The Effect of Group Information on Facial Expression Recognition

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Abstract

This study investigated the influence of group information on facial expression recognition through three experiments. The results revealed: (1) The emotional state of surrounding faces influenced individuals' recognition of the target face's emotion; reaction times were significantly shorter when the emotions were congruent compared to when they were incongruent, and facial expression recognition accuracy was higher. (2) Group information modulated the influence of surrounding faces' emotions on the target face, thereby affecting facial expression recognition. Specifically, under group conditions, individuals' recognition of target facial expressions was influenced by the emotional state of surrounding faces; when the emotions of surrounding faces and the target face were congruent—i.e., consistent with individuals' expectation of emotional consistency among group members established based on perceptual cues—facial expression recognition accuracy was higher and speed was faster; whereas under non-group conditions, individuals were not influenced by the emotional state of surrounding faces. The findings indicate that individuals can recognize facial emotions based on social relationships between interacting individuals; when a group is present, an expectation of emotional consistency among group members is established, which in turn influences facial expression recognition.

Full Text

Influence of Group Information on Facial Expression Recognition

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Abstract

This study investigated the influence of group information on facial expression recognition through three experiments. The findings revealed: (1) The emotional state of surrounding faces influenced individuals' recognition of target facial emotions, with significantly shorter reaction times and higher accuracy when emotions were congruent compared to incongruent conditions. (2) Group information moderated the influence of surrounding facial emotions on target faces, thereby affecting facial expression recognition. Specifically, under group conditions, individuals' recognition of target facial expressions was influenced by the emotional state of surrounding faces. When the surrounding and target faces expressed congruent emotions—aligning with individuals' expectation that group members share emotional consistency based on perceptual cues—facial expression recognition was more accurate and faster. Under non-group conditions, however, individuals were unaffected by the emotional state of surrounding faces. These results demonstrate that individuals can recognize facial emotions based on social relationships between interactive agents. When a group is present, individuals develop an expectation of emotional consistency among group members, which subsequently influences facial expression recognition.

Keywords: facial expression, group information, emotion recognition, emotion congruency, expectation

Emotions arise from interactions between individuals, and accurate recognition of facial expressions significantly impacts social interaction processes (Keltner & Haidt, 1999; Van Kleef, 2009). Previous research has predominantly relied on emotion category theory (Ekman, 1993), presenting facial expressions in isolation to examine how individuals process facial expressions (Adolphs, 2002; Susskind et al., 2007).

Recent studies have found that facial expression recognition depends not only on facial configuration information but also on contextual cues from scenes, body postures, language, and other faces (Aviezer et al., 2008; Gray et al., 2017; Lindquist & Gendron, 2013; Mumenthaler & Sander, 2012; Wieser & Brosch, 2012). In real-life interactions, individuals typically recognize others' facial expressions within social contexts. As a contextual factor in social interaction, whether and how group information influences facial expression recognition remains unclear. Therefore, this study aimed to explore the impact of group information on facial expression recognition.

Extensive research demonstrates that facial expression recognition is not an isolated process; contextual information from beyond the face plays a crucial role (Cao et al., 2023; Gray et al., 2017; Lindquist & Gendron, 2013; Mumenthaler

& Sander, 2012; Wieser & Brosch, 2012), a phenomenon known as context effects in facial expression recognition. These effects manifest as facilitation when context and facial emotions are congruent and interference when they are incongruent (Aviezer et al., 2008; Li et al., 2020; Xu et al., 2014). During real-world interactions, faces often appear within group contexts. Previous studies have examined how group facial emotions influence the processing of target faces within groups (Griffiths et al., 2018), finding that individuals encode group emotions while encoding target face emotions, which subsequently affects memory for target face emotion intensity, biasing it toward the group average. For example, when individuals observe a slightly angry person among a group of more angry people, their memory of the target's emotional state becomes angrier than reality. This effect also appears in facial attractiveness evaluations (Carragher et al., 2021; Walker & Vul, 2013; Ying et al., 2019). These findings indicate that holistic representations of group faces influence encoding of target faces within groups, reflecting integrated processing of group faces. However, no research has investigated the specific influence of group information on facial expression recognition from the perspective of different group attributes.

As a dynamic social structure, groups consist of group members (individuals) whose behavior often results from interactions with others in the social context (Lewin, 1997; Scott, 2017). Research shows that observers can form group information based on stereotypes and also generate perceptions of group existence and boundaries through perceptual cues such as spatial proximity, similarity, and common fate (Campbell, 1958; Morewedge et al., 2013; Sweeny et al., 2013; Xu et al., 2019), thereby perceiving group information. This ability to perceive group information exists from early life stages (Powell & Spelke, 2013), indicating that humans can extract group information through perceptual cues. Studies have found that group information formed through perceptual cues plays an important role in cognitive processing. Dang et al. (2018) manipulated group information through spatial proximity and similarity of group members, finding that participants perceived members of the same group as warmer and more competent. Xu et al. (2019) also found that group perceptions based on perceptual cues led individuals to develop expectations of behavioral consistency among group members. This evidence suggests that group information formed through perceptual cues influences cognitive processing. Based on this, we hypothesized that group information would influence facial expression recognition, an extremely important aspect of cognitive processing.

Furthermore, this study explored how group information influences facial expression recognition. Previous research found that when individuals interact with ingroup members, they can infer unknown attributes of a member based on known attributes of other ingroup members, assuming the member possesses those attributes (Xu et al., 2019). Additionally, when predicting individual behavior in groups, observers tend to make inferences consistent with other group members (Todd et al., 2012). Does the emotional state of other faces in a group similarly influence individuals' recognition of target facial emotions? That is, when a group is present, do individuals infer target facial emotions based on other members' emotional states, but not when no group is present? Research supports this question. Mumenthaler and Sander (2012) found that when surrounding faces' gaze direction pointed toward the target face—indicating social evaluation—not only was the emotion congruency effect enhanced, but accuracy in recognizing target faces also improved when surrounding and target face emotions were functionally related. This study suggested that individuals use connections between faces to judge target face emotions. Subsequently, Mumenthaler et al. (2018) manipulated connections between surrounding and target individuals by changing head orientation, finding that observers only made faster judgments of target emotions when surrounding individuals turned toward the target and emotions were congruent. Gray et al. (2017) obtained similar results by manipulating interactions between target and surrounding individuals through head orientation. Researchers argued that individuals use surrounding individuals' emotional states to infer target face emotions, and this inference only occurs when a certain social interaction relationship exists. Similarly, when individuals perceive surrounding and target faces as belonging to the same group, other group members' emotional states may influence judgments of target face emotions. Therefore, we hypothesized that group information would moderate the influence of surrounding facial emotions on target faces, thereby affecting facial expression recognition.

In summary, this study hypothesized that group information moderates the influence of surrounding facial emotional states on target faces, thereby affecting facial expression recognition. Specifically, under group conditions, the emotional state of surrounding faces influences individuals' judgments of target facial emotions, producing a context effect in emotion recognition—that is, higher accuracy and faster speed when emotions are congruent compared to incongruent. Under non-group conditions, however, surrounding facial emotional states do not influence individuals' judgments of target facial emotions.

Experiment 1: Multiple-Choice Task

Participants

Sample size was calculated using G*Power 3.1 (Faul et al., 2007) with the following parameters: repeated-measures ANOVA, effect size f = 0.25, statistical power 1-$\beta = 0.9$, $\alpha = 0.05$, and number of measurements = 6, yielding a required sample size of 24. Twenty-nine college students (16 females, mean age = 20 ± 1.8 years) were recruited. All participants were native Chinese speakers with normal or corrected-to-normal vision, no color blindness, right-handed, and no history of psychiatric disorders. Participants read and signed informed consent forms before the experiment and received compensation upon completion.

Stimuli and Apparatus

Facial expression images were selected from the NimStim Face Stimulus Set (Tottenham et al., 2009), including 15 happy, 15 fearful, and 15 neutral expressions

(8 males, 7 females). Images were processed in grayscale using Photoshop CS6 to standardize size, brightness, and contrast. All facial materials were cropped to retain only internal facial features (eyes, nose, mouth, cheeks, etc.) while removing hair and ears. Thirty-one participants who did not participate in the formal experiment rated the valence (1 = very negative, 9 = very positive) and arousal (1 = very calm, 9 = very excited) of the facial expression images on a 1-9 scale. Results showed significant differences in valence between happy and fearful faces (happy: $M = 6.71$, $SD = 0.88$; fearful: $M = 3.80$, $SD = 1.48$; $t(29) = 8.05$, $p < 0.001$), but no significant differences in arousal (happy: $M = 6.22$, $SD = 1.29$; fearful: $M = 5.89$, $SD = 1.51$; $t(29) = 1.77$, $p = 0.09$), meeting experimental requirements.

Triangles of different colors were created as body figures using Photoshop: red (RGB: 255, 0, 0), green (RGB: 0, 255, 0), and blue (RGB: 0, 0, 255). During the experiment, bodies and faces were automatically combined.

Stimuli were presented on a 24-inch LED monitor (BenQ XL2430-b) with a vertical refresh rate of 60 Hz. Participants were seated approximately 70 cm from the screen.

Design

A 2 (facial expression: happy, fearful) × 3 (group cue: group, non-group, control) within-subjects design was employed. Dependent variables were the congruence index and discrimination index calculated from slider ratings, following Cristinzio et al. (2010) and Mumenthaler and Sander (2012). The congruence index was calculated by scoring the "correct" facial expression dimension—for example, for a happy face trial, only the "happy" dimension rating on the emotion scale was calculated. The discrimination index was calculated by subtracting the average rating of "incorrect" expression dimensions from the "correct" dimension rating. For a happy face trial, the happy dimension rating was calculated first, then the average of the other five dimensions (anger, surprise, fear, sadness, disgust) was computed, and the latter was subtracted from the former to obtain the discrimination index for that trial. These indices better describe participants' accuracy in judging target facial emotions across different experimental conditions, with higher congruence and discrimination indices indicating more accurate recognition.

The experiment included six conditions: group + happy face, group + fearful face, non-group + happy face, non-group + fearful face, control + happy face, and control + fearful face. Each condition comprised 45 trials, for a total of 270 trials presented randomly. Participants took a break after every 30 trials.

Stimuli were presented and behavioral data recorded using PsychoPy software. The presentation sequence was as follows: First, a fixation cross "+" appeared for 1100-1300 ms (randomized, 1.5° visual angle). In group and non-group conditions, three figures with neutral facial expressions (5.1° × 4.1° visual angle) of random gender were then presented and moved according to specific requirements for 3000 ms: (1) In group conditions, three figures with identical body colors moved in regular circular motion around the center; (2) In non-group conditions, three figures with different body colors moved randomly toward the screen edges. In control conditions, only the fixation cross "+" was presented. The three figures' initial positions were at the vertices of an equilateral triangle (side length = 4.9° visual angle) centered on the screen. After movement, the figures disappeared and a fixation cross "+" appeared for 500 ms. Subsequently, in group and non-group conditions, the three previously presented figures reappeared at the screen center (500 ms) displaying identical facial expressions (happy or fearful), with 5.3° separation between faces. In control conditions, only the central figure was presented. Finally, participants rated the central figure's emotion on a six-emotion scale (anger, happiness, surprise, fear, sadness, disgust). The scale's horizontal dimension represented continuous intensity, with "none" on the left and "a lot" on the right. Participants clicked on the scale to reveal a slider, which they dragged to indicate emotion intensity (Cristinzio et al., 2010; Mumenthaler & Sander, 2012). Pressing the spacebar ended the rating and initiated the next trial (see Figure 1 [Figure 1: see original paper]). The order of the six emotions was fixed within participants but randomized between participants.

Group Manipulation Check

Experiment 1 manipulated group information through movement trajectories (group: circular motion around screen center; non-group: random diffusion toward edges) and body colors (group: uniform red, green, or blue; non-group: random red, green, blue assignment). To verify the effectiveness of the group manipulation, following previous research (Yin et al., 2022; Xu et al., 2019), 50 participants (25 per group) who did not participate in the formal experiment watched videos of either the "group cue presentation phase" (12 females, mean age = 23.08 ± 1.85 years) or "non-group cue presentation phase" (13 females, mean age = 23.96 ± 1.46 years). They rated the degree to which the three figures belonged to the same group using seven items measuring group entitativity (Campbell, 1958). The seven items were based on definitions and characteristics of group entitativity (Campbell, 1958; Crawford et al., 2002): (1) having common goals; (2) having common needs; (3) interdependence; (4) mutual influence; (5) acting according to rules; (6) close connections; (7) mutual acceptance. Participants rated each item on a 1-7 scale (1 = completely disagree, 7 = completely agree), with higher scores indicating greater perceived entitativity.

Results showed internal consistency coefficients for the seven items of $\alpha = 0.80$ for group cues and $\alpha = 0.85$ for non-group cues. An independent samples t-test on mean entitativity ratings revealed significantly higher scores in the group condition (M = 5.07, SD = 0.77) than in the non-group condition (M = 2.63, SD = 1.04), $t(48) = 9.43$, $p < 0.001$, Cohen's $d = 0.91$. Participants perceived the three figures as belonging to the same group to a greater extent in the group condition, confirming effective manipulation.

Data were processed using Python 3.8, with trials exceeding 2.5 standard deviations from the condition mean excluded. SPSS 26.0 was used for repeated-measures ANOVA, with Greenhouse-Geisser correction applied when sphericity assumptions were violated and Bonferroni correction used for multiple comparisons.

Results

Congruence Index A 2 (facial expression: happy, fearful) × 3 (group cue: group, non-group, control) repeated-measures ANOVA on congruence index revealed significant main effects of facial expression, $F(1, 28) = 71.98$, $p < 0.001$, 2 p = 0.72, with higher congruence scores for happy (5.12 ± 0.35) than fearful expressions (2.30 ± 0.35). The main effect of group cue was also significant, $F(2, 56) = 3.54$, $p = 0.036$, 2 p = 0.11. Post-hoc comparisons showed significantly higher congruence scores in the group condition (3.85 ± 0.33) than in the non-group condition (3.58 ± 0.30; $p = 0.011$), with no significant differences between control (3.69 ± 0.31) and group ($p = 0.58$) or non-group conditions ($p = 0.82$). The interaction between facial expression and group cue was not significant (see Figure 2 [Figure 2: see original paper]).

Discrimination Index A 2 (facial expression: happy, fearful) × 3 (group cue: group, non-group, control) repeated-measures ANOVA on discrimination index revealed significant main effects of facial expression, $F(1, 28) = 120.54$, $p < 0.001$, 2 p = 0.81, with higher discrimination scores for happy (4.89 ± 0.36) than fearful expressions (0.81 ± 0.32). The interaction between facial expression and group cue was significant, $F(2, 56) = 3.39$, $p = 0.041$, 2 p = 0.11. Simple effects analysis showed that when recognizing fearful target faces, discrimination scores were significantly higher in the control condition (0.80 ± 0.30) than in the non-group condition (0.45 ± 0.30; $p = 0.031$), with marginally higher scores in the group condition (0.75 ± 0.32) than in the non-group condition ($p = 0.07$), but no significant difference between group and control conditions ($p = 1.00$). When recognizing happy target faces, no significant differences emerged among group (5.00 ± 0.39), non-group (4.80 ± 0.36), and control (4.65 ± 0.39) conditions (ps > 0.05) (see Figure 3 [Figure 3: see original paper]).

Experiment 1, using a multiple-choice task, demonstrated that group information influences facial expression recognition. Specifically, congruence index scores were significantly higher in the group condition than in the non-group condition. For discrimination index scores, the group condition showed higher scores for fearful target faces compared to the non-group condition. Possible explanations include: First, fearful expression recognition is more susceptible to emotional contextual information than positive emotions (Li et al., 2019). Second, since both group and non-group conditions in Experiment 1 presented three emotionally congruent figures during the recognition phase, and previous research shows that congruent surrounding faces facilitate facial expression recognition (Mumenthaler & Sander, 2012), the prior presentation of group information through perceptual cues may have influenced how participants referenced surrounding figures' emotional states, thereby affecting facial expression recognition.

However, because Experiment 1's recognition phase differed across conditions in the number of figures and body colors, Experiment 2 further controlled these physical attribute differences across conditions by presenting three figures with randomly matched body colors in all conditions during the recognition phase. Additionally, we manipulated emotional congruency between surrounding and target faces to examine the combined influence of group information and emotional congruency on facial expression recognition.

Experiment 2: Influence of Group Information and Emotional Congruency on Facial Expression Recognition in a Multiple-Choice Task

Participants

Sample size was calculated using G*Power 3.1 (Faul et al., 2007) with parameters: repeated-measures ANOVA, effect size f = 0.25, power 1-β = 0.9, $\alpha = 0.05$, and number of measurements = 12, yielding a required sample of 16. Twenty-six college students (14 females, mean age = 21.15 $\pm$ 1.99 years) were recruited. All were native Chinese speakers with normal or corrected vision, no color blindness, right-handed, and no psychiatric history. Participants provided informed consent and received compensation.

Design

A 2 (facial expression: happy, fearful) $\times$ 3 (group cue: group, non-group, control) $\times$ 2 (emotional congruency between target and surrounding faces: congruent, incongruent) within-subjects design was employed. Dependent variables were congruence index and discrimination index.

The experiment included 12 conditions: group + happy target + congruent, group + happy target + incongruent, group + fearful target + congruent, group + fearful target + incongruent, non-group + happy target + congruent, non-group + happy target + incongruent, non-group + fearful target + congruent, non-group + fearful target + incongruent, control + happy target + congruent, control + happy target + incongruent, control + fearful target + congruent, and control + fearful target + incongruent. Each condition comprised 30 trials, for a total of 360 trials presented randomly. Participants took a break after every 60 trials. Total duration was approximately 1 hour.

Stimuli were presented using PsychoPy. The presentation sequence was: fixation cross "+" (1100-1300 ms randomized, 1.5° visual angle); three neutral-expression figures (5.1° $\times$ 4.1°) of random gender with randomly matched body colors (red, green, blue) in group and non-group conditions; group figures moved in regular circular motion around the center (3000 ms) while non-group figures moved randomly toward screen edges (3000 ms); control condition showed only the fixation cross "+". Initial positions were at the vertices of an equilateral triangle (side length = 4.9°) centered on the screen. After movement, figures disappeared and a fixation cross "+" appeared (500 ms).

During the facial expression recognition phase, differences from Experiment 1 included: (1) All three conditions presented three figure images (separated by 5.3°, 500 ms) with randomly matched body colors (group and non-group figures remained consistent with the group information phase), reducing perceptual grouping interference from physical cues; (2) Emotional congruency between surrounding and central figures was manipulated: in congruent conditions, all three figures showed the same expression (happy or fearful); in incongruent conditions, when the central figure was happy, surrounding figures were fearful, and vice versa. Finally, participants rated the central figure's emotion on the same six-emotion scale used in Experiment 1 (Cristinzio et al., 2010; Mumenthaler & Sander, 2012). Pressing the spacebar ended the rating and initiated the next trial (see Figure 4 [Figure 4: see original paper]).

Group Manipulation Check

Experiment 2 manipulated group information through movement trajectories (group: circular motion; non-group: random diffusion). Fifty participants (25 per group) who did not participate in the formal experiment watched videos of either the group cue or non-group cue presentation phases and rated group entitativity using the same seven items as in Experiment 1.

Results showed internal consistency coefficients of $\alpha = 0.83$ for group cues and $\alpha = 0.85$ for non-group cues. An independent samples t-test revealed significantly higher entitativity ratings in the group condition (M = 4.94, SD = 1.03) than in the non-group condition (M = 2.63, SD = 1.04), $t(48) = 7.86$, $p < 0.001$, Cohen's d = 1.04, confirming effective manipulation.

Data were processed using Python 3.8, excluding trials beyond 2.5 SD from condition means. SPSS 27.0 was used for repeated-measures ANOVA with Greenhouse-Geisser correction and Bonferroni correction for multiple comparisons.

Results

Congruence Index A 2 (facial expression: happy, fearful) × 3 (group cue: group, non-group, control) × 2 (emotional congruency: congruent, incongruent) repeated-measures ANOVA revealed significant main effects of facial expression, $F(1, 25) = 23.57$, $p < 0.001$, 2 p = 0.48; group cue, $F(2, 50) = 12.72$, $p < 0.001$, 2 p = 0.34; and emotional congruency, $F(1, 25) = 21.81$, $p < 0.001$, 2 p = 0.47.

The interaction between group cue and emotional congruency was significant,

$F(2, 50) = 4.23$, $p = 0.020$, 2 p = 0.15. Under group conditions, congruence index scores were significantly higher in congruent (4.55 ± 0.28) than incongruent conditions (4.23 ± 0.25; $p < 0.001$). Under non-group conditions, no significant difference emerged between congruent (4.20 ± 0.27) and incongruent conditions (4.09 ± 0.26; $p > 0.05$). Similarly, under control conditions, no significant difference appeared between congruent (4.18 ± 0.28) and incongruent conditions (4.11 ± 0.26; $p > 0.05$). Additionally, when target and surrounding faces were emotionally congruent, the group condition (4.55 ± 0.28) showed significantly higher congruence index scores than non-group (4.20 ± 0.27, $p = 0.001$) and control conditions (4.18 ± 0.28, $p < 0.001$), with no difference between non-group and control conditions ($p > 0.05$). When emotions were incongruent, no significant differences emerged among group (4.23 ± 0.25), non-group (4.09 ± 0.26), and control conditions (4.11 ± 0.26; ps > 0.05).

The interaction between group cue and facial expression was significant, $F(2, 50) = 4.30$, $p = 0.030$, 2 p = 0.15. For fearful expressions, congruence index scores were significantly higher in the group condition (3.73 ± 0.27) than in non-group (3.27 ± 0.28; $p < 0.001$) and control conditions (3.38 ± 0.26; $p < 0.001$), with no difference between non-group and control conditions ($p > 0.05$). For happy expressions, no significant differences emerged among group (5.05 ± 0.35), non-group (5.02 ± 0.32), and control conditions (4.91 ± 0.37; ps > 0.05). No other significant interactions were found (ps > 0.05) (see Figure 5 [Figure 5: see original paper]).

Discrimination Index A 2 (facial expression: happy, fearful) × 3 (group cue: group, non-group, control) × 2 (emotional congruency: congruent, incongruent) repeated-measures ANOVA revealed significant main effects of facial expression, $F(1, 25) = 66.48$, $p < 0.001$, 2 p = 0.73; group cue, $F(2, 50) = 13.15$, $p < 0.001$, 2 p = 0.35; and emotional congruency, $F(1, 25) = 22.30$, $p < 0.001$, 2 p = 0.47.

The interaction between group cue and emotional congruency was significant, $F(2, 50) = 3.79$, $p = 0.029$, 2 p = 0.13. Under group conditions, discrimination index scores were significantly higher in congruent (3.77 ± 0.26) than incongruent conditions (3.39 ± 0.24; $p < 0.001$). Under non-group conditions, no significant difference emerged between congruent (3.32 ± 0.25) and incongruent conditions (3.21 ± 0.24; $p > 0.05$). Similarly, under control conditions, no significant difference appeared between congruent (3.34 ± 0.27) and incongruent conditions (3.23 ± 0.26; $p > 0.05$). Additionally, when target and surrounding faces were emotionally congruent, the group condition (3.77 ± 0.26) showed significantly higher discrimination index scores than non-group (3.32 ± 0.25, $p = 0.001$) and control conditions (3.34 ± 0.27, $p = 0.001$), with no difference between non-group and control conditions ($p > 0.05$). When emotions were incongruent, no significant differences emerged among group (3.39 ± 0.24), non-group (3.21 ± 0.24), and control conditions (3.23 ± 0.26; ps > 0.05).

The interaction between group cue and facial expression was significant, F(2,

50) = 5.75, $p = 0.011$, 2 $p = 0.19$. For fearful expressions, discrimination index scores were significantly higher in the group condition (2.35 ± 0.24) than in non-group (1.78 ± 0.25; $p < 0.001$) and control conditions (1.93 ± 0.24; $p < 0.001$), with no difference between non-group and control conditions ($p > 0.05$). For happy expressions, no significant differences emerged among group (4.80 ± 0.35), non-group (4.75 ± 0.34), and control conditions (4.63 ± 0.38; ps > 0.05). No other significant interactions were found (ps > 0.05) (see Figure 6 [Figure 6: see original paper]).

Building upon Experiment 1, Experiment 2 controlled for physical attribute differences across conditions and manipulated emotional congruency between surrounding and target faces during the recognition phase. Similar to Experiment 1, Experiment 2 found that fearful expression recognition was more susceptible to group information influence than happy expression recognition, with significantly higher congruence and discrimination indices for fearful expressions under group versus non-group and control conditions. Importantly, Experiment 2 further demonstrated that emotional congruency between surrounding and target faces influenced target face emotion recognition, producing a context effect in emotion recognition—accuracy was significantly higher when emotions were congruent than incongruent. Group information moderated this effect: under group conditions, target face recognition accuracy was significantly higher when surrounding and target faces were emotionally congruent versus incongruent; under non-group conditions, this difference disappeared.

Furthermore, different experimental tasks in facial expression processing elicit distinct cognitive processes, with forced-choice tasks yielding higher accuracy and faster reaction times than free-labeling tasks (Betz et al., 2019). Therefore, Experiment 3 employed a two-alternative forced-choice task to investigate the influence of group information and emotional congruency on facial expression recognition.

Experiment 3: Influence of Group Information and Emotional Congruency on Facial Expression Recognition in a Forced-Choice Task

Participants

Sample size was calculated using G*Power 3.1 (Faul et al., 2007) with parameters: repeated-measures ANOVA, effect size f = 0.25, power 1-β = 0.9, $\alpha = 0.05$, and number of measurements = 12, yielding a required sample of 16. Thirty-two college students (15 females, mean age = 21.2 ± 1.6 years) were recruited. All were native Chinese speakers with normal or corrected vision, no color blindness, right-handed, and no psychiatric history. Participants provided informed consent and received compensation.

Design

A 2 (facial expression: happy, fearful) × 3 (group cue: group, non-group, control) × 2 (emotional congruency between target and surrounding faces: congruent, incongruent) within-subjects design was employed. Dependent variables were reaction time and accuracy.

The 12 experimental conditions matched those in Experiment 2, with 45 trials per condition, for a total of 540 trials presented randomly. Participants took a break after every 60 trials. Total duration was approximately 0.8 hours.

During the experiment, the procedure differed from Experiment 2 in that during the facial expression recognition phase, participants made keypress responses to classify the central figure's expression after stimulus presentation: "Q" for happy, "P" for fearful, with response mapping counterbalanced across participants. The figure images disappeared after keypress. If no response occurred within 1500 ms, it was recorded as an error and the image disappeared. After a random interval of 1200-1500 ms, the next trial began (see Figure 7 [Figure 7: see original paper]). All other procedures matched Experiment 2.

Group Manipulation Check

Identical to Experiment 2.

Data were processed using Python 3.8, excluding trials beyond 2.5 SD from condition means. SPSS 26.0 was used for repeated-measures ANOVA with Greenhouse-Geisser correction and Bonferroni correction for multiple comparisons.

Results

Reaction Time A 2 (emotional congruency: congruent, incongruent) × 3 (group cue: group, non-group, control) × 2 (facial expression: happy, fearful) repeated-measures ANOVA on reaction time revealed significant main effects of facial expression, $F(1, 31) = 19.63$, $p < 0.001$, 2 p = 0.39, with faster RTs for happy (M = 704.95 ms, SE = 12.55) than fearful expressions (M = 727.42 ms, SE = 12.57); group cue, $F(2, 62) = 140.24$, $p < 0.001$, 2 p = 0.82; and emotional congruency, $F(1, 31) = 25.74$, $p < 0.001$, 2 p = 0.45.

Importantly, the interaction between group cue and emotional congruency was significant, $F(2, 62) = 8.07$, $p < 0.001$, 2 p = 0.21. Simple effects tests showed that in control and group conditions, RTs were significantly shorter in congruent (control: M = 758.78 ms, SE = 11.71; group: M = 678.55 ms, SE = 12.64) than incongruent conditions (control: M = 782.12 ms, SE = 13.35, $p < 0.001$; group: M = 688.15 ms, SE = 13.38, $p = 0.008$). In non-group conditions, no significant difference emerged between congruent (M = 693.92 ms, SE = 13.01) and incongruent conditions (M = 695.59 ms, SE = 13.10; $p = 0.70$). Additionally, when target and surrounding faces were emotionally congruent, RTs in the group condition (M = 678.55 ms, SE = 12.64) were significantly shorter than in non-group (M = 693.92 ms, SE = 13.01, p = 0.004) and control conditions (M = 758.78 ms, SE = 11.71, p < 0.001). When emotions were incongruent, RTs in the group condition (M = 688.15 ms, SE = 13.38) were significantly shorter than in the control condition (M = 782.12 ms, SE = 13.35, p < 0.001), with no difference between group and non-group conditions (p = 0.27). No other significant main effects or interactions emerged (ps > 0.05) (see Figure 8 [Figure 8: see original paper]).

Accuracy A 2 (congruency: congruent, incongruent) × 3 (group: group, non-group, control) × 2 (facial expression: happy, fearful) repeated-measures ANOVA on accuracy revealed a marginally significant main effect of group, F(2, 62) = 3.20, p = 0.049, 2 p = 0.18, but no significant effects emerged in further analyses (ps > 0.05). No other significant main effects or interactions were found (ps > 0.05).

Experiment 3, using a two-alternative forced-choice task, further investigated the influence of group information and emotional congruency on facial expression recognition. Similar to Experiment 2, Experiment 3 found that group information moderated the emotion congruency effect: under group conditions, participants perceived target facial expressions faster when surrounding and target faces were emotionally congruent versus incongruent; this effect disappeared under non-group conditions.

General Discussion

This study examined the influence of group information on facial expression recognition and its specific manifestations. The findings revealed that surrounding faces' emotional states influence target face emotion recognition, producing an emotion congruency effect—recognition is faster and more accurate when surrounding and target faces are emotionally congruent versus incongruent.

Importantly, group information moderated the influence of surrounding faces' emotional states on target faces, thereby affecting facial expression recognition. Specifically: (1) Under group conditions, surrounding faces' emotional states served as a reference for recognizing target facial expressions. When surrounding and target faces expressed congruent emotions—aligning with individuals' expectation of emotional consistency among group members based on perceptual cues—facial expression recognition was faster and more accurate. (2) Under non-group conditions, surrounding faces' emotional states did not influence target face emotion judgments. Additionally, the study revealed a positive emotion advantage effect in facial expression recognition: happy expressions were recognized faster and more accurately than fearful expressions.

The study found that even in the control condition, which lacked group movement cues, surrounding faces' emotional states still influenced target face emotion recognition. Specifically, when surrounding and target faces were emotionally congruent, participants showed shorter RTs and higher accuracy than when emotions were incongruent. This result reflects context effects in facial expression recognition (Gray et al., 2017; Lindquist & Gendron, 2013; Mumenthaler & Sander, 2012; Wieser & Brosch, 2012; Xu et al., 2014), indicating that facial emotion perception is driven not only by facial configuration features but also by contextual influences.

Crucially, this study found that group information influences facial expression recognition by moderating the impact of surrounding faces' emotions on target faces. When individuals perceived target and surrounding faces as belonging to the same group, surrounding faces' emotional states became a reference for target face emotion recognition—recognition was faster and more accurate when emotions were congruent versus incongruent. When individuals perceived target and surrounding faces as not belonging to the same group, this effect disappeared. These results align with previous research. Mumenthaler and Sander (2012) found that when surrounding faces' gaze direction pointed toward the target face—indicating social evaluation—surrounding faces' emotional states influenced target face emotion recognition. In that study, surrounding faces' gaze provided interaction information, expressing social evaluation of the target face. Similar to this study, Gray et al. (2017) found that interactive relationships influence observers' recognition of target facial emotions. Emotional expression in interactive contexts reflects individuals' cognition and attitudes toward interaction partners (Pietroni et al., 2008; Van Kleef, 2009). Therefore, when surrounding and target individuals share a social interaction, observers use surrounding individuals' emotional states as an important reference for inferring target facial emotions (Mumenthaler & Sander, 2012; Mumenthaler et al., 2018; Gray et al., 2017). Since group members interact and depend on one another (Aronson et al., 2015), when observers in this study perceived target and surrounding figures as group members through group cues, they used surrounding faces' emotional states to judge target facial emotions; when they perceived target and surrounding faces as non-group members, they did not use surrounding faces' emotional states for inference.

Moreover, these results indicate that under group conditions, individuals develop expectations of emotional consistency among group members based on perceptual cues. When surrounding and target faces express congruent emotions—matching individuals' expectations—facial expression recognition is faster and more accurate. Cao et al. (2022) found that scene-based expectations influence early perceptual processing of facial expressions: when preceding scenes were emotionally congruent with faces, N170 amplitudes were significantly larger than in incongruent conditions. This suggests that when bottom-up facial emotions align with top-down expectations generated from scenes, individuals allocate more cognitive resources to faces—an expectation sharpening effect (Kok et al., 2012; Lee & Mumford, 2003). When facial emotions contradict prior expectations, relative suppression occurs. Research also shows that when individuals perceive group existence through perceptual cues, they develop expectations of behavioral consistency among group members (Xu et al., 2019). In Experiments 2 and 3, group information was manipulated through virtual figures' movement trajectories: group figures moved in regular circular motion, while non-group figures moved randomly toward edges. These different movement patterns created different group cues, generating different expectations for upcoming target facial expressions.

Thus, in facial expression recognition, when observers perceive three virtual figures as a group through perceptual cues, they develop expectations of emotional consistency. When the three virtual figures display congruent facial expressions—matching individuals' expectations—facial expression recognition accuracy is significantly higher and faster than when expressions are incongruent.

This study also found that happy expressions were recognized faster and more accurately than fearful expressions. This may reflect a late perceptual processing advantage for happy expressions compared to fearful ones (Becker et al., 2011; Calvo & Nummenmaa, 2008; Švegar & Kardum, 2013; Xu et al., 2019). Facial expression processing and decoding require dual processing of valence and specific emotion information (Aguado et al., 2013; Aguado et al., 2019; Dieguez-Risco et al., 2015), with valence processing typically occurring in earlier stages (Moors & De Houwer, 2001). In Experiments 1 and 2, participants rated central figures on a six-emotion scale (anger, happiness, surprise, fear, sadness, disgust). For happy emotions, valence processing alone sufficed for emotion judgment; for fearful emotions, participants needed to process both valence information (positive vs. negative) and emotion category information (anger, fear, or disgust), resulting in a perceptual processing advantage for happy faces. In Experiment 3, participants only judged facial emotion valence. Compared to happy expressions, fearful expressions are inherently more ambiguous (Mumenthaler & Sander, 2012). When facial configuration information cannot accurately convey emotional states, individuals rely more on contextual information to judge facial emotions (Leleu et al., 2015; Li et al., 2020). This phenomenon also appeared in Experiments 1 and 2: fearful expression recognition was more susceptible to contextual information than happy expression recognition. Therefore, in Experiment 3, surrounding figures' emotional states were more referentially meaningful when judging fearful expressions. For happy target faces, individuals could judge emotion valence through the target face alone. For fearful target faces, the ambiguity and uncertainty of the face itself prompted individuals to reference surrounding figures' emotional states to confirm their emotional judgments, resulting in longer RTs for fearful expressions.

Nevertheless, this study has limitations. First, while we found that target facial expression recognition was influenced by surrounding faces' emotional states under group conditions, Experiments 2 and 3 did not include a baseline condition presenting only the target face. Therefore, we cannot determine whether the effect reflects facilitation from emotional congruency or interference from incongruency. Future research should include baseline conditions to further investigate how other group members' emotional states specifically influence target facial expression recognition when groups are present.

Second, the presentation of group information and figures' appearance in this study differed from real-life situations, affecting ecological validity. Future research should present group information in more ecologically valid ways. Third, this study manipulated group information through perceptual cues, but the influence of low-level physical attributes of these cues cannot be completely excluded. Future research could add control experiments with identical physical attributes while interfering with group or non-group information formation to further test group information's influence on facial expression recognition.

Conclusions

This study yielded the following conclusions: (1) As an important context for social interaction, group information significantly influences facial expression recognition. When a group is present, surrounding faces' emotional states become a reference for target face emotion recognition; under non-group conditions, surrounding faces' emotional states do not influence target face emotion recognition. (2) When individuals perceive group existence, they develop expectations of emotional consistency among group members. When group emotions align with these expectations, target face emotion recognition is facilitated. (3) Different facial expression categories involve distinct processing: happy faces are recognized faster and more accurately than fearful faces, demonstrating a happy face recognition advantage effect.

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Note: Figure translations are in progress. See original paper for figures.