Faces around the norm – fMRI of the Face Distortion Aftereffect

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Introduction

Face perception can be strongly affected by adaptation to previously viewed faces. For example, after adapting to a contracted face, a normal face appears expanded [1,2]. Adaptation aftereffects have been demonstrated along many of the dimensions that characterize natural variations in faces, including identity, expression, gender, or ethnicity [3-6]. While these aftereffects share many of the properties of low-level adaptation [7,8], the face adaptation transfers across size, position, and head orientation [2,3,9], implicating sensitivity changes in high-level neural mechanisms.

How adaptation alters face perception can be used to test between alternative models of face coding. In norm-based codes, the individual face is represented relative to a neutral prototype. Because this prototype corresponds to a null response, adaptation to it does not alter sensitivity and thus does not alter the appearance of other faces. Conversely, adapting to a non-average face reduces the response to the adapting face. This shifts the norm or neutral point toward the adapting face, inducing a negative aftereffect in the original prototype. An alternative to norm-based codes is an exemplar code in which faces are represented within mechanisms tuned to particular features or configurations. In this model no facial configuration is special, and adapting to any face should reduce the response to that face and bias the appearance of similar faces.The two models thus make different predictions for asymmetries in the adaptation effects.

Here we tested the neural substrate of these perceptual aftereffects by monitoring the hemodynamic response in face-selective cortical areas while observers viewed an alternation between an original and distorted face using fMRI. This experimental design allowed us to readily compare aftereffects for pairs of faces that varied in the degree to which they differ from a potential prototype.

Methods

13 right-handed, healthy volunteers (4 male, mean age: 27 years) participated in the study. BOLD fMRI was performed at 3 Tesla (Siemens Magnetion Trio; whole-brain EPI, TR 2000ms, TE 36ms, $2x2x4mm^3$) and face stimuli were presented via LCD-goggles in the center of the screen. An even block design was used with 17x18s cycles that started with a normal face and then alternated between a contracted face (adapting image, 18s) followed by a normal face of the same or different identity (test image, 18s) (**Figure c**). Subjects had to view the adapting and test images passively and were instructed to focus their attention on the middle of the screen. Furthermore, the fusiform face area (FFA) [10] in the fusiform gyrus was localized by presenting 18s blocks of grayscale face and house images interleaved with 18s of Fourier-transformed images. Each face and house block was repeated 6 times.

We focused our study on two primary regions of interest: (1) the FFA known for its responsiveness to faces [10,11]; and (2) the Superior Temporal Sulcus (STS), a region linked to changeable aspects within faces, such as direction of gaze and biologically relevant face movements [12-14]. Furthermore, the motion-sensitive human Medial Temporal Area (hMT+) was investigated.

Results and Discussion

Figure a illustrates activation maps and **Figure b** the corresponding average time courses. Both show that responses were significantly stronger when the faces switched from the distorted to the normal face in the FFA ($t=2.73$ $p<0.01$) and STS ($t=2.74$, $p<0.01$). This asymmetry is consistent with a stronger aftereffect in the normal face when subjects are adapted to the distorted face, an asymmetry that is also observed in behavioral measurements of the subjective magnitude of the aftereffects [1-6]. The magnitude of response changes in hMT+ was more similar for the two transitions.

Previous tests for a norm in the neural coding of faces have found that fMRI responses in the FFA are weaker for average than for distinctive faces [15]. Our study instead compares how these responses change with prior adaptation, and reveals larger responses for more average faces. This asymmetry supports a norm-based code in both FFA and STS and suggests that sensitivity changes at these sites might underlie the face distortion aftereffect and play a role in representing individual variations in faces. Our results also point to the critical role that adaptation plays in regulating face norms. To the extent that perceptually more neutral faces are encoded by more neutral response states, adapting to them does not alter face coding since they merely reinforce the existing norm. Conversely, exposure to abnormal faces leads to a recalibration of the norm and consequently to a new pattern of responses – one in which the norm is shifted to be more consistent with the face the observer is currently exposed to. Coding faces relative to a norm has been contrasted to the visual representation of other dimensions which might instead involve an exemplar code. However, the pattern of face aftereffects and the contrast-coding schemes they imply show many similarities to color vision – in which stimuli are represented relative to a neutral gray, which does not adapt other colors, yet is strongly biased by them. Such schemes may therefore reflect a general and widespread strategy in visual processing.

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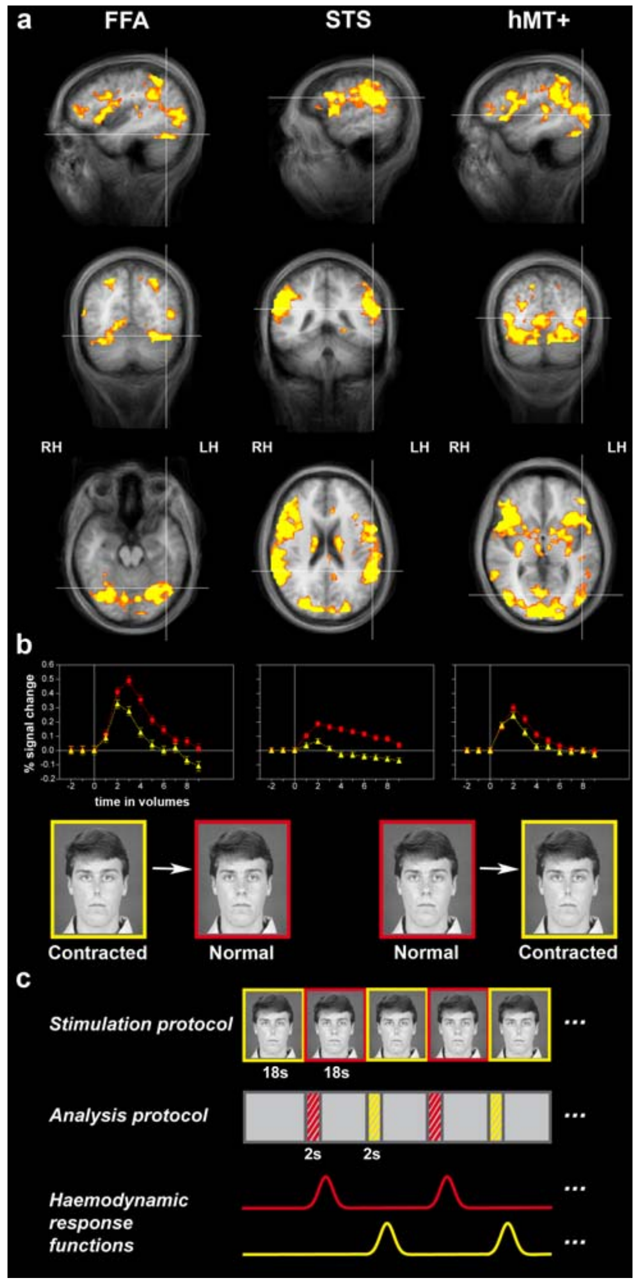

Figure (a) Group activations contrasting the switch (first 2s) of the contracted to the normal face versus the switch of the normal to the contracted face. **(b)** Average time course signals indicating the changes following the adaptation to a contracted face (red) and the adaptation to a normal face (yellow). **(c)** Stimulation and analysis protocol.