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The Look of Fear and Anger: Facial Maturity Modulates Recognition of Fearful and Angry Expressions

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The current series of studies provide converging evidence that facial expressions of fear and anger may have co-evolved to mimic mature and babyish faces in order to enhance their communicative signal. In Studies 1 and 2, fearful and angry facial expressions were manipulated to have enhanced babyish features (larger eyes) or enhanced mature features (smaller eyes) and in the context of a speeded categorization task in Study 1 and a visual noise paradigm in Study 2, results indicated that larger eyes facilitated the recognition of fearful facial expressions, while smaller eyes facilitated the recognition of angry facial expressions. Study 3 manipulated facial roundness, a stable structure that does not vary systematically with expressions, and found that congruency between maturity and expression (narrow face-anger; round face-fear) facilitated expression recognition accuracy. Results are discussed as representing a broad co-evolutionary relationship between facial maturity and fearful and angry facial expressions.

Keywords: facial expressions, maturity, evolution, emotion

The idea that facial expressions are functional has a long tradition within psychology. As early as Darwin's seminal research (1872/1965) and through the current day (e.g., Ekman et al., 1989; Fridlund, 1994; Frijda & Tcherkassof, 1997), there has been a growing consensus that facial expressions evolved as a means of social communication; that is, facial expressions exist as an adaptive solution to effectively and efficiently communicate information related to a target's affective states, motives, future behaviors, and even traits of the expresser (see Parkinson, 2005 for a review).

The ability to accurately encode and decode facial expressions has numerous adaptive consequences. For example, the ability of a perceiver to accurately discriminate between real and fake smiles aids in the approach of potentially cooperative others and the avoidance of threatening others (Brown & Moore, 2002). Conversely, the ability of a target to effectively display an expression of fear is capable of eliciting greater prosocial behaviors from others (Marsh, Kozak, & Ambady, 2007). Studies using event-related potential (ERP) analyses indicate that greater attention is paid to threatening facial expressions, suggesting that their may be an evolved threat detection module in the brain (Schupp et al, 2004). Thus, the communicative value of emitting and accurately recognizing facial expressions is of great importance for targets and perceivers alike.

Despite this growing consensus that facial expressions evolved to serve a communicative function, little is known about why facial expressions evolved to appear in the physical configurations that they do. For example, why does the configuration of a fearful expression result in the widening of the eyes and mouth whereas facial expressions of anger lead to a narrowing of the eyes and a pursing of the lips? Of all possible constellations of features, what adaptive benefit, if any, have these specific facial configurations afforded over other configurations?

Until recently, there have been few attempts to explain the origins and functions of facial expression and the majority of which have posited noncommunicative sources of such configurations. For example, Darwin (1872/1965) suggested that the raising of the eyebrows and widening of the eyes associated with fear or surprise facilitate attending to the environment, while the lowering of the upper eyelid, which is associated with expressions of disgust and anger, functions to shut out a potentially dangerous environment. For disgust, Rosenstein and Oster (1988) have posited that widening the mouth and elevating the tongue serve to block the ability to swallow and allow fluid to drain from the mouth while the compression of the cheeks in reaction to sour substances might act to increase salivation, thus diluting the sour substance. Because bitter and sour flavors are associated with numerous poisonous substances, reflexive facial movements associated with the disgust expression might serve the important survival function of eliminating toxic materials from the mouth before ingestion. In each of these cases, however, the origins of facial configurations appear to be entirely independent of communication.

Bridging this gap, a number of theorists have recently argued that the specific configural changes in facial morphology that accompany some basic emotional expressions might also serve an inherently *communicative* function (e.g., Becker, Kenrick, Neuberg, Blackwell, & Smith, 2007; Le Gal & Bruce, 2002; Penton-Voak, Wisbey, & Pound, 2007; Marsh, Adams, & Kleck, 2005). For example, Becker and colleagues (2007) argue that happy and angry facial expressions co-evolved with characteristics of sexual dimorphism to enhance signals of happiness and anger. By mor-

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phologically altering facial structures to make them appear more masculine, the signal strength of anger (i.e., displaying dominance) becomes stronger. Similarly, insofar as happiness is morphologically similar to more feminine structures, the affiliative intent of happiness is more successfully communicated. Thus, structures related to masculinity facilitate recognition of angry expressions whereas feminine features facilitate the recognition of happy facial expressions (see also Le Gal & Bruce, 2002; Penton-Voak et al., 2007).

The current research focuses on a similar argument recently made by Marsh and colleagues (2005) in which they hypothesize that two basic facial expressions—expressions of fear and anger—may have evolved their configurations in order to mimic the configuration of babyish and mature-looking faces (see Keating, 1985 for a review of literature on physiognomy and perceptions of dominance and submissiveness), thus enhancing the signal value of these expressions. Specifically, if reconfiguring the face to have a more mature appearance (e.g., small eyes, low brows and a large jaw) enhances the anger signal, this stronger signal of dominance may reduce the likelihood of potentially costly aggression. Conversely, by mimicking a babyish face (e.g., larger eyes, higher and more arched brows), a fearful expression may appear even more submissive, disarming, and supplicating than it otherwise would if fear had a different configuration, thus enhancing the signal of fear.

Consistent with this hypothesis, Marsh and colleagues found that targets expressing fear were rated as having traits associated with babyish characteristics, such as dependence, weakness, submissiveness, and naiveté to a greater degree than targets expressing anger while targets expressing anger were judged to possess traits associated with maturity, such as independence, strength, dominance, and shrewdness, to greater degree than targets expressing fear. Fearful expressions were also judged to possess more babyish facial structures than angry expressions, including larger eyes, fuller lips, and higher brows. Marsh and colleagues argue that such associations of fear expressions with babyish facial features and anger expressions with mature facial features serve as initial evidence that fear and anger evolved to mimic babyish and mature features in order to make their expressive signals more submissive and dominant, respectively.

Our goal is to extend Marsh and colleagues' work by providing evidence for a broad, sex-general, and functional relationship between facial expressions of fear and anger and facial structures of babyishness and maturity. First, Marsh and colleagues' evidence is unidirectional. That is, they show evidence that facial expressions influence the perception of mature-babyish facial structures, and mature-babyish traits. If facial expressions and maturity co-evolved to enhance the signals of dominance and submission, the anger-maturity and fear-babyish links should be bidirectional. Thus, not only should anger imply maturity, but greater facial maturity should also facilitate the perception of anger. Similarly, if the fear signal and facial babyishness co-evolved, not only should fearful faces appear more babyish, but more babyish faces should also provide a stronger signal of fear than should mature faces.

The current research sought to provide novel evidence that babyish and mature facial structures enhance the signal strength of fear and anger, respectively. In order to experimentally isolate the role of babyish and mature features in perceiving fearful and angry facial expressions, we directly manipulated facial structures that imply babyishness and maturity. We reasoned that if fearful facial expressions evolved to appear immature to send a stronger signal of supplication, then experimentally altering a target's facial structure to appear more babyish should make a fearful expression on that face appear even more fearful. Furthermore, if angry facial expressions evolved to look mature to send a stronger dominance signal, then experimentally altering the same facial structure to appear more mature should make an angry expression on that face appear angrier. Thus, enhancing babyish features should increase the signal strength of fear, whereas enhancing mature features should increase the signal strength of anger.

To test these hypotheses, Studies 1 and 2 altered target eye size in order to manipulate facial structures related to maturity and immaturity. Much past research indicates that variations in eye size are capable of altering perceptions of babyishness and maturity such that as targets' eye size increases, they are judged to possess more babyfaced characteristics and fewer mature characteristics (e.g., Berry & McArthur, 1985; Keating & Doyle, 2002). Furthermore, because understanding information conveyed by a target's eyes is central to inferring the mental states of others, we considered this to be a valuable feature of the face to manipulate as the initial test of our structure-expression hypothesis. In Study 1, we asked participants to identify expressions of fear and anger, which were altered to have larger, smaller, or original eye size, as quickly as possible. We hypothesized that larger eyes, a babyish feature, would facilitate accurate recognition of fearful expressions, while smaller eyes, a more mature feature, would facilitate accurate recognition of angry facial expressions. Congruency between maturity and expression should enhance the expression signal, thereby facilitating recognition accuracy. Study 2 tested this congruency hypothesis by adopting a visual noise paradigm to simulate an impoverished perceptual environment. Using the logic of a signal-to-noise ratio, if maturity-expression congruency (small-eyed anger; large-eyed fear) increases the signal of the expression, then this signal should be detectable through more noise than an incongruent maturity-expression pairing (large-eyed anger; small-eyed fear).

Study 3 was meant to test the breadth of our hypothesis as well as to rule out alternative explanations for the relationships found in Studies 1 and 2. Study 3 used the same procedure as that outlined in Study 1, but altered the shape of the face to make it more or less mature; in this case, more narrow or more round, respectively. According to our congruency hypothesis, such structural changes, although independent of structural changes associated directly with expressions of fear and anger, should have similar effects on facial expression recognition if one assumes a broad co-evolutionary relationship between structure and expression. Specifically, a rounder (immature) face should lead to greater accuracy in recognizing fear while a more narrow (mature) face should lead to greater accuracy in recognizing anger.

Study 1

We hypothesized that manipulating facial characteristics to be more babyish or mature would increase the signal strength of congruent expressions (i.e., small eyes-anger; large eyes-fear), which should in turn facilitate the recognition of these expressions. While successfully communicating fear and anger can avoid or diffuse potential confrontations (Frijda & Tcherkassof, 1997; Knutson, 1996), these facial displays are only as effective as the perceiver's ability to accurately recognize them. Building on this logic, Study 1 explored the role of babyish and mature facial structures in the recognition of facial expressions of fear and anger. In this study, participants completed a speeded expression recognition task, in which they saw unmanipulated angry and fearful faces, as well as angry and fearful faces with artificially enlarged and reduced eye areas. Participants were asked to identify the expression on each face as quickly and accurately as possible. Because people tend to be very good at identifying facial expressions, we chose a speeded categorization task in order to increase error rates necessary to detect our potential effect. We hypothesized that congruence between the maturity of the face and the dominance of the expression (i.e., small eyes-anger; large eyes-fear) would facilitate the accuracy of expression recognition.

Method

Participants and design. Forty-seven introductory psychology students (28 women; mean age = 18.7 years) volunteered to participate in exchange for partial course credit. Participants included 37 Caucasian participants, one African American participant, and one Asian participant; eight participants did not provide ethnicity information.

The experiment employed a 2(Target Expression: angry; fearful) $\times$ 3(Eye Size: large; small; unmanipulated) repeated-measures design. Notably, none of the predicted interactions were qualified by target or participant sex in any of the studies reported herein. As such, this is not discussed further.

Materials. Stimuli consisted of 3 male and 3 female Caucasian adults posing both a fearful and an angry expression, for a total of 12 stimuli, compiled from the Ekman and Friesen (1976) database.[1] Each stimulus was grayscale, approximately 9.3 $\times$ 6.7 cm in size, and was cropped such that only the face was visible against a white background. The eyes of each of the 12 stimuli were then manipulated via Photomagic 1.0 (1993) to create a version that had 15% larger eyes and a version that had 15% smaller eyes. Thus, the stimulus set included each model posing a fear expression with 15% larger eyes, 15% smaller eyes, and original sized eyes, as well as an anger expression with 15% larger eyes, 15% smaller eyes, and original sized eyes, for a total of 24 stimuli. A 15% increase and decrease in eye area was selected based on previous research indicating that such manipulations in eyes size altered the maturity of target faces without affecting the realism of the faces (Keating & Doyle, 2002). All stimuli were rendered into jpeg format, each with an image resolution of 72 pixels per inch (PPI) for presentation during the experiment (see Figure 1 for example stimuli).

Procedure. Participants arrived at the laboratory in groups of up to four, and were seated in separate computer cubicles to complete the experiment. All instructions and procedures were completed on Dell PC's, with 17" CRT monitors with a screen resolution of 640 $\times$ 480 PPI. All stimuli were presented using the Inquisit 3.0 (2003) software. Participants were instructed that they would see a series of fearful and angry faces on the computer screen, and their task was to identify each face by its expression as quickly and accurately as possible. Participants identified expressions via a keyboard button press, with anger mapped onto the 'a' key (left hand) and fear mapped onto the "5" key on the number pad (right hand). Participants were instructed to keep their fingers placed on the keys used to make the expression discriminations ("a" and "5" keys respectively) to facilitate faster responding. Reminders of the key mappings remained on the screen throughout the experimental trials.

The experimental procedure consisted of 324 trials, separated into three blocks. In each block, participants categorized each of the 36 stimuli by expression three times per block, for a total of 108 trials. Between each block, participants were given a brief break before continuing. Stimuli were presented in a separate random order for each participant. On each trial, a fixation cross ('+') was displayed at the center of the computer screen for 1 s. This fixation cross was then occluded by the stimulus face, which remained on the screen for 200 ms, before being blanked by a white box (see Hugenberg, 2005, for a similar procedure). Thus, although participants had an unlimited amount of time to respond to each stimulus image, the image was presented for only 200 ms. Incorrect categorizations elicited a red "ERROR" message, presented for 1 s at the center of the screen. Identification accuracy and reaction time were recorded for each trial.

After completing the experiment, participants completed a demographics questionnaire, and were then debriefed and thanked for their participation.

Results and Discussion

The primary interest of this study was the extent to which congruency between eye size and expression facilitated the accurate recognition of facial expressions. As such, separate percentages of recognition accuracy were calculated for large-eyed angry, small-eyed angry, unmanipulated angry, large-eyed fearful, small-eyed fearful, and unmanipulated fearful faces, separately for each participant. These accuracy data were subjected to a 2(Target Expression: angry vs. fearful) $\times$ 3(Eye Size: small vs. control vs. large) repeated-measures ANOVA. As predicted, the results revealed a significant interaction between expression and eye size, $F(1, 46) = 27.38$, $p < .001$. Pairwise comparisons indicated that angry expressions with smaller eyes ($M = .93$, $SD = .05$) were recognized significantly more accurately than angry expressions with unaltered eyes ($M = .88$, $SD = .06$), $t(46) = 5.88$, $p < .001$, $d = .86$, or large eyes ($M = .86$, $SD = .07$), $t(46) = 7.30$, $p < .001$, $d = 1.06$. Conversely, recognition accuracy was marginally better for fearful expressions with larger eyes ($M = .90$, $SD = .05$) than those with unaltered (M = .88, $SD = .05$), $t(46) = 1.92$, $p = .061$, $d = .28$, and significantly better than for fearful expressions with smaller eyes (M = .88, $SD = .06$), $t(46) = 2.03$, $p = .048$, $d = .30$ (see Figure 2).

In order to more directly test our congruency hypothesis, the data were averaged across expression to create separate indexes of accuracy in the congruent (small eyes-anger, large eyes-fear), incongruent (large eyes-anger, small eyes-fear), and con-

[1] Facial identities utilized in Study 1 included GS1-25, G2-8, JJ5-13, JJ3-12, MO1-26, MO2-13, NR1-19, NR2-7, SW1-16, SW4-9, JB1-12, and JB1-23 from the Ekman and Friesen Database (1976).

Figure 1. Sample stimuli used in Study 1. The top row represents fearful expressive stimuli and the bottom row angry expressive stimuli. Stimuli on the left have been subjected to 15% eye area reductions, stimuli on the right have been subjected to 15% eye area increases, and stimuli in the middle represent, unaltered (control) stimuli. Figure credit: www.paulekman.com. Reprinted with permission from Ekman and Friesen (1976).

trol (unaltered expressions of fear and anger) expression-eye size conditions. Pairwise comparisons on these indexes indicated that participants were significantly more accurate on congruent trials (M = .91, SD = *.04*) than either control trials (M = .88, SD = *.05*), $t(46) = 5.20$, $p < .001$, $d = .76$, or incongruent trials (M = .87, SD = *.05*), $t(46) = 6.83$, $p < .001$, $d = 1.00$. Although the direction of the means suggested that participants were less accurate on incongruent trials than control trials, these results were only marginally significant, $t(46) = -1.69$, $p = .098$, $d = .25$.[2]

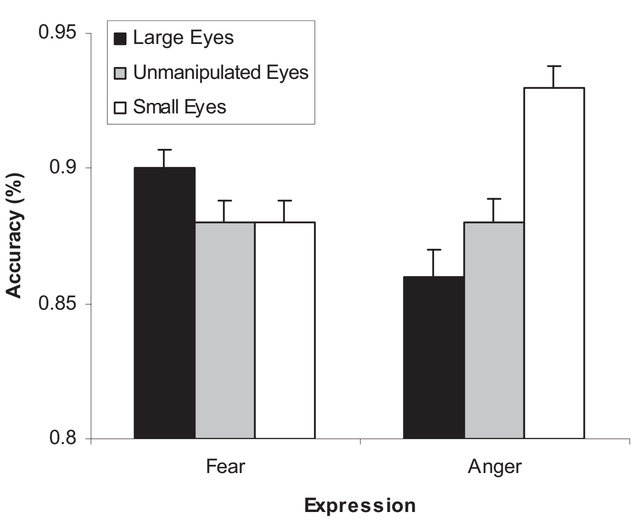

Figure 2. Recognition accuracy for fear and anger expressions across eye size manipulations (Error bars reflect the standard error of the mean).

Consistent with predictions, the results of Study 1 suggest that variations in facial structures associated with variations in perceptions of submissiveness and dominance, specifically eye size, played a significant role in the accurate recognition of fearful and angry facial expressions. Individuals were more accurate in correctly categorizing fearful expressions when the target had a babyish facial feature (larger eyes), as compared to when the face was unmanipulated or displayed a mature facial feature (smaller eyes). Conversely, individuals were significantly more accurate in correctly categorizing angry expressions when the target had a mature facial feature as compared to when the face was unmanipulated or displayed a babyish facial feature. Finally, there was tentative evidence that incongruent structure-expression combinations inhibited accurate expression recognition; however, the strength of this inhibition effect was much weaker than the facilitation elicited by structure-expression congruency. Thus, faces that have more babyish features (larger eyes) appear to display a stronger

[2] Although accuracy can be traded for speed in many tasks, our procedure locked the amount of time perceivers had to view the stimulus. Despite this, secondary analyses of RTs were conducted to ensure a speed–accuracy trade-off was not occurring. RT data in Study 1 yielded a Target Expression × Eye Size interaction, $p < .001$, that closely mirrored the accuracy data, with facilitated RTs for congruent structure-expression pairings. No such interaction was observed in Studies 2 or 3. As such, the accuracy results across studies are not attributable to a speed–accuracy trade-off.

signal of fear, whereas faces that have more mature features (smaller eyes) appear to display a stronger signal of anger, resulting in more accurate responding for these congruent structure-expression combinations. Such a relationship provides initial experimental evidence supporting a co-evolutionary link between facial maturity and facial expressions.

Study 2

The core of our hypothesis is that congruence between the maturity of facial structures and the maturity of facial expressions enhances the signal strength of the expression. Indeed, the information conveyed by a facial expression is only as valuable as a perceiver's ability to accurately decode the expression. Throughout the evolutionary history of humans, individuals were likely confronted by situations in which survival required the ability to decode facial expressions and other social signals under less than optimal conditions. For example, being able to accurately detect a signal of anger or fear quickly, from a great distance, at dusk, or under other perceptually impoverished situations could afford real adaptive benefits. In the context of research on visual perception, it is possible to systematically vary the amount of signal and noise in an image such that the image becomes more or less identifiable. Specifically, adding "visual noise" to an image makes it more difficult to accurately discern the contents of the image (e.g., Pelli & Farrel, 1999). Thus, visual noise can be used to create a suboptimal environment in which a stimulus is observed, which can serve as a more direct test of the signal strength hypothesis.

Study 2 adopted a visual detection paradigm, and relied on systematic manipulations of visual noise to further explore the role of babyish and mature facial structures in facilitating the accurate recognition of fearful and angry facial expressions. If mature facial structures increase the anger signal and babyish structures increase the fear signal, we hypothesized that these stronger signals should be more easily perceptible through increasing amounts of visual noise than should the converse, incongruent structure-expression combinations. Similar to our first study, we anticipated that accuracy at the lowest level of visual noise would offer a conceptual replication of our first study; that is, congruent structure-expression combinations would facilitate recognition accuracy. In essence, the low noise stimuli would be similar in their perceptual quality as compared to Study 1. However, we predicted the accuracy advantage of congruent structure and expression combinations would be most pronounced in middling levels of visual noise, where increasing stimulus degradation would make such congruency between structure and expression of even greater utility in identifying the facial expressions of targets due to the stronger signal conveyed by such congruity. At very high levels of visual noise, however, many structural features may become too obscured, leading structure-expression congruency to have little effect.

Method

Participants and design. Twenty-five Caucasian introductory psychology students (16 women; mean age = 18.7 years) volunteered to participate in exchange for partial course credit.

The experiment employed a 2 (Target Expression: angry; fearful) × 2 (Eye Size: large; small) × 10 (Visual Noise) repeated-measures design.

Materials. Stimuli consisted of two male and two female Caucasian adults posing both a fearful and an angry expression, for a total of eight stimuli; all stimuli were selected from those used in Study 1. Specifically, the large and small eyed versions of each model posing fear and anger were used resulting in a total stimulus set of 16 target faces.

Using the Matlab 6.5 (2002) computer software, a Gaussian noise function was employed to add 10 monotonically increasing levels of visual noise to each of the 16 stimuli (Pelli & Farrell, 1999). As can be seen in Figure 3, this Gaussian noise served to degrade the visual quality of the images. By systematically changing the variance of random pixels in the images, it was possible to vary the signal-to-noise ratio of the stimulus images in a consistent manner. As the standard deviation within the Gaussian noise function is increased, randomly selected pixels vary in shade to a

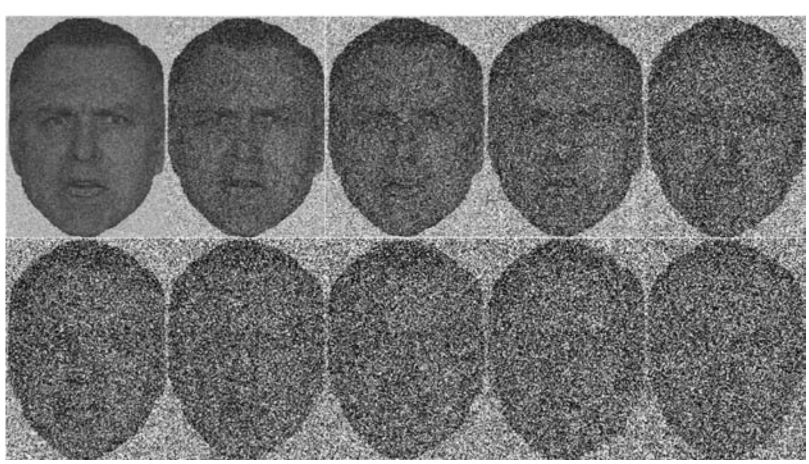

Figure 3. Example of a stimulus subjected to 10 levels of visual noise. Top left face represents the lowest level of visual noise ($\sigma = 20$); bottom right represents the highest level of visual noise ($\sigma = 200$). Figure credit: www.paulekman.com. Reprinted with permission from Ekman and Friesen (1976).

greater degree, thus increasing the amount of visual noise in the images. Each of the 16 stimuli was subjected to 10 levels of noise (as measured by standard deviation; σ = 20–200, at an increment of σ = 20 per level), leading to 10 increasingly "noisy" images per stimulus, for a total of 160 target images. All stimuli were rendered into jpeg format, each with an image resolution of 72 PPI, and were again presented on CRT monitors with a screen resolution of 640 × 480 PPI (see Figure 3, e.g., stimuli).

Procedure. Procedures were identical to those employed in Study 1, except as noted. Participants arrived at the laboratory in groups of up to four, and were seated in separate computer cubicles to complete the experiment. All instructions and procedures were completed on Dell PC's, with 17" CRT monitors. All stimuli were presented using the Inquisit 3.0 (2003) software. Participants were instructed that they would see a series of fearful and angry faces on the computer screen, and their task was to identify each face by its expression as quickly and accurately as possible. It was further explained that visual noise had been added to the images, which could make some of them more difficult to identify than others. Participants were instructed to nonetheless try to identify the expression on each of the faces as quickly and accurately as possible via keyboard button press.

The experimental procedure consisted of 480 trials, separated into three blocks. Participants categorized each of the 160 stimuli by expression once per block. Between each block, participants were given a brief break before continuing. Stimulus presentation was identical to that used in Study 1. Identification accuracy was recorded for each trial. After completing the expression recognition task, participants completed a demographics questionnaire, and were then debriefed and thanked for their participation.

Results and Discussion

Similar to Study 1, the primary dependent measure in this study was expression recognition accuracy. We hypothesized that congruent expression-maturity combinations (i.e., small eyes-anger; large eyes-fear) would be seen more accurately, more deeply into the visual noise. As such, separate indexes of response accuracy were calculated for large-eyed angry, small-eyed angry, large-eyed fearful, and small-eyed fearful faces, at each of the 10 levels of visual noise, separately for each participant.

These data were then subjected to a 2(Target Expression) × 2(Eye Size) × 10(Visual Noise) repeated-measures ANOVA. First, the ANOVA yielded the predicted two-way interaction between Target Expression and Eye Size, $F(1, 24) = 19.12$, $p < .001$. As predicted, the recognition of congruent expression-structure combinations (i.e., large eyes-fear; small eyes-anger) was superior to that of incongruent expression-structure combinations. Replicating the results of Experiment 1, fearful faces with large eyes ($M = .68$, $SD = .20$) were recognized more accurately than were fearful faces with small eyes ($M = .65$, $SD = .18$), $t(24) = 2.80$, $p = .01$, $d = .56$. Conversely, angry faces with small eyes ($M = .79$, $SD = .08$) were recognized more accurately than were angry faces with large eyes ($M = .76$, $SD = .10$), $t(24) = -2.80$, $p = .01$, $d = .56$.

Additionally, this lower-order interaction was subsumed within the predicted three-way interaction between Target Expression, Eye Size, and Noise Level, $F(9, 216) = 2.85$, $p = .003$. Because the three-way interaction involves 40 different within-subjects conditions, to more easily understand the three-way interaction, the accuracy data were recoded into congruent structure-expression combinations (large eyes-fear; small eyes-anger) versus incongruent structure-expression combinations (large eyes-anger; small eyes-fear), plotted separately at each level of visual noise. In order to test our hypothesis that congruency between structure and expression would facilitate accuracy through increasing amounts of visual noise, we conducted Pairwise comparisons, with Bonferroni corrections due to the large number of comparisons, to compare accuracy between congruent and incongruent trials at each level of visual noise. Although not reaching statistical significance based on Bonferroni corrections, congruent structure-expression combinations ($M = .86$, $SD = .14$) did significantly facilitate recognition accuracy compared to incongruent combinations ($M = .82$, $SD = .14$), $t(24) = 2.09$, $p = .048$, $d = .42$, at the lowest level of visual noise based on conventional levels of significance, thus offering a conceptual replication of Study 1.

More germane to the hypotheses of the current study and as can be seen in Figure 4, at middling levels of visual noise, congruent structure-expression combinations facilitated expression recognition compared to incongruent combinations; however this facilitation is eliminated at higher levels of visual noise. Specifically, pairwise comparisons indicated that congruent combinations were recognized with greater accuracy than incongruent combinations at moderate levels of visual noise: level 80 ($M_{\text{Congruent}} = .82$, $SD_{\text{Congruent}} = .14$ vs. $M_{\text{Incongruent}} = .70$, $SD_{\text{Incongruent}} = .16$), $t(24) = 4.43$, $p < .001$, $d = .89$, level 100 ($M_{\text{Congruent}} = .76$, $SD_{\text{Congruent}} = .15$ vs. $M_{\text{Incongruent}} = .68$, $SD_{\text{Incongruent}} = .160$), $t(24) = 2.97$, $p = .007$, $d = .59$. No other pairwise comparisons yielded significant results. Thus, congruent structure-expression combinations were more accurately recognized through visual noise than were incongruent combinations, particularly in the midrange of visual noise.

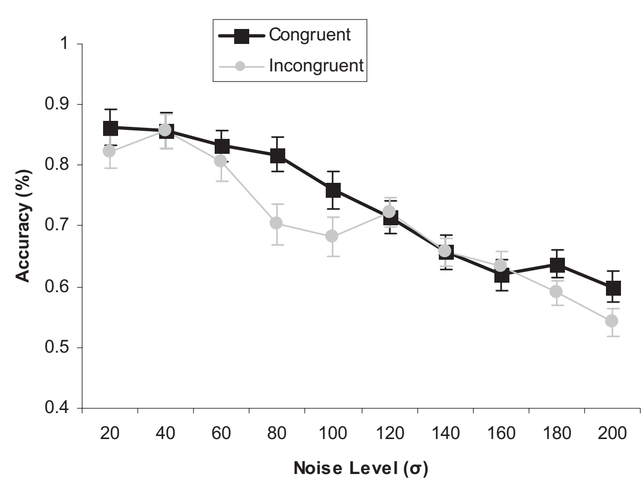

Figure 4. Recognition accuracy for congruent (large eyes-fear; small eyes-anger) and incongruent (small eye-fear; large eyes-anger) structure-expression combinations through visual noise. (Error bars reflect the standard error of the mean.)

Study 3

Thus far, we have found an increasingly robust relationship between physiognomic cues related to babyishness and maturity and their ability to facilitate the recognition of facial expressions of fear and anger, respectively. Despite the clear relationship between eye size and facial structure observed in Studies 1 and 2, a potential concern may arise with our manipulation of babyish and mature facial structures. Specifically, we have shown that manipulations in eye size, which previous research has shown to be strongly related to facial babyishness and maturity, are capable of facilitating the recognition of expressions of fear and anger. Despite this, it is possible that our observed results may not be so much about manipulating the babyishness or maturity of faces, and thereby enhancing the signal strength, but rather perhaps we have just directly manipulated the prototypicality of the expressions themselves. Thus, one might argue that as yet, it is unclear whether the results of our first two studies are due to variations in maturity, per se, or rather are due simply to manipulations of the strength of the expressions of fear and anger themselves.

In support of such a contention, according to well-established analyses of facial expressions (e.g., Facial Action Coding System; Ekman & Rosenberg, 1987), actions commonly associated with the expression of fear include the raising of the eyebrows, raising the upper lids, pulling the moth open, pulling the lips backward horizontally, and drawing the eyebrows together. Conversely, actions associated with the typical expression of anger included lowering and knitting the brows, tightening the eyelids, narrowing the eye openings, tightening and narrowing the lips, and pressing the lips together. As such, an individual expressing fear could naturally acquire bigger and rounder looking eyes, while an individual expressing anger could acquire narrower eyes.

Although there are a number of ways to grapple with this question, one way is to manipulate a feature of the face that is naturally associated with variations in maturity and immaturity, but does *not* systematically vary with prototypical expressions of fear and anger. If this new feature indicative of maturity and immaturity, but not related to natural variations in the expressions of anger and fear, yields facilitated recognition of expressions of fear and anger, we can more confidently assume that we have evidence of a more general co-evolutionary relationship between facial structures that convey maturity and immaturity and enhanced recognition of expressions of anger and fear. Building on this logic, previous research indicates that facial roundness is second only to variations in eye size with respect to individuals' attributions of babyishness and maturity in others (Zebrowitz, Montepare, & Lee, 1993). Specifically, rounder faces are associated with elevated ratings of babyishness while narrower faces are associated with enhanced maturity.

More important, relative facial roundness is not directly related to morphological changes associated with expressions of fear and anger (Ekman & Rosenberg, 1987). Facial roundness is a rather stable facial feature whereas variation in eye size is a much more dynamic, temporally changeable feature of the face. Thus, if rounder faces facilitate recognition for fearful expressions whereas narrower faces facilitate recognition for angry facial expressions, we will have additional evidence for the structure-expression link, but more importantly, evidence that is not easily impeachable via an argument that we have simply made the expression more prototypical, and thus enhanced its strength.

As such, in Study 3 we used the Poser modeling software to create a set of computer-generated faces with relatively rounder or narrower facial structure. We then manipulated each of these models to display both a fearful and an angry facial expression. Consistent with our previous two studies, we hypothesized that congruent structure expression combinations (narrower face-anger; rounder face-fear) would be recognized with greater accuracy than targets with incongruent structure-expression combinations (rounder face-anger; narrower face-fear).

Method

Participants and design. Fifty-five introductory psychology students (34 men; M age = 19.1 years) volunteered to participate in exchange for partial course credit. Participants included 50 Caucasian participants, two African American participants, one Asian participant, and one Hispanic participant; one participant did not provide demographic information.

The experiment employed a 2(Target Expression: angry; fearful) $\times$ 2(Face Shape: round; narrow) repeated-measures design.

Materials. Frontal and side view pictures of three male and three female Caucasian adults were obtained from the Aging Faces Database (Minear & Park, 2004). These were then imported into the Poser 7 software (E Frontier, 2006), and were used to create 3-dimensional avatars of each individual model (six avatars total; three female and three male). Each of these avatars was then manipulated, using the program's facial roundness function, to create an equivalently more round and more narrow version of the original model (1 unit in each direction, respectively). This yielded 12 stimuli; a relatively babyish (facially more round) and mature (facially more narrow) version of all six models.

Each of these 12 stimuli was then further manipulated using morph tools in the Poser software to create an angry and fearful version of each stimulus, for a total of 24 stimuli. As can be seen in Figure 5, congruent with the FACS, fearful expressions had more raised eyebrows and upper eyelids, more open mouths and pulling back lips, whereas angry expressions had more knitted brows and closed eyelids, and tighter snarled lips.[3] The stimulus set included each model posing a fearful expression with a more round face (babyish) and a more narrow face (mature) as well as an anger expression with a more round face (babyish) and a more narrow face (mature). It was important that each of the original six stimuli was subject to identical structural and expression changes. Thus, each face displayed

[3] Although our software used to manipulate facial expressions in Study 3 did not directly manipulate faux muscle groups underlying the face, the manipulations used to create facial expressions were meant to roughly coincide with those FACS action units that tend to be associated with fear (i.e., AU20, AU1 + 5, and AU5 + 7) and anger (i.e., AU2, AU4, AU7, AU23, and AU24), respectively. Although research often indicates that the AU4 action unit (brow lowerer) is implicated in both fearful and angry expressions, the addition of the AU1 + 2 (raising the brows) results in fear having knitting rather than lowering of the brows (see Ekman and Rosenberg for a review of FACS action unit coding for facial expressions).

Figure 5. Sample stimuli from Study 3. The top row: angry male with wide face (left) and angry male with narrow face (right). The bottom row: fearful male with wide face (left) and fearful male with narrow face (right). Reprinted with permission from Minear and Park (2004).

the same magnitude of anger and fear, across the facial roundness manipulation.[4]

Each stimulus was then flattened into a two-dimensional stimulus displaying the entire face directly, rendered into grayscale, resized to approximately 12.4 $\times$ 12.4 cm in size, and was cropped such that only the face was visible against a white background. All stimuli were rendered into jpeg format, each with an image resolution of 72 PPI, and were again presented on 17" CRT monitors with a screen resolution of 640 $\times$ 480 PPI.

Procedure. The procedures for this study were identical to those of Study 1, except as noted. Participants arrived at the laboratory in groups of up to four, and were seated in separate computer cubicles to complete the experiment. All instructions and procedures were completed via computer and all stimuli were presented using the Inquisit 3.0 (2003) software. The experimental procedure consisted of 192 trials, separated into two blocks. In each block, participants categorized each of the 24 stimuli by expression four times per block, for a total of 96 trials. Between each block, participants were given a brief break before continuing. Stimuli were presented in a separate random order for each participant. On each trial, a fixation cross ('+') was displayed at the center of the computer screen for 1 s. This fixation cross was then occluded by the stimulus face, which remained on the screen for 200 ms, before being blanked by a white box. Incorrect categorizations elicited a red "ERROR" message, presented for 1 s at the center of the screen. Viewing angle and size were held constant across all stimuli. Identification accuracy and reaction time were recorded for each trial.

After completing the experiment, participants completed a demographics questionnaire, and were then debriefed and thanked for their participation.

Results and Discussion

As accuracy was the dependent measure of interest in the current study, percentage accurate recognition was calculated at each of the four levels of the independent variables: round-angry, narrow-angry, round-fearful, and narrow-fearful, separately for each participant. These accuracy data were subjected to a 2 (Target Expression: angry vs. fearful) $\times$ 2 (Face Shape: round vs. narrow) repeated-measures ANOVA. This analysis yielded a main effect for neither expression nor facial structure. However, the ANOVA yielded the predicted interaction between Target Expression and Face Shape, $F(1, 54) = 5.63$, $p = .021$. More important to our hypothesis and consistent with Studies 1 and 2, congruent face shape-expression pairings (narrow face-anger; round face-fear) were recognized with greater accuracy than were targets with incongruent combinations (round face-anger; narrow face-fear), $t(54) = 2.37$, $p < .05$, $d = .32$ (see Figure 6).

From these data, it appears clear that congruence between facial maturity and facial expression enhances the expression signal. This study provides further evidence that fearful expressions may have evolved to mimic babyish facial structures and angry expressions to mimic mature structures to facilitate the accurate communication of these emotional states.

Importantly, this study indicates that even stable facial structures that do not necessarily vary with expressions of anger and fear can influence the signal value of fear and anger, so long as they are structures related to babyish and maturity.

[4] To ensure that our manipulations of facial roundness and narrowness did not influence target eye size, two independent raters measured the eye width and height of each target's left and right eyes as well as the total width and height of each target's face. Based on past research (Cunningham, Roberts, Barbee, Druen, & Wu 1995), we computed the eye area of each targets right and left eye by divided the eye height by the face height as well as the eye width by the face width in order to standardize these values. We then multiplied these two values together for each eye to obtain eye areas for each target and computed a single value of eye area by averaging the area of each target's right and left eye. Because the correlations of measurements made by the two raters was high, $r(22) = 1$, $p < .001$, these ratings were averaged to get a composite measure of eye area for each target. Using this average measurement, we subtracted the eye area of the round-face version of each model from the eye area of the narrow-face version of each model (wide anger - narrow anger, wide fear - narrow fear). One sample t tests comparing the mean of this difference score against zero indicated that the round-face and narrow-face versions of each model did not differ from zero, $t(11) = .97$, $p > .35$. Furthermore, these difference scores were not correlated with the accuracy advantage associated with narrow faces-anger and round faces-fear (ps $> .15$). Similar analyses measuring eye size more simply with the formula for an ellipse yielded nearly identical results.

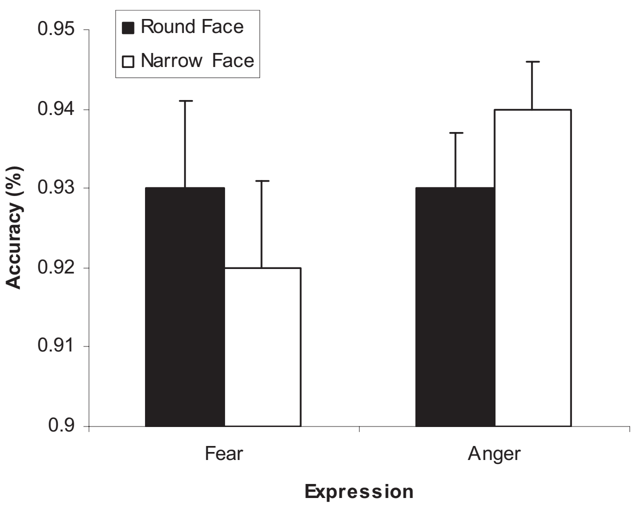

Figure 6. Recognition accuracy for congruent and incongruent structure-expression combinations across facial roundness manipulations. (Error bars reflect the standard error of the mean.)

General Discussion

The current series of studies were designed to provide novel evidence for the evolved basis of the configuration of fear and anger expressions. Previous research suggests that fearful and angry expressions may have evolved in order to mimic babyish and mature facial structures (Marsh et al., 2005) because there may be adaptive benefits from adopting a babyish facial configuration to more powerfully display a signal of submission, and a mature facial configuration to more powerfully display a signal of dominance. Fear is an emotion that communicates that the expresser is submissive, disarming, and nonthreatening (Frijda & Tcherkassof, 1997; Knutson, 1996). Furthermore, babyfaced individuals are also considered submissive and nonthreatening (Keating, 1985). As such, reconfiguring one's face to appear babyish when trying to display a fearful expression offers the adaptive advantage of a fearful expression appearing even more disarming than it otherwise might. Similarly, an adaptive benefit may be had by reconfiguring the face to appear more mature when expressing anger. As mature faces are attributed characteristics such as dominance and independence (i.e., Keating, 1985; Keating & Doyle, 2002), reconfiguring one's face to appear more mature when angry offers the adaptive advantage of an angry expression appearing even more dominant than it otherwise might.

The current research was designed to test the hypothesis that faces that include stronger babyish and mature facial structures (in both variant and invariant facial structures) enhance fearful and angry expressions, respectively. While evolutionary theories can be difficult to directly test in human populations, we reasoned that if such an evolved relationship between expression and maturity exists, then directly manipulating facial maturity should alone be sufficient to modulate the signal strength of expressions. Thus, the expression signal should appear stronger when the expressions and structure are congruent.

Across three studies, we provided evidence for this congruency hypothesis. Study 1 found that the babyish characteristic of larger eyes facilitated the accuracy with which fearful expressions were recognized. Conversely, the mature characteristic of smaller eyes facilitated the accuracy with which angry expressions were recognized. Study 2 adopted a visual noise paradigm to investigate how much visual noise could be added to angry and fearful expressions before the expression "signal" was lost. As predicted, congruency between facial structure and facial expression (larger eyes-fear, smaller eyes-anger) led to more accurate expression recognition through deeper levels of visual noise than did incongruent structure-expression combinations. Finally, Study 3 ruled out a plausible alternative explanation for the findings of Studies 1 and 2 by providing converging evidence that even mature and babyish structures unrelated to the dynamic changes associated with fear and anger are capable of facilitating expression recognition as well. Specifically, faces with enhanced roundness, a babyish facial structure, facilitated the recognition of fear while targets with narrower faces, a mature facial structure, showed a similar recognition advantage. This relationship between facial structure and expression fits nicely into theories arguing that the process of evolution is rather conservative. That is, existing structures (e.g., facial signals of maturity) are co-opted by evolution for new purposes (e.g., displaying emotional signals of submissiveness or dominance), rather than evolving entirely new structures (Jacob, 1977).

Limitations and Future Directions

Although these results are an interesting empirical demonstration of the potential relationship between facial maturity and expressions of anger and fear, one potential explanation for our data is that this structure-expression relationship may be mediated by a perceived change in facial masculinity/femininity. That is, perhaps shrinking eyes and narrowing faces make faces look more masculine, thereby leading to the observed effects on expression recognition. We are not opposed to such an interpretation of these data; in fact, it is well established that facial structures that signal dominance (e.g., brow strength; eye size) covary with facial masculinity (e.g., Becker et al., 2007). While plausible, across our three experiments we found no significant effects for target sex on expression recognition. If our effects are due to the faces seeming more masculine/feminine (i.e., if the eye size effects are mediated by perceived face masculinity/femininity), one would certainly predict that actual male and female faces would elicit even stronger differences. While reducing eye size may make a face more masculine, actually using male faces is more masculine still. That no target sex effects emerged is further indication that our results likely represent a relationship between facial maturity and perceptions of angry and fearful facial expression signals, beyond that which might be predicated on variations in perceived masculinity or femininity of the face alone.

It is also important to note that in Studies1 and 3, the effects of maturity manipulations on anger recognition seemed somewhat larger than the effects on fear recognition. Specifically, post hoc analyses of difference scores (small eyes/anger—large eyes/anger vs. large eyes/fear—small eyes/fear) indicated that the facilitative effect of our eye size manipulations in Study 1 were stronger for angry expressions than fearful expressions. A similar differences, however, was not found when these analyses were conducted with the manipulations of face shape in our third study. Although not predicted, this could result from a simple response bias; the key mappings in the experiments were not counterbalanced, and as such could result in slight differences in responding in a speeded task. Alternately, perhaps a more theoretically appealing explanation is that the typical displays of anger may have more variability than do expressions of fear. Insofar as anger may be displayed differently in different situations, whereas fear is less situationally labile, this could lead the perception of anger, more so than fear, to be more affected by the small structural changes as utilized in the current studies.

One rather novel question raised by the results of the current study is whether or not the configurations of other expressions also evolved by co-opting existing structures? This is certainly a possibility, although each expression likely serves a number of important functions, not all of which would be best served by co-opting structures related to facial maturity and babyishness. For example, as Smith and colleagues (2005) argue, the face has evolved to optimize expression recognition, in part by different expressions displaying nonoverlapping information in order to minimize confusion. Thus, although evidence exists to suggest that structural masculinity and femininity facilitate the recognition of anger and happiness, respectively (e.g., Becker et al., 2007), which suggests another potential co-evolved relationship, we must be somewhat conservative in generalizing these findings to our own, given the multiple constraints on, and functions subserved by each expression, and that in our own data, we found no relationship between target sex and expression recognition. However, it may be the case that any expression whose signal is meant to convey signals related to dominance or submissiveness would benefit from similar structural changes utilized in the current study. As an example, past research indicates that disgust expressions are rated as highly dominant whereas sad expressions are rated as low in dominance (Knutson, 1996). As such, one could sensibly predict that structural changes that facilitate a dominant signal would enhance the recognition of disgust whereas structural changes that facilitate submissiveness would facilitate recognition of sad expressions, respectively.

The current research also indicates that facial expression recognition is sensitive to very subtle structural manipulations of the face. Across the studies, our debriefing indicated that no participants reported noticing that the eyes or shape of target faces varied, despite the fact that these manipulations occurred on a within-subjects basis in all three studies. Although certainly not a central finding of the current research, this suggests that participants' performance was not based upon intentional, strategic decisions. Consistent with other evolutionary phenomenon previously studied, it appears that the human perceptual system is quite sensitive to minor variations in facial structure that signify maturity and babyishness, which themselves have significant influences on how facial expressions are decoded and recognized.

Finally, our data have clear implications for theories of face perception. Classic theory on face perception (e.g., Bruce & Young, 1986) suggests that invariant (e.g., facial structure) and variant (e.g., facial expression) features of the face are processes by separate and only weakly interacting systems. While this may be the case, our own data suggest that relatively invariant facial structures (e.g., facial roundness-narrowness) do play a clear role in how variant facial features (e.g., facial expressions) are processed. Thus, while these structures may be processed in separate systems, our current data and other recent data (e.g., Becker et al., 2007; Le Gal & Bruce, 2002; Hugenberg & Bodenhausen, 2003, 2004; Penton-Voak et al., 2007) suggest that at the very least, these two systems interact more than was previously expected.

Conclusion

Much research has indicated that the wealth of valuable social information conveyed by facial expressions of emotion makes their successful decoding of the utmost importance. There is substantial evidence that specific facial expressions are capable of conveying valuable information, including the expresser's emotions (Ekman, 1993), action tendencies (Frijda, 1986), and social motives (Fridlund, 1994). The current studies support the hypothesis that facial expressions, such as fear and anger, did not evolve into an arbitrary constellation of features. Instead, fear and anger may have evolved to mimic a babyish and mature facial structure, which affords them the adaptive benefit of displaying a stronger signal of submission and dominance than might otherwise be possible.

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