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SEX DIFFERENCES IN PERFORMANCE ON THREE NOVEL CONTINUOUS RESPONSE TASKS

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Summary.—The Dynavision apparatus was used to assess psychomotor differences between men and women first-time users. Subjects, 50 men and 76 women, were tested on three 60-sec. Dynavision response tasks of graded difficulty. An analysis of variance with repeated measures indicated that men performed significantly better than women on all tasks. Performances on all tasks were also significantly different from each other within both sexes (p ≤ .05). Furthermore, a significant interaction between sex and task was based on a greater drop in performance on the most complex task for women than for men.

Research suggests that males and females differ on various measures of psychomotor performance, from reaction time and movement time (6, 7, 8, 9, 13, 18, 19) to hand-eye coordination and motor proficiency (3, 15, 17, 21) and visual skills (5, 20). However, no study to date has investigated the differences between males and females on more complex Dynavision tasks combining several psychomotor abilities that form the cornerstones of athletic performance. The Dynavision is a new and unique psychomotor apparatus, which, unlike other measures of simple or choice response times that are usually discrete and one-dimensional, allows a continuous (60-sec.) measure of numerous variables simultaneously, including response time, peripheral vision, hand-eye coordination, and concentration.

The apparatus consists of a wall-mounted board housing 64 target buttons that illuminate one at a time during each trial. The basic task is to locate and strike the buttons as quickly as possible as they illuminate randomly on the board. After each successful hit, another button illuminates at another random location on the board. The apparatus records and displays a running score (number of hits) as well as the average time required to strike the buttons throughout the trial. A complete summary of results can also be printed. The main performance variable of the Dynavision apparatus is the number of successful responses (hits) a subject can achieve at tasks of varying complexity and duration, rather than reaction time per se. A larger number of hits reflects faster visuomotor responses and thus better performance. The major strength of the Dynavision is the diversity of visuomotor tasks it

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offers, as well as the simplicity of its design and use. However, research has yet to test the effects of sex on Dynavision performance.

The purpose of the present study was to assess sex differences in performance on novel continuous response tasks using the Dynavision apparatus. Based on previous literature, it was hypothesized that men would perform significantly better than women on three continuous Dynavision tasks of graded difficulty.

Method

Subjects

Second-year students (50 men and 76 women) from the Faculty of Physical Education and Health at the University of Toronto participated. The mean age was 20.6 yr. (SD = .96). All subjects were first-time users of the Dynavision apparatus.

Apparatus

The Dynavision is a multidimensional apparatus designed to test and train visuomotor response time and coordination, visual scanning, visual attention in focal and peripheral fields, as well as basic cognitive skills and concentration, within a broad visual training environment. The apparatus consists of a wall-mounted board (1.2 m × 1.2 m) housing 64 small (2 cm × 2 cm) buttons arranged in a pattern of five nested rings (see Fig. 1). The apparatus can be adjusted to accommodate users of different heights as well as seated users, e.g., in wheelchairs. It offers a variety of continuous hand-eye coordination and speed tasks over three standard time periods (30, 60, or 240 sec.). These tasks may be self-paced or apparatus-paced.

On the easier self-paced tasks, target buttons light up one at a time at random locations on the board and do not change location until struck successfully with the fingers or palm of the hand. A successful hit is indicated by an audible beep, at which point the light extinguishes and reappears at another random location on the board. In the more complex apparatus-paced tasks, target buttons also light up one at a time but remain lit only for preset times, e.g., 0.4, 0.5, 0.75, or 1.0 sec., before extinguishing and reappearing at another random location on the board. To record a successful hit in this case, subjects are required to strike an illuminated button before the light extinguishes.

All tasks are performed in low lighting to improve the visibility of the illuminated buttons. To emphasize peripheral visual attention, subjects are instructed to fix their eyes directly forward and to use their peripheral vision to locate target buttons. Any buttons that light up to the right and left of the centre of the board are to be hit with the right and left hands, respectively, while those that light up directly above or below the centre may be hit with either hand.
A light-emitting diode (LED) display near the centre of the board can also be set to display up to seven computer-selected digits for brief, preset exposures, e.g., 0.4, 0.5, 0.75, or 1.0 sec., at 5-sec. intervals. Task complexity can be increased even further by instructing subjects to call out or manipulate these digits, e.g., add or multiply the numbers. This also ensures that the subjects fix their gaze forward and optimize use of peripheral vision during the various tasks.

In one study the test-retest reliability of three Dynavision tasks of graded difficulty was high, with intraclass correlation coefficients ranging from .88 to .97, and paired correlation coefficients ranging from .74 to .92 (11).

Test Variables

The independent and dependent variables were task difficulty and number of successful hits, respectively. Subjects were tested on three Dynavision
tasks of graded difficulty: Simple, Moderate, and Complex. All tasks were 60 sec. in duration and used the full board. The Simple task was self-paced, while both the Moderate and Complex tasks were apparatus-paced. For both the Moderate and Complex tasks, subjects were instructed to read and call out random four-digit numbers displayed on the LED screen, in addition to striking illuminated target buttons. These numbers were displayed for 1 sec. at 5-sec. intervals (for a total of 12 four-digit numbers in 60 sec.). Target buttons remained illuminated for 1 sec. during the Moderate, apparatus-paced task, and the interval was reduced to 0.5 sec. for the Complex Task.

Procedure

Three weeks prior to testing, all subjects participated in a single orientation session consisting of several self-paced and apparatus-paced tasks. Following recommendations by Klavora, et al. (10, 11), the subjects were given instructions regarding optimal stance and distance from the board, button-striking technique, and the importance of focusing the eyes on the centre of the board and using peripheral vision. Although subjects adjusted their stance (distance between the feet) before each trial, they were instructed to stand the same distance away from the board to maintain a uniform size of peripheral field among subjects.

Prior to testing, all subjects completed a General Consent Form. Each subject then performed one 30-sec. self-paced trial run before beginning the three test runs. To ensure that all subjects were given uniform instruction, the same tape-recorded message was played for each subject before each test trial. The total number of successful hits was recorded for each trial.

Results

A $2 \times 3$ analysis of variance (Huynh-Feldt analysis of variance) with repeated measures was used to compare the number of successful hits between male and female subjects on each of the three tasks. Given uneven cell frequency, a Mauchly test of sphericity was calculated (.823). This allowed the adjustment of the $df$ in the tests of within-subjects effects. The analysis generated significant main effects for Sex ($F_{1,124} = 53.26, p < .001$) and Tasks ($F_{1,647.204} = 1564.08, p < .001$). There was also a significant interaction for Task x Sex ($F_{1,647.204} = 30.20, p < .001$). The Friedman repeated-measures analysis of variance on ranks indicated (1) on all three tasks men performed significantly better than women, (2) successful hits on the tasks were significantly different from each other ($p \leq .05$) for each sex, and (3) women exhibited a significantly greater drop in performance on the Complex task than men. Fig. 2 presents a summary of the means.
**DISCUSSION**

Examining sex differences and similarities in psychomotor performance is important in many practical settings. As more women seek and participate in more physically demanding careers (police work, fire-fighting, military, etc.) and are offered increased recreational opportunities in physical activity and sport, identifying sex differences in response to physical work and training is becoming an increasingly relevant issue (16).

Sex differences on various measures of psychomotor performance have been studied for decades. As this is the first study of its kind, it is difficult to compare our results directly to the results of cited studies involving reaction time, movement time, hand-eye coordination, spatial ability, etc. However, Dynavision performance appears to differentiate between men and women on its more complex psychomotor tasks. In comparison with the cited research, Dynavision tasks require dynamic and coordinated responses to randomly moving targets across a relatively large area. These responses require vigorous hand and arm movements over distances varying between 20 cm and 75 cm. All tasks are based on several basic psychomotor abilities (choice response time, hand-eye coordination) and visual skills (peripheral vision, depth perception), and require a considerable sustained concentra-
tion and physical endurance in arm movements. The moderate and complex tasks, during which randomly presented numbers must be called out, place additional stress and concentration demands on the subjects.

The results of the present study indicate that men respond faster than women, consistent with previous research (6, 7, 8, 9, 14, 18, 19). Saar, et al. (18) found that except for movement time values of the youngest subjects, males were significantly faster than females in both reaction time and movement time, and these sex differences became more pronounced across age groups. Although some studies have reported faster simple reaction times among female subjects compared to male subjects, males still exhibited faster overall response times (4, 6, 8, 9, 12).

The smallest sex difference was observed on the Simple task, whereas the largest sex difference occurred on the Complex task. One factor that may account for this significant disparity in performance between men and women is psychomotor endurance. The individual tasks themselves require some endurance to maintain concentration for the entire 60-sec. test period. Considering that the tasks were performed sequentially (with the Complex task performed last in the sequence of test trials) and with limited intervals of rest between trials, it is possible that female subjects experienced a more pronounced fatigue-related decrement in performance compared to their male counterparts. Further, the complexity of the final task may have compounded the apparent motor speed differences between the men and women. However, lack of published research on the effects of sex on psychomotor endurance means this explanation remains speculative.

In the present study, as well as in the study by Kauranen and Vanharanta (9), the women appeared to exercise more caution and use less aggressive movements when completing experimental tasks than the men; as a result, their performances on the various tasks were slower. A majority of the women in this study also tended to move their heads more often than the men to locate target buttons. Almost all men, on the other hand, maintained their gaze directly forward when performing the tasks and, therefore, used their peripheral vision more effectively. Taking this observation into account, as well as the finding that men performed significantly better on all three Dynavision tasks, it can be concluded that men demonstrated greater peripheral visual attention than women. This finding, however, does not support that of Williams and Thriner (20). It is possible that the sociocultural experiences of men in sport contributed significantly to the aforementioned findings. Men have traditionally been more inclined to pursue, and value, sport participation than women. As a result, women’s generally lower participation in sport may be a factor in their lower Dynavision scores.

The present results may also help to confirm a sex difference in muscle recruitment (1). The principle that amount and speed of accuracy is directly
proportional to the number and type of muscles recruited in a task may be a factor when considering the influence of target location (14). Since the Dynavision apparatus consists of target buttons at varying locations, it is likely that striking different target buttons recruits slightly different muscles. Because men performed significantly better than women on all three Dynavision tasks, a sex difference in muscle recruitment may exist.

Ransdell and Wells (16) refer to several morphological characteristics that contribute to a performance advantage for men in sports requiring high-intensity, short-duration movements. The authors note that on average men are approximately 10% taller and 25 pounds heavier than women. Furthermore, total cross-sectional area of muscle in women is about 60 to 85% of that in men. Consequently, the larger frame and muscle mass of men represent an advantage in strength and explosive power. The longer and more powerful arms and legs of men provide a greater driving and rotary force for explosive quality movements, which essentially result in faster motor speed and movement time.

Bell and Jacobs (2) have also reported a sex difference in electromechanical delay, the time interval between the contraction stimulus and the change in electrical activity of the muscle. Considering that electromechanical delay can significantly affect the rate of force development, it is possible that compared to men, women have a less rapid expression of power and are therefore slower in overcoming inertia. However, as in other areas of motor performance, research should be directed towards understanding why many women are slower than men on various psychomotor tasks.

Finally, the present study used the Dynavision to assess sex differences in psychomotor performance among Physical Education and Health students at a large university. It did not take into account subjects' involvement or participation in varied sports. Although the participation in sport and physical activity was relatively similar among the subjects (recreation and intramural), the sports and physical activities in which most men participated tended to be confrontational (football, hockey, rugby, wrestling, etc.) while those in which most women participated tended to be nonconfrontational (badminton, swimming, aerobics, etc.). This ultimately raises the question of whether particular sports or physical activities provide more opportunities for the development of various visual (such as peripheral awareness) and psychomotor skills. It is also worth noting that because the sample consisted of individuals who were probably more athletic than the norm, these women may have been less different from men than had the more average women been tested.

Considering the obvious disparity in Dynavision performance between men and women in activities involving complex psychomotor abilities, whether explained by biological, sociocultural, or other factors, women cannot be
expected to achieve performance equivalent to that of men on many tasks. This finding highlights the need to recognize and appreciate the differences in physical work and training responses between men and women to maximize performance for both sexes in all areas of life.

REFERENCES


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