EXPLORING THE INFLUENCE OF THREAT, AMBIGUITY, AND IDENTITY IN ANGRY FACES

by

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Abstract

The hypothesis that angry faces exert a threat-relevant influence on observers is intuitively and theoretically appealing. The interpretation of findings in support of this hypothesis, however, may be compromised by the possibility that anger is not only more threatening than other affective expressions, such as happiness, but also constitutes a more ambiguous display of facial affect. Chapter 1 of the present work demonstrates this problem on a reaction time task, and discusses the implications of this problem for other experimental tasks designed to evaluate the influence of angry faces. Under conditions that minimize the impact of affect display ambiguity, Chapter 2 provides a demonstration that angry faces do exert an influence consistent with their threat-relevance. Specifically, the findings suggest that the identity of an angry facial expression may make a more salient impression on an observer relative to the identity of a happy facial expression.

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General Introduction

A body of empirical work suggests that the perception of anger influences observers differently from other affective expressions, such as happiness, under the hypothesis that anger uniquely activates processing systems designed to detect and respond to threat. This interpretation, however, may be compromised by the possibility that angry expressions are not only more threatening than other affective expressions, but also constitute a more ambiguous display of facial affect. The goal of the present work was to demonstrate that angry facial expressions may exert an influence that is consistent with their threat-relevance, but to make this demonstration in a manner that evaluates and controls for the potential impact of differences in ambiguity between expressions of anger and happiness.

The present work comprises two chapters. Chapter 1 demonstrates that response time differences to the identification of affect in angry and happy faces, which previous research explained in terms of the threat-relevance of angry faces, can be explained in a more straightforward fashion as a consequence of the greater ambiguity in the affective display of angry relative to happy faces. It is argued that such differences in ambiguity may compromise the interpretation of performance on many tasks designed to evaluate the threat-relevance of angry faces. Several approaches to minimizing this problem are discussed.

Under conditions that minimize concerns regarding ambiguity, Chapter 2 provides evidence that angry expressions exert a unique influence that is consistent with their threat-relevance. Specifically, a priming task is used to evaluate the hypothesis that the identity of an angry facial expression makes a more salient impression on an observer than the identity of a happy facial expression. The findings are discussed with reference to facial affect research and theory, as well as a recent model of negative priming.

Chapter 1

Once more unto the breach, dear friends, once more,
Or close the wall up with our English dead.
In peace there's nothing so becomes a man
As modest stillness and humility:
But when the blast of war blows in our ears,
Then imitate the action of the tiger;
Stiffen the sinews, conjure up the blood,
Disguise fair nature with hard-favour'd rage;
Then lend the eye a terrible aspect;
Let it pry through the portage of the head
Like the brass canon; let the brow o'erwhelm it
As fearfully as doth a galled rock
O'erhang and jutty his confounded base,
Swill'd with the wild and wasteful ocean.
Now set the teeth and stretch the nostril wide,
Hold hard the breath, and bend up every spirit
To his full height!

Henry V (3.1.1-17)

In these opening lines to King Henry's well-known battle speech, Shakespeare depicts the human face assuming an expression of threat. The face also includes many of the features associated with the typical angry face, such as glaring eyes, contracted eyebrows, reared teeth, and flaring nostrils. What is the impact of such a face on an observer who is suddenly confronted with it? An intuitive and theoretically appealing possibility, which may be termed a threat hypothesis, is that the perception of an angry face engages systems involved in detecting and responding to threat. The goal of the present work is to provide evidence consistent with such a hypothesis, but in a manner that explores and resolves some of the problems that plague empirical efforts to evaluate it.

The Threat Hypothesis

The threat hypothesis has a basis in a diverse body of theory and research in facial expression, threat perception, and affect, that collectively emphasize the evolutionary significance of systems that are sensitive to threat associated with faces and/or other stimuli. For instance, theories of facial expression, although divergent in many respects (e.g., Fridlund, 1997; Izard, 1997), converge on the idea that humans have evolved a capacity to perceive and express a wide range of facial expressions, including threat displays, on the grounds that such a capacity facilitates species survival. Fridlund's (1994) Behavioral Ecology View is illustrative in this regard. On this model, facial expressions are characterized as tools that aid social encounters between individuals by providing "reliable, graded, mutually beneficial signals of contingent future action" (Fridlund, 1997, p. 105). Thus, an expression such as happiness may communicate (in effect) "let's play" or "let's be friends", and thus reduce the probability of conflict in a present or future encounter.

A conceptually similar account may be forwarded to explain the importance of threatening expressions such as anger. According to Fridlund (1997), an expression of anger may communicate (in effect) "back off or I'll attack".

Notably, as in the case of happiness and other expressions, the effective communication of anger is conditional upon a sender who can manipulate the appropriate facial musculature (and other display components), and a receiver who can accurately interpret it. From an evolutionary perspective, the importance of both these conditions is compelling: When both conditions are satisfied, the signal ("back off or I'll attack") is successfully communicated, and thus action can be taken to avert conflict (e.g., through flight, appeasement, etc.). As such, the probability of the survival of sender and receiver, and thus the species to which they mutually belong, may be increased. Conversely, given a failure in the appropriate production and/or interpretation of a threat display, the probability of conflict, injury, and death increases, thus reducing the likelihood of species survival. Although not all theorists place as exclusive an emphasis on evolutionary theory as does Fridlund in his account of facial interpretation and expression, other theorists likewise assign a prominent role to evolutionary mechanisms (e.g., Izard, 1997; Ekman, Davidson, & Friesen, 1990).

Theories of threat perception also emphasize the evolutionary value of systems devoted to the processing of threat in facial expressions (e.g., Dimberg & Öhman, 1996; Hansen & Hansen, 1994; Öhman, 1996; Purcell, Stewart, & Skov, 1998). For instance, Hansen and Hansen remark:

Our theoretical perspective is built on the assumption that facial displays of emotion are prototypic, biologically significant, social stimuli. Obviously, automatic processing of facial displays of other individuals would be adaptively advantageous...In particular, it seems to us that evolution would be particularly likely to favor the capacity to efficiently process and respond to threat. (p. 225)

The findings of several studies are consistent with this basic claim. For example, visual search investigations have shown that, within an array of neutral faces, participants can more rapidly detect a single angry face than a single happy face (Eastwood, Smilek, & Merikle, 2000) or another non-threatening face stimulus (Gilboa-Schechtman, Foa, & Amir, 1999).

Other claims focus less on the efficiency with which threat is detected, and more on defense-related responses to threat. For instance, Seligman's (1970) preparedness theory suggests that humans are genetically endowed to more strongly associate avoidance and fear with stimuli that recurrently threatened the survival of their ancestors. Consistent with this claim, studies have repeatedly demonstrated that the conditioning of an angry (i.e., threatening) face to an aversive stimulus is more resistant to extinction than the conditioning of a happy (i.e., non-threatening) face (for a review, see Öhman, 1996). Similarly, startle-probe research has demonstrated that the eyeblink component of the human startle reflex is enhanced during the viewing of unpleasant affective stimuli, including angry faces (Lang, Bradley, & Cuthbert, 1990), suggesting that such stimuli can magnify a basic reflex associated with defense and avoidance.

Theorists have also begun to speculate on the human neural substrates of systems devoted to detecting and/or responding to threat. For instance, in the context of affect research, LeDoux (1996) has described several neural pathways that may be involved in the processing of threat and other affect-relevant information. In particular, he suggests that a thalamo-amygdala pathway may rapidly transmit affective information on the basis of only a rudimentary analysis of a stimulus. For instance, information transmitted along this pathway may enable an individual strolling through a field to recoil from a stimulus even before consciously thinking "snake." LeDoux also notes that transmission via the thalamo-amygdala pathway, relative to transmission via slower (cortical) projections, is more prone to error. Thus, the individual in the foregoing scenario may realize, upon more careful (conscious) analysis, that what looked like a snake was in fact a fragment of rope. LeDoux points out, however, that despite this proneness to error, the rapidity with which information is conveyed along the thalamo-amygdala pathway gives it evolutionary utility. That is, a rapid threat-detection system optimizes the likelihood of survival during encounters with genuine threat, even though it may also increase the number of false alarms during encounters with innocuous stimuli.

The Ambiguity Hypothesis

Despite the appeal of a threat hypothesis, it is notable that variables other than threat may play a role in the influence of angry faces and, more importantly, may compromise the interpretation of experimental findings involving facial affective stimuli. For example, different categories of facial affect may differ with regard to the degree of ambiguity with which their respective affective expressions are displayed. In this regard, the expression of anger may be more ambiguous, and therefore more difficult to interpret or decode, than other expressions, such as happiness, to which anger is often compared in empirical studies. This possibility, which may be termed an ambiguity hypothesis, is consistent with the findings of a number of investigations which suggest that the detection and identification of affect is more difficult for angry than for happy faces (e.g., Boucher & Carlson, 1980; Esteves & Öhman, 1993; Harrison, Gorelczenko, & Cook, 1990; Kirouac & Doré, 1984; McAndrew, 1986; Wagner, MacDonald, & Manstead, 1986). These findings may reflect (at least) several variables that could contribute to greater ambiguity in expressions of anger relative to happiness. First, the facial features that depict anger, such as the mouth, may display more variability than those that depict happiness. For example, note Appendix A, which includes a selection of happy and angry faces often used in facial affect research (Ekman, 1976; Mazurski & Bond, 1993). While most of the happy faces bear open mouths, the angry faces include roughly equal numbers of open and closed mouths. Second, anger represents only one of several different categories of negative facial expression, such as disgust, fear, and sadness; happiness, in contrast, represents the singular positive facial expression. As such, anger, more than happiness, may be confused with other affective facial expressions. Third, the frequency with which angry faces appear in real-world situations may be lower than that of happy faces, and thus render the former less familiar than the latter (Hansen & Hansen, 1994).

Empirical Implications

Thus, the expression of anger, in addition to being relatively more threatening than other affective expressions, may constitute a more ambiguous display of facial affect. Importantly, without an appreciation of the role that ambiguity may play with regard to the impact of the perception of anger, it is possible to misinterpret the processes that may give rise to particular patterns of data. For example, in experiments that involve timed responses to facial expressions (e.g., Hansen & Hansen, 1988), ambiguities in angry faces may engender delays or difficulty in responses to such faces, and thus make it difficult to determine whether threat or ambiguity underlies the obtained pattern of findings. The purpose of this chapter is to explore such a possibility, using a reaction time methodology based on Purcell, Stewart, and Skov (1998) as an illustrative framework.

Purcell and colleagues (1998) devised a simple task in which participants were shown pictures of human faces expressing happiness and anger. In one variant of the task, participants were required to judge the affect in each face as quickly and accurately as possible by pressing one of two keys. In other variants of the task, participants were required to judge non-affective dimensions of these faces, such as gender. The main finding was that responses were slower to angry than to happy faces, although the magnitude of this pattern was greatest in the affect judgement task, and relatively smaller in the tasks involving non-affective judgements to faces.

Prevailing formulations of the threat hypothesis tend to emphasize the rapidity with which angry faces are processed (e.g., Hansen & Hansen, 1994; Öhman, 1996), and therefore Purcell and colleagues' (1998) finding that responses were slower to angry than to happy faces may, on first glance, appear counter-intuitive. In fact, however, Purcell and colleagues concur with the view that angry faces are processed rapidly, in particular by a thalamo-amygdala system involved in the identification of threat (Dember, 1960; LeDoux, 1996). The investigators further suggest, however, that an important consequence of the processing of angry faces is an automatic "freezing" of behaviour, which is assumed to reflect an evolutionarily adaptive reaction to threat (LeDoux, 1996). This freezing reaction, then, was proposed as the basis for the relatively longer responses to angry faces.

In addition, given that responses were slower to angry faces even on tasks involving the judgement of non-affective dimensions of faces, such as gender, Purcell and colleagues (1998) suggested that their findings in general could not be explained as a consequence of greater difficulty in the interpretation of affect in angry than in happy facial expressions. In particular, the investigators suggested that even when attention was deliberately oriented to non-affective dimensions of faces, such as gender, angry but not happy faces automatically engaged attention as a consequence of their threat-relevance, which in turn contributed to the relatively slower responses observed for angry faces.

Although Purcell and colleagues' (1998) threat account is intriguing, the potential that anger is a more ambiguous display of facial affect than happiness may have given rise to their findings. Consistent with an ambiguity hypothesis, the results of the affect judgement task could be explained on the grounds that it is more difficult, and therefore takes longer, to interpret an angry face as expressing "anger" than to interpret a happy face as expressing "happiness". Notably, the same hypothesis may also account for the findings of tasks involving non-affective judgements, such as gender. Under the assumption that ambiguous stimuli are more likely to engage processes designed to disambiguate or interpret such stimuli (e.g., Berlyne, 1969; Kahneman, 1973), angry faces may take longer to process and delay responses regardless of how participants are instructed to deploy their attention during a task.

The threat and ambiguity hypotheses are not mutually exclusive accounts; both may play a role in responses made to affective faces. Given, however, that both hypotheses make the same predictions regarding the influence of angry faces on affect and non-affect judgement tasks, the correct interpretation of Purcell et al.'s (1998) results remains unclear. That is, it is possible that processes described by one, the other, or both hypotheses, underlie task performance patterns. Importantly, similar concerns may extend to other investigations designed to demonstrate differences in the impact of angry relative to happy (or other affective) faces. The purpose of the work described in Chapter 1, therefore, was to test predictions based on the threat hypothesis for an affect judgement task, in a manner that also evaluated concerns suggested by the ambiguity hypothesis. The implications of the findings are considered for other experimental tasks involving affective facial stimuli.

Overview of Experiments

This chapter includes four experiments. Experiment 1 replicated Purcell et al.'s (1993) method and results for a task involving the judgement of affective and non-affective dimensions of faces. Experiment 2 evaluated a prediction based on the ambiguity hypothesis, namely, that observers should find the interpretation of affect more difficult for angry than for happy faces. Experiment 3 tested predictions based on the threat hypothesis for an affect judgement task, but in a manner that also evaluated concerns suggested by the ambiguity hypothesis. Experiment 4 evaluated the generalizability of the conclusions of Experiment 3 across a different stimulus set, by testing predictions based on the threat and ambiguity hypotheses using schematic rather than photographic face stimuli.

Experiment 1

As a starting point for an evaluation of the processes underlying performance on an affect judgement task, the goal of Experiment 1 was to replicate Purcell et al.'s (1998) finding that responses are longer to the judgement of affective and non-affective dimensions of angry versus happy faces. The method of Experiment 1 was therefore modelled on several of Purcell et al.'s key experiments. In an affect judgement condition, participants were shown happy and angry faces, and were required to identify the affect in each presented face as quickly and accurately as possible. In a gender judgement condition, participants performed an identical task, except they were required to identify the gender of each face. A successful replication of Purcell et al. would entail a pattern such that responses were longer to angry than to happy faces, and that this difference was larger in the affect than in the gender judgement condition.

Method

Participants

Thirty-six undergraduate students at the University of Waterloo participated in the experiment. Equal numbers of participants were assigned randomly to the affect and gender judgement conditions. Each participant had normal or corrected-to-normal vision, and was paid $4.00 upon completion of the 20-minute experimental session.

Apparatus and Stimuli

The stimuli were drawn from a set developed by Ekman (1976) and consisted of 20 black-and-white images of human faces, comprising the same ten people expressing happiness and anger, with five males and five females represented within each category of affect (Appendix A).

All stimuli were presented on a 17-inch video monitor using a Pentium-level processor, centred against a white background. Stimuli measured 14.5 x 19 cm and, at a viewing distance of 65 cm, subtended a visual angle of approximately 16.7° vertical by 12.8° horizontal. Superlab software (version 1.04) (Cedrus Corporation, 1991) was used to control stimulus presentation. To render the faces appropriate for use in the present experiment, the original images were digitized, re-sized to 300 x 400 pixels, converted to grayscale, and approximated to one another with regard to relative brightness and contrast. Participants responded to stimuli using a two-button mouse.

Procedure

In the affect judgement condition, participants were instructed that on each trial they would be shown a face expressing happiness or anger on the computer screen. They were asked to identify the specific affect in the face ("happiness" or "anger") as quickly and accurately as possible. Participants in the gender judgement condition were given identical instructions, except that they were asked to identify the gender of each face ("male" or "female"). Participants keyed their responses to one of two buttons on a mouse using the index and middle finger of their dominant hand. The two buttons were labelled according to the relevant judgement, and the order of the labels was counter-balanced across participants.

In both conditions, participants performed 12 practice trials followed by five blocks of 20 experimental trials. Each trial consisted of the following sequence of events: (1) presentation of a face, until the participant made a response; (2) a 1500-ms delay until the presentation of the next face. On each block of trials, all 20 affective face stimuli were shown in random order.

Results and Discussion

Reaction Time

Correct reaction times (RTs) in each experimental condition were submitted to an outlier screening procedure based on Van Selst and Jolicoeur (1994). On each step of this procedure, the most extreme RT value is temporarily removed, the mean and standard deviation of the remaining distribution is calculated, and then cutoff values for each tail of the distribution are computed using the equation $\overline{X} \pm C * SD$ (where C is a constant). If one or both of the smallest or largest RTs are outside these cutoffs, they are permanently removed. On each step that an outlier is found, the algorithm is applied anew to the remaining data. The value of C depends on sample size, such that the estimated final mean is not influenced by sample size. On the basis of this procedure, 1.66% of the RTs were excluded from subsequent analyses.

Figure 1 shows mean RT to happy and angry faces as a function of type of judgement. As predicted, mean RT is slower to angry than to happy faces, although this difference is greater for affect than for gender judgements. A 2 x 2 analysis of variance on RTs, with type of judgement as a between-subjects factor and affect as a within-subjects factor, revealed a main effect of affect, F (1, 34) = 12.19, MSE = 861.96, $p < .01$. As expected, however, this main effect was qualified by a significant interaction between affect and type of judgement, F (1, 34) = 5.95, MSE = 861.96, $p < .025$. Further analysis indicated that mean RT was significantly longer to angry than to happy faces in the affect judgement condition (568 vs. 527 ms, respectively), t (17) = 3.23, $p < .01$, but not in the gender judgement condition (517 vs. 509 ms, respectively), t (17) = 1.33, $p > .20$. No other effect reached significance ($F < 1.21$, $p > .25$). Overall, the obtained pattern is consistent with findings described by Purcell et al. (1998).

Error data

As shown in Table 1, the pattern of error rates indicates that more errors were made in responses to angry than to happy faces. A 2 x 2 analysis of variance on

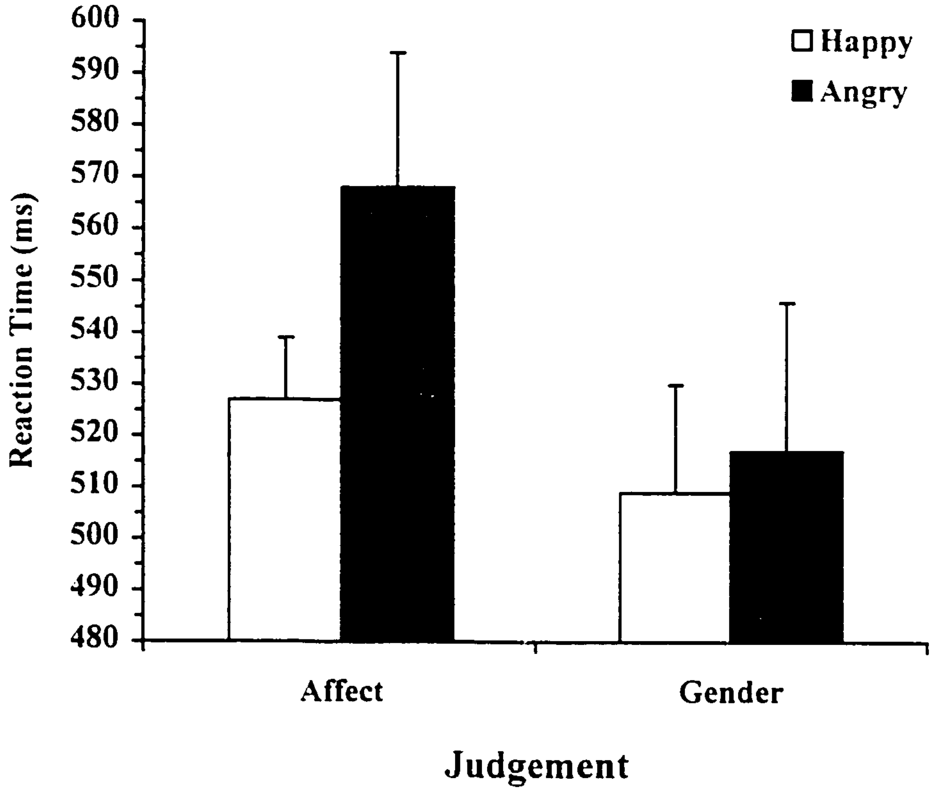


Figure 1. Mean reaction time to happy and angry faces as a function of type of judgement in Experiment 1. Error bars represent standard errors of means.

Table 1. Mean proportion of error in responses to happy and angry faces as a function of type of judgement in Experiment 1.

	Affect of Face	
Judgement	Happy	Angry
Gender	.01	.04
Affect	.03	.03

proportions of error, with type of judgement as a between-subjects factor and affect as a within-subjects factor, confirmed a main effect of affect, $F(1, 34) = 4.20$, $MSE < .01$ $p < .05$, but no other significant effect or interaction (all $Fs < 2.49$, $ps > .10$). This finding, given the obtained RT pattern, suggests that no trade-off occurred between participants' speed and accuracy of responding to face stimuli.

Stimulus Reliability

In order to evaluate the consistency of the impact of face stimuli in the affect judgement condition, reliability coefficients (alpha) were computed on RTs to these stimuli. For happy and angry faces, alpha was .89 and .96, respectively, which suggests that, for each set of face stimuli, responses were highly consistent. These results indicate that the critical RT difference in the affect judgement condition was not an artifact of only a small subset of stimuli.

For a more detailed presentation of the data and analyses for Experiment 1, see Appendices B to E.

Experiment 2

As previously suggested, the finding that responses are longer to angry than to happy faces is not uniquely supportive of Purcell et al's (1998) threat hypothesis. Under the ambiguity hypothesis, which asserts that anger is a more ambiguous facial display than happiness, such a finding would be assumed to reflect greater difficulty in the interpretation of affect in angry than in happy faces. Experiment 2 was designed to make an initial evaluation of this claim.

Participants were shown a number of different face stimuli that expressed any of seven categories of facial expression, six of which were affective and one of which was affectively neutral. For each presented face, participants were required to make two ratings. First, participants were asked to identify the expression in each face, according to one of the seven categories that the face fit best. Second, participants rated the degree of difficulty involved in making each such judgement. Support for the ambiguity hypothesis would be evidenced in a pattern such that, first, participants were more likely to interpret happy faces as expressing happiness than to interpret angry faces as expressing anger; and second, that such judgements were rated as more difficult for angry than for happy faces.

Method

Participants

Eighteen undergraduate students at the University of Waterloo participated in the experiment. Each participant had normal or corrected-to-normal vision, and was paid $6.00 upon completion of the 40-minute experimental session.

Apparatus and Stimuli

The apparatus and stimulus presentation software were the same as in Experiment 1. Given limitations in the availability and quality of face stimuli, each of the six categories of facial expression used in Experiment 2 included different numbers of stimuli: happiness (16), anger (11), disgust (13), fear (10), sadness (9), neutral (14). All happy and angry faces from Experiment 1 were included in the set, as well as several additional faces from these affective categories (see Appendix A). An approximately equal number of males and females were represented within each category. With three exceptions, all stimuli were drawn from Ekman (1976), and were categorized based on the categorization assigned to them in this set. Three facial stimuli (expressing happiness, disgust, and a neutral expression) were drawn from a stimulus set developed by Mazurski and Bond (1993). All stimuli were prepared in the manner described in Experiment 1.

Procedure

Each of the facial stimuli was presented on the computer screen singly and in random order. Participants were required to make two ratings upon each presentation using a keyboard, in a non-speeded but spontaneous manner. First, participants were asked to judge the expression in each face, according to one of the seven categories that they felt it fit best: happy, angry, disgusted, surprised, fearful, sad, or neutral. Second, participants were asked to rate how "easy or hard" it was to make the foregoing judgement, using a 7-point scale, with 1 indicating it was "very easy" to make the judgement, and 7 indicating it was "very hard" to do so.

Results and Discussion

The following analyses are constrained to the 20 facial stimuli relevant to Experiment 1 (Appendix A). Tables 2A and 2B show the proportions with which individual happy and angry faces, respectively, were identified as expressing particular categories of affect. The proportions with which individual happy faces were identified as "happy" are, in absolute terms, quite high. Specifically, all but two happy faces (#05 and #07) were identified as "happy" by 100% of participants. Although the proportions with which individual angry faces were identified as "angry" are also high in absolute terms, they are, as predicted, relatively lower than the corresponding proportions for happy faces. Indeed, only

Table 2A. Proportion of happy faces identified as expressing different categories of affect in Experiment 2.

	Category of Affect						
Face #	Hap.	Ang.	Dis.	Sur.	Fea.	Sad.	Neu.
01	1.0	0.0	0.0	0.0	0.0	0.0	0.0
02	1.0	0.0	0.0	0.0	0.0	0.0	0.0
03	1.0	0.0	0.0	0.0	0.0	0.0	0.0
04	1.0	0.0	0.0	0.0	0.0	0.0	0.0
05	0.94	0.0	0.0	0.05	0.0	0.0	0.0
06	1.0	0.0	0.0	0.0	0.0	0.0	0.0
07	0.89	0.0	0.0	0.11	0.0	0.0	0.0
08	1.0	0.0	0.0	0.0	0.0	0.0	0.0
09	1.0	0.0	0.0	0.0	0.0	0.0	0.0
10	1.0	0.0	0.0	0.0	0.0	0.0	0.0

Table 2B. Proportion of angry faces identified as expressing different categories of affect in Experiment 2.

	Category of Affect						
Face #	Hap.	Ang.	Dis.	Sur.	Fea.	Sad.	Neu.
01	0.0	0.89	0.05	0.0	0.0	0.05	0.0
02	0.0	0.94	0.0	0.05	0.0	0.0	0.0
03	0.0	0.89	0.0	0.0	0.0	0.5	0.5
04	0.0	0.89	0.05	0.05	0.0	0.0	0.0
05	0.0	0.78	0.0	0.11	0.05	0.0	0.05
06	0.0	0.89	0.0	0.11	0.0	0.0	0.0
07	0.0	1.0	0.0	0.0	0.0	0.0	0.0
08	0.0	0.94	0.0	0.0	0.05	0.0	0.0
09	0.0	0.83	0.11	0.0	0.0	0.05	0.0
10	0.0	0.72	0.0	0.0	0.05	0.22	0.0

one angry face (#07) was identified as "angry" by 100% of participants; the remaining faces, in addition to being identified as "angry", were also identified by some participants as "disgusted", "surprised", "fearful", "sad", and "neutral". A t-test confirmed that the average proportion with which happy and angry faces were categorized as "happy" and "angry", respectively, was significantly lower for angry than for happy faces (.88 vs. .98), $t(17) = -3.86$, $p < .01$. These data, therefore, suggest that individuals are less likely to interpret angry faces as expressing "anger" than to interpret happy faces as expressing "happiness". Put another way, angry faces are more likely than happy faces to be interpreted as belonging to other categories of affect. This finding is consistent with predictions based on the ambiguity hypothesis.

Table 3 shows the mean difficulty of interpretation (DOI) rating to individual happy and angry faces, based on participant ratings of how easy or difficult it was to interpret happy faces as expressing "happiness" and angry faces as expressing "anger", with lower numbers indicating lesser difficulty, and higher numbers indicating greater difficulty. As is evident from Table 3, the expression in each angry face has a higher mean DOI rating than the expression in the corresponding happy face, with the exception of face #07. Collapsed across all faces, the difference in the mean DOI rating to angry versus happy faces (2.31 vs. 1.25, respectively) was significant, $t(17) = 6.40$ $p < .001$. These data thus suggest that,

Table 3. Mean (SD) difficulty of interpretation (DOI) rating to happy and angry faces in Experiment 2.

	DOI	
Face #	Happy	Angry
01	1.28 (.96)	2.88 (2.09)
02	1.28 (.57)	2.06 (1.20)
03	1.00 (.00)	2.38 (1.41)
04	1.17 (.38)	3.69 (1.99)
05	1.35 (.61)	2.93 (1.59)
06	1.17 (.51)	1.75 (1.57)
07	1.50 (1.03)	1.50 (1.04)
08	1.28 (.57)	1.71 (1.10)
09	1.44 (.86)	1.60 (.74)
10	1.00 (.00)	2.77 (2.09)

Note. Data excludes participant ratings for happy or angry faces categorized as other than happy or angry, respectively.

even when individuals do interpret angry faces as expressing "anger" and happy faces as expressing "happiness", the judgement is relatively more difficult for the former than for the latter. Again, this finding is consistent with predictions based on the ambiguity hypothesis.

For a more detailed presentation of the data for Experiment 2, see Appendix F.

Experiment 3

Consistent with the ambiguity hypothesis, Experiment 2 demonstrated that the interpretation of affect is more difficult for angry than for happy faces. This hypothesis, therefore, serves as a straightforward alternative to Purcell et al.'s (1998) threat hypothesis as an account of the finding that responses are slower to angry than to happy faces on a task involving the speeded judgement of affect. In short, it may be harder, and therefore take longer, to identify the affect in angry than in happy faces. Arguably, more compelling evidence in favour of the threat hypothesis would involve a demonstration of differences in the influence of angry and happy faces under conditions in which differences in affect display ambiguity between these categories of affect were minimized. The goal of Experiment 3 was to evaluate this possibility.

As in Experiment 1, participants were shown happy and angry faces and were asked to identify the affect in these faces as quickly and accurately as possible. Participants performed this task, however, under two conditions. In a matched stimulus condition, differences in affect display ambiguity between angry and happy faces were minimized; in a mismatched stimulus condition, these differences were maximized, such that greater affect display ambiguity was present in angry than in happy faces. Support for the ambiguity hypothesis would be evidenced in a pattern such that responses were longer to angry than to happy faces in the mismatched stimulus condition, and that this difference was significantly greater than any such difference obtained in the matched stimulus condition.

In contrast, support for the threat hypothesis would be evidenced simply in a pattern such that responses were longer to angry than to happy faces in the matched stimulus condition. That is, in the matched stimulus condition, it is possible to argue that any such response differences would be unlikely to reflect differences in affect display ambiguity between happy and angry faces, given that such differences would be minimized in this condition. Instead, response delays to the judgement of affect in angry faces could be taken to indicate the operation of threat-relevant processes specific to such faces (Purcell et al., 1998).

Method

Participants

Eighteen undergraduate students at the University of Waterloo participated in the experiment. Each participant had normal or corrected-to-normal vision, and was paid $4.00 upon completion of the 25-minute experimental session.

Apparatus and Stimuli

The apparatus and stimulus presentation software were the same as in Experiment 1. The stimuli consisted of two sets of happy and angry faces. In a matched stimulus set, differences in affect display ambiguity between angry and happy faces were minimized; in a mismatched stimulus set, these differences were maximized, such that greater affect display ambiguity was present in angry than in happy faces. The manipulation of affect display ambiguity was based on stimulus data from Experiment 2. The selection procedure for stimuli was as follows: (1) For both matched and mismatched stimulus sets, stimuli were based on happy and angry faces that were categorized as happy or angry, respectively, by at least 16 of 18 participants (i.e., 89%); (2) matched stimuli were selected such that the mean difficulty of interpretation (DOI) rating for happy and angry faces was approximately equal, whereas mismatched stimuli were selected such that the mean DOI rating was higher for angry than for happy faces.

Given limitations in the number of face stimuli available, only five happy and five angry faces were selected for each of the matched and mismatched sets (Appendix G). For the same reason, three of the angry faces appear in both the matched and mismatched sets (#s 1, 3, and 4). Based on the foregoing selection procedure, Table 4 shows the mean DOI rating for happy and angry faces as a function of stimulus set. In the matched set, the mean DOI rating for angry and happy faces differs minimally, suggesting that differences in affect display ambiguity between angry and happy faces are minimized. In contrast, in the mismatched set, the mean DOI rating is higher for angry than for happy faces, suggesting greater affect display ambiguity in angry relative to happy faces.

Table 4. Mean difficulty of interpretation (DOI) rating to selected happy and angry faces as a function of stimulus set in Experiment 3.

	DOI	
Stimulus Set	Happy	Angry
Matched	1.80	1.88
Mismatched	1.12	2.55

Procedure

The procedure consisted of two parts. The first part involved an affect judgement task, and thus the instructions given to participants and the manner of responding were identical to those of the affect judgement condition of Experiment 1.

Participants performed 12 practice trials followed by six blocks of 10 experimental trials. Each trial consisted of the following sequence of events: (1) presentation of a face, until the participant made a response; (2) a 1500-ms delay until the presentation of the next face. For half of the participants, the first three blocks of trials were matched faces and the last three blocks were mismatched faces; for the other half of the participants, this order was reversed. On each block of trials, all 10 faces of a given stimulus set were shown in random order.

The second part of the experiment consisted of a difficulty of interpretation rating task, and was designed to allow for a manipulation check on the degree to which happy and angry faces were in fact matched and mismatched on the degree of difficulty required to interpret their respective affective expressions. Specifically, participants were instructed that they would view each of the faces from the first part of the experiment and, in a non-speeded but spontaneous manner, would rate how "easy or hard" it was to judge whether a face was happy or angry. Participants made their responses on a keyboard using a 7-point scale, with 1 indicating it was "very easy" to make a judgement, and 7 indicating it was "very hard" to make a judgement. All faces appeared singly and in random order, with a new face appearing on the screen following the completion of each rating.

Results and Discussion

Manipulation Check

Figure 2 shows the mean difficulty of interpretation (DOI) rating for happy and angry faces as a function of stimulus condition, with lower numbers indicating lesser difficulty, and higher numbers indicating greater difficulty, in the interpretation of the affect in a face. As expected, in the mismatched stimulus condition, the mean DOI rating for angry faces is higher than for happy faces, whereas the difference in the matched stimulus condition is relatively small and in the opposite direction. Under a 2 x 2 (affect x stimulus condition) repeated measures analysis of variance on DOI ratings, the obtained pattern showed a main effect of affect, F (1, 17) = 7.34, MSE = .97 p < .025, and a main effect of stimulus condition, F (1, 17) = 48.76, MSE = .17, p < .001. As expected, however, these effects were qualified by a significant affect by stimulus condition interaction, F (1, 17) = 50.97, MSE = .30, p < .001.

Further analysis indicated that the mean DOI rating was significantly higher for angry than for happy faces in the mismatched stimulus condition (2.79 vs. 1.24, respectively), t (17) = 6.66, p < .001, but not in the matched stimulus condition (2.54 vs. 2.83, respectively), t (17) = -.98, p > .30. These data suggest that the selection procedure for matched and mismatched stimuli, based on data

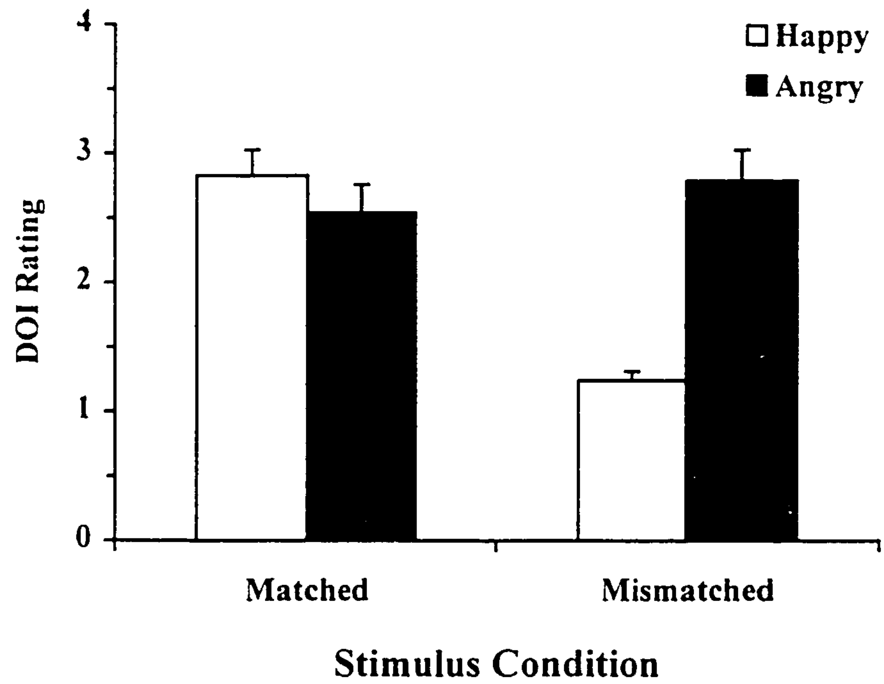


Figure 2. Mean difficulty of interpretation (DOI) rating to happy and angry faces as a function of stimulus condition in Experiment 3. Error bars represent standard errors of means.

from Experiment 2, was successful. Namely, in the matched stimulus condition, the mean DOI rating to happy versus angry faces was not different, suggesting that differences in affect display ambiguity between angry and happy faces were minimized. In contrast, in the mismatched stimulus condition, the mean DOI rating was higher for angry than for happy faces, suggesting greater affective display ambiguity in angry relative to happy faces.

Reaction Time

On the basis of the outlier screening procedure described in Experiment 1, 1.93% of RTs were excluded from subsequent analyses.

Figure 3 shows mean RT to happy and angry faces as a function of stimulus condition. In the matched stimulus condition, mean RT to angry and happy faces differs minimally, whereas in the mismatched stimulus condition, mean RT is longer to angry than to happy faces. A 2 x 2 (affect x stimulus condition) repeated measures analysis of variance on RTs revealed a main effect of affect, F (1, 17) = 6.68, MSE = 24003.87, $p < .025$, that was qualified by the expected interaction between affect and stimulus condition, F (1, 17) = 7.56, MSE = 34063.11, $p < .025$. No other effect was significant ($F < 1.60$, $p > .20$). Further analysis of differences within each stimulus condition revealed that mean RT was significantly longer to angry than to happy faces in the mismatched stimulus condition (650 vs. 570 ms, respectively), t (17) = 2.89, $p = .01$, but not in the matched stimulus condition (631 vs. 638 ms, respectively), t (17) = -.59, $p > .56$.

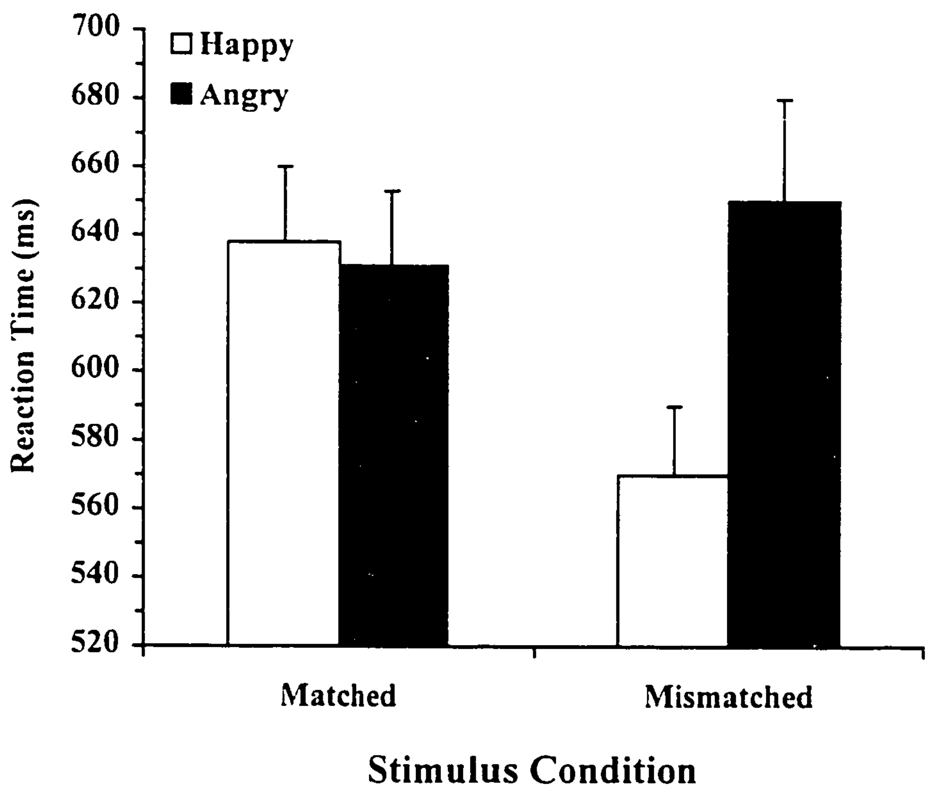


Figure 3. Mean reaction time to happy and angry faces as a function of stimulus condition in Experiment 3. Error bars represent standard errors of means.

The present findings failed to support predictions based on the threat hypothesis. That is, in the matched stimulus condition, in which differences in affect display ambiguity between angry and happy faces were minimized, responses to the judgement of affect in angry and happy faces differed minimally and non-significantly. The findings, instead, are more consistent with predictions based on the ambiguity hypothesis. That is, in the mismatched stimulus condition, in which affect display ambiguity was greater in angry than in happy faces, responses were also longer to angry than to happy faces; and, as noted above, response time differences were minimal and non-significant in the matched stimulus condition. As such, an ambiguity hypothesis offers a straightforward alternative to the threat hypothesis as an account of the results of Purcell et al.'s (1998) affect judgement task, and the present Experiment 1.

Error data

An analysis of error rates, shown in Table 5, revealed no significant effects or interactions (all $\underline{F}$s < 1.08, $\underline{p}$s > .30)

Stimulus Reliability

In order to evaluate the consistency of the impact of face stimuli in both the matched and mismatched stimulus conditions, reliability coefficients (alpha) were computed on RTs to happy and angry face stimuli, respectively, in each condition. For happy and angry faces in the matched stimulus condition, alpha was .84 and .83 respectively; for faces in the mismatched stimulus condition, these values

Table 5. Mean proportion of error in responses to happy and angry faces as a function of stimulus condition in Experiment 3.

	Affect of Face	
Stimulus Condition	Happy	Angry
Matched	.03	.05
Mismatched	.03	.04

were .83 and .84, respectively. These results indicate that the RT findings of Experiment 3 were not an artifact of only a subset of stimuli.

For a more detailed presentation of the data and analyses for Experiment 3, see Appendices H to M.

Experiment 4

Photographic face stimuli, such as those described in Experiments 1 to 3, are often used in empirical studies to evaluate threat-related hypotheses. Schematic face stimuli, however, have also been used to evaluate such hypotheses, albeit with mixed results (e.g., Eastwood et al., 2000; Nothdurft, 1993). The goal of Experiment 4 was to evaluate the generalizability of the conclusions of Experiment 3 by testing predictions based on the threat and ambiguity hypotheses using schematic rather than photographic affective face stimuli.

As is evident in Figure 4, the present schematic face stimuli were constructed on the basis of mouth and eye features. The assumption that faces based on these features could serve as adequate representatives for affective face stimuli was based on several previous findings. First, as noted above, comparable faces have been used with some success in facial affect research. Second, analyses of different facial expressions in terms of their constituent components accord a major role for mouth and eye features, and place less emphasis on other features (e.g., Smith & Scott, 1997). Third, findings based on cell-recording research suggest that feature-sensitive face cells in temporal cortex are responsive primarily to eyes and mouths, and far less so to other face-relevant features such as chins and noses (e.g., Desimone, 1991). Thus, at a neural level, the presence of mouth and eye features in a face may have a unique significance in the representation of a stimulus as a face. Fourth, analyses of happy and angry faces

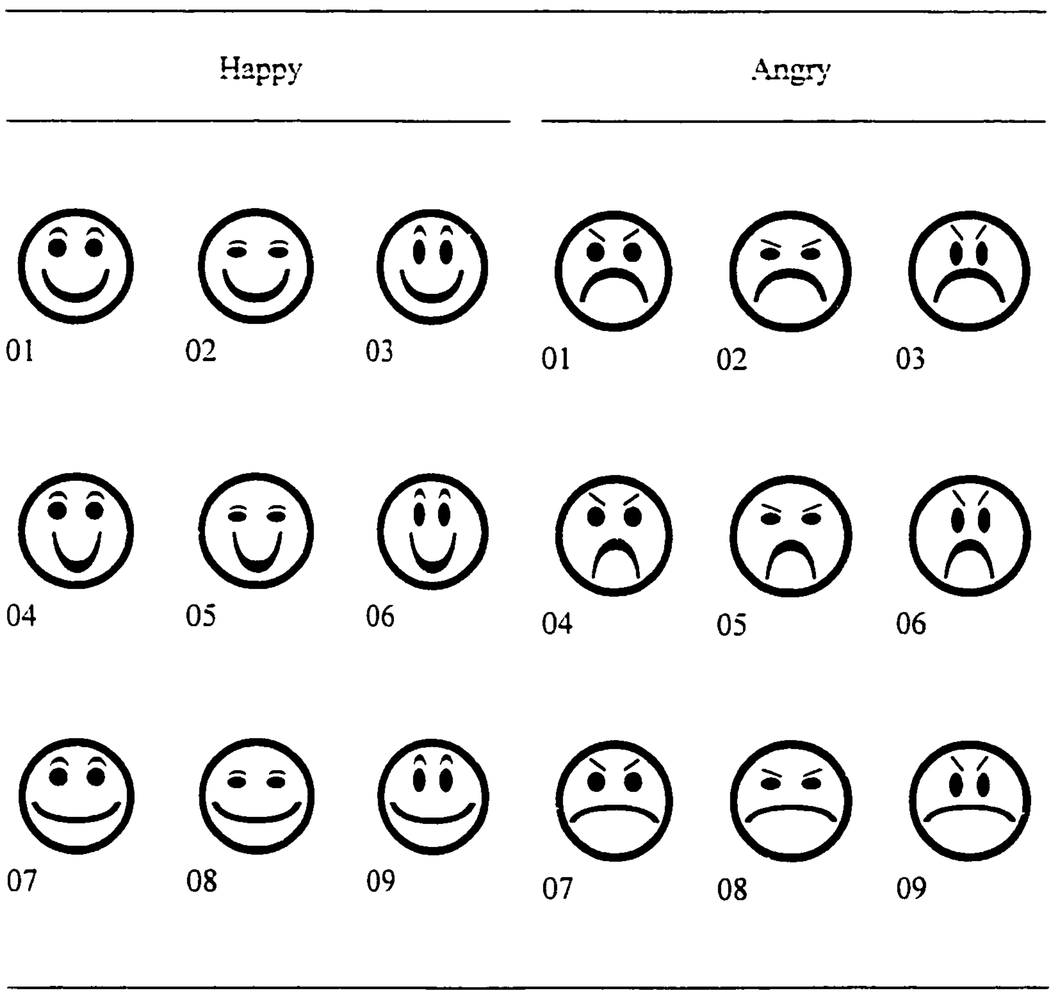


Figure 4. Schematic affective face stimuli in Experiment 4.

in particular reveal that the facial musculature involved in these expressions manipulate primarily aspects of the mouth and/or eyes (Fridlund, 1994).

Several additional properties of the schematic affective face stimuli used in the present experiment are noteworthy with regard to the logic of the specific predictions that were tested. As shown in Figure 4, the schematic faces were constructed such that, across the two categories of happy and angry affect, they shared structurally identical features that were configured in affect-appropriate patterns. Thus, for instance, if an upward arc was used for the mouth of a happy face, then the same arc, turned downward, was used for the mouth of a corresponding angry face.

With regard to performance on the affect judgement task, support for the threat hypothesis would be evidenced in a pattern such that RTs were longer to the judgement of affect in angry than in happy faces. Such a pattern would serve as more compelling support for the threat hypothesis than offered by Purcell et al. (1998) or the present Experiment 1, given that it would be based on stimuli for which differences in affect display ambiguity were minimized across categories of affect as a consequence of the particular construction of these stimuli.

Although facial feature structure was matched across each category of affect, it was varied within each category of affect in two respects. First, mouth curvature was either narrow, moderate, or wide. Second, eyes were either round, laterally-oriented ovals, or vertically-oriented ovals. The foregoing variations were included to explore the manner in which variations in facial structure may influence affect display ambiguity. Evidence for this possibility would be demonstrated in a pattern such that faces with particular mouth or eye structures that showed longer responses on the affect judgement task were <u>also</u> subjectively rated as more difficult to interpret with regard to their affect.

Method

<u>Participants</u>

Eighteen undergraduate students at the University of Waterloo participated in the experiment. Each participant had normal or corrected-to-normal vision, and was paid $4.00 upon completion of the 25-minute experimental session.

<u>Apparatus and Stimuli</u>

The apparatus and stimulus presentation software were the same as those in Experiment 1. The stimuli consisted of 18 schematic faces, half of which expressed happiness and half of which expressed anger (Figure 4, p. 42). The faces were constructed to be as structurally similar as possible, without compromising affective expression. Thus, each set of happy and angry faces included mouths whose degree of curvature was either narrow, moderate, or wide; and eyes that were either round, vertically-oriented ovals, or laterally-oriented ovals. Notably, however, the eyebrow features were different across the two categories of affect, such that eyebrows for happy faces were arched, whereas eyebrows for angry faces were slanted downward toward the centre of the face.

These structural differences were made in order to render each set of faces optimally prototypic of its particular affective category.

Stimuli were centred on the computer screen against a white background. Stimuli measured 11.5 cm in diameter and, at a viewing distance of 65 cm, subtended a visual angle of approximately 10.1° in both the vertical and horizontal directions.

Procedure

The procedure consisted of two parts. The first part involved an affect judgement task, and thus the instructions given to participants and the manner of responding were identical to those of Experiment 1.

Participants performed 12 practice trials followed by four blocks of 18 experimental trials. Each trial consisted of the following sequence of events: (1) presentation of a face, until the participant made a response; (2) a 1500-ms delay until the presentation of the next face. On each block of trials, all 18 face stimuli were shown in random order.

The second part of the experiment was designed to evaluate the manner in which affect display ambiguity varied across faces with different kinds of mouth or eye structures. Participants were presented each of the affective faces and performed the difficulty of interpretation rating task described in Experiment 3. All 18 faces appeared on the computer screen singly and in random order, with a new face appearing following the completion of each rating.

Results and Discussion

Manipulation Check

Figure 5 shows the mean difficulty of interpretation (DOI) rating for happy and angry faces as a function of mouth and eye structure, respectively, with lower numbers indicating lesser difficulty, and higher numbers indicating greater difficulty, in the interpretation of the affect in the face. With regard to mouth structure, the pattern indicates that the mean DOI rating is lowest for moderate mouths, higher for narrow mouths, and highest for wide mouths. With regard to eye structure, the pattern indicates that the mean DOI rating is lowest for eyes that were vertically-oriented ovals, higher for eyes that were round, and highest for eyes that were horizontally-oriented ovals.

A 2 x 3 x 3 (affect x mouth x eyes) repeated measures analysis of variance confirmed a significant effect of mouth structure, F (2, 34) = 22.72, MSE = 1.87, $p < .001$, and eye structure, F (2, 34) = 5.16, MSE = 1.00, $p < .025$. The analysis revealed no effect of affect, F (1, 17) = 1.15, MSE = 2.57, $p > .25$, that is, no significant difference in the interpretability of affect in happy and angry faces. Thus, as intended, differences in affect display ambiguity between angry and happy faces were minimized. No other effect or interaction was significant (all Fs < 1.60, ps > .20).

Further analysis to explicate the effect of mouth structure indicated that the mean DOI rating was higher, and therefore the interpretation of affect more

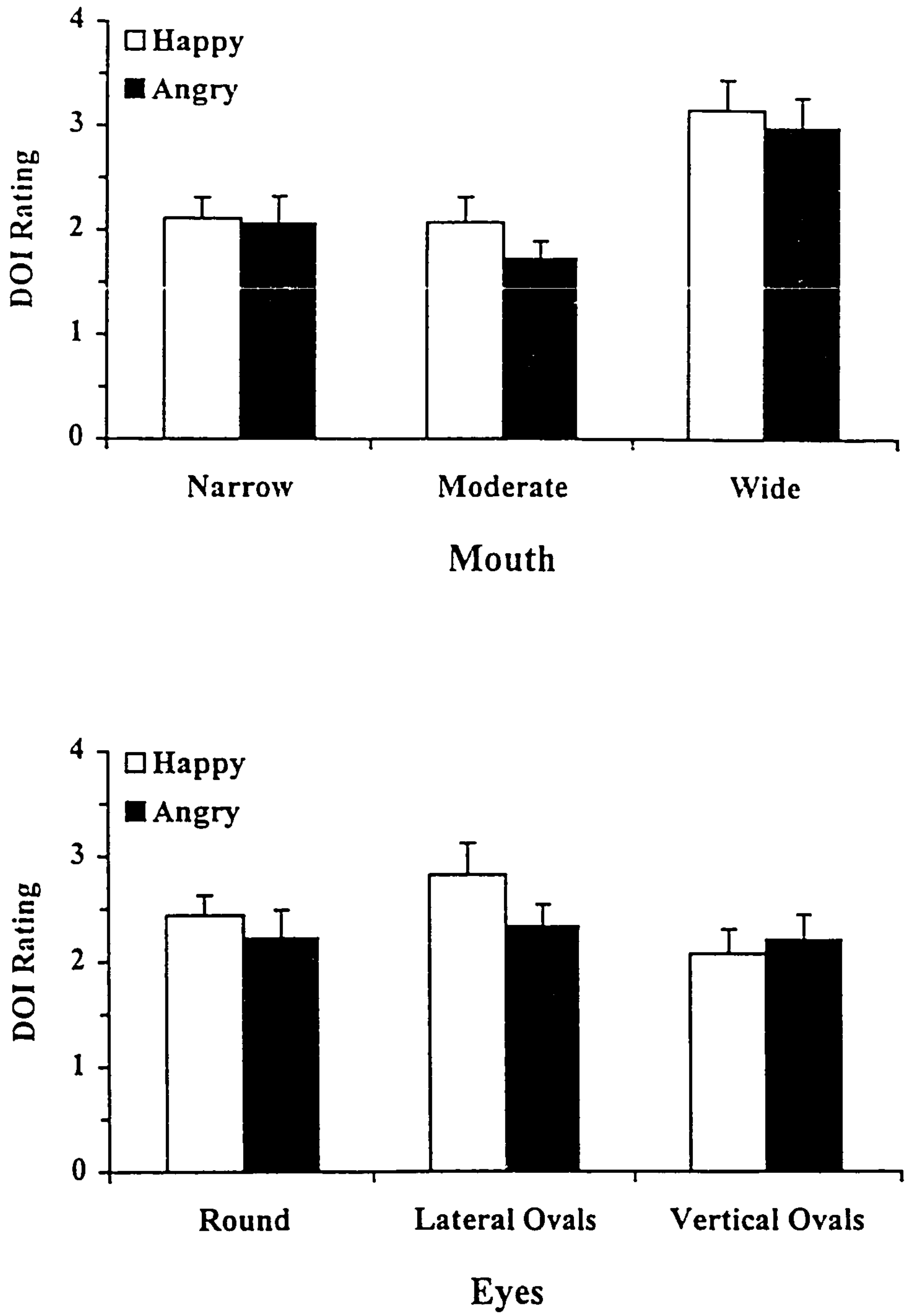


Figure 5. Mean difficulty of interpretation (DOI) rating to happy and angry faces as a function of facial feature structure in Experiment 4. Error bars represent standard errors of means.

difficult, for faces with wide versus moderate mouths (3.07 vs. 1.90, respectively), t (17) = 6.70, p < .001, and for faces with wide versus narrow mouths (3.07 vs. 2.08, respectively), t (17) = 4.32, p < .001. No difference in the mean DOI rating, however, obtained for faces with narrow versus moderate mouths (2.08 vs. 1.90, respectively), t (17) = 1.26, p > .20.

Further analysis to explicate the effect of eye structure revealed that the mean DOI rating was higher for faces whose eyes consisted of laterally-oriented versus vertically-oriented ovals (2.57 vs. 2.14, respectively), t (17) = 4.00, p < .01, suggesting that participants found the interpretation of affect more difficult for faces with the former versus the latter eyes.

Reaction Time

On the basis of the screening procedure described in Experiment 1, 1.70% of RTs were excluded from subsequent analyses.

Figure 6 shows mean RT to happy and angry faces as a function of mouth and eye structure, respectively. With regard to mouth structure, mean RT to happy and angry faces does not differ markedly, but tends to increase across faces with moderate, narrow, and wide mouths, respectively. With regard to eye structure, mean RT to happy and angry faces again does not differ markedly, and appears marginally shorter for faces with round eyes.

A 2 x 3 x 3 (affect x mouth x eyes) repeated measures analysis of variance on RTs revealed no effect of affect, F (1, 17) = .38, MSE = 5981.97, p > .50, or eye

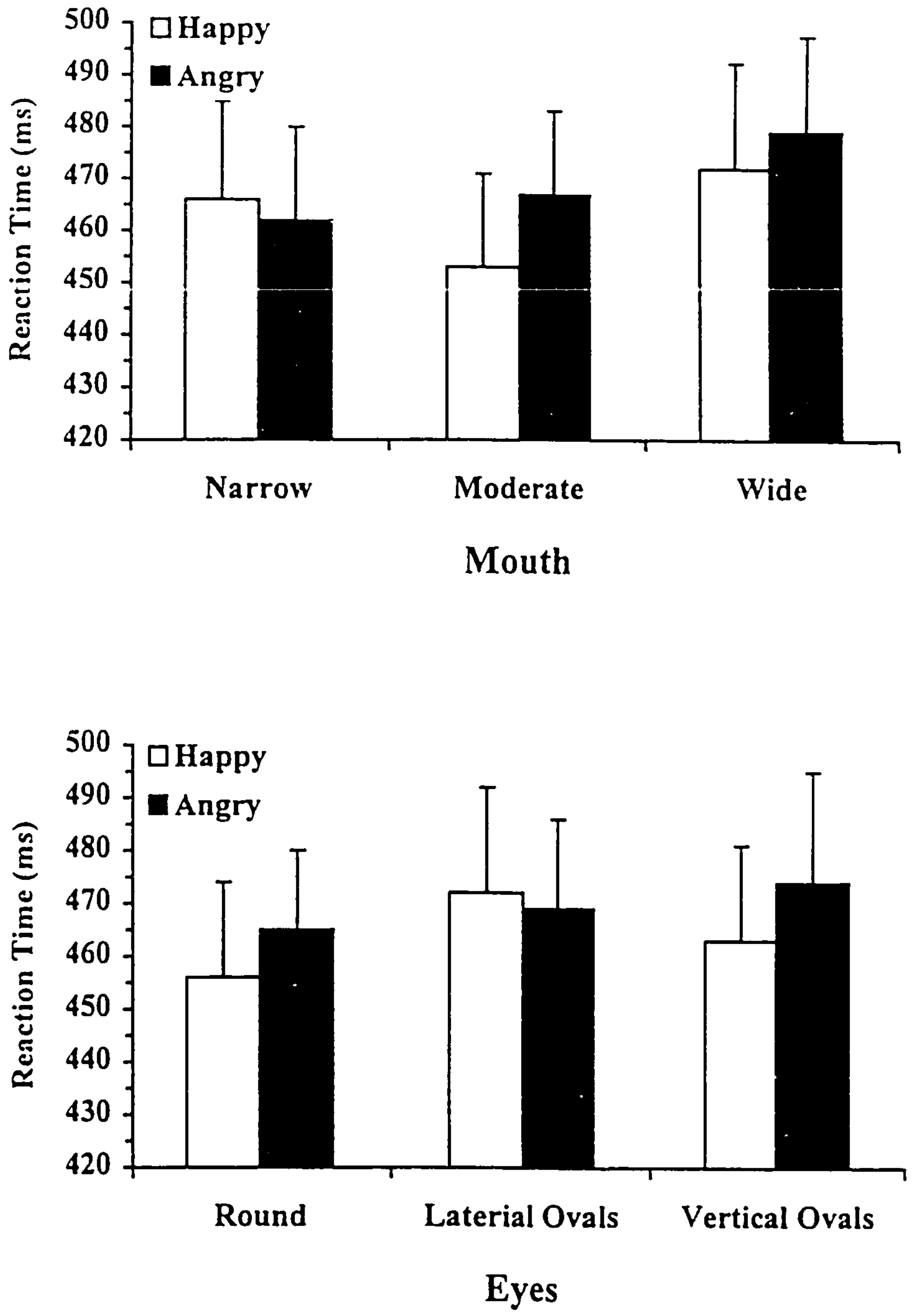


Figure 6. Mean reaction time to happy and angry faces as a function of facial feature structure in Experiment 4. Error bars represent standard errors of means.

structure, $F(2, 34) = 1.90$, $MSE = 1702.66$, $p > .15$, although an effect of mouth structure approached significance, $F(2, 34) = 3.35$, $MSE = 2478.28$, $p = .058$. No other effect or interaction was significant (all $Fs < 2.30$, $ps > .09$). Further analysis to explicate the impact of mouth structure revealed that mean RT was longer to faces with wide than with moderate mouths (475 vs. 460 ms, respectively), $t(17) = 2.77$, $p > .025$.

In sum, the present findings fail to support predictions based on the threat hypothesis. That is, across the affective categories of happiness and anger, which shared structurally identical features and differed minimally in terms of affect display ambiguity, RT to angry and happy faces was not significantly different. The findings do, however, provide tentative support for predictions based on the ambiguity hypothesis. That is, RT to the judgement of affect was longer, and affect was subjectively rated as more difficult to interpret, for faces with wide versus moderate mouth structures.

As noted, the DOI rating data also revealed that participants rated the interpretation of affect more difficult in faces whose eyes consisted of laterally-oriented versus vertically-oriented ovals. Interestingly, however, further analyses to explore the impact of this particular variable on RT revealed no significant differences. The possible implications of this null result are considered in the General Discussion.

Error Data

As shown in Table 6, the pattern of error rates indicates that more errors were made in responses to faces with narrow mouths, in particular relative to those with moderate mouths. A 2 x 3 x 3 (affect x mouth x eyes) repeated measures analysis of variance on proportions of error confirmed a main effect of mouth structure, $F(2, 34) = 3.21$, $MSE = .018$, $p = .053$, but no other effect or interaction (all $Fs < 2.40$, $ps > .10$).

Further analysis to explicate the effect of mouth structure indicated that the mean proportion of error was significantly higher for responses made to faces with narrow versus moderate mouths (.09 vs. .04, respectively), $t(17) = 2.60$, $p < .025$. The obtained error pattern is consistent with predictions based on the ambiguity hypothesis, insofar as it suggests that errors in the judgement of facial affect are more likely to occur in responses made to faces whose expressions are relatively more difficult to interpret.

For a more detailed presentation of the data and analyses for Experiment 4, see Appendices N to T.

Table 6. Mean proportion of error in responses to happy and angry faces as a function of facial feature structure in Experiment 4.

Facial Feature	Affect of Face	
Mouth	Happy	Angry
Narrow	.10	.07
Moderate	.02	.06
Wide	.07	.06
Eyes		
Round	.05	.08
Lateral Ovals	.09	.05
Vertical Ovals	.06	.06

General Discussion

The claim that observers respond differently to anger than to other affective facial expressions as a consequence of the threat-relevance of anger is theoretically compelling (e.g., Dimberg & Öhman, 1996; Hansen & Hansen, 1994). More mundane variables, however, such as differences in affect display ambiguity, may also share an important role in the influence of such faces and, critically, may compromise the interpretation of empirical findings. In particular, the present findings show that longer responses to the judgement of affect in angry than in happy faces, which previous work attributed to the operation of threat-relevant mechanisms (Purcell et al., 1998), do not occur when differences in affect display ambiguity between angry and happy faces are minimized. Instead, the present findings suggest that longer responses to the judgement of affect in angry than in happy faces reflect the fact that expressions of anger are more ambiguous, and therefore more difficult to interpret, than expressions of happiness.

Implications for Facial Affect Research and Theory

Although the present conclusions were based on findings from a task involving the judgement of facial affect, they may extend to tasks in which responses are made to non-affective facial dimensions, such as gender (see Purcell et al., 1998). Specifically, under the assumption that ambiguous stimuli are more likely to engage processes designed to disambiguate or interpret such stimuli (e.g., Berlyne, 1969; Kahneman, 1973), angry faces may take longer to process and delay responses regardless of how participants are instructed to deploy their attention during a task.

The present work has emphasized that affect display ambiguity may slow responding to a face. Depending on task demands, however, such ambiguity may also produce the converse outcome, that is, speeded responding. For example, consider an experiment by Hansen and Hansen (1994), in which participants on each trial were presented with an affective face on either side of a fixation point. On some blocks of trials, participants were required to make a saccadic eye movement from the fixation point to the face that expressed happiness, as quickly and accurately as possible; on other blocks of trials, participants were asked to make a saccade to the face that expressed anger, as quickly and accurately as possible. The results indicated that RTs toward angry faces were shorter than toward happy faces; and, further, when the initial saccade was to the wrong face and participants had to shift their gaze from one face and to the other, RTs away from angry faces were longer than RTs away from happy faces. In short, saccades were faster toward angry faces, but slower away from angry faces.

A threat hypothesis may account for Hansen and Hansen's (1994) findings on the grounds that threat mechanisms rapidly detect threatening stimuli, and then devote extended processing to these stimuli (i.e., given their obvious relevance).

An account based on the ambiguity hypothesis, however, is also plausible. In the present work, relatively greater difficulty in the interpretation of angry affect contributed to a longer delay in responding to angry than to happy faces. In a like fashion, in Hansen and Hansen's experiment, longer delays to saccade away from angry faces may have reflected greater engagement by processes designed to disambiguate and interpret the expression in these faces. Further, under the assumption that ambiguous stimuli may also attract processing resources designed to interpret such stimuli (e.g., Berlyne, 1969; Kahneman, 1973), it may be argued that, in Hansen and Hansen's work, saccades may have been faster toward angry than toward happy faces because of the relatively greater ambiguity associated with the affective display of angry faces. It is, therefore, possible to formulate a reasonable account of Hansen and Hansen's findings based on either a threat or ambiguity hypothesis. Unfortunately, although Hansen and Hansen speculate on several variables, including affect display ambiguity, that may underlie their findings, they provide no empirical means to evaluate the role of such ambiguity in their work.

The present work has emphasized that ambiguity may influence the findings of experiments that involve measures of reaction time. The influence of ambiguity may, however, extend to other experimental tasks. For example, affect display ambiguity will likely influence performance on tasks in which participants are required to identify or detect the affect of briefly presented or masked faces (e.g., Boucher & Carlson, 1980; Esteves & Öhman, 1993). In any given experiment, then, a consideration of the processes assumed to underlie task performance may be useful to determine the extent of the influence of ambiguity (if any) and, importantly, whether efforts must be made to control for it.

Empirical Control Over Affect Display Ambiguity

As previously suggested, claims made on the basis of the ambiguity hypothesis are not necessarily mutually exclusive with claims made on the basis of other hypotheses regarding the impact of affective faces. That is, mechanisms described by one or several hypotheses may underlie the influence of a given affective expression. Importantly, on the basis of procedures that experimentally control for differences in affect display ambiguity, more conclusive claims may be made regarding the role that ambiguity may or may not play in the results of any given experimental task, and therefore more complete accounts may be rendered of the mechanisms underlying the impact of affective faces on observers.

The present results suggest that data based on subjective ratings of the interpretability of affect may be a useful means for measuring or manipulating affect display ambiguity. Both Experiments 3 and 4 demonstrated that the presence or absence of differences in the interpretability of affective facial stimuli, as determined by subjective ratings, corresponded to the presence or absence, respectively, of differences among these stimuli on a separate experimental task. Notably, however, in Experiment 4, differences in the interpretability of affect for stimuli with different eye features did not significantly influence responses to these stimuli on the speeded judgement of affect. This finding, then, suggests that differences in affect display ambiguity may not always correspond straightforwardly to performance patterns on other affect-related tasks. This finding may also (or alternatively) suggest that the operationalization of affect display ambiguity on the basis of subjective ratings may capture some, but not all, of the construct of interest. If so, however, then how might differences in affect display ambiguity be controlled for more rigorously, in particular given that researchers may wish to rule this variable out of the interpretation of a given pattern of results?

The issue merits elaboration. As noted previously, at least several different variables may contribute to differences in affect display ambiguity among different affective facial expressions, including the display variability of facial features, the potential for confusion with related categories of affective facial expression, and familiarity of the affective expression, as a function of frequency of occurrence in real-world situations. Given, therefore, that affect display ambiguity is a construct with many dimensions, each of which may be uniquely difficult to measure, perfect experimental control over ambiguity is unlikely. On the one hand, it may be possible to minimize the influence of specific variables that may contribute to differences in display ambiguity. Thus, for example, variability in facial features across different categories of affect may be greatly minimized through the manipulation of facial feature structure, as in Experiment 4. On the other hand, efforts to eliminate or downplay the potential contribution of several sources of display ambiguity on a given task are more difficult, and may require not only specific measures or manipulations of interpretability, but additional or alternative approaches to the problem.

One promising alternative would involve comparisons of the impact of a number of different categories of facial expression that are similar with regard to their degree of affect display ambiguity but different with regard to their expected affective influence. This approach is illustrated in a recent investigation that evaluated the hypothesis that socially phobic individuals will show an attentional bias toward angry faces, under the assumption that clinically anxious persons are more likely to attend to threat relevant stimuli than to non-threat relevant stimuli (Gilboa-Schechtman et al., 1999). A first prediction was that, when visually searching through a crowd of identical neutral faces, social phobics would more quickly detect a single, discrepant target face when it expressed anger than when it expressed happiness (cf. Hansen & Hansen, 1988). A second prediction was that, because target faces expressing disgust were not assumed to be perceived as threat-relevant by social phobics, such faces would <u>not</u> be detected as quickly as faces expressing anger. Both predictions were supported; that is, when searching through a crowd of neutral faces, social phobics detected a target face faster when it expressed anger than when it expressed happiness or disgust. As such, it is difficult to account for these findings in terms of differences in affect display ambiguity across different categories of affect. Specifically, it is unlikely that angry faces attracted attention more quickly than happy faces as a consequence of processing resources designed to interpret ambiguous stimuli (e.g., Berlyne, 1969; Kahneman, 1973); for, if such processes were operative, they should have presumably led to a comparably rapid detection of disgusted faces which, like angry faces, are likely more difficult to interpret than happy faces (Ekman, 1976). Therefore, the claim that threat – which is uniquely associated with anger – gave rise to the obtained findings is preferable to an account based on ambiguity.

Unresolved Issues

A potential criticism of procedures that attempt to measure or manipulate differences in affect display ambiguity is that they may artificially separate stimulus characteristics that are often confounded in real-world conditions. If, for instance, angry faces are also typically more ambiguous than other affective expressions, then why should methodological efforts be made to control for this fact? Although such a criticism may be based on a valid field observation, it does not itself obviate the need to disentangle empirically the very different mechanisms that may underlie the influence of affective faces on observers.

A related and theoretically more interesting concern, however, is that the influence of affective faces may depend upon the confounding of characteristics such as ambiguity and anger. In other words, it is possible that a relatively ambiguous facial display, such as anger, activates threat-relevant mechanisms by virtue of its ambiguity. Interestingly, this possibility is consistent with a position forwarded by Whalen (1998) in a review of neuroimaging studies of the human amygdala. On the one hand, Whalen notes that the amygdala has been implicated in the processing of affective information, and in particular negative affective information, including angry and fearful facial expressions (e.g., Breiter et al., 1996; Morris, Öhman, & Dolan, 1998). On the other hand, he questions the view that the exclusive role of the amygdala is to process such information. In particular, he makes several notable observations, including: (a) the amygdala may be more involved in the processing of fear and surprise than anger, that is, more involved in expressions which are more ambiguous regarding the nature and origin of a probable threat; and (b) the amygdala is more active when stimulus contingencies are unpredictable. As such, Whalen forwards a broader conception of the amygdala, namely, "as an integral component of a constant and continuous vigilance system, one that is preferentially invoked in ambiguous learning situations of biological relevance" (p. 177). Put another way, a major function of the amygdala may be (in effect) to ask, "What is it?" regarding an unknown stimulus. Whalen goes on to suggest that such a system has survival utility, in that it facilitates the acquisition and analysis of environmental information, including potential threat signals.

Given such a hypothesis, then, the relatively greater affect display ambiguity in anger (and related negative expressions such as fear) need not be regarded as inconsistent with an evolutionary interpretation of their significance. For instance, the fact that angry faces are more ambiguous than happy faces may ensure that the former attract attention more rapidly and are scrutinized longer and more carefully. If, however, the threat-relevance of angry faces is indeed inextricably bound up with their affect display ambiguity, then it follows that a stimulus manipulation procedure to control for such ambiguity could effectively hamper or eliminate the source of an effect. Nonetheless, empirical study of the potential interdependence of these variables could not proceed without the use of some form of stimulus manipulation procedure. The theme of Chapter 1 is that, without some control, measure, or appreciation of display ambiguity, claims regarding the threat-relevant mechanisms that underlie the influence of angry facial expressions may remain, at best, intriguing and unproven.

Chapter 2

Using an experimental methodology based on Purcell et al. (1998), no evidence was found in the experiments reported in Chapter 1 in support of a threat-based hypothesis when differences in affect display ambiguity between angry and happy faces were minimized. The purpose of the work described in Chapter 2 was to re-evaluate the potentially threat-relevant influence of angry faces on observers, within a methodological framework that again minimized problems in ambiguity. The experiments described in Chapter 2, however, involved a modification to the experimental methodology used in Chapter 1 and allowed for the evaluation of a unique variant of the threat hypothesis that emphasized not only facial affect but an additional and ecologically-relevant facial dimension, namely, identity.

Although Purcell et al.'s (1998) affect judgement task involved the presentation of a number of affective faces, each of which depicted a different individual, these differences were not important to the threat-related mechanisms that were proposed to underlie the unique impact of angry faces on observers. In the real world, however, we experience other people's facial expressions not as exemplars of broad affective categories, but as unique identities. Consistent with this intuitive observation, theory and research suggest that facial identity, in addition to facial expression, is analyzed by one of several independent cognitive subsystems involved in face perception. For instance, cell-recording investigations involving monkeys have found cells sensitive to facial identity primarily in the inferior temporal gyrus, and cells sensitive to facial expression primarily in the superior temporal sulcus (Hasselmo, Rolls, & Baylis, 1989). Such a pattern thus suggests, at the level of neural representation, a degree of segregation of systems involved in the processing of identity and expression. In humans, the theorized independence of such systems (Bruce & Young, 1986) has been suggested by the finding that reaction times for matching facial identities are faster for familiar versus non-familiar faces, whereas reaction times for matching facial expressions are not different for familiar versus non-familiar faces (Young, McWeeny, Hay, & Ellis 1986). Also suggestive in this regard are case studies of individuals with prosopagnosia, that is, brain-injured individuals with an impairment in recognizing facial identity, but a spared capacity to recognize facial expression and other face-related information such as age and gender (Sergent & Signoret, 1992; Tranel, Damasio and Damasio, 1988).

The importance of facial identity specifically in the context of threat is suggested in an investigation involving classical conditioning to facial stimuli. Dimberg (1986) classically conditioned the presentation of a particular angry and happy face to a mild electric shock, and then found measurable skin conductance responses (SCR) to the presentation of the angry face in the absence of any shock. Notably, however, an SCR was not elicited when participants subsequently viewed a different (unconditioned) angry face, but was again elicited when the conditioned angry face was again presented. The finding was interpreted to suggest that threat-related conditioning occurred not simply to an angry face, but to an angry face belonging to a particular person.

How might such observations inform predictions inspired by a threat hypothesis? As noted previously (see Chapter 1), the threat hypothesis suggests that stimuli such as angry faces may engage systems involved in detecting and responding to threat. If the evolutionary utility of such systems is to facilitate survival (e.g., Dimberg & Öhman, 1996; Hansen & Hansen, 1994; Öhman, 1996; Purcell et al., 1998), then it may be predicted that the perception of an angry (i.e., threatening) face will involve the processing of not only facial expression, but also other information relevant to survival, including facial identity. In particular, it may be hypothesized that the identity of an angry (i.e., threatening) face will make a more salient impression on an observer than the identity of a happy (i.e., non-threatening) face, because the potential survival cost of failing to notice the former is arguably greater than that of failing to notice the latter. In short, a salient identity hypothesis would suggest that facial identity is more strongly encoded in the context of an angry relative to happy facial expression.

The experiments described in Chapter 2 offer a preliminary evaluation of the salient identity hypothesis. The task used for this purpose required only a minor modification to the affect judgement task described in Chapter 1. Specifically, on each trial of the new task, participants were first shown a prime face, the affective expression of which was either happy or angry. Participants were instructed not to respond to the prime, and that it served no predictive value. Following the prime, participants were shown a target face, the affective expression of which was also either happy or angry. Notably, although the affective expression in this target face could be the same as or different from that of the preceding prime face, the specific identity of the target face always differed from that of the preceding prime face (i.e., was never the same person). Participants were instructed to identify the affect in the target face as quickly and accurately as possible, by pressing one of two keys.

This primed affect judgement task was therefore identical to the affect judgement task described in Chapter 1, except that happy and angry primes were presented before targets. Consequently, the new task included congruent trials, that is, trials on which primes and targets shared the same facial affect (i.e., happy-happy or angry-angry); and incongruent trials, that is, trials on which primes and targets had a different facial affect (i.e., happy-angry or angry-happy). As previously noted, however, facial identity always differed across primes and targets on all trials.

To appreciate how the primed affect judgement task was used to test the salient identity hypothesis, it is important to note two assumptions regarding task performance, and a relevant prediction that follows from these assumptions. First, despite the instruction to ignore primes, it was assumed that on a given trial, the perception of a prime face would facilitate or "prime" recognition for similar stimuli (Collins & Loftus, 1975; Scarborough, Cortese, & Scarborough, 1977; Meyer & Schvaneveldt, 1971). Second, despite the instruction to respond only to affect, it was assumed that participants would also process the facial identity of primes and targets (Bruce & Young, 1986; Hasselmo et al., 1989; Sergent & Signoret, 1992; Tranel et al., 1988; Young et al., 1986).

Given these two assumptions, it was expected that performance on the primed affect judgement task would reflect a pattern such that responses were longer on congruent than on incongruent trials. Specifically, on an incongruent trial, a given prime-target pair differ both in terms of their facial affect (i.e., happy-angry, angry-happy) and facial identity. In short, on such a trial, primes and targets are unambiguously different. In contrast, on a congruent trial, a given prime-target pair have the same facial affect; however, they differ with regard to their facial identity. This arrangement was expected to introduce an element of ambiguity into congruent trials. Namely, the assumption that a prime would facilitate recognition for a similar stimulus was expected to engender a perception that a subsequent target was similar to the prime (i.e., with regard to affect); but the fact that a prime and target had different identities was also expected to engender a perception that the target was different from the prime. This ambiguity was predicted to prompt a delay in processing in order to resolve that, despite their apparent difference (i.e., with regard to identity), prime and target did share the same affect. Importantly, this ambiguity was expected to delay processing on congruent trials such that responses to targets would be slower on congruent than on incongruent trials.

Critically, within this pattern, it was predicted on the basis of the salient identity hypothesis that, on congruent trials, responses would be longer to angry than to happy targets. Specifically, on congruent trials, the ambiguity engendered by the change in identity across prime and target was expected to be more pronounced on angry-angry than on happy-happy trials because, as proposed by the salient identity hypothesis, identity is more strongly encoded for angry than for happy faces. Thus, the resolution of the ambiguity inherent in congruent trials, and therefore responding, was expected to take longer for angry than for happy targets.

Overview of Experiments

Chapter 2 includes 5 experiments. Experiments 5A-C provided a test of the salient identity hypothesis using a primed affect judgement task. Experiment 6 evaluated the role that face identity plays in patterns obtained using a primed affect judgement task. Experiment 7 used schematic rather than photographic face stimuli to test the generalizability of the findings of Experiments 5-6 across a different stimulus set. In order to minimize any potential contribution of differences in affect display ambiguity to the obtained findings (see Chapter 1), the experiments of Chapter 2 included happy and angry face stimuli that, on the basis of the findings of Chapter 1, were not measurably different in RT on speeded affect judgements, subjective ratings of interpretability, and (for schematic faces) facial feature display variability.

Experiment 5A

The goal of Experiment 5A was to provide a test of the salient identity hypothesis using a primed affect judgement task, which involved speeded judgements of the affect of happy and angry face targets which were preceded by happy or angry face primes.

Notably, in order to identify the temporal interval between the onset of a prime and the onset of a target (i.e., stimulus-onset-asynchrony, or SOA) at which the predicted patterns were reliable, the impact of two different prime-target SOAs was explored. In particular, in two different blocks of trials, a 200 ms prime was followed by a target after a 0 ms delay (immediately) or after a 1000 ms delay, thus yielding SOAs at 200 and 1200 ms, respectively. The selection of these intervals was based on previous pilot work involving facial affective stimuli (Gaskovski, Eastwood, & Merikle, 1998). Specifically, this work demonstrated that participants' preference ratings for abstract visual patterns increased when happy faces were shown before the patterns, but decreased when angry (and other affectively negative) faces were shown before the patterns. The findings were interpreted as evidence for affective priming, that is, evidence that a (presumed) affective reaction to a stimulus "spills over" and biases an individual's judgement of a subsequent stimulus (Murphy & Zajonc, 1993).

A key aspect of the findings of the pilot work, relevant to the present experiment, is that the magnitude of the observed affective priming tended to decrease with shorter exposure durations of the affective faces, and in particular at exposures less than 100 ms; and to increase with longer exposure durations, for at least up to 1000 ms. Although, in the present work, a manipulation was made with regard to SOA (i.e., the interval <u>between</u> the onset of a prime and the onset of a target), rather than the exposure duration <u>of</u> a prime or target, it was nevertheless assumed that the findings of the pilot work could be informative for present purposes. As such, in the present work, 200 and 1200 ms SOAs were used because, based on the temporal parameters used in the previous work (i.e., as noted above), the present parameters were expected to approximate the lowest and highest temporal intervals, respectively, at which affective influences would be reliably detected.

Method

Participants

Eighteen undergraduate students at the University of Waterloo participated in the experiment. Each participant had normal or corrected-to-normal vision, and was paid $4.00 upon completion of the 25-minute experimental session.

Apparatus and Stimuli

The apparatus and stimulus presentation software were the same as in Experiment 1. The stimuli were drawn from the "matched" affective faces used in Experiment 3 (Appendix G), and consisted of five faces that expressed happiness and five faces that expressed anger.

Procedure

Participants were instructed that on each trial they would be shown two faces on the computer screen, one after the other, and that each face could express either happiness or anger. Participants were informed that the affect in the first face (i.e., the prime) had no predictive value regarding the affect in the second face (i.e., the target), and that no response was to be made to the first face. Participants were asked to identify the specific affect in the second face ("happiness" or "anger") as quickly and as accurately as possible. Participants keyed their responses to one of two buttons using the index and middle finger of their dominant hand. The two buttons were labelled according to the relevant judgement, and the order of the labels was counter-balanced across participants.

The experiment consisted of two blocks of 80 experimental trials, each of which was preceded by 12 practice trials. Each trial consisted of the following sequence of events: (1) prime (200 ms); (2) blank inter-stimulus interval (0 or 1000 ms, depending on block); (3) the presentation of a target, until the participant made a response; (4) a 1500-ms interval until the next trial. Given these parameters, the prime-target SOA, or interval between the onset of a prime and the onset of a subsequent target, was 200 ms in one block of trials and 1200 ms in another block of trials. The order of blocks was counter-balanced across participants.

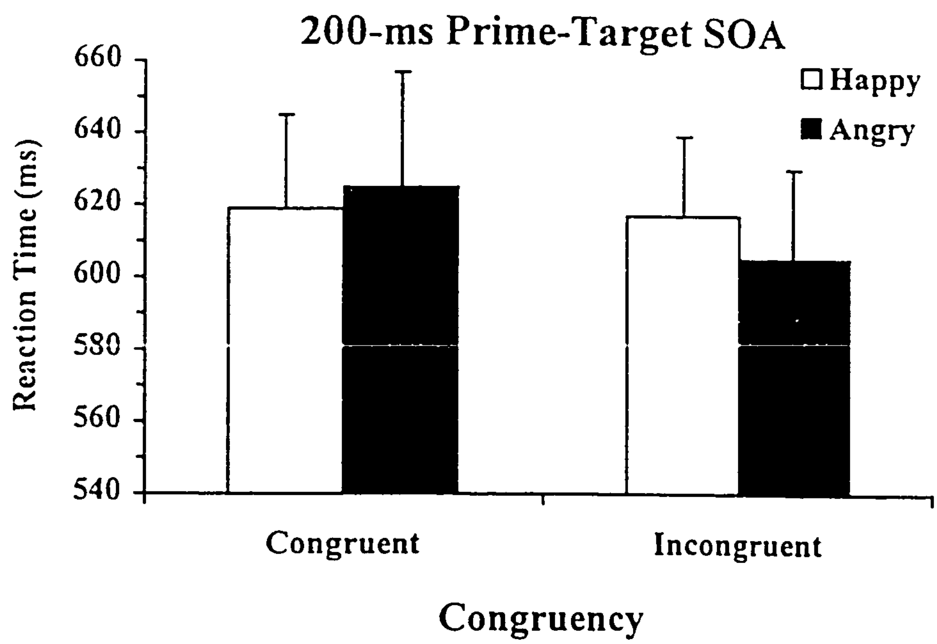
Within each block, each of four prime-target pair combinations (i.e., happy-happy, angry-angry, happy-angry, angry-happy) occurred twenty times. Prime-target pairs were presented in random order. The pairing of specific primes with specific targets was also random, within the following constraints: (1) each stimulus appeared as a prime and target eight times, respectively; (2) no stimulus was ever paired with another stimulus sharing the same facial identity, as well as one other randomly selected stimulus from the other affect group (this latter stipulation ensured equal numbers of all four prime-target combinations).

Results and Discussion

Reaction Time

On the basis of the outlier screening procedure described in Experiment 1, 2.11% of responses were excluded from subsequent analyses.

Figure 7 shows mean RT to happy and angry targets as a function of congruency and prime-target SOA. As predicted, at each SOA mean RT is longer on congruent than on incongruent trials, and longer to angry than to happy targets on congruent trials. A 2 x 2 x 2 (SOA x congruency x target) repeated measures analysis of variance revealed a main effect of congruency, $F(1, 17) = 6.63$, $MSE = 2218.14$, $p < .05$, confirming that mean RT was longer on congruent than on incongruent trials (608 vs. 587 ms, respectively). The analysis also revealed a main effect of SOA, $F(1, 17) = 7.28$, $MSE = 7276.39$, $p < .05$, indicating that mean RT was longer under the 200- versus 1200-ms SOA (617 vs. 578 ms,



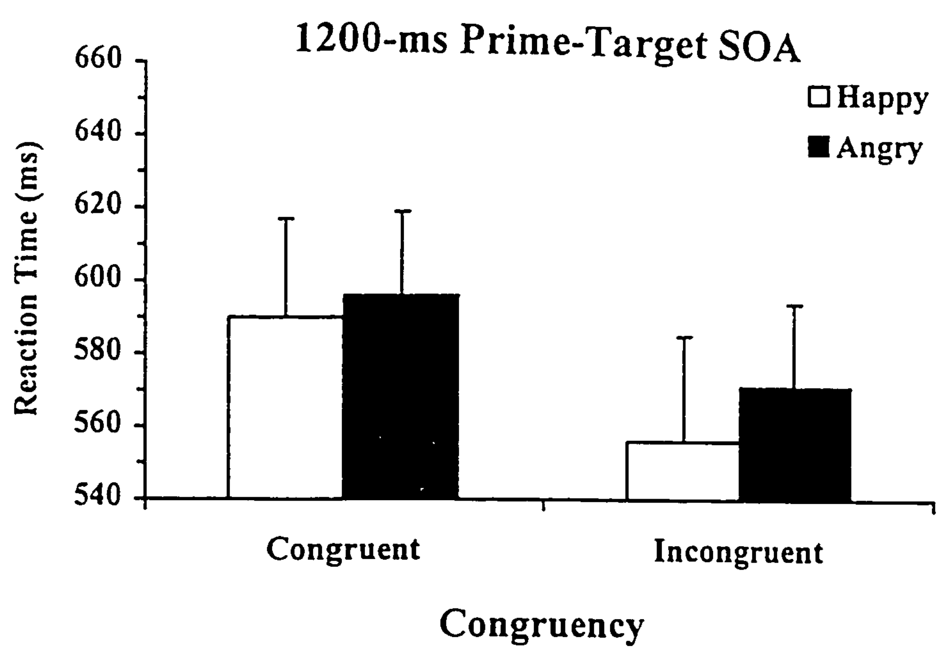


Figure 7. Mean reaction time to happy and angry face targets as a function of congruency and prime-target SOA in Experiment 5A. Error bars represent standard errors of means.

respectively). No other effect or interaction, however, was significant (Fs < 2.90, ps > .10).

As planned, the data were separately analyzed at each prime-target SOA, because the potential impact of the different SOAs on the predicted patterns was unknown. At the 1200-ms SOA, a 2 x 2 (congruency x target) repeated measures analysis of variance on RTs indicated a main effect of congruency, F (1, 17) = 10.49, MSE = 1484.93, p < .01. This main effect is consistent with the same main effect obtained in the overall analysis reported above. No other effect or interaction, however, was significant (Fs < 1.05, ps > .30). At the 200-ms SOA, a 2 x 2 (congruency x target) repeated measures analysis of variance on RTs revealed no significant effects or interactions (Fs < 1.20, ps > .25).

The present findings did not support a key prediction based on the salient identity hypothesis, that is, responses to angry and happy targets on congruent trials differed only minimally and did not yield the expected interaction between congruency and target. As expected, however, performance on the primed affect judgement task produced an overall pattern in which responses were longer on congruent than on incongruent trials, that is, a pattern consistent with the assumed impact of the ambiguity inherent in congruent trials. Further, when the data were analyzed separately by SOA, this pattern held at the 1200-ms prime-target SOA but not at the 200-ms prime-target SOA. Notably, comments made by several participants suggest that a failure to detect a significant pattern at the 200-ms

SOA may have reflected greater difficulty in clearly seeing prime stimuli at this SOA, given that on each trial a prime stimulus was immediately followed by a target stimulus. Thus, it is possible that at the 200-ms SOA, the immediate appearance of targets following primes may have obscured a clear perception of primes and therefore hampered their expected influence.

Error data

The pattern of error rates is shown in Table 7. A 2 x 2 x 2 (SOA x congruency x target) repeated measures analysis of variance on proportions of error revealed no main effects or interactions (all Fs < 1.00, ps > .35). Separate 2 x 2 (congruency x target) repeated measures analyses of variance on proportions of error conducted at each of the two prime-target SOAs likewise yielded no significant effects or interactions (all Fs < 1.20, ps > .25).

For a more detailed presentation of the data and analyses for Experiment 5A, see Appendices U to X.

Table 7. Mean proportion of error in responses to happy and angry face targets as a function of congruency and prime-target SOA in Experiment 5A.

	Congruent		Incongruent	
SOA	Happy	Angry	Happy	Angry
200 ms	.04	.05	.04	.05
1200 ms	.04	.05	.03	.04

Experiment 5B

The findings of Experiment 5A failed to support the salient identity hypothesis. The goal of Experiment 5B was to provide another test of this hypothesis, under modified SOA parameters. Again, in order to identify a prime-target SOA at which predicted patterns were reliable, the impact of two different SOAs was explored. A 1200-ms SOA was selected because, in Experiment 5A, findings were more consistent with predictions at the 1200-ms SOA than at the 200-ms SOA. A 700-ms SOA was also selected, given the possibility that a reliable SOA to detect the predicted patterns could lie between a 200-ms SOA – at which no predicted patterns were detected in Experiment 5A – and a 1200-ms SOA – at which the predicted congruency pattern was detected in Experiment 5A.

Method

Participants

Eighteen undergraduate students at the University of Waterloo participated in the experiment. Each participant had normal or corrected-to-normal vision, and was paid $4.00 upon completion of the 25-minute experimental session.

Apparatus and Stimuli

Apparatus and stimuli were identical to those used in Experiment 5A.

Procedure

The procedure was identical to that of Experiment 5A, except that the two prime-target SOAs were 700 ms and 1200 ms, respectively. That is, in one block of trials, a 200-ms prime presentation was followed by a 500-ms interval before the presentation of a target; whereas in another block of trials, a 200-ms prime presentation was followed by a 1000-ms interval before the presentation of a target.

Results and Discussion

Reaction Time

On the basis of the outlier screening procedure described in Experiment 1, 1.91% of responses were excluded from subsequent analyses.

Figure 8 shows mean RT to happy and angry targets as a function of congruency and prime-target SOA. As expected, at the 700-ms SOA, mean RT is longer on congruent than on incongruent trials, and longer to angry than to happy targets on congruent trials. At the 1200-ms SOA, however, the expected RT differences are smaller and less consistent with predictions. A 2 x 2 x 2 (SOA x congruency x target) repeated measures analysis of variance on RTs revealed only a main effect of SOA, F (1, 17) = 5.90, MSE = 4414.67, $p < .05$, indicating that mean RT was shorter under the 700-ms versus 1200-ms SOA (552 vs. 579 ms, respectively). No other effect or interaction was significant (Fs < 2.75, ps > .10).

As planned, the data were separately analyzed at each prime-target SOA. At the 700-ms SOA, a 2 x 2 (congruency x target) repeated measures analysis of variance on RTs revealed a main effect of congruency, F (1, 17) = 4.62, MSE = 1945.66, $p < .05$, indicating that mean RT was longer on congruent than on

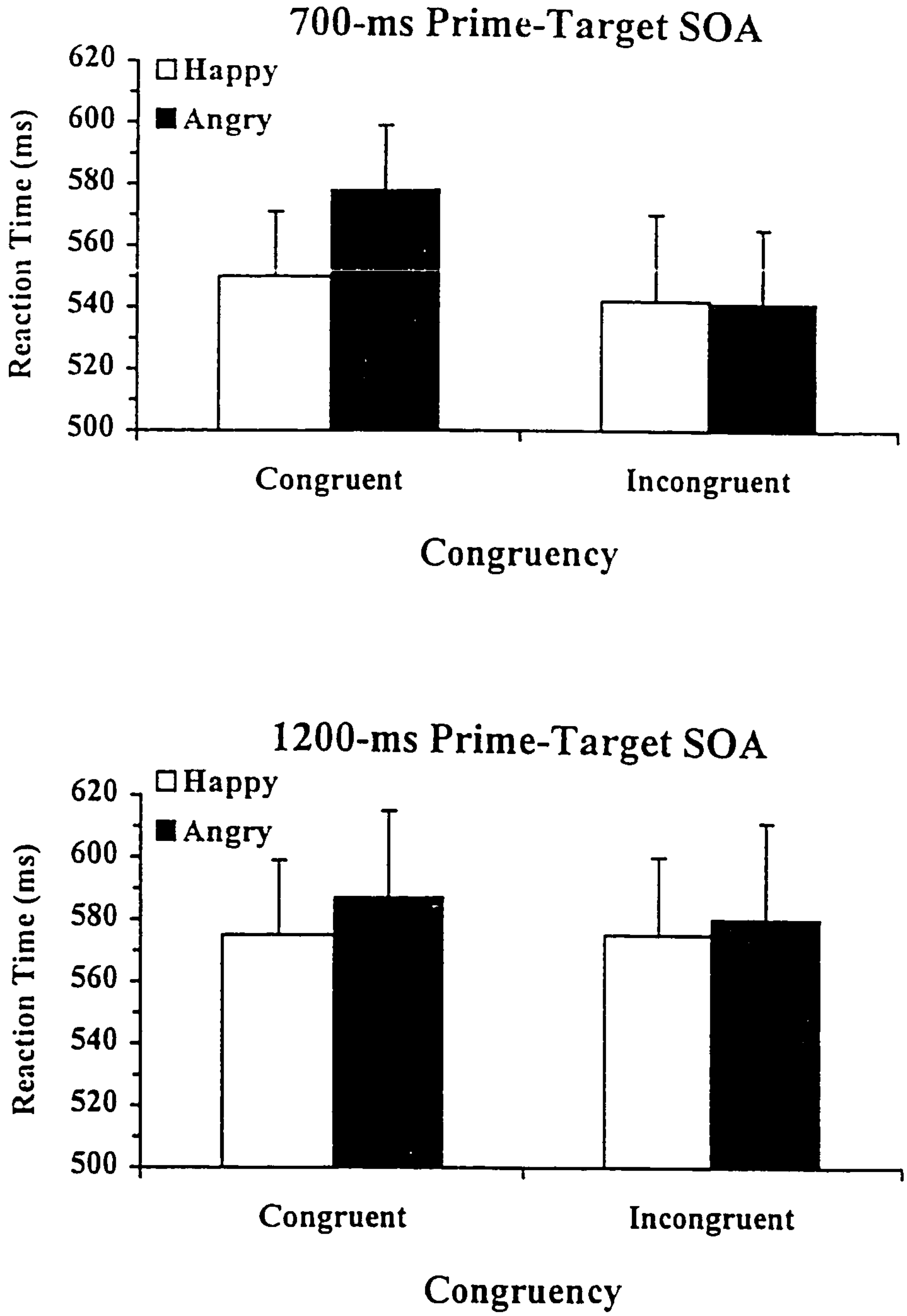


Figure 8. Mean reaction time to happy and angry face targets as a function of congruency and prime-target SOA in Experiment 5B. Error bars represent standard errors of means.

incongruent trials (564 vs. 541 ms, respectively). Consistent with predictions based on the salient identity hypothesis, the main effect of congruency was qualified by an interaction between congruency and target, F (1, 17) = 4.71, MSE = 827.88, $p < .05$ (see Figure 8). Further analysis of the interaction indicated that mean RT was longer to angry than to happy targets on congruent trials (578 vs. 550 ms, respectively), t (17) = 2.10, $p = .051$, but not on incongruent trials (541 vs. 542 ms, respectively), t (17) = -.12, $p > .90$. No other effect was significant (F <1.7, $p > .20$). Also, at the 1200-ms SOA, no significant effect or interaction was obtained (all Fs <.40, ps > .50).

The present results support predictions based on the salient identity hypothesis at a 700-ms prime-target SOA but not at a 1200-ms prime-target SOA. The failure to detect any significant patterns at the 1200-ms SOA was unexpected, given that a main effect of congruency was obtained at this SOA in Experiment 5A. Consistent with other research on similar congruency patterns, however, relatively longer delays between prime and target may lower the probability that a prime will influence a target (Fox, 1995).

Error data

As shown in Table 8, the pattern of error rates indicates that more errors were made in responses on congruent than on incongruent trials (.04 vs. .03, respectively). A 2 x 2 x 2 (SOA x congruency x target) repeated measures analysis of variance on proportions of error confirmed a main effect of

Table 8. Mean proportion of error in responses to happy and angry face targets as a function of congruency and prime-target SOA in Experiment 5B.

	Congruent		Incongruent	
SOA	Happy	Angry	Happy	Angry
700 ms	.04	.05	.03	.04
1200 ms	.05	.03	.02	.03

congruency, $F(1, 17) = 4.78$, $MSE = .001$, $p < .05$, but no other significant effect or interaction (all $Fs < 2.20$, $ps > .15$). Separate error analyses at each SOA revealed no significant effects or interactions (all $Fs < 2.00$, $ps > .15$). The obtained effect of congruency, given the obtained RT pattern, suggests that no trade-off occurred between participants' speed and accuracy of responding to face stimuli.

For a more detailed presentation of the data and analyses for Experiment 5B, see Appendices Y to BB.

Experiment 5C

The findings of Experiment 5B suggested that the predicted patterns were reliable at a 700-ms prime-target SOA. The goal of Experiment 5C, therefore, was to replicate the patterns obtained at the 700-ms SOA of Experiment 5B.

Method

Participants

Eighteen undergraduate students at the University of Waterloo participated in the experiment. Each participant had normal or corrected-to-normal vision, and was paid $4.00 upon completion of the 25-minute experimental session.

Apparatus and Stimuli

Apparatus and stimuli were identical to those used in Experiment 5A.

Procedure

The procedure was identical to that of the 700-ms SOA of Experiment 5B.

Results and Discussion

Reaction Time

On the basis of the outlier screening procedure described in Experiment 1, 2.15% of responses were excluded from subsequent analyses.

Figure 9 shows mean RT to happy and angry targets as a function of congruency. As predicted, mean RT is longer on congruent than on incongruent trials, and longer to angry than to happy targets on congruent trials. A 2 x 2

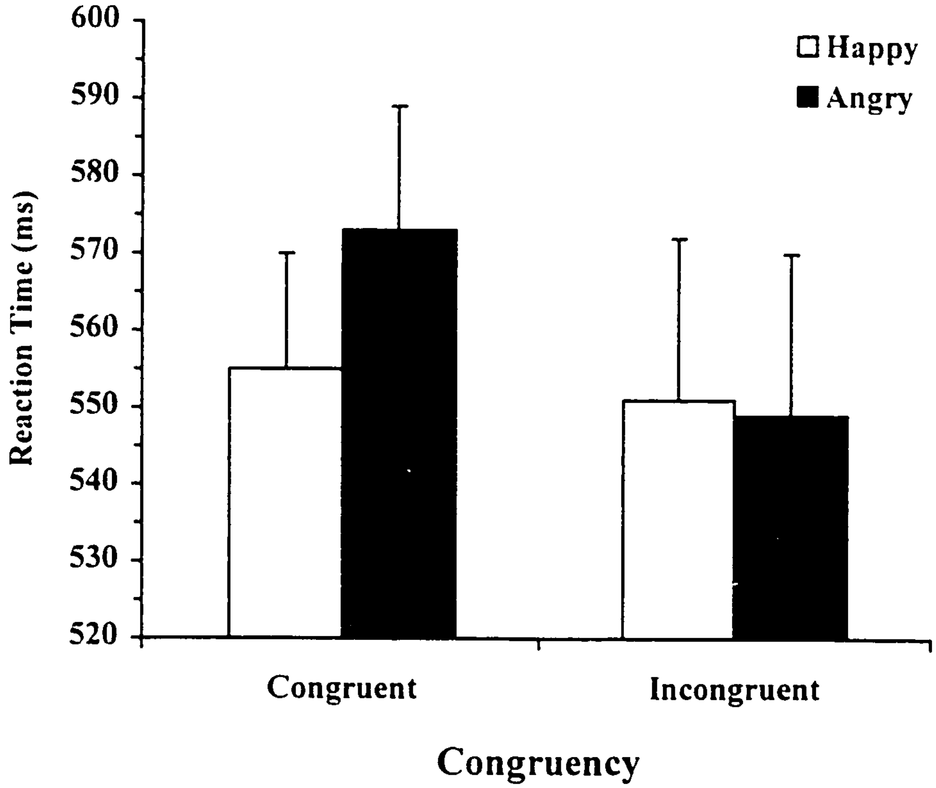


Figure 9. Mean reaction time to happy and angry face targets as a function of congruency in Experiment 5C. Error bars represent standard errors of means.

(congruency x target) repeated measures analysis of variance on RTs, however, did not yield a main effect of congruency, F (1, 17) = 2.06, MSE = 1683.09, p > .15. Also, the congruency by target interaction, predicted on the basis of the salient identity hypothesis, approached but did not reach significance, F (1, 17) = 3.40, MSE = 582.65, p = .083 (see Figure 9). Similarly, the direction of the difference between mean RT to angry and happy faces on congruent trials was consistent with the salient identity hypothesis but did not reach significance (573 vs. 555 ms, respectively), t (17) = 1.36, p > .15. No other effect was significant (F < .60, p > .40). The present findings, therefore, failed to replicate the patterns obtained at the 700-ms SOA of Experiment 5B.

Error data

As shown in Table 9, the pattern of error rates indicates that more errors were made in responses on congruent than on incongruent trials (.06 vs. .03, respectively). A 2 x 2 (congruency x target) repeated measures analysis of variance on proportions of error confirmed a main effect of congruency, F (1, 17) = 5.88, MSE = .01, p < .05, but no other significant effect or interaction (all Fs < .40, ps > .55). The main effect of congruency replicates the pattern obtained in Experiment 5B and likewise suggests that no trade-off occurred between participants' speed and accuracy of responding to face stimuli.

Table 9. Mean proportion of error in responses to happy and angry face targets as a function of congruency in Experiment 5C.

	Affect of Face	
Congruency	Happy	Angry
Congruent	.06	.06
Incongruent	.04	.03

Analysis Across Experiments 5A-C

The lack of statistically significant patterns and the several replication failures observed across Experiments 5A-C may be interpreted as failures to support the salient identity hypothesis. Notably, however, with almost no exception, the direction of the pattern obtained at every SOA of all three experiments was consistent with predictions, namely, mean RT tended to be longer on congruent than on incongruent trials, and (consistent with the salient identity hypothesis) longer to angry than to happy targets on congruent trials (see Figures 7, 8, and 9 on pp. 73, 79, and 84, respectively). Therefore, it is possible that the data reflect the predicted patterns at insufficient levels of power.

To address this possibility, the RT data from all three experiments, collapsed across prime-target SOA, were submitted to a 2 x 2 x 2 analysis of variance, with experiment as a between-subjects factor and congruency and target as within-subjects factors. The findings, depicted in Figure 10, revealed a main effect of congruency, F (1, 51) = 10.24, MSE = 1306.94, $p < .01$, indicating, as expected, that mean RT was longer on congruent than on incongruent trials (581 vs. 566 ms, respectively). More importantly, consistent with the salient identity hypothesis, the analysis also revealed a significant congruency by target interaction, F (1, 51) = 4.52, MSE = 639.35, $p < .05$ (see Figure 10). Further analysis suggested that mean RT was significantly longer to angry than to happy targets on congruent trials (589 vs. 574 ms, respectively), t (17) = 1.91, $p = .03$ (one-tailed), but not

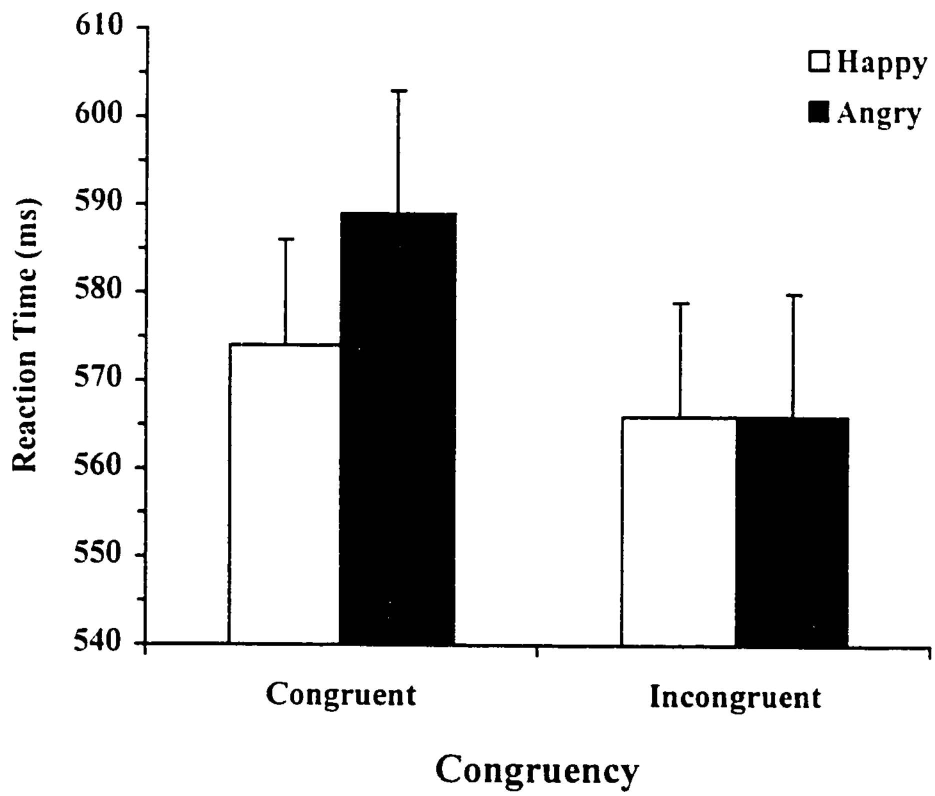


Figure 10. Mean reaction time to happy and angry face targets as a function of congruency, collapsed across Experiments 5A-C. Error bars represent standard errors of means.

on incongruent trials (566 vs. 566 ms. respectively). No other effect or interaction was significant (all Fs < 1.70, ps > .20).

The pattern of errors is shown collapsed across Experiments 5A-C in Table 10 (for error rates by individual experiment, see Tables 7, 8, and 9 on pp. 76, 81, and 86, respectively). The pattern indicates that more errors were made in responses on congruent than on incongruent trials (.05 vs. 03, respectively). A 2 x 2 x 2 analysis of variance on proportions of error, with experiment as a between-subjects factor and congruency and target as within-subjects factors, confirmed a main effect of congruency, $F\ (1, 51) = 7.62$, $\underline{MSE} < .01$, $p < .01$, but no other effect or interaction (all Fs < 1.60, ps > .20). This pattern replicates the pattern obtained in Experiments 5B and 5C and likewise suggests that no trade-off occurred between participants' speed and accuracy of responding to face stimuli.

In sum, the collective findings of Experiments 5A-C provide support for the salient identity hypothesis. Importantly, the present findings suggest that the failure to detect predicted patterns based on the analyses of individual experiments reflected, at least in part, problems with statistical power.

For a more detailed presentation of the data and analyses of Experiment 5C and Experiments 5A-C, see appendices CC-GG.

Table 10. Mean proportion of error in responses to happy and angry face targets as a function of congruency, collapsed across Experiments 5A-C.

	Affect of Face	
Congruency	Happy	Angry
Congruent	.05	.05
Incongruent	.03	.04

Experiment 6

In Experiments 5A-C, primes and targets always had different facial identities. That is, regardless of the congruence or incongruence of their facial affect, primes and targets never pictured the same person. As previously indicated, this difference was assumed to underlie the finding, predicted on the basis of the salient identity hypothesis, that responses were longer to angry than to happy faces on congruent trials. This difference was also assumed to underlie a related and more basic finding, namely, that responses were longer on congruent than on incongruent trials.

The goal of Experiment 6 was to provide empirical support for the assumption that a change in facial identity across primes and targets was critical to the findings of Experiments 5A-C. Specifically, it was predicted that when facial identity is the same rather than different across prime and target, responses would be shorter (rather than longer) on congruent than on incongruent trials. The basis for this prediction of <u>positive priming</u> is empirically well-established. When the facial identity of primes and targets is the same, then primes and targets are represented by the same stimulus on congruent trials (i.e., the same person displaying the same affective expression) but a different stimulus on incongruent trials (i.e., the same person displaying two different affective expressions). Given this arrangement, a prediction of positive priming is entirely consistent with the finding that responses to targets tend to be shorter when primes and targets are perceptually or semantically related relative to when they are unrelated (e.g., Scarborough, Cortese, & Scarborough, 1977; Meyer & Schvaneveldt, 1971).

Method

Participants

Eighteen undergraduate students at the University of Waterloo participated in the experiment. Each participant had normal or corrected-to-normal vision, and was paid $4.00 upon completion of the 20-minute experimental session.

Apparatus and Stimuli

The apparatus and stimulus presentation software were the same as in Experiment 1.

Stimuli included those used in Experiments 5A-C (Appendix G, "matched faces"). Six additional stimuli, however, had to be added in order to ensure that, for each face of a given affect, the stimulus set included the same face identity of opposite affect (Appendix HH). Further, limitations in the availability of stimuli necessitated the use of one face expressing disgust rather than anger (Appendix HH, Angry Face #1). Given that predictions were made only with regard to the congruency of primes and targets, but not with regard to interactions between congruency and affect, the inclusion of a disgusted face was not expected to compromise the interpretation of the results.

Procedure

The instructions given to participants and the manner of responding were identical to those of Experiment 5A.

Participants performed 12 practice trials followed by 96 experimental trials. Trial parameters were identical to those of the 700-ms prime-target SOA used in Experiments 5B-C. Each of four prime-target pair combinations (i.e., happy-happy, angry-angry, happy-angry, angry-happy) occurred 24 times. Prime-target pairs were presented in random order. The pairing of specific primes with specific targets was such that: (1) each face stimulus appeared eight times as a prime and target, respectively; (2) each prime and target of a given pair always shared the same facial identity.

Results and Discussion

Reaction time

On the basis of the screening procedure described in Experiment 1, 2.52% of RTs were excluded from subsequent analyses.

Figure 11 shows mean RT to happy and angry face targets as a function of congruency. The pattern of means suggests a pattern of positive priming, that is, mean RT is shorter on congruent than on incongruent trials. A 2 x 2 (congruency x target) repeated measures analysis of variance on RTs revealed a main effect of congruency, F (1, 17) = 4.67, MSE = 985.32, $p < .05$, confirming that mean RT was shorter on congruent than on incongruent trials (556 vs. 572 ms,

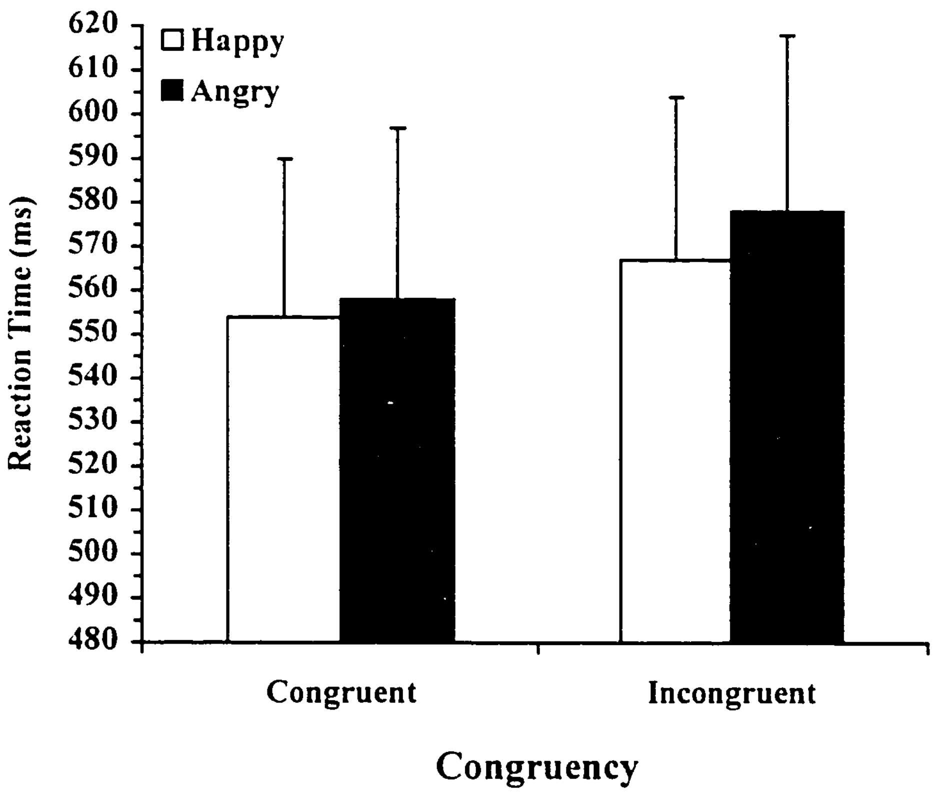


Figure 11. Mean reaction time to happy and angry face targets as a function of congruency in Experiment 6. Error bars represent standard errors of means.

respectively). No other effect or interaction was significant (all Fs < .50, ps > .50). The obtained pattern is consistent with the claim that sameness or difference in face identity across primes and targets is critical as to whether performance on a primed affect judgement task reveals a pattern in which responses are shorter on congruent than on incongruent trials (as in Experiment 6), or longer on congruent than on incongruent trials (as in Experiments 5A-C).

Error data

The pattern of errors is shown in Table 11. A 2 x 2 (congruency x target) analysis of variance on proportions of error did not reveal any significant effects or interactions (all Fs < 1.40, all ps > .25).

For a more detailed presentation of the data and analyses for Experiment 6, see Appendices II to KK.

Table 11. Mean proportion of error in responses to happy and angry face targets as a function of congruency in Experiment 6.

	Affect of Face	
Congruency	Happy	Angry
Congruent	.03	.04
Incongruent	.02	.04

Experiment 7

As noted in Chapter 1, schematic face stimuli have been used to evaluate threat-related hypotheses, with mixed results (e.g., Eastwood et al., 2000; Nothdurft, 1993). Indeed, given their artificial nature, it may be unreasonable to expect schematic faces to exert as strong an influence, affective or otherwise, as photographic faces. Nonetheless, the goal of Experiment 7 was to test the generalizability of the findings of Experiments 5-6 on a primed affect judgement task in which prime and target faces were schematic (rather than photographic) stimuli.

Participants performed the primed affect judgement task under one of two conditions. In a different-identity condition, the task involved faces whose identities always differed across any given prime-target pair, as in Experiments 5A-C. In a same-identity condition, the task involved faces whose identities were always the same across any given prime-target pair, as in Experiment 6. In the different identity-condition, a replication of the findings of Experiments 5A-C would be revealed in a pattern such that responses were longer on congruent than on incongruent trials, and longer to angry than to happy targets on congruent trials. In contrast, in the same-identity condition, a replication of the findings of Experiment 6 would be revealed in a pattern such that responses were shorter on congruent than on incongruent trials.

Method

Participants

Thirty-six undergraduate students at the University of Waterloo participated in the experiment. Equal numbers of participants were randomly assigned to the same- and different-identity conditions. Each participant had normal or corrected-to-normal vision, and was paid $4.00 upon completion of the 20-minute experimental session.

Apparatus and Stimuli

The apparatus and stimulus presentation software were the same as in Experiment 1. The stimuli were drawn from the schematic affective face set used in Experiment 4 (Figure 4, p. 42), and consisted of nine faces that expressed happiness and nine faces that expressed anger.

Procedure

Participants performed a primed affect judgement task, the instructions for which and manner of responding were identical to those described in Experiment 5A. Trial parameters were identical to those of the 700-ms prime-target SOA used in Experiments 5B-C. Participants performed 12 practice trials followed by 72 experimental trials.

In the different-identity condition, irrespective of the congruence or incongruence of their affect, primes and targets never shared the same mouth structure (narrow, moderate, or wide) or the same eye structure (round, laterally-oriented ovals, or vertically-oriented ovals). In contrast, in the same-identity condition, irrespective of the congruence of incongruence of their affect, primes and targets always shared the same identity. That is, primes and targets always shared the same mouth structure and the same eye structure.

In both the same- and different-identity conditions, each of four prime-target pair combinations (i.e., happy-happy, angry-angry, happy-angry, angry-happy) occurred 18 times (i.e., for a total of 72 experimental trials). Prime-target pairs were presented in random order. Each face stimulus appeared eight times as a prime and target, respectively.

Results and Discussion

Reaction time

On the basis of the screening procedure described in Experiment 1, 2.02% of RTs were excluded from subsequent analyses.

Figure 12 shows mean RT to happy and angry face targets as a function of congruency and identity condition. The pattern in the different-identity condition is similar to that observed in Experiments 5A-C. That is, mean RT is longer on congruent than on incongruent trials, and longer to angry than to happy targets on congruent trials. In contrast, the pattern in the same-identity condition is similar to that observed in Experiment 6, that is, mean RT is shorter on congruent than on incongruent trials. A 2 x 2 x 2 analysis of variance on RTs, with identity condition as a between-subjects factor and congruency and target as within-

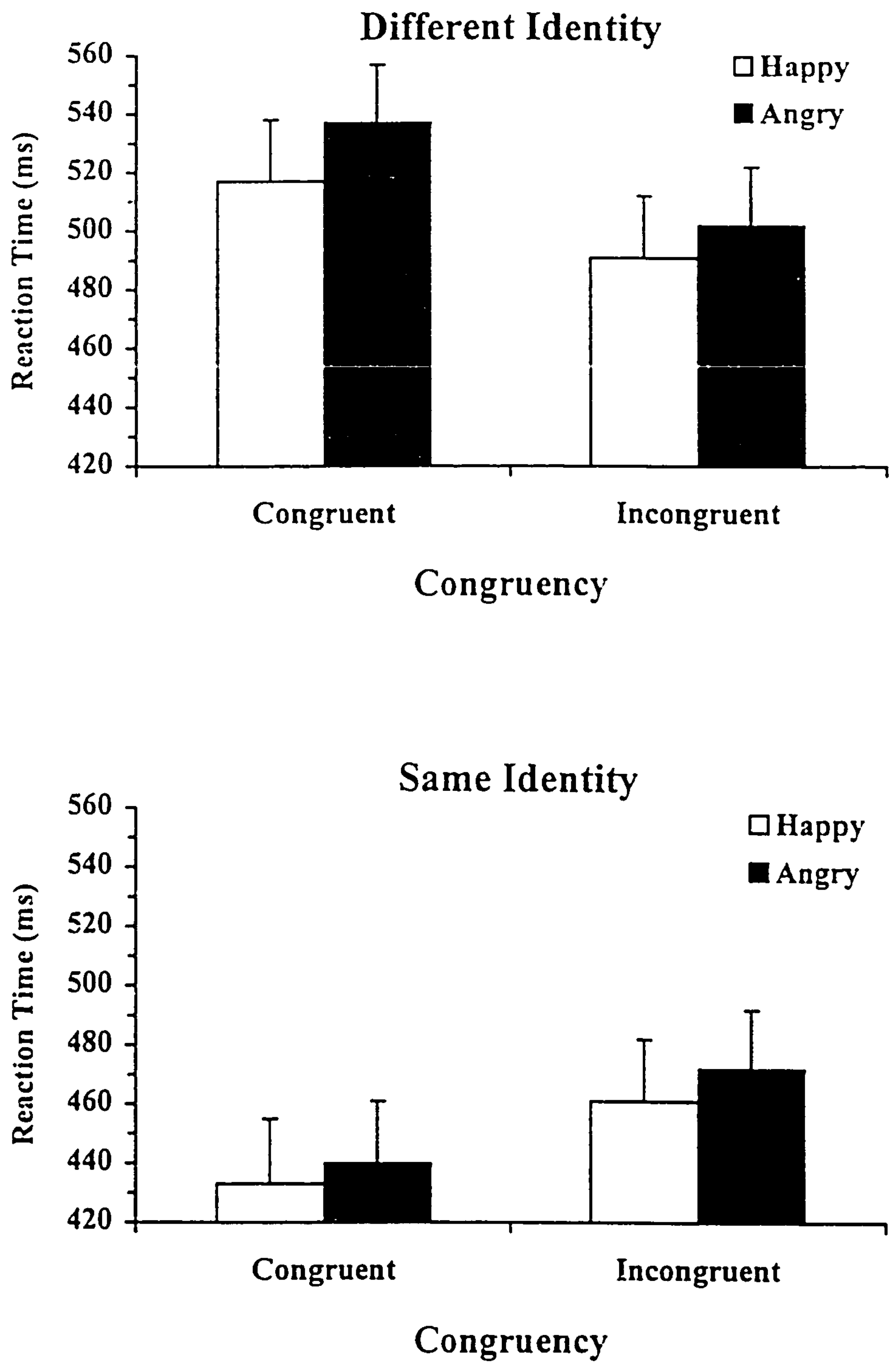


Figure 12. Mean reaction time to happy and angry face targets as a function of congruency and identity condition in Experiment 7. Error bars represent standard errors of means.

subjects factors, revealed a significant interaction between congruency and identity, $F (1, 34) = 19.33$, $MSE = 1728.32$, $p < .001$. Also, an effect of target indicated that mean RT was longer to angry than to happy faces (488 vs. 475 ms, respectively), $F (1, 34) = 5.93$, $MSE = 890.84$, $p < .025$; and an effect of identity indicated that mean RT was longer in the different- than in the same-identity condition (512 vs. 452 ms, respectively), $F (1, 34) = 4.57$, $MSE = 28458.58$, $p < .05$. No other effect or interaction was significant (all $Fs < .70$, $ps > .40$).

Further analysis to explicate the obtained interaction between congruency and identity confirmed that, in the different-identity condition, mean RT was longer on congruent than on incongruent trials (527 vs. 496 ms, respectively), $t (17) = 2.60$, $p < .025$. In contrast, further analysis confirmed an opposite pattern in the same-identity condition, that is, mean RT was shorter on congruent than on incongruent trials (437 vs. 467 ms, respectively), $t (17) = -4.20$, $p < .001$. As predicted, these findings suggest that sameness or difference in face identity across primes and targets is critical to whether performance on a primed affect judgement task reveals a pattern in which responses on congruent trials are shorter or longer, respectively, in comparison to responses on incongruent trials. This conclusion not only supports the same conclusion drawn on the basis of Experiments 5-6, but demonstrates the generalizability of this conclusion across a schematic face stimulus set.

Closer analysis of the present findings, however, failed to demonstrate support for the salient identity hypothesis. That is, although the overall pattern of RTs obtained in the different-identity condition (Figure 12) is similar to that observed in Experiments 5A-C, a 2 x 2 (congruency x target) repeated measures analysis of variance revealed only a main effect of congruency, $F(1, 17) = 6.76$, $MSE = 2535.42$, $p < .05$, an effect of target, $F(1, 17) = 5.43$, $MSE = 812.82$, $p < .05$, but not the expected interaction between congruency and target, $F(1, 17) = .73$, $MSE = 562.84$, $p > .40$.

It was previously demonstrated that a failure to detect a significant interaction between target and congruency in the individual analyses of Experiments 5A, 5B, and 5C, reflected limitations in the statistical power of each of these experiments. Power analysis performed on the present data, however, suggested that a sample size about five to six times larger than the present sample – or, about three times larger than the sample size used for the combined Experiments 5A-C – would be required before the very low level of power associated with the present interaction (namely, .15) would reach statistical significance. The present data do not allow for a clear account of this finding. As previously suggested, however, it is possible that, given their artificial nature, schematic facial stimuli may not exert as strong an affective influence as photographic facial stimuli.

Error data

As shown in Table 12, the pattern of error rates indicates that more errors were made in responses on congruent than on incongruent trials. A 2 x 2 x 2 analysis of variance on proportions of error, with identity condition as a between-subjects factor and congruency and target as within-subjects factors, revealed a main effect of congruency, F (1, 34) = 5.25, MSE < .01, p < .05, indicating a higher proportion of errors on congruent than on incongruent trials (.03 vs. .02, respectively). No other effect or interaction was significant (all Fs < .3.70, ps > .06).

The obtained pattern or errors cannot be interpreted to reflect a speed-accuracy trade-off in the different-identity condition, given that mean RT in this condition was longer on congruent than on incongruent trials. In the same-identity condition, however, the pattern of errors may suggest a speed-accuracy trade-off, given that mean RT in this condition was shorter on congruent than on incongruent trials. To evaluate this possibility, RT and error data in the same-identity condition were re-analyzed after excluding the data of five participants whose error rate on congruent trials was relatively high (i.e., 6% or greater). The re-analysis demonstrated that mean RT was still significantly shorter on congruent than on incongruent trials (440 vs. 469 ms, respectively), t (13) = -3.01, p < .05, although the mean proportion of error across these two conditions was not

Table 12. Mean proportion of error in responses to happy and angry face targets as a function of congruency and identity condition in Experiment 7.

	Congruent		Incongruent	
Identity	Happy	Angry	Happy	Angry
Different	.04	.03	.02	.02
Same	.02	.04	.02	.03

significantly different (.02 vs. .02, respectively), t (13) = .39, $p > .70$. A speed-accuracy tradeoff, therefore, is unlikely to underlie the RT pattern obtained in the same-identity condition.

For a more detailed presentation of the data and analyses for Experiment 7, see Appendices LL-NN.

General Discussion

The purpose of the experiments described in Chapter 2 was to make a preliminary evaluation of the salient identity hypothesis, namely, the claim that the identity of an angry face makes a more salient impression on an observer than the identity of a happy face. For this purpose, participants performed a primed affect judgement task, involving the speeded judgement of the affect of happy and angry face targets preceded by happy or angry face primes. Two findings may be summarized. First, responses to the judgement of target affect were longer when primes and targets had congruent (same) facial affect than when they had incongruent (different) facial affect. This pattern was predicted on the basis of the assumed influence of facial affect and facial identity on congruent and incongruent trials. On an incongruent trial, the fact that a prime and target differed both in terms of their facial affect and facial identity was expected to render prime and target unambiguously different. On a congruent trial, however, the fact that a prime and target had the same affect but different facial identities was assumed to introduce an element of ambiguity upon the appearance of a target, namely, the perception that a target was both the same as and different from a prime. This ambiguity was expected to prompt a delay in processing in order to resolve that, despite their apparent difference, a target did share the same affect as a preceding prime. The duration of this delay was predicted to be sufficient such that responses to targets would take longer on congruent than on incongruent trials.

A second and more important finding, predicted on the basis of the salient identity hypothesis, was that on congruent trials, responses would be longer to angry than to happy targets. Specifically, on congruent trials, the ambiguity engendered by the change in facial identity across prime and target was expected to be more pronounced on angry-angry than on happy-happy trials because, as proposed by the salient identity hypothesis, identity is more strongly encoded for angry than for happy faces. Thus, the resolution of the ambiguity inherent in congruent trials, and therefore responding, was expected to take longer for angry than for happy targets.

The Salience of Angry Face Identities

The claim that anger has a greater threat-related impact on observers relative to other categories of facial expression, such as happiness, is hardly new (e.g., Sackett, 1966; Öhman & Dimberg, 1978). What the present work suggests, however, is that the identity of an angry facial expression makes a more salient impression on an observer than the identity of a happy facial expression. Thus, the perception of an angry face entails not simply the perception of, say, glaring eyes and reared teeth, but the particularly strong encoding of these features in the context of a particular individual. Notably, this conclusion is consistent with hypotheses that emphasize the evolutionary utility of threat detection (e.g., Dimberg & Öhman, 1996; Hansen & Hansen, 1994; LeDoux, 1996). In particular, the relatively greater salience of angry face identities may be evolutionarily useful because the potential survival cost of failing to notice the identity of an individual bearing an angry face is arguably greater than of failing to notice the identity of an individual bearing a non-threatening (e.g., happy) face.

The present claim that the processing of angry faces includes an analysis of facial identity was foreshadowed in work by Dimberg (1986). As previously noted, Dimberg found that skin conductance responses (SCRs) elicited by an angry face conditioned to mild electric shock were not elicited when participants subsequently viewed a different (unconditioned) angry face, but were again elicited when the conditioned angry face was again presented. This finding is consistent with the salient identity hypothesis, insofar as it suggests that conditioning occurred not simply to an angry facial expression, but to an angry face belonging to a particular person.

Notably, however, a problem with Dimberg's study is that it did not include any means to control for affect display ambiguities that may influence the interpretation of affect in angry faces (see Chapter 1). For example, an alternative interpretation of Dimberg's finding is that the failure to elicit an SCR in the presence of the unconditioned angry face was a consequence not of a perceived difference in the identity of the face, but of a perceived difference in the affective expression of the face. Consistent with this concern, it is notable that, in a rating phase of Dimberg's study, in which participants rated the degree to which faces expressed different categories of affect, angry faces received not only high ratings of "angry", but also relatively high ratings of "afraid" (see Dimberg, 1986, Table 1). A more powerful test of the importance of angry facial identity using a conditioning paradigm would involve the use of conditioned and unconditioned angry faces that were different in terms of identity, but minimally different in terms of the interpretability of their facial affect or other factors associated with affect display ambiguity. As such, one of the strengths of the present work, relative to Dimberg's work, is that the importance of angry facial identity was demonstrated in a manner that minimized concerns regarding ambiguity.

Further evaluation of the salient identity hypothesis could usefully address several issues. First, in the present work, the source of the obtained salience differences between angry and happy face identities remains unclear. Although the hypothesized threat-relevance of the former is a theoretically appealing possibility (e.g., Dimberg & Öhman, 1996; Hansen & Hansen, 1994), other variables may also engender such salience differences in the present paradigm. For example, under real world conditions, the frequency of occurrence of angry faces is arguably lower than that of happy faces (Hansen & Hansen, 1994). Although such differences were not found to measurably influence the interpretability of the affect of the present facial stimuli (see Chapter 1), it is nonetheless possible that, as a consequence of their relative infrequency, angry face stimuli and their identities may have been more likely to stand out to participants. Further research, therefore, involving measures more sensitive to threat, would be useful in establishing whether threat perception or another variable underlies the relatively greater salience of angry face identities. A convergence of different methodologies, that control appropriately for potentially confounding differences in affect display ambiguity between happy and angry face stimuli (see Chapter 1), are a prerequisite for such a task.

Second, in the present work, a key prediction based on the salient identity hypothesis was supported in experiments involving photographic face stimuli but not in an experiment involving schematic face stimuli. As previously noted, this discrepancy may be interpreted to suggest that schematic face stimuli do not exert as strong an affective influence as photographic face stimuli. More broadly, however, the discrepancy underscores the fact that findings based on one face stimulus set may not generalize to another face stimulus set. For this reason, the practice – common to many investigations of facial affect – to generalize from findings based on a single face stimulus set (frequently Ekman, 1976) is of some concern. The use of multiple stimulus sets, therefore, may be useful to future investigations of the salient identity hypothesis and other facial affect hypotheses, in order to better inform the degree of generalizability of conclusions.

Third, in the present experiments, the influence of angry face identities was measured over temporal intervals of no more than one second. Arguably, however, the impact of salient events, in particular those associated with threat, would exceed such a short interval. In all likelihood, methodologies more sensitive to longer-term memory mechanisms may offer a more useful evaluation of the influence of angry faces over longer temporal intervals. The methodology used to demonstrate the "false fame" phenomenon, for instance, illustrates this possibility. The false fame phenomenon is based on the finding that participants exposed to non-famous names are more likely to judge these names as famous over longer versus shorter temporal intervals when these names are again presented along with previously unseen non-famous names (Jacoby, Kelley, Brown, & Jasechko, 1989). This finding has been interpreted in terms of the activity of unconscious memory influences that render non-famous names familiar upon their second viewing, simultaneous with a failure in the conscious recollection of the actual source of this familiarity over longer temporal intervals. This interplay of unconscious and conscious influences over time may inform an intriguing prediction based on the salient identity hypothesis. Namely, participants exposed to angry and happy faces may be more likely to perceive the former as familiar over a longer versus shorter delay when these faces are again presented, with neutral expressions, along with previously unseen faces with neutral expressions. This prediction is entirely plausible from the standpoint of any hypothesis that emphasizes an evolutionary basis for the threat-relevance of angry faces: The consequences of forgetting a source of threat, even when it is no longer expressing threat, are far greater than the consequences of forgetting a source of little or no threat.

Implications for Negative Priming

As previously indicated, positive priming is reflected in a pattern such that responses to targets tend to be shorter when primes and targets are perceptually or semantically related relative to when they are unrelated (e.g., Scarborough, Cortese, & Scarborough, 1977; Meyer & Schvaneveldt, 1971). This pattern is reflected in the findings of Experiment 6 and in the same-identity condition of Experiment 7. In contrast, the patterns obtained in Experiments 5A-C, and in the different identity-condition of Experiment 7, reflect a pattern of negative priming, insofar as responses to targets tended to be longer when primes and targets were related (congruent) relative to when they were unrelated (incongruent) (Fox, 1995; May, Kane, & Hasher, 1995). Does current research in negative priming, however, provide a theoretical framework that would predict such a pattern on the primed affect judgement task, and explain it in a manner consistent with the present account?

A temporal discrimination hypothesis of negative priming (Milliken, Joordens, Merikle, & Seiffert, 1998) offers one such framework[1]. This hypothesis suggests that on a task such as the primed affect judgement task, the judgement of the affect of a target is influenced by a comparison between the perceptual representation of the target and the memorial representation of a preceding prime.

This comparison, or "temporal discrimination", between target and prime is assumed to be influenced by the contributions of two processes. An orienting process detects aspects of a target that are "new", and is thus sensitive to differences between a current target and the memorial representation of a preceding prime. If some aspect of a target is detected as new or different, then further perceptual analysis of the target may occur. This further analysis is relatively resource-demanding, because it involves new learning. In contrast, a retrieval process detects aspects of a target that are "old", and is thus sensitive to similarities between a current target and the memorial representation of a preceding prime. This process operates in a relatively "automatic", non-deliberate manner, because it involves the reinstatement of already-learned information.

According to the temporal discrimination hypothesis (Milliken et al., 1998), the relative degree of influence of the orienting and retrieval processes in target responding will differ as a function of the quality of the match between a target and the memorial representation of a prime. For example, the influence of the retrieval process is high when the quality of the match is high – say, when prime and target are identical – because this process is sensitive to similarities between stimuli. In contrast, the influence of the orienting process is high when the quality of the match is low – say, when prime and target are dissimilar – because this process is sensitive to differences between stimuli. Finally, the influence of both processes is present when the quality of the match is intermediate – say, when prime and target are partly similar and partly dissimilar. Importantly, this latter case is critical to the occurrence of negative priming.

To illustrate with regard to the present work, consider the activity of the retrieval and orienting processes on the primed affect judgement task. On this task, it is assumed that each of these processes may register stimulus information based on two face dimensions – affect and identity – that are inherent in each face stimulus (Bruce & Young, 1986; Hasselmo et al., 1989; Sergent & Signoret, 1992; Tranel et al., 1988; Young et al., 1986). On an incongruent trial, a given prime-target pair differ in terms of their facial affect (i.e., happy-angry or angry-happy); also, they differ with regard to their facial identity. Thus, the orienting process, which is sensitive to aspects of a target that are "new", will detect that a target differs from a prime with regard to facial affect and facial identity. Such detection allows for a relatively clear discrimination of a target as new, and thus renders straightforward the judgement of target affect. Notably, the retrieval process, which is sensitive to aspects of the target that are "old", makes little contribution to responding on an incongruent trial, given that neither the facial affect nor facial identity of the target bears any similarity to a preceding prime. In sum, then, on an incongruent trial, the quality of the match between a target and the memorial representation of a prime is low, and thus the orienting process has a dominant influence in responding.

In contrast, on a congruent trial, the quality of the match between a target and the memorial representation of a preceding prime is only intermediate. Thus, both retrieval and orienting processes influence responding. Specifically, on a congruent trial, a given prime-target pair have the same facial affect (i.e., happy-happy or angry-angry) but differ with regard to their facial identity. Thus, the retrieval process, which is sensitive to aspects of a target that are "old", will detect that a target is similar to a prime in terms of facial affect. In contrast, the orienting process, which is sensitive to aspects of a target that are "new", will detect that a target is different from a prime in terms of facial identity. Therefore, on a congruent trial, the collective activity of the orienting process and retrieval process renders ambiguous the discrimination of a target as old or new relative to a preceding prime. As a consequence, the judgement of target affect is delayed until the old/new ambiguity is resolved through additional analysis of the target. Critically, the ambiguity inherent in congruent trials, and the analysis required to resolve this ambiguity, would be predicted to contribute to longer responses made to targets on congruent than on incongruent trials. Such a prediction, then, is identical to that made on the basis of the present account (see Introduction, Chapter 2).

The temporal discrimination hypothesis (Milliken et al., 1998), like the present account, also accommodates a critical prediction based on the salient identity hypothesis, namely, that responses on the primed affect judgement task will be longer to angry than to happy targets on congruent trials (i.e., on angry-angry trials). This prediction involves only a simple extension of the negative priming account of congruent trial performance described above. As indicated, on such a trial the retrieval process is assumed to detect that a target is similar to a preceding prime (i.e., with regard to facial affect), but the temporal discrimination of the target as old or new is rendered ambiguous because the orienting process detects that a target is different from a preceding prime (i.e., with regard to facial identity). It follows, then, that if angry face identities make a more salient impression on observers – that is, are more strongly encoded – then any differences detected in the identities of an angry prime and angry target by the orienting process should be more pronounced than any differences detected between a happy prime and happy target. Given that such differences are assumed to render ambiguous the discrimination of a target as old or new, the larger difference detected on an angry-angry trial relative to happy-happy trial would be predicted to engender greater ambiguity in the discrimination process, and therefore require more time to resolve.

Thus, both the temporal discrimination hypothesis (Milliken et al., 1998) and the present account make the same predictions on the basis of a similar logic. Namely, both accounts assign a central role to the processing of the facial affect and facial identity of primes and targets; both accounts explain negative priming on the primed affect judgement task as a consequence of a processing delay, unique to congruent trials, engendered by the perception that primes and targets are partly similar (i.e., with regard to affect) and partly dissimilar (i.e., with regard to identity); and both accounts support a key prediction based on the salient identity hypothesis with reference to the same mechanisms used to predict a negative priming pattern on the primed affect judgement task. Importantly, insofar as the temporal discrimination hypothesis provides a general framework for understanding negative priming and related phenomena, it situates the present account within a broader theoretical context.

It is noteworthy that the present account, and the account based on the temporal discrimination hypothesis (Milliken et al., 1998), both explain the present findings with reference to interference processes that result in slowed responding. This aspect of the two accounts is important in countering an alternative account of the findings that emphasizes facilitation processes that are more associated with expressions of happiness than with anger. To illustrate such an argument, consider the intuitive assumption that happy faces signal reward. If so, then on a primed affect judgement task, might the identity of happy faces be processed more quickly than the identity of angry faces, and therefore speed (facilitate) responding to happy versus angry faces on congruent trials (i.e., as demonstrated in the present data)? Although theoretically interesting, such a formulation is inconsistent with the logic of the present hypothesis and supporting evidence that, on congruent trials, a change in facial identity across primes and targets engendered ambiguity in the judgement of the affect of targets, and thus interfered with target responding. As such, on congruent trials, the associated finding that responding was slower to angry than to happy faces – because response interference was somewhat greater for the former than the latter – cannot be straightforwardly re-interpreted with regard to processes that facilitate responding to happy faces. Rather, given the present theoretical framework, the finding is most consistent with the claim that, on congruent trials, the change in the identity of happy faces across primes and targets was encoded less strongly, and therefore engendered less response interference, than the corresponding change involving angry faces. As such, any plausible alternative account of the present findings that assigns a unique role to happy rather than angry facial expressions requires not only reference to affective processes that are likely unique to happy faces (e.g., reward), but task-specific predictions that logically follow from the influence of such processes.

Extensions of Face Processing Research

The present work suggests links with, and extensions of, face processing research. Although the primed affect judgement task involves only the judgement to target affect, the present findings clearly suggest that targets are processed both in terms of facial affect and facial identity. This implication is intriguing, to the extent that each of these two facial dimensions arise from a common set of facial features. This implication, however, is consonant with research and theory on face perception, which suggest that separate processing systems govern the analysis of facial expression and facial identity (Bruce & Young, 1986; Hasselmo et al., 1989; Sergent & Signoret, 1992; Tranel et al., 1988; Young et al., 1986).

Thus, the present work may suggest useful ways to extend the exploration of clinical and developmental understandings of face perception. For example, it is possible that individuals with prosopagnosia would not show a pattern of negative priming on the present primed affect judgement task, given that such individuals may experience deficits in the identification of particular faces (i.e., identities) but retain relatively intact processing of other facial characteristics, including affective expression (e.g., Sergent & Signoret, 1992). Importantly, under the assumption that the operation of negative priming mechanisms may be influenced by facial dimensions other than expression and identity, the primed affect judgement task could be extended to include the variation of other dimensions – such as age, gender, gaze-direction, and so forth – that may be of relevance to clinical or developmental research.

Summary

The goal of the present work was to determine whether angry facial expressions may exert an influence that is consistent with their threat-relevance; but, critically, to do so in a manner that evaluated and controlled for the potentially confounding impact of differences in affect display ambiguity between expressions of anger and happiness. The findings suggest two major conclusions. First, differences in affect display ambiguity between angry and happy faces may significantly influence responding to these stimuli on timed or speeded tasks, as well as on other kinds of tasks typically used in facial affect research. Thus, in the absence of experimental control, such differences may compromise the interpretation of the mechanisms underlying the influence of these faces on experimental tasks. For example, without such control, it may be difficult to determine whether different response patterns to angry versus happy faces reflect the influence of ambiguity or another variable, such as threat perception.

Second, in a manner consistent with their threat-relevance, angry facial identities were found to make a more salient impression on observers than happy facial identities. That is, the impact of angry faces reflected not simply the influence of their affective expression, but the influence this expression in the context of a particular individual. Significantly, in the present work, this finding was based on affective face stimuli for which potential differences in the affect display ambiguity between happy and angry faces were minimized.

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Endnotes

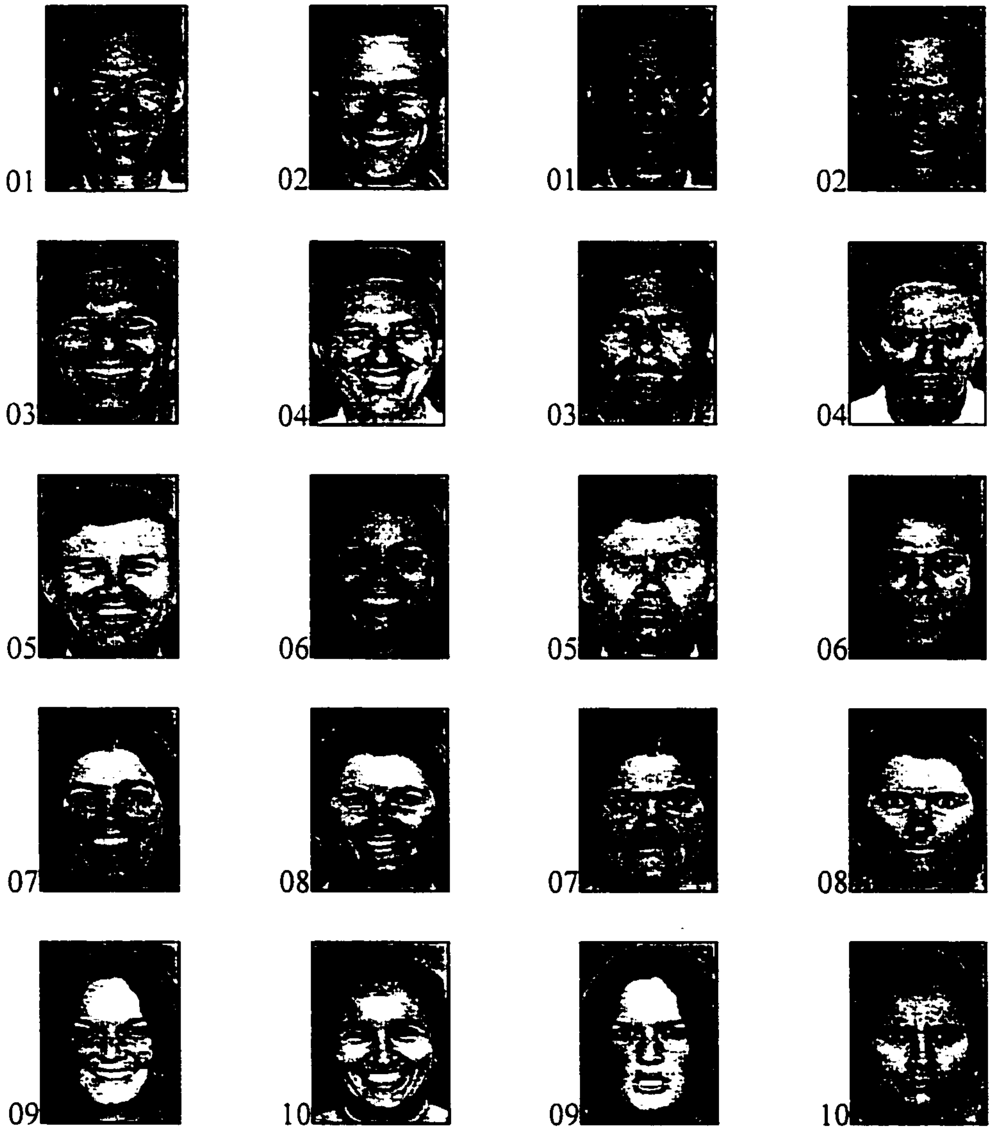
[1] The temporal discrimination hypothesis (Milliken et al., 1998) is only one of several competing accounts of negative priming (for reviews, see Fox, 1995; and May et al., 1995). One its advantages, however, is that it is based on and to some extent subsumes mechanisms described by two other prominent accounts, namely, the inhibition hypothesis (Houghton & Tipper, 1994; Tipper and Cranston, 1985) and the episodic retrieval hypothesis (Neill & Valdes, 1992; Neill, Valdes, Terry, & Gorfein, 1992).

Appendices

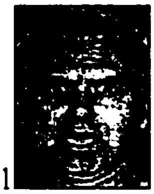
Appendix A

Experiments 1 and 2: Affective Face Stimuli

Happy	Angry



Appendix A (continued)

Happy		Angry
11 	12 	11 
13 	14 	
15 	16 	

Note. Happy and angry stimuli 01-10, respectively, used in Experiment 1; all stimuli used in Experiment 2.

Appendix B

Experiment 1: Mean Reaction Time (RT) (ms) and Proportions of Error (Err) to Happy and Angry Faces as a Function of Judgement, Across Participants (P)

	Gender				Affect			
	Happy		Angry		Happy		Angry	
P	RT	Err	RT	Err	RT	Err	RT	Err
01	534	.02	541	.06	548	.02	623	.00
02	439	.02	437	.10	605	.04	621	.02
03	614	.00	611	.00	541	.06	586	.04
04	404	.00	408	.06	512	.00	567	.08
05	407	.02	425	.08	491	.02	481	.04
06	397	.04	401	.04	623	.02	689	.02
07	489	.00	492	.12	431	.00	445	.00
08	451	.00	444	.00	580	.06	585	.04
09	444	.04	465	.02	501	.00	511	.02
10	457	.00	463	.02	495	.06	529	.02

Appendix B (continued)

	Gender				Affect			
	Happy		Angry		Happy		Angry	
P	RT	Err	RT	Err	RT	Err	RT	Err
11	505	.00	508	.06	552	.00	751	.06
12	442	.00	410	.02	459	.04	491	.02
13	500	.02	529	.00	551	.02	604	.06
14	659	.02	634	.00	519	.04	521	.00
15	535	.00	560	.00	557	.02	658	.00
16	845	.00	915	.00	451	.06	389	.02
17	587	.00	570	.10	546	.02	600	.02
18	456	.04	485	.00	527	.00	579	.08

Appendix C

Experiment 1: ANOVA on Reaction Times

Source	SS	df	MS	F	p
Judgement (J)	21738.45	1	21738.45	1.21	.28
Ps x J	609538.90	34	17927.62		
Affect (A)	10505.66	1	10505.66	12.19	<.01
A x J	5132.14	1	5132.14	5.95	.02
Ps x A x J	29306.51	34	861.96		

Appendix D

Experiment 1: ANOVA on Proportions of Error

Source	SS	df	MS	F	p
Judgement (J)	<.00	1	<.00	.30	.59
Ps x J	.02	34	<.00		
Affect (A)	<.00	1	<.00	4.20	.05
A x J	<.00	1	<.00	2.48	.12
Ps x A x J	.030	34	<.00		

Appendix E

Experiment 1: Mean (SD) Reaction Time (ms) to Happy and Angry Faces on Affect Judgement Task

Face #	Happy		Angry	
01	518	(77)	547	(69)
02	533	(71)	575	(118)
03	523	(71)	537	(89)
04	546	(74)	581	(110)
05	534	(70)	573	(114)
06	511	(71)	574	(92)
07	523	(66)	576	(116)
08	527	(70)	594	(128)
09	540	(89)	590	(107)
10	514	(64)	538	(95)

Note. See Appendix A for faces to which Face #'s correspond.

Appendix F

Experiment 2: Mean (SD) Difficulty of Interpretation (DOI) Rating to

Happy and Angry Faces, Across Participants (P)

	DOI			
P	Happy		Angry	
01	1.00	(.00)	2.00	(1.60)
02	1.11	(.33)	2.33	(1.73)
03	1.00	(.00)	1.50	(0.93)
04	1.40	(.52)	2.33	(1.12)
05	2.10	(.88)	2.90	(1.20)
06	1.00	(.00)	2.20	(2.10)
07	1.50	(.97)	4.20	(2.35)
08	1.75	(1.39)	2.57	(1.62)
09	1.30	(.95)	2.43	(.79)
10	1.20	(.42)	1.30	(.67)
11	1.10	(.32)	1.33	(.50)
12	1.00	(.00)	2.00	(.76)

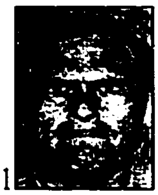
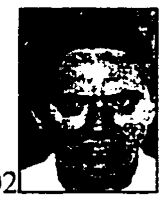
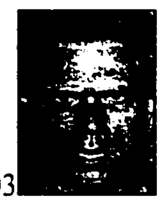
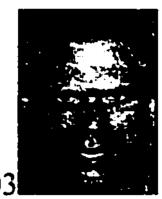
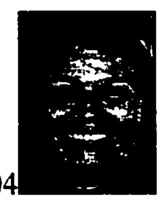
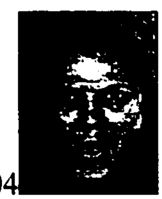
Appendix F (continued)

P	DOI			
	Happy		Angry	
13	1.20	(.42)	2.56	(1.94)
14	1.10	(.32)	2.33	(2.00)
15	1.20	(.63)	1.89	(1.05)
16	1.00	(.00)	1.00	(.00)
17	1.00	(.00)	3.10	(2.02)
18	1.50	(.97)	3.67	(2.07)

Note. Data excludes participant ratings for happy or angry faces categorized as other than happy or angry, respectively.

Appendix G

Experiment 3: Affective Faces as a Function of Stimulus Set

Matched		Mismatched	
Happy	Angry	Happy	Angry
01 	01 	01 	01 
02 	02 	02 	02 
03 	03 	03 	03 
04 	04 	04 	04 

Appendix G (continued)

Matched		Mismatched	
Happy	Angry	Happy	Angry
05 	05 	05 	05 

Appendix H

Experiment 3: Mean (SD) Difficulty of Interpretation (DOI) Rating to Affective Faces as a Function of Stimulus Condition, Across Participants (P)

	Matched				Mismatched			
P	Happy		Angry		Happy		Angry	
01	2.40	(.89)	1.40	(.55)	1.40	(.89)	1.80	(.45)
02	3.60	(1.82)	2.80	(2.05)	1.80	(.84)	3.60	(2.41)
03	2.60	(1.52)	2.20	(1.10)	1.00	(.00)	2.40	(.89)
04	3.00	(1.22)	2.60	(1.34)	1.20	(.45)	3.00	(1.58)
05	1.60	(.89)	3.40	(1.67)	1.00	(.00)	3.00	(1.58)
06	2.20	(1.10)	1.00	(.00)	1.60	(.55)	1.40	(.55)
07	2.00	(1.41)	5.00	(1.00)	1.00	(.00)	5.00	(.71)
08	2.40	(1.14)	3.00	(1.73)	1.00	(.00)	2.60	(.89)
09	4.00	(1.41)	2.00	(.71)	1.60	(.55)	3.40	(2.07)
10	1.60	(.55)	1.40	(.89)	1.00	(.00)	1.00	(.00)
11	3.60	(1.82)	2.00	(.71)	1.00	(.00)	2.40	(1.14)
12	2.20	(1.10)	2.80	(1.79)	1.00	(.00)	2.80	(1.79)

Appendix H (continued)

	Matched				Mismatched			
P	Happy		Angry		Happy		Angry	
13	4.40	(1.52)	2.40	(.89)	1.20	(.45)	2.40	(1.34)
14	3.40	(1.34)	3.00	(1.22)	1.80	(1.10)	3.40	(1.52)
15	3.80	(2.28)	3.40	(2.30)	1.00	(.00)	3.00	(1.58)
16	2.60	(2.61)	2.80	(1.30)	1.40	(.89)	3.60	(1.82)
17	3.60	(1.82)	2.80	(1.64)	1.40	(.55)	4.00	(1.87)
18	2.00	(1.00)	1.80	(1.30)	1.00	(.00)	1.40	(.55)

Appendix I

Experiment 3: ANOVA on Difficulty of Interpretation (DOI) Ratings

Source	SS	df	MS	F	p
Affect (A)	7.09	1	7.09	7.34	.02
Ps x A	16.44	17	.97		
Stimulus Condition (SC)	8.13	1	8.13	48.76	<.01
Ps x SC	2.84	17	.17		
A x SC	15.13	1	15.13	50.97	<.01
Ps x A x SC	5.05	17	.30		

Appendix J

Experiment 3: Mean Reaction Time (RT) (ms) and Proportion of Error (Err) to Affective Faces as a Function of Stimulus Condition, Across Participants (P)

	Matched				Mismatched			
	Happy		Angry		Happy		Angry	
P	RT	Err	RT	Err	RT	Err	RT	Err
01	511	.07	529	.20	590	.07	616	.20
02	510	.00	529	.00	598	.07	597	.07
03	538	.00	565	.00	701	.00	768	.00
04	741	.00	665	.00	581	.00	568	.00
05	660	.00	681	.13	534	.07	610	.00
06	653	.00	643	.13	658	.00	815	.13
07	842	.07	789	.00	549	.00	1028	.00
08	549	.13	521	.07	545	.00	500	.00
09	642	.00	694	.00	576	.00	705	.13
10	632	.20	709	.00	659	.07	724	.00

Appendix J (continued)

	Matched				Mismatched			
	Happy		Angry		Happy		Angry	
P	RT	Err	RT	Err	RT	Err	RT	Err
11	734	.00	762	.00	620	.07	641	.07
12	587	.00	556	.07	424	.00	548	.00
13	655	.00	533	.07	484	.07	595	.00
14	800	.00	773	.00	740	.07	706	.00
15	660	.00	680	.00	570	.00	592	.07
16	590	.00	555	.07	453	.07	593	.07
17	603	.07	641	.13	498	.00	606	.00
18	582	.07	540	.00	476	.00	484	.07

Appendix K

Experiment 3: ANOVA on Reaction Times

Source	SS	df	MS	F	p
Affect (A)	24003.87	1	24003.87	6.68	.02
Ps x A	61048.58	17	3591.09		
Stimulus Condition (SC)	11321.61	1	11321.61	1.59	.23
Ps x SC	121427.45	17	7142.79		
A x SC	34063.11	1	34063.11	7.56	.01
Ps x A x SC	76576.68	17	4504.51		

Appendix L

Experiment 3: ANOVA on Proportions of Error

Source	SS	df	MS	F	p
Affect (A)	<.00	1	<.00	1.07	.32
Ps x A	.06	17	<.00		
Stimulus Condition (SC)	<.00	1	<.00	.10	.76
Ps x SC	.04	17	<.00		
A x SC	<.00	1	<.00	.00	1.00
Ps x A x SC	.04	17	<.00		

Appendix M

Experiment 3: Mean (SD) Reaction Times (ms) to Affective Faces as a Function of Stimulus Condition

Face #	Affect of Face			
Matched	Happy		Angry	
01	686	(141)	617	(121)
02	595	(82)	637	(127)
03	694	(169)	618	(101)
04	586	(99)	641	(128)
05	628	(98)	652	(116)
Mismatched				
01	574	(127)	620	(146)
02	579	(147)	667	(159)
03	577	(77)	591	(119)
04	570	(111)	701	(241)
05	548	(80)	665	(122)

Note. See Appendix G for faces to which Face #'s correspond.

Appendix N

Experiment 4: Mean (SD) Difficulty of Interpretation (DOI) Rating to Happy and Angry Faces as a Function of Mouth Structure, Across Participants (P)

	Happy						Angry					
P	Narrow		Moderate		Wide		Narrow		Moderate		Wide	
01	1.33	(.58)	1.33	(.58)	1.00	(.00)	2.67	(2.08)	1.67	(.58)	1.33	(.58)
02	2.00	(.00)	2.00	(.00)	3.33	(.58)	1.33	(.58)	1.00	(.00)	2.33	(.58)
03	2.00	(.00)	2.00	(.00)	3.00	(.00)	1.33	(.58)	1.33	(.58)	3.00	(.00)
04	1.00	(.00)	1.00	(.00)	2.00	(.00)	1.00	(.00)	1.00	(.00)	1.00	(.00)
05	1.33	(.58)	1.33	(.58)	2.00	(.00)	1.33	(.58)	1.00	(.00)	2.33	(1.15)
06	2.67	(1.15)	2.67	(1.15)	3.33	(1.53)	2.67	(.58)	3.00	(.00)	3.33	(1.15)
07	3.00	(1.00)	3.00	(1.00)	2.00	(1.00)	4.67	(1.53)	1.33	(.58)	5.00	(.00)

Appendix N (continued)

	Happy						Angry					
P	Narrow		Moderate		Wide		Narrow		Moderate		Wide	
08	2.00	(.00)	2.33	(.58)	4.00	(1.00)	2.67	(1.15)	2.67	(1.53)	3.33	(.58)
09	1.67	(.58)	1.33	(.58)	3.67	(1.15)	1.00	(.00)	1.33	(.58)	2.67	(.58)
10	1.00	(.00)	1.00	(.00)	1.00	(.00)	1.00	(.00)	1.00	(.00)	1.00	(.00)
11	1.67	(.58)	1.33	(.58)	4.00	(1.00)	1.33	(.58)	2.33	(.58)	4.67	(1.53)
12	2.67	(.58)	2.67	(1.15)	3.67	(1.53)	1.00	(.00)	1.67	(.58)	2.00	(1.00)
13	3.67	(2.89)	4.67	(1.53)	5.00	(1.00)	2.67	(1.15)	1.67	(1.15)	3.00	(1.00)
14	2.67	(.58)	1.67	(1.15)	4.00	(1.73)	4.00	(2.00)	3.33	(2.31)	4.00	(1.00)
15	3.00	(1.73)	1.33	(.58)	2.67	(1.53)	1.33	(.58)	1.33	(.58)	3.33	(2.08)
16	3.00	(2.65)	1.33	(.58)	3.00	(1.00)	2.33	(.58)	1.33	(.58)	4.00	(1.00)

Appendix N (continued)

	Happy						Angry					
P	Narrow		Moderate		Wide		Narrow		Moderate		Wide	
17	1.33	(.58)	2.33	(.58)	3.33	(.58)	1.33	(.58)	1.67	(.58)	2.67	(.58)
18	2.67	(.58)	4.00	(2.00)	5.67	(1.15)	3.33	(3.21)	2.33	(2.31)	4.67	(1.53)

Appendix O

Experiment 4: Mean (SD) Difficulty of Interpretation (DOI) Rating to Happy and Angry Faces as a Function of Eye Structure, Across Participants (P)

	Happy						Angry					
P	Round		Lateral Ovals		Vertical Ovals		Round		Lateral Ovals		Vertical Ovals	
01	2.67	(2.89)	1.00	(.00)	1.33	(.58)	1.67	(.58)	2.67	(2.08)	1.33	(.58)
02	2.33	(1.53)	2.00	(1.00)	2.00	(1.00)	1.67	(.58)	1.67	(1.15)	1.33	(.58)
03	2.00	(1.00)	2.33	(.58)	2.00	(1.00)	1.67	(1.15)	2.00	(1.00)	2.00	(1.00)
04	1.33	(.58)	1.33	(.58)	1.33	(.58)	1.00	(.00)	1.00	(.00)	1.00	(.00)
05	1.33	(.58)	2.00	(.00)	1.33	(.58)	1.67	(1.15)	2.00	(1.00)	1.00	(.00)
06	3.33	(.58)	3.67	(1.53)	2.00	(.00)	2.67	(.58)	3.00	(1.00)	3.33	(.58)
07	2.33	(.58)	3.00	(.00)	2.00	(1.73)	4.00	(2.65)	3.00	(2.00)	4.00	(1.73)

Appendix O (continued)

	Happy						Angry					
P	Round		Lateral Ovals		Vertical Ovals		Round		Lateral Ovals		Vertical Ovals	
08	3.00	(1.73)	2.67	(.58)	2.67	(1.15)	3.33	(.58)	3.33	(1.15)	2.00	(1.00)
09	1.67	(1.15)	3.00	(1.73)	2.00	(1.00)	1.67	(1.15)	1.67	(.58)	1.67	(1.15)
10	1.00	(.00)	1.00	(.00)	1.00	(.00)	1.00	(.00)	1.00	(.00)	1.00	(.00)
11	2.33	(1.53)	3.00	(1.73)	1.67	(1.15)	2.00	(1.00)	3.33	(2.31)	3.00	(2.00)
12	3.00	(1.00)	4.00	(1.00)	2.00	(.00)	2.00	(1.00)	1.33	(.58)	1.33	(.58)
13	4.00	(1.73)	6.33	(.58)	3.00	(1.00)	2.33	(1.53)	1.67	(.58)	3.33	(.58)
14	3.00	(2.00)	3.67	(1.15)	1.67	(.58)	5.67	(.58)	2.33	(.58)	3.33	(1.15)
15	2.33	(1.53)	2.67	(1.53)	2.00	(1.73)	1.33	(.58)	2.67	(2.08)	2.00	(1.73)
16	2.33	(.58)	3.67	(2.52)	1.33	(.58)	2.33	(.58)	2.67	(1.53)	2.67	(2.08)

Appendix O (continued)

	Happy						Angry					
P	Round		Lateral Ovals		Vertical Ovals		Round		Lateral Ovals		Vertical Ovals	
17	2.33	(.58)	2.00	(1.00)	2.67	(1.53)	1.67	(.58)	2.33	(.58)	1.67	(1.15)
18	3.67	(1.53)	3.33	(1.53)	5.33	(2.08)	2.33	(2.31)	4.33	(2.08)	3.67	(3.06)

Appendix P

Experiment 4: ANOVA on Difficulty of Interpretation (DOI) Ratings

Source	SS	df	MS	F	p
Affect (A)	2.97	1	2.97	1.15	.30
Ps x A	43.76	17	2.57		
Mouth (M)	84.91	2	42.46	22.72	<.01
Ps x M	63.53	34	1.87		
Eyes (E)	10.07	2	5.13	5.16	.01
Ps x E	33.85	34	1.00		
A x M	1.21	2	.61	.48	.62
Ps x A x M	42.57	34	1.25		
A x E	5.08	2	2.54	1.40	.26
Ps x A x E	61.70	34	1.82		
M x E	.94	4	.24	.30	.88
Ps x M x E	53.95	68	.79		
A x M x E	6.94	4	1.74	1.53	.20
Ps x A x M x E	77.28	68	1.14		

Appendix Q

Experiment 4: Mean Reaction Time (RT) (ms) and Proportion of Error (Err) to Happy and Angry Faces as a Function of Mouth Structure, Across Participants (P)

	Happy						Angry					
	Narrow		Moderate		Wide		Narrow		Moderate		Wide	
P	RT	Err	RT	Err	RT	Err	RT	Err	RT	Err	RT	Err
01	604	.08	558	.08	587	.08	557	.00	589	.08	557	.08
02	468	.08	433	.08	455	.08	438	.00	434	.00	461	.00
03	337	.25	335	.00	377	.00	347	.00	376	.08	360	.08
04	372	.17	367	.00	384	.50	395	.17	461	.00	450	.00
05	504	.17	437	.00	438	.08	383	.00	381	.17	383	.17
06	538	.08	467	.00	538	.00	571	.17	584	.00	576	.00

Appendix Q (continued)

	Happy						Angry					
	Narrow		Moderate		Wide		Narrow		Moderate		Wide	
P	RT	Err	RT	Err	RT	Err	RT	Err	RT	Err	RT	Err
07	420	.08	424	.08	406	.08	445	.25	476	.08	460	.08
08	615	.33	543	.00	527	.00	577	.25	574	.08	575	.00
09	364	.00	412	.00	428	.00	423	.08	410	.08	411	.17
10	466	.00	416	.08	493	.08	411	.00	439	.00	460	.08
11	356	.00	383	.00	364	.00	402	.08	419	.00	401	.00
12	482	.08	456	.08	421	.00	397	.00	417	.08	438	.08
13	527	.00	619	.00	691	.00	577	.00	553	.00	625	.00
14	535	.08	586	.00	576	.08	579	.00	513	.00	594	.00

Appendix Q (continued)

	Happy						Angry					
	Narrow		Moderate		Wide		Narrow		Moderate		Wide	
P	RT	Err	RT	Err	RT	Err	RT	Err	RT	Err	RT	Err
15	427	.17	422	.00	421	.00	403	.08	401	.17	466	.08
16	530	.00	449	.00	487	.17	478	.08	485	.00	456	.00
17	436	.08	444	.00	430	.00	478	.08	448	.08	479	.08
18	434	.17	417	.00	447	.08	453	.00	448	.08	476	.08

Appendix R

Experiment 4: Mean Reaction Time (RT) (ms) and Proportion of Error (Err) to Happy and Angry Faces as a Function of Eye Structure, Across Participants (P)

	Happy						Angry					
	Round		Lateral Ovals		Vertical Ovals		Round		Lateral Ovals		Vertical Ovals	
P	RT	Err	RT	Err	RT	Err	RT	Err	RT	Err	RT	Err
01	540	.17	632	.00	569	.08	580	.00	527	.08	594	.08
02	441	.08	457	.08	460	.08	433	.00	440	.00	461	.00
03	336	.08	369	.17	349	.00	376	.08	378	.00	326	.08
04	355	.17	395	.25	369	.25	464	.17	446	.00	408	.00
05	474	.00	443	.00	456	.25	375	.17	373	.08	398	.08
06	482	.00	572	.00	485	.08	603	.17	569	.00	564	.00

Appendix R (continued)

	Happy						Angry					
	Round		Lateral Ovals		Vertical Ovals		Round		Lateral Ovals		Vertical Ovals	
P	RT	Err	RT	Err	RT	Err	RT	Err	RT	Err	RT	Err
07	434	.08	413	.17	403	.00	462	.08	499	.25	430	.08
08	575	.17	570	.08	521	.08	545	.17	585	.17	592	.00
09	413	.00	388	.00	403	.00	430	.17	402	.08	413	.08
10	442	.00	456	.17	477	.00	397	.08	435	.00	473	.00
11	355	.00	374	.00	374	.00	421	.00	394	.00	407	.08
12	443	.00	462	.17	453	.00	429	.00	409	.08	411	.08
13	625	.00	589	.00	623	.00	520	.00	616	.00	619	.00
14	533	.00	592	.17	577	.00	524	.00	542	.00	619	.00

Appendix R (continued)

	Happy						Angry					
	Round		Lateral Ovals		Vertical Ovals		Round		Lateral Ovals		Vertical Ovals	
P	RT	Err	RT	Err	RT	Err	RT	Err	RT	Err	RT	Err
15	412	.08	443	.00	413	.08	442	.08	425	.00	401	.25
16	490	.00	489	.17	488	.00	459	.00	486	.00	473	.08
17	453	.00	412	.08	443	.00	461	.17	473	.08	470	.00
18	403	.08	438	.08	455	.08	466	.08	443	.00	470	.08

Appendix S

Experiment 4: ANOVA on Reaction Times

Source	SS	df	MS	F	p
Affect (A)	2284.04	1	2284.04	.38	.55
Ps x A	101693.43	17	5981.97		
Mouth (M)	13557.97	1.63*	8303.87	3.35	.06
Ps x M	68788.11	34	2023.18		
Eyes (E)	6462.90	2	3231.45	.90	.17
Ps x E	57890.56	34	1702.66		
A x M	4505.85	2	2252.92	.92	.41
Ps x A x M	83714.26	34	2462.18		
A x E	3369.93	2	1684.97	.68	.51
Ps x A x E	83848.53	34	2466.13		
M x E	4472.69	4	1118.17	.45	.78
Ps x M x E	170519.05	68	2507.63		
A x M x E	13505.87	2.97*	4542.03	2.29	.09
Ps x A x M x E	100275.48	68	1983.69		

* adjusted df based on Huynh-Feldt Epsilon for violation of sphericity.

Appendix T

Experiment 4: ANOVA on Proportions of Error

Source	SS	df	MS	F	p
Affect (A)	<.00	1	<.00	.10	.76
Ps x A	.29	17	.02		
Mouth (M)	.12	2	.06	3.21	.05
Ps x M	.61	34	.02		
Eyes (E)	<.00	2	<.00	.29	.75
Ps x E	.47	34	.01		
A x M	.06	2	.03	1.56	.22
Ps x A x M	.66	34	.02		
A x E	.07	2	.03	2.32	.11
Ps x A x E	.48	34	.01		
M x E	.10	4	.03	1.48	.22
Ps x M x E	1.31	68	.02		
A x M x E	.09	4	.02	1.60	.18
Ps x A x M x E	.95	68	.01		

Appendix U

Experiment 5A: Mean Reaction Time (RT) (ms) to Target Faces as a Function of Congruency and Prime-Target SOA, Across Participants (P)

	200-ms SOA				1200-ms SOA			
	Congruent		Incongruent		Congruent		Incongruent	
P	Happy	Angry	Happy	Angry	Happy	Angry	Happy	Angry
01	578	530	628	529	562	531	501	544
02	728	773	702	655	690	714	693	705
03	457	501	528	506	542	508	472	483
04	525	541	523	554	476	446	510	450
05	600	559	640	594	477	492	467	496
06	898	1039	901	962	789	889	753	761
07	614	761	617	642	692	629	669	683
08	757	591	589	579	808	702	693	674
09	629	607	608	612	625	643	574	644
10	606	616	664	612	607	618	497	564

Appendix U (continued)

	200-ms SOA				1200-ms SOA			
	Congruent		Incongruent		Congruent		Incongruent	
P	Happy	Angry	Happy	Angry	Happy	Angry	Happy	Angry
11	574	563	591	532	516	519	479	508
12	574	609	603	613	545	503	534	527
13	623	609	689	592	458	488	534	457
14	470	503	490	484	442	479	431	443
15	597	475	617	535	531	480	518	506
16	588	713	557	611	681	725	615	597
17	779	681	650	731	692	754	633	688
18	523	580	514	545	488	610	444	542

Appendix V

Experiment 5A: ANOVA on Reaction Times

Source	SS	df	MS	F	p
SOA (S)	52964.91	1	52964.91	7.28	.02
Ps x S	123698.58	17	7276.39		
Congruency (C)	14701.89	1	14701.89	6.63	.02
Ps x C	37708.40	17	2218.14		
Target (T)	404.28	1	404.28	.12	.74
Ps x T	59097.75	17	3476.34		
S x C	3056.71	1	3056.71	2.80	.11
Ps x S x C	18574.70	17	1092.63		
S x T	1628.95	1	1628.95	.96	.34
Ps x S x T	28731.71	17	1690.10		
C x T	223.60	1	223.60	.15	.70
Ps x C x T	25225.55	17	1483.86		
S x C x T	1595.54	1	1595.74	1.85	.19
Ps x S x C x T	14658.65	17	862.27		

Appendix V (continued)

Experiment 5A 200-ms Prime-Target SOA: ANOVA on Reaction Times

Source	SS	df	MS	F	p
Congruency (C)	2175.61	1	2175.61	1.19	.29
Ps x C	31039.34	17	1825.84		
Target (T)	205.10	1	205.10	.06	.81
Ps x T	57118.95	17	3359.94		
C x T	1506.87	1	1506.87	.99	.34
Ps x C x T	26006.19	17	1529.78		

Appendix V (continued)

Experiment 5A 1200-ms Prime-Target SOA: ANOVA on Reaction Times

Source	SS	df	MS	F	p
Congruency (C)	15582.98	1	15582.98	10.49	<.01
Ps x C	25243.76	17	1484.93		
Target (T)	1828.14	1	1828.14	1.01	.33
Ps x T	30710.50	17	1806.50		
C x T	312.28	1	312.28	.38	.54
Ps x C x T	13878.01	17	816.35		

Appendix W

Experiment 5A: Mean Proportion of Error to Target Faces as a Function of Congruency and Prime-Target SOA, Across Participants (P)

	200-ms SOA				1200-ms SOA			
	Congruent		Incongruent		Congruent		Incongruent	
P	Happy	Angry	Happy	Angry	Happy	Angry	Happy	Angry
01	.00	.00	.00	.10	.10	.00	.00	.05
02	.00	.00	.05	.00	.00	.00	.00	.05
03	.25	.15	.05	.05	.05	.10	.05	.00
04	.00	.05	.10	.15	.05	.15	.10	.10
05	.05	.10	.05	.10	.00	.05	.05	.00
06	.00	.15	.00	.10	.05	.15	.00	.05
07	.00	.00	.05	.05	.05	.05	.05	.10
08	.05	.00	.05	.00	.00	.00	.00	.00
09	.15	.05	.00	.05	.05	.05	.05	.00
10	.05	.05	.00	.05	.05	.00	.05	.05

Appendix W (continued)

	200-ms SOA				1200-ms SOA			
	Congruent		Incongruent		Congruent		Incongruent	
P	Happy	Angry	Happy	Angry	Happy	Angry	Happy	Angry
11	.00	.00	.10	.00	.05	.00	.05	.00
12	.00	.15	.05	.00	.00	.00	.00	.10
13	.15	.00	.10	.10	.15	.05	.10	.10
14	.00	.00	.05	.05	.00	.05	.05	.00
15	.00	.05	.00	.05	.05	.10	.00	.05
16	.00	.05	.00	.05	.05	.15	.05	.05
17	.00	.05	.10	.00	.00	.00	.00	.10
18	.05	.05	.00	.00	.05	.00	.00	.00

Appendix X

Experiment 5A: ANOVA on Proportions of Error

Source	SS	df	MS	F	p
SOA (S)	<.00	1	<.00	.24	.63
Ps x S	.03	17	<.00		
Congruency (C)	<.00	1	<.00	.15	.71
Ps x C	.05	17	<.00		
Target (T)	<.00	1	<.00	.89	.36
Ps x T	.06	17	<.00		
S x C	<.00	1	<.00	.27	.61
Ps x S x C	.03	17	<.00		
S x T	<.00	1	<.00	.02	.89
Ps x S x T	.01	17	<.00		
C x T	<.00	1	<.00	.01	.92
Ps x C x T	.03	17	<.00		
S x C x T	<.00	1	<.00	.01	.93
Ps x S x C x T	.04	17	<.00		

Appendix X (continued)

Experiment 5A 200-ms Prime-Target SOA: ANOVA on Proportions of Error

Source	SS	df	MS	F	p
Congruency (C)	<.00	1	<.00	.00	1.00
Ps x C	.06	17	<.00		
Target (T)	<.00	1	<.00	.47	.50
Ps x T	.05	17	<.00		
C x T	<.00	1	<.00	.00	1.00
Ps x C x T	.04	17	<.00		

Appendix X (continued)

Experiment 5A 1200-ms Prime-Target SOA: ANOVA on Proportions of Error

Source	SS	df	MS	F	p
Congruency (C)	<.00	1	<.00	.70	.41
Ps x C	.02	17	<.00		
Target (T)	<.00	1	<.00	1.15	.30
Ps x T	.03	17	<.00		
C x T	<.00	1	<.00	.02	.89
Ps x C x T	.03	17	<.00		

Appendix Y

Experiment 5B: Mean Reaction Time (RT) (ms) to Target Faces as a Function of Congruency and Prime-Target SOA, Across Participants (P)

	700-ms SOA				1200-ms SOA			
	Congruent		Incongruent		Congruent		Incongruent	
P	Happy	Angry	Happy	Angry	Happy	Angry	Happy	Angry
01	549	519	512	486	581	569	556	586
02	596	601	676	609	586	574	577	594
03	531	554	491	461	464	541	527	483
04	472	431	442	434	503	443	484	443
05	746	702	667	732	717	577	643	603
06	639	655	585	602	545	660	648	676
07	561	590	519	518	668	650	543	566
08	717	790	892	803	823	875	876	974
09	513	553	434	471	534	529	510	544
10	491	471	486	435	475	474	492	440

Appendix Y (continued)

	700-ms SOA				1200-ms SOA			
	Congruent		Incongruent		Congruent		Incongruent	
P	Happy	Angry	Happy	Angry	Happy	Angry	Happy	Angry
11	430	451	415	425	452	409	404	384
12	539	558	544	503	601	529	687	527
13	465	622	480	523	538	553	563	563
14	612	561	654	603	660	718	563	700
15	469	514	458	492	595	597	591	542
16	601	681	572	621	655	784	694	721
17	486	541	497	506	473	489	485	516
18	475	604	432	507	489	596	502	576

Appendix Z

Experiment 5B: ANOVA on Reaction Times

Source	SS	df	MS	F	p
SOA (S)	26025.94	1	26025.94	5.90	.03
Ps x S	75049.37	17	4414.67		
Congruency (C)	6180.31	1	6180.31	2.74	.12
Ps x C	38310.88	17	2253.58		
Target (T)	4293.60	1	4293.60	1.28	.28
Ps x T	57268.30	17	3368.72		
S x C	3073.72	1	3073.72	2.20	.16
Ps x S x C	23721.33	17	1395.37		
S x T	227.91	1	227.91	.11	.74
Ps x S x T	36025.26	17	2119.13		
C x T	2899.73	1	2899.73	2.43	.14
Ps x C x T	20252.32	17	1191.31		
S x C x T	1186.46	1	1186.46	1.72	.21
Ps x S x C x T	11716.16	17	689.19		

Appendix Z (continued)

Experiment 5B 700-ms Prime-Target SOA: ANOVA on Reaction Times

Source	SS	df	MS	F	p
Congruency (C)	8985.52	1	8985.52	4.62	.05
Ps x C	33076.176	17	1945.66		
Target (T)	3249.97	1	3249.97	1.70	.21
Ps x T	32513.097	17	1912.54		
C x T	3897.93	1	3897.93	4.71	.04
Ps x C x T	14074.01	17	827.88		

Appendix Z (continued)

Experiment 5B 1200-ms Prime-Target SOA: ANOVA on Reaction Times

Source	SS	df	MS	F	p
Congruency (C)	268.51	1	268.51	.16	.70
Ps x C	28956.03	17	1703.30		
Target (T)	1271.53	1	1271.53	.36	.56
Ps x T	60780.46	17	3575.32		
C x T	188.26	1	188.26	.18	.68
Ps x C x T	17894.46	17	1052.52		

Appendix AA

Experiment 5B: Proportion of Error to Target Faces as a Function of Congruency and Prime-Target SOA, Across Participants (P)

	700-ms SOA				1200-ms SOA			
	Congruent		Incongruent		Congruent		Incongruent	
P	Happy	Angry	Happy	Angry	Happy	Angry	Happy	Angry
01	.00	.10	.00	.15	.00	.00	.00	.00
02	.00	.15	.00	.00	.05	.00	.00	.00
03	.00	.15	.00	.10	.00	.00	.05	.00
04	.00	.05	.00	.05	.05	.00	.00	.05
05	.20	.00	.15	.05	.10	.10	.05	.00
06	.00	.05	.00	.00	.00	.00	.00	.00
07	.00	.05	.00	.10	.10	.00	.00	.05
08	.00	.00	.00	.05	.15	.05	.00	.00
09	.05	.05	.00	.00	.00	.05	.00	.00
10	.05	.00	.15	.00	.10	.10	.10	.05

Appendix AA (continued)

	700-ms SOA				1200-ms SOA			
	Congruent		Incongruent		Congruent		Incongruent	
P	Happy	Angry	Happy	Angry	Happy	Angry	Happy	Angry
11	.10	.05	.05	.05	.05	.00	.05	.10
12	.00	.00	.05	.00	.05	.05	.00	.05
13	.10	.15	.00	.05	.00	.05	.00	.10
14	.05	.10	.10	.05	.00	.00	.10	.05
15	.05	.00	.00	.00	.10	.00	.00	.00
16	.00	.00	.00	.00	.00	.00	.00	.00
17	.00	.00	.00	.00	.05	.10	.00	.05
18	.05	.05	.00	.05	.05	.10	.05	.05

Appendix BB

Experiment 5B: ANOVA on Proportions of Error

Source	SS	df	MS	F	p
SOA (S)	<.00	1	<.00	.53	.48
Ps x S	.04	17	<.00		
Congruency (C)	<.00	1	<.00	4.78	.04
Ps x C	.02	17	<.00		
Target (T)	<.00	1	<.00	.36	.56
Ps x T	.05	17	<.00		
S x C	<.00	1	<.00	.03	.86
Ps x S x C	.03	17	<.00		
S x T	<.00	1	<.00	.93	.35
Ps x S x T	.05	17	<.00		
C x T	<.00	1	<.00	.45	.51
Ps x C x T	.02	17	<.00		
S x C x T	<.00	1	<.00	2.12	.16
Ps x S x C x T	.01	17	<.00		

Appendix BB (continued)

Experiment 5B 700-ms Prime-Target SOA: ANOVA on Proportions of Error

Source	SS	df	MS	F	p
Congruency (C)	<.00	1	<.00	1.57	.23
Ps x C	.02	17	<.00		
Target (T)	<.00	1	<.00	.74	.40
Ps x T	.08	17	<.00		
C x T	<.00	1	<.00	.13	.73
Ps x C x T	.02	17	<.00		

Appendix BB (continued)

Experiment 5B 1200-ms Prime-Target SOA: ANOVA on Proportions of Error

Source	SS	df	MS	F	p
Congruency (C)	<.00	1	<.00	1.95	.18
Ps x C	.03	17	<.00		
Target (T)	<.00	1	<.00	.13	.73
Ps x T	.02	17	<.00		
C x T	<.00	1	<.00	1.99	.18
Ps x C x T	.02	17	<.00		

Appendix CC

Experiment 5C: Mean Reaction Time (RT) (ms) and Proportion of Error (Err) to Target Faces as a Function of Congruency, Across Participants (P)

	Congruent				Incongruent			
	Happy		Angry		Happy		Angry	
P	RT	Err	RT	Err	RT	Err	RT	Err
01	538	.00	534	.10	489	.00	494	.00
02	507	.05	506	.10	477	.00	432	.10
03	602	.10	610	.00	650	.00	640	.00
04	426	.00	457	.00	400	.05	409	.00
05	492	.20	562	.10	443	.15	507	.05
06	535	.00	585	.05	538	.10	529	.00
07	460	.05	518	.30	444	.00	439	.15
08	645	.15	555	.05	657	.05	648	.00
09	518	.00	625	.00	525	.05	570	.00
10	594	.05	517	.05	513	.10	501	.00

Appendix CC (continued)

	Congruent				Incongruent			
	Happy		Angry		Happy		Angry	
P	RT	Err	RT	Err	RT	Err	RT	Err
11	578	.15	553	.00	543	.00	472	.00
12	620	.10	605	.05	709	.00	624	.00
13	631	.00	628	.00	545	.00	579	.00
14	542	.10	504	.05	555	.05	484	.05
15	585	.05	715	.00	645	.00	671	.00
16	640	.00	682	.10	673	.00	671	.00
17	597	.00	642	.05	633	.10	691	.05
18	475	.00	513	.00	481	.00	513	.05

Appendix DD

Experiment 5C: ANOVA on Reaction Times

Source	SS	df	MS	F	p
Congruency (C)	3471.99	1	3471.99	2.06	.17
Ps x C	28612.50	17	1683.09		
Target (T)	1107.35	1	1107.35	.55	.47
Ps x T	34110.24	17	2006.48		
C x T	1980.38	1	1980.38	3.40	.08
Ps x C x T	9905.04	17	583.65		

Appendix EE

Experiment 5C: ANOVA on Proportions of Error

Source	SS	df	MS	F	p
Congruency (C)	.01	1	.01	5.88	.03
Ps x C	.03	17	<.00		
Target (T)	<.00	1	<.00	.12	.74
Ps x T	.08	17	<.00		
C x T	<.00	1	<.00	.31	.59
Ps x C x T	.03	17	<.00		

Appendix FF

Experiments 5A-C: ANOVA on Reaction Times

Source	SS	df	MS	F	p
Experiment (E)	65454.89	2	32727.41	.99	.38
Ps x E	1693609.89	51	33208.04		
Congruency (C)	13387.36	1	13387.36	10.24	<.01
E x C	542.92	2	271.46	.21	.81
Ps x C x E	66653.85	51	1306.94		
Target (T)	2918.72	1	2918.72	1.61	.21
E x T	514.12	2	257.06	.14	.87
Ps x E x T	92347.76	51	1810.74		
C x T	2891.74	1	2891.74	4.52	.04
E x C x T	649.45	2	324.73	.51	.61
Ps x E x C x T	32607.05	51	639.35		

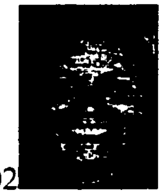
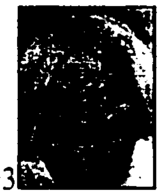
Appendix GG

Experiments 5A-C: ANOVA on Proportions of Error

Source	SS	df	MS	F	p
Experiment (E)	<.00	2	<.00	.44	.65
Ps x E	.16	51	<.00		
Congruency (C)	.01	1	.01	7.62	<.01
E x C	<.00	2	<.00	1.59	.21
Ps x C x E	.07	51	<.00		
Target (T)	<.00	1	<.00	.18	.67
E x T	<.00	2	<.00	.39	.68
Ps x E x T	.14	51	<.00		
C x T	<.00	1	<.00	<.00	.96
E x C x T	<.00	2	<.00	.39	.68
Ps x E x C x T	.06	51	<.00		

Appendix HH

Experiment 6: Additional Affective Faces

Happy	Angry
01 	01 
02 	02 
03 	03 

Appendix II

Experiment 6: Mean Reaction Time (RT) (ms) and Proportion of Error (Err) to Target Faces as a Function of Congruency, Across Participants (P)

	Congruent				Incongruent			
	Happy		Angry		Happy		Angry	
P	RT	Err	RT	Err	RT	Err	RT	Err
01	525	.08	350	.04	451	.04	459	.04
02	526	.04	461	.08	511	.04	501	.00
03	549	.00	576	.00	570	.00	550	.04
04	461	.00	421	.00	480	.00	391	.08
05	399	.08	355	.08	472	.08	401	.00
06	426	.00	461	.00	428	.04	499	.00
07	951	.00	1030	.08	999	.00	1071	.13
08	629	.17	529	.17	534	.04	622	.21
09	829	.00	800	.13	782	.00	766	.13
10	473	.08	557	.00	506	.08	500	.00

Appendix II (continued)

	Congruent				Incongruent			
	Happy		Angry		Happy		Angry	
P	RT	Err	RT	Err	RT	Err	RT	Err
11	605	.04	638	.08	635	.00	589	.00
12	469	.00	437	.04	458	.00	470	.00
13	768	.00	749	.04	845	.00	870	.00
14	402	.00	501	.00	442	.00	505	.00
15	514	.04	576	.00	572	.00	582	.00
16	556	.00	555	.00	530	.00	566	.04
17	471	.04	573	.00	516	.00	546	.00
18	417	.00	478	.00	466	.04	505	.04

Appendix JJ

Experiment 6: ANOVA on Reaction Times

Source	SS	df	MS	F	p
Congruency (C)	4604.44	1	4604.44	4.67	.05
Ps x C	16750.46	17	985.32		
Target (T)	1072.92	1	1072.92	.45	.51
Ps x T	40522.09	17	2383.65		
C x T	193.93	1	193.93	.12	.73
Ps x C x T	26727.49	17	1572.21		

Appendix KK

Experiment 6: ANOVA on Proportions of Error

Source	SS	df	MS	F	p
Congruency (C)	<.00	1	<.00	.94	.35
Ps x C	.02	17	<.00		
Target (T)	<.00	1	<.00	1.13	.26
Ps x T	.04	17	<.00		
C x T	<.00	1	<.00	.41	.53
Ps x C x T	.02	17	<.00		

Appendix LL

Experiment 7 Different-Identity Condition: Mean Reaction Time (RT) (ms) and Proportion of Error (Err) to Target Faces as a Function of Congruency, Across Participants (P)

	Congruent				Incongruent			
	Happy		Angry		Happy		Angry	
P	RT	Err	RT	Err	RT	Err	RT	Err
01	517	.00	558	.06	494	.00	520	.00
02	616	.00	578	.06	602	.06	530	.00
03	535	.06	532	.00	446	.00	461	.00
04	433	.11	448	.06	427	.00	430	.00
05	398	.00	409	.06	377	.06	365	.06
06	531	.06	549	.00	616	.00	611	.00
07	839	.00	861	.00	783	.00	775	.00
08	439	.11	499	.11	339	.00	383	.11
09	538	.00	560	.00	511	.00	549	.00
10	583	.06	651	.06	598	.00	602	.00

Appendix LL (continued)

	Congruent				Incongruent			
	Happy		Angry		Happy		Angry	
P	RT	Err	RT	Err	RT	Err	RT	Err
11	487	.06	462	.06	388	.11	392	.06
12	373	.06	500	.00	524	.11	528	.06
13	668	.00	678	.00	597	.00	628	.00
14	370	.17	402	.00	362	.00	362	.11
15	472	.00	473	.00	414	.00	486	.00
16	472	.00	547	.00	472	.00	492	.00
17	583	.00	550	.00	485	.00	478	.00
18	449	.06	414	.06	398	.00	436	.00

Appendix LL (continued)

Experiment 7 Same-Identity Condition: Mean Reaction Time (RT) (ms) and Proportion of Error (Err) to Target Faces as a Function of Congruency, Across Participants (P)

	Congruent				Incongruent			
	Happy		Angry		Happy		Angry	
P	RT	Err	RT	Err	RT	Err	RT	Err
01	522	.00	494	.00	495	.06	478	.00
02	411	.00	385	.00	404	.00	403	.00
03	477	.00	486	.06	522	.06	458	.00
04	406	.06	452	.06	453	.06	438	.06
05	393	.06	337	.06	387	.00	433	.00
06	347	.00	422	.17	370	.06	427	.06
07	385	.00	436	.06	387	.00	437	.00
08	390	.00	436	.06	456	.00	491	.00
09	399	.00	403	.06	485	.00	436	.00
10	518	.06	511	.00	539	.00	569	.06

Appendix LL (continued)

	Congruent				Incongruent			
	Happy		Angry		Happy		Angry	
P	RT	Err	RT	Err	RT	Err	RT	Err
11	451	.00	415	.06	459	.06	501	.00
12	368	.00	418	.00	472	.00	455	.11
13	436	.06	419	.00	497	.00	490	.00
14	535	.06	558	.06	580	.00	582	.06
15	536	.00	530	.00	509	.00	557	.00
16	399	.06	416	.06	476	.00	468	.06
17	361	.00	412	.00	404	.00	476	.00
18	460	.06	388	.00	410	.00	393	.06

Appendix MM

Experiment 7: ANOVA on Reaction Times

Source	SS	df	MS	F	p
Identity (I)	129957.13	1	129957.13	4.57	.04
Ps x I	967591.69	34	28458.58		
Congruency (C)	5.82	1	5.82	<.00	.95
I x C	33407.16	1	33407.16	19.33	<.01
Ps x C x I	58762.84	34	1728.32		
Target (T)	5282.22	1	5282.22	5.93	.02
I x T	453.17	1	453.17	.51	.48
Ps x I x T	30288.58	34	890.84		
C x T	84.32	1	84.32	.14	.71
I x C x T	375.60	1	375.60	.63	.43
Ps x I x C x T	20198.83	34	594.08		

Appendix NN

Experiment 7: ANOVA on Proportions of Error

Source	SS	df	MS	F	p
Identity (I)	<.00	1	<.00	.09	.77
Ps x I	.08	34	<.00		
Congruency (C)	<.00	1	<.00	5.25	.03
I x C	<.00	1	<.00	.21	.65
Ps x C x I	.03	34	<.00		
Target (T)	<.00	1	<.00	.76	.39
I x T	<.00	1	<.00	3.69	.06
Ps x I x T	.02	34	<.00		
C x T	<.00	1	<.00	.12	.74
I x C x T	<.00	1	<.00	.63	.43
Ps x I x C x T	.06	34	<.00		