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Mixed emotions: Holistic and analytic perception of facial expressions

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In the face literature, it is debated whether the identification of facial expressions requires holistic (i.e., whole face) or analytic (i.e., parts-based) information. In this study, happy and angry composite expressions were created in which the top and bottom face halves formed either an incongruent (e.g., angry top + happy bottom) or congruent composite expression (e.g., happy top + happy bottom). Participants reported the expression in the target top or bottom half of the face. In Experiment 1, the target half in the incongruent condition was identified less accurately and more slowly relative to the baseline isolated expression or neutral face conditions. In contrast, no differences were found between congruent and the baseline conditions. In Experiment 2, the effects of exposure duration were tested by presenting faces for 20, 60, 100 and 120 ms. Interference effects for the incongruent faces appeared at the earliest 20 ms interval and persisted for the 60, 100 and 120 ms intervals. In contrast, no differences were found between the congruent and baseline face conditions at any exposure interval. In Experiment 3, it was found that spatial alignment impaired the recognition of incongruent expressions, but had no effect on congruent expressions. These results are discussed in terms of holistic and analytic processing of facial expressions.

Keywords: Facial expression; Face recognition; Facial affect.

In a single glance, we can extract a wealth of information from the human face regarding the identity, gender, attractiveness and emotional state of its bearer. Given the facility of our face processing abilities, a great deal of research has been devoted to understanding the cognitive operations that mediate our ability to perceive faces so quickly and effortlessly. It has been claimed that faces are recognised more holistically than other types of objects where identification relies not on the recognition of individual features, but on the integration of those features into a

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holistic face representation (Tanaka & Farah, 1993). While few face researchers would disagree that the recognition of facial identity is holistic, there is less consensus about whether the perception of facial expressions is based on the holistic perception of the entire face or on the analytic perception of particular features.

The concept of holistic recognition has been operationalised in inversion studies where the recognition of faces is disproportionately impaired by inversion relative to the recognition of other objects (Yin, 1969). Holistic recognition has also been demonstrated in a part/whole task where the recognition of a face part (e.g., eyes, nose, mouth) is better when tested in the context of the whole face than in isolation (Tanaka & Farah, 1993). Perhaps, the most compelling demonstration of holistic face processing is the face composite task (Young, Hellawell, & Hay, 1987). In this task, a composite face stimulus is created by pairing the top half of one identity (e.g., Brad Pitt) with the bottom half of a different identity (e.g., Tom Cruise). Participants are asked to identify the person in the top half or bottom half of the face. The main finding is that accuracy and reaction-time performance is impaired when the top and bottom face halves are spatially aligned than when misaligned. In the aligned version, it is speculated that the top and bottom halves of the composite face form an integrated, holistic identity rendering it difficult for participants to selectively attend to the identity of the person in just one region of the face. When the composite face is misaligned, holistic processes are disrupted and it is easier for participants to attend to the face in the upper or lower halves.

Applying the composite paradigm, researchers have found evidence for the holistic perception of facial expressions (Calder & Jansen, 2005; Calder, Keane, Young, & Dean, 2000). When the top half of one expression (e.g., anger, fear, sadness) was spatially aligned with the bottom half of another expression (e.g., happiness, disgust, surprise), participants were slower to identify the target top or bottom expression than when the halves were misaligned (Calder et al., 2000) or when the composite expression was inverted (Calder & Jansen, 2005). In the aligned condition, holistic perception causes the contradictory information in the non-target half to interfere with the perception of the expression in the target half. When the top and bottom halves are misaligned, the holistic perception is disrupted allowing the relevant half to be attended to independent of the irrelevant half. For congruent expressions in which the top and bottom expressions matched (e.g., happy top/happy bottom), a holistic advantage was found where reaction times were faster for aligned faces than for misaligned faces irrespective of whether the face halves were from the same person (White, 2000) or from different persons (Calder et al., 2000). Based on evidence from the composite task, it has been suggested that expressions are perceived holistically producing interference effects when aligned face halves display conflicting expressions
and facilitation effects when the face halves display the same expression (Calder et al., 2000; White, 2000).

In contrast to the holistic view, other researchers have argued that the recognition of facial emotion can be analytic, in which recognition focuses on specific parts of the face and not on the integration of the parts into a whole face representation (Chen & Chen, 2010; Ellison & Massaro, 1997; Leppänen, Kauppinen, Peltola, & Hietanen, 2007). Ellison and Massaro (1997) found that when participants categorised whole faces or face parts as "happy" or "angry", their whole-face responses could be reliably predicted based on additive responses to the individual eyebrow and mouth features suggesting that information in the upper and lower halves of the face is perceived independently. Similarly, Chen and Chen (2010) found that when participants were asked to make happy or sad expression judgements to an aligned or misaligned composite face, the alignment of the upper and lower halves had no effect on their classification. In a go/no go task, Leppänen et al. (2007) found that upper eye cues (e.g., eyes narrowing, crow's feet, intraorbital furrow) had little effect on the accuracy of the happy expression. Thus, the current literature is somewhat divided as to whether facial expressions are recognised based on the holistic integration of facial information or the analysis of specific facial features.

The goal of the present research was to examine the conditions of holistic and analytic recognition of facial expressions. Our experiments focused on the two expressions of happy and angry. These expressions were selected because their diagnostic cues are differentially weighted to different halves of the face. Specifically, behavioural experiments (Calder et al., 2000; Smith, Cottrell, Gosselin, & Schyns, 2005) and computer simulations (Cottrell, Branson, & Calder, 2002) have shown that the diagnostic information for a happy expression is primarily conveyed by the smile in the bottom half of the face. In contrast, the brow region in the upper half provides the diagnostic information for an angry expression. Therefore, in an incongruent condition, the dominant half of the angry expression (i.e., top) can be directly pitted against the dominant half of happy expression (i.e., bottom). An additional benefit of using the happy–angry pairing is that the two expressions lie on the opposite ends of the positive–negative valence spectrum and, therefore, form conceptually distinct emotions.

In Experiment 1, a procedure was employed where participants were asked to identify the expression in the target top or bottom half of the face while ignoring information in the non-target portion. As shown in Figure 1, the critical trials were those in which the dominant or "strong" expression halves (i.e., angry top or happy bottom) were presented in either an incongruent expression (e.g., angry top/happy bottom) or a congruent expression (e.g., happy top/happy bottom). The congruent and incongruent conditions were compared to two types of baseline conditions: an isolated baseline condition and a neutral face condition. In the isolated baseline condition, the top or bottom half of a happy or angry expression was presented by itself. The isolated condition provides a pure test of analytic processing given that potentially congruent or incongruent information is completely absent from the stimulus. However, this condition has a limitation in the sense that the target stimulus is an incomplete face rather than a whole intact face.

The neutral face baseline condition avoids this shortcoming by joining the top (or bottom) half of the target expression with the bottom (or top) half of a neutral expression; thus, preserving the whole face stimulus and, presumably, holistic face

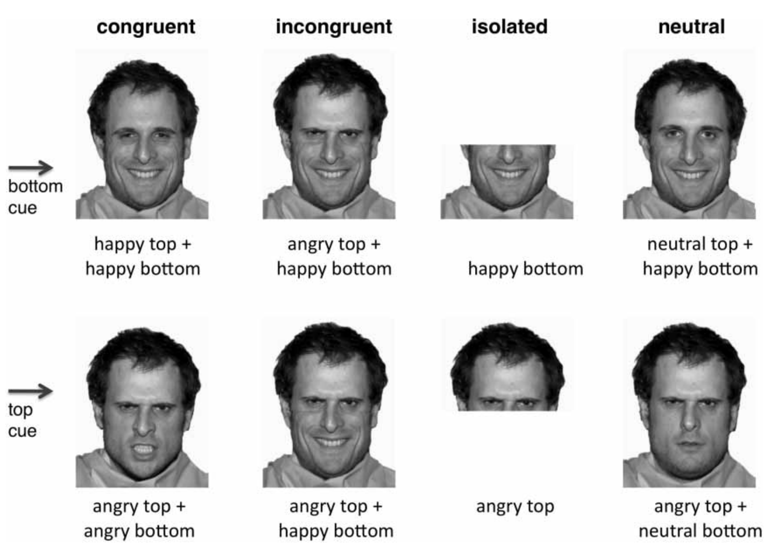


Figure 1. *Examples of "strong" happy expression stimuli used in Experiment 1: (a) congruent happy top/happy bottom expression; (b) incongruent happy bottom/angry top face; (c) a happy bottom/neutral top expression and a happy bottom shown in isolation.*

processing. Depending on how the neutral half interacts with the expressive half, different behavioural outcomes are possible: (1) If the neutral composite is perceived as a weak congruent expression, performance in this condition would be expected to be slightly worse than the congruent condition, but better than isolated baseline condition. (2) If the neutral composite generates a weak incongruent expression, neutral composite performance would be expected to be worse than the isolated baseline condition, but not as poor as performance in the incongruent expression condition. (3) If the neutral composite is perceived analytically, no difference between the isolated and neutral composite condition would be expected.

EXPERIMENT 1: RECOGNITION OF EXPRESSIONS SHOWN IN ISOLATION AND IN CONGRUENT, INCONGRUENT AND NEUTRAL FACES

In Experiment 1, we applied the isolated part and neutral composite face baseline conditions to compare potential effects of holistic interference for incongruent expressions and holistic facilitation for congruent expressions. According to the holistic account, interference effects should be observed in the incongruent condition as evidenced by poorer accuracy and slower reaction times compared to the baseline isolated and neutral conditions. Similarly, facilitation effects should be found in the congruent condition as shown by better accuracy and faster reaction times relative to the baseline conditions. In contrast, a strict analytic view predicts that the congruent and incongruent conditions should not differ from the baseline conditions of the isolated face part and neutral face composite.

Method

Participants. Twenty-four undergraduate students at the University of Victoria (including 4 men; mean age = 21 years, range 19–40 years) with normal or corrected-to-normal vision participated in this experiment for course credit.

Materials. Stimuli were modifications of the grey-scaled images from the NimStim Face Set (Tottenham et al., 2009). The stimuli included four male and four female faces each depicting expressions of anger and happiness. In a previous normative study (Tottenham et al., 2009), the facial expressions were determined to be highly reliable with participants accurately labelling the emotions above the 80% level. The selected happy and angry expressions were open-mouthed expressions with exposed teeth. In total, there were eight individuals posing the basic expressions of happy and angry, for a total stimulus set of eight angry faces and eight happy faces. The "congruent" expressions were the original photographs depicting a happy or angry expression. The "incongruent" expressions were constructed by combining the top of one expression (happy or angry) with the bottom of the other (happy or angry) from the same individual. The neutral baseline faces were created by combining the top (or bottom) half of an expressive face with the bottom (or top) half of a neutral face. The isolated face halves were created by horizontally cutting the top and bottom of each angry and happy expression at the bridge of the nose. This method yielded seven face combinations: (a) congruent strong expression (e.g., happy top/happy bottom); (b) incongruent strong expression (e.g., angry top/happy bottom); (c) incongruent weak expression (e.g., happy top/angry bottom); (d) neutral strong expression (e.g., neutral top/happy bottom); (e) neutral weak expression (e.g., happy top/neutral bottom); (f) isolated strong expression (e.g., happy bottom only); and (g) isolated weak expression (e.g., happy top only).

Design. A within-subjects design was used with the factors of Stimulus Type (congruent expression, incongruent expression, isolated half, neutral expression), and Expression (happy, angry). The to-be-attended region in the first block was counterbalanced across participants. The factors of Stimulus Type and Expression were randomised within each block. The 256 trials were divided into four blocks of 64 trials in which one of the four Stimulus Types was randomly presented with either a strong or weak expression. As we were interested in the influence of unattended information on the perception of diagnostic expression features, the experiment assessed performance in 128 strong expression trials only; the remaining 128 weak expression catch trials were not analysed.

Procedure. The participant sat in a darkened room with his or her eyes approximately 60 cm from a 15-inch LG Flatron F700P monitor on which the faces were presented by a PC computer and E-Prime software. The participants' task was to label the expression shown in the target top or bottom half of the face. Participants were told to attend to the top or bottom of the face through an instructions screen that appeared before the block of trials began. Each trial began with the presentation of a red fixation cross in the centre of the screen for 500 ms. Then, a face stimulus was presented for 50 ms, followed by a query screen which was shown for 5000 ms or until a response was made. The face images were presented at a viewing distance of 60 cm and subtended a visual angle of approximately 6 (horizontal) and 8 (vertical) degrees. Participants responded by pressing the button labelled "A" for angry or "H" for happy on a serial response box.

Results and discussion

The analyses were conducted on strong expression trials only (i.e., weak expression catch trials were not analysed). Separate analyses of variance (ANOVAs) were performed with the dependent measures of accuracy and correct reaction times with Stimulus Type (congruent, incongruent, isolated, neutral) and Expression (happy, angry) as within-subjects factors. Relevant interactions were then investigated by performing simple effects ANOVAs for each expression, happy and angry. Finally, post hoc probes consisting of a series of Bonferroni corrected pairwise comparisons of each Stimulus Type were conducted where appropriate.

Accuracy. An ANOVA performed on labelling accuracy revealed reliable main effects of Expression, $F(1, 23) = 18.97$, $p < .001$, $\eta_p^2 = .45$, and Stimulus Type, $F(3, 69) = 86.29$, $p < .001$, $\eta_p^2 = .79$, as well as a significant Expression by Stimulus Type interaction, $F(3, 69) = 12.90$, $p < .001$, $\eta_p^2 = .36$. Overall accuracy for happy expressions was superior to angry expressions and participants were most accurate when identifying the face in the congruent condition, followed by the part in isolation, then the part in the neutral condition, with poorest performance occurring in the incongruent condition, ps $< .05$.

To better understand the nature of the interaction, separate ANOVAs were performed on Stimulus Type for each expression, happy and angry. For happy expressions, $F(3, 69) = 32.45$, $p < .001$, $\eta_p^2 = .58$, accuracy for incongruent stimuli was inferior to congruent, neutral, and isolated stimuli, ps $< .05$, see Figure 2a. For angry expressions, $F(3, 69) = 61.79$, $p < .001$, $\eta_p^2 = .73$, participants were most accurate identifying the congruent and neutral stimuli, followed by the isolated stimuli, with poorest performance for the incongruent stimuli, ps $< .05$, see Figure 2b. No other differences were reliable.

Reaction time. An ANOVA performed on reaction times for all correctly identified trials revealed reliable main effects of Expression, $F(1, 22) = 8.99$, $p < .01$, $\eta_p^2 = .29$, and Stimulus Type, $F(3, 66) = 9.33$, $p < .001$, $\eta_p^2 = .30$, with the Expression by Stimulus Type interaction approaching significance, $F(3, 66) = 2.38$, $p = .08$, $\eta_p^2 = .10$. As shown in Table 1, participants responded faster to happy expressions than angry expressions and demonstrated slowest performance in the incongruent condition relative to the congruent, isolated and neutral conditions, ps $< .05$.

The interaction was examined with separate ANOVAs comparing Stimulus Type for happy and angry expressions. For happy expressions,

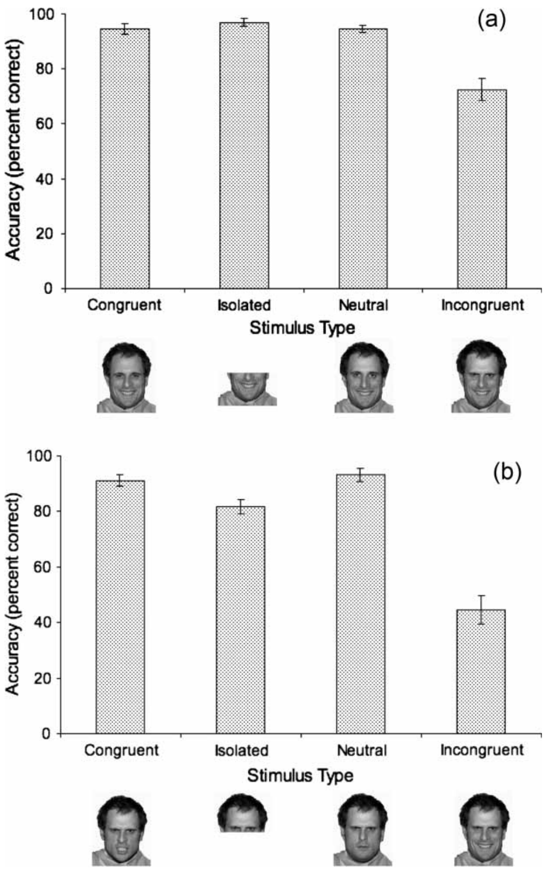


Figure 2. *Experiment 1 results. Mean accuracy for labelling strong happy and angry expression halves. Error bars indicate standard error of the mean. (a) For happy expressions, the mean accuracy in congruent, isolated and neutral conditions was better than in the incongruent condition. (b) For angry expressions, accuracy was best in the congruent and neutral conditions, followed by the isolated condition and the poorest in the incongruent condition.*

$F(3, 69) = 11.89$, $p < .001$, $\eta_p^2 = .34$, incongruent expressions were identified more slowly than congruent, isolated and neutral stimuli, ps $< .05$, see Figure 2a. In contrast, for angry expressions, the influence of Stimulus Type was not significant, $F(3, 66) = 1.22$, $p > .30$, $\eta_p^2 = .05$.

For the happy expression, recognition of the bottom happy expression was identified more slowly and less accurately when paired with an incongruent angry top expression relative to the isolated and neutral composite baseline conditions. This result provides evidence of holistic interference where information in the non-target portion of the face impaired recognition of information in the target face half. These results are consistent with previous experiments (Calder & Jansen, 2005; Calder et al., 2000; White, 2000). In contrast, when paired with a congruent happy top expression, recognition of the bottom happy expression was no faster or more accurate than the baseline conditions. According to the assumptions of the paradigm, recognition of the congruent happy expressions was analytic, unaffected by information in the to-be-ignored face half.

For the angry expression, when paired with the incongruent happy bottom expression, recognition of the top angry expression was less accurate than the isolated and neutral baseline conditions indicating the presence of holistic interference. Recognition of the angry top expression was more accurate in the congruent and neutral composite than the isolated baseline condition. These results suggest that in the presence of congruent or neutral information, recognition of the angry top expression was not purely analytic (i.e., parts-based), but benefited from the presence of whole-face information.

In Experiment 1, we found what could be called a happy advantage; happy expressions were identified more quickly and accurately than angry expressions regardless of their stimulus context (incongruent face, congruent face, isolated, neutral face). Although happy and angry might be

Table 1. *Experiment 1: Mean accuracies reaction times on correct trials (ms), and standard error of the means (in parentheses) where the strong half of a happy or angry expression is presented with a congruent half, in isolation, with a neutral half and with an incongruent half*

	Expression	
Condition	*Happy*	*Angry*
a. Congruent	691^{d} ms (29)	852 ms (61)
b. Isolated	682^{d} ms (26)	900 ms (45)
c. Neutral	678^{d} ms (33)	850 ms (52)
d. Incongruent	$898^{a,b,c}$ ms (63)	933 ms (87)

Note: The superscripts indicate conditions that are reliably different from one another, $p < .05$.

regarded as “bottom” and “top” expressions, respectively, the top and bottom halves may not be equivalently diagnostic for the angry and happy expressions, respectively. For instance, the lower half of the happy expression might be a more potent emotional signal than the upper half of the angry expression. The superior recognition of bottom happy expression, regardless of whether the face half was presented in isolation, in a neutral whole face or in a congruent whole face, speaks to its potency as an indicator of positive affect.

EXPERIMENT 2: CONGRUENT AND INCONGRUENT EXPRESSION RECOGNITION UNDER BRIEF EXPOSURE PRESENTATIONS

The results from Experiment 1 provided evidence for both the holistic and analytic recognition of facial emotions. In the incongruent condition, holistic processing was demonstrated by the interference effects in which the non-target expression half impaired identification of the target expression half. Evidence for analytic processing was indicated by the absence of holistic facilitation in the congruent condition for happy expressions. However, it is possible that the lack of holistic facilitation in the happy condition was due to the high identification rate (i.e., 90% range) of “strong” expressions in neutral and isolated conditions, thereby leaving little room for improvement relative to the congruent condition. In Experiment 2, we reduced overall accuracy by parametrically varying the exposure duration of the face stimulus from 20 ms in the shortest presentation condition to 140 ms in the longest condition. To ensure the abrupt offset of processing, the face stimuli were masked by Gaussian noise of five spatial scales randomly presented in rapid succession.

This method also enabled the observation of the dynamics of holistic and analytic perception of facial expressions. Previous research has shown that holistic effects in identity recognition can be observed after relatively short exposure durations of 50 ms or less (Anaki, Boyd, & Moscovitch, 2007; Richler, Mack, Gauthier, & Palmeri, 2009) or when the presentations of the top and bottom face halves are separated by a noise mask not exceeding 400 ms (Anaki et al., 2007; Singer & Sheinberg, 2006). Longer exposure durations of 1200 ms eliminate the holistic effects and induce an analytic style of processing (Hole, 1994). Based on these studies, we speculate that holistic facilitation effects for the happy expression might be evident at the short exposure durations used in Experiment 2.

If ceiling effects and relatively long exposure duration masked the presence of holistic facilitation in Experiment 1, the difference between the congruent condition and the isolated and neutral baseline conditions for the happy expression should be apparent under the increased processing demands of the shortened exposure duration. On the other hand, if congruent happy expressions are perceived analytically regardless of the encoding, no difference was predicted between the congruent and baseline conditions even at these brief exposure durations.

Method

Participants. Forty-eight new subjects, undergraduate students at the University of Victoria (including 14 men; mean age = 19.97 years, range 18–34 years) with normal or corrected-to-normal vision, participated in this experiment for course credit.

Materials. Face stimuli included the congruent, incongruent, isolated, and neutral faces from Experiment 1, which yielded the same seven different face combinations: (a) congruent strong expression (e.g., happy top/happy bottom); (b) incongruent strong expression (e.g., angry top/happy bottom); (c) incongruent weak expression (e.g., happy top/angry bottom); (d) neutral strong expression (e.g., neutral top/happy bottom); (e) neutral weak expression (e.g., happy top/neutral bottom); (f) isolated strong expression (e.g., happy bottom only); and (g) isolated weak expression (e.g., happy top only).

In addition, ten noise mask stimuli were created. Each mask was comprised of high contrast additive Gaussian white noise at one of five possible spatial scales (see Bacon-Macé, Macé, Fabre-Thorpe, & Thorpe, 2004). These noise stimuli were interleaved in random sequence, together forming a ten-frame dynamic noise mask the sequence of which could be reconfigured on a trial-by-trial basis.

Design. A mixed design was used with the within-subjects factors of Stimulus Type (congruent expression, incongruent expression, isolated half, neutral expression), and Expression (happy, angry) and the between-subjects factor of Exposure Duration (20 ms, 60 ms, 100 ms, 140 ms). The 256 trials were divided into four blocks of 64 trials in which one of the four Stimulus Types was randomly presented with either a strong or weak expression. Participants were randomly assigned to one of the four exposure durations ($N = 12$ per condition). The to-be-attended region (top or bottom) was blocked and alternated, with the first block counterbalanced across participants. The experiment assessed performance in 128 strong expression trials only; the remaining 128 weak expression catch trials were not analysed.

Procedure. The participants' task was to label the expression shown in the target face half. At the beginning of each block of trials, an instruction screen was shown that told participants they were to identify the expression in the top or bottom of the face. The experimental trial began with the presentation of a red fixation cross in the centre of the screen for 250 ms. Then, a face stimulus was presented for 20, 60, 100, or 140 ms, according to the participant's randomly assigned condition. Next, the face stimulus was immediately replaced by a ten-frame dynamic noise mask, which was displayed for 100 ms (i.e., 10 ms per frame). Finally, a query screen was shown for 5000 ms or until a response was made. The face and noise images were presented at a viewing distance of 60 cm and subtended a visual angle of approximately 6 (horizontal) and 8 (vertical) degrees. Participants responded by pressing the key labelled "A" for angry or "H" for happy on a computer keyboard.

Results and discussion

The analysis followed the logic of Experiment 1, focusing on the perception of strong expressions only. Separate ANOVAs were performed with the dependent measures of accuracy and correct reaction times with Stimulus Type (congruent, incongruent, isolated, neutral) and Expression (happy, angry) as within-subjects factors and Exposure Duration (20, 60, 100, 140 ms) as a between-subject factor and then the Happy and Angry expressions were analysed separately across Stimulus Type and Exposure Duration. Potential effects of holistic facilitation and interference were examined by comparing performance in the congruent and incongruent conditions, respectively, to the isolated and neutral baseline conditions.

Accuracy. The ANOVA performed on accuracy revealed a main effect of Stimulus Type, $F(3, 132) = 60.09$, $p < .001$, $\eta_p^2 = .58$, indicating that participants were least accurate in incongruent condition relative to the isolated, neutral and congruent condition, ps $< .05$. The reliable effect of Expression, $F(1, 44) = 30.72$, $p < .001$, $\eta_p^2 = .41$, showed happy expressions were more accurately identified than the angry expressions. Finally, the reliable effect of Exposure Duration, $F(3, 44) = 52.37$, $p < .001$, $\eta_p^2 = .78$, demonstrated that performance was reliably better in the 60 ms, 100 ms, and 140 ms conditions compared to the 20 ms condition. The two-way interaction between Stimulus Type and Exposure Duration was reliable, $F(9, 132) = 2.73$, $p < .01$, $\eta_p^2 = .16$, as was the two-way interaction between Stimulus Type and Expression, $F(3, 132) = 3.80$ $p < .05$, $\eta_p^2 = .08$. No other interactions were reliable.

A separate ANOVA carried out for happy expressions showed a reliable effect of Stimulus Type, $F(3, 132) = 17.73$, $p < .001$, $\eta_p^2 = .29$, and Exposure Duration, $F(3, 44)$, 27.56, $p < .001$,

$\eta_p^2 = .65$, but no reliable interaction between the two factors, $F(9, 132) = 1.31$, $p > .05$, $\eta_p^2 = .08$. At a 20 ms exposure duration, $F(3, 33) = 1.01$, $p > .05$, $\eta_p^2 = .08$, there was no difference between the congruent and the baseline isolated and neutral conditions nor were the differences between the incongruent condition and the isolated and neutral conditions reliable. However, at 60, 100 and 140 ms exposure durations, participants were reliably worse at identifying the happy expression in the incongruent face compared to the isolated and neutral baseline conditions, ps $< .01$. In contrast, there were no accuracy differences between the congruent condition and the isolated and neutral baseline conditions.

A separate ANOVA and planned comparisons of mean accuracy were performed for angry expressions. Overall, there were main effects of Stimulus Type, $F(3, 132) = 45.67$, $p < .001$, $\eta_p^2 = .51$, and Exposure Duration, $F(3, 44)$, 29.09, $p < .001$, $\eta_p^2 = .66$, and a significant interaction between the two factors, $F(9, 132) = 2.79$, $p < .01$, $\eta_p^2 = .16$. At the shortest 20 ms exposure duration, planned comparisons showed that accuracy in the incongruent condition was worse than the congruent, neutral and isolated conditions, and performance in the neutral condition was superior to the congruent and isolated conditions, ps $< .05$. At 60, 100 and 140 ms, participants were less accurate in the incongruent condition relative to the isolated and neutral conditions, ps $< .05$. In contrast, no differences were found between the congruent condition and the isolated and neutral conditions (as shown in Figure 3).

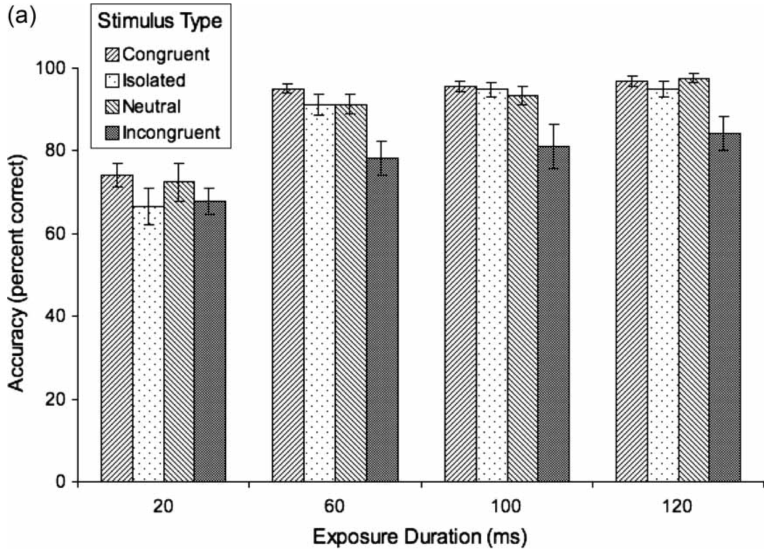
Reaction time. An ANOVA performed on reaction times for all correct trials revealed main effects of Expression, $F(3, 44) = 19.92$, $p < .001$, $\eta_p^2 = .31$, and Stimulus Type, $F(3, 132) = 17.68$, $p < .001$, $\eta_p^2 = .29$, with the main effect of Exposure Duration approaching significance, $F(3, 44) = 2.73$, $p = .06$, $\eta_p^2 = .16$. Participants responded more slowly for angry expressions than for happy expressions and demonstrated slowest performance in the incongruent condition relative to the congruent, isolated and neutral conditions, ps $< .05$.

In addition, the two-way interaction of Exposure Duration and Stimulus Type was reliable, $F(9, 132) = 2.62$, $p < .01$, $\eta_p^2 = .15$, as was the interaction between Expression and Stimulus Type, $F(3, 132) = 2.90$ $p < .05$, $\eta_p^2 = .06$. No other interactions were reliable.

A separate ANOVA and planned comparisons were performed for the happy expression trials. There was a main effect of Stimulus Type, $F(3, 132) = 18.15$, $p < .001$, $\eta_p^2 = .29$, and a significant interaction between Stimulus Type and Exposure Duration, $F(9, 132) = 5.22$, $p < .001$, $\eta_p^2 = .26$; the main effect of Exposure Duration approached significance, $F(3, 44)$, 2.78, $p = .05$, $\eta_p^2 = .16$. At the 20 ms exposure duration, participants were faster in the congruent and neutral conditions relative to the isolated and incongruent conditions, $p < .05$. At 60, 100 and 140 ms exposure conditions, participants were slower in the incongruent happy condition compared to isolated and neutral baseline conditions and the congruent conditions, ps $< .05$. No other differences were reliable (see Table 2).

An ANOVA and planned comparisons were also performed for the angry expressions. Overall, there was a main effect of Stimulus Type, $F(3, 132) = 8.23$, $p < .001$, $\eta_p^2 = .16$, but neither the main effect of Exposure Duration, $F(3, 44) = 1.51$, $p > .05$, $\eta_p^2 = .09$, nor the interaction between Stimulus Type and Exposure Duration, $F(9, 132) = 0.63$, $p > .05$, $\eta_p^2 = .04$, were reliable. At 20 ms, participants were faster to identify the angry expression in the neutral condition than the congruent condition, $p < .05$. No difference was found between the incongruent condition and the neutral and isolated baseline conditions. At 60 ms, reaction time was slower in the incongruent condition compared to the neutral condition, $p < .05$. None of the other differences at 100 ms and at 140 ms were reliable.

In Experiment 2, we manipulated the exposure duration of the face stimulus from 20 ms in the shortest presentation condition to 140 ms in the longest condition. The effect of holistic interference emerged at shortest exposure duration of 20 ms for the angry expression and at the next shortest duration of 60 ms for the happy expression (see Figure 4). Early effects of holistic



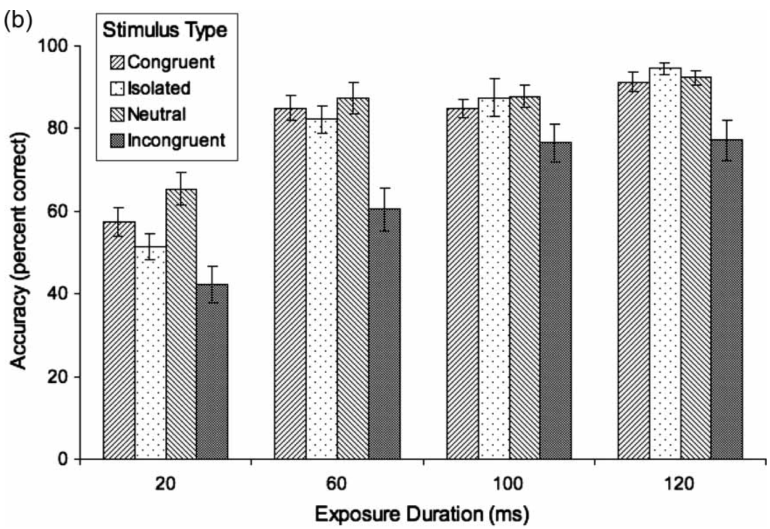


Figure 3. *Experiment 2 results. (a) Mean accuracy for labelling the happy expression in congruent, isolated, neutral and incongruent conditions under exposure durations of 20, 60, 100 and 140 ms. (b) Mean accuracy for labelling the angry expression in congruent, isolated, neutral and incongruent conditions under exposure durations of 20, 60, 100 and 140 ms.*

interference are consistent with the findings from the face identity studies (Anaki et al., 2007; Richler et al., 2009; Singer & Sheinberg, 2006). In contrast, there was little evidence of holistic facilitation as no differences were found between the congruent condition and the baseline conditions at any of the exposure durations. These data are consistent with the claim that incongruent expressions are perceived holistically as evidenced by interference effects and the congruent expressions are perceived analytically as indicated by the absence of holistic facilitation.

Consistent with Experiment 1 results, Experiment 2 demonstrated a happy advantage where

Table 2. *Experiment 2: Mean reaction times on correct trials (ms) and standard errors (in parentheses) for happy expressions and angry expressions presented at four exposure durations of 20, 60, 100, and 140 ms in the congruent, isolated, neutral and incongruent conditions*

	Exposure duration (ms)			
	20	*60*	*100*	*140*
Happy expression				
a. Congruent	$551^{b,d}$ ms (31)	558^{d} ms (41)	412^{d} ms (44)	503^{d} ms (66)
b. Isolated	647^{a} ms (46)	584^{d} ms (51)	407^{d} ms (43)	459^{d} ms (51)
c. Neutral	$512^{b,d}$ ms (22)	564^{d} ms (41)	422^{d} ms (43)	496^{d} ms (67)
d. Incongruent	561^{a} ms (32)	$770^{a,b,c}$ ms (69)	$491^{a,b,c}$ ms (57)	$620^{a,b,c}$ ms (86)
Angry expression				
a. Congruent	745^{c} ms (54)	734 ms (57)	565 ms (66)	663 ms (72)
b. Isolated	629 ms (67)	703 ms (42)	546 ms (60)	571 ms (40)
c. Neutral	627^{a} ms (54)	682^{d} ms (46)	545 ms (77)	594 ms (39)
d. Incongruent	705 ms (101)	836^{c} ms (83)	626 ms (82)	717 ms (76)

Note: The superscripts indicate conditions that are reliably different from one another, $p < .05$.

the bottom happy expression was more quickly and accurately identified than the top angry expression. The happy advantage is consistent with other studies demonstrating a happy superiority effect in expression detection studies (Calvo & Lundqvist, 2008; Juth, Lundqvist, Karlsson, & Öhman, 2005; Leppänen, Kauppinen, Peltola, & Hietanen, 2004; Milders, Sahraie, Logan, & Donnellon, 2008). The happy expression also exerted a greater and earlier interference effect on the recognition of the angry expression than the interference of the angry expression on the recognition of happy expression. The interference of happy expression (by the angry expression) emerged after a 60 ms exposure duration (shown in Figure 4a) whereas interference of the angry expression (by the happy expression) occurred at the earliest exposure duration of 20 ms (as shown in Figure 4b).

EXPERIMENT 3: RECOGNITION OF EXPRESSION IN SPATIALLY ALIGNED AND MISALIGNED FACES

In Experiment 3, holistic perception was directly manipulated by aligning or misaligning the upper and lower halves of the composite expression. According to the holistic view, when the top and bottom halves are aligned, the face is integrated in a holistic percept. When the halves are misaligned, their information cannot be easily combined in a holistic representation and are therefore perceived more analytically. Following the procedure employed in Experiments 1 and 2, participants in Experiment 3 were asked to report the expression in the target half of the face while ignoring the information in the other non-target half. Previous experiments have shown that for incongruent expressions, participants displayed holistic interference where they were slower and less accurate when the faces are aligned than misaligned (Calder et al., 2000) or inverted (Calder & Jansen, 2005). Similarly, for congruent expressions, participants showed evidence of holistic facilitation where they were faster and more accurate in the aligned condition than the misaligned condition (White, 2000).

Method

Participants. Twenty-four undergraduate students at the University of Victoria (including 6 men; mean age = 20 years of age, range 19–22 years) participated in this study for course credit. All participants had normal or corrected-to-normal vision.

Materials. Stimuli were the congruent and incongruent facial expressions from Experiment 1.

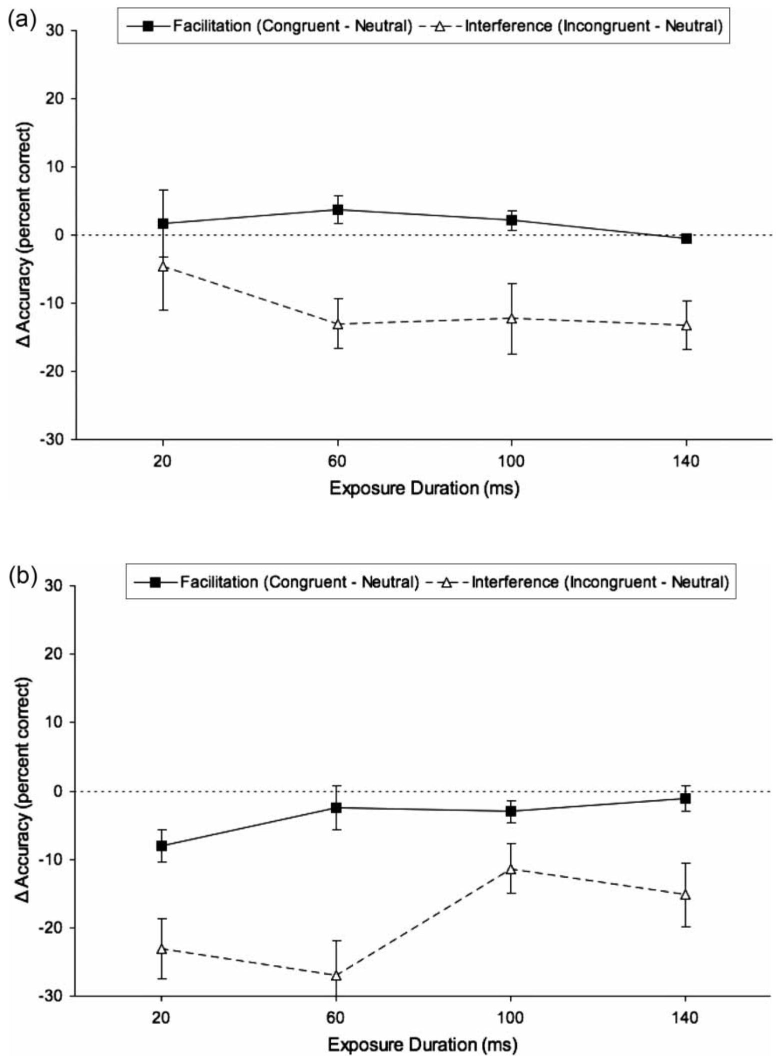


Figure 4. *Effects of facilitation and interference demonstrated in Experiment 2. (a) The happy expression. Facilitation was measured as the mean difference in labelling accuracy between the congruent condition and baseline performance, i.e., either congruent minus neutral (top) or congruent minus isolated (bottom). Interference was measured as the mean difference in accuracy between the incongruent condition and baseline performance, incongruent minus neutral or incongruent minus isolated. (b) The angry expression. Facilitation was measured as the mean difference in labelling accuracy between the congruent condition and baseline performance, i.e., either congruent minus neutral (top) or congruent minus isolated (bottom). Interference was measured as the mean difference in accuracy between the incongruent condition and baseline performance, incongruent minus neutral or incongruent minus isolated. Error bars indicate standard error of the mean.*

Each of the faces was then split horizontally to create the misaligned set. The misaligned stimuli were created by cutting the images in half at the bridge of the nose and then moving the bottom half of the image to the right until the ear and nose were aligned (see Figure 5).

Design. A within-subjects design was used with the factors of Alignment (aligned, misaligned), Congruency (congruent, incongruent) and Expression (happy, angry). The 256 trials were randomly presented in 4 blocks of 128 trials. The to-be-attended region (top vs. bottom) was alternated across blocks with half of the participants instructed to attend to the top region in the first block whereas the other half were initially instructed to attend to the bottom region. Percentage correct and mean reaction time for correct trials were recorded. The experiment assessed performance in 128 strong expression trials only; the remaining 128 weak expression catch trials were not analysed.

Procedure. The participant sat in a darkened room with his or her eyes approximately 60 cm from a 15-inch LG Flatron F700P monitor on which the faces were presented by a PC computer and E-Prime software. At the beginning of each block of trials, the participant were told that their task was to label the top or bottom region of the face as either angry or happy. Each trial began with the presentation of a red fixation cross in the centre of the screen for 250 ms. Then, a face stimulus was presented until a response was made, followed by a 500 ms inter-trial interval. From a viewing distance of 60 cm, the misaligned images subtended a visual angle of approximately 7 and 8 degrees along the horizontal and vertical axes, respectively, whereas the aligned images subtended a visual angle of 6 and 8 degrees in the horizontal and vertical dimensions, respectively. Participants responded by pressing a button labelled with "A" for angry or "H" for happy on a serial response box.

Results and discussion

The analysis was conducted on strong expression trials only (i.e., weak expression catch trials were not analysed).

Accuracy. Results of the composite task are shown in Figure 6. An ANOVA showed a reliable main effect of Alignment, $F(1, 23) = 14.82$, $MS = 510$, $p < .01$, $\eta_p^2 = .39$, demonstrating that participants performed more accurately in the misaligned than in the aligned condition. The main effects of Congruency, $F(1, 23) = 3.54$, $MS = 523$, $p = .07$ $\eta_p^2 = .13$, and Expression, $F(1, 23) = 3.97$, $MS = 732$, $p = .06$, $\eta_p^2 = .15$, approached reliable levels. The interaction between Congruency and Alignment also approached reliable levels, $F(1, 23) = 3.38$, $MS = 231$, $p = .08$, $\eta_p^2 = .13$. There was a reliable interaction between Congruency and Expression, $F(1, 23) = 4.67$, $MS = 273$ $p < .05$, $\eta_p^2 = .17$. No other interactions reached reliable levels.

Separate ANOVAs were performed on happy and angry expressions. For happy expressions, the main effect of Alignment, $F(1, 23) = 9.58$, $p < .01$, $\eta_p^2 = .29$, was reliable, but not Congruency, $F(1, 23) = 1.31$, $p > .10$, $\eta_p^2 = .05$. The interaction between Congruency and Alignment was not reliable, $F(1, 23) = 2.92$, $p > .10$, $\eta_p^2 = .11$. For the angry expression, the main

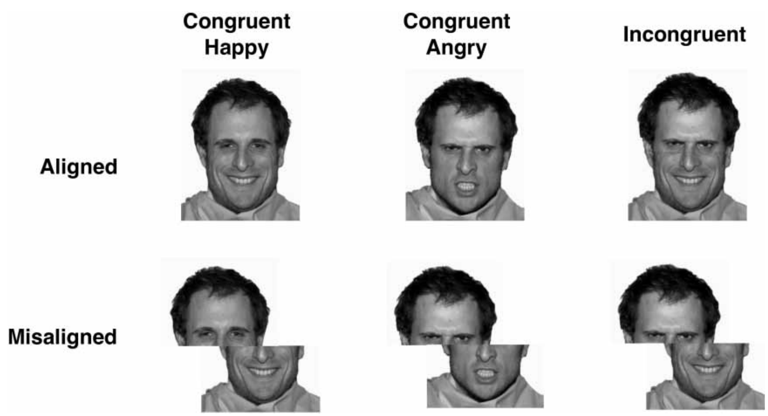


Figure 5. *Examples of congruent happy, congruent angry and incongruent expressions in the aligned and misaligned conditions used in Experiment 3.*

effect of Congruency, $F(1,\ 23) = 10.11$, $p < 01$, $\eta_p^2 = .31$, was reliable. Neither the effect of Alignment, $F(1,\ 23) = 1.42$, $p > .10$, $\eta_p^2 = .06$, nor the interaction between Alignment and Congruency, $F(1,\ 23) = 1.55$, $p > .10$, $\eta_p^2 = .06$, were reliable.

Reaction time. An ANOVA of the reaction-time data revealed that the main effects of Congruency, $F(1,\ 23) = 2.96$, $MS = 96{,}750$, $p = .09$, $\eta_p^2 = .11$, and Expression, $F(1,\ 23) = 3.90$, $MS = 507{,}174$, $p = .06$, $\eta_p^2 = 15$, approached reliable levels. The main effect of Alignment was reliable, $F(1,\ 23) = 8.85$, $MS = 745{,}506$, $p < .01$, $\eta_p^2 = .29$. Critically, the interaction between Alignment and Congruency was reliable, $F(1,\ 23) = 7.92$, $MS = 95{,}922.08$, $p < .01$, $\eta_p^2 = .26$. When the top and bottom halves of congruent and incongruent were misaligned, there was no difference in reaction time, $p > .05$. However, when the halves were aligned, participants were reliably slower to identify incongruent expressions than congruent expressions, $p < .01$. No other interactions were reliable (as shown in Table 3).

A separate ANOVA for the happy expressions showed a reliable main effect of Alignment, $F(1,\ 23) = 6.48$, $p < .02$, $\eta_p^2 = .22$, but not Congruency, $F(1,\ 23) = 0.705$, $p > .10$, $\eta_p^2 = .03$. However, the interaction between Congruency and Alignment $F(1,\ 23) = 6.51$, $p < .02$, $\eta_p^2 = .22$, showed that alignment had a larger negative impact on the recognition speed of incongruent than congruent expressions. For angry expressions, the main effects of Alignment, $F(1,\ 23) = 8.90$, $p < .01$, $\eta_p^2 = .28$, and Congruency, $F(1,\ 23) = 6.29$, $p < .02$, $\eta_p^2 = .22$, were reliable. The interaction between Alignment and Congruency was also reliable, $F(1,\ 23) = 4.30$, $p < .05$, $\eta_p^2 = .16$, showing that the speed of recognising an angry expression was affected more by misalignment when displayed in an incongruent than in a congruent expression.

In Experiment 3, it was found that incongruent expressions were more slowly and less accurately identified in the aligned condition than the misaligned condition. This result replicates previous findings (Calder & Jansen, 2005; Calder et al., 2000; White, 2000) suggesting that the holistic impression of incongruent expressions interferes with access to expression information. In contrast, for faces depicting a congruent expression, there was no difference between the aligned and misaligned condition in terms of accuracy. Interestingly, reaction time was actually faster in the misaligned than the aligned condition; hence, there was no evidence of holistic facilitation. The absence of a facilitation effect for congruent faces differs from the previous findings of White (2000), where he found that reaction times were 33 ms faster in the aligned condition than the misaligned condition. In contrast, we found that reactions were 80 ms *slower* in the aligned than misaligned condition in Experiment 3.

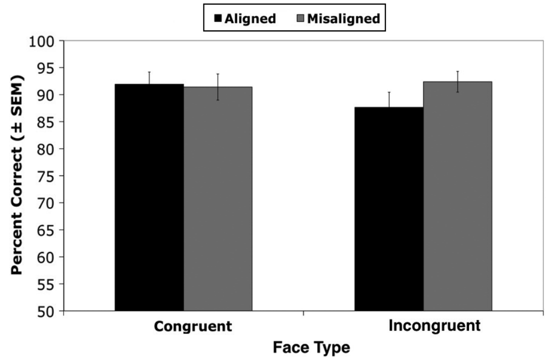


Figure 6. *Experiment 3 results. Mean accuracy for identifying expression halves that are aligned and misaligned and in congruent and incongruent expressions.*

What might explain the divergent findings between the two studies? Whereas the current experiment tested holistic recognition of happy and angry, White (2000) examined holistic recognition of happy, angry, sad and afraid. Previous results have shown that angry and fear are more recognisable from information in the top half of the face, happy is more recognisable from information in the bottom half whereas sad relies on information in both the top and bottom halves of the face (Bassili, 1979; Calder et al., 2000; Smith et al., 2005). The distribution of information across the top and bottom halves for the sad expression in the White study (2000) might have induced a more holistic strategy than the more

Table 3. *Experiment 3: Mean reaction times and standard error of the means for congruent and incongruent expressions with top and bottom halves that were spatially aligned or misaligned*

	Expression	
	Happy	*Angry*
a. Congruent aligned	993^{b} ms (113)	854^{b} ms (45)
b. Congruent misaligned	872^{a} ms (64)	806^{a} ms (51)
c. Incongruent aligned	1088^{d} ms (113)	929^{d} ms (52)
d. Incongruent misaligned	867^{c} ms (57)	821^{c} ms (43)

Note: The superscripts indicate conditions that are reliably different from one another, $p < .05$.

analytic strategy employed by participants in the current experiment.

GENERAL DISCUSSION

The goal of the current study was to examine holistic and analytic routes to expression recognition. In these experiments, participants were asked to report the expression in either the target top or bottom half of the face while ignoring information in the non-target face half. Holistic processing was defined as the degree to which the identification of the expression in the target half was influenced by information in the irrelevant non-target portion relative to identification in the baseline isolated and neutral conditions. Analytic processing was measured as the degree to which identification of the target expression was similar to its identification in the baseline isolated and neutral conditions. The main result of Experiment 1 was that participants were equally fast and accurate to identify the diagnostic halves of happy and angry expressions (happy/bottom; angry/top) in a congruent expression face, in isolation or in a neutral face. However, participants were slower and less accurate identifying the same diagnostic expression half (e.g., happy bottom) when shown in an incongruent expression compared to the isolated and neutral baseline conditions. In Experiment 2, congruent and incongruent expressions were compared against isolated and neutral baseline expressions presented at four exposure durations (20, 60, 100 and 140 ms). Evidence of holistic interference emerged at the 20 ms for angry expressions and 60 ms for happy expressions. However, there was no evidence to indicate the presence of holistic facilitation at any of the four exposure durations. Finally, in Experiment 3, holistic and analytic perception was directly manipulated by spatially aligning and misaligning the top and bottom halves of the composite expression. Consistent with the results from Experiments 1 and 2, holistic interference was found for the incongruent expressions as indicated by a slower response and less accurate in the aligned than misaligned conditions. In contrast, no evidence of holistic facilitation for congruent expressions was observed.

The collective results from these experiments clarify the conditions in which an expression is perceived holistically or analytically. When emotional information is conflicting, the identification of a facial expression is slower, less accurate and more holistic. The holistic findings corroborate results from previous studies (Calder & Jansen, 2005; Calder et al., 2000; White, 2000) indicating that the identification of expression often integrates information from the entire face.

In contrast to the evidence for the holistic processing of incongruent expressions, we did not find any evidence to suggest that congruent expressions of the happy and angry emotions were processed holistically. The absence of holistic facilitation in the congruent expression condition is not consistent with results reported by White (2000). However, in the White study, the basic emotions of sadness whose diagnostic features are distributed over the entire face (Bassili, 1979; Cottrell et al., 2002; Smith et al., 2005) was tested along with the happy, angry and frightened faces. In contrast, the current experiments focused solely on the emotions of angry and happy whose diagnostic information is localised to discrete face regions (angry – top half; happy – bottom half). Our results suggest that when diagnostic information is restricted to a local region, expression recognition can proceed in an analytic fashion. According to this account, analytic processes may extend to the perception of other expressions besides angry and happy. For example, the diagnostic information for the expression of "fear" is concentrated in the upper face region whereas the diagnostic information for "disgust" is located in the lower region. It remains an open question whether these top and bottom expressions are perceived analytically or holistically.

The collective results from our experiments suggest that the routes to expression recognition are both holistic and analytic. In Experiments 1 and 2, when participants were asked to judge the expression in one half of the face, contradictory information in the other half impaired performance as evidenced by slower reaction times and poorer accuracy. According to the holistic view, the incongruent expression composite interfered with the participants' ability to attend to the target half of the face and disregard information in the non-target half. The holistic view was further supported by the findings of Experiment 3, where the interference effect was eliminated when the top and bottom face halves were spatially misaligned, which functionally disrupted the effects of whole face interference.

Under certain conditions, expression recognition is analytic, relying more on local parts than whole face information. In Experiments 1 and 2, we tested two types of analytic baseline conditions. In the isolated baseline condition, only the top half of the angry expression or the bottom half of the happy expression was shown. This was considered a "pure" analytic condition because the stimulus lacked whole face information and contained only the diagnostic half of the expression. The second baseline condition was a whole face stimulus where the diagnostic half (angry-top and happy-bottom) was combined with a neutral half. It is conceivable that the composite neutral face might induce a slight inference effect because the whole face was not an exact match of the prototypical happy or angry expression. However, we did not find reliable differences between the isolated and whole-face conditions. We found that whether shown in isolation or combined with a neutral face, the diagnostic face halves were categorised as quickly and accurately as the whole face, congruent expressions. Hence, in contrast to the holistic interference demonstrated for incongruent expressions, there was no evidence of holistic facilitation in the congruent conditions and, thus, compatible with an analytic processing view. In Experiment 3, the misaligned congruent expressions were, in fact, identified more quickly and more accurately in their aligned versions providing further evidence that congruent expressions are categorised on parts-based information.

However, the current results present something of a paradox: On the one hand, the strong halves of happy and angry expressions are perceived analytically in a congruent or neutral face. On the other hand, the analytic decision is based on the congruency of whole-face information from both halves of the face. Hence, the analytic perception is contingent on whole-face information. This apparent contradiction can be resolved by positing an earlier stage in processing where the whole face stimulus is rapidly appraised in terms of its emotional content. At this early juncture, if the expression in the target half of the face is unequivocal, classification of the expression can be accomplished rapidly without influence from the irrelevant portion of the face. However, if the facial expression is vague or if information is conflicting, expression processing is slowed and susceptible to the effects of holistic information. Reaction-time data from the current experiments provide support for the speeded analytic recognition where participants were faster to classify a strong expression in a congruent face, isolated or neutral face than to classify the same strong expression in an incongruent face. Thus, the latency findings are compatible with the notion that facial expressions can be interpreted via a fast, analytic route of processing or a slower, holistic route.

In conclusion, the reported experiments demonstrate that the perception of facial expressions is not strictly holistic or analytic. It is probably more accurate to characterise emotion recognition as lying on an analytic to holistic processing continuum (Farah, 1991). When a happy or angry expression is presented clearly and unambiguously, its interpretation can proceed quickly in a parts-based or analytic manner. On other occasions, when emotional information is incongruous, vague or ambiguous, holistic face processes are engaged. Given the idiosyncratic and variable nature of everyday facial emotions, it is likely that holistic processing of facial expression is the rule rather than the exception. However, the current results indicate that holistic processing of facial expression is not mandatory. For the expressions of happy and angry when the information is clear-cut, perception of facial affect can be fast, precise and analytic.

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