discussion / Conclusion

As can be seen from Table 1, the correct recognition was better for the combination of frontal view observation and profile recognition than the reverse combination (72.9% vs. 69.2%). An even greater difference occurs with incorrect recognition (25.4% vs. 10.7%). The reason is the poorer memory of profile facial images, because in profile view there are fewer facial features according to which we remember and distinguish faces.
Regarding fixation duration, we see that the fixation duration was shorter in the observation for frontal facial images. This can be seen in both the observation test (frontal 320 ms, profile 349 ms) and the recognition test (frontal 266 ms, profile 308 ms). We see the reason for this in the greater number of facial features in frontal view that attracted participants gaze, so that there are more eye movements and the fixations are consequently shorter.
Results of saccade lengths in the observation process shows that these were shorter in frontal facial images (3.79 °) than in profile facial images (4.72 °). Frontal facial images have more facial features that are relatively close together (eyes, nose, mouth), so saccades are shorter than in profile facial images, where fewer facial features are shown and are further apart. Similarly, the saccades in the recognition test are shorter (4.14°) in frontal facial images than in profile facial images (4.97°).
In Table 3, and we can see that the area and perimeter of the heatmap are larger in the frontal facial images (46029 px and 888 px) than in the profile facial images (39269 px and 784 px). In the case of circularity, the result is the opposite, profile images have a higher circularity (0.805) than frontal images (0.739). These results can again be explained by the structure of the frontal and profile facial images themselves. Frontal facial images have main facial features (eyes, nose, mouth) arranged further apart. In profile facial images, one eye and the nose are the main facial features that attract attention and are close together. Therefor the area of the heatmaps is smaller and consequently the perimeter is smaller. However, these areas are geometrically rounder and the circularity is greater.
The reason for better memory of frontal facial images is that they contains more facial features, so the face provides more information that helps us to remember it. In the frontal facial images, we see a larger part of the face, which was confirmed by the shorter fixation duration. There were more of these fixations, which in turn leads to a better memory of the facial image. A better memory for the frontal facial images due to the placement of the facial features was also confirmed by shorter saccade lengths. Method of heatmap analysis also confirmed that the memory of facial images is better in frontal images, where the area and perimeter of heatmaps are larger and circularity smaller.

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