Fat-Face-Thin Illusion Predicted by Own-Face Shape

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Abstract

The fat-face-thin illusion[2] suggests that inverted photographs of faces look thinner than upright versions of the same face. This hypothesis was tested on 10 subjects using a two-alternative forced choice (2AFC) procedure in which subjects had to choose between members of a pair of upright and inverted photographs of the same face. The width of one member of each pair was varied by a stretch factor across trials, and the point of subjective equality (PSE) was defined as the stretch factor required to make the inverted and upright faces appear to have the same width. Only 5/10 subjects have PSE values consistent with the illusion, and a weighted regression analysis[1] of PSE versus a simple measure of own-face shape accounts for 23.4% of the variance in PSE, with a slope significantly less than zero ($p < 0.001$), indicating that subjects with wide faces tend to perceive normal faces as being narrow. This result is interpreted in terms of a long-term familial face aftereffect, analogous to the short-term face aftereffect[3]. Specifically, if a subject has a wide face then s/he would have been exposed to other family members with similarly wide faces, and should therefore interpret normal faces as being narrow.

Methods

Each stimulus was a pair of images of the same colour photograph, one upright and one inverted, as in the web site listed at the end of this paper (with the background and collar removed electronically). On each trial, two images were presented side by side, and the subject indicated which of them appeared to be more wide/narrow. The stimuli consisted of two complementary sets of stimuli, which we label as *upright* and *inverted*. For simplicity, the upright set is described first.

Within the upright set, the upright face acted as a fixed width reference (ie normal) stimulus whereas the inverted face acted as a variable width comparison stimulus; the comparison stimulus has the same height as the reference stimulus, but its width was varied between trials. The width of the comparison stimulus was determined by a stretch parameter S, which was used to scale the width of the comparison stimulus between S=0.9 and S=1.1, in increments of 0.01, making 21 comparison widths in total. Within the inverted set the roles of the upright and inverted stimulus were swapped, so the inverted face acted as a reference (ie normal) stimulus, whereas the upright face acted as a variable width comparison stimulus. Each pair of images was shown 10 times, making 210 trials per stimulus set, and a total of 420 trials per subject. All stimuli were fully counterbalanced in terms of left-right position, and stimuli were presented in random order.

Subjects allocated even identity numbers were instructed to indicate which of the two images contained the face that was more narrow, and the other subjects were instructed to indicate which of the two images contained the face that was wider. Subjects were undergraduate students between 20-21 years of age.

Stimulus Details: Each normal face was 9 cm hight cm by 5.5 cm, and was presented on a computer screen at a distance of 100 cm from the subject whose head was supported by a chin rest. The images were separated by 6 cm, and were presented against a white background. A response was made by indicating either the left or right image by pressing the 1 or 3 key (respectively) on a numeric keypad. Once a response was made, there was a random interval of between 0.75 and 1.25s before the next stimulus appeared.

Analysis: For each subject, responses from the inverted set were made consistent with those in the upright set by reversing the order of stretch values and swapping the responses made to each stimulus(if this were not done then if the estimated PSE for the upright set is, say 1.1, and for the inverted set would be 0.9=2-1.1). For each subject, the set of 420 responses was fitted to a cumulative Gaussian, which yielded a mean (PSE) and variance, using maximum likelihood estimation. The standard error in the mean (SEM) and in the variance (not shown) of each Gaussian was estimated numerically from the Hessian matrix of second derivatives of the log-likelihood function using MatLab.

Results

There are two main results.

Result 1: The PSE is Subject-Specific: If subjects perceive face shape veridically then a 'neutral' PSE of one is expected. The difference between this neutral PSE and the PSE value estimated for each subject is shown in Figure 2. Seven subjects have a PSE that is significantly different from one, 5 of which are consistent with the fat-face-thin illusion, and 2 of which are consistent with a complementary thin-face-fat illusion. Three subjects have PSE values not significantly different from one.

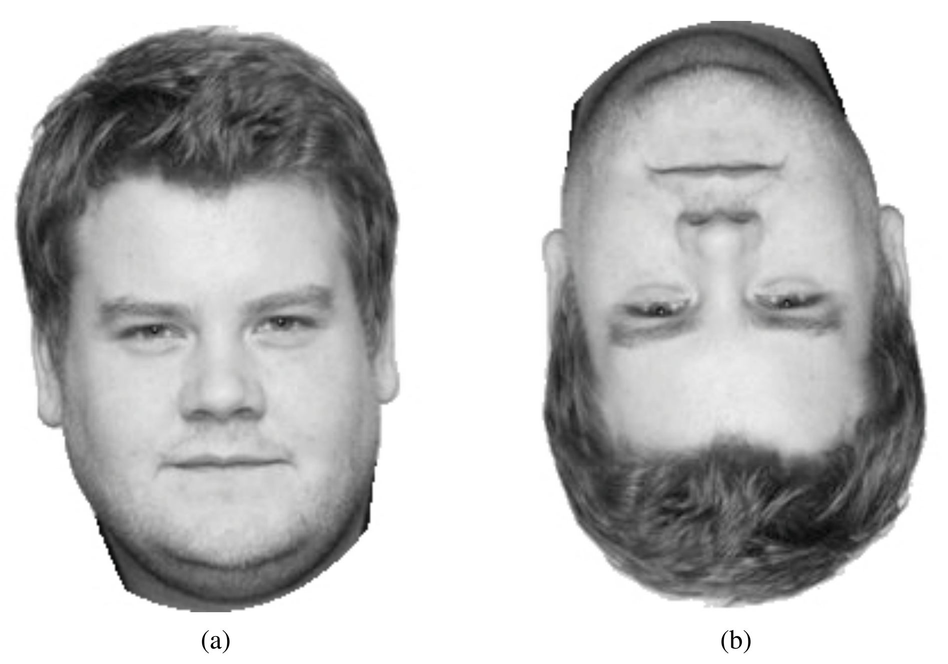

Figure 1: Stimulus pair used in 2AFC experiment. Two normal versions of the face used, so the inverted face should appear thinner than the upright face according to the fat-face-thin illusion.

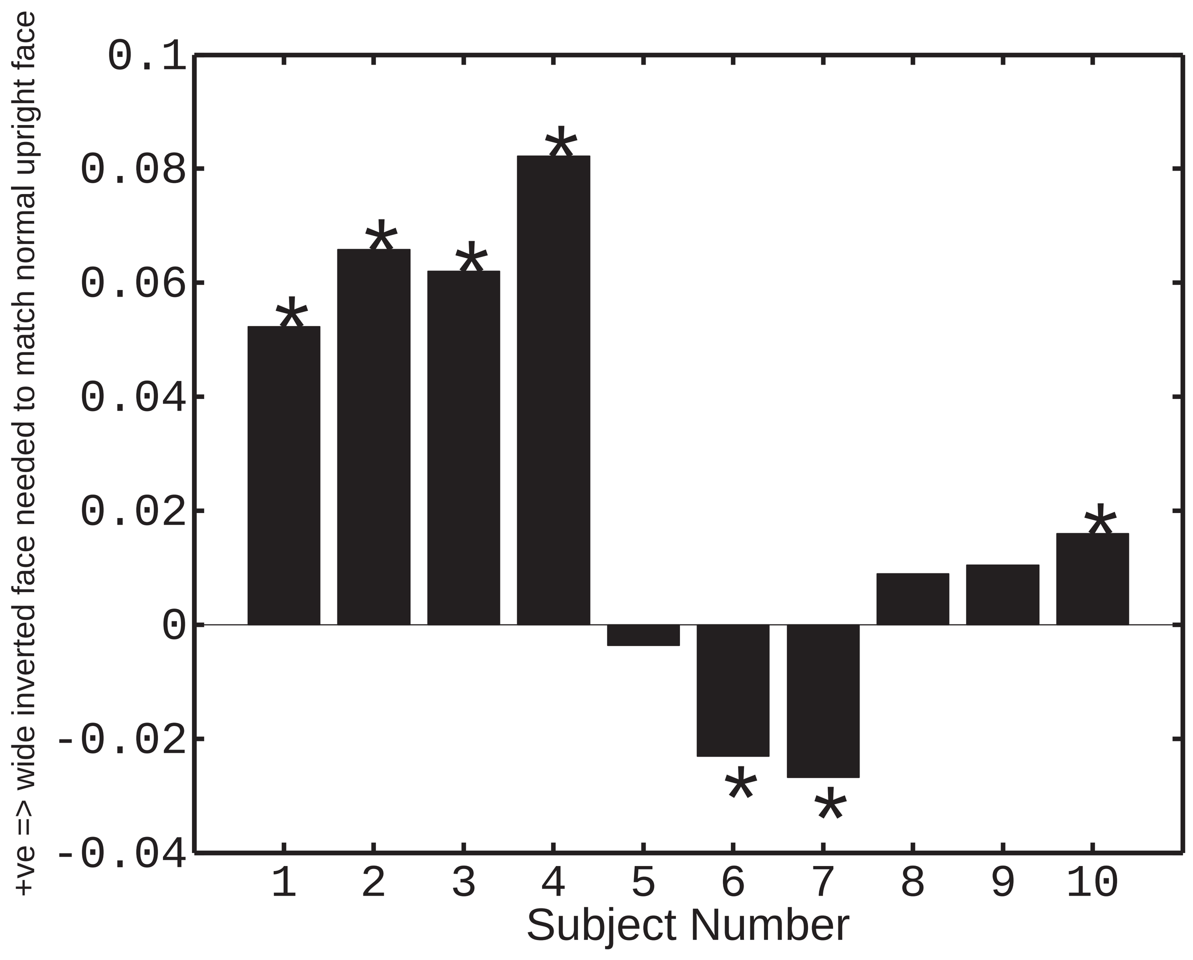

Figure 2: Point of subjective equality (PSE) minus 1, for $N = 10$ subjects. The PSE corresponds to the amount of horizontal stretch S that must be applied to a comparison face in order for it to be perceived as the same width as a normal reference face. Stars indicate PSE values significantly different from 1 ($p < 0.01$).

Result 2: Subject's Own Face Shape Predicts PSE: Each subject's face shape R was measured from a photograph as the width (distance between outer edge of the eyes) divided by height (distance from eye-line to bottom of chin). A weighted least-squares regression (WLSR)[1] of PSE against subjects' own face shape revealed a significant association, as shown in Figure 3. Note that the wide scatter of points in Figure 3 needs to be interpreted in terms of the SEM values indicated in Table 1, as was done in the regression analysis.

A subject with a large PSE value perceives a normal upright face as being the same width as a wide (ie stretched) inverted face. If inverted faces are perceived in an un-biased manner then this implies that a subject with a large PSE value perceives a normal upright face as being wide.

Discussion

The reason for proposing that the PSE should be related to each subject's own face-shape is because the face shape of a subject's family is likely to be similar to the subject's own face shape. Therefore, the face shape to which each subject has been exposed throughout their life is likely to be similar to that subject's own face shape. The simple measure of face-shape used is relatively immune to the amount of fat in the face at any one time, and therefore may reflect the familial average face shape for each subject.

Despite the simplistic measure of face shape, the linear association between PSE and face shape is statistically significant. Given that a subject with a large width/height face ratio has a relatively wide face, the (significant) negative slope of the regression analysis suggests that subjects with wide faces tend to perceive normal upright faces as thin, and vice versa. This, in turn, suggests that subjects may have a long-term face aftereffect, similar to the short-term face shape aftereffects[3].

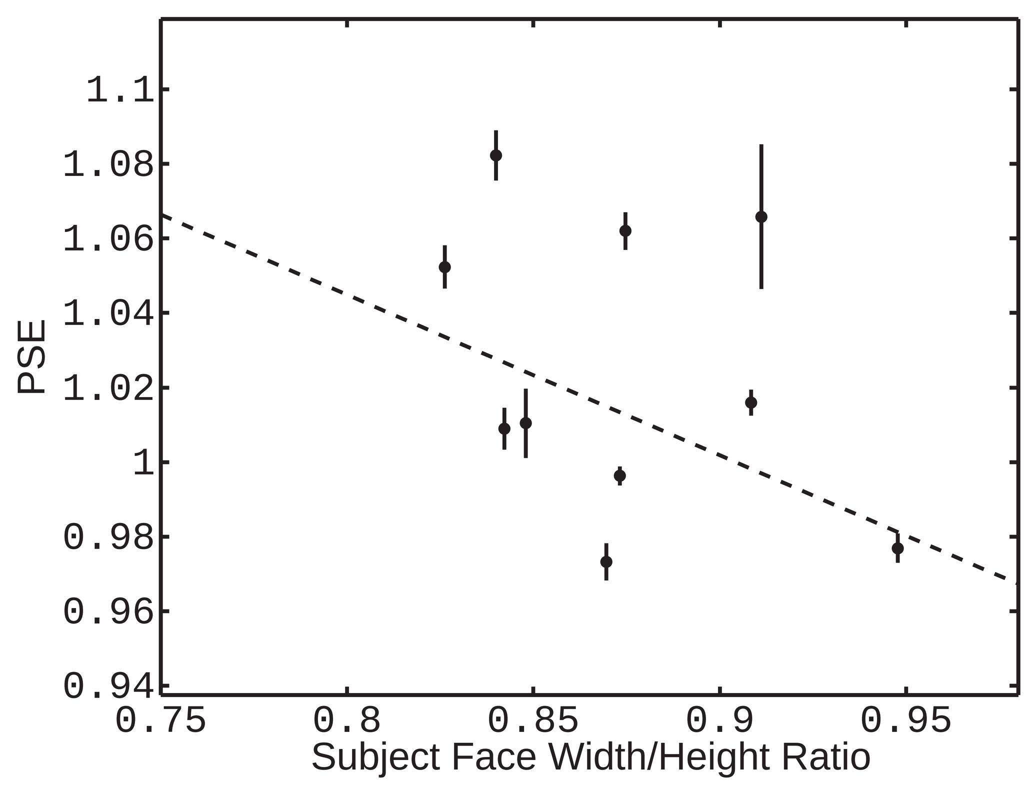

Figure 3: Regression of PSE against subjects' own face shape. A weighted least-squares regression (WLSR) yielded $PSE = -0.430 \times R + 1.389$, where R is the subject's own face width/height ratio (see text), (F(1,8)=6.130,p=0.038). Each weight used in the WLSR is the inverse variance of the estimated PSE value, derived from the SEM value in Table 1. The regression line accounts for 23.4% of the variance, and the sem of the slope is 0.043, so the slope is significantly different from zero ($p < 0.001$). Each error bar has a length of two standard errors in the mean.

References

[1] DS Sivia. *Data Analysis: A Bayesian Tutorial*. Oxford, UK, Clarendon Press, 1996.

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[3] Michael A. Webster and Donald I. A. MacLeod. Visual adaptation and face perception. *Philosophical Transactions of the Royal Society B: Biological Sciences*, 366(1571):1702–1725, 2011.

Acknowledgments: Thanks to Katherine Kane for testing subjects.