Symmetry: The Building Blocks of Facial Recognition

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Introduction

Recognising a face from a multitude of different angles is called a viewpoint-invariance. It is thought that this symmetry plays a key part in the formation of viewpoint-invariance. Previous research has shown that certain areas of the of the temporal lobe have been found to be selective to certain viewpoints, (Kietzmann et al., 2012, 2017), especially with two symmetric viewpoints e.g. -90 and 90 (Flack et al., 2019). More specifically, symmetry effects have been observed within the right occipital face area (OFA), (Chen et al, 2007).

By discovering the role that symmetry plays within the creation of viewpoint-invariance, we gain a larger insight into facial recognition.

The hypotheses were as follows:
1) Symmetry responses will be more evident for unfamiliar faces than familiar faces.

2) Symmetry responses will be more evident to naturally occurring symmetry than to non-naturally occurring symmetry (rotation).

Using a series of three fMRI scans, with each consisting of either familiar, unfamiliar or rotated faces; the current study explores the theory that the human brain computes a viewpoint-invariance of faces, by investigating symmetry and its role in the recognition of faces.

Methods

Three fMRI (functional magnetic resonance imaging) scans were conducted: unfamiliar, familiar and orientation. All 25 participants took part in all three scans (11 male 14 female, mean age 23.5 ± 6.87). During the unfamiliar and familiar scans, the viewpoints of the faces changed.

These viewpoints were:
- (1) right profile (−90°)
- (2) right three-quarter profile (−45°)
- (3) front view (0°)
- (4) left three-quarter profile (45°)
- (5) left profile (90°)

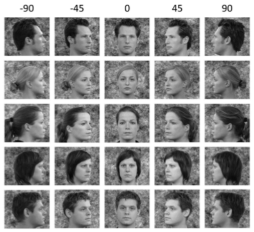

Figure 1: Stimuli used in the unfamiliar face scan.

Methods cont.

Figure 2: Stimuli used in the familiar face scan.

During the orientation scan, the faces were rotated as follows:
- (1) 90° rotated left (−90°)
- (2) 45° rotated left (−45°)
- (3) 0° rotation
- (4) 45° rotated right (45°)
- (5) 90° rotated right (90°)

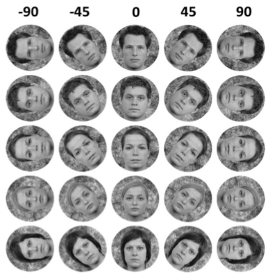

Figure 3: Stimuli used in the orientation face scan.

Images were presented in a block design with each block containing five images. Figure 1 shows the stimulus for the unfamiliar scan, figure 2 shows the stimulus for the familiar scan and figure 3 shows the stimulus for the orientation scan. Figure 4 shows the experimental design of the study.

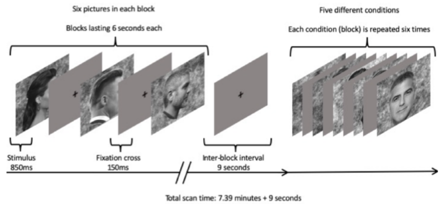

Figure 4: A diagram displaying the experimental design of the study.

Results

MVPA analysis was conducted on the data using masks of facial areas. To determine if there were significant differences, t-tests were run on the appropriate means, figure 5 shows a description of the t-tests.

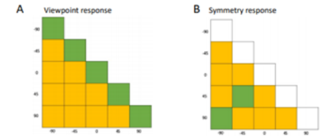

Figure 5: A) the green means compared to the yellow to find a viewpoint response. B) the green means compared to the yellow to find a symmetry response.

Unfamiliar

Significant viewpoint selectivity was found within the OFA (p<.001) and the STS (superior temporal sulcus) (p<.001) (figure 6). Regarding symmetry, the only significant response was in the OFA (p=0.003), (figure 6).

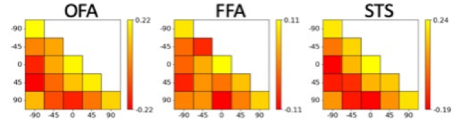

Figure 6: The MVPA analysis matrices for the unfamiliar scan.

Familiar

Significant viewpoint selectivity was found within the OFA (p<.001), the FFA (fusiform face area) (p=.034) and the STS (p<.001) (figure 7). Significant symmetry responses were found in the OFA (p=.042) and the STS (p=.003) (figure 7).

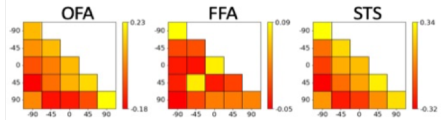

Figure 7: The MVPA analysis matrices for the familiar scan.

Orientation

Significant viewpoint selectivity was found within the FFA (p<.001) (figure 8). Significant, general symmetry responses were found in the FFA (p<.001) and the STS (p<.001) (figure 8).

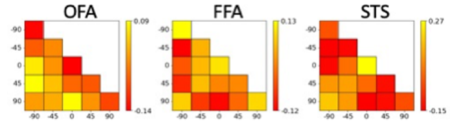

Figure 8: The MVPA analysis matrices for the orientation scan.

Conclusion

The current study hypothesised that symmetry responses will be more evident for unfamiliar faces than familiar faces. As well as, symmetry responses being more evident to naturally occurring symmetry than to non-naturally occurring symmetry (rotation). The first hypothesis yielded unexpected results, with symmetry responses being largely similar with both unfamiliar and familiar faces. Despite this, symmetry responses were found in the OFA in both the familiar and unfamiliar scans, but were not found in the orientation scan. This highlights that symmetry responses, specific to naturally occurring symmetry, rather than general symmetry, were found within the OFA and other lower-level visual areas, providing support for the second hypothesis.

This finding is interesting as it lends itself to the importance of symmetry within faces for recognition. It is evident from the results that, without the natural symmetry produced by an upright face, we see inconsistencies regarding viewpoint selectivity.

This is consistent with previous work (Kietzmann et al., 2012, 2017; Chen et al., 2007), which indicates that selectivity for naturally occurring facial symmetry may be present within the OFA as well as lower-level visual areas.

Future research could possibly include both unfamiliar and familiar rotation scans. This could go on to answer whether facial symmetry specific responses are present with familiar faces or, if when viewpoint-invariance is achieved, facial symmetry ceases to exist, and general-symmetry effects are only present.

References

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