Supplementary Information

Ensemble coding of crowd emotion: Differential hemispheric and visual stream contributions

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Supplementary Results

Supplementary Result 1. RT results of Experiment 1A and Experiment 1B.

- All the relevant plots are shown in **Supplementary Figure 1.**

- We assessed the effect of the emotional distance on participants' response times (RTs) in the avoidance and approach tasks. Two-way ANOVA with factors of task type (avoidance and approach) and emotional distance (-9, -5, +5, and +9) revealed a significant main effect of the task type ($F(1,160) = 10.915$, $p < 0.01$), although neither main effect of the emotional distance ($F(3,160) = 1.397$, $p = 0.210$) or the interaction ($F(3,160) = 1.306$, $p = 0.274$) were significant.

- We also observed a trend of the RTs towards being faster for comparisons involving task-congruent crowd emotion: angry vs. neutral comparison for avoidance task (both levels of emotional distance: -9 and -5) and happy vs. neutral comparison for approach task (both levels of emotional distance: +9 and +5). This observation was confirmed by significant contrast analyses with the contrast of [-9 and -5 vs. +9 and +5] both for avoidance task ($t(80) = 2.26$, $p < 0.03$, with [-9 and -5] being faster than [+5 and +9]) and for approach task ($t(80) = 2.49$, $p < 0.02$, with [+9 and +5] being faster than [-5 and -9]).

- Two-way ANOVA analyses (factors: visual field and emotional valence of the crowd emotion to be chosen) on participants' mean RT for the avoidance and approach tasks revealed that the main effect of emotional valence was significant (avoidance task: $F(1,20) = 20.687$, $p < 0.001$, $\eta_p^2 = 0.506$ and approach task: $F(1,20) = 16.541$, $p < 0.001$, $\eta_p^2 = 0.479$), although the main effect of visual field (avoidance task: $F(1,20) = 0.470$, $p = 0.470$, $\eta_p^2 = 0.026$ and approach task: $F(1,20) = 1.317$, $p = 0.266$, $\eta_p^2 = 0.068$) and the interaction (avoidance task: $F(1,20) = 2.888$, $p = 0.105$, $\eta_p^2 = 0.126$ and approach task: $F(1,20) = 0.298$, $p = 0.592$, $\eta_p^2 = 0.016$) were not significant. This suggests that participants were faster for choosing goal-congruent cues (e.g., choosing angry crowd for avoidance task and choosing happy crowd for approach task) than choosing a neutral crowd over happy crowd for avoidance task or over angry crowd for approach task, both in the LVF and the RVF.

- The results remained the same for median RTs as well: The main effect of emotional valence was significant (avoidance task: $F(1,20) = 16.690$, $p < 0.001$, $\eta_p^2 = 0.455$ and approach task: $F(1,20) = 11.958$, $p < 0.01$, $\eta_p^2 = 0.399$), although the main effect of visual field (avoidance task: $F(1,20) = 0.730$, $p = 0.403$, $\eta_p^2 = 0.035$ and approach task: $F(1,20) = 0.177$, $p = 0.679$, $\eta_p^2 = 0.010$) and the interaction (avoidance task: $F(1,20) = 0.446$, $p = 0.512$, $\eta_p^2 = 0.022$ and approach task: $F(1,20) = 1.435$, $p = 0.246$, $\eta_p^2 = 0.074$) were not significant.

- Together, our RT results show consistent patterns with our accuracy results reported in the main experiments. Furthermore, these RT results also suggest that the differences in accuracy observed in all our main experiments cannot be explained by a speed-accuracy trade-off.

Supplementary Result 2. No effect of the sex of participants (Experiments 1A and 1B).

- All the relevant plots are shown in **<u>Supplementary Figure 2.</u>**

- In Experiment 1A (avoidance task), 12 female and 9 male participants performed the avoidance task. We found no effect by the sex of participants on the accuracy for comparing an angry crowd vs. a neutral crowd and for comparing a neutral crowd vs. a happy crowd during the avoidance task. Nne of the main effects of the sex of participants ($F(1,38) = 0.014$, $p = 0.908$), the valence of the emotional crowd stimuli ($F(1,38) = 2.695$, $p = 0.109$), or the interaction ($F(1,38) = 1.552$, $p = 0.221$) was significant.

- In Experiment 1B (approach task), 11 female and 10 male participants performed the approach task. As shown in Figure SI.2 (a bottom panel), we found the same pattern in Experiment 1B: No significant main effect of the sex of participants ($F(1,38) = 0.105$, $p = 0.748$) or of the emotional valence of the crowd stimuli ($F(1,38) = 0.967$, $p = 0.332$), and no significant interaction ($F(1,38) = 0.721$, $p = 0.401$).

- Thus, the current data sets did not show any significant sex difference in processing of crowd emotions, despite our finding that the sex of face images systematically influenced crowd emotion perception (as described in the results section). Future studies will be needed to examine the sex differences in processing crowd emotion for different task goals (avoidance and approach tasks), by recruiting larger samples of male and female participants.

Supplementary Result 3. Control Experiments 1A and 1B using facial crowds of a mix of different identities: Extension and replication of the results from main experiments.

- All the relevant plots are shown in **Supplementary Figure 3.**

- To test whether facial identity cues interfere with processing of crowd emotion, we ran two control experiments that employed visual stimuli containing intermixed, different identities and directly compared participants' accuracy to Experiments 1A and 1B where the emotional expressions of the same identity were contained. The procedures of the control experiments were identical to Experiments 1A and 1B, except for the presentation of visual stimuli containing intermixed identities. Supplementary Figure 3A demonstrates the display that was used for the control experiments. A new group of 21 participants performed the avoidance task (Control Experiment 1A) and another group of 19 participants performed the approach task (Control Experiment 1B).

- Although we found that participants were slightly less accurate when the display contained intermixed facial identities than when the display contained the emotional expressions of the same identity, the difference was not significant both for the avoidance task ($t(40) = 1.230$, $p = 0.291$, Cohen's d = 0.310) and for the approach task ($t(38) = 1.396$, $p = 0.243$, Cohen's d = 0.385). These results suggest that facial identity cues do not significantly interfere with processing crowd emotion and that participants were still able to extract accurately the average emotion from emotional faces of different identities.

- Furthermore, we also could replicate the other effects that we reported in the main Experiments 1A and 1B, as we summarize below.

  1. Overall RT:
  a. Control experiment 1A (avoidance task): 1.265 seconds (SD: 0.265)
  b. Control experiment 1B (approach task): 0.982 seconds (SD: 0.301)

  2. No Set size effect
  a. Control experiment 1A (avoidance task)
  Accuracy - 8 faces vs. 12 faces: $t(40) = 0.212$, $p = 0.833$
  RT - 8 faces vs. 12 faces: $t(40) = 0.130$, $p = 0.897$
  b. Control experiment 1B (approach task)
  Accuracy - 8 faces vs. 12 faces: $t(40) = 1.234$, $p = 0.224$
  RT - 8 faces vs. 12 faces: $t(40) = 0.169$, $p = 0.867$

  3. The effects of emotional distance
  a. Control experiment 1A (avoidance)
  - Main effect of the emotional distance (four levels: -9, -5, +5, +9) on performance accuracy: One-way repeated ANOVA for Control Experiments 1A showed a significant main effect of emotional distance: $F(3,60) = 6.803$, $p < 0.01$.

- Post hoc Tukey's HSD analyses showed that accuracy increased when the emotional distance between the two crowds being compared increased in the Control experiment 1A (+9 vs. +5: $p < 0.04$; -9 vs. -5: $p < 0.01$).
- We also observed the trend in which participants were more accurate for the crowd emotion that was congruent with the task goal. That is, subjects were more accurate when comparing angry versus neutral crowds (both levels of emotional distance: -9 and -5) than comparing happy versus neutral crowds (both levels of emotional distance: +9 and +5) during Control experiment 1A, although the difference did not reach significance: [-9 and -5 vs. +9 and +5]: $t(80) = 1.496$, $p = 0.139$.

b. Control experiment 1B (approach)

- Main effect of the emotional distance (four levels: -9, -5, +5, +9) on performance accuracy: One-way repeated ANOVA showed the significant main effect of the emotional distance: $F(3,54) = 2.856$, $p < 0.05$.
- Post hoc Tukey's HSD analyses showed that accuracy increased when the emotional distance between the two crowds being compared increased only for happy crowds (+9 vs. +5: $p < 0.02$), although a similar comparison did not reach the significant for angry crowds (-9 vs. -5: $p = 0.229$).
- We also observed the trend in which participants were more accurate for the crowd emotion that was congruent with the task goal. That is, subjects were more accurate when comparing happy versus neutral crowds (both levels of emotional distance: +9 and +5) than comparing angry versus neutral crowds (both levels of emotional distance: -9 and -5), although the difference did not reach the significant: [+9 and +5 vs. -9 and -5]: $t(80) = 1.537$, $p = 0.128$.

<u>4. The right hemisphere dominance for goal-relevant crowd emotion</u>

a. Control Experiment 1A (avoidance task)

- Two-way repeated-measures ANOVA showed a significant main effect of the visual field (LVF vs. RVF) with the accuracy for LVF presentation being greater than RVF presentation ($F(1,20) = 5.151$, $p < 0.04$). However, the main effect of the emotional valence of the crowd to be chosen (angry vs. neutral: $F(1,20) = 3.899$, $p = 0.062$) or the interaction ($F(1,20) = 0.114$, $p = 0.739$) was not significant.
- Post hoc Tukey's HSD pairwise comparison also revealed significantly higher accuracy for an angry crowd in the LVF than an angry crowd in the RVF ($p < 0.02$) and for a neutral crowd in the LVF than a neutral crowd in the RVF ($p = 0.053$).

b. Control Experiment 1B (approach task):

- Two-way repeated-measures ANOVA showed a significant main effect of the visual field (LVF vs. RVF) with the accuracy for LVF presentation being greater than RVF presentation ($F(1,18) = 4.799$, $p < 0.05$). However, the main effect of the emotional valence of the crowd to be chosen (happy vs. neutral: $F(1,18) = 0.017$, $p = 0.898$) or the interaction ($F(1,18) = 0.201$, $p = 0.659$) was not significant.
- Post hoc Tukey's HSD pairwise comparison also revealed significantly higher accuracy for a happy crowd in the LVF than a happy crowd in the

RVF ($p < 0.05$). There was also a trend in which the accuracy for a neutral crowd in the LVF was higher than a neutral crowd in the RVF ($p = 0.052$).

Supplementary Result 4: Replication of the main results when participants' eye movement was controlled in an eye-tracking experiment.

- All the relevant plots are shown in **Supplementary Figure 4.**

- We conducted a control eye tracking experiment where a new group of 18 participants performed the same task as in Experiment 1A, with their eye movement monitored throughout the experiment. Supplementary Figure 4A shows all the participants' eye gaze while the stimuli were presented on the screen, plotted as the proportion of frequency in a heat map (overlaid on one of the sample displays of the experiment). This suggests that participants successfully fixed their eyes to the center during the trials.

- The overall accuracy for this eye tracking task was 65.6% and the overall RT was 1.063 second, which were not significantly different from those we observed in Experiment 1A (accuracy: 64.88% and RT: 1.17 seconds; all *p's* > 0.360).

- From this Control Experiment 2, we again replicated the other effects that we reported in the main experiment (Experiment 1A), as summarized below.

  1. No set size effect:
  Accuracy - 8 faces vs. 12 faces: $t(34) = 0.982$, $p = 0.333$
  RT - 8 faces vs. 12 faces: $t(34) = 0.167$, $p = 0.869$

  2. The effects of emotional distance
  - Main effect of the emotional distance (four levels: -9, -5, +5, +9) on performance accuracy: One-way repeated ANOVA for Control Experiments 1A showed the significant main effect of the emotional distance: $F(3,51) = 10.532$, $p < 0.01$.
  - Post-hoc Tukey's HSD pairwise comparison tests showed that accuracy increased when the emotional distance between the two crowds being compared increased (+9 vs. +5: $p < 0.05$ and -9 vs. -5: $p < 0.01$).
  - A further contrast analysis that compared between [-9 and -5] and [+9 and +5] was not significant in Control experiment 2: $t(68) = 0.636$, $p = 0.527$, despite the trend.

  3. The effects of hemispheric lateralization
  - Two-way repeated-measures ANOVA showed a significant main effect of the visual field ($F(1,17) = 7.914$, $p < 0.02$), with the accuracy for LVF presentation being greater than for RVF presentation. However, the main effect of the emotional valence of the crowd emotion to be chosen (angry vs. neutral: $F(1,17) = 1.101$, $p = 0.309$) or the interaction ($F(1,17) = 1.832$, $p = 0.194$) was not significant.
  - Post hoc Tukey's HSD pairwise comparison also showed significantly higher accuracy for an angry crowd in the LVF than an angry crowd in the RVF ($p < 0.05$) and a neutral crowd in the LVF than a neutral crowd in the RVF ($p < 0.04$).

Supplementary Result 5. Replication of the behavioral results in fMRI experiment (Experiment 2).

- All the relevant plots are shown in **<u>Supplementary Figure 5.</u>**

- In order to show that we replicated the effects reported in the behavioral experiments (Main experiment 1A and Control experiments 1A and 2), here we list the main effect of the emotional distance and relevant contrasts and the effect of sex-specific identity cues, that replicate our main results from the behavioral experiments.

  <u>1. Overall RT:</u>
  a. Crowd emotion condition: 1.004 seconds (SD: 0.155)
  b. Individual emotion condition: 0.998 seconds (SD: 0.165)

  <u>2. The effects of emotional distance</u>
  a. Crowd emotion condition
  - Main effect of the emotional distance (four levels: -9, -5, +5, +9) on performance accuracy: One-way repeated ANOVA for Control Experiments 1A showed the significant main effect of the emotional distance: $F(3,87) = 5.840$, $p < 0.01$.
  - Post-hoc Tukey's HSD pairwise comparison tests showed that accuracy increased when the emotional distance between the two crowds being compared increased (+9 vs. +5: $p = 0.050$ and -9 vs. -5: $p < 0.02$).
  - We also observed the trend in which participants were more accurate for the crowd emotion that was congruent with the task goal. That is, subjects were more accurate when comparing angry versus neutral crowds (both levels of emotional distance: -9 and -5) than comparing happy versus neutral crowds (both levels of emotional distance: +9 and +5), $t(116) = 2.052$, $p < 0.05$ from the contrast of [-9 and -5] vs. [+9 and +5].

  b. Individual emotion condition
  - Main effect of the emotional distance (four levels: -9, -5, +5, +9) on performance accuracy: One-way repeated ANOVA showed the significant main effect of the emotional distance: $F(3,87) = 20.779$, $p < 0.01$.
  - Post-hoc Tukey's HSD pairwise comparison tests showed that accuracy increased when the emotional distance between the two individual faces being compared increased (+9 vs. +5: $p < 0.01$ and -9 vs. -5: $p < 0.01$).
  - We also observed the trend in which participants were more accurate for the individual emotion that was congruent with the task goal. That is, subjects were more accurate when comparing angry versus neutral faces (both levels of emotional distance: -9 and -5) than comparing happy versus neutral crowds (both levels of emotional distance: +9 and +5), $t(116) = 2.649$, $p < 0.01$ from the contrast of [-9 and -5] vs. [+9 and +5].

  <u>3. The effects of sex-specific identity cues</u>
  a. Crowd emotion condition

- The two-way repeated measures ANOVA showed that the main effects of the stimulus sex ($F(1,29) = 3.046$, $p = 0.092$) or of the emotional valence of the face images ($F(1,29) = 3.635$, $p = 0.067$) were not significant. However, the interaction between the sex and the emotion of the facial crowd was significant: $F(1,29) = 4.260$, $p < 0.05$). Post hoc Tukey's HSD pairwise comparison test showed the nature of this significant interaction: the higher accuracy for angry male than angry female crowds ($p < 0.04$) and the higher accuracy for angry male than happy male crowds ($p < 0.05$).
- Furthermore, contrast analysis using the weight of [+3 -1 -1 -1] showed that participants were more accurate for an angry male crowd than any other three conditions (happy male, angry female, and happy female crowds): $t(116) = 2.382$, $p < 0.02$. Since the task was to avoid angrier crowd, this indicates a modulation by task demands, replicating our results from the main experiment 1A (avoidance task).

b. Individual emotion condition

- The two-way repeated measures ANOVA showed that both the main effects of the stimulus sex ($F(1,29) = 8.749$, $p < 0.01$) or of the emotional valence of the face images ($F(1,29) = 13.852$, $p < 0.01$) were statistically significant. However, the interaction between the sex and the emotion of the facial crowd was not significant: $F(1,29) = 0.778$, $p = 0.385$). Post hoc Tukey's HSD pairwise comparison test showed the higher accuracy for an angry than a happy face, both in male ($p < 0.01$) and female ($p < 0.05$) face stimuli. Moreover, an angry male face was more accurately recognized than an angry female ($p < 0.01$).
- Finally, we observed from a further contrast analysis with the weight of [+3 -1 -1 -1] that participants were more accurate for an angry male face than any other three conditions (happy male, angry female, and happy female): $t(116) = 2.052$, $p < 0.05$.

Supplementary Result 6. Replication of the task-goal dependent hemispheric lateralization during crowd emotion processing

- All the relevant plots are shown in **Supplementary Figure 6.**

- In all the behavioral tests we ran and reported here (Main Experiments 1A, 1B, and 2, Control Experiments 1A, 1B, and 2), we could replicate the pattern of the task-goal dependent hemispheric lateralization for crowd emotion processing. The ability to replicate the same pattern in different experiments with different settings (e.g., behavioral testing room or fMRI scanner), with different stimuli (e.g., containing same identity or intermixed identities), and with different cohorts of participants allows us to conclude that this effect is very robust and reproducible. Supplementary Figure 6 shows the task-goal dependent lateralization replicated in all the 6 experimental sessions altogether, to highlight our main finding that that valence of emotional processing can be biased differently in RH and LH, depending on the task goal and viewers' intent.

Supplementary Result 7. Localizer scans for M- and P-pathway regions

- All the relevant plots are shown in **Supplementary Figure 7.**

- We used magnocellular (M) and parvocellular (P) gratings (sample stimuli are shown in Supplementary Figure 7A) and ran a pilot study for functionally localizing regions sensitive to M- and P-stimuli. The specific settings and parameters for this localizer scan were mostly adapted from Denison et al. (2014), with calibration procedures from Kveraga et al. (2007). In this pilot experiment, the M or P stimuli were presented for 18 seconds in a separate block. Each of the M/P stimulus gratings was presented in the center, the left visual field (LVF), and the right visual field (RVF) in a separate block, as well. Including a resting block (for 18 seconds), there were 7 blocks total (three blocks for M stimuli presented in the center, LVF, and RVF + three blocks for P stimuli presented in the center, LVF, and RVF + one resting block). The sequence of the blocks was randomized across the participants. In order to localize the brain areas that were preferentially activated by the M-stimuli and the P-stimuli, we used contrasts of M-stimuli vs. P stimuli.

- As shown in Supplementary Figure 7B, we started observing distinct sets of brain regions activated preferentially for M- vs. P- stimuli even only from a small number of subjects (N= 3). More importantly, we also found that spatially adjacent areas in the right SFG and IPS to those we reported in the current study (mostly activated by crowd emotion stimuli) were activated by M-stimuli whereas spatially adjacent areas of the right FG to those activated by individual emotion stimuli were also activated by P-stimuli in this pilot study.

Supplementary Result 8. The evidence for parallel processing of crowd emotion extraction: no set size effects on the RT data from all the experiments.

- All the relevant plots are shown in **Supplementary Figure 8.**

- Our results from the eye-tracking experiment (Control experiment 2) provide the evidence that extracting crowd emotion of facial groups does not necessarily require participants make more eye saccades towards a few of individual faces. The eye tracking experiment also suggests that extracting crowd emotion does not necessarily require more saccades to foveate individual faces. Supporting this, our RT data for 8 faces and 12 faces did not differ from each other or from the RT for 2 faces in Individual emotion condition (Experiment 2). Supplementary Figure 8 aggregates all the RT data from our main and control experiments, plotted as a function of the number of total items to be processed. We found the flat slope with the increasing number of faces presented in the display (2, 8, and 12). Along with the results from the eye tracking experiment, this result again supports that crowd emotion is extracted in a parallel manner.

- We conducted one-way ANOVA with a fixed factor of the set size (2, 8, and 12 faces total) and a random factor of the experiment (1: Main experiment 2, 2: Main experiment 1A, 3: Control experiment 1A, and 4: Control experiment 2) both on the accuracy and the RT. We found that neither RT nor accuracy showed the significant effect of the set size (2, 8, and 12 faces total), suggesting that viewing more individual faces did not systematically increased the participants' accuracy and response time (Accuracy: $F(2,172) = 1.637$, $p = 0.198$, RT: $F(2,172) = 0.551$, $p = 0.577$). We also conducted linear regression analyses with a dependent variable of the Accuracy and RT with an independent variable of the total number of faces. We found that the total number of faces was not a significant predictor for the accuracy ($\beta = -0.099$, $R^2 = 0.010$, $p = 0.192$) or RT ($\beta = 0.006$, $R^2 = 0.006$, $p = 0.316$). Therefore, our data suggest that participants did not become less accurate or slower when there were more faces to be processed (from 2 up to 12 faces), indicating that extracting crowd emotion of groups of multiple faces does not necessarily require serial processing of individual faces in the groups.

Supplementary Result 9. No interference from the previous trial.

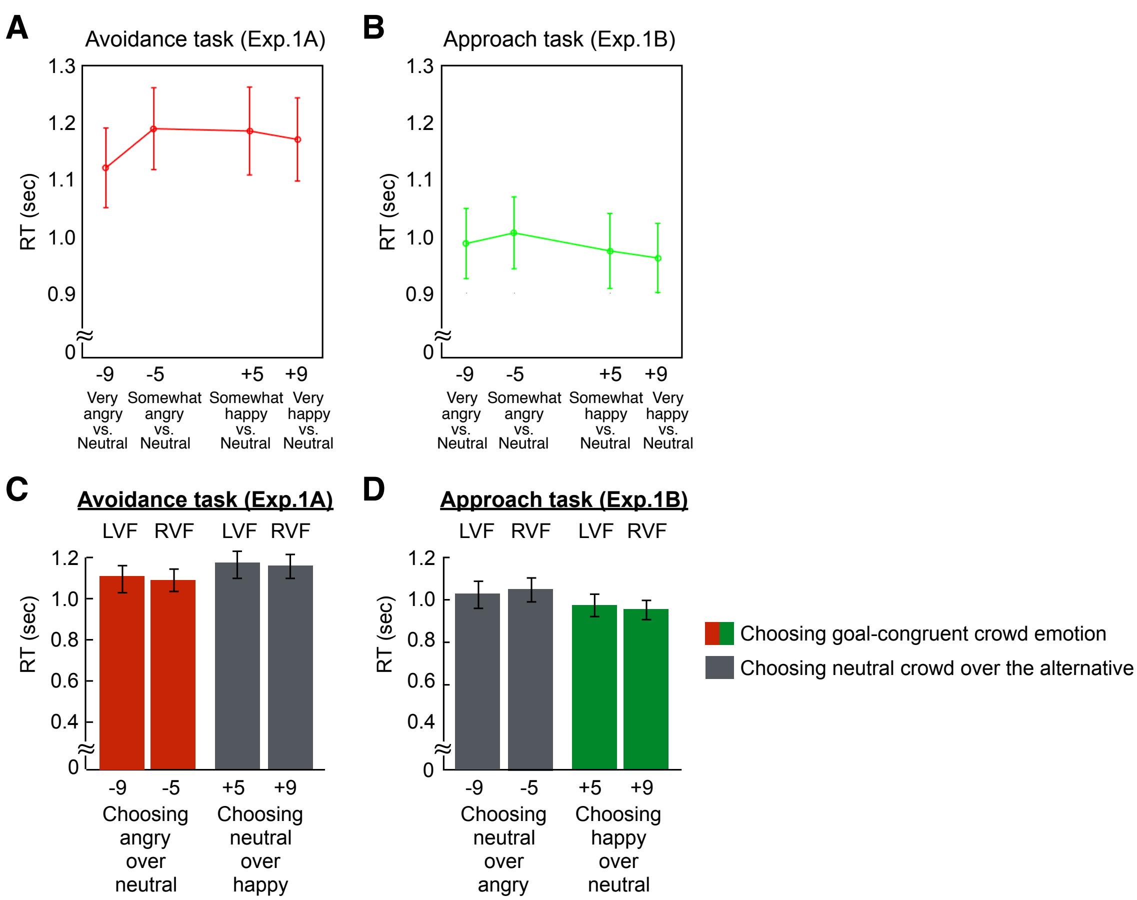
- All the relevant plots are shown in **<u>Supplementary Figure 9.</u>**

- We examined prior trial interference effects by sorting the trials into two different types depending on whether participants had to switch their responses mapping for a neutral crowd compared to the other emotional crowd based on the task: 1) Switch trials: when participants had to switch the response mapped to a neutral crowd from avoided/approached (when compared to a happy/angry crowd) to non-avoided/non-approached (when compared to an angry/happy crowd) or vice versa and 2) Repeated trials: when participants did not have to switch the response mapped to a neutral crowd (either avoided or non-avoided on the two successive trials).

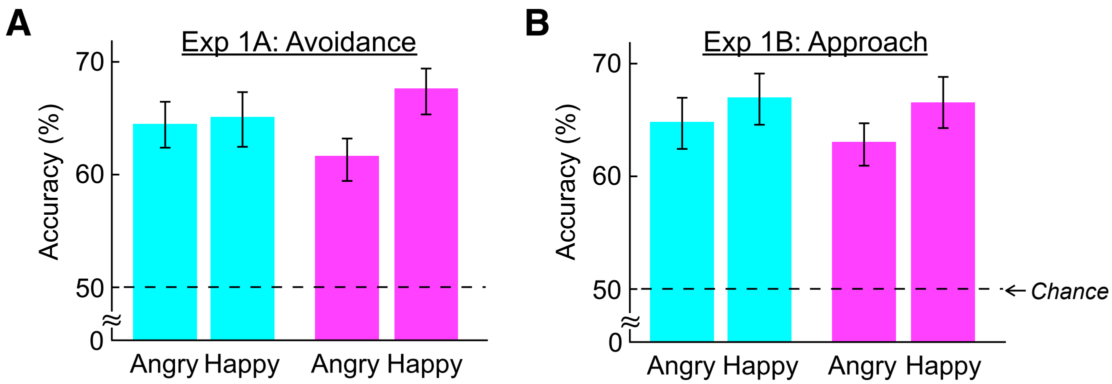
- Neither in the avoidance task nor the approach task did we find any evidence for the prior trial interference effects. We found that the RT or accuracy did not differ for the Switch trials versus the Repeated trials (all *p's* > 0.570). Thus, it seems that our core findings on the slower RT and lower accuracy for task-incongruent trials are not due to such a prior trial interference effect.

Supplementary Figures

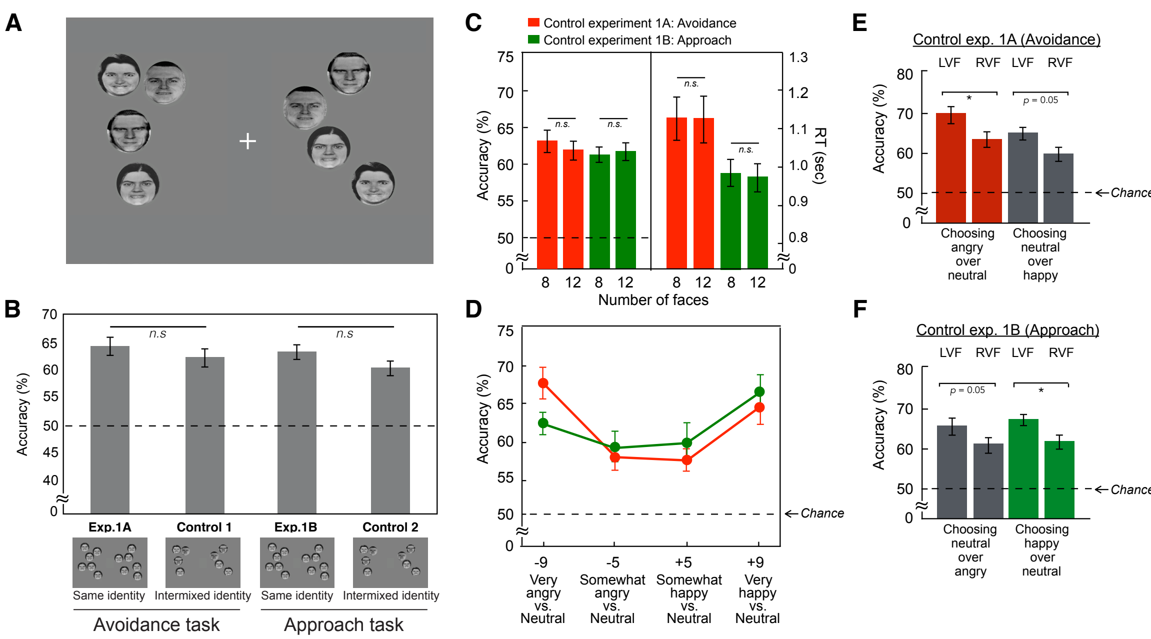
Supplementary Figure 1. RT results of Experiment 1A and Experiment 1B. **(A)** Participants' RTs on Experiment 1A (avoidance task, red line) are plotted as a function of the emotional distance in EU between two facial crowds to be compared. **(B)** Participants' RTs on Experiment 1B (approach task, green line) are plotted as a function of the emotional distance in EU between two facial crowds to be compared. **(C)** Participants' RT for the avoidance task (Experiment 1A), separately plotted for when the crowd to be chosen (an angry crowd when compared to a neutral and a neutral crowd when compared to a happy crowd) is presented in the LVF vs. RVF. **(D)** Participants' RT for the approach task (Experiment 1B), separately plotted for when the crowd to be chosen (a happy crowd when compared to a neutral and a neutral crowd when compared to an angry crowd) is presented in the LVF vs. RVF.



Supplementary Figure 2. No effect of the sex of participants (Experiments 1A and 1B).
(A) Female (pink) and male (blue) participants' accuracy for the avoidance task (Experiment 1A) for the emotional valence of an emotional crowd (Angry vs. Happy). **(B)** Female (pink) and male (blue) participants' accuracy for the approach task (Experiment 1B) for the emotional valence of an emotional crowd (Angry vs. Happy).

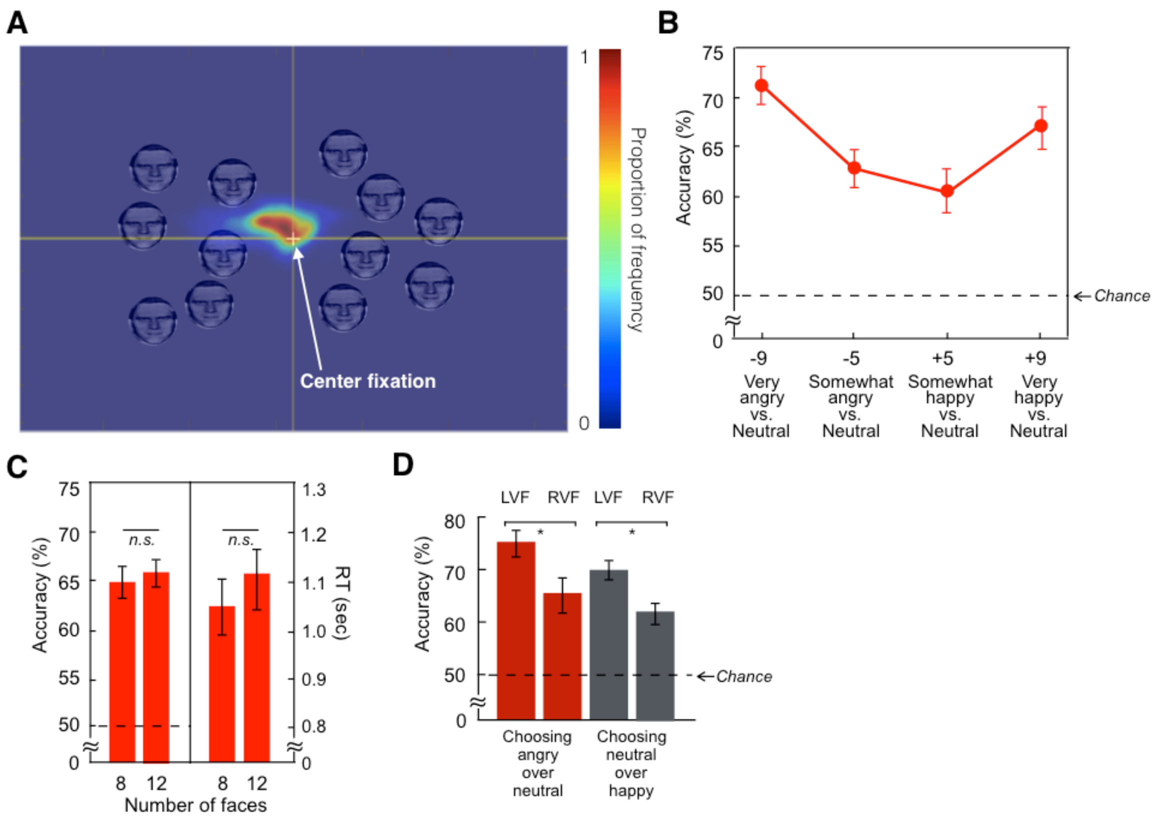


Supplementary Figure 3: Control Experiments 1A and 1B using facial crowds of a mix of different identities: Extension and replication of the results from main experiments.
(A) Sample crowd stimuli for Control Experiments 1A and 1B where different identities were intermixed. **(B)** The overall accuracy for the same identity (main experiments) vs. intermixed identity (control experiments) when participants made avoidance decision and approach decision. The error bars indicate the standard error of the mean (SEM). **(C)** The effect of the number of faces on the accuracy and RT in Control Experiment 1A (avoidance task, red bars) and in Control Experiment 1B (approach task, green bars). **(D)** The effect of the similarity in average emotion between facial crowds on crowd emotion processing: Participants' accuracies on Control Experiment 1A (avoidance task, red line) and Control Experiment 1B (approach task, green line) are plotted as a function of the emotional distance in EU between two facial crowds to be compared. **(E)** Participants' accuracy for the avoidance task (Control Experiment 1A, with intermixed identities), separately plotted for when the crowd to be chosen (an angry crowd when compared to a neutral and a neutral crowd when compared to a happy crowd) is presented in the LVF vs. RVF. **(F)** Participants' accuracy for the approach task (Control Experiment 1B, with intermixed identities), separately plotted for when the crowd to be chosen (a happy crowd when compared to a neutral and a neutral crowd when compared to an angry crowd) is presented in the LVF vs. RVF.



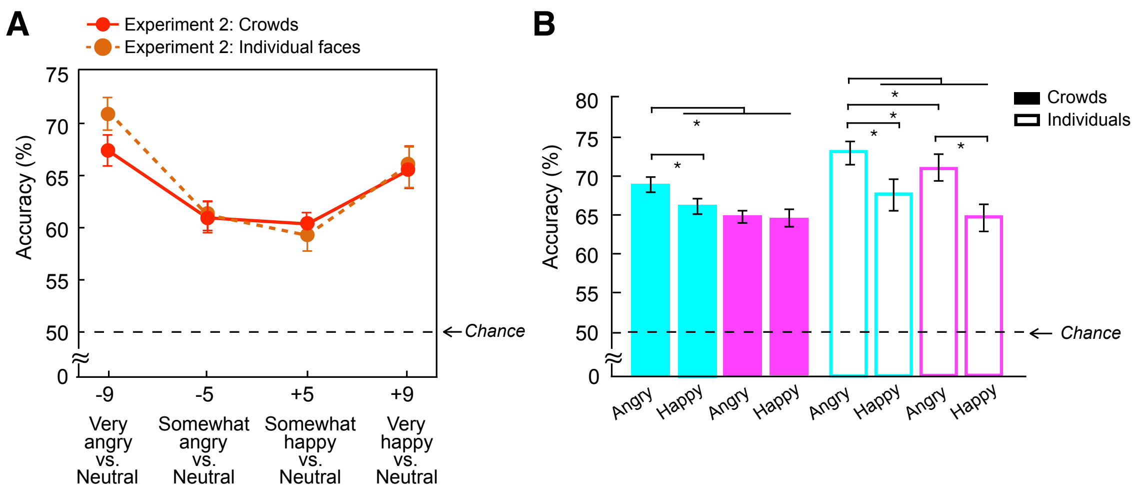
Supplementary Figure 4. Control Experiment 2: Replication of the main results when participants' eye movement was controlled

(A) A sample trial that showed the heatmap of the proportion frequencey of participants' eye gaze during the trial. This ensures that participants fixated their eyes throughout the trial while they extract crowd emotion from the display. **(B)** The effect of the similarity in average emotion between facial crowds on crowd emotion processing: Participants' accuracy on Control experiment 2 (avoidance task with eye movement controlled), plotted as a function of the emotional distance in EU between two facial crowds to be compared. **(C)** The effect of the number of faces on the accuracy and RT in Control Experiment 2. **(D)** Participants' accuracy for Control Experiment 2, separately plotted for when the crowd to be chosen (an angry crowd when compared to a neutral and a neutral crowd when compared to a happy crowd) is presented in the LVF vs. RVF.

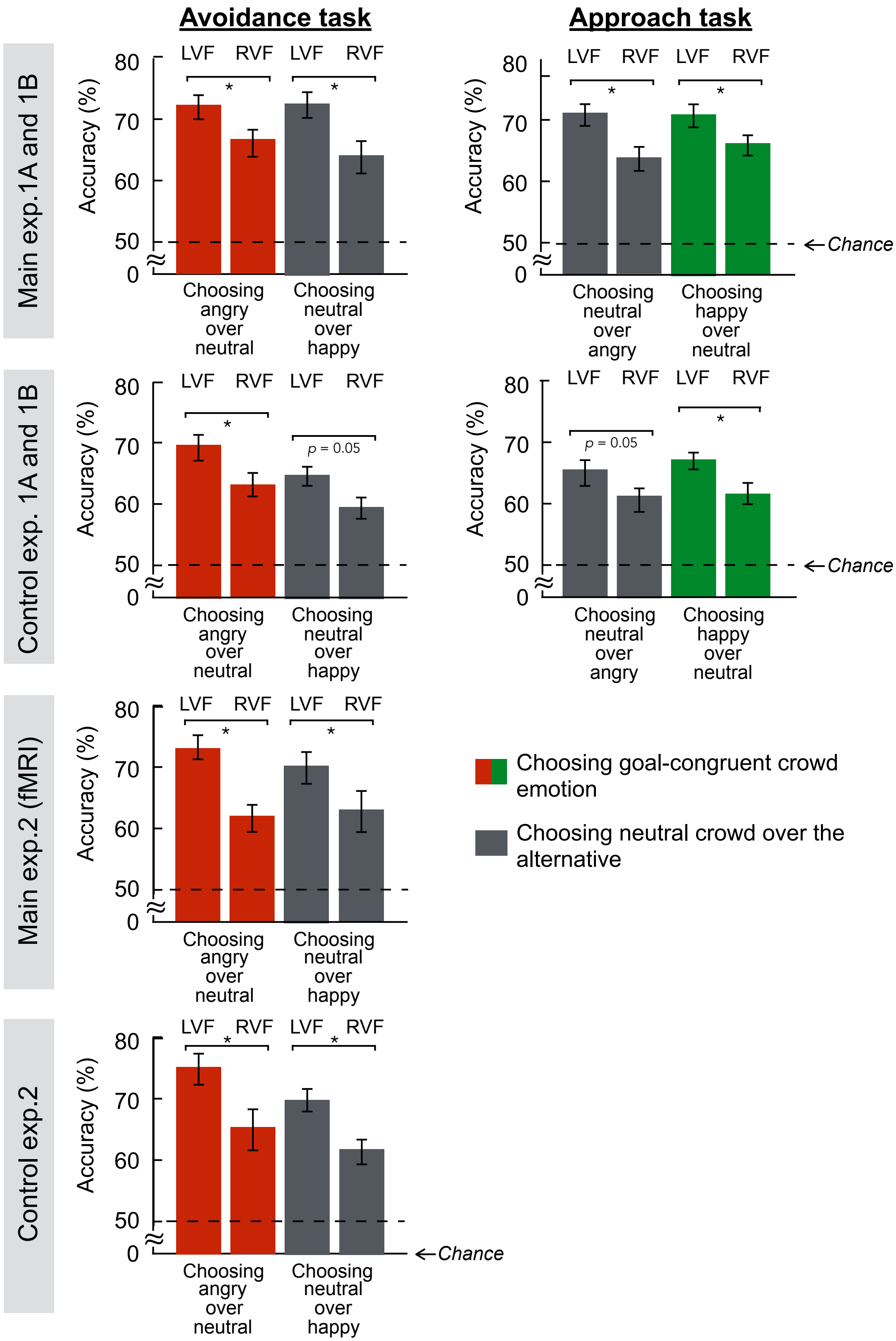


Supplementary Figure 5. Replication of the behavioral results in fMRI experiment (Experiment 2).

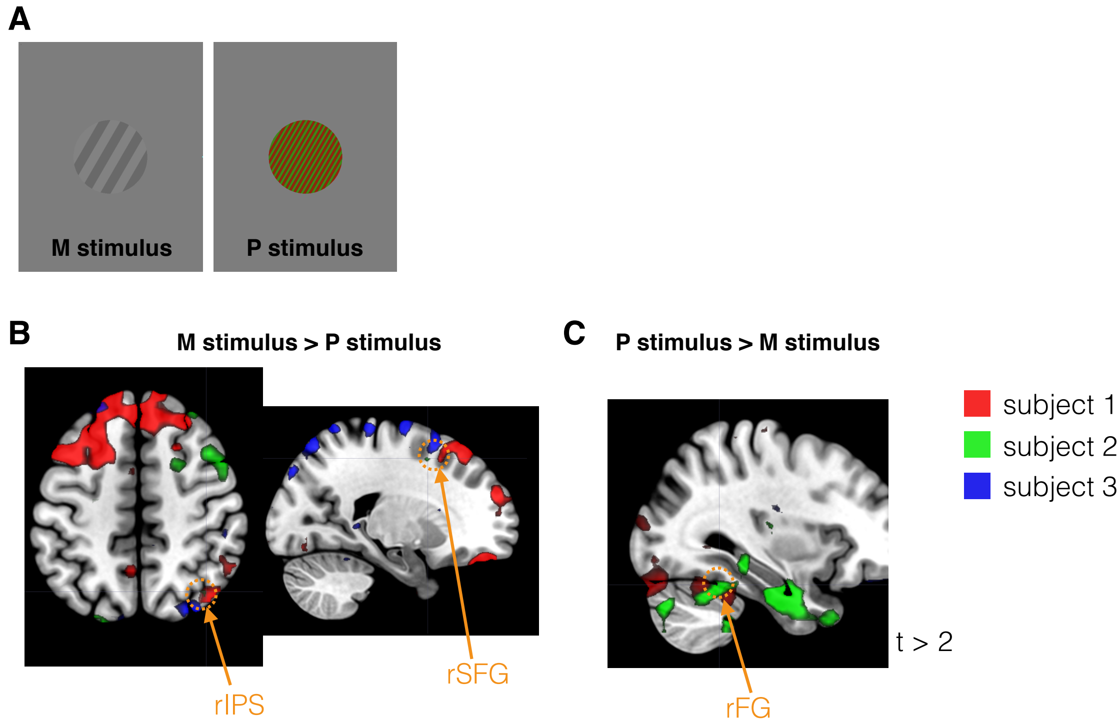
(A) The effect of the similarity in average emotion between facial crowds on crowd emotion processing (red line) and in individual emotion between two faces on individual emotion processing (orange line): Participants' accuracies on Crowd emotion condition and Individual emotion condition in Experiment 2 (fMRI study) are plotted as a function of the emotional distance in EU between two facial crowds or two faces to be compared.
(B) Participants' accuracy for Crowd emotion condition (Color-filled bars) for sex of facial crowds (male crowds vs. female crowds) and for the emotional valence of an emotional crowd (Angry vs. Happy) and accuracy for Individual emotion condition (Outlined bars) for sex of faces (male faces vs. female faces) and for the emotional valence of an emotional face.



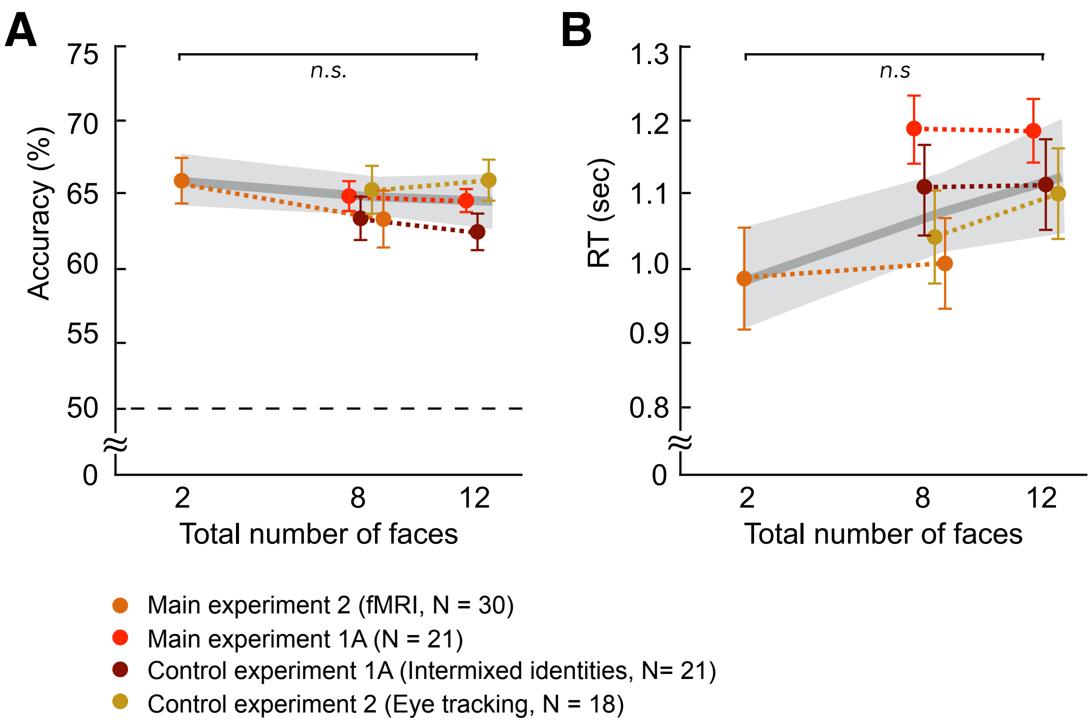
Supplementary Figure 6. Replication of the task-goal dependent hemispheric lateralization during crowd emotion processing in all the studies reported.



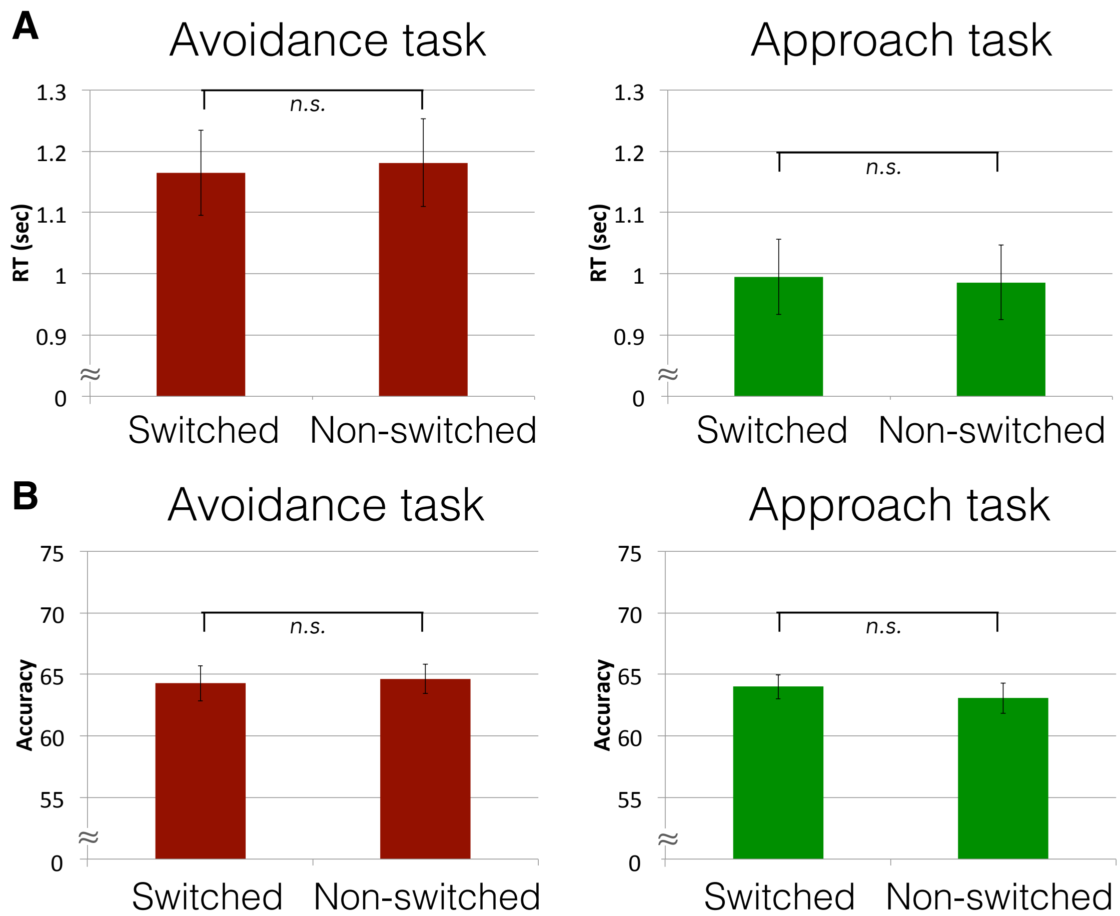
Supplementary Figure 7. Localizer scans for M- and P-pathway regions
(**A**) Example of Magnocellular (M) stimulus and Parvocellular (P) stimulus. **(B)** Brain activation for M stimulus > P stimulus, for the three pilot subjects. **(C)** Brain activation for P stimulus > M stimulus for the three pilot subjects.



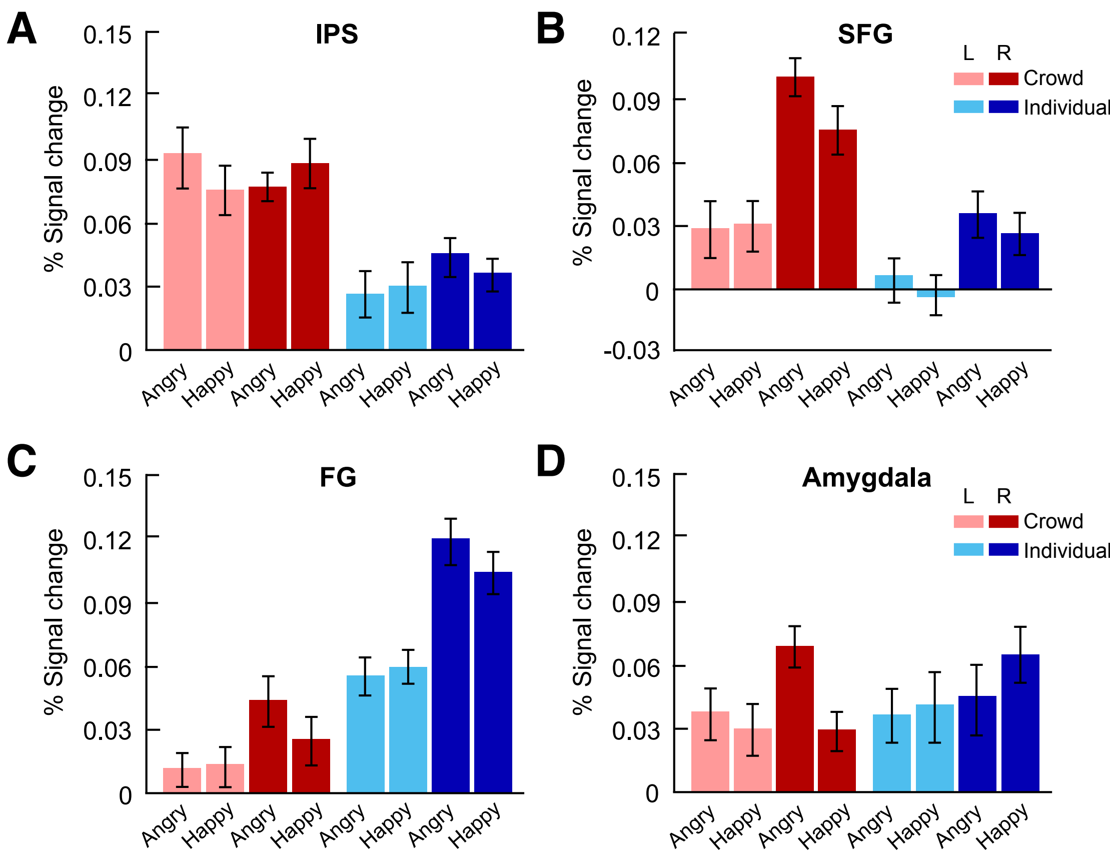
Supplementary Figure 8. The evidence for parallel processing of crowd emotion extraction: no set size effects on the RT data from all the experiments.
(A) Participants' accuracy for Main experiments 1A and 2 and Control experiments 1A and 2, plotted as a function of the total number of faces to be processed. **(B)** Participants' RT for Main experiments 1A and 2 and Control experiments 1A and 2, plotted as a function of the total number of faces to be processed.



Supplementary Figure 9. No interference from the previous trial for RT (A) and for accuracy (B) .



Supplementary Figure 10. Further ROI results: The hemispheric lateralization in the brain activation in IPS (A), SFG (B), FG (C), and Amygdala (D).



Supplementary Tables

Supplementary Table 1. The full list of activation for Crowd emotion minus Individual emotion condition and vice versa, at threshold of *p* < 0.001 and k = 5, uncorrected. – indicates that this cluster is part of a larger cluster immediately above.

Activation location	**MNI coordinates**				
Crowd emotion > Individual emotion	**x**	**y**	**z**	**t-value**	**Extent**
R Visual cortex (BA18)	18	-100	12	6.174	692
L Visual cortex (BA18)	-15	-88	-14	7.872	1524
L Visual cortex (BA19)	-21	-97	14	5.241	-
	-33	-76	-16	4.73	-
R Middle frontal gyrus	36	32	46	5.826	2401
R Superior frontal gyrus	33	8	64	5.664	-
L Middle frontal gyrus	-42	29	36	3.072	26
L Superior frontal gyrus	-24	11	64	3.11	10
	-27	-1	70	2.956	11
R Intraparietal sulcus	39	-58	48	5.665	889
L Intraparietal sulcus	-39	-49	38	4.731	353
R Anterior Insula	30	26	2	5.89	2401
L Anterior Insula	-33	20	4	5.973	146
L Thalamus	-6	-10	20	3.797	293
R Thalamus	9	2	10	3.727	293
L Caudate	-12	5	10	3.003	5
R Caudate	12	23	8	3.148	9
R Supplementary Motor Area	9	32	48	5.187	430
R Superior temporal sulcus	48	-25	-10	4.661	242
	39	-34	4	3.357	10
L Premotor cortex	-39	5	36	4.653	268
	-30	2	46	3.129	13
L Superior parietal lobule	-30	-67	48	3.875	353
L Inferior frontal gyrus	-27	26	22	3.499	12
L Anterior prefrontal cortex	-42	59	8	3.236	48
R Cerebellum	33	-52	-44	3.282	8
Individual emotion > Crowd emotion					
R Visual cortex (BA19)	12	-64	-8	8.054	2557
R Fusiform gyrus	21	-40	-14	5.283	-
R Parahippocampal cortex	21	-37	-14	5.252	-
R Retrosplenial cortex	18	-61	12	4.891	-
L Visual cortex (BA19)	-18	-55	-6	6.948	3520
L Fusiform gyrus	-24	-49	-12	6.191	-
L Parahippocampal cortex	-27	-31	-14	4.694	-
L Retrosplenial cortex	-18	-55	6	5.126	-

L Primary visual cortex (BA17)	-3	-76	10	6.188	5120
R Ventromedial orbitofrontal cortex	6	26	-8	4.176	232
	9	47	-8	3.571	303
L Ventromedial orbitofrontal cortex	-9	44	8	3.675	303
	-21	14	-22	3.456	19
R Precuneus	6	-52	64	3.1	6
L Precuneus	-12	-28	40	3.627	55
P Temporal pole	51	23	-38	4.425	26
R Posterior cingulate cortex	12	-25	42	4.364	64
L Angular gyrus	-42	-67	24	3.7	142
L Posterior insula	-39	-16	0	3.44	17
R Hippocampus	27	-13	-22	3.144	7

Supplementary Table 2. The full list of activation for Crowd emotion minus Individual emotion condition and vice versa, at threshold of *p* < 0.0005 and k = 5, uncorrected. – indicates that this cluster is part of a larger cluster immediately above.

Activation location	MNI coordinates				
Crowd emotion > Individual emotion	**x**	**y**	**z**	**t-value**	**Extent**
L Visual cortex (BA18)	-15	-88	-14	7.281	338
L Visual cortex (BA18)	-21	-97	14	4.998	-
R Middle frontal gyrus	36	32	46	6.267	244
R Inferior frontal gyrus	45	17	30	4.696	-
R Anterior Insula	30	26	2	5.864	105
L Anterior Insula	-33	20	4	5.858	66
R Visual cortex (BA18)	18	-100	12	5.858	301
R Superior frontal gyrus	33	8	64	5.686	84
R Intraparietal sulcus	39	-58	48	5.607	359
R Inferior frontal gyrus	57	17	18	5.544	58
R Supplementary Motor Area	9	32	48	5.000	114
R Prefrontal cortex	33	65	4	4.893	67
R Prefrontal cortex	45	47	22	4.812	37
R Superior temporal sulcus	48	-25	-10	4.709	84
L Intraparietal sulcus	-39	-49	38	4.677	20
L Premotor cortex	-39	5	36	4.364	43
L Thalamus	-6	-10	20	4.160	10
L Cerebellum	-33	-55	-42	3.901	5
L Visual cortex (BA19)	-33	-79	-16	3.888	9
Individual emotion > Crowd emotion					
R Visual cortex (BA19)	12	-64	-8	8.054	3084
L Visual cortex (BA19)	-18	-55	-6	6.742	-
L Visual cortex (BA18)	-6	-73	6	6.421	-
R Temporal pole	51	18	-38	4.564	8
R Posterior cingulate cortex	12	-25	42	4.384	9
R Visual cortex (BA19)	48	-79	16	4.246	35
R Medial orbitofrontal cortex	9	26	-12	4.031	8
L Fusiform gyrus	-24	-49	-12	6.099	3084
R Fusiform gyrus	27	-52	-12	5.740	-
R Parahippocampal cortex	21	-37	-14	5.013	-
L Parahippocampal cortex	-21	-40	-8	4.135	-
R Retrosplenial cortex	18	-58	14	4.460	-
L Retrosplenial cortex	-18	-55	6	5.126	-

Supplementary Table 3. The full list of brain activation during *crowd emotion* comparison involving goal-congruent cue (choosing to avoid an angry over a neutral crowd/face) and during comparison involving goal-incongruent cue (choosing to avoid a neutral vs. a happy crowd/face).

Activation location	MNI Coordinates				
Angry crowd > Happy crowd	**x**	**y**	**z**	**t-value**	**Extent**
L Visual cortex (BA19)	-51	-79	-6	5.106	922
L Visual cortex (BA18)	-39	-94	0	3.973	-
	-12	-106	18	3.515	-
R Visual cortex (BA19)	39	-82	-14	4.866	349
R Visual cortex (BA18)	27	-103	-2	2.572	-
R Orbitofrontal cortex	27	32	-16	4.300	132
	24	59	-2	3.369	32
	21	11	-18	3.243	17
L Orbitofrontal cortex	-39	29	-2	2.876	26
R Medial orbitofrontal cortex	15	53	-20	3.399	-
	6	35	-24	3.246	10
R Parahippocampal cortex	33	-1	-30	3.999	84
R Inferior frontal gyrus	51	17	30	3.945	921
	42	32	20	3.819	-
L Putamen	-30	5	6	3.906	165
	-30	-16	8	3.093	-
R Insula	36	-10	10	3.866	265
L Insula	-36	8	-16	2.848	9
R Caudate Nucleus	12	8	14	2.846	265
R Amygdala	21	-4	-12	3.844	37
R Posterior cingulate cortex	6	-28	32	3.724	57
R Postcentral gyrus	24	-40	76	3.683	41
	48	-22	46	3.331	53
L Postcentral gyrus	-30	-43	52	3.260	93
L Middle temporal gyrus	-36	-16	-30	3.417	15
R Middle temporal gyrus	66	-52	0	3.284	26
R Superior temporal gyrus	57	-58	12	3.162	26
L Superior temporal gyrus	-66	-25	8	3.098	46
R Superior temporal sulcus	54	-37	8	2.837	15
R Superior parietal lobule	24	-70	36	3.148	12
R SupraMarginal Gyrus	51	-19	32	2.988	10
R Cerebelum	24	-46	-24	2.927	16
L Cerebelum	-42	-52	-24	2.807	11
R Superior frontal gyrus	15	-1	78	2.916	10
L Supplementary motor area	-9	-16	56	2.886	10
R Inferior parietal lobule	36	-52	48	2.843	49
Brainstem	0	-37	-34	2.619	7
L Inferior temporal gyrus	-42	35	18	2.588	6
Happy crowd > Angry crowd					
L Dorsal anterior cingulate cortex	0	26	20	-3.415	17
L Middle temporal gyrus	-60	-19	-18	-3.131	21

R Middle temporal gyrus	45	-4	-20	-3.037	15
L Medial prefrontal cortex	-12	41	26	-2.950	12
L Superior frontal gyrus	-24	14	62	-2.873	8
L Superior temporal sulcus	-42	-13	-10	-2.801	7
L Posterior cingulate cortex	-18	-43	30	-2.781	7
L Parahippocampal cortex	-21	-22	-20	-2.752	8

Supplementary Table 4. The full list of brain activation during *individual emotion* comparison involving goal-congruent cue (choosing to avoid an angry over a neutral crowd/face) and during comparison involving goal-incongruent cue (choosing to avoid a neutral vs. a happy crowd/face).

Activation location	MNI Coordinates				
Angry individual > Happy individual	**x**	**y**	**z**	**t-value**	**Extent**
R Dorsal posterior cingulate cortex	12	-46	40	4.160	186
L Dorsal posterior cingulate cortex	-18	-43	32	3.106	20
L Parahippocampal cortex	-27	-37	-10	4.008	44
R Parahippocampal cortex	36	-22	-20	2.865	15
L Angular gyrus	-39	-61	30	3.960	418
R Angular gyrus	57	-55	36	2.863	70
R Cerebellum	42	-46	-46	3.937	140
	39	-73	-50	2.971	140
	21	-70	-38	2.647	6
L Cerebellum	-21	-49	-44	3.704	12
	-12	-43	-18	2.968	11
R Orbitofrontal cortex	39	38	-12	3.792	34
R Middle temporal gyrus	54	-49	-2	3.611	37
	66	-22	-10	2.914	11
L Middle temporal gyrus	-69	-37	2	3.355	13
	-66	-28	-18	3.210	71
L Cuneus	-21	-58	24	3.437	64
L Putamen	-27	-13	4	3.368	40
R Putamen	27	-10	18	3.363	34
R Temporal pole	39	11	-36	3.310	32
	48	20	-34	2.936	19
R Prefrontal cortex	21	62	6	3.228	18
Happy individual > Angry individual					
L Insula	-30	20	4	-4.480	72
R Middle frontal gyrus	33	29	26	-4.095	52
	48	38	34	-3.908	69
L Supplementary motor area	-9	-1	78	-3.848	22
L Temporal pole	-33	11	-50	-3.770	14
L Inferior frontal gyrus	-39	2	24	-3.749	40
	-45	20	16	-2.967	8
R Cerebellum	30	-49	-28	-2.768	6