Orientation-sensitivity to facial features explains the Thatcher illusion

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The Thatcher illusion provides a compelling example of the perceptual cost of face inversion. The Thatcher illusion is often thought to result from a disruption to the processing of spatial relations between face features. Here, we show the limitations of this account and instead demonstrate that the effect of inversion in the Thatcher illusion is better explained by a disruption to the processing of purely local facial features. Using a matching task, we found that participants were able to discriminate normal and Thatcherized versions of the same face when they were presented in an upright orientation, but not when the images were inverted. Next, we showed that the effect of inversion was also apparent when only the eye region or only the mouth region was visible. These results demonstrate that a key component of the Thatcher illusion is to be found in orientation-specific encoding of the expressive features (eyes and mouth) of the face.

Introduction

The impairment in face perception following inversion is often taken as evidence for the specialized processing of faces (Diamond & Carey, 1986; Valentine, 1988; Yin, 1969). The Thatcher illusion provides a compelling example of the cost of face inversion. When the eyes and the mouth are turned upside-down relative to the rest of the face—a transformation now known in the research literature as "Thatcherization"—the facial expression appears grotesque (Thompson, 1980). This distortion of the face is immediately perceived when the face is upright. However, when the image is inverted the grotesque appearance is no longer visible.

The effect of inversion on the perception of facial expression seen in the Thatcher illusion is widely attributed to disruption of configural processing. The distinction between piecemeal processing of local features (such as eyes and mouths) and configural properties based on spatial interrelationships between the features of the face (the configuration) was introduced by Carey and Diamond (1977), who maintained that configural processing is impaired by inversion, whereas feature processing is largely equivalent across upright and inverted faces. For upright faces, then, Carey and Diamond (1977) argued that both configural and featural processing are possible, whereas for inverted faces only feature processing can be used. From this perspective, it follows that the cause of the disruptive effect of inversion in the Thatcher illusion reflects the disruption of configural processing, and many researchers have adopted this intuitively appealing line of reasoning.

The idea of the importance of configural information in upright face perception has been popularized and elaborated to such an extent that Maurer, Le Grand, and Mondloch (2002), found it necessary to distinguish three different types of configural information involved in face processing that were often elided: (a) first-order relational information, which is the basic arrangement of face features with two eyes above the nose, above the mouth; (b) holistic information, which integrates facial features into a whole; and (c) second-order relational information, which encodes the spatial relationships between facial features. In these terms, the inability to

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detect the grotesque expression in inverted Thatcherized images is generally thought to be due to reduced sensitivity to the second-order configuration of the face (Bartlett & Searcy, 1993; Carbon & Leder, 2005; Hoehl & Peykarjou, 2012; Maurer, Le Grand, & Mondloch, 2002; Murray, Yong, & Rhodes, 2000; Rhodes, 1988).

Although many studies have shown that the ability to perceive second-order configural properties of the face may indeed be affected by inversion, these effects are not as strong as the Thatcher illusion (Bartlett & Searcy, 1993; Boutsen & Humphreys, 2003; Leder, Candrian, Huber, & Bruce, 2001; Maurer, Le Grand, & Mondloch, 2002; Rhodes, Brake, & Atkinson, 1993). This suggests that existing explanations of the illusion may not be sufficient (Talati, Rhodes, & Jeffery, 2010). Similarly, while demonstrations of holistic face perception, such as the composite effect, show strong effects of inversion (Rossion, 2013; Young, Hellawell, & Hay, 1987), holistic processing is not usually considered to be the cause of the Thatcher illusion.

In the present study, we therefore revisited configural accounts of the Thatcher illusion by investigating whether the effect of inversion on the illusion might still be evident when information about the interrelationships between face parts (i.e., second-order configuration) is entirely absent. This was achieved by presenting local regions of the face (eyes or mouth) in isolation. First, we measured the perceptual impact of the Thatcher illusion by asking participants to judge whether two whole face images presented upright or inverted were identical or different (in any way). Our prediction was that participants should be more able to discriminate normal from Thatcherized versions of a face image when presented upright, but that performance should be reduced when presented upside down. Next, we asked participants to perform the same task, but with only the mouth or the eye region of each image. Based on configural accounts of the illusion, we would predict there should be no difference in discrimination for upright and inverted presentations of these local features, since no information concerning the second-order configuration is present. However, if the illusion is based on a disruption to feature-based processing, we would expect a similar disruption in perception when the images are inverted.

Materials and methods

Participants

Twelve participants took part in Experiment 1 (mean age 25.1, ± 3.7; 7 female) and 12 participants took part in Experiment 2 (mean age 20.8, ± 2.6; 9 female). Sample size was determined before data collection began and was based on the analysis of a previous published study using a similar methodology (Psalta et al., 2013). The study was approved by the Psychology Department Ethics Committee at the University of York. Participants were students from the University of York.

Stimuli

Face stimuli were Ekman faces selected from the Facial Expressions of Emotion Stimuli and Tests (FEEST) set (Young, Perrett, Calder, Sprengelmeyer, & Ekman, 2002). Seven individuals posing six expressions (neutral, happiness, anger, disgust, fear, and sadness) were selected based on the following three main criteria: (a) A high recognition rate for all expressions (mean recognition rate in a six-alternative forced-choice experiment: 94%; Young et al., 2002), (b) consistency of the action units (muscle groups) across different individuals posing a particular expression, and (c) visual similarity of the posed expression across individuals. Each face image was Thatcherized by inverting the mouth and eyes by 180°. Figure 1 shows examples of images from Experiment 1 and 2.

Experiment 1

The aim of Experiment 1 was to determine ability to discriminate normal from Thatcherized face images in upright and inverted orientations. Visual stimuli (7 × 11°) were viewed at a distance of approximately 57 cm. Participants were presented simultaneously with two whole face images to the left and right of a fixation cross. The center of each image was 5° from the fixation cross. Images were presented for 800 ms and participants were asked to indicate whether the images were completely identical or different in any way. There was a 2-s interstimulus interval before the next trial.

There were six conditions:

(*a*) *normal-normal, same Identity;* two identical images of a normal face.
(*b*) *Thatcherized-Thatcherized, same identity;* two identical images of a Thatcherized face.
(*c*) *normal-Thatcherized, same identity;* the normal face and the Thatcherized face of the same person.
(*d*) *normal-normal, different Identity;* normal face images of two different people.
(*e*) *Thatcherized-Thatcherized, different identity;* Thatcherized face images of two different people.
(*f*) *normal-Thatcherized, different identity*; a normal face and a Thatcherized face of two different people.

There were 72 trials per condition, giving a total of 432 trials per run. Trials were presented in a pseudorandomized order. The order of the trials was kept constant

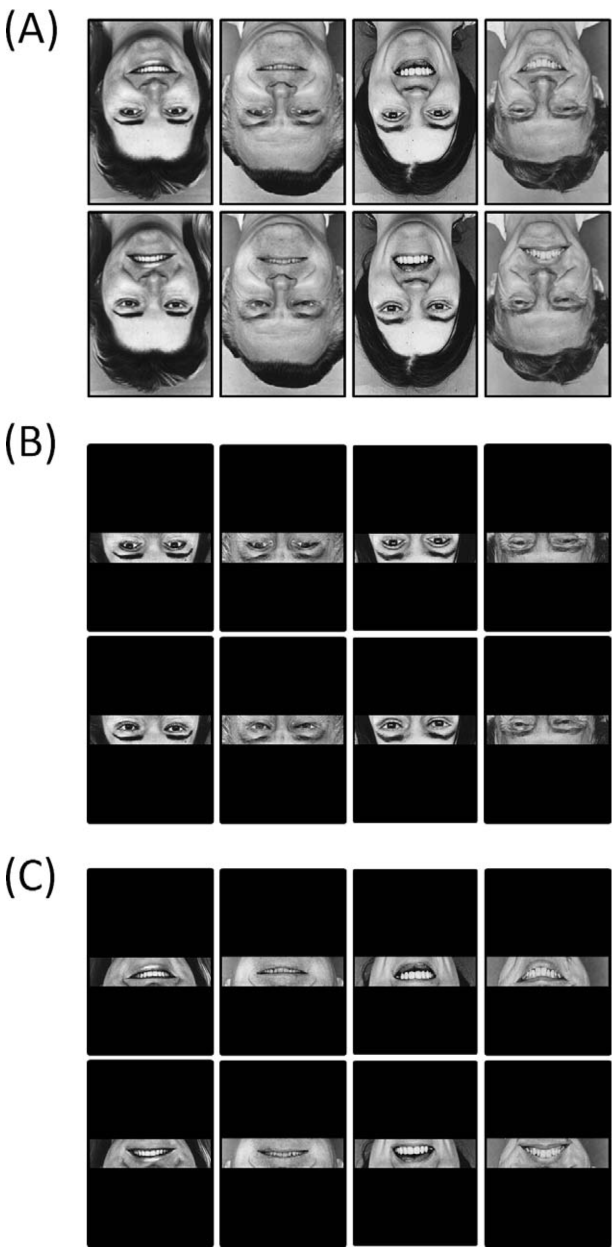

Figure 1. Examples of normal and Thatcherized images. (A) Whole face images show normal (top) and Thatcherized (bottom) expressions from different individuals used in Experiment 1. (B–C) show the corresponding images from the eye region and mouth region, respectively that were used in Experiment 2. Invert page for the upright view of images.

across all participants. Percent correct responses and reaction time to each condition was determined for each participant. The experiment involved two separate runs in which the images were all inverted or all upright.

Experiment 2

The aim of Experiment 2 was to determine the ability to discriminate normal and Thatcherized faces in upright and inverted orientations when only the mouth region or only the eye region of each image was shown. Stimuli were created by horizontally cropping the faces from Experiment 1, so that only a strip containing the eye region or the mouth region remained. Examples are shown in Figure 1B (eye region) and Figure 1C (mouth region). Note that cues to the upright or inverted orientation of each horizontal strip are implied by the eyebrows and the shape of the corresponding part of the face outline (Figure 1). Visual stimuli ($7° \times 2°$) were viewed at a distance of approximately 57 cm. The procedure and image conditions were identical to Experiment 1. Trials with eye regions or with mouth regions were presented in separate blocks.

Results

Experiment 1

To determine the degree to which the Thatcher illusion was evident in our images, we used a behavioral paradigm in which participants observed two simultaneously-presented whole face images. These pairs of images could be both normal (*normal-normal*), both Thatcherized (*Thatcherized-Thatcherized*) or one normal and one Thatcherized (*normal-Thatcherized*). The images could also be of the same or a different identity, and the image pairs could be presented upright or inverted. Participants were simply asked to indicate by a button press whether the two images were identical or different in any way.

Accuracy judgments (Figure 2) show that participants were able to perform this task at well above chance level (50%) in all conditions except when an inverted normal image was paired with an inverted Thatcherized image (*normal-Thatcherized*) with the same identity. The high error rate found for inverted stimuli in the *normal-Thatcherized same identity* condition reflects a failure to notice any differences between normal and Thatcherized versions of the same person's face when these images are inverted. A 3×2 ANOVA was carried out to determine the effect of Condition (*normal-normal, Thatcherized-Thatcherized, normal-Thatcherized*) and Orientation (*upright, inverted*) on accuracy. This was run separately for the same identity and different identity conditions.

Accuracy for the same identity images is shown in Figure 2C. There was a significant effect of Condition, $F(2, 22) = 147.8$, $p < 0.001$, and Orientation, $F(1, 11) = 83.5$, $p < 0.001$. There was also a significant interaction between Condition × Orientation, $F(2, 22) = 228.1$, $p < 0.001$. The significant interaction was due to the lower accuracy in *normal-Thatcherized* condition (14.8% ± 4.3%) compared to *normal-normal* [93.4% ± 0.1%; $t(11)$

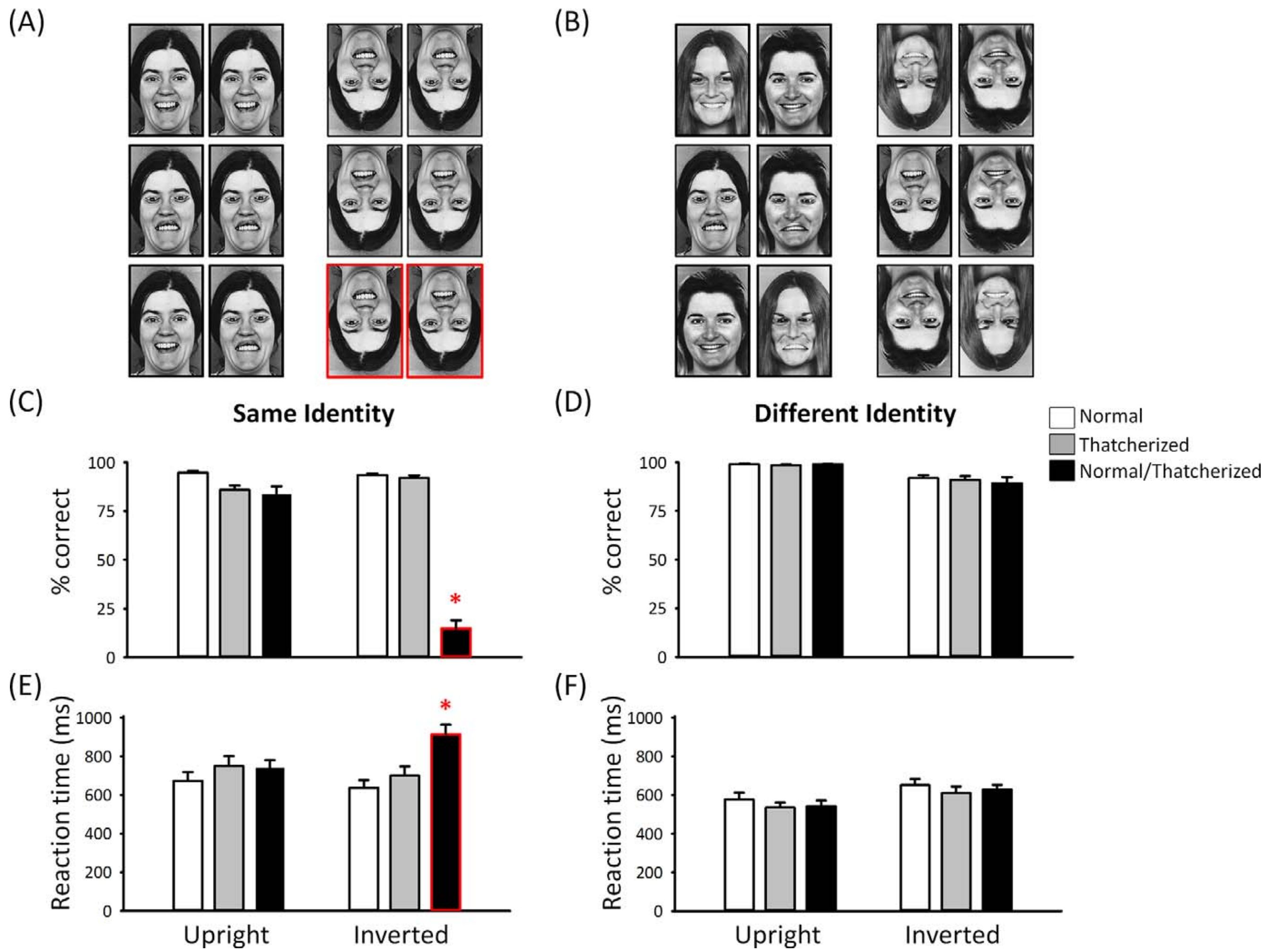

Figure 2. Experiment 1: Pairs of faces with (A) the same identity image or (B) different identity were presented in the upright or inverted orientation. Pairs of faces could both be normal (top), both be Thatcherized (middle) or be normal and Thatcherized (bottom). Participants were asked to report whether the images were identical or different. Percent correct performance was determined for (C) same identity and (D) different identity faces. Performance was well above chance (50%) for all conditions except for the same-identity normal/Thatcherized inverted condition (red, $*p < 0.001$). This demonstrates that participants were unable to discriminate the grotesque expression from a normal expression when the faces were inverted, leading to below-chance performance (chance = 50% correct). Reaction Time (ms) was also measured for (E) same identity and (F) different identity faces. Reaction time was similar for all conditions except for the same-identity normal/Thatcherized inverted condition (red, $*p < 0.001$). Error bars represent ±1 standard error across participants.

= 18.5, $p < 0.001$] or *Thatcherized-Thatcherized* [92.0% ± 1.3%; $t(11) = 17.3$, $p < 0.001$] conditions when the images were *inverted.* In contrast, there was no difference between the *normal-Thatcherized* (83.7% ± 4.0%) and the *Thatcherized* (85.9% ± 2.2%) [$t(11) = 0.6$, $p = 0.59$] conditions and only a small difference when comparing *normal-Thatcherized* (83.7% ± 4.0%) to *normal* (94.6% ± 1.0%) [$t(11) = 2.9$, $p < 0.001$] when the images were upright. A similar pattern was evident for reaction time.

Accuracy for the different identity images is shown in Figure 2D. There was no significant effect of Condition, $F(2, 22) = 1.2$, $p = 0.33$, or any interaction between Condition × Orientation, $F(2, 22) = 1.2$, $p =$ 0.33. However, there was a significant effect of Orientation, $F(1, 11) = 13.8$, $p < 0.001$. The effect of Orientation was due to a lower accuracy for *inverted* compared to *upright* images for *normal* [99.0% ± 0.4% upright; 91 ± 1.6 % inverted; $t(11) = 4.2$, $p = 0.001$], *Thatcherized* [98.5% ± 0.5% upright; 90.9% ± 2.1% inverted; $t(11) = 3.7$, $p < 0.01$], and *normal-Thatcherized* [99.0% ± 0.3% upright; 89.2% ± 3.2% inverted; $t(11) = 3.0$, $p < 0.05$] conditions.

Response times for the same identity conditions are shown in Figure 2E. A 3 × 2 ANOVA was carried out to determine the effect of Condition (*normal-normal, Thatcherized-Thatcherized, normal-Thatcherized*) and Orientation (*upright, inverted*) on the same identity and different identity conditions. There was a significant effect of Condition, $F(2, 20) = 8.4$, $p < 0.01$, and a significant interaction between Condition × Orientation, $F(2, 20) = 15.9$, $p < 0.001$. However, there was no significant effect of Orientation, $F(1, 10) = 0.9$, $p = 0.37$. The significant effect of Condition was due to slower RT to the *normal-Thatcherized* condition (914.5 ± 50.3 ms) compared to *normal-normal* [637.4 ± 40.3; $t(10) = 4.2$, $p < 0.01$] or *Thatcherized-Thatcherized* [700 ± 48; $t(10) = 3.1$, $p < 0.01$] conditions when the images were inverted. In contrast, there was no difference between the *normal-Thatcherized* and the *normal-normal* [$t(11) = 1.9$, $p = 0.09$] or *Thatcherized-Thatcherized* [$t(11) = 0.2$, $p = 0.847$] conditions when the faces were *upright*.

Response time for the different identity images is shown in Figure 2F. There was a significant effect of Condition, $F(2, 22) = 4.5$, $p < 0.05$, and a significant effect of Orientation, $F(1, 11) = 5.3$, $p < 0.05$. However, there was no interaction between Condition × Orientation, $F(2, 22) = 0.1$, $p = 0.94$. The significant effect of Orientation was due to a slower response to *inverted* (629.4 ± 31 ms) compared to *upright* (551.6 ± 30 ms) faces.

Experiment 2

The aim of Experiment 2 was to determine the effect of inversion on ability to discriminate normal from Thatcherized images when only the mouth or only the eye region was shown.

Eye region

The ability to discriminate differences based on the eye region is shown in Figure 3. Accuracy judgments show that participants were able to perform this task above chance (50%) in all conditions except when an inverted normal image was presented with an inverted Thatcherized image with the same identity. A 3 × 2 ANOVA was carried out to determine the effect of Orientation on judgments of *normal*, *Thatcherized,* and *normal-Thatcherized* images.

For the same identity images (Figure 3C), there was a significant effect of Condition, $F(2, 22) = 35.0$, $p < 0.001$, and Orientation, $F(1, 11) = 20.5$, $p = 0.001$, on accuracy. There was also significant interaction between Condition × Orientation, $F(2, 22) = 28.2$, $p < 0.001$. The interaction was due to lower accuracy for the *normal-Thatcherized* condition (40.1% ± 7.1%) compared to both the *normal-normal* [87.7% ± 2.7%; $t(11) = 5.9$, $p < 0.001$] and *Thatcherized-Thatcherized* (91.7% ± 1.9%) conditions when the images were *inverted*. In contrast, there was no significant difference between the *normal-Thatcherized* (87.2% ± 3.4%) and the *Thatcherized-Thatcherized* [84.3% ± 4.3%; $t(11) = 0.8$, $p = 0.45$] conditions and only a slight difference between the *normal-Thatcherized* and *normal-normal* upright conditions [95.4% ± 1.8%; $t(11) = 3.2$, $p < 0.01$] when the images were presented upright.

For the different identity images (Figure 3D), there was a significant effect of Condition, $F(2, 22) = 24.9$, $p < 0.001$, but there was no significant effect of Orientation, $F(1, 11) = 2.1$, $p = 0.17$, and no interaction between Condition × Orientation, $F(2, 22) = 0.5$, $p = 0.64$. The effect of Condition was due to higher accuracy for the *normal-Thatcherized* (98% ± 0.8%) condition compared to the *normal-normal* (91% ± 2.0%) and *Thatcherized-Thatcherized* (93% ± 1.1%) conditions.

Next, we measured RT to each condition. For the same identity conditions (Figure 3E), there was a significant effect of Condition, $F(2, 22) = 4.9$, $p < 0.05$, but no significant effect of Orientation, $F(1, 11) = 0.5$, $p = 0.84$, or any significant interaction between Condition × Orientation, $F(2, 22) = 2.3$, $p = 0.12$. The significant effect of Condition was due to a faster RT for *normal-normal* condition (962 ± 81 ms) compared to *Thatcherized/Thatcherized* (997 ± 86 ms) *and normal-Thatcherized* (1098 ± 113 ms) conditions. For the different identity images (Figure 3F), there was no significant effect of Condition, $F(2, 22) = 0.6$, $p = 0.55$ or Orientation, $F(1, 11) = 0.08$, $p = 0.78$, and no significant interaction between Condition × Orientation, $F(2, 22) = 1.7$, $p = 0.21$.

Mouth region

The ability to discriminate differences in the mouth region is shown in Figure 4. Accuracy judgments show that participants were able to perform this task above chance (50%) in all conditions except when an inverted normal image was presented with an inverted Thatcherized image with the same identity. A 3 × 2 ANOVA was carried out to determine the effect of Orientation on judgments of *normal*, *Thatcherized* and *normal-Thatcherized* images.

Accuracy for the same identity images is shown in Figure 4C. There was a significant effect of Condition, $F(2, 22) = 29.5$, $p < 0.001$, and Orientation, $F(1, 11) = 12.2$, $p = 0.01$. There was also significant interaction between Condition × Orientation, $F(2, 22) = 15.0$, $p < 0.001$. The significant interaction was due to the lower proportion of correct responses to *normal-Thatcherized* (47.9% ± 8.8%) images compared to *normal-normal* [94.5% ± 1.5%; $t(11) = 5.1$, $p < 0.001$] or *Thatcherized-Thatcherized* [90.0% ± 2.5%; $t(11) = 4.6$, $p = 0.001$] when the images were *inverted*. In contrast, there was no significant difference between the *normal-Thatcherized* (87.2% ± 2.9%) and the *Thatcherized-Thatcherized* [91.1% ± 1.4%; $t(11) = 0.8$, $p = 0.45$] conditions, and only a small difference when comparing the *normal-Thatcherized* condition to the *normal-normal* [93.5% ± 1.4%; $t(11) = 2.4$, $p < 0.05$] condition.

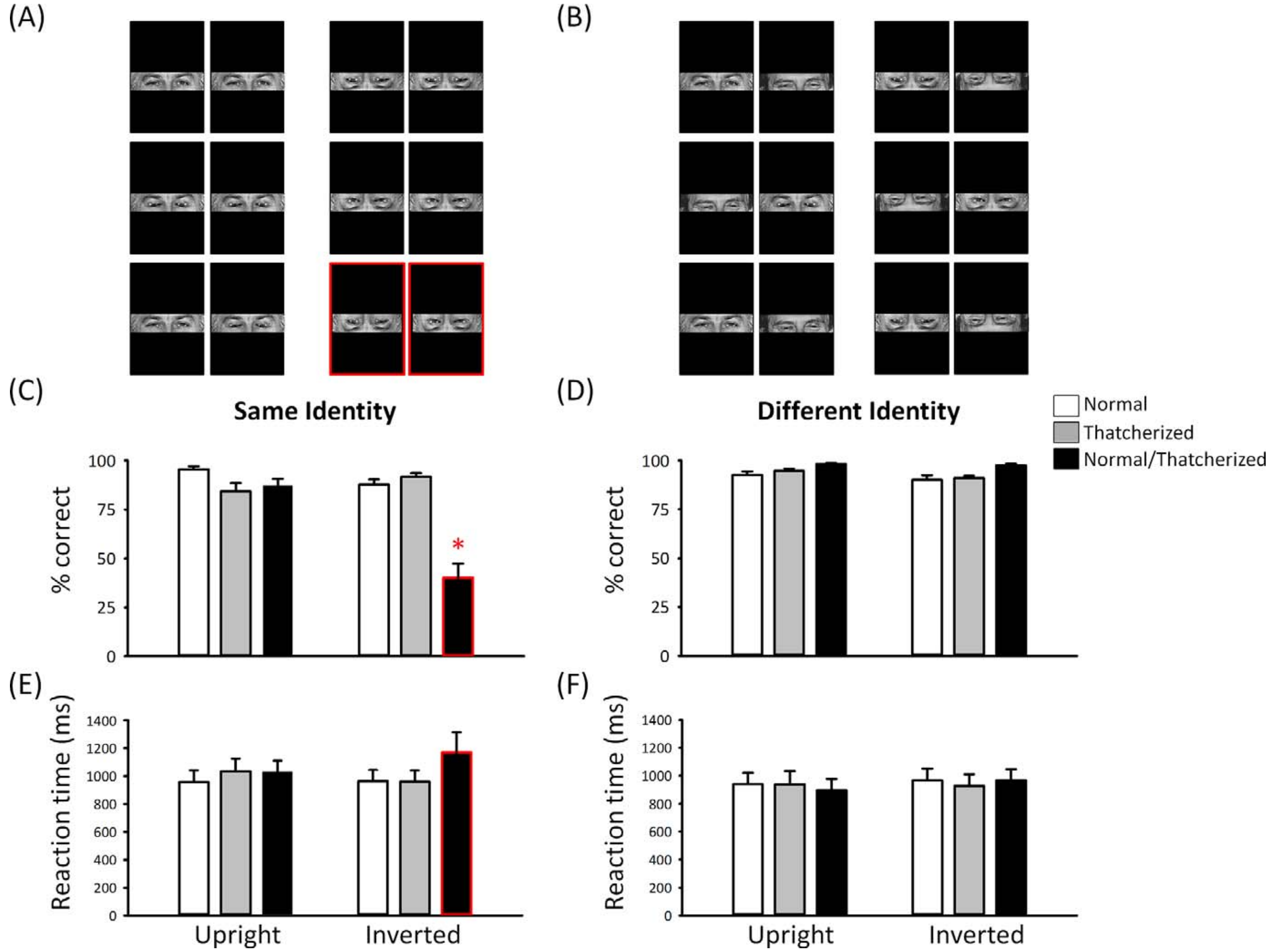

Figure 3. Experiment 2: Discrimination of the eye region with (A) same identity or (B) different identity images presented in an upright or inverted orientation. Pairs of eye regions could both be normal (top), both be Thatcherized (middle) or be normal and Thatcherized (bottom). Participants were asked to report whether the images were identical or different. Percent correct performance was determined for (C) same identity and (D) different identity faces. Performance was above chance (50%) for all conditions except for the same-identity normal/Thatcherized inverted condition (red, $*p < 0.001$). Error bars represent ±1 standard error across participants.

Accuracy for the different identity images is shown in Figure 4D. There was a significant effect of Condition, $F(2, 22) = 5.2$, $p < 0.05$, and a significant effect of Orientation, $F(1, 11) = 11.8$, $p < 0.01$. However there was no significant interaction between Condition × Orientation, $F(2, 22) = 0.6$, $p = 0.56$. The effect of Condition was due to a higher number of correct responses in the *normal*-*Thatcherized* (98.4% ± 0.7%) condition compared to the *normal*-*normal* (96% ± 1.2%) or *Thatcherized*-*Thatcherized* (95% ± 1.6%) conditions. The effect of Orientation was due to a higher number of correct responses to upright (98% ± 1.0%) compared to inverted (94.9% ± 1.3%) images.

Next, we determined the effect of Condition and Orientation on RT values. Reaction Time for the same Identity conditions is shown in Figure 4E. There was a significant effect of Condition, $F(2, 22) = 6.6$, $p < 0.01$, but no significant effect of Orientation, $F(1, 11) = 2.3$, $p = 0.16$, and no significant interaction between Condition × Orientation, $F(2, 22) = 1.9$, $p = 0.17$. The significant effect of Condition was due to a slower reaction time of *normal*-*Thatcherized* (982 ± 69.4 ms) compared to *normal*-*normal* (837 ± 60 ms) or *Thatcherized*-*Thatcherized* (921 ± 61 ms) upright images. Reaction time for the different identity images is shown in Figure 4F. There was a significant effect of Condition, $F(2, 22) = 10.1$, $p < 0.01$, but no significant effect of Orientation, $F(1, 11) = 0.83$, $p = 0.38$, or any significant interaction between Condition × Orientation, $F(2, 22) = 0.23$, $p = 0.80$. The significant effect of Condition was due to a faster reaction time to the *normal*-*Thatcherized* condition (838 ± 58 ms) compared to the *normal*-*normal* (880 ± 59 ms) or *Thatcherized*-*Thatcherized* (870 ± 60 ms) conditions.

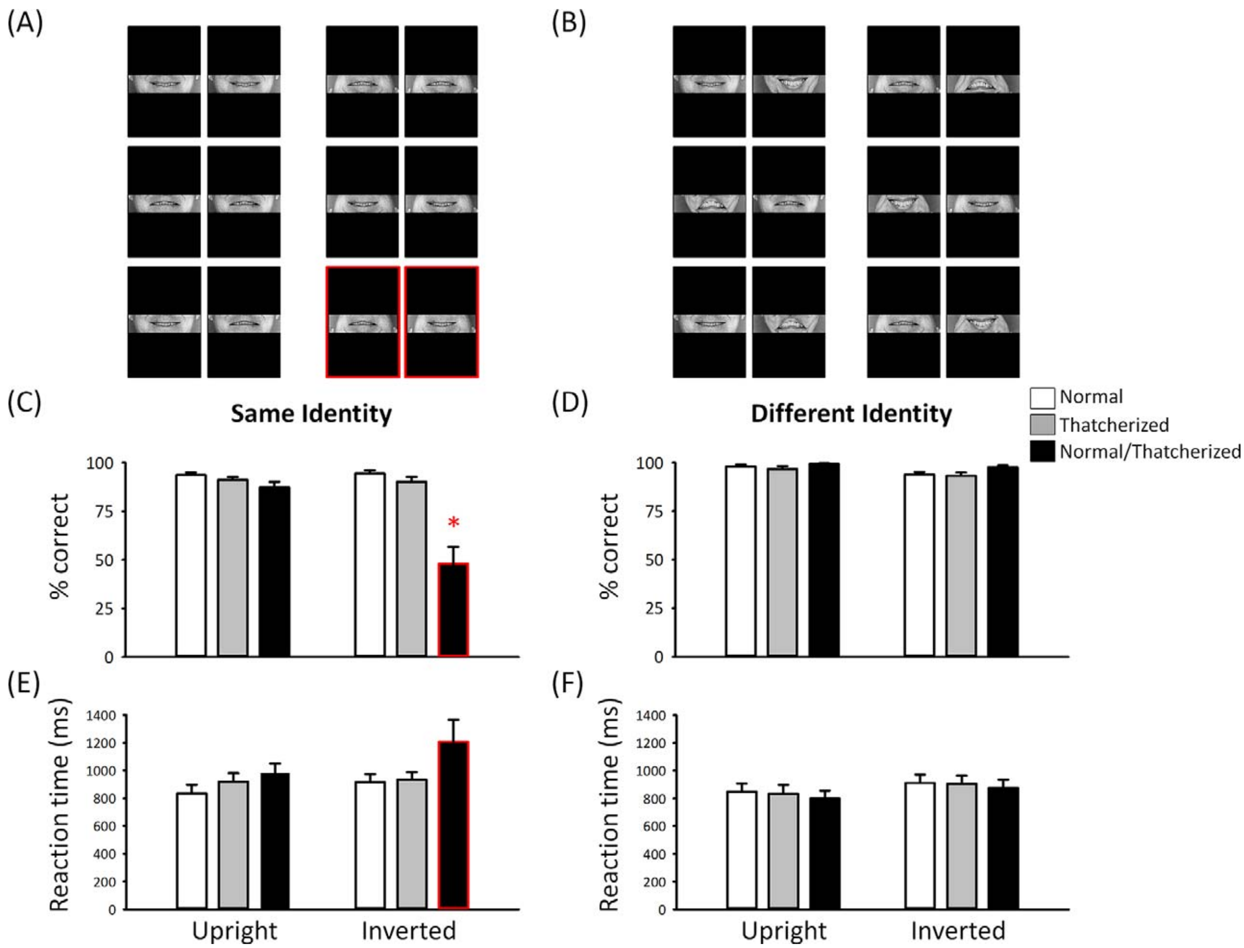

Figure 4. Experiment 2: Discrimination of the mouth region with (A) same identity or (B) different identity images presented in an upright or inverted orientation. Pairs of mouth regions could both be normal (top), both be Thatcherized (middle) or be normal and Thatcherized (bottom). Participants were asked to report whether the mouth images were identical or different. Percent correct performance was determined for (C) same identity and (D) different identity faces. Performance was above chance (50%) for all conditions except for the same-identity normal/Thatcherized inverted condition (red, $^*p < 0.001$). Error bars represent ±1 standard error across participants.

Image differences

The key finding across each experiment was that inversion severely disrupted ability to discriminate normal from Thatcherized images of the same face or of the eye or mouth regions from the same face. So, we determined the low-level differences between the image properties of normal and Thatcherized images created from the same face. First, we calculated the mean absolute difference in gray value across corresponding pixels in pairs of images from the same identity (Figure 5A). Next, we measured the correlation of gray values from corresponding pixels in the same image pairs (Figure 5B). These analyses were performed on the whole face (as used in Experiment 1) and on the eye and mouth regions (Experiment 2). An ANOVA revealed a significant effect of pixel differences across the different image conditions, $F(2, 10) = 28.4$, $p < 0.001$. This was due to a progressive increase in the mean difference for gray values for each pixel between images from the whole face (pixel diff: 5.6 ± 1.2), from the mouth (pixel diff: 15.3 ± 1.8) and from the eye (pixel diff: 21.4 ± 3.3) regions. An ANOVA on the correlation values also revealed a significant effect, $F(2, 10) = 28.0$, $p < 0.001$. Again this was due to a progressive decline in the similarity of the images from the whole face ($r = 0.95 \pm 0.01$) to the mouth ($r = 0.78 \pm 0.03$) and eye ($r = 0.71 \pm 0.03$) regions. These results highlight that the reduced ability to discriminate normal from Thatcherized images when they were inverted was evident despite substantial low-level differences in the images.

Discussion

Previous attempts to explain the dramatic effect of orientation in the Thatcher illusion have held that its cause lies in the disruption of configural processing

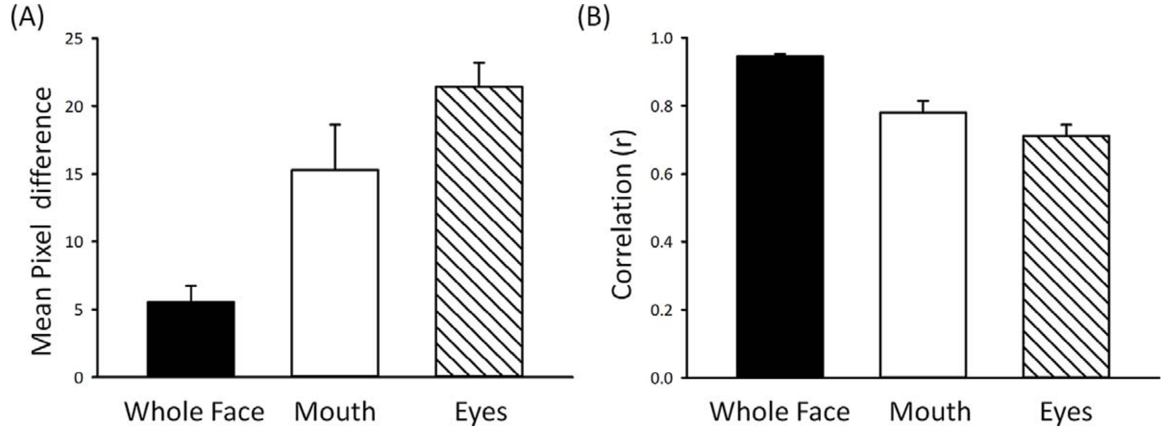

Figure 5. Mean differences and correlations across normal and Thatcherized versions of images of the same identity. (A) low-level differences between the image properties of normal/Thatcherized conditions of the same identity across the different features (whole face, mouth, and eyes), and (B) correlation between corresponding pixel values in images of normal/Thatcherized conditions of the same identity, across the different features (whole face, mouth, and eyes) used in the study. Errors represent one standard error.

(Bartlett & Searcy, 1993; Bertin & Bhatt, 2004; Edmonds & Lewis, 2007). Configural processing is thought to be essential to perceiving the grotesque expression, and its disruption leads to the expression not being seen correctly when the image is upside down. The aim of this study was to explore the role of spatial configuration in the Thatcher illusion. Participants judged whether simultaneously presented images were identical, or different in any way.

We found that participants were easily able to discriminate a normal face from a Thatcherized version of the same face when the images were presented upright. However, when the images were inverted, performance fell below chance level because participants simply failed to notice the difference between the images. This simple perceptual test offers strong evidence of how poorly the inverted Thatcherized expression is perceived.

To determine whether the illusion could be explained by a disruption to the overall facial configuration, we measured performance when only the eye region or only the mouth region of each image was visible. Again, participants were easily able to discriminate a normal from a Thatcherized version of the same image when upright. However, when the images were inverted, participants were at chance levels. It is important to note that local information about the orientation of the eye or mouth regions is evident in these images, for example, the position of eyebrows or the shape of the visible part of the jaw. This could be considered as local "configural" information. However, when only the mouth region or eye region is shown, any second-order configural information about the spatial relationships between facial features is entirely absent.

Our results suggest that previous attempts to explain the Thatcher illusion have been mistaken in ignoring the possibility that inversion disrupts feature processing. Instead, locally-inverted facial features (mouth or eyes) are themselves perceived as being abnormal, if they are interpreted as being in an upright orientation. However, when the image is interpreted as inverted, the precision with which the features are encoded is diminished and the features do not look grotesque. As we show that these effects can be found for the face as a whole and for the isolated mouth and eye regions, this effect cannot be explained by a disruption to second-order configural processing. Rather, our analysis of the Thatcher illusion shows that it depends primarily on sophisticated perceptual encoding of local face regions that are taken to be upright by the perceptual system. When the perceptual system interprets the features as being inverted, it is less able to encode them accurately.

A further remarkable aspect of the Thatcher illusion is that the low-level differences between a normal and Thatcherized image are identical in the upright and inverted orientations. So, it seems odd that when participants were asked only to make a simple visual discrimination between images based on any differences whatsoever, they failed to get above chance with the inverted images. In Experiment 2, the only cue to the orientation of the face is the jaw line for the mouth region and the eye brows / bridge of the nose for the eye region. Nevertheless, it appears that these cues are sufficient to provide the critical orientation cues that influence our perception of the facial features. The magnitude of the inversion effect was lower in Experiment 2, but this was presumably because the low-level image differences as a proportion of the whole image were greater in this Experiment 2 (see Figure 5). Our findings suggest that low-level image discrimination of faces can be influenced by the context in which the face is perceived. This fits with recent studies that have demonstrated how the global properties of natural images (including faces) can influence low-level feature detectors (Neri, 2011, 2014). It is possible that the inability to detect image differences may reflect feedback from higher to lower visual regions.

The Thatcher illusion also demonstrates a degree of independence between the processing of facial identity and expression. The identity of a Thatcherized face can still be recognized when the face is upside down, albeit with some difficulty, whereas the ability to perceive the grotesque facial expression is completely lost. Inversion appears to be having a differential effect on the processing of facial expression and identity. This dissociation is consistent with a variety of evidence that facial identity and expression are processed along parallel processing streams (Bruce & Young, 2012; Haxby, Hoffman, & Gobbini, 2000; Young & Bruce, 2011). In a recent study (Psalta et al., 2013), we found a neural correlate of the Thatcher illusion in the posterior STS—a face-selective region that is thought to be involved in the processing of facial expression (Allison, Puce, & McCarthy, 2000; Baseler, Harris, Young, & Andrews, 2013; Engell & Haxby, 2007; Harris, Young, & Andrews, 2012). This was reflected by an increased response in the STS when there was a change in the image from a normal to a Thatcherized face. However, there was no increase in response from a normal to a Thatcherized face when the faces were inverted.

In conclusion, our results show that the inability to detect the grotesque expression in the inverted Thatcher illusion can be explained by a reduced sensitivity to inverted facial features. This interpretation contrasts with previous work that has suggested that the Thatcher illusion reflects configural processing. We do not, of course, deny other clear evidence that configural processing plays a role in face perception and that it is disrupted by inversion. However, we suggest that the explanation of the Thatcher illusion lies with the orientation-specific encoding of local expressive features (eyes and mouth).

Keywords: face, Thatcher illusion, expression, inversion

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