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A Tale of Two Types of Perspective Taking: Sex Differences in Spatial Ability

Margaret R. Tarampi, Nahal Heydari, and Mary Hegarty
Department of Psychological & Brain Sciences, University of California, Santa Barbara

Abstract
Sex differences in favor of males have been documented in measures of spatial perspective taking. In this research, we examined whether social factors (i.e., stereotype threat and the inclusion of human figures in tasks) account for these differences. In Experiment 1, we evaluated performance when perspective-taking tests were framed as measuring either spatial or social (empathetic) perspective-taking abilities. In the spatial condition, tasks were framed as measures of spatial ability on which males have an advantage. In the social condition, modified tasks contained human figures and were framed as measures of empathy on which females have an advantage. Results showed a sex difference in favor of males in the spatial condition but not the social condition. Experiments 2 and 3 indicated that both stereotype threat and including human figures contributed to these effects. Results suggest that females may underperform on spatial tests in part because of negative performance expectations and the character of the spatial tests rather than because of actual lack of abilities.

Keywords
spatial ability, perspective taking, individual differences, stereotype threat, gender, open materials

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Perspective taking is a construct of interest in many subdisciplines of psychology, from developmental to social to cognitive. Two main traditions of research on perspective taking stem from classic studies using the three-mountain task (Piaget & Inhelder, 1948), in which children view a physical model of three mountains and judge how the model would appear to an observer in a different position and orientation. Young children demonstrate egocentrism in this task, that is, inability to take another person's perspective. Stemming from this classic study, one research tradition focuses on perspective taking as a visuospatial task, whereas another focuses on perspective taking as a social task of theory of mind or empathy.

People's ability to imagine the relative locations of objects and environments from a perspective other than their own is often characterized as an aspect of spatial ability (Hegarty & Waller, 2004; Zacks, Mires, Tversky, & Hazeltine, 2002). In measures of this ability, social agents are typically not present in the scene, and large individual differences are observed. Research on social perspective taking has focused on people's understanding of others' beliefs or mental states. In social-perspective-taking studies, people are commonly instructed to make mentalizing judgments about an agent within a specific context, and typical adults perform at ceiling (Achim, Guitton, Jackson, Boutin, & Monetta, 2013).

Spatial and social perspective taking are not mutually exclusive. In many social situations, people engage in spatial perspective taking to monitor social intentions (Shelton, Clements-Stephens, Lam, Pak, & Murray, 2011), to plan joint actions (Pezzulo, Iodice, Ferraina, & Kessler, 2013), or to communicate (Schober, 1993). Frith and Frith (2010) propose that the ability to detect potential agents is an involuntary social signal that activates automatic systems in the "social brain" supporting interaction and cooperation. It is possible that these systems include spatial perspective taking, which is facilitated by the

Corresponding Author:
Margaret R. Tarampi, Department of Psychological & Brain Sciences, University of California, Santa Barbara, 1810 Psychology East, Santa Barbara, CA 93106-9660
E-mail: margaret.tarampi@sagecenter.ucsb.edu

presence of potential agents (Amorim, 2003; Michelon & Zacks, 2006; Surtees, Noordzij, & Apperly, 2012). Observers engage in spontaneous perspective taking when a social agent is visible (e.g., Tversky & Hard, 2009), which suggests that embodied cognitive processes that simulate sensorimotor processes enable cognition in support of social goals (Kessler & Wang, 2012). There is also evidence for a relationship between perspective taking and emotional empathy (Ruby & Decety, 2004) and between perspective taking and autism spectrum conditions (Hamilton, Brindley, & Frith, 2009). In one study, participants with more social ability, as measured by the Autism-Spectrum Quotient (AQ; Baron-Cohen, Wheelwright, Skinner, Martin, & Clubley, 2001), performed better on a spatial-perspective-taking task that included an agent in the scene, consistent with the social functional role of perspective taking (Shelton et al., 2011).

Here, we focus on sex differences in spatial-perspective-taking ability. In the sex-differences literature, this ability has received less attention than other spatial abilities, such as mental rotation and spatial perception (e.g., Linn & Peterson, 1985; Voyer, Voyer, & Bryden, 1995). However, a male advantage in spatial-perspective-taking tests, such as the Money road-map test (Money, Alexander, & Walker, 1965) and the object-perspective-taking task (Hegarty & Waller, 2004) has been reported in several studies (e.g., Fields & Shelton, 2006; Meneghetti, Pazzaglia, & De Beni, 2012; Zacks et al., 2002). Spatial skills predict science, technology, engineering, and math (STEM) achievement (Humphreys, Lubinski, & Yao, 1993) and can be trained (Uttal et al., 2013), so it is important to understand the factors that influence performance on measures of these skills. Interestingly, no sex differences have been documented in social perspective taking. Moreover, women are often characterized as empathizers who are more skilled and motivated than men in social situations (Baron-Cohen, 2002), which suggests that women may perform better when spatial thinking is tested in a social context.

First, we examined how the inclusion of social agents in tests of spatial perspective taking affected sex differences in performance. We tested the hypothesis that women perform better than men when perspective taking is tested in a social context, that is, when an agent is present in the scene and they have to take the perspective of the agent.

Second, we tested the hypothesis that women perform relatively poorly on measures of spatial perspective taking, in part because of stereotype threat, that is, reminders of a pertinent negative stereotype about their group's performance (Steele, 1997). Our hypothesis was suggested by preliminary findings that spatial performance is affected by stereotype threat. Females perform more poorly on a mental rotation test when primed to think about their gender identity than when primed with a task-irrelevant identity, whereas males show the opposite pattern of performance (McGlone & Aronson, 2006). Moreover, both women and men perform better on a mental rotation test if they have been informed that their gender has superior spatial ability (Moè & Pazzaglia, 2006). A preliminary study of stereotype threat in perspective taking has shown that framing an imagined self-rotation task as a test of perspective taking in which there is a female advantage enhanced women's performance while degrading men's performance (Wraga, Duncan, Jacobs, Helt, & Church, 2006).

We examined these social influences on two tests of spatial perspective taking (Hegarty & Waller, 2004; Money et al., 1965). First, we investigated the effects of adding a human figure to the stimuli and asking participants to assume the perspective of that figure, rather than specifying this perspective more abstractly. Second, we looked at whether the framing of these tests, as measuring spatial versus empathetic abilities, affects sex differences, and we examined how these framing effects are influenced by gender stereotypes. Finally, we examined whether social skills, as measured by the AQ, moderate the effects, such that they correlate with perspective-taking performance when participants are given a social but not spatial context (social-moderation hypothesis).

Experiment 1

In Experiment 1, we compared performance on spatial and social conditions of the perspective-taking tasks. In the spatial condition, unmodified tests were framed as spatial and emphasized the stereotype that males have an advantage over females on spatial tasks. In the social condition, the tests were modified by the inclusion of human figures and were framed as social, with females having an advantage over males.

Method

Participants. A total of 139 undergraduates (age range = 18–22 years) at the University of California, Santa Barbara participated in return for course credit. Four participants were excluded from analyses because they scored below chance on the spatial-orientation test. The remaining participants were 65 males (32 in the social condition and 33 in the spatial condition) and 70 females (34 in the social condition and 36 in the spatial condition). An a priori power analysis informed by a pilot study determined that this sample size would give us .8 power to detect a medium-sized effect.

Materials. The experiment consisted of two timed pencil-and-paper tests of perspective-taking ability: the

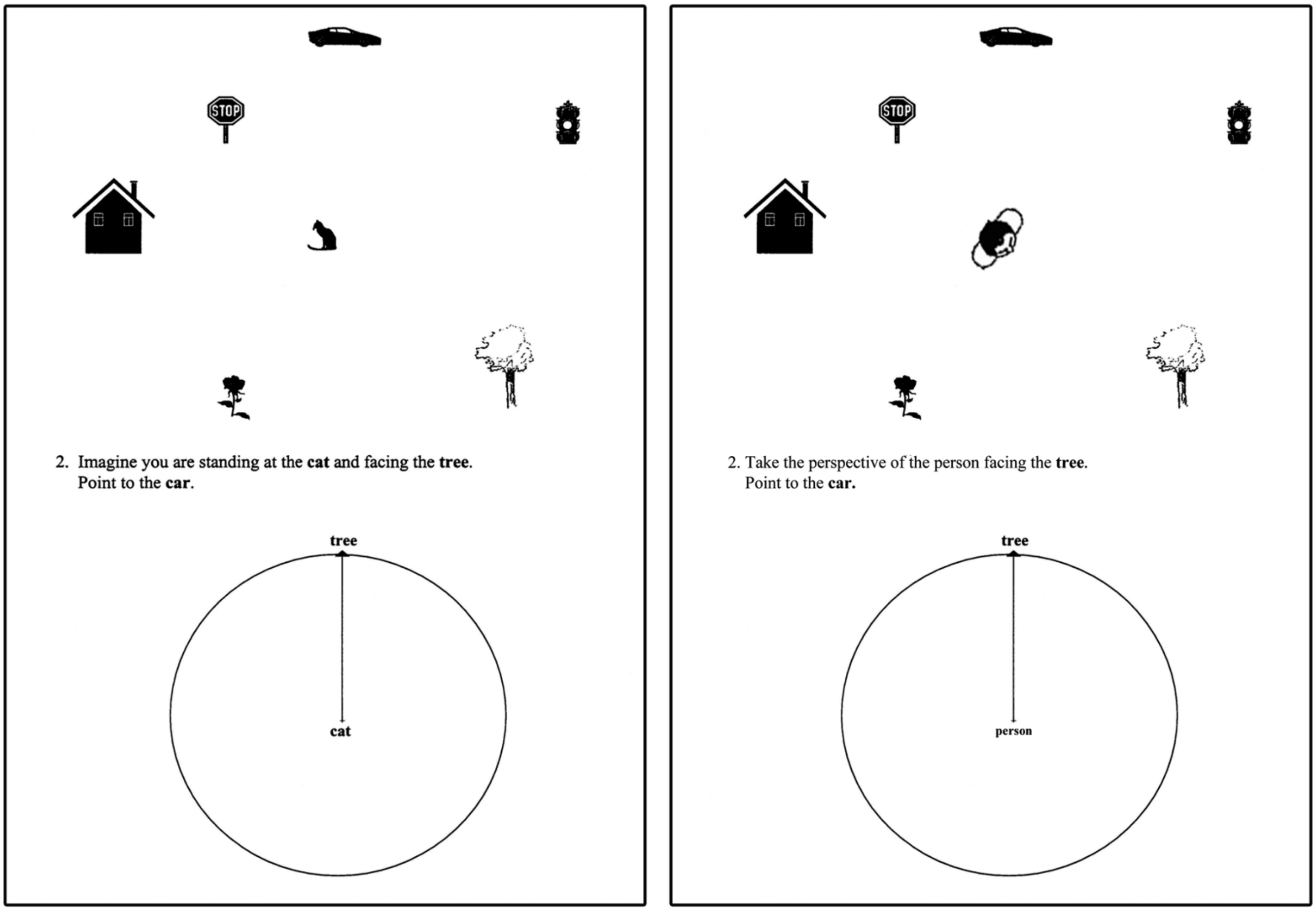

Fig. 1. Example trial from the original spatial-orientation test (left), in which participants were asked to imagine themselves standing in the place of an object within an array, and the modified spatial-orientation test (right), in which they were asked to imagine themselves standing in the place of a human figure. On both versions, participants were asked to imagine they were facing another object and then to use the circle at the bottom of the page to draw an arrow pointing to the location of a third object.

object-perspective/spatial-orientation test (Hegarty & Waller, 2004) and the standardized road-map test of direction sense (the *road-map test*; Money et al., 1965; modified by Zacks et al., 2002). In the spatial-orientation test, participants were shown an array of objects. In the spatial condition (Fig. 1, left panel), a statement instructed participants to imagine standing in the place of one object on the map, facing another object, and indicating the direction to a third object (e.g., "Imagine you are standing at the cat and facing the tree. Point to the car."). Below the array of objects was a circle with an arrow that pointed toward the object that participants imagined facing. Participants drew a second arrow to indicate the direction to the third object. The test was the same in the social condition (Fig. 1, right panel), except that a human figure rather than an object was the starting location, and participants were asked to take the perspective of the person as they indicated the relative direction to a third object. Participants were not allowed to make any marks on the array or rotate the page. Responses were scored by calculating the absolute angular deviation from the correct answer for each trial (which could range from 0° to 180°) and averaging these errors across trials. Unanswered items were assigned an angular deviation of 90° as chance performance.

The road-map test consisted of a bird's-eye diagram of a path through a city (see Fig. 2, left panel). Participants were instructed to imagine walking along the path and write either "R" or "L" at each corner to indicate whether to take a right or left turn. The social version of the task included a human figure at every corner (see Fig. 2, right panel). Participants in the social condition were instructed to imagine themselves taking the perspective of the person as he or she walked along the path. Their score was the number of corners labeled correctly.

The AQ (Baron-Cohen et al., 2001) is a questionnaire that measures the extent to which adults of normal intelligence express traits associated with autism spectrum

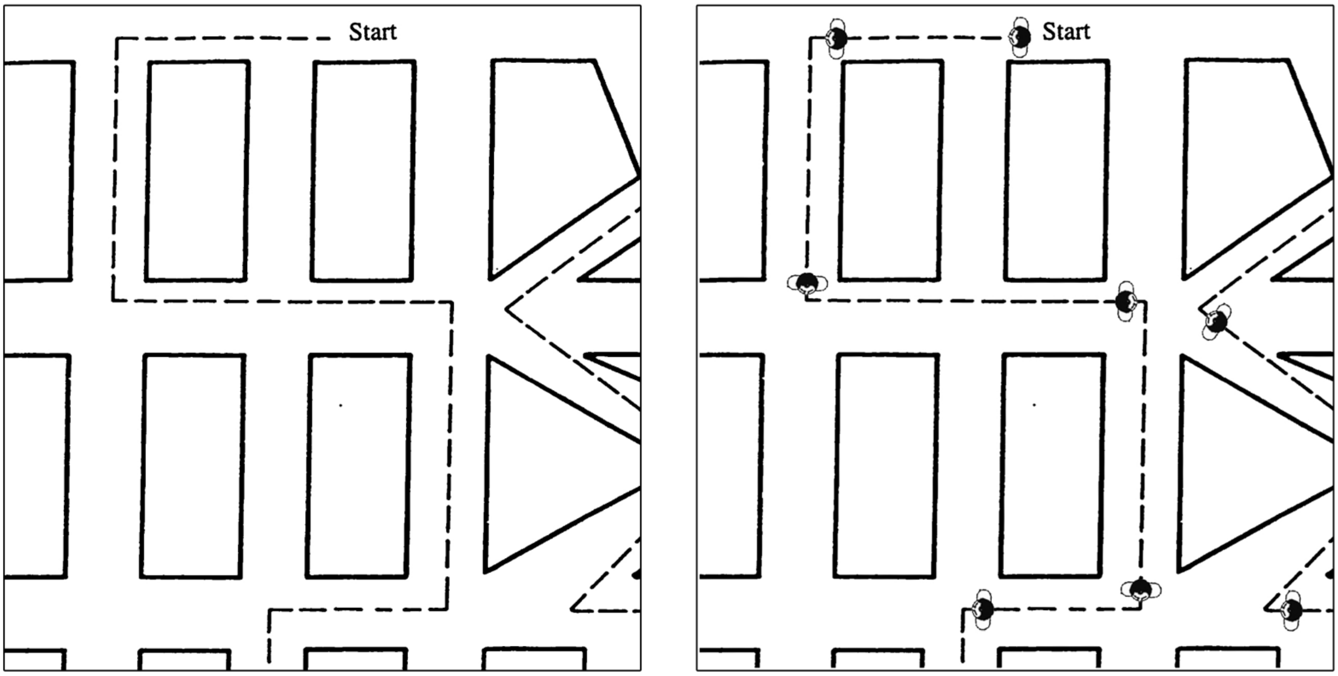

Fig. 2. Sample section of the original road-map test (left) and the modified road-map test (right). In both versions of the test, participants saw a bird's-eye diagram of a city with a dashed line indicating a path through it. Participants were instructed to imagine walking along the path and write "R" or "L" at each corner to indicate whether the path took a right or left turn. The modified version differed from the original only in that a human figure was present at each turn in the path.

disorder. The questionnaire consisted of 50 items asking participants to rate their agreement (from *strongly agree* to *strongly disagree*) with statements such as "I prefer to do things with others rather than on my own." It is scored with respect to five traits: social skill, communication, perseveration, attention to detail, and imagination. Following Shelton et al. (2011), we created a composite of the scores on the social-skill and communication subscales; combined scores had a possible range of 0 to 20, with higher scores indicating poorer social skills.

Procedure. Males and females were tested individually or in same-sex groups of 2 to 8 participants. In both conditions, participants were told that they would complete two tasks that would test their perspective-taking ability. Participants in the spatial condition were given unmodified tests and also received the following information, which emphasized that perspective taking is a spatial ability in which men have an advantage over women:

> Perspective-taking ability can be thought of as a measure of spatial ability. Spatial ability is a cognitive ability that is defined as understanding the relations between objects in space and being able to mentally manipulate them and respond correctly. Males often score higher on measures of spatial ability.

Participants in the social condition were given modified tests, which included human figures, and received the following additional information, which emphasized that perspective taking is an empathetic ability in which women have an advantage over men:

> Perspective-taking ability can be thought of as a measure of empathetic ability. Empathetic ability is a social ability that is defined as being able to identify with and understand what another person is seeing or feeling, and respond appropriately. Females often score higher on measures of empathetic ability.

The participants then completed the two perspective-taking tasks, with task order counterbalanced across participants. On the road-map test, participants were given 30 s to complete as many of the 32 items as they could. On the spatial-orientation test, they were allowed 5 min to complete 12 test items. Finally, they completed the AQ.

Results

We predicted that females would perform better on the perspective-taking tasks in the social condition than in the spatial condition. Scores on the spatial-orientation test and

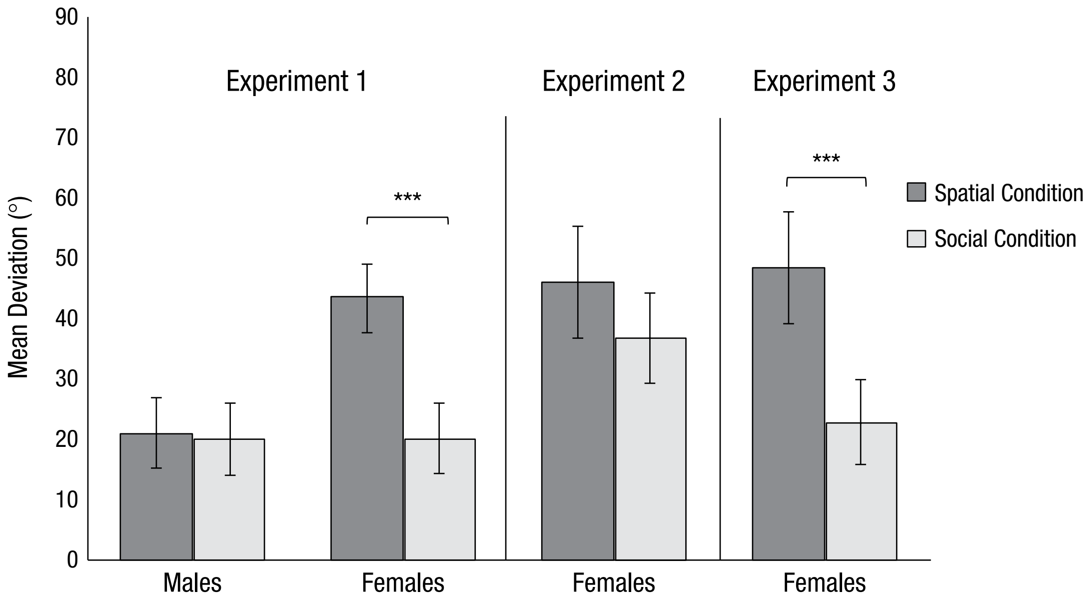

Fig. 3. Mean degree of deviation from the correct direction on the spatial-orientation test in Experiments 1 through 3. Deviation is shown as a function of sex and condition, with higher deviation indicating poorer performance. Error bars indicate 95% confidence intervals. Asterisks indicate significant differences between conditions (*** $p < .001$).

road-map test departed from normality and were subsequently analyzed using log-transformed values and nonparametric tests. These results did not differ appreciably from analyses using raw values, which are presented here.[1]

We first tested our predictions for the spatial-orientation test. A 2 (sex: male, female) × 2 (condition: social, spatial) between-subjects analysis of variance (ANOVA) found significant main effects of sex, $F(1, 131) = 14.22$, $p < .001$, $\eta_p^2 = .10$, $d = 0.61$, and condition, $F(1, 131) = 16.84$, $p < .001$, $\eta_p^2 = .11$, $d = 0.67$. As predicted, there was a statistically significant interaction between sex and condition, $F(1, 131) = 14.18$, $p < .001$, $\eta_p^2 = .10$. Consistent with our hypothesis, the analysis showed that females were more accurate (had lower angular error) in the social condition ($M = 20.13°$, $SD = 13.99$, 95% confidence interval, or CI = [14.30, 25.96]) than in the spatial condition ($M = 43.43°$, $SD = 23.02$, 95% CI = [37.77, 49.10]), $t(68) = 5.08$, $p < .001$, $d = 1.22$. However, the performance of males did not differ significantly between the spatial condition ($M = 21.12°$, $SD = 14.74$, 95% CI = [15.20, 27.04]) and social condition ($M = 20.12°$, $SD = 14.72$, 95% CI = [14.11, 26.13]), $t(63) = 0.27$, $p = .79$ (see Fig. 3). Moreover, males performed better than females in the spatial condition, $t(60) = 4.83$, $p < .001$, $d = 1.15$, whereas female and male performance in the social condition did not differ significantly, $t(64) = 0.01$, $p = .996$.

Performance on the road-map test showed a similar pattern (see Fig. 4). A 2 (sex: male, female) × 2 (condition: social, spatial) between-subjects ANOVA showed main effects of sex, $F(1, 131) = 23.78$, $p < .001$, $\eta_p^2 = .15$, $d = 0.82$, and condition, $F(1, 131) = 4.62$, $p = .033$, $\eta_p^2 = .03$, $d = 0.36$, and a significant interaction between sex and condition, $F(1, 131) = 4.61$, $p = .034$, $\eta_p^2 = .03$. Consistent with our hypothesis, the analysis showed that females were more accurate in the social condition ($M = 11.59$, $SD = 5.29$, 95% CI = [9.80, 13.37]) than in the spatial condition ($M = 7.69$, $SD = 3.80$, 95% CI = [5.96, 9.43]), $t(68) = 3.55$, $p = .001$. Once again, male performance did not differ between the spatial condition ($M = 14.06$, $SD = 5.32$, 95% CI = [12.25, 15.87]) and social condition ($M = 14.06$, $SD = 6.46$, 95% CI = [12.22, 15.90]), $t(63) = .001$, $p = .999$. Moreover, males were more accurate than females in the spatial condition, $t(67) = 5.76$, $p < .001$, $d = 1.38$, but there was no significant difference between female and male performance in the social condition, $t(64) = 1.71$, $p = .09$.

As shown in Table 1, scores on the AQ (composite of the social-skill and communication subscales) were not significantly correlated with scores on either perspective-taking task, which means that there was no evidence that this measure moderated performance in the social condition. Results did not change appreciably when we used the overall AQ score or when we excluded individuals with high overall AQ scores (> 22, which indicates autistic tendencies).

Discussion

In Experiment 1, sex differences in perspective taking were eliminated when the tests were both framed as

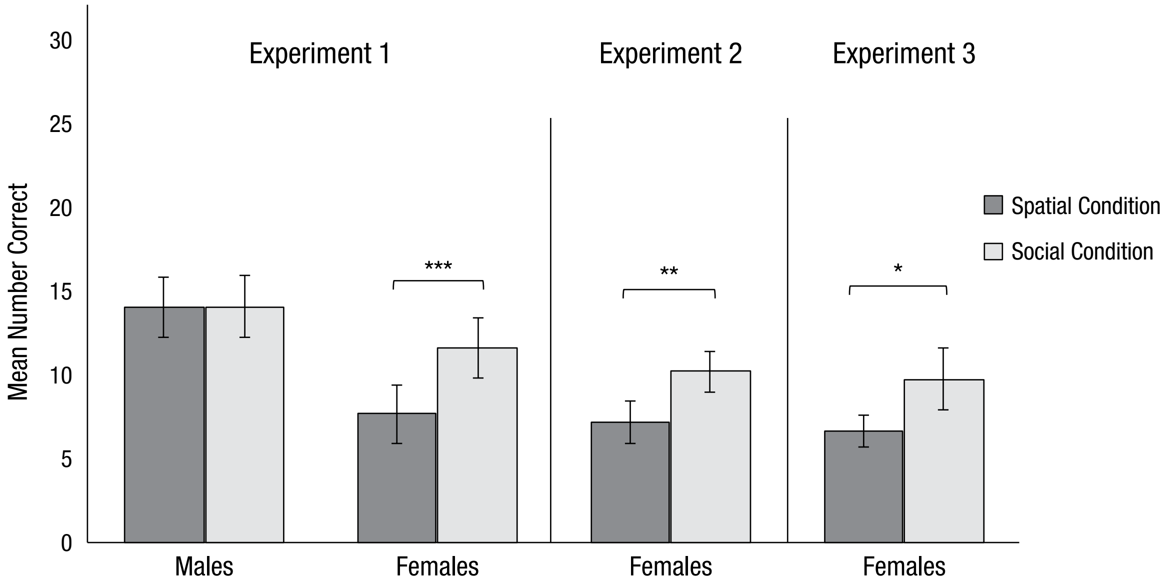

Fig. 4. Mean number of corners labeled correctly on the road-map test in Experiments 1 through 3. Correct responses are shown as a function of sex and condition. Error bars indicate 95% confidence intervals. Asterisks indicate significant differences between conditions (* $p < .05$, ** $p < .01$, *** $p < .001$).

measures of social perspective taking and included human figures. These effects might have been due to stereotype threat, the presence of human figures in the tests, or both. To test the unique contribution of each of these factors, we conducted two further experiments. In Experiment 2, we manipulated the instructions but kept the tests in their original format (without human figures), and in Experiment 3, we kept the standard instructions but manipulated the presence of human figures in the tests. Because we found no performance differences for males in Experiment 1, the subsequent experiments focused on female performance.

Table 1. Correlations Between Perspective-Taking Measures and Autism-Quotient Scores

Sex and condition	Spatial-orientation test	Road-map test
	Experiment 1	
Males		
Spatial	−.007, p = .97	−.283, p = .11
Social	.084, p = .65	−.201, p = .27
Females		
Spatial	.037, p = .83	−.038, p = .83
Social	−.215, p = .22	.290, p = .10
	Experiment 2	
Females		
Spatial	.129, p = .50	−.381, p = .04
Social	.149, p = .43	−.557, p < .01
	Experiment 3	
Females		
Spatial	−.177, p = .36	−.020, p = .92
Social	−.295, p = .11	−.080, p = .67

Note: Autism-quotient scores were obtained by creating a composite of the social-skill and communication subscales of the Autism-Spectrum Quotient (Baron-Cohen, Wheelwright, Skinner, Martin, & Clubley, 2001).

Experiment 2

Method

Participants. Sixty-five females from the University of California, Santa Barbara between the ages of 18 and 22 years participated for course credit. Five participants were excluded from analyses because they scored below chance on the spatial-orientation test. The remaining 60 participants were randomly assigned to each condition (spatial or social).

Materials. The perspective-taking tests were the same as in the spatial condition of Experiment 1 (with no human figures), and the AQ was again administered. A questionnaire on gender differences (see Table 2) was added to assess participants' stereotypes regarding sex differences in spatial abilities and empathy. This served as a manipulation check that our instructions had primed the relevant stereotypes.

Procedure. Participants completed the two tasks individually or in groups of 2 to 8. Participants in each condition (spatial and social) received the same instructions as in the corresponding conditions of Experiment 1. All

Table 2. Scores on the Questionnaire Assessing Gender Stereotypes in Experiments 2 and 3

	Experiment 2		Experiment 3	
Question	Spatial condition	Social condition	Spatial condition	Social condition
Who is good at imagining something spatially?	−.57	.03	−.14	−.06
Who is more empathetic?	.50	.70	.72	.81
Who is good at solving perspective-taking tasks?	−.27	.37	−.28	.06
Who is good at navigation?	−.40	−.37	−.17	−.26
Who is good at mental rotation tasks?	−.57	−.10	−.14	−.06

Note: Participants answered each question on a continuum from "only males" to "only females." Scores ranged from −1 (males were considered to have more ability than females) to 1 (females were considered to have more ability than males), with 0 indicating that males and females were considered to have equal ability.

were given the original versions of the spatial-orientation test and road-map test, with the order of these tests counterbalanced across participants, followed by the AQ and the gender-differences questionnaire.

Results

On the spatial-orientation test, the degree of deviation from the correct direction (angular error) was not significantly different between the spatial and social conditions (see Fig. 3), although angular error was higher in the spatial condition (M = 46.01°, SD = 24.69, 95% CI = [36.79, 55.23]) than in the social condition (M = 36.78°, SD = 20.02, 95% CI = [29.31, 44.26]), between-subjects $t(58)$ = 1.59, p = .12. This result suggests that stereotype threat did not strongly influence female performance on this task.

In contrast, performance on the road-map test was significantly different in the spatial and social conditions (Fig. 4). Participants in the social condition (M = 10.20, SD = 3.26, 95% CI = [8.98, 11.42]) were more accurate than those in the spatial condition (M = 7.20, SD = 3.46, 95% CI = [5.91, 8.49]), between-subjects $t(58)$ = 3.46, p = .001, which suggests an influence of stereotype threat on performance in this task.

As shown in Table 1, the AQ was significantly correlated in both conditions with scores on the road-map test but not with scores on the spatial-orientation test. Chi-square tests of independence were run on ratings from the gender-differences questionnaire. These tests indicated that participants in the spatial condition agreed more with the statements that males are good at imagining things spatially, $\chi^2(1, N = 60) = 13.67$, $p < .001$, solving perspective-taking tests, $\chi^2(1, N = 60) = 12.51$, $p = .002$, and performing mental rotation, $\chi^2(1, N = 60) = 10.13$, $p = .006$, which indicates that we were successful in priming the stereotype of male superiority in spatial tasks. In contrast, effects of our manipulation were marginal with respect to gender differences in navigation, $\chi^2(1, N = 60) = 4.94$, $p = .08$, and not significant for empathy, $\chi^2(1, N = 60) = 1.95$, $p = .38$. Regardless of condition, participants held a strong stereotype for females as being more empathetic than males and for males as being good at navigation (see Table 2).

Discussion

Females were more accurate on the road-map test in the social condition than in the spatial condition; a similar trend for the spatial-orientation test was not statistically significant. A possible explanation of this discrepancy is that participants viewed the road-map test as more typical of a spatial task than a social task.

Experiment 3

To determine whether human figures in the displays alone can enhance the performance of females, we compared performance with and without human figures in Experiment 3 and gave only the standard instructions for the tests (i.e., no stereotype-threat manipulation).

Method

Participants. Sixty-seven females from the University of California, Santa Barbara between the ages of 18 and 22 years participated for course credit. Eight were excluded because they scored lower than chance on the spatial-orientation test. Participants were randomly assigned to conditions (30 to the social condition, 29 to the spatial condition).

Materials. The perspective-taking tasks were the same as in Experiment 1. Participants in the spatial condition completed the original version of the tasks, while those in the social condition completed the tasks that included human figures. Participants in both conditions were given the AQ and gender-differences questionnaire (see Tables 1 and 2).

Procedure. Participants were tested individually or in groups of 2 to 8. The procedure was the same as in Experiment 1, except that participants in both conditions were told before completing the tasks only that they would "complete two tasks that test your perspective-taking ability." No stereotype-threat manipulation was given. Participants in the spatial condition completed the original tasks, while participants in the social condition completed the revised tasks that included human figures.

Results

Accuracy on the spatial-orientation test differed between conditions (see Fig. 3). As predicted, participants in the social condition (M = 22.87°, SD = 19.26, 95% CI = [15.81, 29.93]) performed significantly better (i.e., with less angular error) than participants in the spatial condition (M = 48.45°, SD = 24.25, 95% CI = [39.22, 57.67]), between-subjects $t(58) = 4.54$, $p < .001$.

There was also a significant difference between conditions in performance on the road-map test, as shown in Figure 4. Again, participants in the social condition (M = 9.77, SD = 4.94, 95% CI = [7.96, 11.59]) performed better than those in the spatial condition (M = 6.69, SD = 2.48, 95% CI = [5.75, 7.63]), between-subjects $t(58) = 3.02$, $p = .004$.

There were no significant correlations between scores on the AQ and performance on either task (see Table 1); therefore, there was no evidence that social skills moderated the effects of including a human figure. Responses to the gender-differences questionnaire (Table 2) did not differ significantly between conditions. As in Experiment 2, participants held a strong stereotype that females are more empathetic than males and a weaker stereotype that males are better at navigation than females.

Discussion

Performance on both perspective-taking tests was significantly better in the social than in the spatial condition, which indicates that including human figures alone is sufficient to enhance the performance of females in perspective taking.

General Discussion

We examined the impact of social influences (i.e., stereotype threat and the presence of a human figure) on tests of spatial perspective taking. When these tests were administered as usual, they demonstrated a robust sex difference favoring males. When instructions were changed to frame the tests as measures of empathy, female performance was significantly better on the road-map test but not on the spatial-orientation test, which possibly reflects a difference in whether these tasks are viewed as typical spatial-ability tests. The precise mechanisms underlying these effects are beyond the scope of this study but might include anxiety (Steele, 1997), depletion of working memory resources by attempts to suppress negative stereotypes (Beilock, Rydell, & McConnell, 2007; Schmader & Johns, 2003), and increased motivation in the positive-stereotype conditions (Moè & Pazzaglia, 2006). Alternatively, framing the tasks as measures of empathy may engage automatic social processes.

Here, we framed the tests as measuring either social or spatial abilities and reminded participants of gender differences in these abilities. Consistent with previous studies of mental rotation of objects (McGlone & Aronson, 2006) and the self (Wraga et al., 2006), our results showed that such framing reduced sex differences. However, our framing manipulations differed from those used in mental-rotation studies, in which either gender identity was primed (McGlone & Aronson, 2006) or sex differences were misrepresented as favoring women (Wraga et al., 2006). Our results add to the literature on framing and sex differences in spatial abilities and indicate that sex differences can be reduced without inducing false stereotypes of female superiority that have no basis in fact. Our results may have been driven by the explicit stereotype prime alone or the framing instructions coupled with the activation of corresponding positive stereotypes (Dar-Nimrod & Heine, 2006; Wraga et al., 2006). A pilot study indicated that framing perspective-taking tasks as social was not sufficient to significantly improve female performance. It remains to be seen whether an explicit stereotype prime without framing instructions would be sufficient. In future research it will also be important to examine whether framing effects generalize to other spatial tasks with sex differences, such as the water-level task and other measures of perspective taking, including those that focus on the visual appearance rather than the spatial location of objects (Surtees, Apperly, & Samson, 2013).

When the tests were modified to include human figures, females performed significantly better, and as well as males. Observed individual differences in spatial perspective taking may therefore be a reflection of the context in which spatial ability is measured (i.e., tests without human figures). The presence of a human figure may cause strategy differences (Kaiser et al., 2008) centered around engagement of embodied or social brain systems (e.g., Frith & Frith, 2010; Kessler & Wang, 2012). For example, participants may rely on mental rotation in unmodified tests but mental simulation of the body on modified tests. The superior performance of women when a human figure is included in the test offers an interesting avenue for training women's perspective taking in situations in which the perspective to be imagined is specified more abstractly. For example, perspective taking could initially be trained in a social context with social supports that gradually fade. In future research, it will also be important to examine when sex differences in perspective taking emerge developmentally and whether social supports at an early age can be used to aid the development of this spatial-thinking skill.

Contrary to previous research (Shelton et al., 2011), our results showed limited and inconsistent support for the relationship of good social skills and spatial perspective taking. Both empathy and social skills are multidimensional constructs. More focused and objective measures of empathy or social skills may map onto spatial perspective taking better than general measures.

In summary, our research confirmed sex differences favoring males in two psychometric measures of spatial perspective taking: the spatial-orientation test and the road-map test. However, it also indicated that when social schemas are activated by the inclusion of a human figure, these sex differences disappear, which suggests that different abilities may be tapped in social contexts. Moreover, it indicates that observed sex differences in perspective taking reflect stereotype threat at least in part. Taken together, these results indicate that the way in which people measure spatial abilities may be underestimating female abilities—an important issue given the rise of interest in spatial skills as a predictor of STEM achievement (Humphreys et al., 1993). More generally, experimental and psychometric studies of perspective taking need to take account of social factors.

Action Editor

Alice O'Toole served as action editor for this article.

Author Contributions

All authors contributed to the study design. M. R. Tarampi and N. Heydari made the stimuli, N. Heydari collected the data, and all authors collaborated on the data analysis. M. R. Tarampi and N. Heydari drafted the manuscript, and M. Hegarty provided critical revisions. All authors approved the final version of the manuscript.

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Declaration of Conflicting Interests

The authors declared that they had no conflicts of interest with respect to their authorship or the publication of this article.

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Note

1. There were no significant effects of collective-testing condition (number of participants in the room) on test performance in any of the experiments, and our results did not change appreciably when this variable was entered as a covariate in the analyses.

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