

**Research Article****Sex Variation of Motion Stereotypic Response among Adult Bengalee Population for the Operation of Some Simple Control-Display Units**

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Gender.**ABSTRACT**

Population stereotype point out to a long-term habit and well embedded knowledge of a particular population. This study was carried out to evaluate the variation in index of reversibility, response preference and response initiation time among male and female subjects for some simple analog control-display units. A total of 999 subjects were responded, among them 591 were male and 408 were female (having the age range of 15-60 years). To conduct the study five types of analog displays viz., rotary control knob with horizontal display, rotary control knob with vertical display, and rotary control knob with circular display, horizontally aligned rocker switches and vertically aligned rocker switches for electric lights were fabricated. The subjects were asked to move the control to get the desired display and the response preference and response initiation time were noted as the results. The results showed that the best control-display unit was the rotary control-vertical display combination on the basis of index of reversibility for both sexes. Statistical analysis of the data showed that preferred response percentage or were significantly ($P < 0.05$ or less) different for both sexes in case of all the rotary control analog display operations but for rocker switch-electric light unit operation it was found that both group showed similar stereotypic strength and direction. Response initiation time also found to be significantly ($P < 0.001$) different, it was also found that higher preferred response percentage showed shorter response initiation time. It may be concluded that gender has a profound impact on motion stereotypic responses.

Introduction

Men are stereotyped as independent, and goal oriented while women are interdependent, communal, and oriented toward others [1, 2]. These stereotypes influenced important life outcomes such as job hiring and promotion [3-5], job performance evaluations [6, 7] and educational performance [8]. Cultural differences in independence-interdependence were evident in the fields such as communication [9], creativity [10], and even basic cognitive processing [11].

In an old study which was done around 1924 by Weber, he found that within the linen textile factory men are at an advantage on the wide machine while on the other hand, at the narrow machine it appears that female workers unquestionably are the best suited. In other kinds of work it was noted that men and women contribute similarly: On the machines for the narrow linen it seems that male and female work compete, to the extent that able female workers show at least the same

output as the able men. Sex differences are big, profoundly rooted and substantial. Men and women still have different natures, and, generally speaking, different preferences, talents and interests. These differences can be explained in part by hormones and other physiological and chemical distinctions between men and women. Thus they won't disappear unless we mess with our fundamental biological natures [12]. The issue of brain difference becomes increasingly important the more words a teacher uses to teach a lesson (that is, the less diagrammatic a teacher is). The male brain, on average, relies more heavily than does the female on spatial-mechanical stimulation and thus is inherently more stimulated by diagrams, pictures, and objects moving through space than by the monotony of words. If a teacher uses a lot of words, the male brain is more likely than the female to get bored, sleep and be restless [13]. Research suggests that boys and girls do learn differently. In the USA, scientists [14] argue that biological gender differences influence the way boys and girls learn. The two eminent authors [15] admit four sex differences

which appear to be universal, i.e. true for all cultures: Females have greater verbal ability but males excel in visuo-spatial and mathematical ability. According to McGuiness & Pribram [16] Males have greater muscular strength, and are more physically active than females but females excel in tasks requiring fine motor skills.

Stereotypes are conditioned reflexes which have turn into subconscious and 'automatic' [17]. Population stereotype is generally portrayed as the chance with which a response is preferred, while stimulus-response compatibility is illustrated by the rapidity and correctness with which a response is elicited [18]. Both the population stereotype and compatibility are vital considerations in human factors and engineering psychology. The thought of operational characterization and measurement for stereotypy was proposed by two scientists [19] in the year 1981. In a set of dichotomous responses, e.g., toggle up for on, down for off, a proportion of 0.5 indicates no preference and a proportion of 1 represents a perfect stereotype [20-23]. The majority proportion of responses ($\geq 50\%$) for a testing condition is a measure of the strength of stereotype [24]. A value of 50% indicates no choice preference while a value of 100% specifies a perfect stereotype.

Displays offer information about operational situation, and control devices enable operators to take required actions and change the state of a human-machine arrangement [25]. During operating a control user must expects a result that is the consequence of the control on the display. It is probable to guide operators to drive systems that do not go after the stereotypes but this will take a longer training time and the performance of the operators may turn down when positioned in an emergency state. An indirect relationship between control and display can create problems for the operator [26, 27]. Research on control and motion relationships has been ongoing for a long time mostly on Chinese and American population but there is a lack of studies on Indian population.

Reversibility of stereotypes is an important issue for designing of different control systems. In case of movement compatibility, reversibility is an expression which illustrate the state where, a person who rotate a control clockwise to increase the display value will also rotate the control anticlockwise to decrease the display value to the objective value [24]. Previous research on movement compatibility showed that a person's expectations are not always reversible. In the study of the operation of water taps, [28] used a quantitative measure, Index of Reversibility (IR); the IR was evaluated from the sum of two products. One product was derived from the proportion of anticlockwise responses for increasing the flow and the proportion of clockwise responses for decreasing the flow. The other product was derived from the proportions of the opposite pair of responses. The index ranges from a value of zero indicating absolute non-reversibility to a value of 1 for perfect reversibility, which occurs when the response to 'increasing the flow' is opposite to the response to 'decreasing the flow' [29]. Designers of man-

machine interfaces should use stereotypes with a reasonable degree of reversibility to diminish uncertainty and improve effectiveness and protection [29]. The recommendations on well-matched interface designs should result in more swift response times and less error. This is mostly relevant to the industry.

The present study was aimed to examine the similarities and differences in preferred response percentage of male and female subjects of Bengalee (Indian) population for operation of different combinations of control-displays units. Results were noted and analyzed. Percentage of response preference and response initiation time was compared for both the genders and efforts have also been made to study the reversibility of stereotype for all these configurations.

Materials and Methods

Site and Subjects

A cross sectional study was performed on a total of nine hundred ninety-nine (N=999) subjects from six different district viz. East Midnapore, West Midnapore, Purulia, Bankura, Howrah and Burdwan district of West Bengal state were responded for the study, 591 subjects were adult male and 408 were adult female. All the subjects were right handed and they used right hand to manipulate the control-display units. Ethical approval and prior permission was obtained from the Institutional Ethics Committee before commencement of the study. The study was performed in accordance with the ethical standards of the committee and with the Helsinki Declaration. Prior to the experimental trial, the subjects were approached during field visits and the protocol was explained verbally in local language (Bengali). Informed consent was also obtained from each participant during field visits.

Determination of control response stereotype

Simulation of control–display combination:

Different combinations of control and displays were simulated for performing the experiments. Some simple analog displays (vertical, horizontal and semicircular) with different controls (rotary switches and rocker switches) were set on wooden / Bakelite box separately for each combination of control and display. The following combinations were made:

Rotary motion switches and display combinations

The motion stereotype of the subject was studied by using a rotary switch and an analog display. Three systems were made for this purpose:

- (A) A rotary control knob and an analog display system in which an indicator moves in horizontal direction.
- (B) A rotary control knob and an analog display system in which an indicator moves in vertical direction.
- (C) A control knob and an analog display system in which an indicator moves in circular pattern.

The subjects were asked to operate the control knob to cause a movement of the indicator in a particular direction (left or right, and up or down). The subject's effort to rotate the control knob (either clockwise or counterclockwise) for desired movement of display indicator was recorded. In case of semicircular display, the subjects were asked to move the display pointer for increasing (or decreasing) the scale.

Operation of rocker switches for 'on' response:

Rocker switches were connected to the electric lights. The switches were aligned in two directions: (A) vertical (B) horizontal.

The subjects were asked to operate the switch to make the light on or off. They have to press the switch to make the lower end depressed or upper end depressed (while the other end will remain raised) in the first case and in the second case it is required to press the switch to make the right end depressed or left end depresses (while the other end will remain raised). The mode of operation of the subjects was recorded.

Index of reversibility

Reversibility of stereotypes is a great issue for designing of different control systems. In case of movement compatibility, reversibility is a phrase which describes the situation where, a subject who turns a control clockwise to increase the display value will also turn the control anticlockwise to decrease the display value to the target value [24]. Previous studies on movement compatibility confirm that an operator's expectations are not for all the time reversible. The index value ranges from a value of 0 which indicates absolute non-reversibility to a value of 1 for perfect reversibility, it will

occur when the response to 'increasing instruction' is opposite to the response to 'decreasing instruction' [24]. The index of reversibility (IR) was calculated with the help of the sum of two products. One product was obtained from the proportion of clockwise-for-increase (CI) and anticlockwise-for-decrease (AD) responses, and the other from the proportion of the opposite pair of anticlockwise-for-increase (AI) and clockwise-for-decrease (CD) responses [24].

$$IR = p (CI) p (AD) + p (CD) p (AI)$$

Here 'p' was the proportion (A proportion was a name we give to a statement that two ratios were equal.)

$$p (CI) = \frac{\text{sum of clockwise to increase (right) response}}{\text{total no. of subjects took part in the study}}$$

Likewise,

$$p (AD) = \frac{\text{sum of anti clockwise to decrease (left) response}}{\text{total no. of subjects took part in the study}}$$

$$p (CD) = \frac{\text{sum of clockwise to decrease (left) response}}{\text{total no. of subjects took part in the study}}$$

$$p (AI) = \frac{\text{sum of anti clockwise to increase (right) response}}{\text{total no. of subjects took part in the study}}$$

Response initiation time

The time between stimulus and the beginning of movement, was used as an index of the difficulty of information processing. Digital timer was used for recording response initiation time (RIT) for different combination of control and displays.

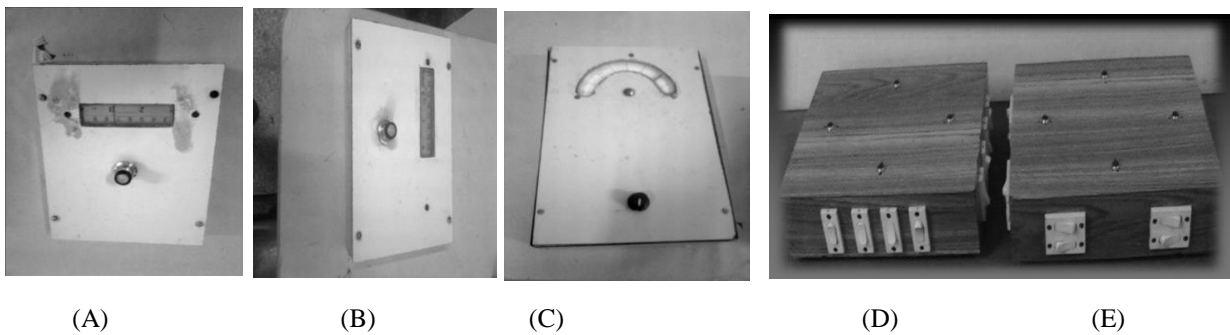


Fig 1: control- display units used in the study

Statistical analysis: Student's t test and Chi square test were performed by origin pro software and MS Excel respectively. Graph pad software was used to perform linear regression.

Results

Percentage of preferred responses for analog display operations

Table 1: Preferred response percentage of adult male and female subjects for different sets of rotary control and analog display units

Type of display and direction to the subjects	Responses in controlling				Chi square test (level of significance)
	Clock wise response (%)		Anti clock wise response (%)		
	Male subjects (n=591)	Female subjects (n=408)	Male subjects (n=591)	Female subjects (n=408)	
horizontal display (move to right)	77.66	68.87	22.34	31.13	P<0.01
horizontal display (move to left)	23.01	33.33	76.99	66.67	P<0.05
vertical display (move up)	85.62	97.30	14.38	2.70	P<0.001
vertical display (move down)	18.27	7.35	81.73	92.65	P<0.001
Semi circular display (move clock wise)	69.71	77.45	30.29	22.55	P<0.01
Semi circular display (move anticlockwise)	29.78	21.32	70.22	78.68	P<0.05

of female

Table 1 showed a comparison of preferred response percentage of male and female subjects during operation of rotary control analog displays. For the vertical display when the subjects were asked to move the indicator upward, 85.62% of males and 97.30% of females operated the rotary switch in clockwise direction but when they were asked to move the indicator downward, 81.73% of male and 92.65% of female subjects moved the rotary switch in anti clockwise direction. In both cases direction of motion stereotype were found to be similar but stereotypic strength were significantly (P<0.001) different among male and female subjects.

In case of the circular display when the subjects were asked to move the indicator towards right, 69.71% of male and 77.45 %

subjects moved the rotary switch in clockwise direction but for the opposite direction 70.22% of male and 78.68% of female subjects operated the rotary switch in anti clockwise direction. Here is also found that direction of motion stereotype among the both group were not changed but the strength of stereotype was significantly (p<0.05 or less) different among the groups. Table 2 portrayed the percentage of responses (left/right and up /down) of male and female subjects regarding rocker switch operation when the subjects were asked to put the light 'on' by means of horizontally aligned rocker switch, 74.62% of male and 74.26% of female subjects pressed the switches towards the right side while in case of vertically aligned switches 64.97% of male and 62.00% of female subjects pressed the switch downward. For both cases direction and strength of motion stereotype were same.

Table 2: Directional motion stereotypes of adult male and female subjects for different sets of rocker switch

Type of display and instructions to the subjects	Responses in controlling				Chi square test (level of significance)
	Left/Down%		Right/Up%		
	Male subjects (n=591)	Female subjects (n=408)	Male subjects (n=591)	Female subjects (n=408)	
horizontal rocker switch (on)	25.38	25.74	74.62	74.26	NS
vertical rocker switch (on)	64.97	62.00	35.03	38.00	NS

Major direction of motion stereotypes found in the study

Table 3 illustrated the major direction of motion stereotype which were clockwise to right (CR) and anticlockwise to left (AL) stereotype for the horizontal display-rotary switch where as strong clockwise to clockwise (CC), anticlockwise to

anticlockwise (AA) stereotype for semi circular display-rotary switch. Clockwise to up (CU) and anticlockwise to down (AD) stereotype were found to be strong in vertical display-rotary switch. Right to ‘on’ (RO) and down to ‘on’ (DO) stereotypes were found to be strong for rocker switch-electric light operation.

Table 3: Major direction of motion stereotypes found for all control-display units tested in this study

Control-display configurations	Direction of motion stereotype
Rotary control –horizontal display	CR, AL
Rotary control –vertical display	CU, AD
Rotary control –semi circular display	CC, AA
horizontal rocker switch	RO, LO
vertical rocker switch	DO,UO

Index of reversibility

Table 4: Comparison of index of reversibility (IR) found for rotary control analog display units of male and female subjects

Control-display configurations	Indexes of reversibility (IR) for Male	Indexes of reversibility (IR) for female
Rotary control –horizontal display	0.649	0.563
Rotary control –vertical display	0.726	0.903
Rotary control –semi circular display	0.580	0.657

The indexes of reversibility (IR) for all the configurations were calculated. Table 4 depicted a comparison of the index of

reversibility (IR) obtained with all the control-display configurations studied. The results showed that the strongest IR was found for the rotary control-vertical display combination for both the gender.

Response Initiation Time (RIT)

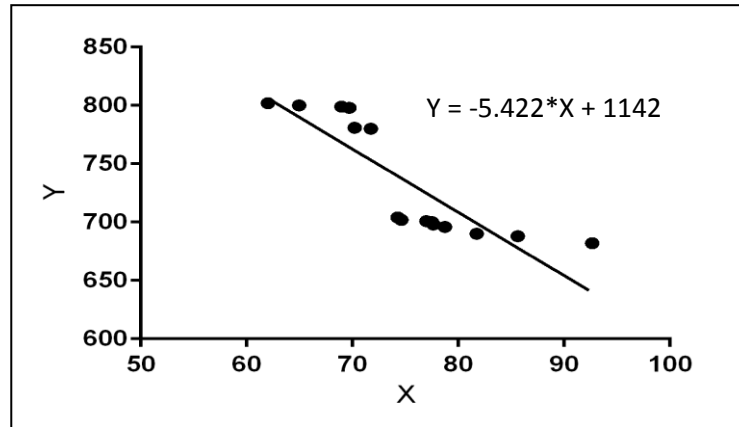


Fig 2: Average response time vs. preferred response percentage

Table 5 showed the mean response initiation time of male and female subjects which was found to be significantly ($p < 0.001$) different. Male subjects showed shorter mean response initiation time than the female subject.

Table 6 represented that this experiment on rotary control-display and rocker switch-electric right configurations, the average response times calculated with a digital timer was 731.31 ms and a standard deviation of 50.39 ms. The regression analysis for the preferred response percentage (p) showed that the higher the preferred response percentage, the lesser the mean response time (Fig. 2) and the expression relating response time and preferred response percentage is: Response initiation time (ms) = $1142 - 5.422 * p$ ($r^2 = 0.724$, $p < 0.0001$).

Table 5: Comparison of mean response initiation time (ms) of male and female subjects for all control- display unit operation

Mean Response initiation time (ms) of male subjects	Mean Response initiation time (ms) of female subjects
704.5±23.387	802.9±12.301*

* With respect to male subjects $P < 0.001$

As predicted from the equation, the mean response initiation time ranges from 599.8 ms ($p = 100\%$) to 870.9 ms ($p = 50\%$). The regression equation shows that a significant decrease in

response time could be accomplished if there is a high level of compatibility built between the control and display units.

Table 6: result of regression analysis (by graph pad software): preferred response percentage (p) vs. response initiation time (RIT) for all the control-display units

Best-fit values	
Slope	-5.422 ± 0.9285
Y-intercept	1142 ± 70.14
X-intercept	210.7
1/Slope	-0.1844
95% Confidence Intervals	
Slope	-7.428 to -3.416
Y-intercept	990.7 to 1294
X-intercept	174.0 to 290.3
Goodness of Fit	
R square	0.7240
S_{y,x}	27.37
F and P value	
F	34.10
P Value	< 0.0001
Deviation from horizontal	Significant
Mean response initiation time ± SD (ms)	731.31 ± 50.39
Equation	
	$Y = -5.422 * X + 1142$

Discussion

From this study it was found that the stereotypic responses of both male and female were in same direction but stereotypic strength or preferred response percentage were found to be significantly ($p < 0.05$ or less) different for rotary control analog display operations. This difference of preferred response percentage could be supported by the following facts that sex differences are deeply rooted and significant [12]. Men and women have different natures and different preferences which can be explained by hormones and other physiological and chemical peculiarities between genders. The male brain, in a gross, depends a lot on spatial-mechanical stimulation than the female brain does [13], biological gender differences also influence the way boys and girls learn [14]. Males even have greater mathematical ability than females [15]. Males have greater muscular strength and they are physically more active than females but females do extremely well in tasks requiring fine motor skills [16]. These all examples are rooted to the cognitive level as the motion stereotypic response which needs hand-eye-brain collaboration for the operation of machines.

In case of rocker switch operation there was no significant difference found between the stereotypic responses of male

and female subjects. This might be due to the fact that this type of switch is frequently used domestically so there must a factor of long term practice which may leads to similar preference among male and female subjects besides this factor numerous factors can affect the information-gathering and decision-making processes of operators, like contents of the provided information, the way information is provided, and the knowledge of the operators [25]. Response preferences also exists, these preferences are found under certain conditions, and vary with different factors [30].

It was found in this study that strong clockwise to right (CR) and anticlockwise to left (AL) stereotype were found for the horizontal display-rotary switch where as strong clockwise to clockwise (CC), anticlockwise to anticlockwise (AA) stereotype were found in semi circular display rotary switch. These findings were matched well with the findings of Chan and Chan [24]. Clockwise to up (CU) and anticlockwise to down (AD) stereotype were found to be strong in vertical display- rotary switch. This observation varies from the results of Chan and Chan [24]. Right to 'on' (RO) and down to 'on' (DO) stereotypes were found to be strong for rocker switch-electric light operation, this particular type of units were not tested in any previous study.

In consideration of the index of reversibility, the compatibility of rotary control-vertical display combination was the best for both the sex. This result differs from the findings of Chan and Chan [24] where rotary control- circular display combination was reported to be the best configuration. This difference might be due to the difference in population (Chan and Chan worked on Hong Kong Chinese population). In a study of motion stereotypes for moving a signal in a specified direction for different control - display units, the Chinese students showed stereotypes which differs from U.S. students [21], so it can be said that IR may vary population to population.

It was found that mean response initiation time of the females were found to be significantly ($p < 0.001$) longer than the males for operation of all the control display units. This finding corroborated the findings of the other studies where it was concluded that in most of the age groups, males have faster reaction times than females, and this female disadvantage is not reduced by practice [31]. The other finding regarding response initiation time from this study was that the higher the preferred response percentage, the lesser the mean response initiation time. The same finding was reported by Chan and Chan [24] who worked on the Hong Kong Chinese population, so it can be said that negative correlation between response initiation time and preferred response percentage is not dependent on population type.

Conclusion

From this study it can be concluded that gender has a profound impact on the different aspects of motion stereotype, i.e., response preference, and response initiation time. In consideration of the index of reversibility, the compatibility of rotary control-vertical display combination was found to be the best for both sexes. The negative correlation coefficients found for the mean response initiation time and preferred response percentage showed that males and females in general needed to do less mind work in a compatible setup.

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