Biases in spatial bisection induced by viewing male and female faces

Zaira Cattaneo[1,2*], Susanna Schiavi[3], Carlotta Lega[1], Chiara Renzi[2], Matteo Tagliaferri[1], Jana Boehringer[4], Claus-Christian Carbon[4], & Tomaso Vecchi[2,3]

1. Department of Psychology, University of Milano-Bicocca, Milano, Italy
2. Brain Connectivity Center, IRCCS Mondino, Pavia, Italy
3. Department of Psychology, University of Pavia, Italy
4. Department of General Psychology and Methodology, University of Bamberg, Bamberg, Germany

*** Corresponding author:**

zaira.cattaneo@unimib.it

Abstract

Research on visual attention triggered by face gender is still relatively sparse. In the present study, three experiments are reported in which male and female participants were required to estimate the midpoint of a line (i.e., the "line bisection task"): at each end of the line a face was presented. Depending on the experimental condition, faces could be of the same gender (i.e., two males or two females) or the opposite gender. Experiment 1 and 2 findings converged in showing that when a male face was presented at the right and a female face at the left endpoint of the line, a clear rightward bias emerged compared to the other experimental conditions, indicating that male faces captured attention more than female faces. Importantly, male faces used across Experiment 1 and 2 were rated as more threatening than female faces, suggesting that perceived level of threat may have been responsible for the observed bias toward the male face. **Experiment 3 corroborated this hypothesis by finding an attentional bias toward the male face with high threat (angry) faces but not with low threat (smiling) faces.**

Keywords: bisection; gender effects; visual attention; spatial; sex; own-gender bias; opposite-gender bias; evolution; **threatening faces**

Introduction

Previous studies suggest the existence of an own gender bias (OGB) in memory for faces. In particular, the majority of studies report a systematic OGB in females (e.g., Ge, et al., 2008; Loven, Herlitz, & Rehnman, 2011; Loven, et al., 2012; Rehnman & Herlitz, 2006, 2007; Wright & Sladden, 2003). For males, findings are more controversial: although there is some evidence of higher males' memory performance for male than female faces (e.g., Ge, et al., 2008; McKelvie, Standing, Stjean, & Law, 1993; Shaw & Skolnick, 1994, 1999), in most published studies men showed no OGB or even an opposite gender bias (e.g., Going & Read, 1974; Ino, Nakai, Azuma, Kimura, & Fukuyama, 2010; Lewin & Herlitz, 2002; Loven, et al., 2011; Rehnman & Herlitz, 2007). The origin of the OGB in memory is still unclear, being possibly related to perceptual expertise (e.g., Ramsey, Langlois, & Marti, 2005; Ramsey-Rennels & Langlois, 2006) or social cognitive and motivational factors (for a review see Young, Hugenberg, Bernstein, & Sacco, 2012).

The existence of an OGB in memory raises the question of whether male and female faces capture attention to a different extent at encoding depending on the gender of the viewer. In this regard, a previous study employing a divided attention paradigm has demonstrated that women's OGB in memory for faces does not depend on women processing female faces more deeply than male faces (Loven, et al., 2011). In a following study investigating possible interactions between the own-race bias and the OGB, Loven et al. (2012) found that own-race female faces were overall fixated longer, i.e., received more visual attention, by both male and female participants; however, memory biases did not seem to be directly dependent on viewing duration time (Loven, et al., 2012). Critically, no study so far has directly investigated whether male and female faces affect orienting of attention to a different extent and in a similar vein in male and female viewers.

One of the most employed paradigms in clinical and research contexts to investigate distribution of spatial attention is the line bisection task, in which participants are required to indicate the midpoint of a line. Neurologically healthy individuals usually show a subtle but systematic leftward bisection bias in this task, known as "pseudoneglect" (see Jewell & McCourt, 2000) – probably due to a right-hemisphere dominance in spatial attention. Notably, several studies have shown that the bisection bias may be modulated by the simultaneous presentation of concurrent stimuli carrying directional information, such as arrows, digits of different magnitude (Bonato, Priftis, Marenzi, & Zorzi, 2008; Cattaneo, Fantino, Mancini, Mattioli, & Vallar, 2012; Cattaneo, Fantino, Tinti, Silvanto, & Vecchi, 2010; de Hevia, Girelli, & Vallar, 2006) or other manipulations known to differently affect activation of the two hemispheres (Nicholls, et al., 2012). Only a few published studies have used faces as flankers in visual line bisection (Claunch, et al., 2012; Giardina, Caltagirone, Cipolotti, & Oliveri, 2012; Tamietto, et al., 2005), but none of them investigated whether and how face gender biases attention. The major aim of our study was to specifically investigate whether orienting of attention in male and female participants in a visual line bisection task is affected by the simultaneous presentation of bilateral face flankers, in which the two flanker faces are of the same or opposite gender.

Experiment 1

Method

Participants

Twenty-four students (12 males, mean age = 22.3 years, *SD*= 2.28, range: 20-28 years; with no significant difference in age between male and female participants, *p*=.29), all right-handed, assured by a standard inventory (Oldfield, 1971), took part in the experiment.

Face stimuli

The face set consisted of 8 different young Caucasian faces, 4 female (F) and 4 male (M), showing a neutral emotional expression (see Figure 1A), taken from the Bamberg Face Database. To reduce facial distinctiveness and make the different faces more average-like (Busey, 1998), each facial stimulus was obtained by linear morphing of 4 different original faces using Fantamorph (Abrosoft ©). Moreover, faces were free of jewelry, glasses, and adjusted in order to remove distinctive hairstyles. Faces were placed on a white background and inserted in a circle with a diameter of 2.5° of visual angle (see Figure 1A). Male and female faces were rated for attractiveness and distinctiveness (‘‘How easily would the face stand out in a crowd?’’) by a further group of 32 students (16 males, mean age = 20.8 years, *SD*=1.58, none of which participated in the main experiment) using a 7-point Likert scale (1—low, 7—high) (cf. Carbon, Gruter, Gruter, Weber, & Lueschow, 2010). The faces were presented sequentially on a computer screen in a random order. Participants rated all faces on a single dimension at a time (the order of dimension being rated was counterbalanced across participants) and were allowed to view the face as long as they wished.

Pressing of a key between 1 and 7 brought up the next face to be judged. Before starting the rating, all faces were presented once in random order to familiarize participants with each face and to illustrate the full range of faces. For each measure (attractiveness and distinctiveness), a mean rating was calculated for each face, on each variable, by averaging relevant scores across male and female raters. Mean attractiveness rating scores were 3.02 (*SD*=.30) for male faces and 3.35 (*SD*=.35) for female faces. Attractiveness scores were overall comparable for male and female faces (p=.12); however, male raters tended to judge female faces as more attractive than male faces (p=.025). Distinctiveness rating scores were comparable for male faces (mean=2.95, *SD*=1.39) and female faces (mean=3.20, *SD*=1.26) (p=.29), in both male and female raters (*ps*>.05).

[insert Figure 1 about here]

Procedure

Participants were seated in front of a 12.1-inch PC (1024 x 786 pixels) screen at an approximate distance of 57 cm. The task was a computerized cued line bisection task. The time course of an experimental trial is presented in Figure 1b. In each trial a black line flanked by two circles (diameter of 2.5 deg, placed at a distance of approximately 0.3 deg from the ends of the line) was presented. In the “baseline condition” the circles were empty; in the “face condition” the circles contained a face. To increase stimulus variability and to reduce the possibility of assessing the center of the line by merely inspecting the frame of the screen two different line lengths were used (measuring approx. 8 deg and 12 deg) that could appear in eight different positions: specifically, lines were always displaced 50 pixels right or left from the center and displaced 50 or 150 pixels up or down from the center. Across the experiment, long and short lines appeared an equal number of times in each of the eight possible positions. Participants were instructed to indicate the line midpoint by mouse clicking (using their right hand). The mouse cursor was a fully vertical arrow that appeared underneath either the left or the right extreme of the line and moved only horizontally. The initial position (left or right) of the cursor was randomly assigned for each trial. The line remained visible on the screen until participants responded. Before starting the experiment, participants were presented with a series of practice trials in which they were only required to bisect short and long lines, while no flankers were present. The experiment consisted of 32 baseline trials in which lines were flanked by empty circles, and 64 “face trials” in which lines were flanked by faces. Baseline and face trials were presented in separate blocks; the order of blocks was counterbalanced across participants. For half of the face trials, flankers were faces of the same gender (F-F and M-M trials), for the other half faces used as flankers were of the opposite gender (F-M and M-F). Across the experiment, each face appeared an equal number of times as left flanker and right flanker, and in all possible combinations with the other faces. In baseline trials (i.e., empty circles as flankers), participants' bisection response was followed by a blank screen (1000 msec), hence a new line was presented. In trials belonging to the faces block, the bisection response was followed by a blank screen (500 msec), hence a face was presented in the middle of the screen. By pressing the left/right key (using their left hand) (cf. Claunch, et al., 2012) participants had to indicate whether the face matched either one of the faces that were used as flankers in the preceding bisection trial; in half of the trials the correct response was "yes". After response, the target face disappeared and a blank screen was presented for 1000 msec; hence a new trial started. The memory test was introduced in faces trials in order to make sure that participants paid attention to the face flankers (see Claunch, et al., 2012). Prior to the experiment participants were informed about the memory test and were instructed to pay attention to the face flankers. The instructions emphasized the combination of speed and accuracy, but no time limit was imposed either in the bisection or in the memory task. The whole experiment lasted approx. 25 min. The software E-prime 2.0 (Psychology Software Tools, Inc., Pittsburgh, PA, USA) was used for stimuli presentation and data recording.

Results

Analyses were performed on participants' mean percentage deviations from the true midline. More specifically, deviations from the veridical center were converted to signed percentage scores (negative if bisections were to the left, positive if they were to the right) by subtracting the true half-length of the line from the measured distance of each setting from the left extremity of the line (this bias was automatically computed by the software in pixels), and then dividing this value by the true half-length and multiplying the quotient by 100 (e.g., Cattaneo, et al., 2012). The changes in line length and position did not constitute experimental manipulations, and were therefore not analyzed.

Figure 2 shows participants' mean bisection biases in the different experimental conditions. In none of the five experimental conditions, the bias was significantly different from "0" (the true midline, all *ps*>.05). A mixed-design ANOVA was performed on the mean percentage biases with participants' gender as between-subjects variable and flanker condition (blank circles, M-F, F-M, M-M, and F-F) as within subjects-variables. The analysis revealed a main effect of flanker condition, $F(4, 88)=5.082$, $p=.001$, $\eta_p^2=.19$. The main effect of participants' gender was not significant ($p=.71$) and neither was the interaction flanker condition by gender ($p=.62$). Post-hoc pairwise comparisons (Bonferroni correction applied) for the flanker condition showed that in the F-M condition, participants significantly deviated to the right compared to the baseline condition (empty circles), $t(23)=4.19$, $p=.005$; compared to the M-F condition, $t(23)=4.20$, $p=.005$, and compared to the F-F condition, $t(23)=3.12$, $p=.049$ (without Bonferroni correction, the F-M condition was also significantly different from the M-M condition, with participants deviating more rightward in the former than in the latter condition, $t(23)=2.08$, $p=.049$). No other comparison reached significance. On average participants took 2254 msec to bisect the lines.

[insert Figure 2 about here]

Although the memory task in our experiment was only introduced to ensure that participants paid attention to the faces prior to bisecting, we also looked at memory performance. Accuracy in the memory test was very high for both male (mean=94.5%, *SD*=4.9) and female (mean=91.8%, *SD*=6.8) faces. A mixed-design ANOVA on participants' detection sensitivity (d', MacMillan & Creelman, 1991) with gender of the target face as within-subjects variable and participants' gender as between-subjects variable showed a significant effect of face gender, $F(1,22)=5.80$, $p=.025$, $\eta_p^2=.21$. The main effect of participants' gender was not significant ($p=.63$). The interaction participants' gender by face gender approached significance, $F(1, 22)=4.27$, $p=.051$, $\eta_p^2=.16$. Post-hoc comparisons showed that male participants remembered male faces significantly better than female faces, $t(11)=2.92$, $p=.014$, whereas face gender did not significantly affect memory performance in females ($p=.79$). Similar analyses carried out on response latencies (RT) showed a significant main effect of face gender, $F(1,22)=5.92$, $p=.024$, $\eta_p^2=.21$, with RT being faster for male (842 msec) than for female faces (868 msec). Nor participants gender ($p=.89$) nor the interaction participants' gender by face gender were significant ($p=.79$).

Discussion

Results of Experiment 1 show that male and female participants' attention was similarly preferentially oriented toward the male face. However, this was the case only for trials in which the male face was presented at the right end of the line. Overall, results of Experiment 1 do not support the existence of an OGB in the way spatial attention is allocated to faces. Given these somehow unexpected results, we carried out an additional experiment (Experiment 2) on a new group of participants using the same paradigm but with different male and female faces, in order to verify the reliability of our findings. In this second experiment, the bisection test was followed by a rating test in which participants had to rate male and female faces used across Experiment 1 and 2 in terms of their perceived level of threat. In fact, the threat trait may be critical in biasing participants' attention: from an evolutionary perspective, males may attract attention more than females being more likely than females to act as aggressors and previous studies showed that male faces are usually perceived as more threatening than female faces (e.g., Al-Janabi, MacLeod, & Rhodes, 2012).

Experiment 2

Method

Participants

Twenty students (10 males, mean age = 22.1 years, *SD*= 2.69, range: 18-30 years; with no significant difference in age between male and female participants, p=.09), all right-handed (Oldfield, 1971), took part in the experiment (none of them had taken part in Experiment 1).

Face stimuli

The face set consisted of 8 different Caucasian young faces, 4 female (F) and 4 male (M), showing a neutral emotional expression. Stimuli were selected on the basis of a previous rating test (carried out for a different study) in which 10 participants (5 male, mean age = 23.3, *SD*= 1.51) were required to evaluate distinctiveness and attractiveness of a large sample of faces (60 male faces and 60 female faces, all free of jewelry, glasses, and adjusted in order to remove distinctive hairstyles) taken from the Bamberg Face Database and by the FEI Database (Thomaz & Giraldi, 2010; see http://fei.edu.br/~cet/facedatabase.html), using a 7-point Likert scale, as described for the rating of the faces used in Experiment 1. The 4 female faces and the 4 male faces used in Experiment 2 were selected to be perfectly matched in terms of distinctiveness (mean for female faces = 3.60, range 3.50-3.90; mean for male faces = 3.60, range 3.50-3.90) and attractiveness (mean for female faces = 2.80, range 2.10-3.10; mean for male faces= 2.60, range 2.20-3.20).

Procedure and "threat-level" rating test

The paradigm for the bisection task was identical to that of Experiment 1 (same number of trials, structure, and instructions) except for the empty circles baseline condition that was not included. After completion of the bisection task, participants were presented with a computerized rating task. In the rating task, a face (covering approximately 4 x 4 deg of visual angle) was centrally presented on a gray computer screen. Below each face, the 7-point Likert scale "1 2 3 4 5 6 7" was presented. Participants had to press on the computer keyboard the key that better corresponded to the perceived threat level of the face, with "1" meaning "No threatening at all" and "7" meaning "Highly threatening". Faces were presented in random order and each face remained visible until participants responded. Before starting the rating test, all faces were presented once in random order to familiarize participants with the full range of faces.

Results

Bisection task

Figure 3 shows participants' mean bisection bias in the different experimental conditions. Analyses were performed on participants' mean percentage deviations from the true midline, as in Experiment 1. In none of the four conditions, the bias was significantly different from "0" (the true midline, all *ps*>.05). A repeated-measures ANOVA with participants' gender as between-subjects variable and flanker condition (M-F, F-M, M-M, and F-F) as within subjects-variable revealed a main effect of flanker condition, $F(3, 54)=4.52$, $p=.007$, $\eta_p^2=.20$. Neither participants' gender ($p=.19$) nor the interaction participants' gender by flanker condition were reached significance ($p=.10$). Post-hoc pairwise comparisons (Bonferroni correction applied) showed that in the F-M condition participants deviated significantly more to the right compared to all the other conditions: M-F, $t(19)=3.69$, $p=.007$ F-F, $t(19)=3.08$, $p=.042$; and M-M, $t(19)=3.28$, $p=.014$. No other comparison reached significance. On average participants took 2476 msec to bisect the lines.

[insert Figure 3 about here]

Accuracy in the memory task was very high for both male faces (mean=94.4%, *SD*=3.89) and female faces (mean=94.6%, *SD*=4.70). A repeated-measures ANOVA on d' scores for the memory performance revealed no main effect of face gender (F<1, p=.80), no main effect of participants' gender (p=.29) and no significant interaction between the two factors (p=.33). A similar analysis on mean RT revealed a significant main effect of face gender, $F(1,18)=4.96$, $p=.039$, $\eta_p^2=.22$, with RT being faster for male (834 msec) than for female faces (878 msec). Nor participants' gender (p=.15) nor the interaction participants' gender by face gender were significant (p=.20).

<u>Rating test</u>

Analysis was performed within participant. A repeated-measures ANOVA with face gender and set (faces used in Experiment 1 vs. faces used in Experiment 2) as within-subjects variables and participants' gender as between-subjects variable revealed a significant effect of face gender, $F(1, 18)=61.27$, $p<.001$, $\eta_p^2=.77$, and a significant effect of Set, $F(1, 18)=44.12$, $p<.001$, $\eta_p^2=.71$. Participants' gender was not significant (p=.47), nor were any of the possible interactions (all *ps* >.11). Overall, male faces were rated as significantly more threatening (mean=3.56, *SD*=8.02) than female faces (mean=2.57, *SD*=7.75). Moreover, faces presented in Experiment 2 (mean=3.78, *SD*=8.74) were perceived as significantly more threatening than faces presented in Experiment 1 (mean=2.35, *SD*=8.75).

An additional analysis was carried out to verify whether the subjectively overall perceived level of threat in male faces was related to the magnitude of the rightward bias observed in F-M trials. Although a trend was present for which participants giving higher threatening scores tended to err more rightward in F-M trials, the correlation between threat scores for male faces and magnitude of the "toward the male bias" in F-M trials failed to reach significance (one-tailed, Pearson r=.24, p=.17).

Discussion

Results of Experiment 2 mainly replicated those of Experiment 1. In particular, in trials in which the female face was positioned at the left end of the line and the male face at the right end of the line (i.e., F-M trials), participants bisected the line significantly more to the right compared than in all the other experimental conditions (i.e., M-M, F-F, and M-F trials). As in Experiment 1, the male face in M-F trials did not bias participants to bisect more to the left compared to M-M e F-F trials. Importantly, again resembling Experiment 1's findings, this pattern was found regardless of participants' gender. Importantly, rating scores for level of threat showed that male faces used across Experiment 1 and 2 were perceived as significantly more threatening than female faces. Our analyses also showed that faces used in Experiment 2 were overall perceived as more threatening than those used in Experiment 1, possibly due to the morphing procedure used in Experiment 1 reducing faces threatening traits. If the perceived level of threat was the main responsible for the "toward-the-male" bias we observed across Experiment 1 and 2 in F-M trials compared to the other experimental trials (M-M, F-F, M-F), **this bias should be modulated by the faces' perceived level of threat. In particular, it should be reduced or canceled out with no threatening faces (i.e., smiling/happy faces), whilst being evident with high threatening faces (i.e., angry faces).** These hypotheses were directly investigated in Experiment 3.

Experiment 3

Method

Participants

Twenty-two students (11 males, mean age = 21.7 years, *SD*= 1.61, range: 19-26 years; with no significant difference in age between male and female participants, p=.74), all right-handed (Oldfield, 1971), took part in the experiment (none of them had taken part in the previous two experiments).

Material and Procedure

The face set (see Figure 4A) consisted of 8 different young Caucasian faces, 4 male (M) and 4 female (F) faces, taken from the Karolinska Directed Emotional Face database (KDEF, Lundqvist et al., 1998). Faces showed either an angry expression or a happy/smiling expression. For each emotion category (angry, happy) there were 2 M and 2 F faces. Face stimuli were selected from a larger subset of the KDEF on the basis of a previous rating test in which 16 participants (8 male, mean age = 26.3, *SD*= 3.7, none of them taking part in the main experiment) were required to evaluate angry and happy faces in terms of perceived distinctiveness and level of threat, using a 7-point Likert scale, as described for the rating of the faces used in Experiment 1. For each category (angry, happy), female and male faces were selected so to be matched both in terms of distinctiveness and level of threat. For the trait distinctiveness, mean rating scores were: 4.66 (SD=1.39) and 4.41 (SD=1.14) for angry F and M, respectively; and, 4.00 (SD=.97) and 4.16 (SD=.70) for happy F and M, respectively. For the trait threat, mean rating scores were: 3.88 (SD=1.20) and 3.94 (SD=.95) for angry F and M, respectively; and 1.34 (SD=.40) and 1.50 (SD=.75) for happy F and M, respectively. Overall, angry faces were perceived as significantly more threatening than happy faces, $t(15)=8.70$, $p<.001$.

The experimental procedure for the bisection task was the same as that used in Experiment 1 and 2. However, in this experiment only F-M and M-F trials were included, for a total of 64 trials: 16 F-M and 16 M-F trials for each level of threat (high/angry and low/happy). The same pair of F-M and M-F faces was presented four times (once in each of the four possible positions on the screen, half of the times with the long and half of the times with the short line). Angry and happy faces trials were randomly intermixed within the same experimental block. Target faces used in the memory task showed the same emotion (happiness vs. anger) as the flankers used in the preceding bisection trial.

Results

The mean bisection bias in the different experimental conditions is shown in Figure 4. In none of the experimental conditions, the bisection bias was significantly different from “0” (the true midline, all ps>.05). A repeated-measures ANOVA with flanker position (F-M vs. M-F) and level of threat (low/happy faces vs. high/angry faces) as within-subjects variables and participants’ gender as between-subjects variable revealed no significant main effect of flanker position, $F(1,20)=1.61$, $p=.22$, no significant main effect of perceived level of threat, $F(1,20)<1$, $p=.87$, and no significant effect of participants’ gender, $F(1, 20)<1$, $p=.77$. The interaction flanker position by level of threat was significant, $F(1, 20)=4.79$, $p=.041$, $\eta_p^2=.19$. Post-hoc comparisons showed that participants' bisection bias was comparable for M-F and M-F trials with low threat (happy) faces, $t(21)<1$, $p=.48$. Conversely, a significant toward the male bias was observed for high threat faces, $t(21)=4.33$, $p<.001$. None of the other possible interactions reached significance (all *ps* >.14). On average participants took 2783 msec to bisect the lines.

Memory accuracy for low-threat faces was equal to 93.4% (*SD*=5.2) for female faces and 96.1% (*SD*=4.44) for male faces. Memory accuracy for high-threat faces was 93.2% (*SD*=8.6) for female faces, and 94.0% (*SD*=7.3) for male faces. A repeated-measures ANOVA on the d' measure with level of threat and face gender as within-subjects variables and participants' gender as between-subjects variable revealed no significant effects for the main factors: face gender ($p=.43$), level of threat ($p=.42$) and participants' gender ($p=.80$). None of the interactions reached significance (all *ps*>.12). Analyses on mean RT did not show any significant effect (all *ps* >.11).

Discussion

Results of Experiment 3 show that when male and female faces used as flankers in a line bisection task were balanced in terms of their perceived level of threat, participants' bisection bias was not anymore affected by the left/right position of the male face when the level of perceived threat was low (smiling faces). However, for high threatening/angry faces, a "toward the male bias" was still observed, even if male and female faces were initially selected to be matched in terms of threat level.

General Discussion

Overall, our findings suggest that male and female faces orient spatial attention in a significantly different vein. In particular, results of Experiment 1 showed that when faces of the same gender were used as flankers in a visual line bisection task, participants' bisection bias did not significantly differ from the bias shown in a baseline condition in which blank circles were used as flankers. However, when the two flanker faces were of different sex and the male face was positioned at the right end of the line (condition F-M), a clear rightward bias (i.e., in the direction of the male face) emerged compared to the other experimental conditions. When a male face appeared at the left end of the line and a female face at the right end of the line (condition M-F), a leftward bias was observed, whose magnitude however was comparable to that of the leftward bias shown in the baseline condition. Critically, these effects were not modulated by participants' gender. Hence, male and female participants' attention was similarly preferentially oriented toward the male face when this was presented at the right end of the line. The same pattern was observed in Experiment 2, in which different male and female faces were used as flankers and a new group of participants was tested, indicating that findings of Experiment 1 were reliable. Critically, a rating test showed that male faces used across Experiment 1 and 2 were perceived as more threatening than female faces (regardless of rater's gender). **When male and female faces used as flankers were matched *a priori* for level of threat (Experiment 3), participants' bisection bias was not significantly affected by the position of the male face when faces' level of threat was low (happy faces). However, with high threatening faces (angry faces), participants showed a significant bias toward the male face (as in the first two experiments).**

In discussing our findings, we first focus on why attention was captured more by a male than a female face appearing at the right endpoint of the line; the lack of a male bias **in Experiment 1 and 2** for male faces used as left flankers will be discussed in a later paragraph. Perceptual distinctiveness is unlikely to be responsible for the effects we reported, since male and female faces used across our experiments did not differ in that aspect (as verified by preliminary rating studies, see Method sections for details). Rather, the higher salience of male faces may more likely depend on social or motivational factors. Accordingly, Giardina et al (2012) have recently reported that in a physical distance judgment task in which faces were used as flankers, participants were biased toward the side cued by their own face, underestimating the portion of space cued by the face of another person. Giardina et al. (2012) hypothesized that one's own face is a more salient attentional stimulus than faces of other people and that "others" might be more preferentially associated to extrapersonal/far space. Perceived social distance thus appears to affect physical distance estimation (Giardina, et al., 2012).

In line with this, one might have expected an own gender bias (OGB) to emerge in our bisection task, with male and female participants deviating more toward the male and the female faces respectively, because individuals of one's own gender are typically perceived as socially "closer" (cf. Maccoby, 1988). Nonetheless, in both Experiment 1 and 2 **(and in Experiment 3 with high threatening faces)** we found that participants consistently deviated toward the male face, regardless of their own gender. From an evolutionary perspective, male faces may be particularly critical in attracting attention since males are much more likely than females to act as aggressors. **A wealth of research (based on different experimental paradigms) suggests the existence of an attentional**

bias to threat, according to which attention (especially in anxious individuals) is preferentially captured by threatening sources of information (for reviews, see Cisler, Bacon, & Williams, 2009; Cisler & Koster, 2010). There is evidence that male faces may be perceived as more threatening than female faces (e.g., Al-Janabi, MacLeod, & Rhodes, 2012). Although this effect seems to be particularly evident for out-group male faces (e.g., Navarrete et al., 2006), male faces used in our Experiment 1 and 2 were overall rated as significantly more threatening than female faces. In this perspective, our findings are in line with previous studies reporting higher efficiency in the categorization of male than female faces in perceptually degraded conditions (e.g., Cellerino, Borghetti, & Sartucci, 2004; Wild, et al., 2000). Accordingly, greater cuing effects for gaze cues from masculinized (i.e. dominant) versus feminized (i.e. subordinate) faces have been reported in both male and female observers (Jones, et al., 2010). Similarly, a greater gaze-cuing effect for high-status faces than for low-status faces has recently been reported (Dalmaso, Pavan, Castelli, & Galfano, 2012).

In Experiment 3, in which male and female faces were matched *a-priori* for perceived level of threat, no bias toward the male face was reported with low threatening (happy) faces. However, a bias toward the male face was observed when flankers consisted of angry (high threatening) faces. Data of Experiment 3 suggest that even when controlling for level of threat, male faces may attract attention more than female faces when level of perceived threat is high, likely because males are implicitly perceived as potentially more threatening than female faces. Indeed, previous studies suggest that implicit and explicit measures of face threat can be dissociated (Hugenberg & Bodenhausen, 2003). In this view, it is possible that angry male faces were "by default" implicitly perceived as more threatening (and hence salient) than **angry** female faces (cf. Wrangham & Peterson, 1996), although this was not evident when using an explicit measure of threat (i.e., rating). **This dissociation between explicit evaluation and implicit perception of threat may also account for the lack of a significant correlation between threat scores and the "toward the male" bias reported in Experiment 2.**

If threatening or dominance traits that are typically more associated with males than females (e.g., Al-Janabi, et al., 2012; Jones, et al., 2010) account for the significant rightward shift of attention we reported when a male face appeared at the right and a female face at the left endpoint of the line in both Experiments 1 and 2, a corresponding symmetrical leftward shift in attention should have emerged when the male face appeared on the left and the female face on the right. However, this was not the case. Different factors may account for this asymmetrical pattern. The lack of a significantly stronger leftward bias in trials in which the male face was positioned at the left endpoint and the female face at the right endpoint of the line is consistent with previous studies showing that the effect of directional cueing in line bisection is likely to be more effective in counteracting a pre-existing bias than in boosting it (e.g., Cattaneo, et al., 2012, 2013; Laeng, Buchtel, & Butter, 1996; Tamietto, et al., 2005). The asymmetry in the effects we reported depending on the male face position may also be related to lateralization of emotional processing. In particular, according to "approach-withdrawal" models of emotional processing, emotional states driving approach- and withdrawal-related behavior are preferentially processed by left and right-frontal regions (see Demaree, Everhart, Youngstrom, & Harrison, 2005, for a review). In this view, anger (or threat) has been categorized as an "approach" state, being related to an action preparation finalized to respond to the potential danger (see Demaree et al., 2005). Accordingly, we might speculate that the rightward bias observed when the male face appeared at the right endpoint of the line may have resulted from the summation of a higher activation of the left hemisphere (this shifting attention to the right visual field) induced by viewing a potential threatening face *per se* (i.e., a male face; see also Freidman & Forster, 2005, Experiment 3) and its right position. Finally, there is some evidence for a right hemisphere advantage in processing female faces, likely depending on maternal cradling habits (Parente & Tommasi, 2008; Rhodes, 1985), a left hemisphere advantage for processing emotional male faces has also been observed (Stafford & Brandaro, 2010), but the origins of this advantage are less clear. Although methodological differences may partially account for contrasting results, our data suggest that other factors may counteract a leftward (Stafford & Brandaro, 2010) bias for female faces, overall favoring processing of male versus female faces (see Cellerino, et al., 2004; Wild, et al., 2000).

To ensure that participants paid attention to the faces before bisecting, a memory task was introduced requiring participants to indicate - after bisection - whether a presented face matched one of the two face flankers. Encoding time was not controlled in this task (with line and faces remaining visible till participants bisected the line, e.g., on average for 3 sec) and the recognition test immediately followed the encoding phase. Not surprisingly, memory performance was almost at ceiling. Previous studies reported either an OGB in episodic memory (e.g., Wright & Sladden, 2003), or even a female face advantage in priming tasks (e.g., Godard & Fiori, 2010). In contrast, an overall memory advantage for male faces emerged in the first two experiments (either in terms of detection sensitivity and/or response latencies). It is possible that the memory advantage observed across the first two experiments depended on male faces being perceived as more threatening, in agreement with previous studies demonstrating that angry (threatening) faces are better remembered than neutral faces (e.g., Jackson et al., 2009; see also Ackerman et al., 2006). **However, according to this view, in Experiment 3 high threatening faces should have been remembered better than low threatening faces, whereas this was not the case. However, our findings on memory performance should be interpreted and** compared with caution to previous studies**: our task required** immediate recognition and very low memory load, **put** no constraints on encoding duration, **and was not intended to measure memory in a systematic way but rather to ensure that participants paid attention to the face flankers. Therefore, our data do not allow to draw any strong conclusions on a possible effect of face gender on male and female participants' memory accuracy.**

Female faces used in Experiment 1 were rated as more attractive overall than the male faces, a pattern often reported in other studies employing different face sets (Loven, et al., 2012; McLellan & McKelvie, 1993; Rhodes, Sumich, & Byatt, 1999). There is evidence that more beautiful faces preferentially capture attention (Leder, Tinio, Fuchs, & Bohrn, 2010; Liu & Chen, 2012; Sui & Liu, 2009). However, attractiveness did not seem to play a critical role in orienting attention in our study. It is worth stressing though that studies interested in effects of attractiveness on attentional orienting typically contrasted very attractive with very unattractive faces (Leder, et al., 2010). This was not the case in our experiment 1 in which faces were rated as of average beauty overall which possibly masked any effects of attractiveness for orienting spatial attention.

Finally, it is worth mentioning that none of the directional bisection biases was significantly different from "0" (the true midline) across the three Experiments. The lack of a significant leftward bias in face trials may depend on faces increasing arousal level possibly reducing the leftward bias (see Cattaneo et al., 2012). However, the leftward bias failed to reach significance also in the baseline condition of Experiment 1, in which circles and not faces were used as flankers. In evaluating these results it is important to consider that pseudoneglect is a subtle bias and may need a large number of trials to emerge (see Jewell & McCorut, 2000), and that several studies reported individuals with reliable rightward deviations or no significant deviation from centre (e.g., Braun & Kirk, 1999; Cowie & Hamill, 1998). Importantly though, the lack of a significant bias against the true midline does not anyhow harm our conclusions that were based on statistical significant comparisons across conditions.

In sum, our findings suggest that gender of a face is a critical variable in affecting allocation of spatial attention as measured in a line bisection task: in particular, male faces seem to capture attention more than female faces, both in male and female viewers, possibly due to evolutionary reasons (i.e., male faces, or more generally men, being perceived as potentially threatening stimuli).

References

Ackerman, J. M., Shapiro, J. R., Neuberg, S. L., Kenrick, D. T., Schaller, M., Becker, D. V., Griskevicius, V., & Maner, J. K. (2006). They all look the same to me (unless they're angry): From out-group homogeneity to out-group heterogeneity. *Psychological Science, 17*, 836-840.

Al-Janabi, S., MacLeod, C., & Rhodes, G. (2012). Non-threatening other-race faces capture visual attention: Evidence from a dot-probe task. *Plos One, 7*(10), e46119.

Anderson, U. S., Perea, E. F., Becker, D. V., Ackerman, J. M., Shapiro, J. R., Neuberg, S. L., et al. (2010). I only have eyes for you: Ovulation redirects attention (but not memory) to attractive men. *Journal of Experimental Social Psychology, 46*(5), 804-808.

Bonato, M., Priftis, K., Marenzi, R., & Zorzi, M. (2008). Modulation of hemispatial neglect by directional and numerical cues in the line bisection task. *Neuropsychologia, 46*(2), 426-433.

Braun, J.B., Kirk, A. (1999) Line bisection performance of normal adults: two subgroups with opposite biases. Neurology 53: 527-532.

Busey, T. A. (1998). Physical and psychological representations of faces: Evidence from morphing. *Psychological Science, 9*(6), 476-483.

Carbon, C. C., Gruter, T., Gruter, M., Weber, J. E., & Lueschow, A. (2010). Dissociation of facial attractiveness and distinctiveness processing in congenital prosopagnosia. *Visual Cognition, 18*(5), 641-654.

Cattaneo, Z., Fantino, M., Mancini, F., Mattioli, F., & Vallar, G. (2012). Listening to numbers affects visual and haptic bisection in healthy individuals and neglect patients. *Neuropsychologia, 50*(5), 913-925.

Cattaneo, Z., Fantino, M., Tinti, C., Silvanto, J., & Vecchi, T. (2010). Crossmodal interaction between the mental number line and peripersonal haptic space representation in sighted and blind individuals. *Attention Perception & Psychophysics, 72*(4), 885-890.

Cattaneo, Z., Lega, C., Vecchi, T., & Vallar, G. (2013). Listening to white noise counteracts visual and haptic pseudoneglect. *Perception*.

Cellerino, A., Borghetti, D., & Sartucci, C. (2004). Sex differences in face gender recognition in humans. *Brain Research Bulletin, 63*(6), 443-449.

Cisler, J.M., Bacon, A.K., & Williams, N.L. (2009). Phenomenological characteristics of attentional biases towards threat: a critical review. *Cognitive Therapy and Research,* 33:221–234.

Cisler, J.M., & Koster, E.H.W. (2010). Mechanisms of Attentional Biases towards Threat in the Anxiety Disorders: An Integrative Review. *Clinical Psychology Review, 30(2): 203.*

Claunch, J. D., Falchook, A. D., Williamson, J. B., Fischler, I., Jones, E. M., Baum, J. B., et al. (2012). Famous faces but not remembered spaces influence vertical line bisections. *Journal of Clinical and Experimental Neuropsychology, 34*(9), 919-924.

Cowie, R., & Hamill, G. (1998). Variation among nonclinical subjects on a line bisection task. *Perceptual and Motor Skills* 86: 834.

Dalmaso, M., Pavan, G., Castelli, L., & Galfano, G. (2012). Social status gates social attention in humans. *Biology Letters, 8*(3), 450-452.

Demaree, H.A., Everhart, D.E., Youngstrom,E.A., and Harrison, D.W. (2005). Brain lateralisation of emotional processing: historical roots and a future incorporating 'dominance'. *Behavioral and Cognitive Neuroscience Reviews*, 4, 3, 3-20.

de Hevia, M. D., Girelli, L., & Vallar, G. (2006). Numbers and space: a cognitive illusion? *Experimental Brain Research, 168*(1-2), 254-264.

Friedman, R. S., & Förster, J. (2005). Effects of motivational cues on perceptual asymmetry: Implications for creativity and analytical problem solving. *Journal of Personality and Social Psychology*, 88, 263–275.

Giardina, A., Caltagirone, C., Cipolotti, L., & Oliveri, M. (2012). The role of right and left posterior parietal cortex in the modulation of spatial attentional biases by self and non-self face stimuli. *Social Neuroscience, 7*(4), 359-368.

Godard, O., & Fiori, N. (2010). Sex differences in face processing: are women less lateralized and faster than men? *Brain and Cognition,* 73, 3, 167-175.

Going, M., & Read, J. D. (1974). Effects of uniqueness, sex of subject, and sex of photograph on facial recognition. *Perceptual and Motor Skills, 39*, 109-110.

Hugenberg, K., & Bodenhausen, G.V. (2003) Facing prejudice: implicit prejudice and the perception of facial threat. *Psychologycal Science*, 14(6):640-3.

Ino, T., Nakai, R., Azuma, T., Kimura, T., & Fukuyama, H. (2010). Gender differences in brain activation during encoding and recognition of male and female faces. *Brain Imaging and Behavior, 4*(1), 55-67.

Jackson, M.C., Wu, C.Y., Linden, D.E., Raymond, J.E. (2009). Enhanced visual short-term memory for angry faces. *Journal of Experimental Psychology: Human Perception and Performance,* 35(2):363-74.

Jewell, G., & McCourt, M. E. (2000). Pseudoneglect: A review and meta-analysis of performance factors in line bisection tasks. *Neuropsychologia, 38*(1), 93-110. doi: 10.1016/s0028-3932(99)00045-7

Jones, B. C., DeBruine, L. M., Main, J. C., Little, A. C., Welling, L. L. M., Feinberg, D. R., et al. (2010). Facial cues of dominance modulate the short-term gaze-cuing effect in human observers. *Proceedings of the Royal Society B-Biological Sciences, 277*(1681), 617-624.

Laeng, B., Buchtel, H. A., & Butter, C. M. (1996). Tactile rod bisection: Hemispheric activation and sex differences. *Neuropsychologia, 34*(11), 1115-1121.

Leder, H., Tinio, P. P. L., Fuchs, I. M., & Bohrn, I. (2010). When attractiveness demands longer looks: The effects of situation and gender. *Quarterly Journal of Experimental Psychology, 63*(9), 1858-1871.

Lewin, C., & Herlitz, A. (2002). Sex differences in face recognition: Women's faces make the difference. *Brain and Cognition, 50*(1), 121-128.

Liu, C. H., & Chen, W. F. (2012). Beauty is better pursued: Effects of attractiveness in multiple-face tracking. *Quarterly Journal of Experimental Psychology, 65*(3), 553-564.

Loven, J., Herlitz, A., & Rehnman, J. (2011). Women's own-gender bias in face recognition memory: The role of attention at encoding. *Experimental Psychology, 58*(4), 333-340.

Loven, J., Rehnman, J., Wiens, S., Lindholm, T., Peira, N., & Herlitz, A. (2012). Who are you looking at? The influence of face gender on visual attention and memory for own- and other-race faces. *Memory, 20*(4), 321-331.

Lundqvist D., Flykt A., Öhman A. (1998). The Karolinska Directed Emotional Faces – KDEF. Stockholm: CD-ROM from Department of Clinical Neuroscience, Psychology section, Karolinska Institutet; ISBN 91-630-7164-9.

Maccoby, E. (1988). Gender as a social category. *Developmental Psychology, 24*, 755–765.

Macmillan, N. A., Creelman, C. D. (1991). *Detection Theory: A User's Guide*. New York : Cambridge University Press.

McKelvie, S. J., Standing, L., Stjean, D., & Law, J. (1993). Gender differences in recognition memory for faces and cars: Evidence for the interest hypothesis. *Bulletin of the Psychonomic Society, 31*(5), 447-448. d

McLellan, B., & McKelvie, S. J. (1993). Effects of age and gender on perceived facial attractiveness. *Canadian Journal of Behavioural Science, 25*(1), 135-142.

Meissner, C. A., & Brigham, J. C. (2001). Thirty years of investigating the own-race bias in memory for faces: A meta-analytic review. *Psychology Public Policy and Law, 7*(1), 3-35.

Navarrete, C.D., Olsson, A., Ho, A.K., Mendes, W.B., Thomsen, L., Sidanius, J. (2009). Fear extinction to an out-group face: the role of target gender. *Psychologycal Science*, 20, 155-158.

Nicholls, M. E., Thomas, N. A., Loetscher, T., Wignall, S., Yates, M. J., Forte, J. D., et al. (2012). The relationship between vertical stimulation and horizontal attentional asymmetries. *Quarterly Journal of Experimental Psychology, 65*(12), 2384-2396.

Oldfield, R. C. (1971). The assessment and analysis of handedness the edinburgh inventory. *Neuropsychologia, 9*(1), 97-113.

Parente, R., & Tommasi, L. (2008). A bias for the female face in the right hemisphere. *Laterality, 13*(4), 374-386.

Ramsey-Rennels, J. L., & Langlois, J. H. (2006). Infants' differential processing of female and male faces. *Current Directions in Psychological Science, 15*(2), 59-62.

Ramsey, J. L., Langlois, J. H., & Marti, N. C. (2005). Infant categorization of faces: Ladies first. *Developmental Review, 25*(2), 212-246.

Rehnman, J., & Herlitz, A. (2006). Higher face recognition ability in girls: Magnified by own-sex own-ethnicity bias. *Memory, 14*(3), 289-296.

Rehnman, J., & Herlitz, A. (2007). Women remember more faces than men do. *Acta Psychologica, 124*(3), 344-355.

Rhodes, G. (1985). Perceptual asymmetries in face recognition. *Brain and Cognition, 4*(2), 197-218.

Rhodes, G., Sumich, A., & Byatt, G. (1999). Are average facial configurations attractive only because of their symmetry? *Psychological Science, 10*(1), 52-58.

Richeson, J. A., & Trawalter, S. (2008). The threat of appearing prejudiced and race-based attentional biases. *Psychological Science, 19*(2), 98-102.

Schoning, S., Engelien, A., Kugel, H., Schafer, S., Schiffbauer, H., Zwitserlood, P., et al. (2007). Functional anatomy of visuo-spatial working memory during mental rotation is influenced by sex, menstrual cycle, and sex steroid hormones. *Neuropsychologia, 45*(14), 3203-3214.

Shaw, J. I., & Skolnick, P. (1994). Sex-differences, weapon focus, and eyewitness reliability. *Journal of Social Psychology, 134*(4), 413-420.

Shaw, J. I., & Skolnick, P. (1999). Weapon focus and gender differences in eyewitness accuracy: Arousal versus salience. *Journal of Applied Social Psychology, 29*(11), 2328-2341.

Stafford, L. D., & Brandaro, N. (2010). Valence specific laterality effects in free viewing conditions: The role of expectancy and gender of image. *Brain and Cognition, 74*(3), 324-331.

Sui, J., & Liu, C. H. (2009). Can beauty be ignored? Effects of facial attractiveness on covert attention. *Psychonomic Bulletin & Review, 16*(2), 276-281.

Tamietto, M., Corazzini, L. L., Pia, L., Zettin, M., Gionco, M., & Geminiani, G. (2005). Effects of emotional face cueing on line bisection in neglect: A single case study. *Neurocase, 11*(6), 399-404.

Thomaz, C.E., & Giraldi, G.A. (2010). A new ranking method for Principal Components Analysis and its application to face image analysis. I*mage and Vision Computing*, *28 (6)*, 902-913.

Van Vleet, T. M., & Robertson, L. C. (2006). Cross-modal interactions in time and space: Auditory influence on visual attention in hemispatial neglect. *Journal of Cognitive Neuroscience, 18*(8), 1368-1379.

Wild, H. A., Barrett, S. E., Spence, M. J., O'Toole, A. J., Cheng, Y. D., & Brooke, J. (2000). Recognition and sex categorization of adults' and children's faces: Examining performance in the absence of sex-stereotyped cues. *Journal of Experimental Child Psychology, 77*(4), 269-291.

Wrangham, R.W., & Peterson, D. (1996). Demonic males: Apes and the origins of human violence. Boston: Houghton Mifflin.

Wright, D. B., & Sladden, B. (2003). An own gender bias and the importance of hair in face recognition. *Acta Psychologica, 114*(1), 101-114.

Young, S. G., Hugenberg, K., Bernstein, M. J., & Sacco, D. F. (2012). Perception and motivation in face recognition: A critical review of theories of the cross-race effect. *Personality and Social Psychology Review, 16*(2), 116-142.

Figure captions

Figure 1. A) The female (upper panel) and male (lower panel) faces used as face flankers in the line bisection task. **B)** The time course of an experimental trial in the face block.

Figure 2. Mean percentage deviation from the veridical line midpoint for the different experimental conditions of Experiment 1. Error bars depict ±1 SEM. Asterisks indicate significant differences (Bonferroni-corrected) between experimental conditions.

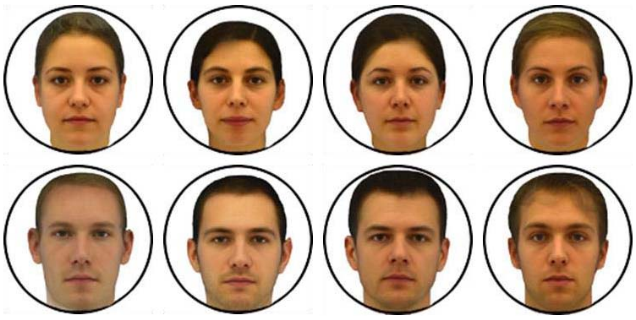
Figure 3. Mean percentage deviation from the veridical line midpoint for the different experimental conditions of Experiment 2. Error bars depict ±1 SEM. Asterisks indicate significant differences (Bonferroni-corrected) between experimental conditions.

Figure 4. A) The low threat/happy (upper panel) and high threat/angry (lower panel) female and male faces used in Experiment 3. B) Mean percentage deviation from the veridical line midpoint for the different experimental conditions of Experiment 3. Error bars depict ±1 SEM. Asterisks indicate significant differences between M-F and F-M trials.

Figures

Figure 1

A)



B)

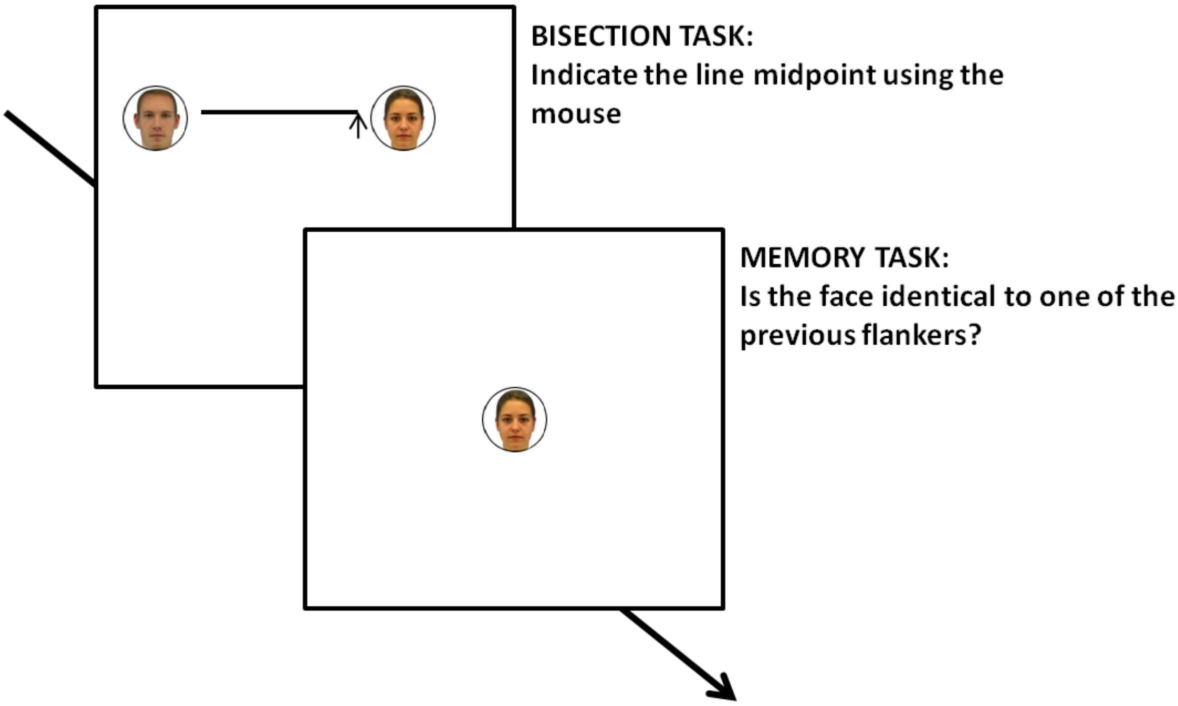
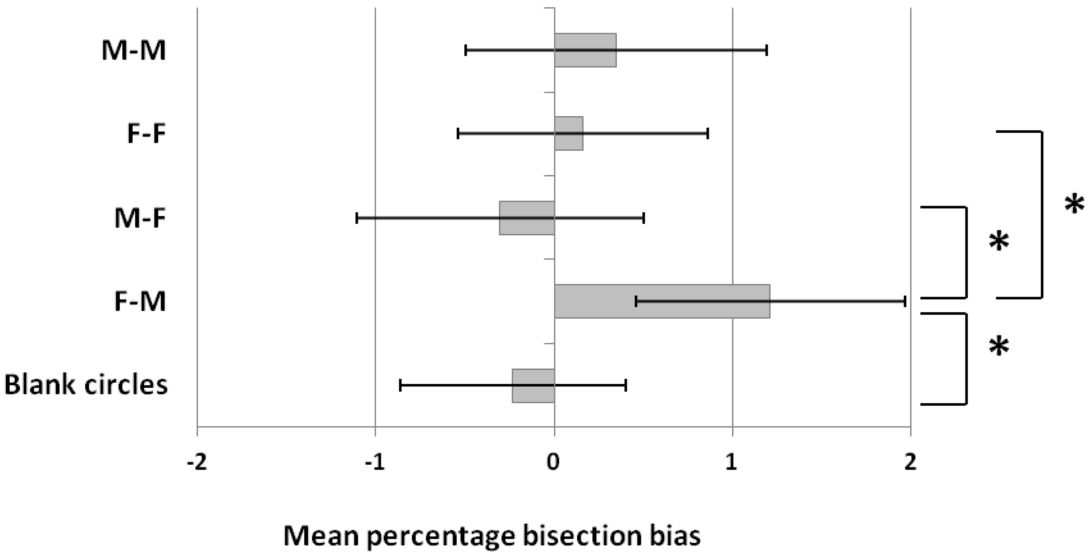


Figure 2



M-M
F-F
M-F
F-M
Blank circles
-2
-1
0
1
2
Mean percentage bisection bias
*
*
*

Figure 3

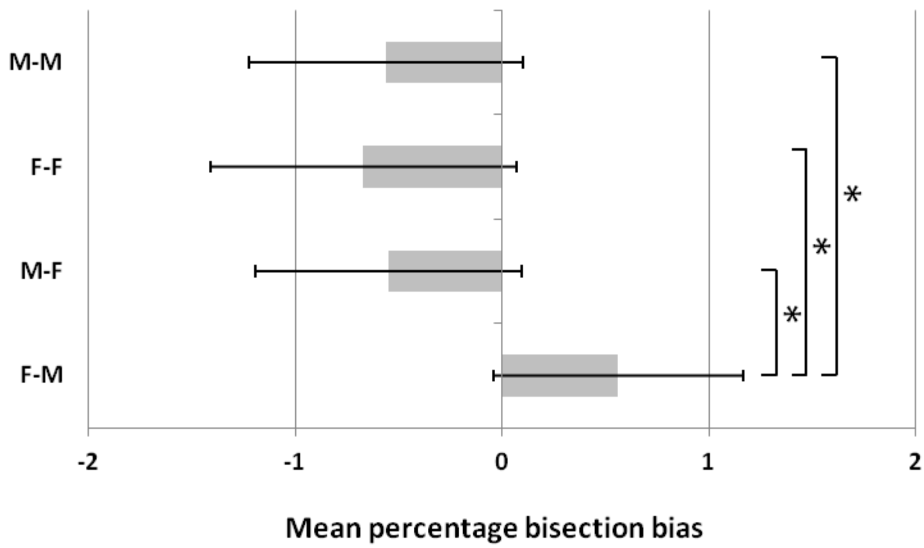
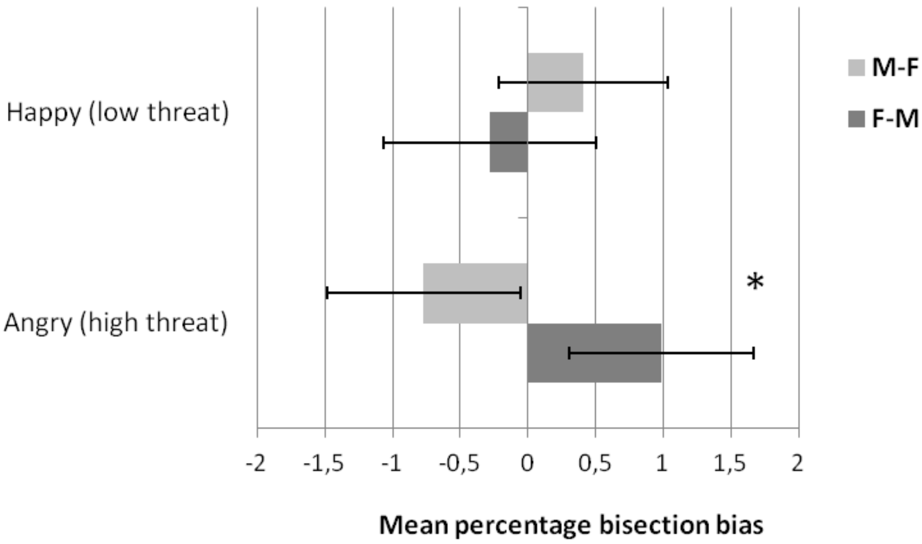


Figure 4

A)

B)



Happy (low threat)
Angry (high threat)
M-F
F-M
*
-2
-1,5
-1
-0,5
0
0,5
1
1,5
2
Mean percentage bisection bias

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