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MEN ARE MORE ACCURATE THAN WOMEN IN AIMING AT TARGETS IN BOTH NEAR SPACE AND EXTRAPERSONAL SPACE[1]

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Summary.—Men excel at motor tasks requiring aiming accuracy whereas women excel at different tasks requiring fine motor skill. However, these tasks are confounded with proximity to the body, as fine motor tasks are performed proximally and aiming tasks are directed at distal targets. As such, it is not known whether the male advantage on tasks requiring aiming accuracy is because men have better aim or is better in the proximal domain in which the task is usually presented. 18 men (M age = 20.6 yr., SD = 3.0) and 20 women (M age = 18.7 yr., SD = 0.9) performed 2 tasks of extrapersonal aiming accuracy (> 2 m away), 2 tasks of aiming accuracy performed in near space (< 1 m from them), and a task of fine motor skill. Men outperformed women on both the extrapersonal aiming tasks, and women outperformed men on the task of fine motor skill. However, a male advantage was observed for one of the aiming tasks performed in near space, suggesting that the male advantage for aiming accuracy does not result from proximity.

Sex differences in performance can be observed in numerous motor tasks. For instance, men are more accurate than women at hitting targets (e.g., Jardine & Martin, 1983; Watson & Kimura, 1989; Watson & Kimura, 1991; Sykes, Tottenham, & Saucier, 2004). Conversely, women perform tasks of fine motor skill more quickly and accurately than men (e.g., Tiffin, 1968; Bornstein, 1985; Spreen & Strauss, 1991; Nicholson & Kimura, 1996).

Sex differences in aiming accuracy have been suggested to be associated with differential sports experience, although two lines of evidence suggest that this is not the case. First, the sex difference in aiming accuracy appears in 4-yr.-old children (Lunn & Kimura, 1989), presumably a time in which both sexes would have similar experience. Second, gay men have been less accurate at throwing a ball at a target than heterosexual men, although differential experience with sports did not significantly account for this difference (Hall & Kimura, 1995). Additionally, when sports history is partialled out, a large sex effect on aiming accuracy prevails (Watson & Kimura, 1991).

It has also been suggested that differences in size and masculinity can account for sex differences in motor skill (Peters, Servos, & Day, 1990).

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However, in the Lunn and Kimura study (1989), the children studied were of an age in which they were most likely to be the same size. Further, in the Hall and Kimura study (1995), heterosexual men were more accurate at hitting a target than both gay men and heterosexual women. The performance of gay men and heterosexual women was not significantly different, despite significant differences in size and muscularity of these two groups. Finally, there are numerous studies which show that finger size does not significantly affect fine motor skill (e.g., Hall & Kimura, 1995; Nicholson & Kimura, 1996).

However, one other difference between tasks of aiming accuracy and those of fine motor skills is where these tasks are performed. That is, tasks involving aiming accuracy require participants to hit targets that are distal to the body (extrapersonal space, >2 m from the body), whereas tasks of fine motor skill require participants to interact with items proximal to the body (near space, <1 m from the body). Thus, these sex differences in motor performance confound proximity with the type of skill (aiming accuracy vs fine motor movements). Numerous studies have suggested that the male advantage observed in aiming accuracy may result from proximity to the target (e.g., Watson & Kimura, 1991; Hall & Kimura, 1995); however, this has not previously been examined. Additionally, a PET study by Weiss, Marshall, Wunderlich, Tellman, Halligan, Freund, Zilles, and Fink (2000) showed that pointing tasks performed in near and far space activate different brain regions in men (women were not examined). However, it is not yet known whether there are sex differences in brain activation when pointing at near and far space. As such, it appears that proximity may be an important factor potentially mediating sex differences observed on motor tasks of aiming accuracy and fine motor skill.

The purpose of this study was to investigate how proximity to the target affects performance on tasks requiring aiming accuracy. Participants performed numerous tasks requiring aiming accuracy in near and extrapersonal space, as well as performing a test of fine motor skill, i.e., Purdue Pegboard. The test of fine motor skill was included to ensure that our sample was representative of the population, as indicated by a female advantage on this task. To test aiming accuracy in near space, one novel task requiring aiming accuracy was developed. It was hypothesized that, if proximity to the body predicts sex differences in motor skill, then a male advantage would be found for aiming tasks that occur in extrapersonal space, and a female advantage would be found for aiming tasks that occur in near space. Correlations were also examined to assess relatedness among the aiming tasks and the task measuring fine motor skill. It was expected that the extrapersonal projectile aiming task and laser aiming tasks performed in near and extrapersonal space would be significantly positively correlated with one another. However, as the computer-aiming task utilized skills and measures that were quite different from the other aiming tasks, we did not expect them to be correlated. The task of fine motor skill was not expected to be correlated with the aiming task.

Method

Participants

Eighteen men (*M* age = 20.6 yr., *SD* = 3.0) and 20 women (*M* age = 18.7 yr., *SD* = 0.9) were recruited from the participant pool in introductory psychology at the University of Saskatchewan. To keep the sample as congruent as possible, all participants were right-handed, as assessed by questionnaire (Elias, Bryden, & Bulman-Fleming, 1998). Participants were awarded one credit toward their research participation requirement.

Tasks and Procedure

All participants were tested individually by the same researcher. The testing session began by the participants providing informed consent, followed by the completion of a questionnaire containing questions regarding demographic information, computer experience (self-assessment, 7-point Likert-type scale), laterality, and throwing experience or any other experiences that might account for differential skill between the hands. Following completion of the questionnaire, all participants performed four tasks assessing aiming accuracy and one task of fine motor skill. All tasks were performed with both the right and left hands in a counterbalanced order. The order of the tasks was also counterbalanced among the participants.

Extrapersonal projectile aiming.—Participants performed an extrapersonal aiming task (as in Saucier & Kimura, 1998). Participants threw a Velcro-covered ball that was 4.2 cm in diameter at a carpet covered target that was 285 cm from where they stood. The target was a 6.5-cm × 6.5-cm square, located in the middle of a 145-cm × 145-cm carpet backdrop. The target was 147 cm above the floor.

Participants were required to throw the ball underhand at the target. Participants were given five practice trials, followed by 10 test trials for each hand. Each test trial was scored by measuring the distance between the ball and the closest edge of the target. The average of these distances was the participants' score for each hand.

Extrapersonal laser aiming.—Participants aimed a laser pointer at a target that was distant from them. Participants held the laser 230 cm from the target board. The centre of the target board was 158.5 cm above the floor. The target board was a 56-cm × 71-cm piece of cardboard with ten separate, randomly placed targets drawn on it. The targets were numbered circles, 4.2 cm in diameter.

Participants were required to aim the laser at the specified numbered target (as indicated by the researcher). Participants were instructed to 'aim, click, and release the button' on the laser pointer to keep each trial separate, instead of creating one continuous path. The laser point was only visible during the 'clicking of the button', so no online or offline correction during the trial was allowed. Participants were given 10 practice trials, followed by 10 test trials for each hand. Participants' performance on this task was recorded using a video camera. Each test trial was scored by measuring the distance between the place in which the laser first appeared and the closest edge of the target. The average of these distances was the participants' score for each hand.

Laser aiming in near space.—Participants aimed a laser pointer at a target that was close to them. To keep participants from holding the hand too close to the target, participants were required to rest the hand which held the laser pointer on a stand that was 88 cm from the target board. The centre of the target board was 138 cm above the floor. The target board was a 21.5-cm × 28-cm piece of cardboard with ten separate, randomly placed targets drawn on it. The targets were lettered circles, 1.6 cm in diameter.

Participants were required to aim the laser at the specified lettered target (as indicated by the researcher). Participants were instructed to 'aim, click, and release the button' on the laser pointer to keep each trial separate, instead of creating one continuous path. The laser point was only visible during the 'clicking of the button', so no online or offline correction during the trial was allowed. Participants were given 10 practice trials, followed by 10 test trials for each hand. Participants' performance on this task was recorded using a video camera. Each test trial was scored by measuring the distance between the place where the laser first appeared and the closest edge of the target. The average of these distances was the participants' score for each hand.

Computer aiming.—Participants performed a computerized aiming task in near space (also known as 'the multidirectional point-select task', described in International Organization for Standardization, 1998, 9241-9). A target was displayed on the computer screen (19-in. monitor; Pentium III computer, 450 MHz). Participants sat 60 cm away from the monitor. Participants were instructed to move the cursor to the target as quickly and accurately as possible and to click on it using a mouse. The computer screen displayed 24 circles 1.5 cm in diameter. These circles were arranged in a circle 14.5 cm in diameter. The target circle was a different colour than the others (green instead of white). Once the target circle was successfully selected, a different circle would become the target. If the target was not successfully selected, the participant would have to try to select it again until successfully completing the trial. Only one circle was the target at any one time, and the target selection alternated from side to side among the 24 circles until all 24 circles had been used as targets. Each test trial was scored using the average path length the cursor traveled between targets, the average number of errors, and the total time to complete the task, for each hand.

Purdue Pegboard.—The Purdue Pegboard was used as a test of fine motor skill, at which women typically score higher than men (Tiffin, 1968). Participants were required to pick up pegs one at a time from the cup in the board and then place them in holes in the board one at a time. This was done until all of the holes were filled. The time to complete the task was recorded. Each participant performed three trials: one with the right hand, one with the left hand, and one with both hands at the same time. Participants were scored on how quickly they could complete the task.

Results

Extrapersonal Projectile Aiming Task

A repeated-measures analysis of variance was performed for the extrapersonal projectile aiming task. For the analysis, the accuracy of participants' extrapersonal aiming was analyzed using sex (male, female) as the between-subjects measure and hand (right, left) as a within-subjects measure. The dependent measure was the average distance between the first 'hit' point and the closest edge of the target. Initially an analysis of covariance was run, using throwing experience as the covariate; however, this covariate was not significant, and so only the analyses of variance are reported. The reliability of this task was estimated by Cronbach alpha.

As predicted, the extrapersonal projectile aiming task exhibited a significant main effect of sex ($F_{1,36}=3.62$, $p=.03$, $\eta^2=0.09$), with men outperforming women (Table 1). There was also a significant main effect of hand used to aim ($F_{1,36}=19.12$, $p<.001$, $\eta^2=0.35$), with the right hand outperforming the left hand [right hand average deviation from center ($M=8.70$ cm, $SD=4.33$; left hand average deviation from centre $M=11.88$ cm, $SD=5.08$)]. For the extrapersonal projectile aiming task, the interaction between sex and hand was not significant ($F_{1,36}=0.50$, $p=.46$, $\eta^2=0.01$). The extrapersonal projectile aiming task was reliable ($\alpha=.75$).

TABLE 1
SIGNIFICANT MALE ADVANTAGE ON AIMING TASKS (CM) AND SIGNIFICANT FEMALE ADVANTAGE ON FINE MOTOR TASK (SEC.)

Task	*F*	*df*	*p* (1-tailed)	Men *M*	Men *SD*	Women *M*	Women *SD*
Extrapersonal Projectile*	3.62	1,36	.03	8.98	3.91	11.46 cm	4.09
Laser	11.19	1,36	.002	5.48	5.28	8.71 cm	6.43
Purdue Pegboard	19.98	1,36	.001	57.89	6.09	51.18 sec.	3.73

*On all tasks a high score indicates poorer performance than a low score.

Extrapersonal and Near Laser Aiming Tasks

A repeated-measures analysis of variance was performed to examine whether there was a sex or hand difference in participants' accuracy on either the near or extrapersonal laser aiming task and to investigate the association between these two tasks. For the analysis, the accuracy of participants' aiming was analyzed using proximity (near, extrapersonal) and hand (right, left) as a within-subject measures, and sex (male, female) as the between-subjects measure. The dependent measure was the average distance between the first 'hit' point and the closest edge of the target. Initially an analysis of covariance was run, using throwing experience as the covariate; however this covariate was not significant, so only the analyses of variance are reported. The reliability of this task was estimated with Cronbach alpha.

The laser aiming tasks exhibited a significant main effect of sex ($F_{1,36}$= 11.19, p=.002, η^2=0.24), with men outperforming women (Table 1). Not surprisingly the laser aiming tasks also exhibited a significant main effect of proximity ($F_{1,36}$=80.73, p<.001, η^2=0.69), with performance in near space being more accurate than performance in extrapersonal space (M=3.05 cm, SD=1.31; and M=11.31 cm, SD=6.21, respectively). The interaction between sex and proximity was also significant ($F_{1,36}$=6.30, p=.02, η^2=0.15; male near: M=2.55 cm, SD=0.83; male extrapersonal: M=8.42 cm, SD= 6.20; female near: M=3.51 cm, SD=1.51; female extrapersonal: M=13.92 cm, SD=5.06). *Post hoc* tests indicated a significant male advantage in both near and extrapersonal space, but the effect was greater in extrapersonal space ($F_{1,36}$=5.65, p=.02, η^2=0.14, and $F_{1,36}$=9.06, p=.005, η^2=0.20, respectively). There was no main effect for hand ($F_{1,36}$=1.22, p=.28, η^2=0.03). Further, there were no significant interactions for hand × sex, hand × proximity, and hand × proximity × sex ($F_{1,36}$=2.58, p=.12, η^2=0.07; $F_{1,36}$=0.31, p=.58, η^2=0.01; and $F_{1,36}$=2.49, p=.12, η^2=0.07, respectively). The near laser aiming task and the extrapersonal laser aiming task were reliable (α=.78 and α=.84, respectively).

Computer Aiming Task

Three repeated-measures analyses of variance were performed for the computer aiming task, analyzing time, missed targets and path length, respectively. For each analysis, the accuracy of the participants' aiming in near space was analyzed, using sex (male, female) as the between-subjects measure and hand (right, left) as a within-subject measure. The dependent measures were the average path length, average number of missed targets, and total time to complete the task. Initially analyses of covariance were run using computer experience as the covariate; however, this covariate was not significant for any of the analyses so only analyses of variance are reported. The reliability of these tasks was estimated by Cronbach alpha.

The computer aiming task exhibited a main effect of hand used to aim for the total time per target to complete the task ($F_{1,36}=269.35$, $p<.001$, $\eta^2=0.88$), with the right hand outperforming the left (right $M=22.54$ sec., $SD=2.29$; left $M=35.95$ sec., $SD=5.15$). There were no other significant effects for the average time per target. For the average number of missed targets, there was also a main effect of hand used to aim ($F_{1,36}=40.19$, $p<.001$, $\eta^2=0.53$), with the right hand outperforming the left hand (right $M=0.05$ errors, $SD=0.05$; left $M=0.12$ errors, $SD=0.08$). There were no other significant effects for the average number of missed targets.

For the average path length, there was also a main effect of hand used to aim ($F_{1,36}=147.15$, $p<.001$, $\eta^2=0.80$), with the right hand outperforming the left hand (right $M=434.06$ mm, $SD=40.86$; left $M=590.95$ mm, $SD=87.88$). However, there was also a significant interaction between hand used to aim and sex ($F_{1,36}=6.24$, $p=.02$, $\eta^2=0.15$) (male right: $M=444.89$ mm, $SD=47.89$; male left: $M=568.14$ mm, $SD=71.48$; female right: $M=424.3$ mm, $SD=31.43$; female left: $M=611.48$ mm, $SD=97.63$). *Post hoc* tests indicate that, although the right hand required significantly shorter path lengths ($p<.05$), women required shorter path lengths than men with the right hand but this difference was not significant ($p>.05$). This pattern was reversed for the left hand, as men required significantly shorter path lengths than did women ($p<.05$). There were no other significant effects observed for the computer aiming task. The computer aiming task was reliable for time per target ($\alpha=.81$) and path length ($\alpha=.79$). The computer aiming task was not reliable for missed targets ($\alpha=.36$), although there were so few missed targets (averaging <1 per person) that this measure may not be meaningful.

Purdue Pegboard

A repeated-measures analysis of variance was performed for the Purdue Pegboard, with the total time to complete the task as the dependent measure and sex (male, female) as the between-subjects independent measure and also hand used to place the pegs in the holes (right, left, both) as a within-subject independent measure. The reliability of this task was assessed by Cronbach alpha.

As predicted, the Purdue Pegboard exhibited a significant main effect of sex ($F_{1,36}=19.98$, $p<.001$, $\eta^2=0.36$), with women outperforming men (Table 1). There was also a significant main effect of hand used to place the pegs ($F_{1,36}=145.46$, $p<.001$, $\eta^2=0.80$), with the right hand outperforming the left hand and both hands (right $M=51.17$ sec., $SD=6.09$; left $M=57.54$ sec., $SD=6.78$; both $M=66.18$ sec., $SD=6.61$). The interaction between sex and hand was not significant ($F_{1,36}=0.07$, $p=.94$, $\eta^2=0.001$). Performance on the Purdue Pegboard of the left hand, right hand, and both hands combined was reliable ($\alpha=.85$).

Correlations Among the Aiming Tasks

A Pearson correlation was performed to estimate relatedness among the aiming tasks and the task of fine motor skill. Correlations among the extrapersonal projectile aiming task, the computer aiming task, the near and extrapersonal laser aiming tasks, and the Purdue Pegboard were examined. To reduce the number of comparisons made, the results of the right and left hand were averaged for each aiming task.

Significant positive values were found among the extrapersonal projectile aiming task and the near and extrapersonal laser aiming tasks (Table 2). As expected, performance on the computer aiming task and on the Purdue Pegboard did not correlate with performance on the other aiming tasks (Table 2).

TABLE 2
PEARSON INTERCORRELATIONS AMONG AIMING TASKS ($N = 38$)

Aiming Task	1	2	3	4	5
1. Extrapersonal Projectile		.45†	.30*	.06	–.08
2. Extrapersonal Laser			.29*	.06	–.23
3. Near Laser			.19	–.10	
4. Computer (path length)					–.21
5. Purdue Pegboard					

*$p < .05$, 1-tailed. †$p < .01$, 1-tailed.

Discussion

As predicted, men were more accurate than women on both extrapersonal aiming tasks. Men were also significantly more accurate at the near laser aiming task, and there was a simple main effect of sex favoring men on the computer aiming task (for left hand only). As expected, women performed significantly better than men on the Purdue Pegboard, indicating that our sample was comparable to others reported elsewhere. As expected, the near and extrapersonal laser aiming tasks and the extrapersonal projectile aiming task were significantly correlated, but the Purdue Pegboard and the computer aiming tasks were not. Collectively, the results suggest that the male advantage for aiming accuracy is not related to proximity to the body because the male advantage emerges in both extrapersonal and near space. However, the interaction between sex and proximity found on the near space and extrapersonal laser aiming tasks indicates that, although proximity mediates the sex difference (with near space showing a smaller effect than extrapersonal space), it does not negate it.

For the computer aiming task, there was only a simple main effect of sex for performance with the left hand (path length only), which may at first appear to be problematic. However, as the computer aiming task required the use of a mouse, it is likely the case that there was no simple main effect of sex for the right hand as most university students are highly skilled at using a mouse with the dominant hand. This position is further supported by the limited number of errors made by participants, which occurred, on average, less than one per trial. As sex differences are enhanced by difficulty (e.g., Collins & Kimura, 1997) and as completion of the computer aiming task was more difficult for the left hand than the right hand (as indicated by significantly worse performance with the left hand), it is likely that the sex difference on this task only emerged when difficulty was increased by having participants perform it with the left hand.

The significant correlations among the performance on the extrapersonal projectile aiming task and the near and extrapersonal laser aiming tasks indicate that there was high relatedness among the tasks, despite large differences in the way these tasks were performed. Specifically, the extrapersonal projectile aiming task required gross ballistic motor movements as well as fine motor movements, i.e., at the time of ball release, whereas the laser aiming tasks only required fine motor movements. As such, it does not appear that the male advantage on extrapersonal aiming tasks and the female advantage on tasks of fine motor skill in near space are dependent on either proximity to the task or the type of motor movement required. Rather it appears that the requirements of the tasks themselves mediate the sex differences observed on them: men are better at accurately aiming, whereas women are better at performing tasks of speeded fine motor skill, e.g., Purdue Pegboard.

The results of this study appear to indicate that the male advantage found in aiming accuracy is not simply due to proximity, as a male advantage was found on both near and extrapersonal aiming tasks. It appears that this male advantage can be found across different types of aiming tasks, requiring quite different motor movements. This study did not specify the basis for the male advantage noted on aiming tasks, but we did rule out the possibility that proximity is a confounding factor in this observed sex difference. Further research is required examining other factors that could potentially mediate the sex differences observed in aiming.

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