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Person (mis)perception: functionally biased sex categorization of bodies

Kerri L. Johnson[1,*], Masumi Iida[2] and Louis G. Tassinary[3]

[1] *Department of Communication Studies and Department of Psychology, University of California at Los Angeles, 2330 Rolfe Hall, Los Angeles, CA 90403, USA*
[2] *School of Social and Family Dynamics, Arizona State University, 951 South Cady Mall, Tempe, AZ 85287, USA*
[3] *Department of Visualization, Texas A&M University, College Station, TX 77843, USA*

Social perception is among the most important tasks that occur in daily life, and perceivers readily appreciate the social affordances of others. Here, we demonstrate that sex categorizations are functionally biased towards a male percept. Perceivers judged body shapes that varied in waist-to-hip ratio to be men if they were not, in reality, exclusive to women, and male categorizations occurred more quickly than female categorizations (studies 1 and 4). This pattern was corroborated when participants identified the average body shapes of men and women (study 2) and when we assessed participants' cognitive representations (study 3). Moreover, these tendencies were modulated by emotion context (study 4). Thus, male categorizations occurred readily and rapidly, demonstrating a pronounced categorization bias and temporal advantage for male judgements.

Keywords: person perception; sex categorization; sexual dimorphism; waist-to-hip ratio; body perception

1. INTRODUCTION

Social categorization is among the most important tasks facing perceivers. Abundant evidence suggests that categorizations of sex, race, age and even sexual orientation occur in a largely obligatory fashion [1,2], and through the use of cues in the face and body [3,4]. Here, we propose that sex categorization which relies on body cues may be systematically biased towards a male percept.

Although both face and body cues inform sex categorizations, there is reason to suspect that their use may not promote equivalent accuracy. Sex categorization that relies on facial cues, for example, necessarily occurs at a relatively close physical proximity. Evidence suggests that sexually dimorphic cues inform sex categorizations in a dynamic fashion [3], and that such judgements are overwhelmingly accurate [5].

The body communicates meaningful information to others, including social category membership [4], intentions [6], emotions [7,8] and even physical vulnerability [9]. These perceptions can be accomplished from a substantial physical distance, in part, because of the body's size. While perceiving others at a distance may produce some errors in social perceptions, it also provides an important benefit—allowing a perceiver to avoid others who may pose threats to personal safety [10]. Social perceptions therefore instantiate social affordances [11–13], and they are likely to vary, depending on another person's physical formidability [14,15].

The formidability of men and women is asymmetric. Compared with women, men are not only physically stronger [15], but also prone to aggression [14] and violent crime [16]. Consequently, unknown men pose a potential threat to perceivers. These differences may compel perceivers to avoid risky others (men), but embolden perceivers to approach benign others (women).

We propose that these considerations will affect sex categorizations. Specifically, sex categorizations are likely to weigh risk factors and situational contexts in a manner that optimizes personal safety. In social perception, accuracy is undoubtedly desirable in some circumstances, but it may be costly in others. The physical proximity necessary to achieve accurate social perception may foreclose one's option to avoid contact with physically formidable others. Therefore, social perceptions from body cues are likely to be not only error-prone, but also systematically biased. Miscategorizing a woman to be a man may unnecessarily compel a perceiver to avoid contact, but it is an error committed in prudence. Miscategorizing a man to be a woman, by contrast, is an error that may expose a perceiver to physical risks.

Thus, the costs associated with sex-categorization errors are hypothesized to be asymmetric. Put directly, miscategorizing a woman to be a man is a low-cost error; miscategorizing a man to be a woman is an error that is potentially costly to one's physical safety. Such asymmetric costs would therefore lead perceivers to adopt a 'better safe than sorry' heuristic that produces systematic errors that maximize utility, as observed in other judgements [17,18].

Taken together, the tendency for sex categories to cue physical formidability and a proclivity towards perceptual biases that minimize potential costs to oneself led us to predict that sex categorization would be systematically biased towards a male percept. More specifically, we predicted that any body that is not, in reality, exclusive to women would evidence a significant male categorization bias. We also predicted that male categorizations would be rendered more quickly than female categorizations

* Author for correspondence (kerri.johnson@ucla.edu).

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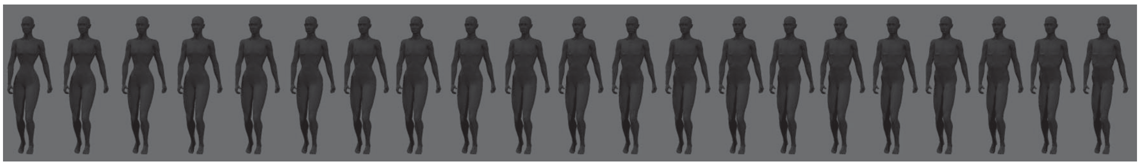

Figure 1 Stimuli used in studies 1, 2 and 4. Waist-to-hip ratio (WHR) increased in increments of two one-hundredths of a unit from an 'hourglass' WHR = 0.50 to a more 'tubular' WHR = 0.90.

insofar as a rapid categorization also enables a rapid retreat if warranted, thus also serving self-protective goals. Here, we describe four studies in which we explored the prevalence of biases in sex categorization (studies 1 and 2), the cognitive representation of men's and women's bodies (study 3), and the contextual determinants of sex-categorization biases (study 4).

2. STUDY 1

(a) *Method*

(i) *Participants*

Fifty-three undergraduates (36 women, 17 men) participated in exchange for course credit.

(ii) *Materials and procedure*

Stimuli included 21 computer-generated bodies [4,19,20] that varied in a sexually dimorphic cue, the waist-to-hip ratio (WHR; figure 1).

Bodies were presented in five blocks of trials on a Macintosh computer running customized software. In a preview block, participants merely viewed each body to become familiar with the range of stimuli. In subsequent blocks, each trial consisted of a 'ready?' prompt (1000 ms) followed by a randomly selected body. Participants categorized sex via a button press.

(iii) *Comparison group*

For comparison, we obtained body measurements of 4803 army recruits (2261 men, 2542 women) from existing databases [21,22], a population that we have found to be anthropometrically comparable to our own research population. We computed each recruit's WHR, using standard anthropometric markers.

(b) *Results and discussion*

(i) *Analytic strategy*

We sought to: (i) specify the actual distribution of men and women who embody each WHR, (ii) describe the distribution of male/female categorizations for each WHR, and (iii) compare these two distributions.

(ii) *Actual sex distribution*

We first characterized the distribution of men and women for each WHR among the army recruits. As seen in figure 2, WHRs of 0.62 and below were non-existent; WHRs between 0.64 and 0.72 were exclusive to women. The first WHRs in which men were represented was at a WHR = 0.74. Although men were rare in this category (0.6%), their presence demarcated a significant departure from exclusivity, $\chi^2_1 = 12.169$, $p < 0.001$. This was true for every WHR thereafter, and the difference increased with WHR (see the electronic supplementary material for full χ^2 statistics). Thus, beginning with a WHR of 0.74, body shapes are not exclusive to women.

We used two methods to identify the WHR that demarcates the boundary at which bodies shift from being predominantly women to being predominantly men (i.e. the *actual* boundary). We coded each recruit's sex (0 = male, 1 = female), and we compared the distribution with chance (i.e. expected value = 0.50). As notated in figure 2, WHRs between 0.64 and 0.78 were common for women, χ^2_1s from 118.642 to 498.071, all ps < 0.0001; WHRs between 0.82 and 1.09 were common for men, χ^2_1s from 103.039 to 301.884, all ps < 0.0001; a WHR = 0.80 was androgynous, $\chi^2_1 = 0.162$, $p = 0.688$ (see the electronic supplementary material for full χ^2 statistics). These findings demonstrate a dramatic and rapid shift in sex distribution for a WHR of 0.80.

Second, we estimated the relationship between body shape and sex distribution by regressing recruit sex onto WHR. The effect of WHR was strong, $B = -5.674$, s.e. = 0.067, $t = -84.461$, $p < 0.0001$. We identified the specific WHR that demarcated the boundary at which the sex ratio shifted from being predominantly women to being predominantly men by solving for the equation, $-B_0/B_1$ [23]. This calculation also identified the actual boundary between men's and women's bodies to be a WHR = 0.8049.

(iii) *Perceived sex distribution*

Next, we tested our prediction that systematic biases in sex categorizations would be evident beginning with body shapes that were not exclusive to women. We computed an index that represented each participant's proportion of 'female' judgements (range = 0–1) for each WHR.

We characterized the distribution of sex categorizations across the WHRs in two ways. First, we computed each participant's proportion of 'female' categorizations for each body shape, and we compared this against an expected value of 50 per cent, using one-sample *t*-tests with Bonferroni corrections. As notated within figure 2 and elaborated in the electronic supplementary material, bodies with WHRs between 0.50 and 0.66 were reliably judged to be female; bodies with WHRs between 0.70 and 0.90 were reliably judged to be male. Judgements of bodies with WHR = 0.68 did not differ from chance, indicating the boundary at which perceptions shifted from being predominantly male to being predominantly female.

Second, we tested the shape of the distribution using generalized estimating equations (GEEs) [24] to account for repeated judgements within participant and to accommodate a dichotomous dependent variable. Not surprisingly given the response distribution, we found a significant effects for linear and quadratic functions, Bs = −30.915 and 18.599, s.e.s = 1.883 and 8.549, zs = −16.420 and 2.180,

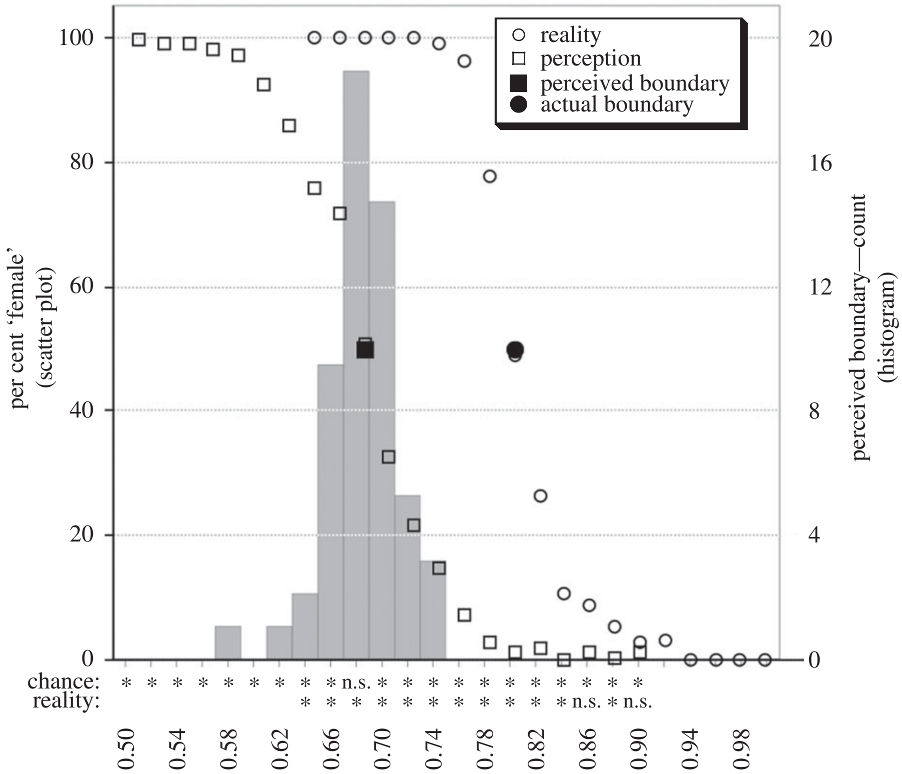

Figure 2 Perceived and actual sex distributions from study 1. Scatter plot curves depict the percentage of women within each WHR category in reality (circles) and perception (squares). The histogram depicts the number of participants whose perceived boundary fell at each WHR. Sex distributions that differ from an expected value of 50% and for which the perceived distribution differs from the actual distribution are noted below the figure by an asterisk.

and $ps < 0.0001$ and $= 0.029$, and a marginally significant effect for the cubic function, $B = 161.322$, s.e. $= 87.501$, $z = 1.840$ and $p = 0.65$.

We also quantified the exact perceptual boundary for each participant by running logistic multilevel analyses in HLM v. 7.0 [25]. We used each participant's estimated intercept and slope coefficients (calculated using an empirical Bayes approach) [26, pp. 90–102] to calculate each participant's perceptual boundary between male and female bodies. This measure confirmed the WHR at which each participant's perceptual boundary between female and male body shapes ($M = 0.685$, s.e. $= 0.004$, range $= 0.576$–0.746; see notation in figure 2). This estimate did not differ by participant sex, $t_{51} = 1.061$, $p = 0.294$.

(iv) *Comparing the distributions*

Next, we tested our prediction that sex categorizations would be biased. We compared the perceived sex distribution with the actual sex distribution in army recruits within each WHR category, using one-sample *t*-tests with Bonferroni corrections (see notation in figure 2 and electronic supplementary material). No recruit embodied WHRs between 0.50 and 0.62. Nevertheless, our participants readily categorized these bodies to be women. WHRs that fell between 0.64 and 0.72 were exclusive to women in the army database, yet participants' categorizations did not reflect this. Instead, participants judged a sizable portion of targets within each of these WHR categories to be men, with a preponderance of 'male' judgements by a WHR = 0.70. This disparity between perception and reality continued up to a WHR of 0.88.

We also compared the perceived boundary (calculated for each observer as described above) against the actual anthropometric boundary (WHR = 0.8049) using a one-sample *t*-test. The perceived boundary ($M = 0.68$, s.e. $= 0.004$) was substantially smaller, $t_{52} = -29.799$, $p < 0.001$.

These findings are consistent with our prediction that sex categorizations reflect a male bias for all body shapes that are not exclusive to women. Indeed, a WHR of 0.74—the body shape where we observed the first departure from being exclusive to women—compelled 85 per cent 'male' judgements. Additionally, we also observed a significant bias for two smaller WHRs that are, in reality, exclusive to women (i.e. WHRs = 0.70 and 0.72).

(v) *Response latency*

Finally, we tested our prediction that 'male' categorizations would be rendered more quickly than 'female' categorizations. Using GEE, we regressed response latency onto WHR (centred at WHR = 0.70), sex category judgement (effect coded, male $= -0.5$, female $= 0.5$) and their interaction. When centred at a WHR = 0.70, response latencies were 459 ms longer for 'female' judgements than 'male' judgements, $B = 459.949$, s.e. $= 137.952$, $z = 3.330$, $p = 0.0009$, and increased with WHR, $B = 1694.740$, s.e. $= 473.708$, $z = 3.580$, $p = 0.0003$. Most importantly, the interaction between the two was significant, $B = 8973.584$, s.e. $= 1420.842$, $z = 6.32$, $p < 0.0001$.

According to our hypothesis, a temporal advantage for male categorizations should occur for any WHR where variability exists. Therefore, we followed the significant interaction by testing the simple slope of sex at four other relevant benchmarks: the WHR demarcating the perceived sex boundary (i.e. WHR = 0.6850), the WHR demarcating the actual sex boundary (i.e. WHR = 0.8049) and the WHR demarcating the most extreme 'female' and 'male' WHRs (i.e. WHRs = 0.50 and 0.90, respectively). Testing these benchmarks, in particular, provided compelling tests for the specificity and generality of the male categorization temporal advantage. A significant temporal advantage for male categorizations began with the perceived boundary (280 ms advantage), and continued through the actual boundary (1357 ms advantage) and extreme 'male' WHR (2254 ms advantage), Bs = 280.478, 1357.308 and 2254.666, s.e.s = 115.772, 267.196 and 405.133, zs = 2.420, 5.080 and 5.570, ps = 0.015, and <0.0001, respectively. Below the perceived boundary, in contrast, we found no temporal advantage for male categorizations.

Thus, two important patterns emerged in these data. First, the perceived boundary between men's and women's bodies was a body shape that was exclusive to women. Second, bodies for which a male categorization is tenable (even if unlikely) showed a remarkable male categorization bias. It is important to note that the only bodies which evidenced a significant female categorization bias were those body shapes that do not exist in nature. Moreover, beginning at the perceived boundary, male categorizations were rendered more quickly than female categorizations. Thus, as predicted, male categorizations were both conservative and quick.

(vi) *Replication analysis*

These findings provide evidence that perceivers exhibit a male categorization bias, yet they do not eliminate the possibility that perceivers relied on the range of stimuli to render judgements. If participants used this strategy, they may have surmised that the boundary lay at the midpoint of the scale of WHRs. We aimed to overcome this concern in several ways. Here, we replicated our key finding using a more narrow range of stimuli. Specifically, 102 participants categorized bodies with body shapes that were within observed human variation (i.e. WHRs between 0.64 and 0.90). Once again, the perceived boundary ($M = 0.75$, s.e. = 0.003) was significantly below the actual boundary, one-sample $t_{101} = -15.236$, $p < 0.0001$, thus corroborating our initial observations. We next aimed to provide additional support for our claims using an identification task (study 2) and a reverse-correlation technique (study 3).

3. STUDY 2

(a) *Method*

(i) *Participants*

Thirty-one students (six women, 25 men) participated in this study for course credit.

(ii) *Materials and procedure*

Stimuli included the 21 bodies from study 1. Bodies were presented simultaneously to participants in a questionnaire (e.g. as the stimuli appear in figure 1). Within the 'line-up,' participants identified the average male body, the average female body, and the boundary between the two. The average male and female bodies were described to be 'the body that best represents the body shape of the men (women) you encounter each day.' The boundary was described as, 'the point in the line up where, in reality, the distribution of men/women changes from being mostly female to being mostly male.' Participants were warned that the line-up depicted bodies that do not really exist in nature, and that their responses should reflect the bodies of men and women they see day to day.

(b) *Results and discussion*

We initially included participant sex as a factor in all analyses. No effect involving participant sex reached significance and as such, it was dropped from all analyses.

We analysed the WHRs selected for each judgement (i.e. the average male body, the average female body, and the boundary between), using a repeated-measures ANOVA. These judgements differed from one another, $F_{2,58} = 240.900$, $p < 0.001$. The WHR selected to represent the average female ($M = 0.568$) was significantly smaller than the WHR selected to represent the average male ($M = 0.819$), $t_{30} = -18.690$, $p < 0.001$. Both of the perceived averages differed from the perceived boundary shift ($M = 0.713$), t_{30}s = −14.470 and 10.540, for the average male and female, respectively, both ps < 0.001.

Importantly, these selections also differed from the anthropometric norms observed in study 1. We compared the selected WHRs with the anthropometric mean WHRs for men ($M = 0.892$), woman ($M = 0.716$), and the boundary between the two ($M = 0.8049$). Each judgement differed significantly from the corresponding estimate in the army database, t_{30}s = −20.86 (female), −4.980 (male) and −12.690 (boundary), all ps < 0.01. Thus, we again found evidence that perceivers exhibit a male categorization bias.

4. STUDY 3

In study 3, we used a reverse-correlation image classification paradigm [27,28] to identify the cognitive representation for men's and women's bodies. In this technique, random noise patterns were superimposed over a single base image. Across hundreds of two alternative forced choice trials, participants identified which of two images resembled a specified category. When the noise patterns that a participant identified are collapsed across trials, the resulting images are theorized to depict a visual representation of the parameters that perceivers' used in their judgements. In study 3, we examined participants' representations for sexually dimorphic body shapes. This technique has been used to identify the representations of individuals, emotion/social categories and aesthetic preferences [27]. Importantly, this technique is distribution free insofar as the base image remains constant across stimuli (here the anthropometric boundary WHR = 0.8049), a characteristic that is ideal for testing biases in sex categorization.

(a) *Method*

(i) *Participants*

Twenty-four students (13 women, nine men, two unreported) participated in this study for $10.

(ii) *Materials and procedure*

Participants completed a reverse-correlation image categorization task. Stimulus pairs were created using a base image of a body facing backward (WHR = 0.8049; the anthropometric boundary). Using scripts from prior research [28], 60 noise patterns were created; these were added to and subtracted from the base image to create 60 unique two alternative forced choice pairings. Across 700 trials, these presumed male/female pairs were presented in random order to participants on a Macintosh computer running customized software. Participants identified which image (left or right) depicted the woman with the presumption that the unselected image depicted the man.

We averaged across all noise patterns that were identified as women/not-women to reconstructed each participant's classification image for women and men. We then computed the WHR for each classification image from measurements of the width of the waist and hips in pixels, using the standard anthropometric landmarks in study 1. Finally, we reconstructed aggregate classification images by collapsing across all participants' judgements.

(b) *Results and discussion*

Participants' classification image for the female body had a WHR ($M = 0.681$, s.e. $= 0.008$) that was significantly smaller than both the anthropometric boundary and the anthropometric average woman, one-sample t_{23}s $= -14.675$ and -4.137, ps < 0.0001 (figure 3*a*). Participants' classification image for the non-selected (i.e. male) body had a WHR ($M = 0.875$, s.e. $= 0.009$) that was significantly larger than the anthropometric boundary but marginally smaller than the anthropometric male body, one-sample t_{23}s $= 7.651$ and -1.926, ps < 0.0001 and $= 0.067$ (figure 3*b*). Thus, using a method that is not vulnerable to scaling effects, we again found evidence for a significant male bias in sex category representations.

Across four studies using three distinct methods, we have found consistent evidence for a systematic male categorization bias. Bodies that are more common of women are nevertheless categorized as men a significant portion of the time; the representation of the average female—measured by both identification and in reverse correlations—is anthropometrically extreme. We contend that these biases reflect perceivers' goal to minimize potential costs in social interactions [18].

5. STUDY 4

Having established this bias, we next sought to understand its functional underpinnings. The male categorization bias is likely to vary across contexts. Contexts that signal danger tends to alter cognitions [29], and they compel perceivers to parse their social world into stark 'us' and 'them' categories [10]. We predicted such circumstances may also compel more extreme biases, both in the absolute degree of bias and in the speed with which judgements are rendered. Contexts that signal safety, in contrast (e.g. a benign interaction in one's office), may relax categorization biases. In study 4, we tested these predictions experimentally.

(a) *Method*

(i) *Participants*

Two hundred and thirty-seven undergraduate students (196 women, 38 men, three unreported) participated in exchange for course credit.

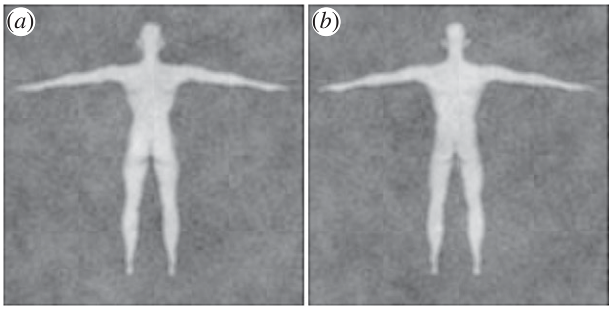

Figure 3 Reverse correlation classification images from study 3. (*a*) Images depict the average classification images the body identified to depict the woman and (*b*) the unselected body, by default, the male body.

(ii) *Materials and procedure*

Participants judged the sex category of stimuli from study 1 in two blocks—one prior to and one after viewing a movie clip. Between the two, participants were randomly assigned to view one of four movie clips that reliably induce different states [30] including: (i) Fear—a woman is chased through a darkened house by a murderer; (ii) Positive—a dog comically attacks a man; (iii) Sadness—a young boy learns of his father's death; and (iv) Control—a screen saver of fractal images.

(b) *Results and discussion*

(i) *Boundary differences*

As in study 1, we estimated the perceived boundary for each participant, separately for pre- and post-manipulation categorizations. We analysed these boundaries using a two (participant sex) by four (condition) ANCOVA. The pre-manipulation boundary was related to the post-manipulation boundary, $F_{1,225} = 14.141$, $p = 0.001$, and it was therefore included as a covariate. Post-manipulation boundaries varied by condition, $F_{3,225} = 2.920$, $p = 0.035$. Using planned contrasts, we compared the post-manipulation boundary in the Fear condition with other conditions. Boundaries in the Fear condition ($M = 0.687$, s.e. $= 0.026$) were significantly lower than in the Sad or Positive conditions (Ms $= 0.702$ and 0.692, s.e.s $= 0.024$ and 0.041), t_{115}s, $=2.429$ and 2.286, ps $= 0.019$ and 0.024, respectively; it did not differ, however, from the Control condition ($M = 0.692$, s.e. $= 0.022$), $t_{116} = 0.429$, n.s.

These data provide some evidence that sex-categorization biases are sensitive to context. Participants in the Fear and Control condition exhibited the strongest sex-categorization biases. This suggests that although sex-categorization biases may be normative, they can be relaxed in some contexts (e.g. when in positive or sad states). The relatively small size of these differences is unsurprising for two reasons. First, these differences moderate an already robust bias. Second, this manipulation, although reliable, is non-consequential for perceivers. More pronounced biases are likely to manifest in real-life contexts (e.g. the fear that accompanies being followed by a stranger at night).

(ii) *Temporal advantages*

In study 1, we found a temporal advantage for male categorizations. We tested whether this advantage varied as a function of condition and WHR, specifically for post-manipulation judgements. We excluded trials for which response latency was more than 3 s.d.s greater

Table 1 Response latencies (ms) as a function of condition in study 3.

	emotion condition			
	Fear	Control	Sad	Positive
actual boundary				
male	884.66	927.02	990.55	920.79
female	1544.41	1442.53	1559.29	1457.53
temporal advantage	659.75	515.51	568.74	536.74
perceived boundary				
male	1064.34	1089.34	1243.78	1021.38
female	1173.44	1152.94	1198.65	1135.89
temporal advantage	109.09	63.60	−45.13	114.51

than the mean because some latencies were exceedingly long (maximum = 51 550 ms). Using GEE, we regressed response latency onto judgement (effect coded, male = −0.5, female = 0.5), WHR (centred at its midpoint) and condition (dummy coded). Importantly, the three-way interaction was significant, $F_{3,9583} = 9.500$, $p < 0.0001$, suggesting that sex-specific temporal advantages varied across condition and WHR. To test the nature of this interaction, we contrasted the simple slope of sex in the Fear condition against the corresponding simple slopes in the other conditions, separately for two benchmark WHRs (table 1).

At the perceived boundary between men and women (i.e. WHR = 0.68), male categorizations were significantly faster than female categorizations in the Fear condition, $B = 109.090$, s.e. = 35.509, $z = 5.500$, $p < 0.0001$. Similar differences were obtained in the Control and Positive conditions, Bs = −45.489 and 5.417, s.e.s = 49.394 and 49.422, zs = −0.920 and 0.110, respectively, n.s. The opposite pattern was obtained in the Sad condition, $B = -154.230$, s.e. = 48.871, $z = -3.160$, $p = 0.002$. Thus, at a perceptually androgynous WHR, we observed a significant temporal advantage for male categorizations among three of the four conditions.

At the actual boundary (i.e. WHR = 0.80), male categorizations were again significantly faster than female categorizations in the Fear condition, $B = 659.750$, s.e. = 47.569, $z = 13.870$, and $p < 0.0001$. At this benchmark, this difference was most pronounced in the Fear condition. The temporal advantage was attenuated somewhat in the Sad condition, $B = -91.019$, s.e. = 64.084, $z = -1.420$, $p = 0.156$; and it was significantly reduced in the Control and Positive conditions, Bs = −144.240 and −123.010, s.e.s = 66.799 and 65.951, zs = −2.160 and −1.870, ps = 0.031 and 0.062, respectively. Thus, for bodies that arouse confident male percepts—in spite of their actual androgyny—the male categorization temporal advantage was most pronounced in the Fear condition.

Collectively, these findings highlight a pattern of systematic biases that are consistent with contextual modulation. The tendency for sex categorization to be biased was common to all conditions, but was most pronounced in the Control and Fear conditions. These tendencies were slightly relaxed in the Sad and Happy conditions. This suggests that although a male categorization bias may be pronounced, in general, it may be attenuated somewhat when one's context promotes a relaxation of vigilance. Additionally, analyses of response latencies provided additional support. Overall, male categorizations occurred more quickly than female categorizations. This tendency was strongest in the Fear condition, especially when categorizing bodies that are overwhelmingly judged to be men.

6. GENERAL DISCUSSION

Across four unique studies and one replication that used diverse methods, we documented a consistent pattern in which perceivers were biased to judge others to be men. In all studies, we found that perceivers categorized bodies to be men, even when the WHRs were actually more common to women. This was true in diverse tasks including categorization (studies 1 and 4), identification (study 2), and reverse-correlation (study 3). Moreover, male categorizations were rendered more rapidly than female categorizations (studies 1 and 4). Finally, we demonstrated that these biases are contextually sensitive (study 4).

Collectively, these findings support our hypothesis that sex categorizations are functionally biased towards a male percept. Although this bias produces sex-categorization errors, they should not be construed as mistakes. Indeed, unknown men and women are not equally formidable. The tendency to err on the side of caution highlights a remarkable sensitivity to the social affordances of others. Consequently, sex-categorization biases are functional, even though they are error-prone [17,18].

(a) *Specificity considerations*

We have argued that the male categorization biases stemmed from a functional bias. Two additional factors warrant consideration. First, others have argued persuasively that certain social categories serve as 'default' social judgements [31–33]. Although this perspective is consistent with the pattern of results that we have described, it does not provide an alternate theoretical account. To our reckoning, our analysis of this tendency pinpoints the functional underpinnings that lead 'male' to be the default social judgement.

Second, our reliance on computer-generated stimuli opens the possibility that sex-categorization biases may be observed only for judgements of tightly controlled stimuli, but not for other complex stimuli. To gain some insight into the generality of the effect, we reanalysed data from other research [34] of which a subset is relevant here. Participants categorized the sex of point-light-defined walking motions of actual men and women. We analysed sex-categorization biases for two walking speeds—one self-paced, and one accelerated pace. We reasoned that to the extent that a sex-categorization bias exists, it may be modulated by the speed of a person's approach such that biases would be more pronounced for judgements of individuals who are approaching rapidly. As predicted, male categorizations were 11 per cent more likely than female categorizations, $B = -0.114$, s.e. = 0.048, $z = -2.370$, $p = 0.018$, odds ratio (OR) = 0.892. This tendency was exacerbated for accelerated walks, $B = -0.139$, s.e. = 0.054, $z = -2.600$, $p = 0.009$, OR = 0.869. Moreover, similar biases have been observed for judgements of other point-light-defined motions: male categorization biases are more pronounced when the target moves in an angry fashion [35] or when a target is approaching the viewer [36]. Thus, the male categorization bias appears to generalize to other perceptions, including body motions, and it appears to be modulated by factors such as emotion state, facing direction and speed of approach that could heighten a perceiver's vigilance.

(b) *Durability considerations*

Male categorization biases may persist in spite of occasional disconfirmation of initial impressions. It is important to note that this bias is presumed to be functional precisely because it enables perceivers to alter their behaviours to avoid physically formidable others. In such cases, categorization errors will escape disconfirmation entirely. Therefore, these functional ends will justify the biased cognitive representations, enabling categorization biases to persist.

At times, however, the benefits of bias will be outweighed by the importance of accuracy. Upon interaction, it is unlikely that a categorization error will persist, even if it occurred initially. Instead, when in close proximity of another person, sexually dimorphic cues are likely to be highly salient. Therefore, whereas early in perception, the mere possibility that a target may be a man may be sufficient to compel a male categorization, the accumulation of additional information that is less ambiguous (e.g. facial cues) and that is redundant across perceptual modalities (e.g. voice) will ultimately afford an accurate percept in a dynamic fashion [3]. Indeed, perceivers are near perfect in sex categorizations of faces [3,5]. From our perspective, therefore, biases in social perception are likely to occur primarily, if not exclusively, in circumstances in which the perceiver may stand to benefit from the bias (e.g. perception at a distance), but are unlikely to endure further scrutiny.

Although categorization errors are unlikely to persist during interactions, they may nevertheless impact evaluative social judgements. Perceptions of attractiveness, for example, vary as a function of perceived gender typicality [19]. To the extent that the cognitive representations for bodies are biased, perceived attractiveness may suffer. A body shape that is, in reality, female-typed may be perceived as masculine and therefore unattractive for a woman. Consistent with other research, this is likely to produce preferences for extreme body shapes, particularly for women [19,37].

7. CONCLUSION

Social perception is among the most important tasks that occur in daily life. We propose that these perceptions are functionally biased. According to our findings, perceivers rapidly and readily categorize others as men, thus manifesting a conservative bias in sex perception.

The studies reported in this manuscript conform to the ethical polices specified by the American Psychological Association, and they were approved by the Institutional Review Board at the University of California, Los Angeles.

REFERENCES

1 Brewer, M. B. 1988 A dual process model of impression formation. In *Advances in social cognition*, vol. 1 (eds R. S. Wyer & T. K. Srull), pp. 1–36. Hillsdale, NJ: Erlbaum.

2 Rule, N. O., Ambady, N., Adams Jr, R. B. & Macrae, C. N. 2008 Accuracy and awareness in the perception and categorization of male sexual orientation. *J. Pers. Soc. Psychol.* **95**, 1019–1028. (doi:10.1037/a0013194)

3 Freeman, J. B., Ambady, N., Rule, N. O. & Johnson, K. L. 2008 Will a category cue attract you? Motor output reveals dynamic competition across person construal. *J. Exp. Psychol. Gen.* **137,** 673–690. (doi:10.1037/a0013875)

4 Johnson, K. L. & Tassinary, L. G. 2005 Perceiving sex directly and indirectly: meaning in motion and morphology. *Psychol. Sci.* **16**, 890–897. (doi:10.1111/j.1467-9280.2005.01633.x)

5 Johnston, L., Miles, L. & Macrae, C. N. 2010 Male or female? An investigation of factors that modulate the visual perception of another's sex. In *Social psychology of visual perception* (eds E. Balcetis & G. D. Lassiter), pp. 103–122. New York, NY: Psychology Press.

6 Runeson, S. & Frykholm, G. 1983 Kinematic specification of dynamics as an informational basis for person and action perception: expectation, gender recognition, and deceptive intention. *J. Exp. Psychol. Gen.* **112,** 595–615. (doi:10.1037/0096-3445.112.4.585)

7 Chouchourelou, A., Matsuka, T., Harber, K. & Shiffrar, M. 2006 The visual analysis of emotional actions. *Soc. Neurosci.* **1**, 63–74. (doi:10.1080/17470910600630599)

8 Pollick, F. E., Lestou, V., Ryu, J. & Cho, S. B. 2002 Estimating the efficiency of recognizing gender and affect from biological motion. *Vision Res.* **20**, 2345–2355. (doi:10.1016/S0042-6989(02)00196-7)

9 Gunns, R. E., Johnston, L. & Hudson, S. M. 2002 Victim selection and kinematics: a point-light investigation of vulnerability to attack. *J. Nonverbal Behav.* **26,** 129–158. (doi:10.1023/A:1020744915533)

10 Miller, S. L., Maner, J. K. & Becker, D. V. 2010 Self-protective biases in group categorization: what shapes the psychological boundary between 'us' and 'them'? *J. Pers. Soc. Psychol.* **99,** 62–77. (doi:10.1037/a0018086)

11 Zebrowitz, L. A. & Collins, M. A. 1997 Accurate social perception at zero acquaintance: the affordances of a Gibsonian approach. *Pers. Soc. Psychol. Rev.* **1,** 204–223. (doi:10.1207/s15327957)

12 Neuberg, S. L., Kenrick, D. T. & Schaller, M. 2011 Human threat management systems: self-protection and disease avoidance. *Neurosci. Biobehav. Rev.* **35,** 1042–1051. (doi:10.1016/j.neubiorev.2010.08.011)

13 Kenrick, D. T., Neuberg, S. L., Geiskevicius, V., Becker, D. V. & Schaller, M. 2010 Goal-driven cognition and functional behavior: the fundamental motives framework. *Curr. Dir. Psychol. Sci.* **19**, 63–67. (doi:10.1177/0963721409359281)

14 Archer, J. 2004 Sex differences in aggression in real-world settings: a meta-analytic review. *Rev. Gen. Psychol.* **4**, 291–322. (doi:10.1037/1089-2680.8.4.291)

15 Sell, A., Cosmides, L., Tooby, J., Sznycer, D., von Rueden, C. & Gurven, M. 2009 Human adaptations for the visual assessment of strength and fighting ability from the body and face. *Proc. R. Soc. B* **276**, 575–584. (doi:10.1098/rspb.2008.1177)

16 Daly, M. & Wilson, M. 2003 Evolutionary psychology of lethal interpersonal violence. In *The international handbook of research on violence* (eds W. Heitmeyer & J. Hagan), pp. 709–734. New York, NY: Wesview.

17 Haselton, M. G. & Buss, D. M. 2000 Error management theory: a new perspective on biases in cross-sex mind reading. *J. Pers. Soc. Psychol.* **78,** 81–91. (doi:10,1037110022-3514.78.1.81)

18 Haselton, M. G. & Nettle, D. 2006 The paranoid optimist: an integrative evolutionary model of cognitive

biases. *Pers. Soc. Psychol. Rev.* **10**, 47–66. (doi:10.1207/s15327957pspr1001_3)

19 Johnson, K. L. & Tassinary, L. G. 2007 Compatibility of basic social perceptions determines perceived attractiveness. *Proc. Natl Acad. Sci. USA* **104**, 5246–5251. (doi:10.1073/pnas.0608181104)

20 Johnson, K. L., Lurye, L. E. & Tassinary, L. G. 2010 Sex categorization among preschool children: increasing sensitivity to sexually dimorphic cues. *Child Dev.* **81**, 1346–1355. (doi:10.1111/j.1467-8624.2010.01476.x)

21 Clauser, C. E., Tebbetts, I. O., Bradtmiller, B., McConville, J. T. & Gordon, C. C. 1987–1988 Measurer's handbook: US army anthropometric survey (technical report NATICK/TR-88/043, AD A202 721). Natick, MA: US Army.

22 Gordon, C. C., Bradtmiller, B., Churchill, T., Clauser, C. E., McConville, J. T., Tebbetts, I. O. & Walker, R. A. 1988 Anthropometric survey of US army personnel: methods and summary statistics (technical report NATICK/TR89/044, AD A225 094). Natick, MA: US Army.

23 Cohen, J., Cohen, P., West, S. G. & Aiken, L. S. 2003 *Applied multiple regression/correlation analysis for the behavioral sciences*. Mahwah, NJ: Lawrence Erlbaum Associates.

24 Fitzmaurice, G. M., Laird, N. M. & Ware, J. H. 2004 *Applied longitudinal analysis*. New York, NY: John Wiley and Sons.

25 Raudenbush, S. W., Bryk, S. S. & Congdon, R. 2011 HLM 7 for Windows (*computer software*). Lincolnwood, IL: Scientific Software International, Inc.

26 Raudenbush, S. W. & Bryk, A. S. 2002 *Hierarchical linear models*, 2nd edn. Thousand Oaks, CA: Sage Publications.

27 Todorov, A., Dotsch, R., Wigboldus, D. H. J. & Said, C. P. 2011 Data-driven methods for modeling social perception. *Soc. Pers. Psychol. Compass* **5/10**, 775–791. (doi:10.1111/j.1751-9004.2011.00389.x)

28 Karremans, J. C., Dotsch, R. & Corneille, O. 2011 Romantic relationship status biases memory of faces of attractive opposite-sex others: evidence from a reverse-correlation paradigm. *Cognition* **121**, 422–426. (doi:10.1016/j.cognition.2011.07.008)

29 Schaller, M., Faulkner, J., Park, J. H., Neuberg, S. L. & Kenrick, D. T. 2004 Impressions of danger influence impressions of people: an evolutionary perspective on individual and collective cognition. *J. Cult. Evol. Psychol.* **2**, 231–247. (doi:10.1556/JCEP.2.2004.3-4.4)

30 Gross, J. W. & Levenson, R. W. 1995 Emotion elicitation using films. *Cogn. Emot.* **9**, 87–108. (doi:10.1080/02699939508408966)

31 Purdie-Vaughns, V. & Eibach, R. 2008 Intersectional invisibility: the ideological sources and social consequences of non-prototypicality. *Sex Roles* **50**, 337–391. (doi:10.1007/s11199-008-9424-4)

32 Strossner, S. J. 1996 Social categorization by race or sex: effects of perceived non-normalcy on response times. *Soc. Cogn.* **14**, 247–276. (doi:10.1521/soco.1996.14.3.247)

33 Smith, E. R. & Zárate, M. A. 1992 Exemplar-based model of social judgment. *Psychol. Rev.* **99**, 3–21. (doi:10.1037/0033-295X.99.1.3)

34 Lick, D. J., Johnson, K. L. & Gill, S. V. In press. Deliberate changes to gendered body motion influence basic social perceptions. *Social Cogn.*

35 Johnson, K. L., McKay, L. & Pollick, F. E. 2011 Why 'he throws like a girl' (but only when he's sad): emotion affects sex-decoding of biological motion displays. *Cognition* **119**, 265–280. (doi:10.1016/j.cognition.2011.01.016)

36 Shouten, B., Troje, N. F. & Verfaille, K. 2011 The facing bias in biological motion perception: structure, kinematics, and body parts. *Atten. Percept. Psychophys.* **73**, 130–143. (doi:10.3758/s13414-010-0018-1)

37 Tassinary, L. G. & Hansen, K. A. 1998 A critical test of the waist-to-hip-ratio hypothesis of female physical attractiveness. *Psychol. Sci.* **9**, 150–155. (doi:10.1111/1467-9280.00029)