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Featural vs. Holistic Processing and Visual Sampling in the Influence of Social Category Cues on Emotion Recognition

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Abstract

Past research demonstrates that emotion recognition is influenced by social category cues present on faces. However, little research has investigated whether holistic processing is required to observe these influences of social category information on emotion perception, and no studies have investigated whether different visual sampling strategies (i.e., differences in the allocation of attention to different regions of the face) contribute to the interaction between social cues and emotional expressions. The current study aimed to address this. Participants categorized happy and angry expressions on own- and other-race faces, and male and female faces. In Experiments 1 and 2, holistic processing was disrupted by presenting inverted faces (Experiment 1) or part faces (Experiment 2). In Experiments 3 and 4 participants' eye-gaze to eye and mouth regions was also tracked. Disrupting holistic processing did not alter the moderating influence of sex and race cues on emotion recognition (Experiments 1, 2, 4). Gaze patterns differed as a function of emotional expression, and social category cues, however, eye-gaze patterns did not reflect response time patterns (Experiments 3 and 4). Results indicate that the interaction between social category cues and emotion does not require holistic processing and is not driven by differences in visual sampling.

Keywords: Emotion recognition, Social categorization, Eye-tracking, Person Perception, Holistic processing

Featural vs. Holistic Processing in the Influence of Social Category Cues on Emotion Recognition

Faces are complex social stimuli. At a glance, we can recognize social information that changes from moment to moment (e.g., emotional expression) and cues that do not (e.g., race, sex, and age). Early models of face processing proposed that these changeable and fixed cues were processed independently (e.g., Bruce & Young, 1986), but a large body of research now demonstrates that these cues can interact. For example, facial cues indicating race, sex, and age influence the speed and accuracy of recognizing emotional expressions (Becker, Kenrick, Neuberg, Blackwell, & Smith, 2007; Bijlstra, Holland, & Wigboldus, 2010; Craig, Koch, & Lipp, 2017; Craig & Lipp, 2017, 2018; Craig, Mallan, & Lipp, 2012; Hugenberg, 2005; Hugenberg & Sczesny, 2006).

One approach to investigating these interactive influences of social information on emotion perception is to measure changes in the presence and magnitude of the happy advantage, the faster categorization of happy expressions as happy than of negative expressions like anger as angry (Lepännen & Hietanen, 2003). Participants are faster to categorize happiness than anger on female faces, but this happy advantage is reduced or absent for male faces (Becker et al., 2007; Bijlstra et al., 2010; Craig & Lipp, 2017; Hugenberg & Sczesny, 2006). Similarly, participants are faster to categorize happy than angry male own race, but not other race faces (Bijlstra et al., 2010; Craig et al., 2012; Hugenberg, 2005). The influence of social category cues on emotion recognition also depends on which social categories are made salient. For instance, a happy advantage has been found for White male faces when they are encountered with other-race male faces, but not when encountered with own-race female faces in studies contrasting happiness with anger (Lipp, Craig, & Dat, 2015), as well as with sadness or fear (Craig, Koch, & Lipp, 2017). This is consistent with the broader literature demonstrating the important role of context in facial emotional expression recognition (e.g., see Wieser & Brosch, 2012 for a review).

It has been proposed that this modulation of the happy advantage occurs as faces are automatically categorized along social dimensions (Brewer, 1988). This categorization happens along contextually relevant dimensions (Craig, Koch, & Lipp, 2017; Craig, Zhang, & Lipp, 2017; Lipp et al., 2015). The initial categorization elicits an implicit evaluation which facilitates the recognition of evaluatively congruent expressions (Craig, Koch, & Lipp, 2017; Hugenberg, 2005; Hugenberg & Sczesny, 2006). Happy expressions presented on faces representing relatively positive categories (e.g., females and own race faces) are categorized more quickly than evaluatively incongruent angry expressions. Relative to alternative explanations that rely on the effects of stereotypes or face structure, this evaluative congruence account is best suited to explain the comparable influence of social cues on emotion recognition when categorizing happiness vs. a range of negatively valenced expressions. These include anger, which is evaluatively congruent, stereotypically congruent, and structurally overlapping with particular social category cues (e.g., Male faces; Hess, Adams, Grammer, & Kleck, 2009; Plant, Hyde, Keltner, & Devine, 2000) but also sadness, fear, and negative surprise which are evaluatively congruent but do not share stereotypes or structural similarity with the task relevant social category (Craig, Koch, & Lipp, 2017; Hugenberg, 2005; Hugenberg & Sczesny, 2006). It is currently not clear how the faces are initially processed to extract the social category information that provides this evaluation and whether the face processing or visual sampling strategy used to process the faces differs as a function of task context.

Face Processing Strategies

Most studies investigating which face processing strategy is used focus on how identity information is processed to allow for subsequent recognition of the face. Face processing strategies described include featural and holistic processing. Featural processing refers to processing the face in a piecemeal way. Only a single feature or a couple of separate features like a big nose, skin tone, or a toothy grin are used to identify a person's identity, race, sex, or facial expression. Alternatively, holistic processing refers to processing that takes into account the relationships between the features (configurations) in order to recognize a person's identity, race, sex, or facial expression (e.g., see Maurer, Le Grand, & Mondloch, 2002 for a review). A role of holistic processing is inferred when performance on a face processing task is impaired in conditions when the whole face is disrupted such as by inverting the face (e.g., Leder & Bruce, 2000; Rhodes, Brake, & Atkinson, 1993) or presenting top and bottom parts of the face separately and slightly displaced (e.g., Young, Hellawell, & Hay, 1987). These approaches have also been applied to understand how facial cues like race, sex, and emotional expression are processed.

Studies investigating the role of featural vs. holistic processing in the recognition of single social cues (e.g., race, sex) suggest that recognition of these social cues is quickest and most accurate in the presence of whole, upright faces, but these cues can still be recognized accurately when the whole is disrupted through inversion, scrambling or through presenting only part faces (Zhao & Bentin, 2011; Levin, 1996; Zhao & Hayward, 2010). However, in all these studies, race/sex categorization was the focal task. When race and sex cues influence emotion perception, processing of this social information is incidental.

Only a couple of studies have investigated involvement of holistic processing in the interaction between social cues and emotional expressions and these studies found inconsistent results. Aguado and colleagues (2009) found that the sex of the faces influenced the speed of emotion recognition when faces were presented whole and upright (Experiment 1) or inverted (Experiment 2) and also when participants categorized only top or bottom halves of faces (Experiment 3). These findings suggest that sex cues are quickly extracted and influence emotion recognition when this social category information is not task relevant, even when holistic processing is disrupted. Karnadewi and Lipp (2011) looked at the role of holistic processing on the influence of race and sex on emotion recognition in the Garner paradigm. Contrary to the results of Aguado and colleagues, Karnadewi and Lipp found that both sex and race cues influenced emotion recognition when the faces were upright, but when holistic processing was disrupted through inversion, race cues influenced emotion processing, but sex cues did not.

Current Study

Relevant past research leads to inconsistent conclusions. The results from Karnadewi and Lipp (2011) suggest that disruption of holistic processing also disrupts the influence of sex cues on emotion recognition, but findings of Aguado et al. (2009) suggest that sex cues influence emotion perception even when holistic processing is disrupted. Further, no previous research has addressed whether fluctuations in the magnitude of the happy advantage for White male faces due to the other faces they are encountered with are dependent on holistic face processing or changes in visual sampling strategy.

As such, the aim of the current study was to extend previous work regarding the mode of facial processing and visual sampling strategies underlying the moderating influence of social category information (race and sex) on emotion perception under different task contexts. Participants categorized happy and angry expressions on White male faces presented along with White female faces in one task, and Black male faces in the other. We investigated whether context driven fluctuations in the magnitude of the happy advantage are dependent on participants' use of holistic face processing or changes in the way visual information is sampled from key emotion relevant face regions. In the first two experiments, holistic processing was disrupted through inversion (Experiment 1) or by presenting only part faces (Experiment 2) to determine the contribution of holistic processing in the moderating influence of race and sex cues on emotion perception. Experiments 3 and 4 used eye-tracking to further examine which sources of facial information participants sampled when making emotion judgements and whether these differed as a function of the social categories made salient by the task.

Experiment 1

In Experiment 1, it was predicted that inversion would not alter the moderating influence of sex (Aguado et al., 2009) or race (Karnadewi & Lipp, 2011) on emotion recognition. Consistent with the findings of Lipp et al. (2015) participants should be faster to categorize happiness than anger on White male faces but not Black male faces when these faces are encountered together, but faster to categorize happiness than anger on White female faces but not White male faces when these faces are encountered together.

Method

Participants. Participants were 58 undergraduate volunteers (8 Males, M_{age}=22.84, SD_{age}=6.95) who received course credit in return for participation. Consistent with previous research investigating the influence of racial cues on emotion perception (e.g., Craig et al., 2012; Hugenberg, 2005; Kubota & Ito, 2007), participants who identified as a member of the racial outgroup depicted in the stimuli (Black African/African American) were not included in analysis in any of the experiments reported below. In Experiment 1, one additional participant took part, but was not included in analysis for this reason. This exclusion did not influence results in any experiment.

Given the challenges of precisely determining the appropriate sample size using power calculation for fully repeated measures effects with repeated trials (Baker et al., 2021; Guo et al., 2013), determination of sample size was guided by previous research. The most similar previous study with a comparable method and number of trials per condition (Lipp et al., 2015) reported a significant effect of social category cues on emotion recognition in samples of 29 (Experiment 1) and 32 (Experiment 2). We aimed for a minimum of 32 participants in each experiment or between subjects condition. We oversampled where time during semester and resources allowed. A basic power analysis not taking into account the number of trials per condition indicates that a sample size of 32 participants provides an 80% chance of detecting a medium effect size (Cohen's d_z=0.51) which is smaller than those for the Sex × Emotion and Race × Emotion interactions in categorization times observed in previous studies (d_z>0.63; Lipp et al., 2015).

Stimuli. Photographs of 24 individuals (8 representing each category [White female, White male, Black male] expressing happiness and anger were used. These faces were sourced from the Nimstim database (Tottenham et al., 2009) and the MSFDE (Beaupré & Hess, 2005). All images were edited so that only the face was shown. All backgrounds, necks, hair etc. were removed. Face images were converted to grayscale where necessary, resized and placed on a grey background 187×240 pixels in size. These images were those originally used in the Lipp et al. (2015) study. The upright version of each of these images was also rotated 180^{O} to create a set of inverted images.

Procedure. Experiment 1 took place in a small group laboratory with four testing terminals separated by partitions. After providing informed consent, participants were seated in front of a 24in LED monitor with a screen resolution of 1920×1080 pixels and a refresh rate of 120Hz. The experiment was executed using DMDX (Forster & Forster, 2003). Participants were instructed that they would complete four tasks for this experiment. In all tasks, participants were presented with White male faces expressing happiness and anger. In the race tasks, these White male faces were categorized along with happy and angry Black male faces and in the sex tasks, these White male faces were categorized along with happy and angry White female faces. Participants completed one version of each task with upright faces and inverted faces. The order of these tasks was counterbalanced such that the two inverted face tasks always came first, but half of the participants completed the race tasks before the sex tasks (or vice versa).

Participants were instructed that each face would appear on the screen one at a time and that they should categorize the face as happy or angry by pressing the right and left shift keys on a QWERTY keyboard as quickly and accurately as they could. Task order and response mapping were counterbalanced across participants, but response mapping was held constant across tasks for each participant. Within each task, on each trial a black fixation cross was presented on a grey screen for 500ms. This was then replaced by one of the 32 images (8 White male, 8 White female/Black male faces expressing happiness or anger) for 1000ms or until a response was made. Each face was presented 3 times resulting in 96 trials in each task and 384 trials across the four tasks. Each main task was preceded by a practice task 16 trials in length.

Data processing and analysis. Incorrect responses and response times faster than 100ms or response times over three standard deviations beyond each participant's mean were removed as invalid responses. Mean response times and error rates were calculated for each trial type within each task. Response times and error rates were submitted to separate 2 (Face orientation: upright, inverted) × 2 (Task: sex task, race task) × 2 (Face type: White male, other [White female/Black male]) × 2 (Emotional expression: Happy, Angry) repeated measures ANOVAs. Additionally, to specifically investigate whether fluctuations in the magnitude of the happy advantage for White males differed with inversion, response times and error rates for White male happy and angry faces were submitted to a separate 2 (Face orientation: Upright, inverted) × 2 (Task: Sex task, Race task) × 2 (Emotional expression: Happy, Angry) repeated measures ANOVA. In all experiments error rates were analyzed in the same manner. In general, patterns of error rates did not indicate a speed accuracy tradeoff and were consistent with response times so only response time data are presented for brevity. Data from six participants were not included in analysis as more than half of their responses in at least one condition were missing or invalid suggesting that they did not follow instructions. To allow for ease of comparison across experiments, a summary table of all main effects and interactions across all experiments is provided in an online supplement.

Some studies find no significant influence of participant sex on the moderating effect of facial sex cues on emotion recognition (e.g., Lipp et al., 2015). Others have found that the direction of the effect is the same in both male and female participants; however, the effect is significantly larger in female participants (Becker et al., 2007; Craig & Lipp, 2017; Hugenberg & Sczesny, 2006). As such, participant sex was initially included in all analyses as an additional factor. These analyses did not reveal any consistent influence of participant sex so results in the main text are presented collapsed across this factor. On the few occasions where a significant moderating influence of participant sex was observed, these are detailed in footnotes.

Results

Response times. As can be seen in Figure 1, in the sex tasks, a happy advantage emerged for White female, faces and an anger advantage emerged for White male faces. In the race tasks, no angry advantage was observed for White male faces regardless of whether faces were upright or inverted. This impression was confirmed in the results of the statistical analysis. There was a significant Face type × Emotion interaction[1], $F(1,51)=16.91$, $p<.001$, $\eta_p^2=.25$, and a Task × Face type × Emotion interaction, $F(1,51)=41.00$, $p<.001$, $\eta_p^2=.45$. Following up the three-way interaction revealed that, in the sex tasks, participants were faster to categorize happiness than anger on White female faces, $t(51)=7.28$, $p<.001$, $d_z=1.01$, but faster to categorize anger than happiness on White male faces, $t(51)=3.18$, $p=.003$, $d_z=0.44$. In the race task, however, participants were numerically faster to categorize happiness than anger on White male faces, though this difference did not reach significance, $t(51)=1.97$, $p=.054$, $d_z=0.27$, but were no faster to categorize happiness or anger on Black male faces, $t(51)=0.28$, $p=.782$, $d_z=0.04$.

In addition to these key effects, overall, participants completed the sex tasks faster than the race tasks, $F(1,51)=10.04$, $p=.003$, $\eta_p^2=.16$. There was also a significant inversion effect where participants were significantly faster to respond when the faces were upright than when they were inverted, $F(1,51)=33.95$, $p<.001$, $\eta_p^2=.40$. Although participants were slower to categorize emotional expressions on inverted faces, face orientation did not significantly moderate the interaction between race or sex and emotion, *F*s<1.99, *p*s>.165, $\eta_p^2<.04$ and no other effects were significant, *F*s<2.70, $p>.106$, $\eta_p^2<.05$.

Insert Figure 1 about here

Considering the influence of task and face inversion on the processing of expressions on White male faces alone, the Task × Emotion × Inversion interaction was not significant, $F(1,51)=0.01$, $p=.926$, $\eta_p^2<.01$, indicating that fluctuations in the happy advantage for White male faces as a function of the other faces they are encountered with, did not differ for upright and inverted faces.

Discussion

[1] There was a significant Face type × Emotion × Participant Sex interaction, $F(1, 50)=4.63$, $p=.036$, $\eta_p^2=.09$. This interaction emerged as for female participants, happiness ($M=570.91$, $SD=76.22$) was categorized faster than anger ($M=585.44$, $SD=76.62$) for White female and Black male faces considered together, $t(50)=3.38$, $p=.001$, $d_z=0.50$, but not for White male faces, $t(50)=1.41$, $p=.04$, $d_z=0.21$; ($M=578.90$, $SD=81.79$ [Happiness], $M=572.09$, $SD=74.77$ [Anger]). Male participants were no faster to categorize happiness ($M=588.81$, $SD=102.97$) or anger ($M=600.84$, $SD=102.04$), on Black male and White female faces averaged together $t(50)=1.12$, $p=.276$, $d_z=.42$, or happiness ($M=579.00$, $SD=84.51$) or anger ($M=596.06$, $SD=110.64$) for White male faces, $t(50)=1.40$, $p=.168$, $d_z=0.53$.

As predicted, social category information in the face moderated emotion recognition and the magnitude of the happy advantage for White male faces depended on the other faces they were encountered with. In the sex task, participants were faster to categorize happiness than anger on White female faces, but faster to categorize anger than happiness on White male faces. When these same White male faces were encountered along with Black male faces, participants tended to be faster to categorize happiness than anger on White male faces and were no faster to categorize either emotion on Black male faces. Participants were also slower to categorize expressions on inverted than upright faces. This suggests that participants may have found this task more difficult and adjusted their decision threshold resulting in slower judgements. Despite this, the moderating influence of social category information on emotion recognition was still observed for inverted faces.

Considering the White male faces alone, there was also no evidence that change in the magnitude of the happy advantage as a function of the other faces encountered in the task was influenced by disrupting holistic processing. Though it is possible that another form of disruption may have different consequences. Using part faces is another way to disrupt holistic processing and may provide an indication of which features (e.g., eye region or mouth region) are more important if participants are prioritizing attention to different facial features across the different tasks.

Experiment 2

It was predicted that a happy advantage for White males would be observed when these faces were encountered along with Black male faces, but not White female faces. Consistent with Experiment 1, it was predicted that this moderating influence of social cues would occur despite holistic processing being disrupted by presenting only part faces.

Method

Participants. Ninety-seven MTurk workers at least partially attempted both tasks (i.e., provided some response times in both the race and the sex task) in the current study in return for US $1.85. Ten of these participants took part but identified their ethnic background as African

American or as mixed including African American so were not included in the sample. This resulted in a sample of 87 participants (48 Males, M_{age}=37.26, SD_{age}=10.42).

Stimuli. The upright face stimuli used in Experiment 1 were edited for use in Experiment 2. Each of the faces was split horizontally across the bridge of the nose into a top half and a bottom half. These face halves were placed on a grey background 187×120 pixels in size. This resulted in two sets of face stimuli (top halves and bottom halves).

Procedure. Participants were randomly assigned to complete either the 'top halves' or the 'bottom halves' version of the task to maximize task completion in the online environment. There were 42 participants assigned to see top halves and 45 participants assigned to see bottom halves who at least partially attempted both the race and sex tasks. The procedure was similar to Experiment 1, however, some changes were made to adapt the task to the online environment. The experiment was executed using Inquisit Web 4. As participants were recruited via MTurk, the screen size and resolution varied across participants, and the image size was set to occupy 10% of the screen by height. The task was presented on a black background with a white fixation cross. Response mapping instructions were presented on the screen throughout the tasks. A block of 12 practice trials preceded each task and error feedback was provided during the practice task only.

Data processing and analysis. Data were processed as described in Experiment 1. Mean response times were submitted to a 2 (Face part: tops, bottoms) × 2 (Task: race task, sex task) × 2 (Face type: White male, other [Black male/White female]) × 2 (Emotional expression: happy, angry) mixed ANOVA with face part manipulated between subjects and the remaining factors manipulated within subjects. Data from one participant in the bottom halves task and six participants in the top halves task could not be included in analysis as they provided no valid responses or more than 50% of their responses were missing or invalid in at least one condition.

Results

Response times. As there was a significant four-way Face part × Task × Face type × Emotion interaction, $F(1,78)=13.29$, $p<.001$, $\eta_p^2=.15$, we looked at the Task × Face type × Emotion interaction for the top halves group and the bottom halves group separately.

Top halves. Consistent with previous research there was a significant Task × Face type × Emotion interaction, $F(1,35)=55.90$, $p<.001$, $\eta_p^2=.62$. However, this interaction emerged as participants were faster to categorize anger than happiness on Black male faces, $t(35)=4.26$, $p<.001$, $d_z=0.71$, but no faster to categorize happiness or anger on White male faces in the race task, $t(35)=0.59$, $p=.560$, $d_z=0.10$. In the sex task, participants were faster to categorize anger than happiness on White male faces, $t(35)=5.54$, $p<.001$, $d_z=0.92$, but no faster to categorize happiness or anger on White female faces, $t(35)=1.00$, $p=.326$, $d_z=0.17$. Overall, when categorizing the top halves of faces, participants were faster to categorize anger than happiness, $F(1,35)=10.72$, $p=.002$, $\eta_p^2=.23$. No other effects were significant, $F\text{s}(1,35)<3.25$, $p\text{s}>.080$, $\eta_p^2<.09$.

Looking at responses for White male faces only indicated that categorization times for White male faces differed significantly as a function of task, $F(1,35)=26.70$, $p<.001$, $\eta_p^2=.43$.

Insert Figure 2 about here

Bottom halves. Consistent with the pattern observed with whole faces, there was a significant Task × Face type × Emotion interaction, $F(1,43)=15.95$, $p<.001$, $\eta_p^2=.27$. In the race task, participants were faster to categorize happiness than anger on White male faces, $t(43)=4.35$, $p<.001$, $d_z=0.66$, but not on Black male faces, $t(43)=1.03$, $p=.307$, $d_z=0.16$. In the sex task participants were faster to categorize happiness than anger on White female faces, $t(43)=3.50$, $p=.001$, $d_z=0.53$, but not White male faces, $t(43)=1.89$, $p=.065$, $d_z=0.28$. In addition to this key effect, participants were, overall faster to categorize happy than angry expressions, $F(1,43)=13.52$, *p*=.001, η_p^2=.24 and were faster to respond in the sex task than in the race task, *F*(1,43)=5.92, *p*=.019, η_p^2=.12[2]. No other effects were significant, *F*s(1,43)<2.57, *p*>.116, η_p^2=05.

As above, looking at responses for only White male faces indicated that categorization times for White male faces differed significantly as a function of task, *F*(1,43)=10.03, *p*=.003, η_p^2=.19.

Discussion

Consistent with Experiment 1, disrupting the whole by presenting part faces did not attenuate the moderating influence of social category cues on emotion recognition. There was evidence of a moderating influence of race and sex in both top halves and bottom halves of faces. When categorizing the top halves of faces, angry expressions were categorized faster on average. This anger advantage was enhanced for the relatively negative face category (Other-race faces in the race task, White male faces in the sex task) and attenuated for the relatively positive face category (White male faces in the race task, White female faces in the sex task). When categorizing bottom halves, a happy categorization advantage emerged. Consistent with the pattern observed for whole faces, this advantage was enhanced for the relatively positive face category (Own-race faces in the race task, female faces in the sex task). Looking at only the White male faces across the two tasks, the relative speed of recognizing the expressions differed as a function of categorizing top or bottom halves. Although the absolute differences in categorization times differed, the direction of the shift across tasks was comparable (from an anger advantage to no difference in the top halves task and from no difference to a happiness advantage in the bottom halves task).

Presenting inverted or part faces can be used to identify a role of holistic processing in the interactive influence of social category information on emotion recognition. However, this approach is not a sensitive method for investigating whether different visual sampling strategies are implemented for different types of faces or within different tasks. As such, Experiments 3 and 4

[2] There was also a significant Face type × Participant Sex interaction, *F*(1, 42)=5.47, *p*=.024, η_p^2=.12, which emerged as males categorized expressions faster on White male faces (*M*=648.02, *SD*=104.05) than Black male and White female faces considered together (*M*=659.50, *SD*=110.30), *t*(42)=2.66, *p*=.011, d_z=0.51, whereas females, *t*(42)=0.88, *p*=.386, d_z=.21, did not categorize expressions faster on White male faces (*M*=628.66, *SD*=108.55) or Black male and White female faces considered together (*M*=623.89, *SD*=102.00).

used eye-tracking to measure eye-movements while participants perform the emotion recognition tasks. Eye-tracking can provide a more fine-grained indication of how visual sampling differs for different face types and whether these differences map onto the response time biases observed.

Experiments 3

In Experiments 3 and 4, it was predicted that response time patterns would be consistent with Experiment 1. Consistent with previous research, it was predicted that participants may look towards the eye-region more for own race than other race faces (Kawakami et al., 2014), and angry than happy faces (Eisenbarth & Alpers, 2011). As no previous studies have investigated how eye-gaze patterns towards the same faces may vary as a function of the other faces in the task, no specific predictions were made in relation to the interaction between social cues and emotional expressions.

Methods

Participants. Participants were 37 volunteers (11 Males, M_{age}=24.30, SD_{age}=7.20) who took part in exchange for course credit or $15 AU. Two additional participants who identified as African took part but were not included in the final sample due to identifying as a member of the racial outgroup represented in the stimuli.

Apparatus. This experiment was deployed using Experiment Builder 1.10.1241 (SR Research Ltd, Mississauga, Canada) and presented on a 24-inch widescreen LCD monitor with a screen resolution of 1920×1080 and a refresh rate of 60Hz. Eye movements were recorded with an SR Research tower-mounted EyeLink1000 Plus, which derives eye-gaze position using a pupil center corneal reflection technique. Monocular gaze was recorded at 1000Hz, with up to 0.01° spatial resolution and 0.25° accuracy, using a 9-point calibration. Participant responses were recorded using two buttons on a button box (left and right) of a RESPONSEPixx 5-button response box (VPixx Technologies Inc, Montreal, Canada). Response mapping was counterbalanced between participants but remained constant within each participant.

Stimuli. Experiment 3 used the same upright faces used in Experiment 1. As eye movements were recorded in Experiment 3, the images were enlarged so that eye movements to specific regions of interest in the face could be investigated with greater precision. Images were sized to be 748×960 pixels in size.

Procedures. Experiment 3 was similar to the upright tasks in Experiment 1; however, a number of changes were made to incorporate eye-tracking measures. Participants were seated at an approximate viewing distance of 70cm with their head secured in the chin-rest within the tower-mount setup. A brief calibration procedure was performed at the beginning of the task. Participants made their responses using a button box. In order to ensure that sufficient eye-tracking data were available, each face stimulus was presented for a fixed duration of 2000ms. In total 192 trials were presented. Throughout the task, participants' gaze was monitored by the experimenter from a second control computer. Recalibrations were performed whenever the participant moved their head out of the chin-rest (e.g., to take a break between tasks) or when the estimated location of gaze moved away from the fixation cross that participants were instructed to fixate on at the beginning of each trial.

Data processing and analysis. Response time and accuracy data were analyzed as described above. Raw eye-gaze samples were initially cleaned using a two-sample noise reduction filter (Stampe, 1993). Fixations were subsequently defined as gaze samples below a $30°s^{-1}$ velocity threshold and an $8000°s^{-2}$ acceleration threshold. Polygonal areas of interest (AOIs) were then spatially defined over the eye and mouth region of each face image, as well as an additional AOI to delineate the entire face region. Sufficient eye-tracking data were available from the time between stimulus onset and response. Given this, we specifically extracted the eye-tracking data from this time window, for all correct trials, as it best represents the information being sampled while the emotion judgement is made. The key eye-tracking variable of interest was dwell time, the average percentage of time that participants spent fixating at the eyes and mouth of faces until a response was made, expressed as a proportion of the total time spent fixating on the face. We also looked at the initial orienting of gaze towards the eye and mouth regions as being the tendency to initially saccade towards the mouth or eye regions relative to the other parts of the face at the onset of each trial. Dwell time and initial orienting scores were averaged for the Eye AOI and the Mouth AOI and submitted to separate 2 (Task: race task, sex task), 2 (Face type: White male, Other [Black Male, White Female]) × 2 (Emotional Expression: happy, angry) repeated measures ANOVAs. To supplement each of these analyses a separate 2 (Task: race task, sex task) × 2 (Emotional Expression: happy, angry) ANOVA was conducted including only White male faces to specifically investigate whether eye-tracking patterns for the same faces differed as a function of task. We excluded data from nine participants who did not complete both tasks due to calibration difficulties or who did not provide useable data in both tasks due to difficulties with eye-tracking. We also excluded three participants who completed the task with uncorrected vision (without their glasses) due to initial difficulties tracking their eye movements while wearing glasses.

Results

Response times. Consistent with previous experiments, there was a significant Task × Face type × Emotion interaction, $F(1,23)=39.84$, $p<.001$, $\eta_p^2=.63$. In the sex task, participants were significantly faster to categorize happiness (M=728.94, SD=170.06) than anger (M=762.14, SD=138.81) on White female faces, $t(23)=2.20$, $p=.038$, $d_z=0.67$, but were no faster to categorize anger (M=726.87, SD=140.38) or happiness (M=760.01, SD=166.56) on White male faces, $t(23)=1.86$, $p=.075$, $d_z=0.38$. In the race task, participants were significantly faster to categorize happiness (M=751.93, SD=185.20) than anger (M=791.16, SD=175.92) on White male faces, $t(23)=2.88$, $p=.008$, $d_z=0.59$, but faster to categorize anger (M=767.59, SD=176.18) than happiness (M=796.78, SD=172.69) on Black male faces, $t(23)=2.27$, $p=.033$, $d_z=0.46$. No other interactions or main effects were significant, Fs<2.50, ps>.127, η_p^2s<.10

Looking at White male faces only, the magnitude of the happy advantage differed significantly as a function of task, $F(1,23)=14.38$, $p=.001$, $\eta_p^2=.39$.

Eye AOI

Dwell times. Unlike in response times, there was no Task × Face type × Emotional Expression interaction, $F(1,23)=0.05$, $p=.822$, $\eta_p^2<.01$. The pattern of dwell times indicated that participants spent a greater proportion of time looking at the eye-region of angry faces than happy faces, (main effect of emotion, $F(1,23)=8.23$, $p=.009$, $\eta_p^2=.26$). They also looked more at the eye-region of the Black male and White female faces averaged together than the White male faces, $F(1,23)=11.20$, $p=.003$, $\eta_p^2=.33$. No other effects were significant, Fs<2.80, ps>.108, $\eta_p^2=.11$.

Looking specifically at the influence of task on dwell time on White male faces, there was no main effect of task and no Task × Emotion interaction, $Fs<2.36$, $ps>.139$, η_p^2s<.09, suggesting that the proportion of time spent gazing at the eye region of White male faces did not change as a function of the other faces encountered in the task.

Initial orienting. Again, unlike the pattern of response times, there was no significant Task × Face type × Emotional expression interaction in initial orienting towards the eyes, $F(1,23)=0.48$, $p=.494$, $\eta_p^2=.02$. Consistent with the pattern observed in dwell times, participants were more likely to initially fixate on the eye region of angry faces than of happy faces, $F(1,23)=11.73$, $p=.002$, $\eta_p^2=.34$. No other effects were significant, Fs<4.17, $p>.053$, $\eta_p^2<.15$.

Looking specifically at the influence of task on fixations to the eye AOI of White male faces, there was no main effect of task or Task × Emotion interaction, Fs<1.35, $ps>.257$, η_p^2s<.06.

Insert Figure 3 about here

Mouth AOI.

Dwell times. As with eye gaze towards the Eye AOI, eye gaze toward the Mouth AOI was not consistent with response times. No Task × Face Type × Emotional expression interaction emerged, $F(1,23)=1.53$, $p=.229$, $\eta_p^2=.06$. Looking at the pattern of dwell times, participants spent a greater proportion of time looking at the mouth region of happy than angry faces, $F(1,23)=6.70$, $p=.016$, $\eta_p^2=.23$, more time looking at the mouth region of Black male and White female faces considered together than White male faces, $F(1,23)=13.17$, $p=.001$, $\eta_p^2=.36$, and more time looking at the mouth region in the race task than in the sex task, $F(1,23)=8.07$, $p=.009$, $\eta_p^2=.26$. These main effects were qualified by a Task × Face type interaction, $F(1,23)=6.62$, $p=.017$, $\eta_p^2=.22$. This interaction emerged as participants looked at the mouth region of Black male faces in the race task more than of White female faces in the sex task, $t(23)=3.60$, $p=.002$, $d_z=0.73$, but dwell times on the mouth region of White male faces did not differ between tasks, $t(23)=1.65$, $p=.113$, $d_z=0.34$. No other effects were significant, Fs<2.77, $p>.110$, $\eta_p^2<.11$.

Looking specifically at gaze patterns for White male faces across the two tasks, there was no main effect of task and no Task × Emotion interaction, Fs<2.71, $ps>.113$, η_p^2s$<.11$.

Initial Orienting. Again, no significant Task × Face type × Emotional expression interaction emerged in initial orienting towards the mouth region, $F(1,23)=0.79$, $p=.383$, $\eta_p^2=.03$. The overall pattern of initial orienting to the mouth was consistent with the pattern observed in the dwell time measure. Participants were more likely to initially fixate on the mouth of happy faces than of angry faces, $F(1,23)=4.98$, $p=.036$, $\eta_p^2=.18$. They were also more likely to initially fixate on the mouth region of the Black male and White female faces averaged together than the White male faces, $F(1,23)=6.88$, $p=.015$, $\eta_p^2=.23$. These main effects were moderated by a Task × Face type interaction, $F(1,23)=4.54$, $p=.044$, $\eta_p^2=.17$, and a Task × Emotion interaction, $F(1,23)=5.52$, $p=.028$, $\eta_p^2=.19$[3]. The Task × Face type interaction reflected that participants initially fixated on the mouth region of Black male faces in the race task more than of White female faces in the sex task, $t(23)=2.44$, $p=.023$, $d_z=0.50$, but were no more likely to fixate on the mouth region of White male faces in either the race or the sex task, $t(23)=0.69$, $p=.498$, $d_z=0.14$. The Task × Emotion interaction emerged as participants were more likely to initially fixate on the mouth region of happy than angry

[3] There was a significant Task × Emotional Expression × Participant Sex interaction, $F(1, 22)=5.15$, $p=.033$, $\eta_p^2=.19$. This interaction emerged as female participants initially fixated on the mouth region of happy faces ($M=28.50$, $SD=29.29$) more than angry faces ($M=21.86$, $SD=22.62$) in the race task, $t(22)=2.28$, $p=.033$, 0.57, but not the sex task ($M=24.24$, $SD=30.74$ [happy]; $M=19.90$, $SD=25.44$ [angry]), $t(22)=1.87$, $p=.075$. Male participants did not engage more with the mouth region as a function of emotion in the sex task ($M=13.36$, $SD=16.09$ [happy]; $M=19.34$, $SD=23.42$ [angry]) or the race task ($M=30.20$, $SD=34.76$ [happy]; $M=22.19$, $SD=27.73$ [angry]), $ts<1.94$, $p>.065$, d_zs<0.69.

faces in the race task, $t(23)=3.04$, $p=.006$, $d_z=0.62$, but no more likely to initially fixate on the mouth region of happy or angry faces in the sex task, $t(23)=0.43$, $p=.674$, $d_z=0.09$.

Looking specifically at the influence of task on processing of emotions on White male faces, there was no main effect of task and no Task × Emotion interaction, $Fs<1.85$, $ps>.187$, $\eta_p^2s<.07$.

Experiment 4

Methods

Participants. Participants were 43 volunteers (11 Males, $M_{age}=24.30$, $SD_{age}=7.20$) who took part in exchange for course credit or $15 AU.

Stimuli, procedures, data processing, and analysis. The procedures used for Experiment 4 were similar to those used in Experiment 3, with the exception of the following modifications. Five actors per condition (White female, White male, Black male) were included from the stimulus set used in Experiment 3 and were presented both upright and inverted (rotated 180°). To ensure that sufficient eye-tracking data were available, each face stimulus remained on the screen for an additional 2000ms following the participant's response. A gaze-contingent manipulation was additionally implemented to provide a stricter examination of initial orienting effects. For each trial, the face stimulus would only appear when participant's fixation was detected at the location of the fixation cross, which was positioned approximately equidistant from the eye and mouth regions. This allowed for a consistent start-location of participant's gaze before orienting toward the eye or mouth region occurred. All participants completed four tasks (sex and race categorization tasks under both upright and inverted conditions), which resulted in a total of 400 trials.

In Experiment 4, eye-tracking data were collected by research assistants who were more experienced in running eye-tracking studies and more stringent recruitment restrictions were applied (e.g., participants were asked to remove eye makeup before commencing the testing session). This resulted in fewer calibration and eye-tracking difficulties and no datasets were lost due to calibration failures or missing data. One participant was identified as an outlier and excluded from final analysis as their overall response time was over three standard deviations slower than the mean response time for all participants. Data processing and analysis proceeded as described in Experiment 3. Data were submitted to a four-way Orientation × Task × Face type × Emotional expression repeated measures ANOVA.

Results

Response Times.

Consistent with Experiment 1, there was a significant Task × Face type × Emotion interaction, $F(1,41)=41.40$, $p<.001$, $\eta_p^2=.50$, that was not further moderated by face orientation, $F(1,41)=0.11$, $p=.737$, $\eta_p^2<.01$. This interaction emerged as participants were faster to categorize happiness ($M=693.14$, $SD=134.00$ [upright]; $M=739.07$, $SD=144.78$ [inverted]) than anger ($M=742.70$, $SD=144.32$ [upright]; $M=761.74$, $SD=132.46$ [inverted]) on White female faces, $t(41)=4.53$, $p<.001$, $\eta_p^{2=}0.70$, but not happy ($M=715.61$, $SD=147.43$ [upright]; $M=743.31$, $SD=136.64$ [inverted]) or anger ($M=703.02$, $SD=156.37$ [upright]; $M=734.15$, $SD=139.78$ [inverted]) White male faces, $t(41)=1.17$, $p=.248$, $d_z=0.18$, in the sex task. In the race task, participants were faster to categorize happiness ($M=699.13$, $SD=151.86$ [upright]; $M=734.21$, $SD=162.45$ [inverted]) than anger ($M=736.44$, $SD=141.44$ [upright]; $M=766.00$, $SD=154.50$ [inverted]) on White male faces, $t(41)=3.53$, $p=.001$, $d_z=0.54$, but not on happy ($M=730.28$, $SD=142.09$ [upright]; $M=771.40$, $SD=166.46$ [inverted]) or angry ($M=738.52$, $SD=147.39$ [upright]; $M=749.31$, $SD=149.89$ [inverted]) Black Male faces, $t(41)=0.68$, $p=.498$, $d_z=0.11$.

In addition to this key effect, overall, participants were faster to categorize expressions on upright than on inverted faces, $F(1,41)=11.11$, $p=.002$, $\eta_p^2=.21$, and were also overall faster to categorize expressions on White male than on White female and Black male faces averaged together, $F(1,41)=14.01$, $p=.001$, $\eta_p^2=.26$. These effects were qualified by a significant Orientation × Face type × Emotion, $F(1,41)=5.41$, $p=.025$, $\eta_p^2=.12$, and a Task × Face type × Emotion interaction, $F(1,41)=41.40$, $p<.001$, $\eta_p^2=.50$. The Orientation × Face type × Emotional expression interaction reflected that, for upright faces, there was no difference in response times for upright happy and angry White male faces, $t(41)=1.34$, $p=.187$, $d_z=0.21$, but participants were faster to recognize happy than angry expressions on upright Black male and White female faces averaged together, $t(41)=3.38$, $p=.002$, $d_z=0.52$. No difference in categorization of happy and angry faces was observed for inverted White male faces or White female/Black male faces (averaged across tasks), $ts(41)<1.03$, $ps>.309$, $d_zs<.16$.

Comparing responses to White male faces across tasks, participants were significantly faster to categorize emotions on upright than inverted faces, $F(1,41)=9.15$, $p=.004$, $\eta_p^2=.18$. There was also a significant Task × Emotion interaction that emerged as participants were faster to categorize happiness than anger on White male faces in the race task, $t(41)=3.52$, $p=.001$, $d_z=0.54$, but not in the sex task, $t(41)=1.17$, $p=.248$, $d_z=0.18$.

Eye AOI.

Dwell times. As in response times, there was a significant Task × Face type × Emotion interaction $F(1,41)=4.27$, $p=.045$, $\eta_p^2=.09$[4]. Unlike the pattern of response times, however, this interaction emerged as in the sex task, participants looked more at the eye region of angry than happy White female faces, $t(41)=3.56$, $p=.001$, $d_z=0.55$, but not White male faces, $t(41)=0.30$, $d_z=0.05$. In the race task, participants did not look more in the eye region of either happy or angry Black male, $t(41)=0.81$, $p=.423$, $\eta_p^2=0.12$, or White male faces, $t(41)=1.72$, $p=.092$, $d_z=0.27$. No other effects were significant, $F(1,41)=2.28$, $p=.139$, $\eta_p^2=.05$ (See Figure 4a [upright] and 5a [inverted]).

[4] In this task, there was a significant Orientation × Task × Face type × Emotion × Participant sex interaction, $F(1, 40)=5.58$, $p=.023$, $\eta_p^2=.12$. To break down this five-way interaction, we considered the influence of sex in the upright and inverted face tasks separately. This revealed a four-way Task × Face type × Emotion × Participant sex interaction approaching significance for upright faces, $F(1,40)=3.76$, $p=.060$, $\eta_p^2=.086$, but not for inverted faces, $F(1, 40)=1.62$, $p=.211$, $\eta_p^2=.04$, suggesting the upright faces tasks as the main source of this interaction. Male participants in the upright race task spent a greater portion of time fixating on the eye region of Black male faces ($M=35.03$, $SD=28.84$) than White male happy faces ($M=31.16$, $SD=29.81$), $t(40)=2.21$, $p=.033$, $d_z=0.61$, but not Black ($M=32.11$, $SD=28.97$) or White male ($M=32.51$, $SD=29.19$) angry faces, $t(40)=0.28$, $p=.781$, $d_z=0.08$. Such a difference between White male and White female faces was not observed in the sex task for either happy ($M=32.84$; $SD=29.41$ [White male]; $M=34.01$, $SD=29.46$ [White female]) or angry faces ($M=33.17$, $SD=26.92$ [White male]; $M=36.50$, $SD=28.97$ [White female]), $ts(40)<1.55$, $p>.128$, $d_zs<.43$. Conversely, in the sex task, female participants spent a greater portion of time fixating on White female ($M=26.71$, $SD=21.81$ than White male faces ($M=24.71$, $SD=20.94$ when both happy, $t(40)$ 2.16, $p=.037$, $d_z=0.40$, and angry ($M=28.80$, $SD=21.65$ [White female]; $M=24.66$, $SD=20.14$ [White male]), $t(40)=2.88$, $p=.006$, $d_z=0.55$. In the race task female participants spent a greater portion of time fixating on Black male ($M=32.11$, $SD=28.97$) than White male faces ($M=24.77$, $SD=20.55$) when angry, $t(40)=3.18$, $p<.003$, $d_z=0.59$, but not when happy ($M=24.75$, $SD=20.26$ [Black male]; $M=24.11$, $SD=21.98$ [White male]), $t(40)=0.55$, $p=.587$, $d_z=0.10$.

In addition, participants, overall, spent significantly longer looking at the eyes of upright than inverted faces, $F(1,41)=44.98$, $p<.001$, $\eta_p^2=.52$. Participants also spent longer looking at Black male and White female faces considered together than White male faces, $F(1,41)=20.54$, $p<.001$, $\eta_p^2=.33$, and longer looking at the eyes of angry than happy faces, $F(1,41)=4.40$, $p=.042$, $\eta_p^2=.10$. There was also a significant Orientation × Face type interaction, $F(1,41)=5.41$, $p=.025$, $\eta_p^2=.12$, which emerged as participants looked at the eye region of Black male and White female faces averaged together significantly more than White male faces when upright, $t(41)=4.27$, $p<.001$, $d_z=0.66$, and inverted faces, $t(1,41)=2.02$, $p=.050$, $d_z=0.31$, but the effect was larger for upright faces. No other effects were significant, $Fs(1,42)<2.28$, $ps>.139$, $\eta_p^2<.05$.

Comparing gaze patterns towards White male faces across tasks, indicated no differences as a function of task. Participants spent a greater proportion of time looking in the eye region of upright than inverted faces, $F(1,41)=43.27$, $p<.001$, $\eta_p^2=.51$, but no other effects were significant, $Fs<1.38$, $p>.246$, $\eta_p^2<.03$.

Initial orienting. In initial orienting towards the eye AOI, unlike in response times, there were no significant Task × Face type × Emotion, $F(1,41)=0.04$, $p=.839$, $\eta_p^2<.01$, or Orientation × Task × Face type × Emotion interactions, $F(1, 41)=0.06$, $p=.804$, $\eta_p^2<.01$. Looking at the overall pattern of initial orienting, participants were significantly more likely to first fixate on the eyes of upright than of inverted faces, $F(1,41)=45.94$, $p<.001$, $\eta_p^2=.53$. They were also significantly more likely to first fixate on the eyes of White female and Black male faces considered together compared to White male faces, $F(1,41)=4.27$, $p=.045$, $\eta_p^2=.09$. This main effect was moderated by a significant Task × Face type interaction, $F(1,41)=6.29$, $p=.016$, $\eta_p^2=.133$, which emerged as participants initially fixated on the eye region of White female faces more than White male faces in the sex task, $t(41)=3.27$, $p=.002$, $d_z=0.50$, but did not fixate more on the eyes of White male or Black male faces in the race task, $t(41)=0.03$, $p=.973$, $d_z<.01$. No other effects were significant, Fs $(1,41)<2.91$, $ps>.096$, $\eta_p^2 s<.07$ (See Figures 4b [upright] and 5b [inverted]).

Comparing gaze patterns towards upright and inverted White male faces across tasks indicated that treatment of White male faces did not differ with a change in task context. Participants initially looked towards the eyes more for upright than inverted faces, $F(1, 41)=41.62$, $p<.001$, $\eta_p^2=.50$, but no other effects were significant, Fs<0.39, ps$>.54$, $\eta_p^2<.01$.

Mouth EOI

Dwell times. Consistent with response times, there was a significant three-way Task × Face type × Emotion interaction, $F(1,41)=11.83$, $p=.001$, $\eta_p^2=.22$. This effect, however, emerged as when combining upright and inverted faces, in the sex task, participants looked more at the mouth of White female than White male faces when the face was happy, $t(41)=2.68$, $p<.011$, $d_z=0.41$, but not when the face was angry, $t(41)=0.87$, $p=.390$, $d_z=0.13$. In the race task, participants looked at the mouth region more for Black male than White male faces when happy, $t(41)=9.07$, $p<.001$, d_{z-} $_{=}1.40$, and angry, $t(41)=4.56$, $p<.001$, $d_z=0.70$. Comparing dwell times for happy and angry faces for each face type revealed no significant differences, $ts<1.82$, $p>.077$, $d_z<.28$ (See Figures 4c [upright] and 5c [inverted]).

In addition to this key effect, overall, participants spent more time fixating on the mouths of inverted than upright faces, $F(1,41)=93.16$, $p<.001$, $\eta_p^2=.69$, as well as in the race task than the sex task, $F(1,41)=4.74$, $p=.035$, $\eta_p^2=.10$, and for Black male and White female faces averaged together than White male faces, $F(1,41)=63.80$, $p<.001$, $\eta_p^2=.61$. There was also a significant Task × Face type interaction, $F(1,41)=35.21$, $p<.001$, $\eta_p^2=.46$, that emerged as participants spent more time looking at the mouth region of Black male faces in the race task than White female faces in the sex task, $t(41)=4.04$, $p<.001$, $d_z=0.62$. For White male faces, however, dwell times on the mouth region did not differ across tasks, $t(41)=0.11$, $p=.909$, $d_z=0.02$. No other effects were significant, $F(1,41)<3.96$, $p>.053$, $\eta_p^2<.09$.

Comparing responding to upright and inverted White male faces across tasks again indicated no difference in gaze patterns as a function of task context. Participants spent a greater proportion of time looking at the mouth region of inverted than upright faces, $F(1,41)=86.81$, $p<.001$, $\eta_p^2=.68$, but no other effects were significant, $Fs<3.76$, $p>.059$, $\eta_p^2=.08$.

Initial Orienting. Again, there was a significant Task × Face type × Emotion interaction, $F(1,41)=5.17$, $p=.028$, $\eta_p^2=.11$. This interaction emerged, as when averaging across upright and inverted faces in the race task, participants initially fixated on the mouth region more for angry than happy White male faces, $t(41)=2.16$, $p=.036$, $d_z=0.33$, but not Black male faces, $t(41)=1.07$, $p=.291$, $d_z=0.17$. In the sex task, participants did not initially fixate more on the mouth of happy or angry White male, $t(41)=0.25$, $p=.800$, $d_z=0.04$, or White female faces, $t(41)=0.27$, $p=.788$, $d_z=0.04$, (See Figures 4d [upright] and 5d [inverted]).

In addition to this key interaction effect, participants initially fixated on the mouth region of inverted faces more than of upright faces, $F(1,41)=74.93$, $p<.001$, $\eta_p^2=.65$. They also initially fixated more on the mouth region of Black male and White female faces averaged together than of White male faces, $F(1,41)=24.12$, $p<.001$, $\eta_p^2=.37$. These effects were moderated by a significant Task × Face type interaction, $F(1,41)=13.67$, $p=.001$, $\eta_p^2=.25$, as participants initially fixated on the mouth region of Black male faces more than of White female faces when comparing race and sex tasks, $t(41)=2.64$, $p=.012$, $d_z=0.41$, but did not differ in their initial fixation towards the mouth region of White male faces as a function of task, $t(41)=0.22$, $p=.830$, $d_z=0.03$. No other effects were significant, $F(1, 41)<3.83$, $p>.057$, $\eta_p^2<.09$.

Comparing gaze patterns to upright and inverted White male faces across task again indicated no influence of task context on how participants initially fixated on White male faces. Participants initially fixated on the mouth region of inverted faces more than upright faces, $F(1, 41)=72.45$, $p<.001$, $\eta_p^2=.64$, but no other effects were significant, $F(1, 41)<2.85$, $p>.099$, $\eta_p^2<.07$.

General Discussion

The aim of the current study was to identify whether differences in the mode of face processing or visual sampling strategies underlie the moderating influence of social category information (race and sex) on emotion perception under different task contexts. As predicted, in all experiments, the moderating influence of social category cues on emotion recognition was observed. Participants tended to categorize happiness faster than anger on the relatively more positively evaluated faces in each task (White females in the sex task, White males in the race task). In Experiment 2, where part faces were presented, the pattern of results differed as a function of whether participants categorized top halves or bottom halves of faces, but an evaluatively congruent moderating influence of the social category information in the face remained. For top halves, anger was categorized faster on the relatively more negatively evaluated faces whereas on bottom halves, happiness was categorized faster on the relatively more positively evaluated faces. Across all experiments and resisting different types of manipulations to disrupt holistic processing, response time differences between recognizing happy and angry expressions always differed for White males as a function of the other faces they were encountered with.

These findings are consistent with previous studies reporting that the race and the sex of a face can influence the speed and accuracy with which an emotional expression is recognized using whole upright faces (Becker et al. 2007; Bijlstra et al., 2010; Craig & Lipp, 2017; Craig et al., 2012; Hugenberg, 2005; Hugenberg & Sczesny, 2006). They are also consistent with previous studies demonstrating that emotional expressions on the same White male faces are categorized at different speeds depending on the other faces they are encountered with (Craig, Zhang, & Lipp, 2017; Craig, Koch, & Lipp, 2017; Lipp, Craig, & Dat, 2015). Finding that social cues still influenced emotion perception when holistic processing was disrupted replicates the results of Aguado et al. (2009) who found that the influence of sex on emotion recognition was comparable when presenting upright and inverted faces as well as top or bottom face halves. These results do not replicate findings of Karnadewi and Lipp (2011) who found that Garner interference of race cues on emotion recognition is not disrupted by inversion, but Garner interference of sex cues is. This difference between the current study and Karnadewi and Lipp (2011) is likely due to the use of different indicators of an interaction (Garner interference vs. presence/absence of a Social cue × Emotion interaction in response times) or differences in face set size employed (Lipp, Karnadewi, Craig, & Cronin, 2015).

Looking at the eye-tracking data, despite the relatively smaller sample sizes adopted and thus lower power to detect small effects, eye-movements to faces differed as a function of expression and social category membership. There was, however, little indication that differences in emotion recognition times between tasks were driven by differences in visual sampling. In the current study, participants, overall, spent a greater proportion of time looking at the eye region than the mouth region of upright faces. An overall preference for looking towards the eyes of upright faces when processing emotional expressions is consistent with previous studies measuring gaze patterns during emotion recognition (Eisenbarth & Alpers, 2011; Schurgin et al., 2014) as well as studies using behavioural approaches to identify key regions important for recognition of emotions (Wegrzyn et al., 2015). Also consistent with past studies (Eisenbarth & Alpers, 2011; Schurgin et al., 2014), participants in the current study dwelled on the eye region relatively longer for angry faces, and the mouth region relatively longer for happy faces.

Although gaze patterns align with previous research, there is a dissociation between the patterns of results for eye gaze and response times. In Experiment 4, when faces were inverted, participants maintained a bias towards looking to the top half of the face. The greater proportion of time spent looking to the eye region of upright faces, became a bias for looking towards the mouth region of inverted faces, a finding that is consistent with other studies measuring eye-tracking with upright and inverted faces (e.g., Xu & Tanaka, 2013). Although participants spent relatively more time looking at different features of the upright and inverted faces, a comparable moderating influence of social category cues on response times emerged in both modes of presentation. Moreover, additional analyses comparing gaze patterns for the same White male faces indicated no evidence for a change in gaze patterns between the race and sex tasks across two different indices (dwell times and initial orienting), two different regions of interest important to emotion recognition (eyes and mouth) and two experiments. These findings provide an indication that the influence of social category cues on emotion recognition speed is independent from gaze patterns.

Further, across experiments, there was evidence of a greater proportion of time spent and more initial orienting towards the eye and particularly mouth regions of Black male faces (sometimes this was observed specifically for happy expressions). This heightened attention did not result in faster recognition of expressions on these faces or a happy advantage for Black male faces when greater attention was paid towards the mouth region. If anything, the gaze patterns observed are more consistent with a bottom-up contrast driven mechanism. The happy faces used in the current study all displayed open-mouthed smiles (teeth showing) and the majority of the angry expressions were also open-mouthed. The gaze patterns are consistent with the idea that the high contrast between the darker skin of the Black male faces and white teeth (and to a lesser extent the white sclera) present in the emotional expressions resulted in more attention towards these areas for Black male faces. Though, this additional time spent looking in these areas did not seem to relate to the patterns of emotion recognition times observed. Further to the above findings, these results indicate that shifts in emotion recognition times observed as a function of the task context do not seem to be related to differences in visual sampling across tasks.

Implications for Theory and Future Research

The visual-structural account proposes that the influence of social cues on emotion recognition is due to the overlap between visual information signaling both social category and emotional expression cues (Becker et al., 2007), whereas the evaluative account suggests that implicit evaluations based on the race/sex of the faces facilitate recognition of evaluatively congruent expressions (Hugenberg, 2005). These two explanations are hard to tease apart when using photographs of real faces as the social cues are inherently recognizable attributes of real faces that cannot be removed/masked without affecting visual information conveying emotional expression. Even when inverting or presenting only part faces, structural overlaps between social category and emotional cues can still be present (e.g., the angular jaw line and pronounced brow that may facilitate recognition of anger and slow recognition of happiness on male faces are present in the bottom and top half of the face respectively and when the face is inverted). It is possible that both mechanisms occur concurrently (see Craig & Lee, 2020, for a review relating to the influence of sex cues on emotion recognition).

Despite this, the current pattern of results is most consistent with the evaluative congruence account (Craig, Koch, & Lipp, 2017; Lipp et al., 2015) rather than other possible accounts (like the visual structural account, Becker et al., 2007). In the current study, it was repeatedly demonstrated that the speed of recognizing expressions on White male faces depended on the other faces in the task. This indicates that information beyond the visual structural cues in the face is an important determinant of emotion recognition speed. While it is possible that this effect emerged due to participants sampling information from different parts of the face in different tasks, eye-tracking results demonstrated that this was not the case. Though gaze patterns towards key areas relevant for emotion recognition did differ as a function of the social information on the face, these differences in gaze patterns were not consistent with differences in behavioural responses. Gaze patterns towards the same White male faces never differed as a function of task whereas emotion recognition times did.

Further to this, using various manipulations to alter the visual and structural information available (e.g., through presenting part faces or through inversion), we found consistent evidence that social category information present on the face influences emotion perception in an evaluatively congruent manner. Interestingly, presenting only the top halves of faces facilitated an overall recognition advantage for anger. This does suggest that certain visual information in the eyes facilitates recognition of certain expressions (at least in the context of this two-alternative forced-choice task); however, the influence of social category cues still acted to facilitate recognition of evaluatively congruent expressions (facilitating an angry advantage for the relatively negatively evaluated social category in the task). Together, these findings provide evidence for the role of broad social evaluations on the speed of emotion recognition.

These results add specificity to current models of person perception, such as the Dynamic Interactive Model of Person Construal (Freeman & Ambady, 2011). Within this model, social cues recognizable from the face and body can interact depending on the extent to which the social cues overlap perceptually and conceptually. Interactions can be driven bottom-up by shared visual structural information, as well as top-down via shared stereotypes/associations. Results from the eye-tracking experiments suggest that the moderating influence of social category cues on emotion perception in tasks of this nature are strongly driven by top-down influences from shared associations rather than bottom-up visual structural overlap, as gaze patterns did not reflect response time patterns. Although different task contexts did alter the speed of processing expressions on White male faces, this was not due to the task context promoting different visual sampling strategies as gaze patterns towards White male faces were comparable across tasks.

These results indicate that the moderating influence of social category information is most likely to occur at a stage of processing after visual sampling and initial face processing has taken place. The finding that gaze patterns for White male faces never differed between tasks also suggests that task specific knowledge does not feedforward to a point where it alters the way that visual information is sampled from the faces. As these influences of social categorization occur beyond the visual sampling stage, different methods are needed to pinpoint the underlying mechanism. This may be achieved using other methods and measures that provide access to the processing stages leading up to the behavioral response or that are sensitive to racial prejudice such as response time modelling (e.g., Tipples, 2019) or EEG/ERPs (e.g., Gimenez-Fernandez, 2020; Kubota & Ito 2007).

To our knowledge, only one study has investigated where in the decision process the interaction between facial sex cues (but not race cues) and emotional expression emerges using response time modelling (Tipples, 2019). Using a drift diffusion modelling approach, Face sex × Emotional expression interactions emerged in non-decision time. This measure includes the time taken to initially perceive the face and make a motor response (suggesting that perceptual information contributes to the bias). An interaction was also observed in boundary separation which is the amount of information needed to make a decision (suggesting that more information needs to be gathered before a response is made for counter-evaluative combinations). No interaction was found in the rate of evidence accumulation towards the decision threshold. These findings are consistent with the broader literature suggesting that overlap in both visual structural information and social category-based associations can contribute to the interaction between sex and emotion (see Craig & Lee, 2020 for a review). Future research using this approach could be used to identify where in the decision making and response process the interaction between race and emotion emerges. There is some evidence to suggest that, unlike facial sex cues, the influence of race on emotion perception is due to overlapping evaluations and not due to overlapping visual/structural information as the bias has been observed in computer generated stimuli that were identical in facial structure and only differed in skin tone (Craig et al., 2012; Hugenberg, 2005). Response time modelling may also allow further examination of the processes involved in fluctuations in the happy advantage for White male faces.

Previous research has identified an in-group eye-bias when looking at own and other race faces, such that more time is spent looking at the eyes of in-group members (including racial in-group members; Kawakami et al., 2014). In the current study, however, we did not find evidence that participants looked more at the eye region of in-group faces. If anything, the current results suggest that a greater proportion of time was spent looking at the eyes of Black male than White male faces. It is likely that this difference in gaze biases is due to differing task demands as the eye bias has been identified in tasks where participants were freely viewing the faces or trying to encode the identity of the faces for subsequent recognition (Kawakami et al., 2014). Compared to the demands of free viewing or identity encoding, the emotion recognition task we employed is a task performed under time pressure. It is also a task that can be accurately completed by focusing on key facial features (e.g., the shape of the mouth), perhaps explaining why no in-group eye-bias was observed. However, these results do add a caveat to previous research. The in-group eye-bias appears to be specific to certain task demands. Further research will be required to identify further boundary conditions for this effect.

In conclusion, we found evidence that social category information (like race and sex cue) influences the speed of emotion recognition. These effects are also context specific and depend on the relative evaluation of the social categories within the task. In the current study, we used various manipulations of holistic processing and measures of visual sampling. In doing so, we found little evidence that the moderating influences of social category information or context were due to shifts in the face processing strategies adopted or the visual information sampled while performing the tasks.

Figures and Tables

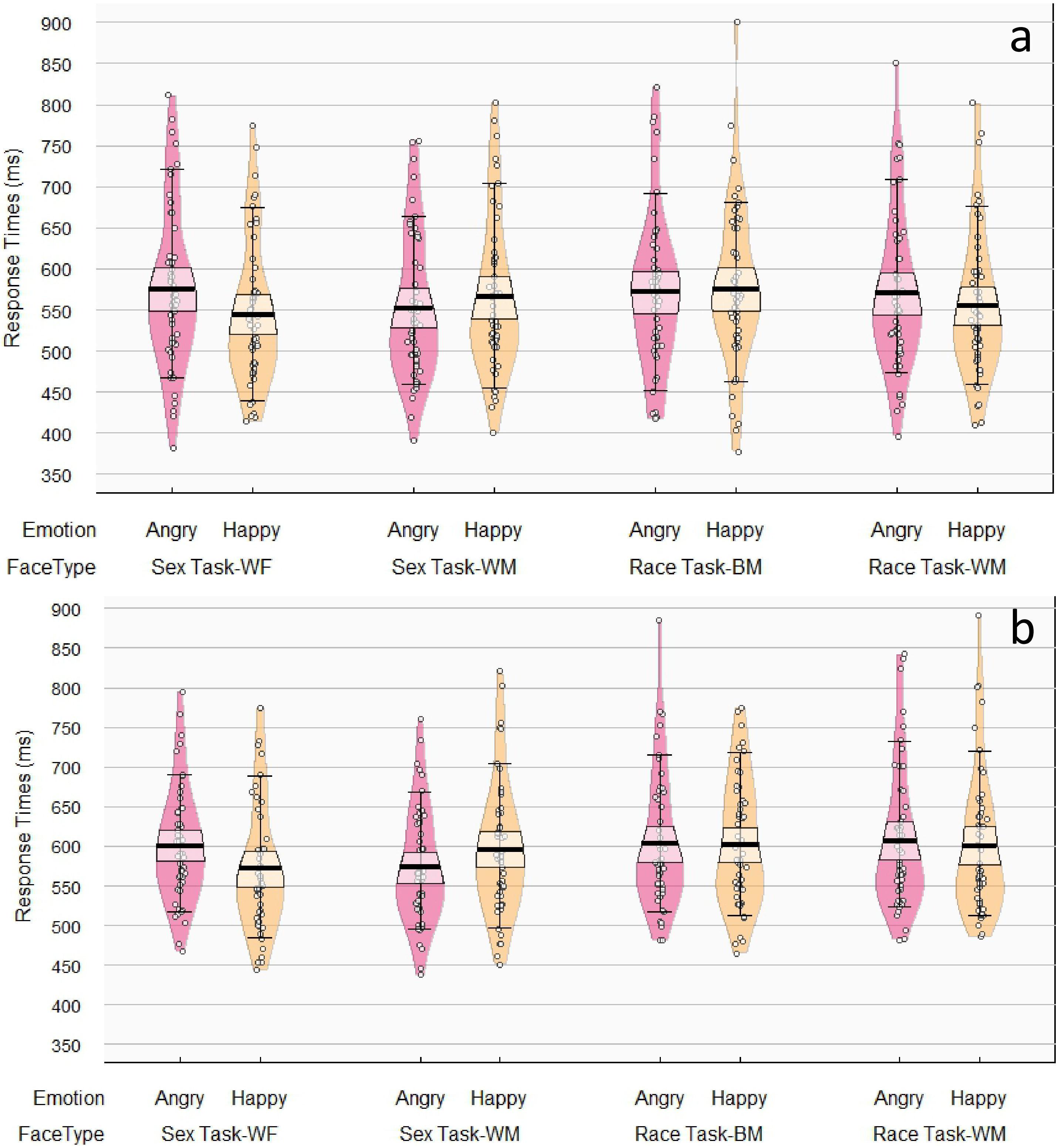

Figure 1. Pirate plots of emotion recognition times as a function of the sex or race of the faces and the emotional expression (happy or angry) for upright faces (upper panel [Figure 1a]) and inverted faces (lower panel [Figure 1b]) in Experiment 1. Colored beans represent the density of the distribution of condition response times. Dark black bars represent overall condition means. Light shaded areas represent 95% confidence intervals. Whiskers represent 10^{th} and 90^{th} percentiles and white dots represent individual participants' mean condition response times.

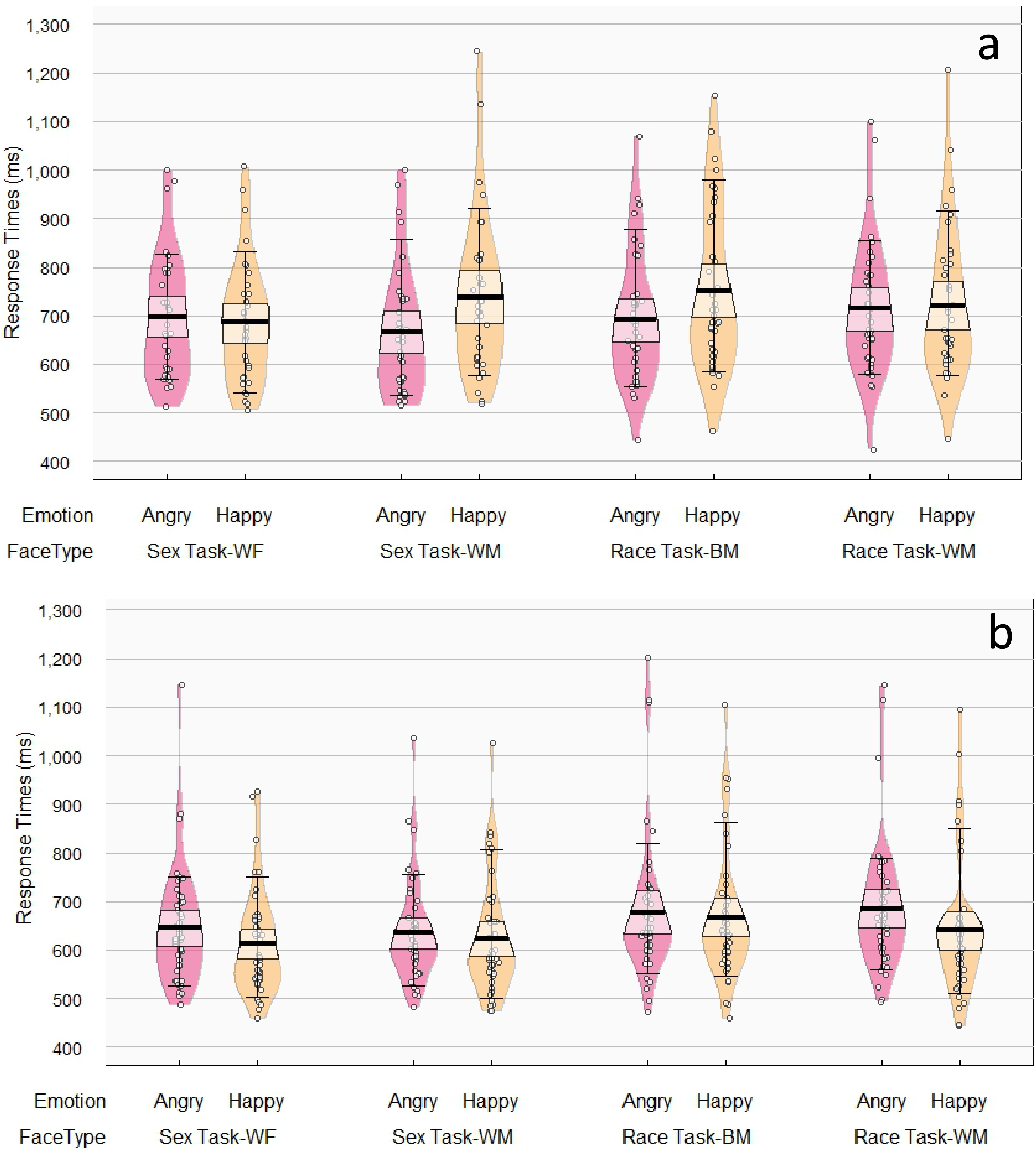

Figure 2. Pirate plots of emotion recognition times as a function of the sex or race of the faces and the emotional expression (happy or angry) for top halves (upper panel [Figure 2a]) and bottom halves of faces (lower panel [Figure 2b]) in Experiment 2. Colored beans represent the density of the distribution of condition response times. Dark black bars represent overall condition means. Light shaded areas represent 95% confidence intervals. Whiskers represent 10^{th} and 90^{th} percentiles and white dots represent individual participants' mean condition response times.

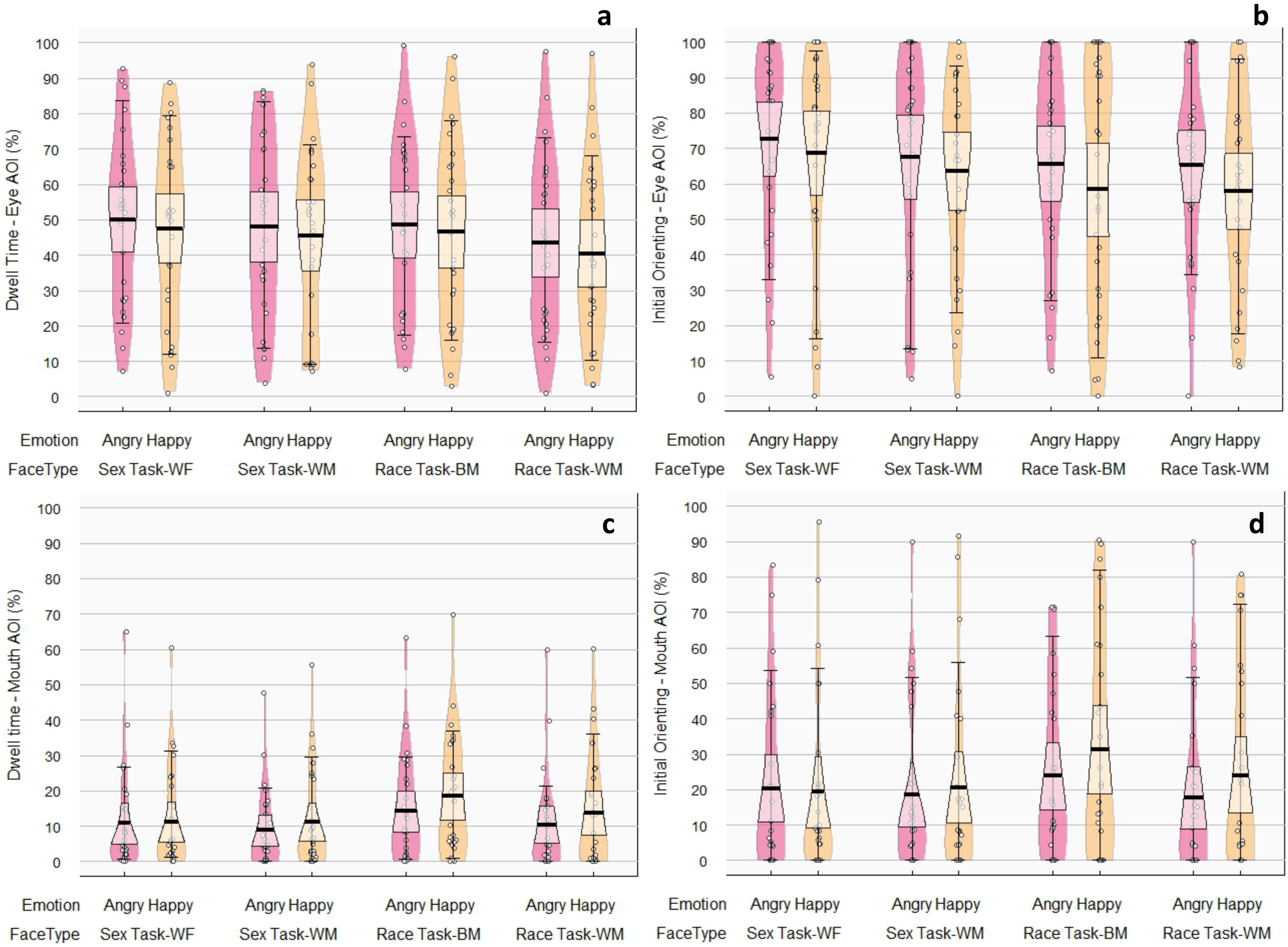

Figure 3. Dwell times (left panels) and initial orienting (right panels) towards the eye AOI (top panels) and mouth AOI (bottom panels) as a function of the sex or race of the faces and the emotional expression (happy or angry) in Experiment 3. Colored beans represent the density of the distribution of condition response times. Dark black bars represent overall condition means. Light shaded areas represent 95% confidence intervals. Whiskers represent 10^{th} and 90^{th} percentiles and white dots represent individual participants' mean condition response times.

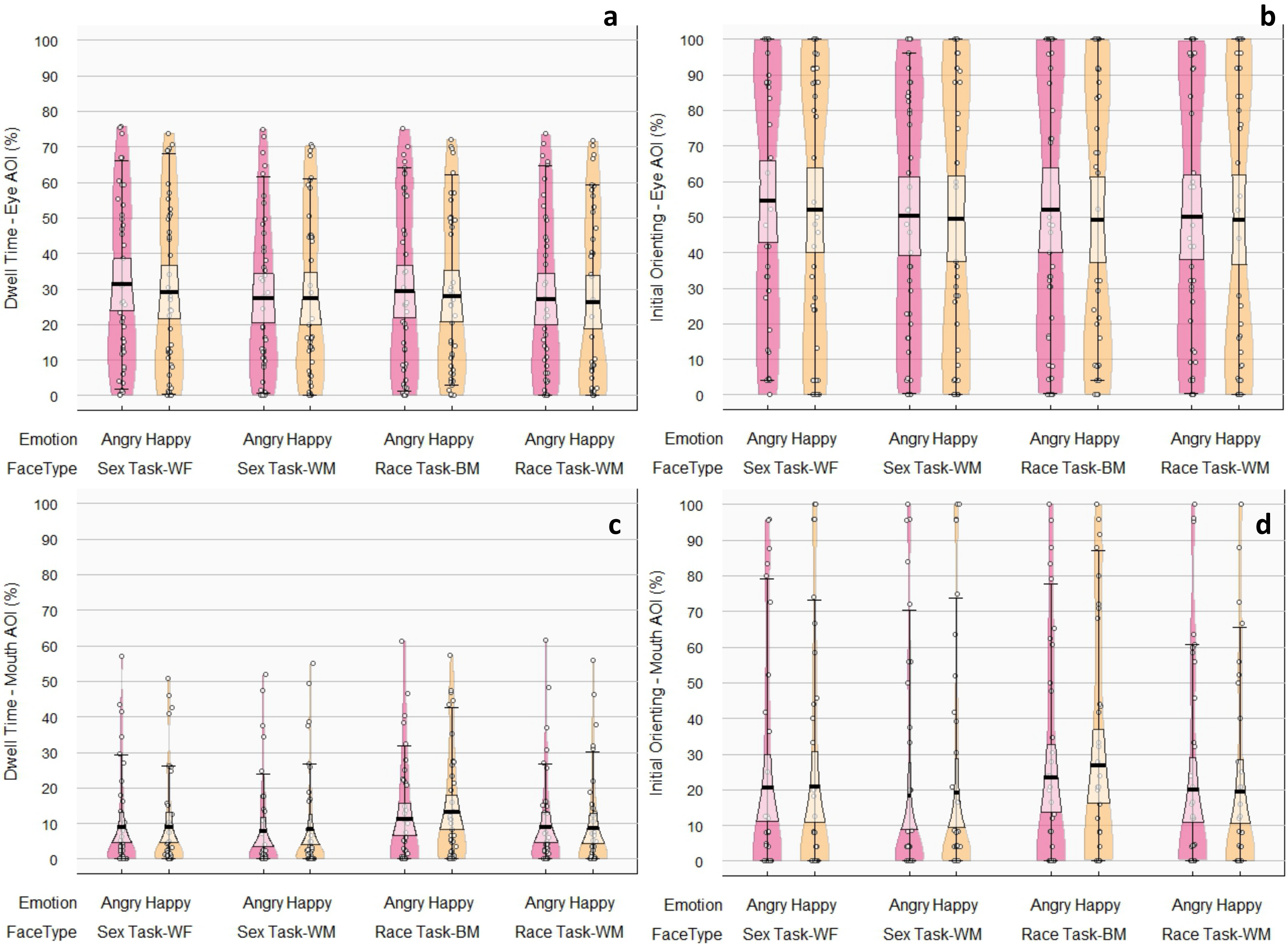

Figure 4. Dwell times (left panels) and initial orienting (right panels) towards the eye AOI (top panels) and mouth AOI (bottom panels) as a function of the sex or race of the faces and the emotional expression (happy or angry) for Upright faces in Experiment 4. Colored beans represent the density of the distribution of condition response times. Dark black bars represent overall condition means. Light shaded areas represent 95% confidence intervals. Whiskers represent 10th and 90th percentiles and white dots represent individual participants' condition response times.

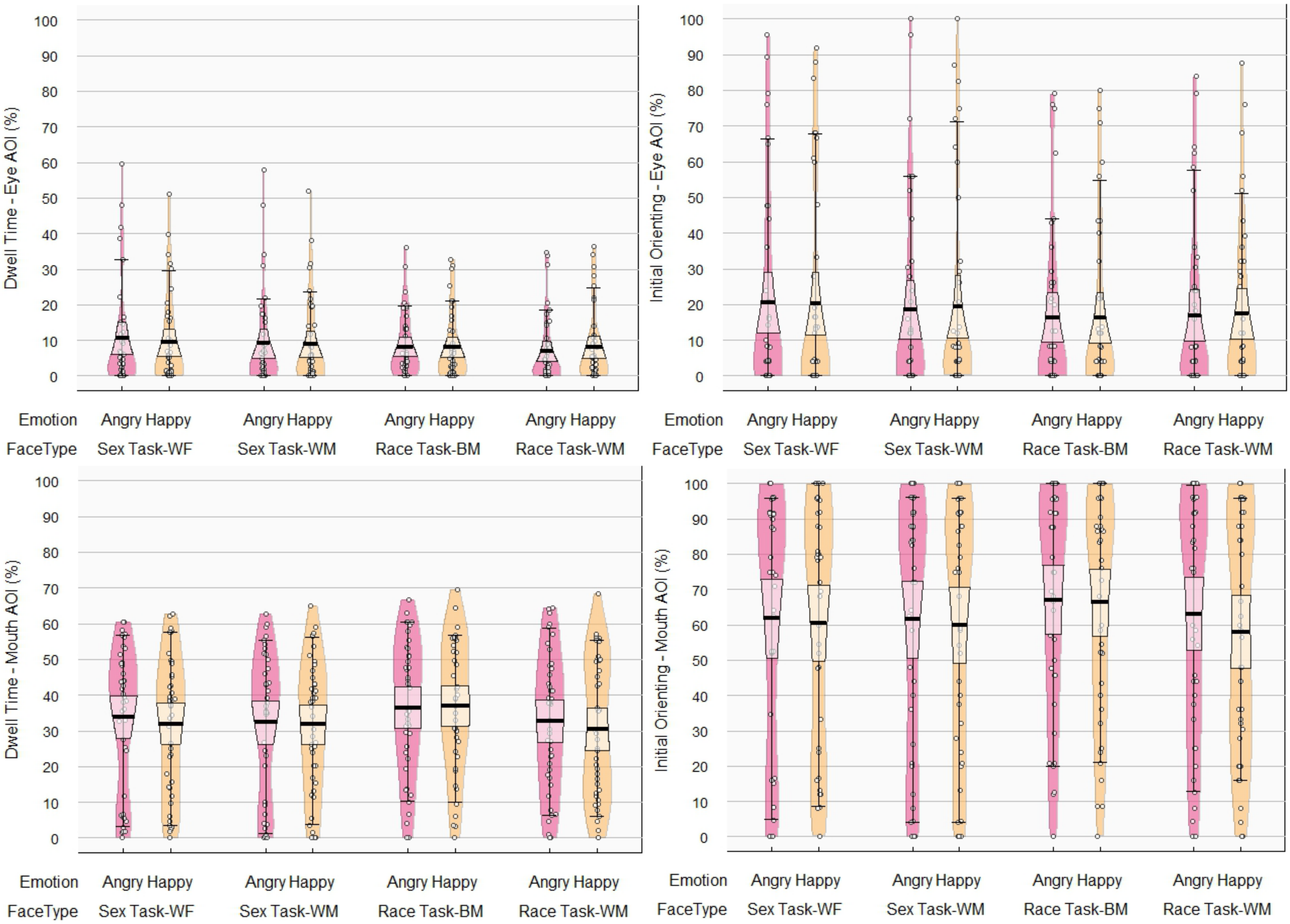

Figure 5. Dwell times (left panels) and initial orienting (right panels) towards the eye AOI (top panels) and mouth AOI (bottom panels) as a function of the sex or race of the faces and the emotional expression (happy or angry) for inverted faces in Experiment 4. Colored beans represent the density of the distribution of condition response times. Dark black bars represent overall condition means. Light shaded areas represent 95% confidence intervals. Whiskers represent 10th and 90th percentiles and white dots represent individual participants' mean condition response times.

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