Provided for non-commercial research and education use.
Not for reproduction, distribution or commercial use.

This article appeared in a journal published by Elsevier. The attached copy is furnished to the author for internal non-commercial research and education use, including for instruction at the authors institution and sharing with colleagues.

Other uses, including reproduction and distribution, or selling or licensing copies, or posting to personal, institutional or third party websites are prohibited.

In most cases authors are permitted to post their version of the article (e.g. in Word or Tex form) to their personal website or institutional repository. Authors requiring further information regarding Elsevier's archiving and manuscript policies are encouraged to visit:

http://www.elsevier.com/copyright

Author's personal copy

Author's personal copy

adapting to the 30° side view impaired discrimination. Similarly, Rhodes, Watson, Jeffery, and Clifford (2010) discovered that 5 min of adaptation to an average Asian or Caucasian face reduced identification thresholds for faces from the adapted relative to the unadapted race.

In this study, we performed three experiments to test whether visual adaptation can improve gender discrimination. In the first and the second experiments, subjects adapted to male, female and gender-neutral faces, and then gender discrimination thresholds were measured for female faces (Experiment 1) and male faces (Experiment 2). If the re-calibration theory of adaptation (Barlow, 1990) can be applied to high-level vision, face adaptation should enhance discrimination around the adapted state. Specifically, adapting to a male/female face should reduce discrimination thresholds for male/female faces. In the third experiment, we tested whether the discrimination enhancement induced by face adaptation could be generalized to a different face view. Subjects adapted to the front view and the 30° side view of female faces, and then gender discrimination thresholds were measured for the front view of female faces.

2. Methods

2.1. Participants

Author's personal copy

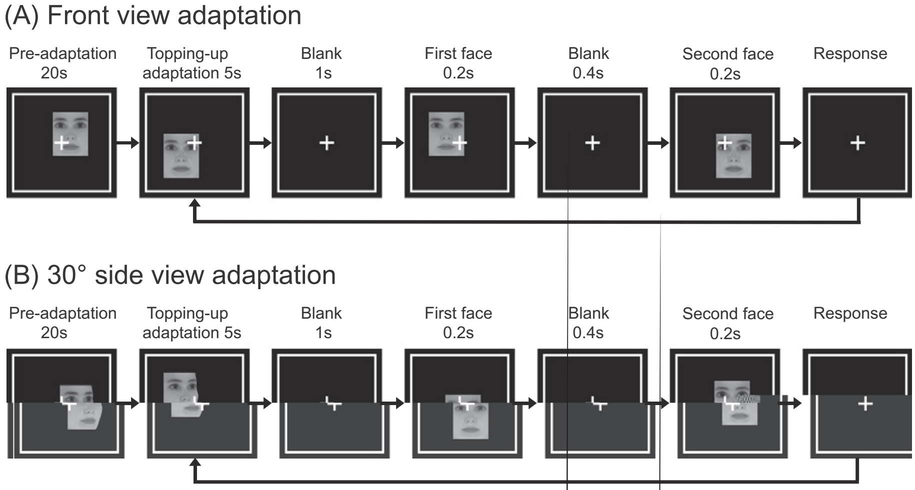

Fig. 2. Schematic description of experimental procedures. Following pre-adaptation and topping-up adaptation to a face, two test faces with slightly different gender strengths were presente to a front view in Exper

In Experiment 2, we attempted to measure gender discrimination thresholds at the gender strength of 20 without adaptation and after adaptation to faces with gender strengths of 20, 50 and 80. The experimental procedure was identical to that in Experiment 1. In Experiments 1 and 2, all adapting and test faces were face front views.

In Experiment 3, we measured gender discrimination thresholds at the gender strength of 80 without adaptation and after adaptation to a front face view and a 30° face side view (Fig. 2B). The 30° side view were generated by projecting a 3D face model with a 30° in-depth rotation angle onto the monitor plane. These two adapting faces had the same identity and had a gender strength of 80. Test faces were around the front face view. Similar to the experimental procedure in Experiments 1 and 2, each subject participated in four daily sessions and completed one staircase for each adaptation condition (front view and 30° side view) and the no adaptation condition in a daily session. The temporal order of the three staircases in a session was randomized. Subjects were asked to take a rest of at least 5 min between staircases to avoid carry-over effects. Twelve subjects were randomly assigned to three groups, with four subjects in one group. Each group of subjects were tested with one morph continuum.

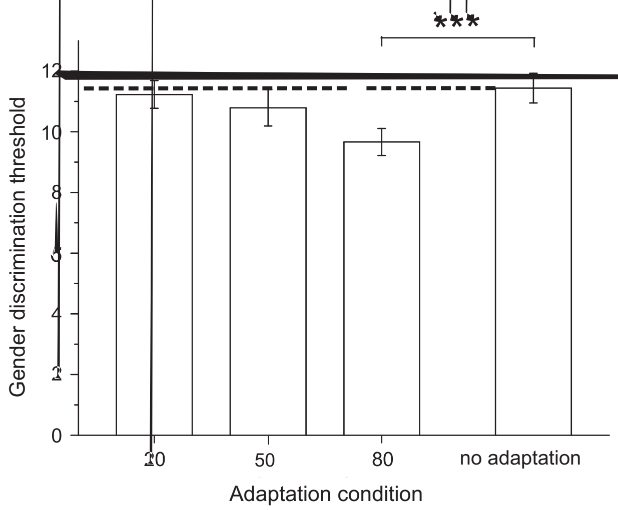

Fig. 3. Gender discrimination thresholds at the gender strength of 80 without adaptation and after adaptation to faces with gender strengths of 20, 50 and 80. Asterisks indicate a statistically significant difference between adaptation conditions ($^{***}p < 0.001$). Error bars denote 1 SEM calculated across subjects.

3. Results

Experiment 1 measured the effects of adaptation to male, female and gender-neutral faces on gender discrimination for female faces. Gender discrimination thresholds in these three adaptation conditions are shown in Fig. 3, along with the threshold measured without adaptation. A repeated-measures analysis of variance (ANOVA) of discrimination threshold was performed with adaptation condition as a within-subject factor. The main effect of adaptation condition was significant ($F(3, 36) = 6.965$, $p = 0.001$). We run planned t-tests to compare discrimination thresholds between face adaptation conditions and no adaptation condition. Relative to the gender discrimination thresholds without any adaptation, subjects' discrimination thresholds for female faces significantly reduced after adapting to a female face ($t(11) = 6.426$, $p < 0.001$), but not after adapting to a male face ($t(11) = 0.6$, $p = 0.561$) or a gender-neutral face ($t(11) = 1.65$, $p = 0.127$). Although the reduction was not large (15.4%), it was quite consistent across subjects. We further run planned t-tests to compare discrimination thresholds between different adaptation conditions. The thresholds after female face adaptation were (marginally) significantly lower than those after male face adaptation ($t(11) = 4.144$, $p = 0.002$) and gender-neutral face adaptation ($t(11) = 2.13$, $p = 0.057$).

Experiment 2 measured the effects of adaptation to male, female and gender-neutral faces on gender discrimination for male faces. Fig. 4 shows gender discrimination thresholds after adaptation and without adaptation. Similar to Experiment 1, a repeated-measures ANOVA of discrimination threshold showed a significant main effect of adaptation condition ($F(3, 36) = 6.67$, $p = 0.001$). Planned t-tests showed that, relative to the gender discrimination thresholds without any adaptation, subjects' discrimination thresholds for male faces significantly reduced after adapting to a male face ($t(11) = 6.559$, $p < 0.001$), but not after adapting to a female face ($t(11) = 1.331$, $p = 0.21$) or a gender-neutral face ($t(11) = 1.472$, $p = 0.169$). Note that the reduction (11.2%) was also quite consistent across subjects. We further run planned t-tests to compare discrimination thresholds between different adaptation conditions. The thresholds after male face adaptation were significantly lower than those after female face adaptation

Author's personal copy

Author's personal copy

ence (e.g. perceptual learning) can dramatically improve our discrimination ability (Bi, Chen, Weng, He, & Fang, in press; Fahle & Poggio, 2002). However, the visual experience in the current study was only 25 s.

Experiment 3 demonstrated that the gender discrimination improvement induced by adaption could be generalized to a differ-

Author's personal copy

Regan, D., & Hamstra, S. J. (1992). Shape discrimination and the judgment of perfect symmetry: Dissociation of shape from size. Vision Research, 32, 1845–1864.
Rhodes, G., Jeffery, L., Watson, T. L., Clifford, C. W. G., & Nakayama, K. (2003). Fitting the mind to the world: Face adaptation and attractiveness aftereffects. Psychological Science, 14, 558–566.
Rhodes, G., Maloney, L. T., Turner, J., & Ewing, L. (2007). Adaptive face coding and discrimination around the average face. Vision Research, 47, 974–989.
Rhodes, G., Watson, T. L., Jeffery, L., & Clifford, C. W. G. (2010). Perceptual adaptation helps us identify faces. Vision Research, 50, 963–968.
Riesenhuber, M., & Poggio, T. (2002). Neural mechanisms of object recognition. Current Opinion in Neurobiology, 12, 162–168.
Rotshtein, P., Henson, R. N. A., Treves, A., Driver, J., & Dolan, R. (2005). Morphing Marilyn into Maggie dissociates physical and identity face representations in the brain. Nature Neuroscience, 8, 107–113.
Suzuki, S., & Grabowecky, M. (2002). Evidence for perceptual "trapping" and adaptation in multistable binocular rivalry. Neuron, 36, 143–157.
van Lier, R., Vergeer, M., & Anstis, S. (2009). Filling-in afterimage colors between the lines. Current Biology, 19, R323–R324.
Watson, T. L., & Clifford, C. W. G. (2003). Pulling faces: An investigation of the face-distortion aftereffect. Perception, 32, 1109–1116.
Watson, A. B., & Pelli, D. G. (1983). QUEST: A Bayesian adaptive psychometric method. Perception & Psychophysics, 33, 113–120.
Webster, M. A., Kaping, D., Mizokami, Y., & Duhamel, P. (2004). Adaptation to natural facial categories. Nature, 428, 557–561.
Webster, M. A., & Maclin, L. H. (1999). Figural aftereffects in the perception of faces. Psychonomic Bulletin & Review, 6, 647–653.
Welling, L. L. M., Jones, B. C., Bestelmeyer, P. E. G., DeBruine, L. M., Little, A. C., & Conway, C. A. (2009). View-contingent aftereffects suggest joint coding of face shape and view. Perception, 38, 133–141.
Wilson, H. R., Loffler, G., & Wilkinson, F. (2002). Synthetic faces, face cubes, and the geometry of face space. Vision Research, 42, 2909–2923.
Wojciulik, E., Kanwisher, N., & Driver, J. (1998). Covert visual attention modulates face-specific activity in the human fusiform gyrus: fMRI study. Journal of Neurophysiology, 79, 1574–1578.
Yeh, S. L., Chen, I. P., De Valois, K. K., & De Valois, R. L. (1996). Figural aftereffects and spatial attention. Journal of Experimental Psychology: Human Perception and Performance, 22, 446–460.
Zhao, L., & Chubb, C. (2001). The size-tuning of the face distortion aftereffect. Vision Research, 41, 2979–2994.