Results

6.1 General demographic profile of the Bengali population:

General demographic profile of the adults: The Mean and SD of the height, weight and BMI values of the adult subjects has been shown in **Table 6.1A**. It showed that the Mean height, weight and BMI of the adult urban male were significantly (P<0.001) higher than that of the rural male. The mean weight of urban female is found to be significantly (P<0.01) higher than that of the rural female, but in case of mean Height and BMI there were no significant difference was found between rural and urban females. There was significant difference (P<0.01 or less) among adult male and female for height, weight and BMI.

Table 6.1 A: Height, weight and BMI of the Adult subjects in terms of Mean ± SD

Parameters	Adult (n=5228)			
	Male (n=2600)		Female (n=2628)	
	Rural (n=1300)	Urban (n=1300)	Rural (n=1314)	Urban (n=1314)
Height (cm)	161.41±11.23	167.23±11.12***	153.21±12.43***	154.21±11.55$$$
Weight (kg)	63.24±13.54	67.22±12.33***	48.54±13.24***	50.12±15.34##$$$
BMI(kg/m^2)	19.12±9.42	24.01±12.33***	20.21±15.13*	21.01±14.12$$$

*P<0.05 w.r.t rural male, ** P<0.01 w.r.t rural male, ***P<0.001 w.r.t rural male, ##P<0.01w.r.t rural female, $$$P<0.001 w.r.t urban male

General demographic profile of the children: The Mean and SD of the height, weight and BMI values of the children subjects has been shown in **Table 6.1 B**. It showed that the mean weight of the urban male children were significantly (P<0.05) higher than the rural male. Same finding was recorded for female children. There was a tendency of higher mean values between rural and urban females for height, weight and BMI. Same trend was found in rural and urban males also. There was no significant difference between male and female children for height, weight and BMI.

Table 6.1 B: Height, weight and BMI of the children subjects in terms of Mean ± SD

Parameters	Children (n=500)			
	Male		Female	
	Rural (n=125)	Urban (n=125)	Rural (n=125)	Urban (n=125)
Height (cm)	124.25±23.43	127.22±24.42	123.45±15.93	124.22±25.33
Weight (kg)	23.25±32.64	32.33±33.22*	22.65±16.32	28.33±24.73#
BMI(kg/m^2)	14.46±25.22	18.32±24.45	15.42±23.23	18.11±24.63

* $p<0.05$ w.r.t rural male, #$p<0.05$ w.r.t rural female

Discussion: Body composition is an important indicator of health status in children and adults (Norgan, 1990; Immink et al, 1992; Rolland-Cachera, 1995; Hills & Byrne, 1998; Malina et al, 1998; Bunc, 2001; Deurenberg et al, 2003). BMI is a quite dependable indicator of obesity for the majority people. BMI is viewed simply as a way to indicate approximate Body Fat % (Seidell and Flegal, 1997). This indicator practically does not assess body fat directly, although research has revealed that BMI correlates to the direct measurements of body fat, like underwater weighing and DXA (Mei et al, 2002, Garrow and Webster, 1985). So, BMI can be considered as a low-cost and easy-to-perform alternative for direct measurements of body fat which that may lead to health related troubles.

According to WHO (2000) classification of BMI, the average BMI of the male and female subjects (rural and urban) volunteered in the present study were in normal range. The children took part in the study as subjects also in normal BMI range (5th to 85th Percentile) according to Center for Disease Control and Prevention (2009). In the present study the gender difference in BMI was found for the adult rural and urban subjects, this finding was corroborated with the findings of recent studies by Vijayalakshmi and colleagues (2017), Kaun and colleagues (2011) and Aslam and associates (2010). The present study showed significantly higher mean height and weight of adult male than that of the female (both rural and urban), this finding was also matched well with the finding of Aslam and colleagues (2010). Taylor and associates (1997) also suggested the same fact that adult men were taller and heavier than adult women. There was no significant difference found among male and female children for height, weight and BMI. This finding was in conformity with the findings of some other studies (Forbes, 1987 and Kelly et al, 1992) which concluded that prepubertally, sexual dimorphism in body composition was considered insignificant and before the puberty boys and girls had approximately same average body heights and weights.

The present study showed that in case of adult subjects there were significant rural-urban variations in case of height, weight and BMI. This is might be due to the fact that significant changes were taking place in the urban-rural conditions and it significantly influenced the biological alteration of the populations. Living in areas differentiated by population size can be associated with differences in eating practice, sport amenities, hygiene and health services and prospects for physical exercises (Tsimeas et al, 2005). The present study showed that the urban children had significantly higher body weight than the rural children (both male and female). This variation in weight might be due to the fact that children's growth was inhibited when they did not get proper amount of nutrition or lost it through illness, both of these situations happened due to unfavorable societal, ecological, dietary and public health service elements (Black et al, 2013; UNICEF, 1990; Scrimshaw and SanGiovanni, 1997). At the domestic level, living in urban area promoted children nutrition appeared to be partially related with improved financial condition and higher education of mothers in urban than in rural families (Garrett and Ruel, 1999). Community-level elements were also significant which included hygiene, the amount, types, and cost of accessible foodstuff; and physical and monetary right of entry to the medical support and the quality of the same (Rutherford, 2010) but there were many studies which had reported conflicting proofs in samples from different countries and cultures and with a variety of age ranges. Bielicki (1986) and Eiben and associates (2005) concluded that within a specific country or cultural settings in Europe, children from urban areas had bigger body size than children from rural areas, but there were no significant differences found in the physical growth in children who were from urban and rural settlements in United States and Canada (Malina et. al., 1981; Eveleth and Tanner, 1990; Pena Reyes et. al., 2003). Lin and associates (1992) concluded the same for China's children in urban-rural conditions. Database from Africa, also exposed that urban-rural variations are obvious in the growth and body size (Cameron et al, 1992; Pawloski, 2002) of the population but Vyas et al. (2012) reported in their study that the urban and rural boys of Gandhi Nagar did not exhibit significant differences in their body composition. Singh et al. (2017) suggested that place (urban or rural) of residence has impact on the anthropometric characteristics like, height and weight among the children. Monyeki and colleagues (2005) also found rural-urban variation in body composition of South African school children. This body weight difference occurs may be due to both social selection and social causation mechanisms (Jokela et. al., 2009). The demographic opus of rural and urban populations clarified major, but not all the rural-urban dissimilarities in weight (Jeffery et al., 1996). The connection between urban dwelling and fatness in LMICs (Low-middle income countries) is determined mostly by higher Socio Economic Status in urban areas (both individual and community level), which put forward the fact that urban abode only may not the reason of greater body weight in developing countries like India. Dwelling in rural or urban surroundings did not influence the rate of fatness but the paternal obesity was a significant forecaster of obesity in offspring and besides that, obese parents had a tendency to dish up high calorie food to their children (de Morais Macieira et. al., 2017). So basically there may be or may not be some rural-urban variation in body composition. This variation may be depended on the population type (based on country or culture) and some other factors.

6.2 Motion Stereotype of Bengali population for operating some control-display units:

In the present study different types of control-display units have been used for determining motion stereotype of the Bengali (Indian) population. The results of the experimental study have been presented in the following paragraphs.

Table 6.2 A represented the motion stereotype (% of respondents) for Rotary control-Analog display operation of all the adult subjects. It was noted that “clockwise to right", “anticlockwise to left”, “clockwise to up”, “anticlockwise to down”, “clockwise to clockwise”, “anticlockwise to anticlockwise”, “clockwise to increase” and “anticlockwise to decrease” direction of motions were dominant. Strongest stereotype was found for semicircular display-rotary switch operation and weakest stereotype was noted for Horizontal Display-rotary switch operation.

Table 6.2 A: Motion stereotype (% of respondents) for Rotary control-Analog display operation of all the adult subjects

Type of Display and Instruction to the subjects	Adult (n=5228)	
	Direction of motion	
	Clockwise (%)	Anti-clockwise (%)
Horizontal Display-rotary switch (Move to Right)	75.78	24.22
Horizontal Display- rotary switch (Move to Left)	26.59	73.41
Vertical Display-rotary switch (move to up)	73.43	26.57
Vertical Display-rotary switch (move to down)	19.78	80.22
Semi Circular Display-rotary switch (move clockwise)	80.60	19.40
Semi Circular Display-rotary switch (move anti clockwise)	21.92	78.08
intensity testing display-rotary switch (increase)	78.27	21.73
intensity testing display- rotary switch (decrease)	21.44	78.56

Motion stereotype (% of respondents) for rocker switch-electric light unit operation of all the adult subjects were represented by Table 6.2 B. It was noted that “right to on”, “left to off”, “down to on” and “up to off” were the dominant motion stereotypes. Vertical rocker switch-electric light showed the strongest stereotype among the subjects while horizontal rocker switch-electric light unit showed the poorest stereotype among the Bengali (Indian) population.

Table 6.2 B: Motion stereotype (% of respondents) for rocker switch-electric light unit operation of all the adult subjects

Type of control display unit and instruction to the subjects	**Adult (n=5228)**	
	Direction of motion	**Response (%)**
Horizontal rocker Switch-electric light (on)	Right	70.77
	Left	29.23
Horizontal rocker Switch-electric light (off)	Right	41.18
	Left	58.82
Vertical rocker Switch-electric light (on)	Up	17.21
	Down	82.79
Vertical rocker Switch-electric light (off)	Up	84.83
	Down	15.17

Table 6.2 C depicted the motion stereotype (% of respondents) for rocker switch-electric light unit operation of all the adult subjects. It was noted that “clockwise to increase”, “anticlockwise to decrease”, “right to increase”, “left to decrease”, “up to increase” and “down to decrease” stereotypes were dominant.

Motion stereotype (% of respondents) for digital display operation of the adult subjects was depicted by Table 6.2 C. It was noted that “clockwise to increase”, “anticlockwise to decrease”, “right to increase”, “left to decrease”, “up to increase” and “down to decrease” motion stereotypes were prominent among the studied population. Digital display- vertically sliding switch showed the strongest stereotype and digital-display rotary switch interface showed the weakest stereotype strength among the Bengali (Indian) population.

Table 6.2 C: Motion stereotype (% of respondents) for digital display operation of the adult subjects (n=4887)

Type of control-display and instruction to the subjects	Direction of motion	Response (%)
Digital Display- Rotary switch (increase the number)	Clockwise	79.23
	Anti-Clockwise	20.77
Digital Display- Rotary switch (decrease the number)	Clockwise	28.22
	Anti-Clockwise	71.78
Digital Display- Horizontally sliding switch (increase the number)	Move to Right	76.47
	Move to Left	23.53
Digital Display- Horizontally sliding switch (decrease the number)	Move to Right	26.74
	Move to Left	73.26
Digital Display- Vertically sliding switch (increase the number)	Move to Up	82.46
	Move to Down	17.54
Digital Display- Vertically sliding switch (decrease the number)	Move to Up	15.69
	Move to Down	84.31

Table 6.2 D depicted the Index of reversibility (IR) of all the control-display units for adults. It was found that among the analog displays vertical rocker switch- electric light display showed highest IR and horizontal rocker switch-electric light display showed lowest IR. In case of digital displays Digital display-vertically sliding switch showed best IR value while Digital display-horizontally sliding switch showed poorest IR value. IR value represented the compatibility among the user and the interface.

Table 6.2 D: Index of reversibility (IR) of all the control-display units for adults

Control-display configurations	**Index of reversibility (IR)**
	Adult
Rotary control –horizontal display	0.621
Rotary control –vertical display	0.642
Rotary control –semi circular display	0.672
Rotary control- intensity testing display	0.661
horizontal rocker switch-electric light display	0.537
vertical rocker switch- electric light display	0.728
Rotary control –digital display	0.627
Digital display-horizontally sliding switch	0.623
Digital display-vertically sliding switch	0.723

Mean response initiation time (ms) of adult for operation of all the control display units were represented by **Table 6.2 E**. It was noted that digital display operation took longer significantly (P<0.001) longer response initiation time than that of the analog display.

Table 6.2 E: Mean response initiation time (ms) of adult for operation of all the control display units

Display type	**Mean response initiation time (ms)**
Analog	769.53±45.39
Digital	871.37±52.95***

***P<0.001

Gender variation in motion stereotype: Comparison of the motion stereotypic response (expressed in term of % of respondents) for all the combinations of Rotary control-Analog display operation between the studied adult male (n=2600) and female (n=2628) has been presented in the Table 6.2 F. The results showed that no variation was noted in the direction of motion stereotype between the adult male and female subjects however the strength of stereotype were found to be significantly (P<0.05 or less) different between them except for the response of the operation of vertical display (for move to down instruction). It was also noted that in most of the cases adult male subjects showed higher motion stereotype strength than their female counterpart.

Table 6.2 F: Comparison of motion stereotype (% of respondents) for Rotary control-Analog display operation between adult male and female subjects

Type of Display and Instruction to the subjects	Adult (n=5228)			
	Male (2600)		Female (n=2628)	
	Clockwise (%)	Anti-clockwise (%)	Clockwise (%)	Anti-clockwise (%)
Horizontal Display-rotary switch (Move to Right)	80.23	19.77	71.35***	28.65
Horizontal Display-rotary switch (Move to Left)	22.54	77.46	30.59	69.41***
Vertical Display-rotary switch (move to up)	76.35	23.65	70.55***	29.45
Vertical Display-rotary switch (move to down)	21.35	78.65	18.23	81.77
Semi Circular Display-rotary switch (move clockwise)	82.65	17.35	78.58***	21.42
Semi Circular Display-rotary switch (move anti clockwise)	16.42	83.58	27.36	72.64***
Intensity testing display-rotary switch (increase)	80.23	19.77	76.33**	23.67
Intensity testing display-rotary switch (decrease)	24.69	75.31	18.23	81.77*

*** $p<0.001$, ** $p<0.01$, * $p<0.05$ w.r.t adult male

In rocker switch there is only on / off operation. Comparison of the motion stereotype (% of respondents) for the operation of rocker switch-electric light unit between the studied adult male and female were represented in Table 6.2 G. It was noted that no difference was found between the direction of motion stereotype between adult male and female subjects but the strength of stereotype was found to be significantly (P<0.01 or less) different for each rocker switch-electric light unit operation. It was found that in most of the cases adult female showed higher stereotype strength than the male subjects.

Table 6.2 G: Comparison of motion stereotype (%) for rocker switch-electric light unit operation among between the adult (n=2600) male and female (n=2628) subjects

Type of control display unit and instruction to the subjects	Adult (n=5228)		
	Response (%)	**Male (n=2600)**	**Female (n=2628)**
Horizontal rocker Switch-electric light (on)	Right	67.31	74.20***
	Left	32.69	25.80
Horizontal rocker Switch-electric light (off)	Right	34.62	47.68
	Left	65.38	52.32***
Vertical rocker Switch-electric light (on)	Up	21.81	14.35
	Down	78.19	85.65**
Vertical rocker Switch-electric light (off)	Up	82.30	87.33***
	Down	17.70	12.67

*** p<0.001, ** p<0.01, * p<0.05 w.r.t adult male

Comparison of Index of reversibility (IR) for all the control-display units between adult male and female were presented in the **Table 6.2 H**. On the basis of calculated index of reversibility it was noted that for adult male the highest IR was found for Rotary control-semi circular display. In case of adult female, highest IR was found for vertical rocker switch-electric light display. Lowest IR was found for horizontal rocker switch-electric light display for both sexes. It was also noted that there were up to 13.35% difference found between the IR values of adult male and female. It was revealed that the magnitude of IR among the male subjects was greater than that of the female subjects by about 2.12% to 13.35% in different configurations of analog controls and displays.

Table 6.2 H: comparison of Index of reversibility (IR) between the adult male and female for all analog display tested in the study

Control-display configurations	Index of reversibility (IR)		% difference of IR between adult male and female
	Adult		
	Male	**Female**	
Rotary control –horizontal display	0.666	0.583	13.29 %
Rotary control –vertical display	0.651	0.631	3.12%
Rotary control –semi circular display	0.719	0.629	13.35%
Rotary control-intensity testing display	0.653	0.667	2.12%
horizontal rocker switch-electric light display	0.553	0.511	7.89%
vertical rocker switch- electric light display	0.682	0.766	11.62%

The results Comparison of motion stereotype for the operation of rotary switch-digital display unit of the adult male and female have been shown in Table 6.2 I. It was noted that no difference was found in the direction of motion stereotype between adult male and female subjects but the strength of stereotype was found to be significantly (P<0.05 or less) different except digital display- vertically sliding switch operation for decreasing the number.

Table 6.2 I: Comparison of motion stereotype (%) for digital display operation between the adult male and female

Type of control-display and instruction to the subjects	**Response (%)**	**Adult (n=4887)**	
		Male (n=2447)	**Female (n=2440)**
Digital Display- Rotary switch (increase the number)	Clockwise	82.22	76.23***
	Anti-Clockwise	17.78	23.77
Digital Display- Rotary switch (decrease the number)	Clockwise	23.70	32.75
	Anti-Clockwise	76.30	67.25***
Digital Display- Horizontally sliding switch (increase the number)	Move to Right	72.33	80.61***
	Move to Left	27.67	19.39
Digital Display- Horizontally sliding switch (decrease the number)	Move to Right	29.79	23.69
	Move to Left	70.21	76.32*
Digital Display- Vertically sliding switch (increase the number)	Move to Up	80.30	84.63***
	Move to Down	19.70	15.37
Digital Display- Vertically sliding switch (decrease the number)	Move to Up	17.70	13.69
	Move to Down	82.30	86.31

*P<0.05, **P<0.01, ***P<0.001 with respect to adult male

Index of reversibility (IR)

Table 6.2 J depicted the comparison of Index of reversibility (IR) for all the digital display operation between adult male and female subjects. It was noted from the results that digital display-horizontally sliding switch showed highest IR for both sexes. Lowest IR was found for digital display-vertically sliding switch in case of adult male but for adult female the lowest IR was found in case of rotary control – digital display unit. Percent difference was noted between adult male and female subjects in IR values up to 12.38%. It was noted that the magnitude of IR among the female subjects was greater than that of the female subjects by about 7.73% to 12.38% in different configurations of analog controls and displays.

Table 6.2 J: comparison of Index of reversibility (IR) for all the digital displays between the adults male and female

Control-display configurations	**Index of reversibility (IR)**		**% difference of IR between adult male and female**
	Adult		
	Male (n=2447)	**Female (n=2440)**	
Rotary control –digital display	0.669	0.591	12.38%
Digital display-vertically sliding switch	0.590	0.661	11.35%
Digital display-horizontally sliding switch	0.696	0.752	7.73%

Response initiation time

The response initiation time was measured for the operation of control-display unit. **Table 6.2 K** represented the comparison of mean response initiation time (ms) of adult male and female subjects during operation of the entire control display unit. Adult male subjects showed 716.1 ms mean response initiation time for the operation of analog display and 814.6 ms for the operation of digital display while their female counterpart showed 822.4 ms mean response initiation time for analog control-display unit operation and 928.3 ms for the operation of digital display. Statistically significant ($P<0.001$) difference was found among the adult male and female subjects in mean response initiation time for both the display types (analog and digital).

Table 6.2 K: Mean response initiation time (ms) of adult male and female subjects for operation of the entire control display units.

Display type	Subject	Mean response initiation time (ms)
Analog	Adult male (n=2600)	716.1±44.32
	Adult female (n=2624)	822.4±46.44***
Digital	Adult male (n=2447)	814.6±58.22
	Adult female (n=2440)	928.3±47.67***

***P<0.001 with respect to adult male

Comparison of motion stereotype between adults and children

In the following tables a comparison of motion stereotype was presented between adult human subjects and children. Usually the adult humans are habituated to operate control-display units in their day to day life. But the children were not much aware about control-display compatibility during their operation. It was hypothesized that that there may be some differences in motion stereotype among two groups.

Table 6.2 L represented the comparison of motion stereotype (% of respondents) for rotary control-analog display operation between adult and children subjects. It was noted that there was no variation in direction of motion stereotype between adult and children subjects and there was no statistically significant difference was found in stereotype strength also. It was also noted that for children subjects, strongest stereotype strength was noted in semicircular display-rotary switch operation and poorest stereotype strength was noted in intensity testing display operation.

Table 6.2 L: Comparison of Motion stereotype (% of respondents) for Rotary control-Analog display operation between adult and children

Type of Display and Instruction to the subjects	Adult (n=5228)				Children (n=500)			
	Male (2600)		Female (n=2628)		Male (n=250)		Female (n=250)	
	CW (%)	ACW (%)	CW (%)	ACW (%)	CW (%)	ACW (%)	CW (%)	ACW (%)
Horizontal Display (Move to Right)	80.23	19.77	71.35***	28.65	76.40	23.60	82.40	17.60
Horizontal Display (Move to Left)	22.54	77.46	30.59	69.41***	22.00	78.00	29.60	70.40
Vertical Display (move to up)	76.35	23.65	70.55***	29.45	80.80	19.20	76.40	23.60
Vertical Display (move to down)	21.35	78.65	18.23	81.77	24.00	76.00	17.60	82.40
Semi Circular Display (move clockwise)	82.65	17.35	78.58***	21.42	80.80	19.20	86.40	13.60
Semi Circular Display (move anti clockwise)	16.42	83.58	27.36	72.64***	20.60	79.40	27.20	72.80
Intensity testing display (increase)	80.23	19.77	76.33**	23.67	78.40	21.60	80.40	19.60
Intensity testing display (decrease)	24.69	75.31	18.23	81.77*	28.80	77.20	31.60	68.40

*P<0.05 w.r.t adult male, **P<0.01 adult male, ***P<0.001 adult male

CW- Clockwise ACW-Anticlockwise

Comparison of Motion stereotype (%) for rocker switch-electric light unit operation between adult and Children were depicted by **Table 6.2 M.** It was noted that likewise the analog display operation there was no variation in direction of motion stereotype between adult and children subjects and there was no statistically significant difference was found in stereotype strength also. Vertical rocker Switch-electric light unit operation showed strongest stereotype among the children, while horizontal rocker Switch-electric light unit portrayed poorest stereotype strength.

Table 6.2 M: Comparison of Motion stereotype (%) for rocker switch-electric light unit operation between adult and Children

Type of control display unit and instruction to the subjects	Adult (n=5228)			Children (n=500)	
	Response (%)	**Male (n=2600)**	**Female (n=2628)**	**Male (n=250)**	**Female (n=250)**
Horizontal rocker Switch-electric light (on)	Right	67.31	74.20***	72.40	78.40
	Left	32.69	25.80	27.60	21.60
Horizontal rocker Switch-electric light (off)	Right	34.62	47.68	39.60	37.60
	Left	65.38	52.32***	60.40	62.40
Vertical rocker Switch-electric light (on)	Up	21.81	14.35	18.00	20.80
	Down	78.19	85.65**	82.00	79.20
Vertical rocker Switch-electric light (off)	Up	82.30	87.33***	86.40	88.00
	Down	17.70	12.67	13.60	12.00

**P<0.01w.r.t adult male, ***P<0.001 w.r.t adult male

Comparison of Index of reversibility (IR) for all the analog control-display units between adult and children were represented by **Table 6.2 N.** It was noted that up to 10.92% difference in IR values were found between the adult and children subjects. It was found the magnitude of IR among the adult male subjects was greater than that of the male children subjects in most of the cases by about 2.59% to 5.28% in different controls and displays. In case of female subjects adult-children difference was greater in comparison to their male counterpart. The percentage difference was greater in adult subjects by about 5.71% to 8.60 % in different control-display configurations.

Table 6.2 N: Comparison of Index of reversibility (IR) for all the analog control-display units between adult and children

Control-display configurations	Index of reversibility (IR)				% difference	
	Adult (n=5228)		Children (n=500)		Adult male vs. male children	Adult female vs. female children
	Male	Female	Male	Female		
Rotary control-horizontal display	0.666	0.583	0.648	0.632	2.74%	8.07%
Rotary control-vertical display	0.651	0.631	0.660	0.671	1.37%	6.14%
Rotary control-semi circular display	0.719	0.629	0.682	0.666	5.28%	5.71%
Rotary control-light intensity testing display	0.653	0.667	0.620	0.612	5.18%	8.60%
horizontal rocker switch-electric light display	0.553	0.511	0.547	0.570	2.59%	10.92%
vertical rocker switch- electric light display	0.682	0.766	0.733	0.722	7.21%	5.91%

Comparison of motion stereotype (%) for digital display operation between adult subjects (n=4887) and children subjects (n=386) were represented by **Table 6.2 O.** It was noted that there was no variation in direction of motion stereotype between adult and children for operation of digital displays. No significant difference was found in stereotype strength of the adult and children subjects for digital display operations.

Table 6.2 O: Comparison of motion stereotype (%) for digital display operation between adult subjects (n=4887) and children subjects (n=386)

Type of control-display and instruction to the subjects	Response (%)	Adult		Children	
		Male (n=2447)	**Female (n=2440)**	**Male (n=196)**	**Female (n=190)**
Digital Display- Rotary switch (increase the number)	Clockwise	82.22	76.23***	72.96	80.00
	Anti-Clockwise	17.78	23.77	27.04	20.00
Digital Display- Rotary switch (decrease the number)	Clockwise	23.70	32.75***	25.00	22.11
	Anti-Clockwise	76.30	67.25	75.00	77.89
Digital Display- Horizontally sliding switch (increase the number)	Move to Right	72.33	80.61***	78.06	82.11
	Move to Left	27.67	19.39	21.94	17.89
Digital Display- Horizontally sliding switch (decrease the number)	Move to Right	29.79	23.69	31.12	27.89
	Move to Left	70.21	76.32*	68.88	72.11#
Digital Display- Vertically sliding switch (increase the number)	Move to Up	80.30	84.63***	86.22	76.32
	Move to Down	19.70	15.37	13.78	23.68
Digital Display- Vertically sliding switch (decrease the number)	Move to Up	17.70	13.69	9.69	12.63
	Move to Down	82.30	86.31	90.31	87.37

*P<0.05 w.r.t adult male, **P<0.01 w.r.t adult male, ***P<0.001 w.r.t adult male

Table 6.2 P depicted the comparison of Index of reversibility (IR) for all the digital displays between adults (n=4887) and children (n=386). It was noted that up to 12.08 % difference in IR values were found between the adult and children subjects for digital display operation. It was found the magnitude of IR among the male children subjects was greater than that of the adult male subjects in most of the cases by about 2.68 % to 12.90 % in different controls and displays. In case of male subjects adult-children difference was greater in comparison to their female counterpart.

Table 6.2 P: Comparison of Index of reversibility (IR) for all the digital displays between adults (n=4887) and children (n=386)

Control-display configurations	Index of reversibility (IR)				Adult male vs. male children	Adult female vs. female children
	Adult		Children			
	Male (n=2447)	Female (n=2440)	Male (n=196)	Female (n=190)		
Rotary control –digital display	0.669	0.591	0.615	0.667	8.41%	12.08%
Digital display-vertically sliding switch	0.590	0.661	0.606	0.642	2.68%	2.92%
Digital display-horizontally sliding switch	0.696	0.752	0.792	0.697	12.90%	7.59%

Comparison of Mean response initiation time (ms) between adult and children subjects during operation of all the control display unit were presented in **Table 6.2 Q.** It was found that significant ($P<0.001$) difference in mean response initiation time was observed between adult male and male children as well as between adult female and female children for both analog and digital display operation.

Table 6.2 Q: Comparison of Mean response initiation time (ms) between adult and children subjects during operation of the entire control display unit

Display type	Subject	Mean response initiation time (ms)
Analog	Adult male (n=2600)	716.1±44.32
	Male children (n=250)	801.2±18.11***
	Adult female (n=2624)	822.4±46.44
	Female children (n=250)	834.2 ±10.22###
Digital	Adult male (n=2447)	814.6±58.22
	Male children (n=196)	910.1±12.46***
	Adult female (n=2440)	928.3±47.67
	Female children (n=190)	938.2±11.65###

***P<0.001 w.r.t adult male ###P<0.001 w.r.t adult female

Dominant pattern of motion stereotypes found in the study for Bengali (Indian) population (adult and children) were presented by **Table 6.2 R.** It was noted that pattern of direction of motion stereotype in adult and children (both sexes) of Bengali (Indian) population was similar.

Table 6.2 R: Pattern of motion stereotypes found in the study for Bengali (Indian) population (adult and children)

Control- display units	**Major direction of motion stereotypes**
Rotary control –horizontal display	Clockwise to right, Anticlockwise to left
Rotary control –vertical display	Clockwise to up, Anticlockwise to down
Rotary control –semi circular display	Clockwise to clockwise, Anticlockwise to anticlockwise
Intensity testing display	Clockwise to increase, Anticlockwise to decrease
Horizontal rocker switch-electric light unit	Right to on, Left to off
Vertical rocker switch-electric light unit	Down to on, Up to off
Rotary control –digital display	Clockwise to increase, Anticlockwise to decrease
Digital display-vertically sliding switch	Up to increase, Down to decrease
Digital display-horizontally sliding switch	Right to increase, Left to decrease

Table 6.2 S represented the comparison of general stereotypes found for two similar control-display units among Chinese, American (Yu and Chan, 2004) and Bengali (Indian) population (present study). The results of the present study were compared with the results of a previous study (Yu and Chan, 2004). Two common control-display units were found which were used in the previous study as well as in the present study. So, the comparison was done for these two control display units. It was noted that there was a variation in response preference percentage among the three populations i.e., Chinese, American and Bengali (Indian).

Table 6.2 S: Comparison of general stereotypes found for two similar control-display units among Chinese, American (Yu and Chan, 2004) and Bengali (Indian) population

Control-display units and instructions to the subjects	**Direction of motion stereotype % of Hong Kong Chinese population**		**Direction of motion stereotype % of American population**		**Direction of motion stereotype % of Bengali (Indian)**	
Semicircular display-rotary switch (anticlockwise)	**CW (%)**	**ACW (%)**	**CW (%)**	**ACW (%)**	**CW (%)**	**ACW (%)**
	13	87	5	95	21.92	78.08
Digital display-rotary switch (increase the number)	80	20	86	14	74.06	25.94

Discussion: Cognition is the information-handling aspect of human behavior (Lezak, 1995) like perception, memory, thinking, learning, expressive functions, attention and decision-making. So motion stereotype of a person during operating a control-display unit, solely depends on decision-making process, may be termed as a cognitive function. The present study showed that the direction of motion stereotype was the same for most of the control display units among adult male and female but the stereotype strength, index of reversibility and mean response initiation time were found to be significantly different these differences in stereotypic response might be due to the fact that men and women were not only physically different but they were different in cognitive functioning also (Kimura, 1999). Females, during postovulatory period of their menstrual cycle, may have advantages in decision-making tasks like Stroop test and disadvantages in attention related tasks like "Visual Reaction Time", as compared to their male counter parts (Upadhayay and Guragain, 2014). Usually, females show better performance in verbal fluency, perceptual swiftness, correctness and fine motor abilities, whereas males do better than females in spatial abilities, working memory and mathematical skills (Sherwin, 2003 and Zaidi, 2010). Men are in general independent and goal oriented while women are interdependent and in most of the cases dependent others (Eagly and Steffen, 1984; Spence and Helmreich, 1978). These social stereotypes influenced important life outcomes such as job hiring and promotion (Cuddy et al., 2004; American Sociological Review 2005) job performance evaluations (Fuegen et al., 2004; Heilman and Okimoto, 2007) and educational performance (Gudykunst et al., 1996). Cultural differences in independence-inter dependence were evident in the fields such as communication (Schwartz, 1999), creativity (Nisbett et al., 2001), and even basic cognitive processing (Rhoads, 2004). Women usually do better than men in episodic memory (Herlitz & Rehnman, 2008), but men do better in spatial tasks (Lövden et al., 2007).

There are significantly different patterns of brain activation amid male and female subjects in response to a variety of cognition related tasks and in various models (Bell et al., 2006). The biological and the societal factors are concerned in sex differences in cognitive performance appear clear of doubt (WILDER, 1996). Adult females and males showed dissimilar average patterns of academic accomplishment and points in cognitive skill tests (Halpern, 2004). Cerebral anatomy and functions showed gender difference (Reiss et al., 1996 and Gorski, 1998). So the cognitive function may also influenced by Gender difference. Gonadal hormones might play a significant function in the development of sex differences in cognition (Gooren and Kruijver, 2002; Thijssen, 2002).

In the present study, for the rotary control-horizontal scale display, there were strong clockwise-to-right (CR) and anticlockwise-to-left (AL) stereotypes were found to be dominant. This finding was in conformity with the findings of Hotta and Yoshioka (1988) and Chan and Chan (2007). For rotary control-vertical display clockwise to up (CU) and anticlockwise to down (AD) stereotypes were found to be dominant. For the rotary control-semi circular display, strong clockwise-clockwise (CC) and anticlockwise-anticlockwise (AA) relationships were found which was very similar to the results of Chan and Chan (2007).

For Horizontal rocker switch-electric light, strong "right to on (RO)" and "left to off (LO)" stereotypes were found to be dominant whereas for vertical rocker Switch-electric light strong "down to on (DO)" and "up to off (UO)" stereotypes were strong.

For the rotary control-digital display, strong clockwise-to-increase (CI) and anticlockwise-to-decrease (AD) stereotypes were found which was again in conformity to the findings of Chan and Chan (2007). For digital display-vertically sliding switch "up to increase (UI)" and "down to decrease (DD)” stereotypes were dominant but in case of digital display–horizontally sliding switch “right to increase (RI)” and “left to decrease (LD)” stereotypes were strong.

Overall the digital display-horizontally sliding switch showed the best compatibility (IR- 0.792) with the subjects and horizontal rocker switch-electric light display showed the poorest compatibility (IR- 0.511) with the subjects.

In the present study for analog displays the average response initiation time ranged from 716.1ms to 834.2 ms where as it was found to be much higher for digital displays, the range was 814.6 ms to 938.2 ms. So the subjects took longer time to respond in case of digital displays.

The adult and children subjects (both male and female) showed significant difference in mean response initiation time but for the other components of stereotypic responses (like direction of motion stereotype, strength of stereotype or index of reversibility) they did not show much differences. This finding supports the Piaget’s Cognitive Development Theory (1936), according to which in the Concrete Operational Stage (6-11years) the children for the first time starts to think rationally, their thinking becomes more logical and organized. So it was assumed that they may not be habituated in operating a lot of control-display units being children but they at least can think logically and try their best to respond to the stimulus for the operation of control-display units but at this point in development they tend to struggle with abstract and hypothetical concepts while the adults can think abstractly and reasonably about hypothetical problems. So it can be said that this group of children can act logically according to the instruction but as they struggle with abstract thinking they might take longer time to initiate response against the stimulus. Speed of information processing increases exponentially from early childhood to early adulthood (Kail, 1991); so the adult subjects took lesser time to respond to the stimulus. The male subjects (both adult and children) in the present study took lesser time to respond to the stimulus than their female counter part. Some other recent studies (Jain et al., 2015 and Karia et al., 2012) also reported similar findings (in case of the adults). Interestingly the children also showed sex difference in mean response initiation time. However, this particular finding did not matched with the findings of previous studies. One possible reason might be the fact that the population they studied was different from the population of the current study; difference in cultural environment (Kennedy, 2000) has predominant impact on cognitive performance.

6.3 Colour Stereotype Profile of the Bengali population

Colours can provide useful resources of information coding. In many industrial methods using proper colors to represent different conditions on man machine interface is vital for monitoring and operating jobs. Assigning colours properly matched with color associations for a population could decrease the chance of wrong interpretation of the information and improve safety through the quick identification of operating situations (Hopkin, 1994). In the market some products were available which used colour codes for on / off operation, but there was lack of consistency for using colour codes. For example, in Fig 6.3.1, red colour was used for 'on' operation (left fig.) as well for 'off' operation (right fig.). The use of these two products in the same organization may lead to error in operations in control. Valdez & Mehrabian, (1994) suggested that long-wavelength colors (warm hues like, yellow and red) are more affecting than the short-wavelength colors (cool hues like blue and green). Warm colors generally increase the heart rate and hunger (Berman, 2007) makes them trendy choices for restaurants.

Fig 6.3.1: In two products (manufactured by different companies) in a same organization opposite colour coding used for similar ("on" and "off") operation

In the present investigation colour stereotype of Bengali population has been represented. Psychological impression of colours may have some stereotypic pattern which can be used in day to day life and industrial process. We have used some criteria of colour display in relation to psychological response of the human subjects to find certain stereotypic pattern.

Table 6.3 A represented the Percentage (%) of color stereotype (for different criterion) of all the subjects (n=3627). There were total four criteria with nine different colours in the fabricated colour-chart. The following criteria regarding representation of colour were used:

Criterion I: Thermal sensation of colour - “hot” and “cold” sensation,

Criterion II: Colour impression of “on” and “off” response,

Criterion III : Colour impression of “safe zone” and “danger zone”

Criterion IV: Colour impression of traffic signals - “go”, “caution” and “stop”.

The subjects were asked to choose one of the nine colours which according to them were mostly associated with each criterion.

In the present study the colour stereotype was determined by the percentage of respondents preferred a colour for a particular criterion. The preference of above 50% subjects was taken as cutoff value for a definite colour stereotype. With the increase of percentage of subjects selecting a colour indicated the increase of the strength of stereotype.

The results **(Table 6.3 A)** showed that the majority (66.42%) of the subjects preferred “Red” colour to represent “Hot” sensation, 35.65% of the subjects indicated “Blue” colour to represent “cold” sensation. For criterion II 54.30% of the subjects preferred “Green” colour to indicate “on” and 47% of them liked to use “Red” colour for “off” response. For the criterion III 38% of the subjects liked to use green colour to represent “Safe zone” and 77.4% of the subjects chose “Red” colour to be associated with “danger zone”. For the criterion IV, 75.30% of the subjects preferred “green” colour to represent “Go” sign, where as 46.20% of the subjects chose yellow colour to represent “caution” sign and 76.50% of the subjects preferred “Red” colour to represent “Stop”.

Table 6.3 A: Percentage (%) of color stereotype (for different criteria) among all the subjects (n=3627)

Colors	Criteria								
	Criterion I		Criterion II		Criterion III		Criterion IV		
	Hot	Cold	On	Off	Safe zone	Danger zone	Go	Caution	Stop
Red	66.42	1.46	14.41	47.0	0.25	77.4	5.16	21.90	76.50
Blue	2.59	35.65	8.68	13.10	14.7	1.65	6.20	6.09	4.49
Green	2.45	7.66	54.30	11.0	37.9	1.21	75.30	8.52	2.78
Yellow	6.46	6.45	7.78	3.36	35.4	2.56	7.02	46.20	3.64
Pink	7.83	12.30	1.13	3.58	0.99	4.05	1.99	2.40	2.15
White	2.23	23.0	9.65	4.33	4.96	4.44	0.25	1.63	1.87
Black	6.15	4.38	1.32	14.90	1.90	5.34	0.50	5.49	7.20
Violet	2.59	7.39	1.16	1.90	2.81	0.99	3.58	1.63	-
Orange	3.28	1.71	1.57	0.83	1.09	2.36	-	6.14	1.37

It may be summarized that for present population the red color represented the hot sensation clearly because more that 66% of the studied population selected this colour for hot sensation. However, for cold sensation there was no clear cut indication, although a higher percentage of the subjects pointed out blue as the colour for cold sensation than that of other colours but the percentage was much below the 50%.

In case on-off response most of the subjects indicated green as the colour for ‘on’ response. Although red colour was selected for off response by a larger number of subjects than that of other colours but the percentage was below the 50%. Therefore, it may be stated that the colour for ‘off’ response was not definitive.

For defining safe and danger zone most of the subject selected red colour as danger zone. So it may be designated as the stereotype for the selected population. On the other hand, there was no definite colour stereotype for safe zone because no colour had more than 50% preference, although green colour had the maximum percentage of preference.

In case of selecting colour for traffic signal there were definite colour stereotypes for ‘go’ and ‘stop’ response. A large percentage of subjects opted green and red colours for ‘go’ and ‘stop’ responses respectively. No clear cut stereotype was obtained for ‘caution’, although higher percentage of subjects selected yellow colour than that of other colours for this response but it was below the 50%.

Table 6.3 B represented comparison of colour stereotype between male and female subjects. The results showed that for criterion I, which represented hot / cold sensation of colour, the preferred colour was the same in both male and female subjects that is, a greater percentage of the subject of both sexes preferred red colour to represent hot sensation. It was noted that 79.2% of the males and 51% of the females selected “Red” colour for “Hot” and 31.2% of the males and 41.1% of females preferred “blue” colour for “cold”. The percentage of preference was significantly different (P<0.001) between male and female subjects. It may be pointed out that in both male female subjects there was no definite colour stereotype for cold sensation as in both cases the largest percentage of response for blue colour was well below the 50%.

Table 6.3 B: Comparison of color stereotype (percentage of respondents) for criterion I between male (n=1987) and female (n=1640) subjects

Colors	Criterion **I**			
	Hot		**Cold**	
	Male	**Female**	**Male**	**Female**
Red	79.2	51.0 ***	0.45	2.68
Blue	2.32	2.93	31.2	41.1 ***
reen	1.11	4.09	12.8	1.40
Yellow	4.08	9.27	11.1	2.94
Pink	6.84	9.02	19.8	3.29
White	0.01	3.48	17.6	29.5
Black	2.47	10.6	4.28	4.51
Violet	2.66	4.51	2.77	10.8
Orange	1.31	5.10	-	3.78

***P<0.001 with respect to male

Table 6.3 C. depicted the comparison of criterion II, that is, the preference of colour for representing on / off response. It was noted that 58.9 % of the male and 48.7% of the female preferred green colour for “on” concept and the stereotype strength was significantly (P<0.001) different among them. Therefore, a clear stereotype of ‘on’ response (green colour) was obtained in case of male subjects but in case of female subjects it was definitive (below 50%). On the other hand, 63.7% of the male preferred red colour for “Off” and 27.9% of the female preferred black colour for “off” concept and 26.6% of the female subjects opted for red colour for representing off status. Hence, among female subjects there was no clear indication of colour stereotype for off status. So, here the colour preference was found to be different male and female subjects.

Table 6.3 C: Comparison of color stereotype (percentage of respondents) for criterion II between male (n=1987) and female (n=1640) subjects

Colors	Criterion **II**			
	On		**Off**	
	Male	**Female**	**Male**	**Female**
Red	16.2	12.3	63.7	26.6
Blue	6.89	10.9	10.9	15.7
Green	58.9	48.7 ***	12.0	9.82
Yellow	1.91	14.9	2.32	4.63
Pink	1.01	1.28	2.62	4.76
White	11.8	7.01	3.07	5.85
Black	-	2.29	4.13	27.9
Violet	2.11	-	1.26	3.48
Orange	1.18	2.62	-	1.26

***P<0.001 with respect to male

For Criterion III**,** the colour preference to represent safe and danger zones**,** **Table 6.3 D** also had the same story to portray, the similar colour preference for the same criterion in both the sexes but significantly (P<0.001) different stereotype strength were found between the sexes. About 41.6% of the males and 33.4% of the females preferred green colour for indicating "safe zone" and 87.4% of the male and 65.4% of the female preferred red colour for "danger" sign. Therefore, the results depicted that the red was the stereotype colour for indicationg danger zone in both male and female subjects. However, there was no definite colour stereotype for safe zone for the both the genders because the maximum percentage of responses, in favour of green colour representing safe zone, were below 50% in both the sexes.

Table 6.3 D: Comparison of color stereotype (for criterion III) percentage (%) between male (1987) and female (1640) subjects

Colors	Criterion **III**			
	Safe zone		**Danger zone**	
	Male	**Female**	**Male**	**Female**
Red	0.15	6.82	87.4	65.4***
Blue	17.9	10.9	1.01	2.44
Green	41.6	33.4 ***	1.51	0.85
Yellow	33.7	30.9	0.15	5.49
Pink	1.17	0.85	2.63	5.08
White	3.27	7.01	1.11	8.48
Black	0.45	3.66	2.77	8.23
Violet	1.31	4.63	-	2.20
Orange	0.45	1.83	3.42	1.83

***P<0.001 with respect to male

The response of the subjects towards the colour display for traffic signal was compared between two sexes. The results (**Table 6.3 E)** showed that for “Go” action 78.2% of the males and 71% of the females preferred green colour. For “Caution” 53.5% of the males and 37.3% of the females preferred yellow colour. For “stop” action 79.7% of the males and 72.5% of the females preferred red colour. Similar colour preference was found for both sexes but strength of stereotype were found to be significantly (P<0.01 or less) different for each criterion.

From the above results it was observed that the colour stereotypes for the action ‘Go” and ‘Stop’ was the same for both male and female subjects. The green colour was selected for the action ‘Go’ by the subjects of both the genders. Similarly, for the ‘Stop’ action both the male and female subjects were opted for red colour. The strength of stereo type was high in both the cases. For the action ‘Caution’ yellow colour was preferred by the male subjects. The strength stereotype was marginal. However, in case of female subjects there was no clear cut stereotype for the ‘Caution’, as less than 50 % of female subjects preferred yellow colour for ‘Caution’, although the percentage of response was the largest among the other coluors.

Table 6.3 E: Comparison of color stereotype (for concept IV) percentage (%) between male (1987) and female (1640) subjects

Colors	Criterion **IV**					
	Go		**Caution**		**Stop**	
	Male	**Female**	**Male**	**Female**	**Male**	**Female**
Red	4.73	5.67	28.8	13.4	79.7	72.5 **
Blue	2.37	10.9	4.68	7.80	3.82	5.30
Green	78.2	71.0**	6.95	10.4	1.31	4.57
Yellow	6.40	8.35	53.5	37.3 ***	2.21	5.37
Pink	0.86	3.53	-	5.30	3.37	0.67
White	0.30	0.18	0.63	2.30	1.61	2.20
Black	0.60	0.37	1.86	9.88	5.44	9.39
Violet	6.54	-	0.81	2.62	-	-
Orange	-	-	2.77	11.0	2.54	-

**P<0.01 with respect to male, ***P<0.001 with respect to male

The following results represent the comparison of colour stereotype between the subjects of rural and urban areas.

It was found from results (**Table 6.3 F)** that for criterion I (thermal sensation of colour) , 53.8 % of the urban females and 54.6% of the rural females preferred the red colour for “hot” sensation and 42.4% of the urban females and 41.8% of the rural females preferred the blue colour for “cold” sensation. There was no significant difference between the rural and urban female subjects for stereotype strength or colour preference.

From the results stated above it may stated that in female subjects there was a clear stereotype for red colour which represented hot sensation in both the rural and urban areas. On the other hand no definitive colour stereotype was shown for cold sensation in the subjects of both rural and urban areas. However, the larger percentage of subjects indicated the blue colour for sensation of cold (but below 50%).

Table 6.3 F: Comparison of color stereotype (percentage of respondents) for criterion I (thermal sensation of colour) between females of urban and rural areas

Female U=824 R=826	Colors	Criterion I			
		Hot		Cold	
		Urban	Rural	Urban	Rural
	Red	53.8	54.6	3.16	2.18
	Blue	2.55	3.27	42.4	41.8
	Green	3.52	4.60	0.49	2.30
	Yellow	5.3	7.14	0.73	0.97
	Pink	10.1	7.87	2.67	3.87
	White	3.40	3.51	30.0	31.7
	Black	10.8	9.32	3.52	5.45
	Violet	5.83	3.15	12.7	8.72
	Orange	4.70	6.54	4.373	3.01

Table 6.3 G showed that for criterion II (colour impression for on and off response), 48.1 % of the urban females and 48.7% of the rural females preferred green colour for “on” and 26.5% of the urban females and 29.1% of the rural females preferred black colour for “off”. There was no significant difference found between the rural and urban female subjects for stereotype strength or colour preference. Therefore, it may be pointed out that when the

female subjects were divided into urban and rural groups there was no clear cut colour stereotype for ‘on’ and ‘off’ response.

Table 6.3 G: Comparison of color stereotype (percentage of respondents) for criterion II (colour impression for on and off response) between females of urban and rural areas

Female U=824 R=826	**Colors**	Criterion **II**			
		On		**Off**	
		Urban	**Rural**	**Urban**	**Rural**
	Red	12.9	11.6	25.2	27.7
	Blue	11.3	10.3	14.6	16.6
	Green	48.1	48.7	10.3	9.20
	Yellow	15.2	14.4	6.55	2.63
	Pink	0.97	1.57	5.70	3.75
	White	6.67	7.26	5.34	6.30
	Black	2.55	3.27	26.5	29.1
	Violet	-	-	3.40	3.51
	Orange	2.31	2.90	2.41	1.21

Table 6.3 H showed that for criterion III (colour impression of safe and danger zones), 30 % of the urban females and 36.3% of the rural females preferred green colour for representing “safe zone” and 67.2% of the urban females and 68.8% of the rural females preferred red colour for “Danger zone”. There was no significant difference found between the rural and urban female subjects for stereotype strength or colour preference. It may be summarized that when the female subjects were categorized into rural and urban groups the red colour was representing the danger zone. On the other hand the colour stereotype for safe zone was not definitive.

Table 6.3 H: Comparison of color stereotype (percentage of respondents) for criterion III (colour for safe and danger zones) between females of urban and rural areas

Female U=824 R=826	Colors	Criterion **III**			
		Safe zone		**Danger zone**	
		Urban	**Rural**	**Urban**	**Rural**
	Red	0.73	-	67.2	68.8
	Blue	12.4	9.20	1.94	2.91
	Green	30.0	36.3	0.73	0.97
	Yellow	39.2	37.1	5.83	5.08
	Pink	0.97	0.73	7.40	4.00
	White	6.19	5.75	10.2	6.66
	Black	3.71	3.51	1.84	8.47
	Violet	4.37	4.84	2.43	1.90
	Orange	2.43	2.57	2.43	1.21

From the **Table 6.3 I** showed comparison of colour stereotype between rural and urban areas and it was observed that for criterion IV (colour impression for traffic signal) 69 % of the urban females and 73.9% of the rural females preferred green colour for "Go" response and 37.3 % of the urban females and 36.9 % of the rural females preferred yellow colour for "caution" but 71.7% of the urban females and 72.4% of the rural females preferred red colour for "stop" response. There was no significant difference between the rural and urban female subjects for stereotype strength or colour preference.

Thus it can be stated that when female subjects were divided into rural and urban areas the green and red colours represented 'Go' and 'Stop' responses respectively and the colour stereotype was definitive. On the other hand for the 'Caution' response there was no clear cut colour stereotype.

Table 6. 3 I: Comparison of color stereotype (percentage of respondents) for concept IV (colour for traffic signal) between females of urban and rural areas

Female U=824 R=826	Colors	Criterion **IV**					
		Go		**Caution**		**Stop**	
		Urban	**Rural**	**Urban**	**Rural**	**Urban**	**Rural**
	Red	5.95	5.33	12.7	13.9	71.7	72.4
	Blue	13.8	7.75	8.62	6.90	5.10	5.45
	Green	69.0	73.9	9.95	10.8	5.10	4.71
	Yellow	8.74	7.87	37.3	36.9	5.22	5.45
	Pink	2.51	4.12	7.28	3.27	0.73	0.61
	White	-	0.30	3.11	2.52	3.17	1.82
	Black	-	0.73	8.13	11.5	8.98	9.56
	Violet	-	-	2.31	2.91	-	-
	Orange	-	-	10.6	11.3	-	-

In the following paragraphs the comparison of colour stereotypes between rural and urban areas has been discussed for male subjects.

For criterion I (thermal sensation of colours) it was noted that 81.2% of the urban males and 78.1% of the rural male preferred red colour for "hot" sensation and 30.5% of the urban males preferred pink colour for "cold" sensation and 43% of the rural males preferred blue colour for "cold" sensation (**Table 6.3 J).** There was no significant difference found among the urban and rural male for preference or strength of colour stereotype. Therefore, it may be pointed out that there was a clear cut colour stereotype with a high level of strength. The red colour was selected for hot sensation by the male subjects of both rural and urban areas. However, there was no definite colour stereotype for cold sensation. Rural and urban male subjects had preference of different colours for the same sensation.

Table 6.3 J: Comparison of color stereotype (percentage of respondents) for concept I (thermal sensation of colours) between males of urban and rural areas

Male U=1043 R=944	Colors	Criterion **I**			
		Hot		**Cold**	
		Urban	**Rural**	**Urban**	**Rural**
	Red	81.2	78.1	0.30	0.64
	Blue	2.01	2.50	23.9	43.0
	Green	2.11	-	8.15	7.38
	Yellow	2.97	5.30	11.5	10.6
	Pink	6.71	7.00	30.8	7.63
	White	0.67	1.80	17.4	20.9
	Black	1.92	3.07	4.31	4.24
	Violet	1.34	0.64	3.64	5.61
	Orange	1.07	1.59	-	-

It was noted from the **Table 6.3 K** that for criterion II (colour for on and off response), 62.6% of the urban males and 61.7% of the rural males preferred green colour for "on". About 65.8% of the urban males preferred red colour for "off" action and 62.6% of the rural males preferred red colour for "off". There was no significant difference among the urban and rural male for preference or strength of colour stereotype.

Thus it may be affirmed that when the male subjects were divided into rural and urban areas a definite colour stereotype for the impression of on and off response was found which was contrary to that of the female subjects. Although there no significant difference in the strength of colour stereotype between rural and urban areas the subject showed green and red colours as the impression of 'on' and 'off' action respectively.

Table 6.3 K: Comparison of color stereotype (percentage of respondents) for concept II (colours for on and off response) between males of urban and rural areas

Male U=1043 R=944	**Colors**	Criterion **II**			
		On		**Off**	
		Urban	**Rural**	**Urban**	**Rural**
	Red	15.5	16.8	65.8	62.6
	Blue	6.52	1.31	11.0	10.8
	Green	62.6	61.7	11.6	12.4
	Yellow	1.34	2.54	1.63	3.07
	Pink	1.22	0.85	3.64	1.48
	White	11.0	12.7	2.30	3.92
	Black	-	-	3.16	5.19
	Violet	1.05	3.28	0.86	0.54
	Orange	0.77	0.82	-	-

Table 6.3 L represented that for criterion III (colour for safe and danger zones), 41.15% of the urban males and 41.2% of the rural males preferred green colour for "safe zone" indication and 88.3% of the urban males and 86.4% of the rural males preferred red colour for "danger zone". There was no significant difference between the urban and rural male for preference or strength of colour stereotype. From the above findings it may be stated that the colour stereotype for the danger zone was the red colour for the male subjects of both rural and urban areas. This stereotype was of high strength. However, no clear cut stereotype was noted for the safe zone the male subjects of both rural and urban areas. The similar findings was also obtained in case of female subjects.

Table 6.3 L: Comparison of color stereotype (percentage of respondents) for concept III (colour for safe and danger zones) percentage (%) between males of urban and rural areas

Male U=1043 R=944	Colors	Criterion III			
		Safe zone		Danger zone	
		Urban	Rural	Urban	Rural
	Red	-	0.32	88.3	86.4
	Blue	18.7	17.0	1.05	0.95
	Green	41.15	42.2	0.67	2.44
	Yellow	34.3	33.1	-	0.32
	Pink	1.53	0.64	3.16	2.12
	White	3.07	3.50	1.53	0.64
	Black	0.29	0.64	1.92	3.71
	Violet	0.38	2.33	-	-
	Orange	0.58	0.37	3.37	3.42

Table 6.3 M represented that for criterion IV (colour for traffic signal), 79.1% of the urban males and 77.1% of the rural males preferred green colour for "Go" action and 56.4% of the urban males and 50.4% of the rural males preferred yellow colour for "caution" but 81.3% of the urban males and 78% of the rural males preferred red colour for "stop" action. There was no significant difference found between the rural and urban female subjects for stereotype strength or colour preference.

It appeared from the above discussion that there was definite colour stereotype for male subjects of rural and urban areas but there was no difference between two areas. The 'Go', 'Caution' and 'Stop' actions were represented by green, yellow and red colours respectively. The green and red colours showed high level of stereotype strength. The green colour had marginal stereotype strength, particularly for the subjects rural areas. The female subjects had the direction colour stereotype but the yellow colour did not show definite colour stereotype for caution.

Table 6.3 M: Comparison of color stereotype (percentage of respondents) for concept IV (colour for traffic signal) between males of urban and rural areas

Male U=1043 R=944	**Colors**	Criterion **IV**					
		Go		**Caution**		**Stop**	
		Urban	**Rural**	**Urban**	**Rural**	**Urban**	**Rural**
	Red	2.97	6.67	28.0	29.8	81.3	78.0
	Blue	2.11	2.65	3.45	6.04	3.74	3.92
	Green	79.1	77.1	6.62	7.31	0.67	2.01
	Yellow	7.77	5.08	56.4	50.4	1.05	3.50
	Pink	0.38	1.38	-	-	4.31	2.33
	White	0.29	0.32	0.58	0.64	1.15	2.12
	Black	0.58	0.64	2.88	0.74	5.37	5.51
	Violet	6.80	6.16	0.86	0.74	-	-
	Orange	-	-	1.21	4.33	2.41	2.61

Discussion: The results showed that the percentage of colour preferences for each and every criterion was significantly different (P<0.01 or less) between male and female subjects, this finding might be supported by the similar finding of Ling & Hurlbert (2001) who carried out a systematic examination of colour preference across children, young adults and the elderly and the results indicated a significant sex difference in colour preference for each and every group except 61-88 yrs group.

The present study indicated that red colour was found to be associated with the symbols of "hot", "danger", "off" and "stop" while the blue colour was associated with the "cold" sensation symbol, these associations found in the study were previously mentioned in some other studies (Riley, 1995; Arnheim, 1962; Taylor, 1962) for some other population also. Recent research also suggested that red is usually being linked with warm/hot, and blue with cold and these colours have a real impact on information processing efficacy and object temperature insight (Ho, 2015).Other than this green colour was found to be preferred by the subjects for “on”, “safe area” and “go” symbols and yellow colour for “caution” symbol. There are some colour associations which are considered worldwide, like red for warmness but cross-culture differences were observed to be present. In a work scientist duo (Chan and Courtney, 2001) studied stereotypes for color with the Hong Kong Chinese population and found an interesting fact that there was a deviation and oddness of subjects ’ preferences of colors with the international standards. The present study showed that clear cut colour stereotypes were found for red (chosen for “hot” sensation, “danger zone”, and “stop”) and green (chosen for “on” response and “go”) Same kind of colour preferences were observed among the Hong Kong Chinese subjects (Chan and Courtney, 2001), there was also no clear stereotype found for “caution” which was found in Americans (they preferred yellow colour for “caution”) This difference might be due to the fact that cross-culture differences were observed to be present in such colour and sign associations; the findings revealed the significance of taking the cultural issue into concern when developing traffic signs (Ng and Chan, 2007), Cultural dominant color habituation plays an important role in eliciting responses to the color stimuli, different cultures fluctuate in using color, which affects individual responses, like the Ndembo of Zambia do not distinguish orange as a colour, while the Hindus consider orange colour as sacred (Singh, 2006). The strongest associations found in the study were red and stop (76.50%), red and danger (77.40%), and green and go (75.30%) which matched with daily experiences of the subjects this finding was also matched well with the finding of Chan and Courtney (2001) but the strengths were found to be higher in the studied population than the Hong Kong Chinese population. Red had the highest percentage associations with four out of the nine criterions tested, viz. hot, danger, off and stop this finding is also corroborated with the finding of Chan and Courtney (2001) who also found the red to be the mostly preferred colour for their experiment but red colour showed an adverse impact on cognitive function (Elliot and Maier, 2007). Red usually being linked with warm/hot, and blue with cold. These colours have a real impact on information processing efficacy and object temperature insight (Ho, 2015). The searching time to find clear-cut information could be cut down by assignment of appropriately designed color screens (Van Darr and Deshe, 2002).Connection of colors with concepts offers industrial designers the understanding about the significance of the color coding they utilize (Osgood et al., 1975; Jacobs et al.,1991; Chan and Courtney, 2001). Colors always draw attention, have impact on moods, illuminate and emphasize features of the environment (Teller & Bornstein, 1987) so colour stereotype of a population should be kept in mind during colour coding of the interfaces.

Sometimes manufactures or designers did not pay any attention to colour stereotype of the population. Different manufacturers used opposite colour code for the same operation for example, it was noted that for the 'off' operation one manufacturer used red and other manufacturer used green colour for the same, as shown in Fig 6.3.1. In the present study it was found that the colour stereotype for 'off' was the red for Bengali (Indian) population. It was noted that one of products was not in conformity with the colour stereotype of the studied population.

6.4 Impact of stress on motion stereotype:

Influence of Cardiovascular stress on motion stereotype of male workers of a small scale pole manufacturing plant:

In the present section the impact of physiological stress on motion stereotype has been investigated. The physiological stress was determined in terms cardiovascular stress. During physical work the cardiovascular stress increases in comparison to resting condition. The extent of stress was measured by determining cardiovascular stress index (CSI), as discussed in the Methods and materials (Chapter 5 and section 5.7).

Table 6.4 B represented that the mean working heart rate of the workers which was found to be higher significantly ($p<0.001$) of the factory workers. According to the computed CSI values (Trites *et.al.*, 1993) a classification (**Table 6.4 A**) was done on the basis of their percentile values. According to this CSI classification 27.27% subjects were found to be under light stress, 45.45% subjects were in moderate stress and 27.27% subjects were under high stress (**Table 6.4 C**) after scheduled work at factory.

According to cardio vascular stress index (CSI) level the subjects were divided into three categories. The CSI of the selected subjects in the pole manufacturing industry was determined from the resting, working and maximal heart rate. The percentile values of CSI were computed and subjects were categorized into three groups i.e., light stress, moderate stress and high stress. **Table 6.4 A** represented the classification of stress level according to CSI using percentile values. Up to 35th percentile value of CSI it was considered light stress, from 36th to 70th percentile values were considered as moderate stress and above 70th percentile was taken as high stress.

Table 6.4 A: Classification stress according to CSI values

CSI values Up to 35th percentile (Up to 23.70)	Light stress
CSI values from 36th to 70th percentile (24.00 – 26.00)	Moderate stress
CSI values above 70th percentile (26.87 and above)	High stress

Table 6.4 B: Heart Rate in resting (n=44) and after work (n=44) condition

Parameter	Mean Resting Heart rate (beats /min)	Mean working Heart rate (beats /min)
Heart rate (beats /min)	81.87 ±11.68	129.59 ±16.76***

*** P<0.001

Table 6.4 C: Percentage of workers under different cardiovascular stress levels

CSI value range	Stress level	No of subjects
Up to 23.70	Light stress	27.27%
24.00 – 26.00	Moderate stress	45.45%
26.87 and above	High stress	27.27%

Table 6.4 D depicted the result of response time of the workers for the operation control initiation time at different stress levels and the analysis of results (one way ANOVA) it was noted that there was a significant difference (P<0.01) of response initiation time among the workers at different stress levels. It was revealed that the mean response initiation time decreased significantly with the gradual increase of stress level.

Table 6.4 D: Response initiation time (ms) for control display operation at different stress levels

Stress level	Response initiation time (Mean ± SD)	F value
Normal resting	726.22 ±10.22	3241.3341**
Light stress	993.83 ±5.98	
Moderate stress	806.42 ±8.58	
High stress	707.42 ±4.87	

**P<0.01

Comparison of direction of motion stereotype (% of respondents) of the factory workers for different sets of rotary control- display operation at normal resting state and different levels of physiological stress presented in **Table 6.4 E**. From the Chi square test results it was noted that the percentage of stereotype responses (stereotype strength) was significantly different (P<0.05 or less) among four groups from different stress levels except in case of horizontal display with rotary switch for "move the indicator left" instruction. It was also noted that in some cases at stressed conditions direction of motion stereotype were also altered.

Table 6.4 E: Comparison of direction of motion stereotype (% of respondents) of the factory workers for different sets of rotary control- display operation at normal resting state and different levels of physiological stress

Type of display and instruction to the subjects	**Response in resting condition (n=33)**		**Response in light stress (n=12)**		**Response in moderate stress (n=20)**		**Response in high stress (n=12)**		**Level of significance (Chi square test)**
	CW (%)	**ACW (%)**	**CW (%)**	**ACW (%)**	**CW (%)**	**ACW (%)**	**CW (%)**	**ACW (%)**	
Horizontal display with rotary switch (move the indicator right)	75.75	24.25	75	25	70	30	25	75	P<0.05
Horizontal display with rotary switch (move the indicator left)	12.12	87.88	33.33	66.67	20	80	25	75	NS
Vertical display with rotary switch(move the indicator up)	75.75	24.25	75	25	15	85	66.67	33.33	P<0.001
Vertical display with rotary switch (move the indicator down)	21.21	78.78	25	75	15	85	83.33	16.67	P<0.001
Semi Circular display with rotary switch (move the indicator clockwise)	81.82	18.18	75	25	85	15	16.67	83.33	P<0.001
Semi Circular display with rotary switch (move the indicator anti clockwise)	12.12	87.88	16.67	83.33	90	10	33.33	66.67	P<0.001

CW- clock wise **ACW**- anti clockwise

Table 6.4 F illustrated the comparison of direction of motion stereotypes (% of respondent) of the factory workers for different sets rocker switch-electric light operation ("on" response) at normal resting state and different levels of physiological stress. It was noted that there was a significant difference in response percentage (strength of motion stereotype) of the workers at different stress level and at normal resting state for Horizontal rocker switches-electric light unit operation. Direction of motion stereotype was also found to be altered at stressed conditions.

Table 6.4 F: Comparison of direction of motion stereotypes (% of respondent) of the factory workers for different sets rocker switch-electric light operation ("on" response) at normal resting state and different levels of physiological stress

Control-display unit	Response	Response (%) in normal resting condition	Response (%) in light stress	Response (%) in moderate stress	Response (%) in high stress	Chi square test (level of significance)
Horizontal rocker switches-electric light	**Towards Right**	51.52	58.33	25	100	P<0.001
	Towards Left	48.48	41.67	75	0	
Vertical rocker switches-electric light	**Downward**	72.73	58.33	65	66.67	NS
	Upward	27.27	41.67	35	33.33	

NS - not significant

Table 6.4 G represented the comparison of index of reversibility (IR) of the factory workers at different stress levels for rotary control- display units. The results showed that the reversibility was altered for each stress level for all the three rotary control-display units. When all three cases were considered it was revealed that the index of reversibility was the highest during work under in light stress and it was the lowest in moderate physiological stress. **Table 6.4 H** represented the percent difference of IR values of the subjects from different stress level for all the control-display units operation. It was noted that up to 122.41percent difference in IR values were found between different the subjects under different stress levels. Highest percent difference was found between normal resting and moderate stress group and lowest value was noted for normal resting and light stress group.

Table 6.4 G: The indexes of reversibility (IR) for all the control-display configurations in different stress conditions

Control-display configurations	**Index of reversibility (IR) (at normal resting state)**	**Index of reversibility (IR) (at light stress)**	**Index of reversibility (IR) (at moderate stress)**	**Index of reversibility (IR) (at high stress)**
Rotary control – horizontal display	0.704	0.583	0.620	0.375
Rotary control – vertical display	0.635	0.625	0.255	0.388
Rotary control –semi circular display	0.748	0.667	0.180	0.388

Table 6.4 H: Percent difference of IR of the subjects from different stress level for all the control-display units operation

Percent (%) difference of IR at different stress level						
Control-display configurations	**Normal resting vs. light stress**	**Light stress vs. moderate stress**	**Moderate stress vs. high stress**	**Normal resting vs. moderate stress**	**Light stress vs. high stress**	**Normal resting vs. high stress**
Rotary control - horizontal display	18.80	6.15	49.24	12.69	43.42	60.98
Rotary control - vertical display	1.59	84.09	41.37	85.39	46.79	48.29
Rotary control - semi circular display	11.45	115	73.24	122.41	52.89	63.38

Discussion: The results revealed that work at pole factory imposed stress on the workers. CSI classification showed that the stress imposed on the subject after the same work schedule were not similar and this finding may be supported by a report of National Association of Mental Health (2005) which illustrated that individuality and the approach of coping of the workers can affect the outcome of stress. So it may be said that same amount of work load or stressor can cause stress which may vary individual to individual. In this study it was found that due to the work stress the heart rate of the workers were significantly increased. The same fact was reported in some other studies (Dawans *et. al.*, 2011; Vrijkotte, et al., 2000; Lundberg, et al., 1996). Stressful conditions may trigger stress hormone release, which in turn increase the heart rate (Lupen et. al., 2006). The stress hormone epinephrine can be taken as an example which works through binding with beta-1 adrenergic receptors at the SA node of the heart to elevate heart rate (Raff & Levitzky, 2011). It was noted that there was no significant difference between the motion stereotypic responses of right and left handed workers for operation of all the control-display units. Similar finding was suggested by Simpson and Chan (1988) where they found no significant differences between left-handed and right-handed subjects with any of the control-display relationships they studied. Porac and Searleman (2002) also showed the absence of association of handedness with cognitive performance in their study. It might be due to the fact that most of the products manufactured today are designed for the right-handed population and left-handed users need to get used to. So, the finding of no difference between the response of right-handed and left- handed workers may be an indication of that adaptation. This study opened up the fact that increased stress level altered the direction of motion stereotype. In high and moderate stress the direction of motion stereotype was changed for all the control-display units except for rotary switch unit operation with horizontal display (move to left) and for vertically aligned rocker switch operation with electric light as display where the direction of motion stereotype was similar for all the stress levels. So it can be said that work related stress had a definite impact on the stereotypic response of the subjects. It meant that increased stress at work might alter the cognitive response of an operator. Thus it indicated that altered cognitive response influenced the human- machine interaction during stress condition which might affect performance of the workers. Wastell and Newman (1996) also concluded in their study that a properly designed military system should enhance the performance by lowering the stress of the operator. Schellenkens *et. al.* (2000) revealed some persistent effect of demanding day long office work on cognition of the workers. According to a report (2007) of the Work Foundation titled 'stress at work', the most persistent factor behind work related stress is work load. In consideration of the index of reversibility, it was found that the man- machine compatibility of rotary control horizontal display was the lowest in high stress and the highest in light stress. For Rotary control with vertical display and rotary control with circular display the lowest IR was found in moderate stress while the highest IR was found for both the above units in case of light stress. The best configuration of IR found in this study was rotary switch unit with circular display and this finding corroborated with the findings of another study (Chan & Chan, 2007b). So, it can be said that stress had an impact on index of reversibility (IR). Increased stress decreased the IR values. In other words it can be stated that the dominance of stereotypic response for a control-display unit was decreased. It has been noticed that the response initiation time of the subjects were gradually decreased with increased stress, which meant that the factory workers respond gradually faster to the instructions with an increase in stress. This might be due to the fight-or-flight response, by which our body's sympathetic nervous system reacted to a stressful events, body makes higher amount of the chemicals cortisol, adrenaline and noradrenaline, which in turn trigger higher heart rate and mental alertness which helps to protect ourselves in a stressful situations (Lupen et. al., 2006), so we become more alert and react faster to any stimulus. Davranche et al. (2006) found that due to exercise arousal (state of attention or alertness) increased which improved reaction time. VaezMousavi et. al. (2009) concluded that among some of the participants reaction time was found to be fastest with an intermediate level of arousal (state of attention or alertness), and declines when the subject is either too much relaxed or too much tensed, while others showed the opposite phenomenon , in general, reaction time tended to get better as arousal increased.

Influence of Heat stress on the motion stereotype of bell metal workers (male):

In the present investigation effect of heat stress on motion stereotypic pattern was studied. The workers engaged in the manufacturing of bell metal products had to expose to heat stress during working hours. The stereotypic pattern of the workers under different levels of heat stress was studied. The level of heat stress in the workstation of the bell metal workers was evaluated in terms of different heat stress parameters. Bell metal product manufacturing has different stages or steps. In first step bell metal is melted in a high temperature, the workers are compelled to work under that high temperature during melting of the metal. During some other processing jobs of bell metal product manufacturing, like shaping the product by hammering and scrapping high temperature was not needed. So in the present study motion stereotype of the bell metal workers was done in these two states of environment where the temperature difference was high. Motion stereotype was evaluated when the workers were at high heat stress (during melting job of the bell metal) and then motion stereotype was again evaluated when there is no heat stress (during other processing jobs of bell metal). Then motion stereotype at this two states were compared with each other.

Table 6.4 I represented the recorded values of different thermal parameters during different performing bell metal processing jobs. It was fond that the mean values of Wet Bulb Globe Temperature in indoor (WBGTi) during other processing jobs of bell metal was 29.4±2.63 °C. It was revealed that during executing bell metal melting job the WBGTi was found to be significantly ($P<0.001$) higher than the WBGTi recorded during other processing jobs of bell metal. Other thermal parameters like wet bulb temperature, dry bulb temperature, globe temperature, relative humidity and humidity index were also found to be significantly ($P<0.05$ or less) higher than that of during melting job.

As mentioned in the Methods and materials (Chapter 5, Section 5.7.3, and Table 5.7.3.A) cut off value of WBGT index is 30 °C (for 25-50% of work) in case of the moderate workers. Above this WBGT level heat stress was can be imposed on the workers (OSHA, 2017).so it can be said that during melting jobs of bell metal processing the workers were exposed to high heat stress (46.3±5.36 °C) and during other processing jobs of bell metal there was no heat stress (29.4±2.63 °C) imposed on the workers.

Table 6.4 I: Thermal parameters recorded during different bell metal processing jobs

Thermal parameters	During bell metal melting job (mean ±SD)	During other processing jobs of bell metal (mean ±SD)
Wet bulb temp ((℃)	36.8±3.37	24.3±1.88**
Dry bulb temp (℃)	51.9±3.89	38.8±4.37**
Globe temp (℃)	65.5±9.58	39.5±5.49**
WBGTi (℃)	46.3±5.36	29.4±2.63**
Relative Humidity (%rh)	2.2±3.1	0.6±4.17*
Humidity Index	76.7±6.91	44.4±4.84**

*P<0.01, **P<0.001

Table 6.4 J: Comparison of Motion stereotype (% of respondents) of the subjects without heat stress and the subjects at higher heat stress for different sets of rotary control -analog display units

Type of display and direction to the subjects	Responses in controlling				Chi square test (level of significance)
	Clock wise response (%)		Anti-clockwise response (%)		
	Subjects work under higher level of heat stress (n=103)	Subjects working without heat stress (n=103)	Subjects work under higher level of heat stress (n=103)	Subjects working without heat stress (n=103)	
horizontal display (move to right)	86.40	100	13.60	0	P<0.001
horizontal display (move to left)	16.50	2.91	83.50	97.09	P<0.001
vertical display (move up)	88.35	97.09	11.65	2.91	P<0.05
vertical display (move down)	23.30	8.74	76.70	91.26	P<0.01
Semicircular display (move clock wise)	87.38	96.12	12.62	3.88	P<0.05
Semicircular display (move anti-clockwise)	10.68	4.85	89.32	95.15	NS

NS-not significant

Comparison of motion stereotype (%) of the subjects without heat stress and the subjects at higher heat stress level for different sets of rotary control-analog display units were represented by **Table 6.4 J.** It was noted that there was a significant difference (P<0.05 or less) in response preference percentages (strength of motion stereotype) between the bell metal workers without heat stress and bell metal workers with high heat stress except for semicircular display (move anti-clockwise instruction) . It was also noted that there was no difference in direction of motion stereotype between these two groups.

Table 6.4 K represented the comparison of motion stereotype (% of respondents) of the subjects no heat stress and the subjects at higher heat stress level for the operation of different sets of rocker switch-electric light units. It was found that there was no significant difference in the direction or strength of stereotype between the both groups.

Table 6.4 K: Comparison of motion stereotype (% of respondents) of the subjects without heat stress and the subjects at higher heat stress for different sets of rocker switch-electric light unit operation

Type of display and instructions to the subjects	Responses in controlling Left/Down%			Chi square test (level of significance)
		Subjects work under higher level of heat stress (n=103)	Subjects without heat stress (n=103)	
Horizontal rocker switch-electric light (on)	Right	51.46	56.31	NS
	Left	48.54	43.69	
Vertical rocker switch (on)	Up	2.72	1.45	NS
	Down	97.28	98.55	

NS- not significant

Table 6.4 L showed that Comparison of Index of Reversibility of the subjects from high heat stress and no heat stress for rotary control analog display units operation. It was noted that the higher index of reversibility was found in the subjects without heat stress than the subjects under higher heat stress.

Table 6.4 L: Comparison of index of reversibility (IR) of the subjects from high heat stress and no heat stress for rotary control analog display units operation

Control-display configurations	Indexes of reversibility (IR) of the subjects at higher heat stress	Indexes of reversibility (IR) of the subjects without heat stress
Rotary control –horizontal display	0.744	0.971
Rotary control –vertical display	0.705	0.889
Rotary control –semicircular display	0.794	0.916

Table 6.4 M: comparison of mean response initiation time (sec) for all control- display unit operation

Control-display configurations	Response initiation time of the subjects at higher heat stress (sec)	Response initiation time of the subjects without heat stress (sec)
Rotary control –horizontal display (move to right)	1.01±0.52	0.6±0.24**
Rotary control –horizontal display (move to left)	0.99±0.54	0.59±0.22**
Rotary control –vertical display (move to up)	1.13±0.58	0.59±0.25**
Rotary control –vertical display (move to down)	1.38±0.77	0.61±0.20**
Rotary control –semicircular display (move clockwise)	0.93±0.43	0.63±0.22**
Rotary control –semicircular display (move anti clockwise)	1.08±0.53	0.63±0.20
Horizontally aligned rocker switch	0.86±0.56	0.71±0.22*
Vertically aligned rocker switch	0.97±0.71	0.60±0.21**

** P<0.001, * P<0.01

Table 6.4 M depicted that the mean response initiation time during operation of each and every control-display units was found to be significantly (P<0.05 or less) lesser in case of the subjects without heat stress than the subjects under higher heat stress level , except for operation of

The preferred response percentages were plotted (**Fig 6.4.1**) against response initiation times of the subjects and it was found that there was a negative linear regression between response initiation time and preferred responses. The preferred response was decreased with the increase rate of response initiation time.

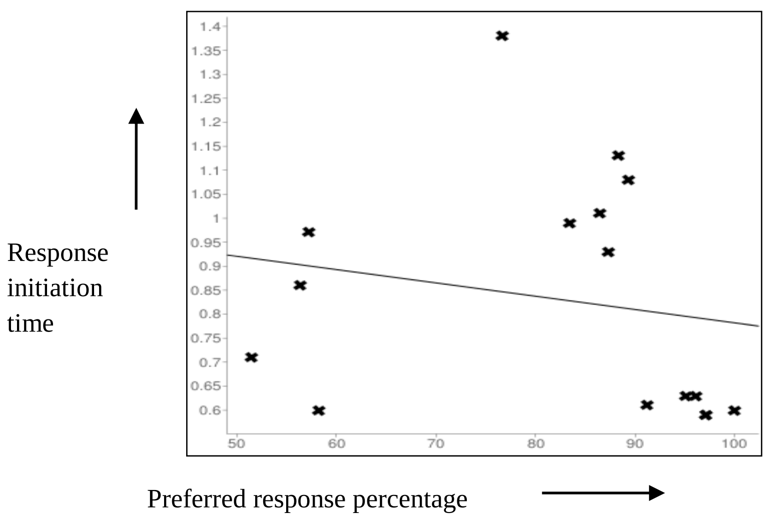

Fig 6.4.1: Average response initiation time vs. preferred response percentage

Discussion: This study revealed the fact that high heat stress level can change the preferred response percentage (strength of motion stereotype) which might be supported by the finding of Kahya (2007) who concluded that human performance is influenced by a vast range of environmental factors in working systems among them heat stress is a common one. Index of reversibility of the bell metal workers was also found to be decreased in case of high heat stress. That means the compatibility between the workers and the control display units were also decreased in heat stress condition. The International Standard for heat stress uses WBGT to recommend work-rest limits for work in hot environments (OSHA, 2017) and suggested that WBGT value of 30 ℃ is the cut off value. Above which value of WBGT, heat stress can be imposed on the moderate workers. In the present study the WBGTi was 46.3 ℃ during bell metal melting job, which causes alteration in strength of motion stereotype. Ramsey and colleagues (1983) in their study found that unsafe work behaviour in a products manufacturing plant and a foundry was minimal within the comfort range of 17–23 ℃ WBGT, but unsafe acts increased significantly at higher temperatures up to 35 ℃ WBGT. Result of this study is matched with the results of the study of Pilcher and colleagues (2002) who concluded that ambient temperature above 32°c led to a significant decline in individual’s cognitive function. Radakovicet and colleagues (2007) showed that heat stress has mild effects on simple physiological performance and significantly effects on complex cognitive task.

In the present study at higher heat stress condition response initiation time of the bell metal workers were found to be increased significantly ($P<0.05$ or less) this finding is corroborated with the findings of another study (Mazloumi et al. 2014) where it was concluded that heat stress can impair reaction time and some of the other cognitive functions. It was found that the higher the preferred response percentage, the lesser the mean response initiation time. The same finding was reported by Chan and Chan (2007). So it could be said that heat stress has a predominant impact on response preference percentage (strength of stereotype) and index of reversibility as well as on response initiation time of the bell metal workers.

Influence of job related psychological stress on motion stereotype of Information technology (IT) office workers (male):

The effects of psychological work stress on motion stereotype were investigated. For this purpose a group of workers from IT industries were selected. The male subjects (n=100) from IT sector were divided into three groups according to level of the job related psychological stress, as discussed in the Methods and materials (chapter 5, section 5.7.2). **Table 6.4 N** depicted that 18% of the subjects were under low psychological stress, 50% were under moderate and 32% subjects were under high psychological stress.

Table 6.4 N: Distribution of the subjects (n=100) according to the OSI (occupational stress index) scores (Srivastava and Singh, 1984)

Level of job related psychological stress	**OSI Score**	**Percentage (%) of subject (n=100)**
Low	46-122	18
Moderate	123-155	50
High	156-230	32

The motion stereotype (%) of the subjects under low, moderate and high levels of job related psychological stress for the operation of rotary control-analog display were represented by Table 6.4 O. It was found that there was no significant difference in direction or strength of motion stereotype among these three groups.

Table 6.4 O: Motion stereotype (% of respondents) of the subjects under low, moderate and high job related psychological stress for the operation of rotary control-analog display

Responses	Job related psychological stress level	Type of display and direction to the subjects							
		horizontal display (move to right)	horizontal display (move to left)	vertical display (move up)	vertical display (move down)	Semi circular display (move clock wise)	Semi circular display(move anti clockwise)	Intensity testing display (increase)	Intensity testing display (decrease)
Clock wise response (%)	Low (n=18)	83.33	33.33	72.22	33.33	88.89	16.67	94.44	11.11
	Moderate (n=50)	90.00	40.00	80.00	40.00	100.00	20.00	92.00	10.11
	High (n=32)	78.13	43.75	68.75	43.75	93.75	21.87	87.50	9.37
Anti clock wise response (%)	Low (n=18)	16.67	66.67	27.78	66.67	11.11	83.33	5.56	88.89
	Moderate (n=50)	10.00	60.00	20.00	60.00	0.00	80.00	8.00	90.00
	High (n=32)	21.87	56.25	31.25	56.25	6.25	78.13	12.5	90.63
Chi square test (level of significance)		NS	NS	NS	NS	NS	NS	NS	NS

Table 6.4 P: Motion stereotype (% of respondents) of the subjects under low, moderate and high job related psychological stress for the operation of different rocker switch-electric light unit operation

Type of display and instructions to the subjects	Responses	Job related psychological stress level			Chi square test (level of significance)
		Low	Moderate	High	
horizontal rocker switch-electric light (on)	Right (%)	77.78	82.00	71.88	NS
	Left (%)	22.22	18.00	28.12	
horizontal rocker switch-electric light (off)	Right (%)	27.78	22.00	28.12	NS
	Left (%)	72.22	78.00	71.88	
Vertical rocker switch- electric light (on)	Up (%)	0.00	0.00	0.00	NS
	Down (%)	100.00	100.00	100.00	
Vertical rocker switch- electric light (off)	Up (%)	94.44	96.00	93.75	NS
	Down (%)	5.56	4.00	6.25	

The motion stereotype (% of respondents) of the subjects under low, moderate and high job related psychological stress for the operation of different rocker switch-electric light unit operation was represented by **Table 6.4 P.** It was found that there was no significant difference in direction or strength of motion stereotype among these three groups.

Table 6.4 Q represented the motion stereotype (% of respondents) of the subjects under low, moderate and high job related psychological stress for the operation of different digital display unit operation. It was shown that there was no significant difference in direction or strength of motion stereotype among these three groups.

Table 6.4 Q: Motion stereotype (% of respondents) of the subjects under low, moderate and high job related psychological stress for the operation of different digital display unit operation

Type of control-display and instruction to the subjects	**Response %**	**Job related psychological stress level**			**Chi square test (level of significance)**
		Low (n=18)	**Moderate (n=50)**	**High (n=32)**	
Digital Display- Rotary switch (increase the number)	Clockwise	88.89	80.00	71.88	NS
	Anti-Clockwise	11.11	20.00	28.12	
Digital Display- Rotary switch (decrease the number)	Clockwise (%)	16.67	12.00	28.12	NS
	Anti-Clockwise	83.33	88.00	71.88	
Digital Display- Horizontally sliding switch (increase the number)	Move to Right	100.00	98.00	93.75	NS
	Move tom Left	0.00	2.00	6.25	
Digital Display- Horizontally sliding switch (decrease the number)	Move to Right	5.56	10.00	12.50	NS
	Move tom Left	94.44	90.00	87.50	
Digital Display- Vertically sliding switch (increase the number)	Move to Up	94.44	98.00	93.75	NS
	Move to Down	5.56	2.00	6.25	
Digital Display- Vertically sliding switch (decrease the number)	Move to Up	11.11	10.00	12.50	NS
	Move to Down	88.89	90.00	87.50	

Table 6.4 R depicted that the comparison of mean response initiation time (ms) of the subjects under Low, moderate and high Job related psychological stress. These three groups showed significantly ($P<0.01$) different mean response initiation time. Subjects under moderate

psychological stress showed shortest mean response initiation time and longest mean response initiation time was noted in high psychological stress.

Table 6.4 R: Mean Response Initiation time (ms) of the subjects under low, moderate and high job related psychological stress for the operation of all the control-display unit operation

Mean Response Initiation time (ms)			F value
Low Job related psychological stress (n=18)	**Moderate Job related psychological stress (n=20)**	**High Job related psychological stress (n=32)**	20.518*
827.3±7.02	801.4±8.05	862.1±13.22	

*P<0.01 w.r.t low and moderate Job related psychological stress

The Index of Reversibility (IR) of the subjects under low, moderate and high job related psychological stress for the operation of all the control-display units were represented in **Table 6.4 S**. It was found that IR values were decreased gradually from low to high psychological stress for all most all the control display unit operation. That means psychological stress decreased compatibility between control-display and the users.

Table 6.4 S: Index of Reversibility (IR) of the subjects under low, moderate and high job related psychological stress for the operation of all the control-display unit operation

Control-display configurations	**Index of reversibility (IR)**		
	Job related low Psychological stress	**Job related moderate Psychologica l stress**	**Job related high Psychologic al stress**
Rotary control –horizontal display	0.611	0.580	0.535
Rotary control –vertical display	0.574	0.560	0.523
Rotary control –semi circular display	0.759	0.800	0.746
Light intensity testing unit	0.846	0.836	0.805
Horizontal rocker switch	0.623	0.679	0.596
Vertical rocker switch	0.944	0.960	0.938
Digital display-rotary switch	0.759	0.728	0.596
Digital display- horizontally sliding switch	0.944	0.884	0.828
Digital display-vertically sliding switch	0.846	0.844	0.828

Discussion: It was found that there is negative linear regression equation produced between response initiation time and preferred response. Preferred response was increased with the decreased rate of response initiation time. So it can be said that quicker response initiation time could be accomplished if there is a high compatibility put up between the control and display unit. This finding is also well matched with the finding of Chan and Chan (2007).

Clockwise to "right", clockwise to "increase", clockwise to clockwise, anti clock wise to "decrease", anti clockwise to "left", anti clockwise to anti clockwise, "right" to "on", "left" to "off", "down" to "on", "up" to "off", right to increase, left to decrease, up to increase and down to decrease stereotypes were found to be dominant for the control-display units tested in this study. These stereotypes were accordance with warrick's principles (1947).

There was no statistically significant difference found among the low, moderate and high stressed groups for the direction and strength of motion stereotype this is may be due to the fact that the subjects were well trained and well adapted in control-display operation, being IT professionals they every day use computers, laptops, mobile phones, personal cars etc. which all has different type of control display unit settings. The response initiation time was found to be significantly ($P<0.01$) different. Shortest response initiation time was found in moderate stressed group. This might be due to the fight-or-flight response, by which our body's sympathetic nervous system reacted to a stressful events, body makes higher amount of the chemicals cortisol, adrenaline and noradrenaline, which in turn trigger higher heart rate and mental alertness which helps to protect ourselves in a stressful situations (Lupen et. al., 2006), so we become more alert and react faster to any stimulus. Davranche et al. (2006) found that due to exercise arousal (state of attention or alertness) increased which improved reaction time. VaezMousavi et. al. (2009)

concluded that among some of the participants reaction time was found to be fastest with an intermediate level of arousal (state of attention or alertness), and declines when the subject is either too much relaxed or too much tensed, while others showed the opposite phenomenon, in general, reaction time tended to get better as arousal increased.

6.5 Impact of spatial arrangement of controls on motion stereotype of adults:

Spatial ability or visuo-spatial ability is the capability to understand reason and memorize the spatial associations among objects or space. There are four general types of spatial abilities which are (i) spatial or visuo-spatial perception, (ii) spatial visualization, (iii) mental folding and (iv) mental rotation (Donnon et al., 2005). Each of these abilities has exclusive properties and significance to many types of tasks. For example, mental rotation is the mental ability to manipulate and rotate 2D or 3D objects in space quickly and accurately (Donnon et al., 2005).Visual-spatial skills are used for everyday use from navigation, understanding or fixing tools, understanding or estimating distance and measurement, and performing a job. Spatial abilities are also essential for achievement in the fields like technical aptitude, sports, natural sciences, mathematics, engineering, physics and chemistry. Spatial abilities not only involve in understanding the external world but also involve in processing the exterior information and analysis it through visual illustration in the brain. Although spatial visualization is often linked with science or mathematics, persons from other professions also need to use spatial visualization skills as a part of their work, like artists and graphic designers, geologists, surgeons, and photographers.

Fig: 6.5.1 and Fig: 6.5.2 showed the orientation of rotary switches on the digital and analog control-display units used for this study. There were rotary switches on the three planes (3 dimensionally) of each unit i.e., Y-Z planes on the both side (right side and left side) X-Z plane and on X-Y plane. The subjects were asked to choose the plane and the clockwise or anti clockwise motion to complete the tasks ("increase the number" / "decrease the number" or "move the indicator clockwise"/move the indicator anticlockwise") assigned to them.

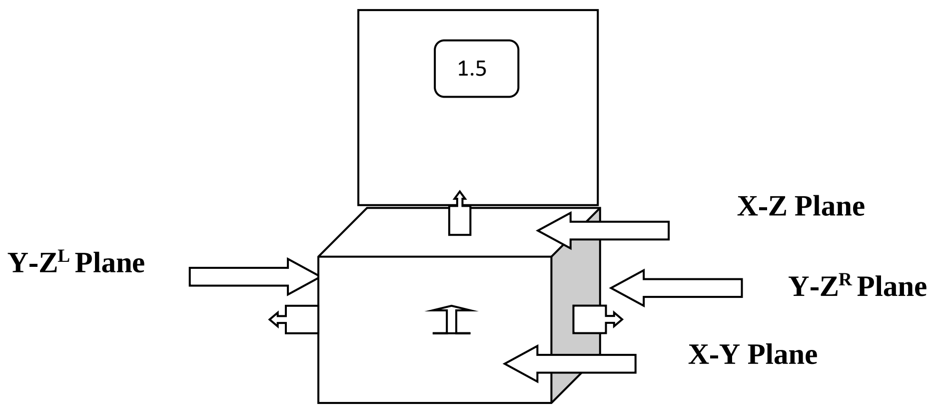

Fig: 6.5.1: Planes where the rotary switches situated on the digital display unit in this study

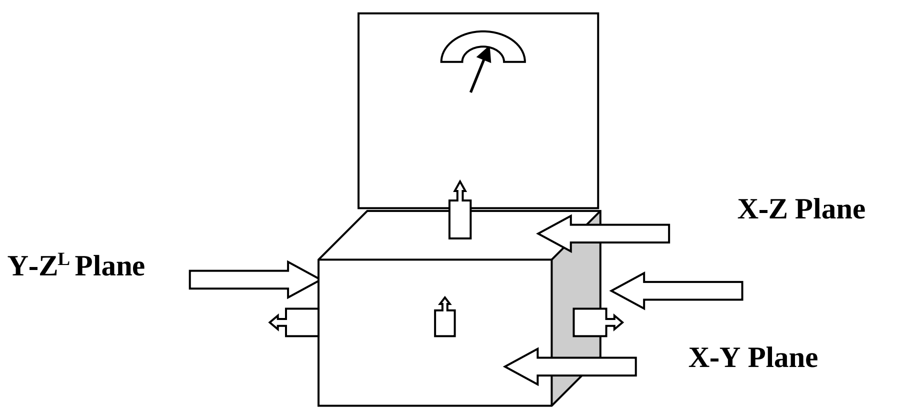

Fig: 6.5.2: Planes where the rotary switches situated on the analog display unit in this study

The direction of motion stereotype of rotary switches which were placed in the chosen position in three dimensional planes (Y-Z^R, Y-Z^L, X-Y, X-Z Plane) for the operation of digital and analog displays were represented by **Table 6.5 A** for adult male and female subjects**.** It was noted that in case of both digital and analog displays to increase the number, and decrease the number majority of the subjects (both sexes) preferred to use the rotary switch situated at Y-Z^R (Y-Z Right) plane. Least chosen plane by the subjects (both sex) was Y-Z^L (Y-Z Left) plane.

Table 6.5 A: Direction of motion and chosen position (Y-Z^R, Y-Z^L , X-Y, X-Z Plane) of rotary switches for the operation of digital and analog display with spatially arranged rotary switches for adult male (n=250) and female (n=250) subjects

Display type and instruction to the subject		Chosen plane by the subjects (%)	Direction of motion stereotype (%)		Chosen plane by the subject (%)	Direction of motion stereotype (%)		Chosen plane by the subject (%)	Direction of motion stereotype (%)		Chosen plane by the subject (%)	Direction of motion stereotype (%)	
		$Y\text{-}Z^R$ Plane	**CW**	**ACW**	**$Y\text{-}Z^L$ Plane**	**CW**	**ACW**	**X-Y Plane**	**CW**	**ACW**	**X-Z Plane**	**CW**	**ACW**
Digital (Increase the number)	**M**	84.80	92.0	8.00	-	-	-	6.00	80.00	20.00	9.20	86.96	13.04
	F	74.80	86.0	14.0	-	-	-	7.20	83.33	16.67	18.00	100	0.00
Digital (Decrease the number)	**M**	72.00	6.00	94.0	-	-	-	12.00	13.34	86.66	16.00	12.50	87.50
	F	80.00	8.00	92.0	-	-	-	12.00	16.67	83.33	8.00	25.00	75.00
Semi circular Analog (move clockwise)	**M**	92.00	96.0	4.00	-	-	-	3.20	87.50	12.50	4.80	83.33	16.67
	F	90.00	92.0	8.00	-	-	-	2.00	100.00	0.00	8.00	95.00	5.00
Semi circular Analog (move anti clockwise)	**M**	86.00	14.0	86.0	-	-	-	4.00	30.00	70.00	10.00	20.00	80.00
	F	82.00	16.0	84.0	-	-	-	8.00	10.00	90.00	10.00	4.00	96.00

Index of Reversibility for the operation of digital and analog display with spatially arranged rotary switches for adult male (n=250) and female (n=250) subjects was represented by **Table 6.5 B.** It was found that overall in a totality (by adding up IR values of digital display-spatially and semi circular display) higher IR values were noted in case of $Y\text{-}Z^R$ plane, that means the compatibility was also maximum in this plane for the studied population.

Table 6.5 B: Index of Reversibility of adult male (n=250) and female (n=250) subjects for the operation of digital and analog display with spatially arranged rotary switches

Display type	Index of reversibility (IR)							
	$Y\text{-}Z^R$ plane		$Y\text{-}Z^L$ plane		X-Y plane		X-Z plane	
	Male	Female	Male	Female	Male	Female	Male	Female
Digital display-spatially arranged rotary switch	0.869	0.803	-	-	0.720	0.722	0.796	0.750
Semi circular display-spatially arranged rotary switch	0.835	0.785	-	-	0.650	0.900	0.700	0.914

The mean response initiation time (ms) of adult male and female subjects for the operation of the digital and analog display with spatially arranged rotary switches has been represented in **Table 6.5 C**. It was found that the mean response initiation time (ms) of the male and female subject for digital and analog display operation were significantly (P<0.001) different. It was also found that the mean Response initiation time (ms) was found to be significantly different (P<0.001) for operating digital and analog display in case of male subjects. Female subjects also showed significant (P<0.001) difference in mean response initiation time for digital and analog display operation. Overall (in case of both analog and digital displays) male subjects showed significantly (P<0.001) shorter response initiation time than their female counter part.

Table 6.5 C: Mean response initiation time (ms) of adult male (n=250) and female (n=250) subjects for the operation of the digital and analog display with spatially arranged rotary switches

Mean Response initiation time (ms)			
Digital display (n=250)		**Analog display**	
Male (n=250)	**Female (n=250)**	**Male (n=250)**	**Female (n=250)**
705.2±36.45	765.5±42.33***	804.6±33.31###	827.3±38.41***$$$

***P<0.001 w.r.t male, ### w.r.t male for digital display, $$$ w.r.t female for digital display

Discussion: Spatial ability is the inborn ability, old studies confirmed that "spatial visualization is basically the ability to control an object or pattern in the mind" (Kahle, 1983), some other researchers reported that "spatial visualization involved in complex, many-step control of spatially provided information" (Linn & Petersen, 1985). The results of the present study suggested that the male subject has significantly ($P<0.001$) shorter i.e., better response initiation time than their female counterpart for operating spatially designed control display units, this finding could be explained by the finding of Michèle and Eliane (2003) who have suggested that men on average have one standard deviation higher spatial intelligence quotient than women, this area is one of the few where clear cut sex variation in cognition come into sight. A study suggests that male superiority in spatial navigation is more likely derived from hormonal differences (Edward et al., 2013). In the present study it was found that the $Y\text{-}Z^{R}$ plane that is the sagittal plane was chosen by the studied population among the three planes and the highest IR value was also noted in case of this plane. This finding is matched well with the findings of Chan and Chan (2007a) who also found strongest IRs in case of plane 2 (as designated in their study) i.e., the sagittal plane. So, the Chinese population was also preferred the same plane for operation of rotary control-display unit, that means it could be said that there was no population related variation in plane selection for rotary control-display operation, however some other population based studies might be helpful to reach at any definite conclusion regarding this.

6. 6 Influence of handedness on motion stereotype:

In any population there are right handed and left handed people. There are many ways to determine right and left handedness of the persons. One of the ways to determine handedness is to assess the grip strength of the hand. In the present study this method was applied for assessing handedness of studied population. **Table 6.6 A.** depicted the frequency and percentage of the right handed and left handed subjects divided according to their hand grip strengths**.** It was noted that 89% of the total subjects were right handed and the rest were left handed. Among them 525 were male and 475 were female. Among the male subjects 87.62% were right handed and 12.38% were left handed. Among the female subjects 90.53% were right handed and 9.47% were left handed.

Table 6.6 A: According to hand grip strength frequency and percentage of left handed and right handed subjects

Total (n=1000)			
Male (n=525)		**Female (n=475)**	
Right hander (n=460)	**Left hander (n=65)**	**Right hander (n=430)**	**Left hander (n=45)**
87.62%	12.38%	90.53%	9.47%

Table 6.6 B depicted the comparison of motion stereotype (%) between right hander and left hander adult subjects (n=1000) for different sets of rotary control- display combinations. It was noted that in the operation of all the rotary control-analog display units there was a significant (p<0.05or less) difference among the right hander and left hander subjects (both sexes) in percentage of response preferences i.e., in stereotype strength. The direction of motion stereotype i.e., the motion stereotype pattern was found to be similar between right hander and left hander subjects. In case of operating rotary switch with horizontal and vertical displays the strength of

stereotype was greater in left handed males and females than that of right handed subjects. On the other hand the strength of stereotype was significantly greater in right handed subjects than that of left handed subjects in case of using semicircular display as well as changing light intensity.

Table 6.6 B. Comparison of motion stereotype (%) between right hander and left hander adult subjects (n=1000) for different sets of rotary control- display combinations

Type of display and direction to the subjects	**Responses in control**							
	Clock wise response (%)				**Anti clock wise response (%)**			
	Male		**Female**		**Male**		**Female**	
	RH (n=460)	**L.H (n=65)**	**RH (n=430)**	**LH (n=45)**	**RH (n=460)**	**LH (n=65)**	**RH (n=430)**	**LH (n=45)**
horizontal display (move to right)	70.43	100.0*	62.33*	86.67#	29.57	0.00	37.67	13.33
horizontal display (move to left)	31.74	0.00	40.23	11.11	68.26	100*	59.77*	88.89#
vertical display (move up)	67.83	98.46*	59.30*	84.44#	32.17	1.54	40.70	4.54
vertical display (move down)	30.00	0.00	23.56	11.11	70.00	100*	76.44*	88.89#
Semi circular display (move clock wise)	90.00	64.62*	84.88*	91.11#	10.00	35.38	15.12	8.89
Semi circular display(move anti clockwise)	8.04	32.31	13.95	13.33	91.96	67.69*	86.05*	86.67#
Intensity testing display (increase)	88.91	61.54*	93.02*	82.22#	11.09	38.46	6.98	17.78
Intensity testing display (decrease)	13.04	40.00	6.98	17.78	86.96	60.00*	93.02**	82.22#

***P<0.05 w.r.t right hander male** ****P<0.01 right hander male** **#P<0.05 w.r.t right hander female**

LH- Left hander
RH- right hander
The results of comparison of motion stereotype (%) between right hander and left hander adult subjects (n=1000) for different sets of digital displays were represented in **Table 6.6 C**. It was shown that there was a significant (P<0.05 or less) difference between right hander and left

hander subjects for response percentage i.e., stereotype strength for all the control-display units viz, rotary switch, horizontally aligned sliding switch, and vertically oriented sliding switch. It was noted that the strength of stereotype was significantly greater in right handed male and female subjects than that of left handed subjects. The direction of motion stereotype or motion stereotype pattern was similar among all the subjects for same control-display.

Table 6.6 C: comparison of motion stereotype (%) between right hander and left hander adult subjects (n=1000) for different sets of digital displays

Type of control-display and instruction to the subjects	**Response (%)**	**Adult**			
		Male		**Female**	
		Right hander (n=460)	**Left hander (n=65)**	**Right hander (n=430)**	**Left hander (n=45)**
Digital Display- Rotary switch (increase the number)	Clockwise	90.00	64.62*	96.05***	84.44# $$$
	Anti-Clockwise	10.00	35.38	3.95	15.56
Digital Display- Rotary switch (decrease the number)	Clockwise	11.09	36.92	6.98 (30)	15.56
	Anti-Clockwise	88.91	63.08*	93.02*	84.44# $$$
Digital Display- Horizontally sliding switch (increase the number)	Move to Right	86.09	58.46*	90.70*	80.00#$$$
	Move tom Left	13.91	41.54	9.30	20.00
Digital Display- Horizontally sliding switch (decrease the number)	Move to Right	5.00	24.62	10.00	6.67
	Move to Left	95.00	75.38*	90.00**	93.33#
Digital Display- Vertically sliding switch (increase the number)	Move to Up	91.96	69.23*	96.05*	88.89#$$$
	Move to Down	8.04	30.77	3.95	11.11
Digital Display-Vertically sliding switch (decrease the number)	Move to Up	10.00	35.38	6.05	8.89
	Move to Down	90.00	64.62*	93.95*	91.11##

***P<0.05 w.r.t right hander male, **P<0.01 right hander male, ***P<0.001 right hander male, #P<0.05w.r.t left hander male, ## P<0.01w.r.t left hander male,** $$$P<0.001 w.r.t right hander female

Table 6.6 D represented the comparison of motion stereotype (%) between the right hander and left hander adult subjects (n=1000) for different sets of rocker switch-electric light combinations From the above results it was revealed that the direction of motion stereotype for the operation of rocker switch with different displays was the same in both left handed and right handed male and female subjects. However the strength of stereotype (preferred response percentage) was different between left and right handed subjects. It may be summarized that the direction of stereotype was the same in both male and female subjects while using rocker switch for on and off response. However, the strength stereotype in male and female subjects was greater in right handed subjects than that of their left handed counterpart.

Table 6.6 D. comparison of motion stereotype (%) between the right hander and left hander adult subjects (n=1000) for different sets of rocker switch-electric light combinations

Type of display and instructions to the subjects	**Response**	**Male**		**Female**	
		Right hander (n=460)	**Left hander (n=65)**	**Right hander (n=430)**	**Left hander (n=45)**
horizontal rocker switch-electric light (on)	Right (%)	90.00	64.62*	95.81**	84.44#$$$
	Left (%)	10.00	35.38	4.19	15.56
horizontal rocker switch-electric light (off)	Right (%)	9.13	33.85	5.12	13.33
	Left (%)	90.87	66.15*	94.88*	86.67#
vertical rocker switch-electric light (on)	Up (%)	3.91	21.54	7.44	6.67
	Down (%)	96.09	78.46*	92.56*	93.33#
vertical rocker switch-electric light (off)	Up (%)	90.00	64.62*	96.05***	84.44#$$$
	Down (%)	10.00	35.38	3.95	15.56

***P<0.05 w.r.t right hander male, **P<0.01 w.r.t right hander male, ***P<0.001 w.r.t right hander male, #P<0.05w.r.t left hander male, $$$ w.r.t right hander female**

Index of reversibility (IR)

Comparison of the index of reversibility (IR) of right hander and left hander adult (1000) subjects for all the control-display configurations tested in this study was represented by **Table**

6.6 E. It was showed that for right hander male subjects the highest value of IR was found for vertically aligned rocker switch-electric light combination and the lowest value of IR was found for rotary control-vertical display. For right hander female subjects the highest IR was found for horizontally aligned rocker switch-electric light combination and the lowest IR was found for Rotary control –horizontal display. For left hander male subjects the highest IR was found for Rotary control –horizontal display and the lowest IR was noticed for Rotary control-light intensity display. For left hander female subjects the highest IR was found for digital display-vertically sliding switch and the lowest IR was found for combination of digital display-horizontally sliding switch.

From the results it appeared that the index of reversibility (IR) was higher in left handed male and female subjects than that of right handed subjects only in cases of rotary switch with horizontal and vertical displays. The same trend was noted in female subjects using circular display. In other combinations of control -display the right handed subjects showed higher values of IR.

Table 6.6 E. Comparison of the index of reversibility (IR) of right hander and left hander adult (1000) subjects for all the control-display configurations tested in this study

Control-display configurations	**Indexes of reversibility (IR)**			
	Male		**Female**	
	RH (n=460)	**LH (n=65)**	**RH (n=430)**	**LH (n=45)**
Rotary control –horizontal display	0.575	1.000	0.524	0.785
Rotary control–vertical display	0.571	0.985	0.550	0.768
Rotary control –circular display	0.836	0.552	0.751	0.801

Rotary control-light display	0.788	0.523	0.870	0.708
Horizontally aligned rocker switch-electric light	0.827	0.547	0.911	0.753
Vertically aligned rocker switch-electric light	0.869	0.583	0.892	0.799
Digital display-rotary switch	0.811	0.538	0.896	0.737
Digital display- horizontally sliding switch	0.825	0.543	0.826	0.680
Digital display-vertically sliding switch	0.755	0.556	0.905	0.820

Table 6.6 F represented the percent difference of IR of all the adult left hander and right hander subjects for all the control-display units. It was noted that there was percent difference of IR up to 53.97% between right hander and left hander subjects. It was revealed the amount of IR among the right hander subjects was greater than that of the left hander subjects by about 9.86% to 53.97% in different configurations of controls and displays. In case of male subjects handedness difference was greater in comparison to their female counterpart.

Table 6.9 F: Percent (%) difference of IR of right hander and left hander subjects for all the control-display configurations tested in this study

Percent (%) difference of IR between right hander and left hander subjects		
Control-display configurations	**Right hander male vs. left hander male**	**Right hander female vs. left hander female**
Rotary control –horizontal display	53.97%	39.88%
Rotary control–vertical display	53.21%	33.08%
Rotary control –circular display	40.92%	6.44%
Rotary control-light display	40.43%	20.53%
Horizontally aligned rocker switch-electric light	40.76%	18.99%
Vertically aligned rocker switch-electric light	39.39%	10.99%
Digital display-rotary switch	40.47%	19.47%
Digital display- horizontally sliding switch	41.23%	19.39%
Digital display-vertically sliding switch	30.36%	9.86%

Response Time

The mean Response Time of the right handed and left handed male and female subjects for the operation of all the control display units were represented by **Table 6.6 G.** It was found that right handed male showed 786.2 ms mean response initiation time while right handed females showed 744.1 ms mean response initiation time. There was a significant (P<0.001) difference among right handed male and female in this regard. Left handed male showed a mean response initiation time of 703.4 ms and that of female showed 728.3 ms which represented a significant (P<0.001) difference between them. Right handed male and left handed male also showed significant (P<0.001) difference in mean response initiation time. The same trend was seen among right hander female and left hander female also.

It may be summarized that left handed subjects, both male and female, had significantly better response initiation time than that of their right handed counterpart. It was also noted that right handed females had lesser response initiation time than that of males.

Table 6.6 G: Mean Response Time (ms) of the right hander and left hander subjects for the operation of all the control display units

Mean Response Initiation time (ms)			
Male		**Female**	
RH (n=460)	**LH (n=65)**	**RH (n=430)**	**LH (n=45)**
786.2 ±54.44	703.4 ±42.34***	744.1 ±67.87***	728.3 ±44.32###$$$

***P<0.001 w.r.t right handed male, ###P<0.001 w.r.t left handed male, $$$ P<0.001w.r.t right handed female

Discussion: The population drawn in the present study showed that a very small percentage (11%) of the population was left handed, this finding is corroborated with the finding of Franklin (2008) and Mandal and Dutta (2001) who concluded in their study that left hand is chosen by a small number of people in the population. Mandal and Dutta (2001), after conducting a chain of studies reported that near about 10% humans population is left-handed, but the occurrence rate differ depending on, age, sex and cultural or geographical variations.

In the present study it was found that for all the aspects of motion stereotype (stereotype strength, index of reversibility and response initiation time) except the direction of stereotype, left and right handed (both male and female) subjects showed significant variations. These variation in cognitive performance may be supported by the conclusion drawn regarding difference in cognitive ability among the right handed and left handed individuals, by the others studies done all over the world, like there is variation in left-handers and right handers in smartness factors (Faurie et al., 2006; Ghayas & Adil, 2007), variation also seen in departments like foreign language learning i.e., in skillfulness and rapidity. Spatial perception skills are also different among them, creativity and visual memory is also different between right and left handed (Kopiez & Sommer, 1999; Kõve, 1997) people. In case of flexibility and their capability of switching over their hands for performing tasks, rapidity in thinking when playing computer games or sports (Pawlik-Kienlen, 2008) there are also some prominent variation between right and left handed subjects.

The rate of left-handedness may differ within a range of 4% to16%, maybe for biological, cultural or estimation basis (Perelle and Ehrman, 1994). Left-handers should not be scientifically excluded as subjects from research works in cognitive studies (Willems et al., 2014). Either the right or the left hemisphere of brain can be dominant for motor function, ensuing in either left or right-handedness; it appears to be an issue of natural variation (Gutwinski et al., 2011). Left-handedness is mostly found in men than in women (McKeever, 2000; Raymond et al., 1996; McManus, 1991), finding of the present study also supports this fact. Numerous studies have revealed the fact that corpus callosum of left-handers is generally found to be larger (Luders et al, 2010; Witelson, 1985; Beaton, 1997) which may be an indication of better inter-hemispheric connectivity. This connectivity may be linked with some cognitive skills, like fluency in language, retentiveness (Hines et al., 1992; Christman and Propper, 2001), better performance in attention and memory related tasks (Chaudhary, 2009). Better inter-hemispheric connectivity in left-handers helps them score above 131 in IQ test and to have outstanding mathematical skills (Casey et al., 1992; Crow et al., 1998; Hicks and Dusek, 1980). Left-handedness is common among talented musicians (Aggleton et al., 1994; Kopiez et al., 2006), may be partially because they are better at using both hands at a time (Judge and Stirling, 2006). In addition, left-handedness is very common among successful sportspersons, predominantly in one-on-one games like tennis, judo, baseball, fencing and boxing (Annett, 1985; Raymond, 1996; Voracek, 2006). There is variation in learning styles between right-handers and left-handers (Chaudhary, 2009). Superior inter-manual harmonization (Gorynia and Egenter, 2000; Judge and Stirling, 2003) is also found among the left-handers.

The present study showed that mean response initiation time is lesser in left handed subjects than the right handed subjects (both in case of male and female) this finding is corroborated with the finding of previous studies which have suggested that there is an inborn advantage for the left-handers in reaction time (Dane and Erzurumluoglu, 2003; Al-Hashel et al., 2016). This difference might be caused by a scientific reason which was suggested by Takeda and colleagues (2010) who suggested that the variation in the response time between left handed and right handed people depends on a laterality equilibrium of hand motor abilities.

So it may might be said that the stereotype strength ($P<0.01$ or less), index of reversibility and response initiation time ($p<0.01$ or less) were found to be significantly different between right hander and left hander subjects for operation of all the control display units.

6.7 Impact of socio economic status on motion stereotype of adults:

The selected adult subjects (n=5228) of the present study were classified according to modified B. G. Prasad Socio-economic scale (Singh et. al, 2017), as presented in **Table 6.7 A.** It was noted from the results that the largest percentage of subjects were belonging to lower middle class (41.6%) followed by the Social middle class (36.8%). The lowest percentage of subjects was found in the upper class. No subject was belonged to the lower class.

Table6.7 A: Classification of the adult (n=5228) subjects according to modified B. G. Prasad Socio economic scale (Singh et. al, 2017)

Social class	% of subjects		% of subjects in each class
	Male	Female	
Upper class	6.92	8.37	7.66
Upper middle class	14.58	13.32	13.94
Middle class	36.27	37.29	36.78
Lower middle class	42.23	41.02	41.62
Lower class	-	-	-

Motion Stereotype of Adult males:

Table 6.7 B showed the variation in Motion stereotype response (%) of the adult male subjects (n=2600) from different social class for Rotary control-Analog display operation of. It was found that there was a significant (P<0.01 or less) association between the socioeconomic status or social class and motion stereotype percentage but there was no significant difference found in the direction of motion stereotype of male subjects from different social class. Significant difference of stereotype strength was found between and within almost all the social classes.

Table 6.7 B: Variation in motion stereotype (% of respondents) of the adult male subjects (n=2600) from different social class for Rotary control-Analog display operation

Responses	Social class	Type of display and direction to the subjects							
		horizontal display (move to right)	horizontal display (move to left)	vertical display (move up)	vertical display (move down)	Semi circular display (move clock wise)	Semi circular display(move anti clockwise)	intensity testing display (increase)	intensity testing display (decrease)
Clock wise response (%)	Upper (n=180)	88.33	2.78	80.56	11.11	94.44	5.56	88.89	23.33
	Upper middle (n=379)	89.71	22.43	76.52	23.48	87.07***	15.57	89.71	26.12
	Middle (n=943)	76.35*** ###	21.53	79.53	25.98	81.65***# #	16.22	79.22***# ##	20.78
	Lower middle (n=1098)	79.23 ***###$ $$	26.59	72.86* *##$$	18.31	80.05***# ##$$$	18.67	76.41** *###$$$	27.78
Anti clock wise response (%)	Upper (n=180)	11.67	97.22	19.44	88.89	5.56	94.44	11.11	76.67
	Upper middle (n=379)	10.29	77.57 ***	23.48	76.52 ***	12.93	84.43** *	10.29	73.88
	Middle (n=943)	23.65	78.47 ***	20.47	74.02 ***	18.35	83.78** *	20.78 (196)	79.22 ##
	Lower middle (n=1098)	20.77	73.41 ***### $$$	27.14	81.69 ***### $$$	19.95	81.33** *###	23.59 (259)	72.22* *$$

***P<0.001 w.r.t social upper class, **P<0.01 w.r.t social upper class, ###P<0.001 w.r.t upper middle class, ## P<0.01 w.r.t upper middle class, $$$P<0.001 w.r.t middle class, $$P<0.01 w.r.t middle class

Table 6.7 C depicted the variation in motion stereotype (% of respondents) of adult male (n=2600) subjects from different social class for rocker switch- electric light unit operation. it was noted that there was a significant (P<0.01 or less) association between the socioeconomic status or social class and motion stereotype percentage but there was no difference in direction of motion stereotype among the male subjects from different social class for different rocker switch electric light operation

Table 6.7 C: Variation in motion stereotype (% of respondents) of adult male (n=2600) subjects from different social class for all the rocker switch- electric light unit operation

Type of display and instructions to the subjects	**horizontal rocker switch-electric light (on)**		**horizontal rocker switch-electric light (off)**		**vertical rocker-electric light switch (on)**		**vertical rocker-electric light switch (off)**	
Responses	Right %	Left %	Right %	Left %	Up%	Down %	Up%	Down %
Upper class (n=180)	72.22	27.78	33.33	66.67	18.33	81.67	86.11	13.89
Upper middle class (n=379)	73.88	26.12	31.40	68.60	20.84	79.16	81.79	18.21
Middle class (n=943)	68.93*#	31.07	32.13	67.87	19.83	80.17	85.37#	14.63
Lower middle class (n=1098)	62.84***##$$$	37.16	38.07	61.93*#$	24.41	75.59*#$	79.23**##$$$	20.77

***P<0.001w.r.t upper class, **P<0.01 w.r.t upper class, *P<0.05w.r.t upper class, #P<0.05, ##P<0.01 and ###P<0.001 w.r.t upper middle class, $P<0.05 and $$$P<0.001 w.r.t middle class

Index of reversibility (IR) of the adult male (n=2600) subjects from different social class for all the control-display units operation has been represented by **Table 6.7 D.** It was found that IR value gradually decreased in all most all the control display unit operation from upper class towards lower middle class. **Table 6.7 E represented the percent difference of IR** of all the adult male subjects **between different social classes** for all the control-display units. It was noted that there was percent difference of IR up to 34.56% between each and every social classes for the male subjects. Highest percentage difference in IR values was noted between Lower middle class and upper class and lowest percentage difference was noted between upper middle class and middle class.

Table 6.7 D: variation in Index of reversibility (IR) of the adult male (n=2600) subjects from different social class for all the control-display units operation

Control-display configurations	**Index of reversibility (IR)**			
	Upper class (n=180)	**Upper middle class (n=379)**	**Middle class (n=943)**	**Lower middle class (n=1098)**
Rotary control –horizontal display	0.862	0.719	0.650	0.608
Rotary control –vertical display	0.738	0.641	0.642	0.645
Rotary control –semi circular display	0.895	0.755	0.714	0.688
Rotary control-light intensity testing display	0.707	0.690	0.671	0.617
horizontal rocker switch-electric light display	0.574	0.589	0.557	0.531
vertical rocker switch- electric light display	0.729	0.685	0.713	0.650

Table 6.7 E: Percent difference of IR of all the adult male (n=2600) subjects among different social classes for all the control-display units

Percent (%) difference of IR among different social classes						
Control-display configurations	**Upper class vs. upper middle class**	**Upper middle class vs. middle class**	**Middle class vs. lower middle class**	**Lower middle class vs. upper class**	**Upper class vs. middle class**	**Upper middle class vs. lower middle class**
Rotary control – horizontal display	18.09	10.08	6.68	34.56	28.04	16.73
Rotary control – vertical display	14.07	0.16	0.47	13.45	13.91	0.62
Rotary control – semi circular display	16.97	5.58	3.71	26.15	22.50	9.29
Rotary control-light intensity testing display	2.43	2.79	8.39	13.60	5.22	11.17
horizontal rocker switch-electric light display	2.58	5.58	4.78	7.78	3.01	10.36
vertical rocker switch- electric light display	6.22	4.01	9.24	11.46%	2.22	5.24

The mean response initiation time of adult male (n=2600) subjects from different social class during operation of all control display units has been presented in Table 6.7 F. longest response initiation time (722.2 ms) was found among the subjects from lower middle class and the shortest RIT (714.3 ms) was found among the upper class. The ANOVA results showed that the mean response initiation time of these four social classes were significantly (P<0.01) different. The results depicted that the mean response initiation time of the adult male subjects was gradually increased from upper class towards lower middle class. Thus it appeared that the performance of upper class was the best among all the social classes.

Table 6.7 F: Mean response initiation time (ms) of adult male (n=2600) subjects during operation of all control display units

Mean Response Initiation time (ms)				**F-value**
Upper class (n=180)	**Upper middle class (n=379)**	**Middle class (n=943)**	**Lower middle class (n=1098)**	14.006*
714.3 ±32.45	717.2 ±27.22	719.1 ±18.74	722.2 ±10.22	

*P<0.01

Motion Stereotype of Adult females:

Table 6.7 G represented the variation in motion stereotype (% of respondents) of the adult female (n=2628) subjects from different social class for Rotary control-Analog display operation. It was noted that for each and every control-display operation there was a significant (P<0.01 or less) association between socioeconomic status or social class and the stereotype percentage but there was no difference was noted in direction of motion stereotype of the females from different social class. It was also noted that significant (P<0.01 or less) difference found in motion stereotype percentage (stereotype strength) between and within different all most all the social classes.

Table 6.7 G: Variation in motion stereotype (% of respondents) of the adult female (n=2628) subjects from different social class for rotary control-Analog display operation

Responses	**Social class**	**Type of display and direction to the subjects**							
		Horizontal display (move to right)	Horizontal display (move to left)	Vertical display (move up)	Vertical display (move down)	Semi circular display (move clock wise)	Semi circular display(move anti clockwise)	intensity testing display (increase)	intensity testing display (decrease)
Clock wise response (%)	Upper class (n=220)	81.82	25.45	79.55	13.64	86.36	20.91	89.09	15.91
	Upper middle class (n=350)	71.43**	34.29	65.71**	25.71	70.00###	30.00	74.29###	25.71
	Middle class (n=980)	71.43***	28.57	71.43**#	15.31	79.59##$$$	25.51	74.49###	25.51
	Lower middle class (n=1078)	69.11***	32.28	69.48**###	19.39	78.85***###$$$	29.50	76.07***###	28.11
Anti clock wise response (%)	Upper class (n=220)	18.18	74.55	20.45	86.36	13.64	79.09)	10.91	84.09
	Upper middle class (n=350)	28.57	65.71#	34.29	74.29***	30.00	70.00#	25.71	74.29**
	Middle class (n=980)	28.57	71.43$	28.57	84.69###	20.41	74.49$	25.51	74.49***
	Lower middle class (n=1078)	30.89	67.72*#	30.52	80.61***##$$$	21.15	70.50*##	23.93	71.89**###

*P<0.05, ** P<0.01, ***P<0.001 w.r.t Upper class, #P<0.05, ##P<0.01 and ###P<0.001 upper middle class $P<0.01, $$P<0.01 and $$$ P<0.001 w.r.t middle class, @P<0.05 w.r.t social class III

Variation in motion stereotype (% of respondents) the adult female subjects (n=2628) from different social class for rocker switch- electric light unit operation (on / off response) has been shown in **Table 6.7 H.** It was observed that there was a significant (P<0.01 or less) association between socioeconomic status or social class and the stereotype percentage (stereotype strength) but no difference was noted in direction of motion stereotype among the adult females from different social class. It was also noted that in all most all the rocker switch operation there was significant (P<0.05 or less) within and between the females from each and every social class.

Table 6.7 H: Variation in motion stereotype (% of respondents) of the adult female (n=2628) subjects from different social class for all the rocker switch- electric light unit operation

Type of display and instructions to the subjects	**horizontal rocker switch (on)**		**horizontal rocker switch (off)**		**vertical rocker switch (on)**		**vertical rocker switch (off)**	
Responses	Right (%)	Left (%)	Right (%)	Left (%)	Up (%)	Down (%)	Up (%)	Down (%)
Upper class (n=220)	84.09 (185)	15.91 (35)	38.64 (85)	61.36 (135)	9.09 (20)	90.91 (200)	90.91 (200)	9.09 (20)
Upper middle class (n=350)	84.29** (260)	25.71 (90)	48.57 (170)	51.43 (180)	14.29 (50)	85.71# (300)	91.43 (320)	8.57 (30)
Middle class (n=980)	74.49***### (730)	25.51 (250)	50.00 (490)	50.00## (490)	13.27 (130)	86.73## (850)	86.73 ##$$ (850)	13.27 (130)
Lower middle class (n=1078)	71.89**### (775)	28.11 (303)	47.12 (508)	52.88*# (570)	16.42 (177)	83.58**### (901)	85.81 (925) *### $$$	14.19 (153)

*P<0.05 w.r.t upper class, ** P<0.01 w.r.t upper class, #P<0.05 w.r.t upper middle class, ##P<0.01 w.r.t upper middle class, ###P<0.001 w.r.t upper middle class, $$P<0.01 w.r.t middle class and $$$ P<0.001 w.r.t middle class

Index of reversibility (IR) of all the adult female (n=2628) subjects from different social class for all the control-display units operation has been represented in **Table 6.7 I.** It was noted that comparatively higher IR values found in upper class for all control display units operation of female subjects from all the social class.

Table 6.7 I: Index of reversibility (IR) of all the adult female (n=2628) subjects from different social class for all the control-display units operation

Control-display configurations	Index of reversibility (IR)			
	Upper class (n=220)	**Upper middle class (n=350)**	**Middle class (n=980)**	**Lower middle class (n=1078)**
Rotary control –horizontal display	0.656	0.567	0.592	0.568
Rotary control –vertical display	0.715	0.576	0.649	0.619
Rotary control –semi circular display	0.712	0.580	0.645	0.618
Rotary control-light intensity testing display	0.767	0.618	0.620	0.614
horizontal rocker switch- electric light display	0.577	0.507	0.500	0.513
vertical rocker switch- electric light display	0.835	0.796	0.770	0.740

Table 6.7 J represented the percent difference of IR values of all the adult female subjects between different social classes for all the control-display units operation. It was noted that there was percent difference of IR up to 22.16% between each and every social classes of the female subjects. Highest percentage difference in IR values was found between the subjects from upper class and upper middle class. Lowest percentage difference in IR values was found between middle class and lower middle class.

Table 6.7 J: Percent (%) difference of IR values of all the adult female (n=2628) subjects between different social classes for all the control-display units operation

Percent (%) difference of IR between different social classes						
Control-display configurations	**Upper class vs. upper middle class**	**Upper middle class vs. middle class**	**Middle class vs. lower middle class**	**Lower middle class vs. upper class**	**Upper class vs. middle class**	**Upper middle class vs. lower class**
Rotary control – horizontal display	14.55	4.31	4.14	14.38	10.27	0.18
Rotary control – vertical display	21.53	11.92	4.73	14.39	9.68	7.20
Rotary control – semi circular display	20.43	10.61	4.28	14.14	9.87	6.34
Rotary control- light intensity testing display	21.52	0.32	0.97	22.16	21.20	0.65
horizontal rocker switch-electric light display	12.92	1.39	2.57	11.74	14.30	1.18
vertical rocker switch- electric light display	4.78	3.32	3.97	12.06	8.10	7.29

The comparison of mean response initiation time of all the female subjects from different social class was represented by **Table 6.7 K.** It was found that subjects from upper class showed shortest mean RIT **(**810.2 ms) and longest mean RIT was found in the subjects from lower middle class (821.4 ms). It was found that the mean response initiation time of these four social classes were significantly (P<0.01) different. Like male adult subjects female subjects also showed gradually increased RIT with the changes of upper class to lower middle class.

Table 6.7 K: Comparison of mean response initiation time (ms) of the female subjects from all the social class for operation of all the control display units

Mean Response Initiation time (ms)				F value
Upper class (n=220)	**Upper middle class (n=350)**	**Middle class (n=980)**	**Lower middle class (n=1078)**	27.917*
810.2±42.33	811.1±35.65	819.2±19.45	821.4±12.33	

*P<0.01

Discussion: The majority (41.62%) of the subjects of the present study is from lower middle class and only 7.66% subjects are from upper class. From the results it was noted that the there was a significant association between the socioeconomic status (in case of both sex) and stereotype strength that means they are dependent on or related to each other. Mean response initiation time was also significantly different among the four social classes (for both sexes), it was noted that upper class has the shortest response initiation time and lower middle class has the longest (for both sexes), interestingly mean response initiation time was noted to increase from upper class to lower middle class. Strength of IR was also found to be different for each social class (for both sexes). These variation in cognitive functions of the subjects for variation in SES may be supported by the findings of some other studies like, Duncan and Magnuson (2012) who concluded that experimental and quasi-experimental studies concerning manipulation of family income which is an important factor for prediction of socioeconomic status, have confirmed steady links with a number of cognitive functions, socio Economic Status was strongly associated with the level of hemispheric specialization in Broca's area (Raizada et al., 2008). Subjects from low Socioeconomic conditions perform below than the subjects of higher socioeconomic background in aptitude tests and academic achievements (Duncan et al., 1994; Bradley and Corwyn, 2002). Subjects from low Socioeconomic backgrounds are also more likely to fail in courses and drop out of school than the high Socioeconomic group (McLoyd, 1998), aptitude tests and academic success clearly reflects person's cognitive skills. Interventions aiming to make children's home atmosphere more favorable for cognitive development, showed that higher SES households portrayed more progress than the lower SES ones (Bakermans-Kranenburg et al., 2005). , SES usually consists of a number of components, each of which represents separate resources that might help in children's cognitive development in distinct ways (Duncan and Magnuson, 2003). Economic disadvantage damages cognitive development by two different ways, the quality of family relationships (Chase-Lansdale and Pittman, 2002; McLoyd, 1990; McLoyd et al., 1994) and allostatic load, (Evans et al., 2007) which is a biological index. Low socioeconomic background is related to minor cognitive ability (Mani, Mullainathan, Shafir, & Zhao, 2013; Spears, 2011) but some other studies showed that the poor people are not less cognitively able but they are the victims of their own pessimistic point of view, they believe they are not enough good which would trim down the mental resources and has a negative impact on the cognitive performance (Hall, Zhao, & Shafir, 2014; Haushofer & Fehr, 2014). Studies showed that the poor people are more rational than the rich people (Hall, 2008; Shah, Shafir, & Mullainathan, 2015; Spears, 2013). Childhood socioeconomic status (SES) is associated with cognitive achievement throughout life, SES is a vital forecaster of neurocognitive performance, chiefly in language and executive function, SES differences are also found in neural processing (Hackman and farah, 2009). SES may have a selective impact on hippocampal-prefrontal-dependent working memory and slight impact on striatal-dependent technical memory (Leonard et al., 2015). Higher SES is associated with higher level of cognitive performance (Gottfried et al., 2003; Sirin, 2005). Cognitive functions like language (Fernald et al., 2013; Hoff, 2013), executive work ability (EF; Lawson et al, 2017; Raver et al., 2013) and memorizing ability varies with SES (Noble et al., 2015; Markant et al., 2016). Brain activity varied by SES (Demir et al., 2015) measured by parental education level and profession. Adult SES decides the relationship between childhood SES and cognitive functions (Lyu and Burr, 2015). Not only the lowest stratum but all levels of SES affect emotional and cognitive development to varying degrees (Adler and Rehkopf, 2008; Duncan et al., 1994; Noble et al., 2007; Sirin, 2005). There are reasonable impact of SES on declarative memory of a person and spatial cognition (Noble et al., 2007; Farah et al., 2006; Levine et al., 2005). So it is evident that socioeconomic status has predominant impact on cognitive skills.

6.8 Impact of Education Level on motion stereotype:

Educational status is the educational attainment or level of education of individuals. Education level may be related to the cognitive ability of the people. The present study was designed to know whether the education level was associated with the motion stereotype pattern of the subjects. For this view the studied population was divided into five categories, viz., illiterate, primary educated, secondary educated, graduate and post graduate and above.

Classification of the selected adult subjects (n=5228) according to their educational level was shown in **Table 6.8 A.** It was noted that all over majority of the subjects had secondary education. While only 10.65 % subjects had highest level of education (post graduate and above). Percentage of illiterate subjects was higher in females than in males. Majority of the male subjects had secondary level education but majority of the female subjects had primary level education.

Table 6.8 A: Classification of the adult (n=5228) subjects according to their educational level

Education Level	Percentage		General Percentage
	Male	Female	
Illiterate	19.23	27.40	23.34
Primary	19.23	23.14	21.20
Secondary	26.92	20.40	23.64
Graduate	23.08	19.29	21.17
Post graduate and above	11.54	9.78	10.65

Table 6.8 B represented the variation in motion stereotype (% of respondents) the adult male (n=2600) subjects from different education levels for Rotary control-Analog display operation. It was noted that Chi square test showed a significant ($P<0.001$) difference in the stereotype percentage (stereotype strength) among all the groups for each and every control-display unit operations. But there was no difference in the direction of motion stereotype among the subjects

from different education levels. In general it was noticed that in all most all the cases, percentage of respondents was found to increase gradually with the increase of education level for the clockwise response of the rotary control for operating all combination of control-display units. Similarly, in case of anticlockwise response the same trends of results were obtained.

Table 6.8 B: Variation in motion stereotype (% of respondents) of the adult male (n=2600) subjects from different education levels for Rotary control-Analog display operation

Responses	**Education level**	**Type of display and direction to the subjects**							
		horizontal display (move to right)	horizontal display (move to left)	vertical display (move up)	vertical display (move down)	Semi circular display (move clock wise)	Semi circular display(move anti clockwise)	Light display (increase)	Light display (decrease)
Clock wise response (%)	Illiterate (n=500)	60.00	40.00	62.00	34.20	70.00	30.00	69.20	32.40
	Primary (n=500)	70.00	30.00	69.80	24.00	80.00	20.00	78.00	28.00
	Secondary (n=600)	88.33	13.33	81.67	16.67	86.67	11.67	83.33	21.67
	Graduation (n=700)	92.86	16.00	82.86	17.14	86.43	11.57	82.86	21.43
	Post Graduation and above (n=300)	85.33 ***	14.67	85.33 ***	14.67	91.33 ***	8.67	90.00 ***	20.00
Anti clock wise response (%)	Illiterate (n=500)	40.00	60.00	38.00	65.80	30.00	70.00	30.80	67.60
	Primary (n=500)	30.00	70.00	30.20	76.00	20.00	80.00	22.00	72.00
	Secondary (n=600)	11.67	86.67	18.33	83.33	13.33	88.33	16.67	78.33
	Graduation (n=700)	7.14	84.00	17.14	82.56	13.57	88.43	17.14	78.57
	Post Graduation and above (n=300)	14.67	85.33 ***	14.67	85.33 ***	8.67	91.33 ***	10.00	80.00 ***

*****P>0.001**

Variation in motion stereotype (% of respondents) of the adult male (n=2600) subjects for rocker switch- electric light unit operation was depicted by **Table 6.8 C.** Chi square test results showed that there was a significant (P<0.001) difference found in the motion stereotype percentage (stereotype strength) among all the five groups for each and every control-display unit operations but the direction of motion stereotype of the subjects from different education levels was found to be constant or similar. So basically in case of the adult male it was found that the stereotype strength of the subjects increased with the increase in education level for the operation of vertical and horizontal rocker switch with electric light displays.

Table 6.8 C: Variation in motion stereotype (% of respondents) the adult male (n=2600) subjects from different education level for rocker switch- electric light unit operation

Type of display and instructions to the subjects		horizontal rocker switch-electric light (on)		horizontal rocker switch-electric light (off)		vertical rocker switch-electric light (on)		vertical rocker switch-electric light (off)	
Responses		Right %	Left %	Right %	Left %	Up%	Down %	Up%	Down %
Education level	Illiterate (n=500)	60.00 (300)	40.00 (200)	44.00 (220)	56.00 (280)	40.00 (200)	60.00 (300)	60.00 (300)	40.00 (200)
	Primary (n=500)	62.00 (310)	38.00 (190)	40.00 (200)	60.00 (300)	25.40 (127)	74.60 (373)	85.80 (429)	14.20 (71)
	Secondary (n=600)	70.00 (420)	30.00 (180)	31.67 (190)	68.33 (410)	16.67 (100)	83.33 (500)	86.50 (519)	13.50 (81)
	Graduation (n=700)	71.43 (500)	28.57 (200)	28.57 (200)	71.43 (500)	14.29 (100)	85.71 (600)	88.71 (621)	11.29 (79)
	Post Graduation and above (n=300)	73.33 (220) ***	26.67 (80)	30.00 (90)	70.00 (210) ***	13.33 (40)	86.67 (260) ***	90.33 (271) ***	9.67 (29)

*****P<0.001**

Mean response initiation time (ms) of adult male (n=2600) subjects from different education levels, during operation of all control display units was represented in **Table 6.8 D**. There was a significant (P<0.001) difference in mean response initiation time found among the five groups. It was noted that the mean response time of the subjects for operating control display units was gradually decreased with the increase of education level. Thus results indicated that the education level had an influence for the improvement of response initiation time of the subjects

Table 6.8 D: Mean response initiation time (ms) of adult male (n=2600) subjects during operation of all control display units

Mean Response Initiation time (ms)					**F value**
Education level					
Illiterate (n=500)	**Primary (n=500)**	**Secondary (n=600)**	**Graduate (n=700)**	**Post graduate and above (n=300)**	112.22 *
722.2 ±16.32	718.3 ±20.13	710.7 ±12.43	706.3 ±10.22	703.4 ±24.44	

*P<0.01

The Index of reversibility (IR) of the adult male (n=2600) subjects for from different education levels for all the control-display units operation was depicted by **Table 6.8 E.** It was noted that IR was gradually increased from lower to higher education levels in most of the control-display operation.

Table 6.8 E: The Index of reversibility (IR) of the adult male (n=2600) subjects from different education levels for all the control-display units operation

Control-display configurations	**Indexes of reversibility (IR)**				
	Education level				
	Illiterate (n=500)	**Primary (n=500)**	**Secondary (n=600)**	**Graduate (n=700)**	**Post graduate and above (n=300)**
Rotary control-horizontal display	0.520	0.580	0.781	0.791	0.750
Rotary control-vertical display	0.538	0.603	0.711	0.716	0.750
Rotary control-semi circular display	0.580	0.704	0.781	0.780	0.842
Rotary control-intensity testing display	0.568	0.623	0.689	0.688	0.740
Horizontal rocker switch-electric light	0.512	0.524	0.573	0.592	0.593
Vertical rocker switch-electric light	0.520	0.676	0.743	0.777	0.796

Table 6.8 F represented the variation in motion stereotype (% of respondents) of the adult female (n=2628) subjects from different education levels for Rotary control-Analog display operation. Chi square test was done among the responses of the subjects from five education levels to compare their strength of motion stereotype and it was found that there was a significant (P<0.001) difference among the strength of motion stereotype of the five groups but no difference in the direction of motion stereotype of the subjects were noted.

Table 6.8 F: Variation in motion stereotype (% of respondents) the adult female (n=2628) subjects from different education levels for Rotary control-Analog display operation

Responses	**Education level**	**Type of display and direction to the subjects**							
		horizontal display (move to right)	horizontal display (move to left)	vertical display (move up)	vertical display (move down)	semicircular display (move clock wise)	semicircular display(move anti clockwise)	Intensity testing display (increase)	Intensity testing display (decrease)
Clock wise response (%)	Illiterate (n=720)	62.50	37.22	62.50	31.94	66.67	33.33	66.94	30.00
	Primary (n=608)	67.43	32.24	70.72	17.11	82.24	25.99	77.14	14.47
	Secondary (n=536)	76.49	27.24	72.76	12.31	85.82	29.10	79.29	14.18
	Graduation (n=507)	76.92	27.02	74.95	11.24	82.84	23.08	80.87	13.22
	Post Graduation and above (n=257)	83.66 ***	22.18	79.38 ***	8.56	79.77 ***	18.68	85.60 ***	12.45
Anti clock wise response (%)	Illiterate (n=720)	37.50	62.78	35.50	68.06	33.33	66.67	33.06	70.00
	Primary (n=608)	32.57	67.76	29.28	82.89	17.76	74.01	22.86	85.53
	Secondary (n=536)	23.51	72.76	27.24	87.69	14.18	70.90	20.71	85.82
	Graduation (n=507)	23.08	72.98	25.05	88.76	17.16	76.92	19.13	86.79
	Post Graduation and above (n=257)	16.34	77.82 ***	20.62	91.44 ***	20.23	81.32 ***	14.40	87.55 ***

*****P<0.001**

Variation in motion stereotype (% of respondents) the adult female (n=2628) subjects from different education levels for rocker switch- electric light unit operation was depicted by **Table**

6.8 G. There was a significant (P<0.01or less) difference was found in the strength of stereotype and education level for each and every control-display operations. It was also noted that there was no difference in the direction of motion stereotype of the subjects from different education levels A gradual increase in strength of motion stereotype was found for the operation of vertical rocker switch (both in "on" and "off" responses) from lower level of education to higher level.

Table 6.8 G: Motion stereotype (%) for rocker switch- electric light unit operation among all the adult female (n=2628) subjects

Type of display and instructions to the subjects		horizontal rocker switch-electric light (on)		horizontal rocker switch-electric light (off)		vertical rocker switch-electric light (on)		vertical rocker switch-electric light (off)	
Responses %		Right	Left	Right	Left	Up	Down	Up	Down
Education level	Illiterate (n=720)	62.50	37.50	49.86	50.14	30.42	69.58	74.31	25.69
	Primary (n=608)	78.95	21.05	45.56	54.44	11.18	88.82	90.46	9.54
	Secondary (n=536)	76.49	23.51	49.81	50.19	8.58	91.42	91.42	8.58
	Graduation (n=507)	78.90	21.10	49.70	50.30	7.30	92.70	92.70	7.30
	Post Graduation and above (n=257)	81.71 ***	18.29	38.13	61.87 **	2.72	97.28 ***	97.28 ***	2.72

*****P<0.001, **P<0.01**

Mean response initiation time (ms) of adult female (n=2628) subjects from different education levels for operation of all control display units was represented by **Table 6.8 H.** ANOVA was applied to test the significant difference of mean RIT of these five groups and It was shown that there was a significant (P<0.01) difference in mean response initiation time among the five groups. So likewise the male subjects the female also showed decreased response initiation time with increased education level. So the response initiation time of the female subjects was also found to be positively influenced by education level.

Table 6.7 H: Mean response initiation time (ms) of adult female (n=2628) subjects during operation of all the control display units

Mean Response Initiation time (ms)					F value
Education level					
Illiterate (n=720)	**Primary (n=608)**	**Secondary (n=536)**	**Graduate (n=507)**	**Post graduate and above (n=257)**	52.334*
827.3±14.22	825.4±18.23	818.2±22.34	813.1±28.67	808.8±39.24	

*P<0.01

Index of reversibility (IR) for all the control-display units of the adult female (n=2628) subjects was depicted by **Table 6.8 I.** It was noted that likewise male subjects in case of females also a general gradual increase in IR values were noted from lower education to higher education levels.

Table 6.8 I: Index of reversibility (IR) for all the control-display units of all the adult female (n=2628) subjects

Control-display configurations	Indexes of reversibility (IR)				
	Education level				
	Illiterate (n=720)	**Primary (n=608)**	**Secondary (n=536)**	**Graduate (n=507)**	**Post graduate and above (n=257)**
Rotary control –horizontal display	0.532	0.562	0.621	0.624	0.687
Rotary control –vertical display	0.545	0.636	0.672	0.693	0.743
Rotary control –semi circular display	0.556	0.565	0.650	0.677	0.686
Rotary switch-light intensity display	0.568	0.693	0.710	0.727	0.767
Horizontal rocker switch-electric light	0.500	0.526	0.501	0.502	0.575
Vertical rocker switch-electric light	0.595	0.814	0.843	0.865	0.947

Discussion: Results revealed that the higher level of education among male and female were associated with stronger motion stereotype, we know that motion stereotype is a cognitive ability and cognitive skills portrayed by a population are strongly associated with the economic growth of the country (Hanushek and Woessmann, 2008). Now we know that one of the important economic growth factors of a country is human resource, its quality and quantity both are equally important. The quality of human resource depends on education. The theory of impact of education on economic growth was supported by Barro (1991) and Sala-i-Martin et al. (2004). Higher level of cognitive skill is linked with better education (Heckman et al., 2006; Heineck and Anger, 2010) level. It was evident that Cognitive ability (as measured by commonly used IQ tests) is positively affected by education level (Falch and Sandgren Massih, 2011). Education has a significant contributory impact on cognitive skills, and formal schooling is the foremost determinant of problem solving skills, each additional year of schooling elevates average skills by almost 4.5% or about one-quarter of a standard deviation of cognitive skill score distribution (Green and Riddell, 2009). Higher levels of education is even linked with a lower risk of dementia (Evans et al., 1993; Jones et al., 2006), as well as better performance on different tests of cognition (Cagney & Lauderdale, 2002; Lee et al., 2003; Lyketsos et al., 1999), including tests of executive function (Wecker et al., 2005) and set shifting (van Hooren et al., 2007). A higher level of education is also found to be associated with successful cognitive aging in later life (Albert et al., 1995; Cagney & Lauderdale, 2002; Hultsch et al., 1999; Lindenberger & Baltes, 1997). It was evident from the present study that response initiation time got faster significantly ($P<0.01$) with higher level of education for both male and female subjects, this finding matches well with the finding of Ng and Chan (2012) who concluded that factors like age, sex, education level had significant impact on response time to visual and auditory stimulus. Previous studies point out that the variation in reaction time were due to processing time (Miller and Low, 2001), and higher levels of education were strongly associated with greater central executive efficiency and information processing rate (Bosma et al., 2003; Tun and Latchman, 2008). This means that the higher the education level, the faster will be the response.

6. 9 Rural-urban variation of motion stereotype:

Based on population density, growth, facilities, employment prospects, education, etc. human settlement is mainly divided into two classes i.e. Urban and Rural. According to the census report, the rural-urban distribution in India is 68.84% and 31.16% correspondingly (Chandramouli, 2011). In general, a rural area is a geographic region that is positioned outside towns and cities.

Typical rural areas have a small population mass and small settlement. Agricultural areas are usually rural, as are other types of areas such as forest. The urban area is a place having a minimum population of 5,000 of density, 400 persons per square kilometer (1,000/sq mi) or higher and 75% plus of the male working population employed in non-agricultural occupations.

In the present work rural-urban variation was studied because from the previous research works it was noted that living in rural areas might differ from urban dwelling by different factors (Wong & Palloni, 2009; Salinas et al., 2010), Urban and rural subjects were from different socioeconomic strata and as we know socioeconomic status has a huge impact on cognitive performance (Banerjee et al., 2019) so, to evaluate the impact of this variation on the motion stereotype of Bengali (Indian) population, both rural and urban subjects were included in this study.

Table 6.9 A represented the gender wise distribution of the rural and urban subjects who volunteered in the study**.** The male and female subjects from rural and urban areas were randomly selected to conduct the study.

Table 6.9 A: distribution of the rural and urban male and female subjects in the studied population

Total (n=5228)			
Rural (n=2614)		**Urban (n=2614)**	
Male	**Female**	**Male**	**Female**
1300 (49.73%)	1314 (50.27%)	1300 (49.73%)	1314 (50.27%)

Motion stereotype (%) of rural and urban subjects for different sets of rotary control-display combinations were represented in **Table 6.9 B**. It was found that for ‘move to right’ instruction in case of horizontal display-rotary control unit the subjects of both rural and urban areas predominantly executed clockwise motion and for “move to left” instruction they selected anticlockwise motion of the control.

For vertical display-rotary control when the subjects were instructed to move the pointer up both rural and urban subjects selected clockwise motion of the control and on the other hand for "move to down" instruction both the group of subjects exhibited anticlockwise direction of motion of the control.

For semi-circular display-rotary control (instruction) subjects of both rural and urban setup predominantly exhibited clockwise motion of control to move the pointer of the display towards right and for the "move to left" instruction they selected anticlockwise direction of motion.

To increase the intensity, in case of intensity testing by rotary control –light intensity, most of the subjects of both the rural and urban groups showed clockwise motion of the control and for "decrease the intensity" instruction they selected anticlockwise direction of motion

From the above findings it appeared that the predominant direction of motion stereotype was the same in both rural and urban subjects. However, the frequency of response was different. It was noted that in most of the cases the frequency of response in particular direction (say, Clockwise motion) was higher in urban subjects than that of rural subjects. For all the rotary control-analog display units there were significant ($p<0.01$or less) differences among rural and urban subjects (for both sexes). Thus the strength of stereotype was different between rural and urban subjects.

Table 6.9 B. Motion stereotype (%) of rural and urban subjects for different sets of rotary control- display combinations

Type of display and direction to the subjects	Responses in control							
	Clock wise response (%)				Anti clock wise response (%)			
	Male (n=2600)		Female (n=2628)		Male (n=2600)		Female (n=2628)	
	Rural (n=1300)	Urban (n=1300)	Rural (n=1314)	Urban (n=1314)	Rural (n=1300)	Urban (n=1300)	Rural (n=1314)	Urban (n=1314)
horizontal display (move to right)	75.85	84.62 ###	68.49	74.20 **	24.15	15.38	31.51	25.80
horizontal display (move to left)	25.08	20.00	32.88	28.31	74.92	80.00 ##	67.12	71.69 ***
vertical display (move up)	72.69	80.00 ###	68.04	73.06 ***	27.31	20.00	31.96	26.94
vertical display (move down)	24.66	18.00	21.61	14.84	75.34	82.00 ###	78.39	85.16 *
Semi circular display (move clock wise)	84.62	80.69 ##	76.64	80.67	15.38	19.31	23.36	19.33
Semi circular display(move anti clockwise)	19.23	13.62	31.51	23.21	80.77	86.38 ###	68.49	76.79 ***
Intensity testing display (increase)	76.92	83.54 ###	73.82	78.84 **	23.08	16.46	26.18	21.16
Intensity testing display (decrease)	27.15	22.23	20.17	16.29	72.85	77.77 ##	79.83	83.71 ***

##P<0.01 w.r. t rural male, ### P<0.001 w.r.t rural male, *P<0.05 w.r.t. rural female, **P<0.01 w.r.t rural female, ***P<0.001 w.r.t rural female

Motion stereotype (%) of rural and urban subjects for different sets of rocker switch-electric light combinations was represented by **Table 6.9 C.** It was noted that in case of horizontal rocker switch-electric light, to "on" the light the majority of the both rural and urban subjects predominantly selected to press the switch in rightward direction and for "off" instruction they pressed the switch in leftward direction.

In case of vertical rocker switch-electric light to "on" the light the majority of both rural and urban subjects predominantly pressed the switch in downward direction and for "off" instruction they pressed the switch in upward direction.

From the above results it may be pointed out that there was no difference in the direction of motion stereotype of rocker switch-light intensity display between rural and urban subjects. However, the percentage of response (strength) for the motion stereotype was different in rural and urban subjects for all the cases. There was a general tendency of higher frequency in urban subjects than that of rural subjects.

It was observed that there were significant ($p<0.01$or less) differences in the percentage of response in a particular direction among the rural and urban subjects of both the sexes. This indicated that the stereotype strength was significantly higher in the subjects of urban areas in comparison to that of rural areas.

Table 6.9 C: Motion stereotype (%) of rural and urban subjects for different sets of rocker switch-electric light combinations

Type of display and instructions to the subjects	**Response (%)**	**Responses in controlling**			
		Male (n=2600)		**Female (n=2628)**	
		Rural (n=1300)	Urban (n=1300)	Rural (n=1314)	Urban (n=1314)
horizontal rocker switch-electric light (on)	Right	63.31	71.31 ##	71.54	76.86 **
	Left	36.69	28.69	28.46	23.14
horizontal rocker switch-electric light (off)	Right	37.59	31.54	48.63	46.73
	Left	62.31	68.46 ##	51.37	53.27
vertical rocker switch-electric light (on)	Up	24.38	19.23	16.29	12.40
	Down	75.62	80.77 ##	83.71	87.60 **
vertical rocker switch-electric light (off)	Up	79.92	84.69 ##	84.09	90.56 ***
	Down	20.08	15.31	15.91	9.44

##P<0.01w.r.t rural male, **P<0.01 w.r.t rural female, ***P<0.001 w.r.t rural female

Comparison of the index of reversibility (IR) of rural and urban subjects for all the control-display configurations tested in this study was represented in **Table 6.9 D.** It was noted that for rural male subjects the highest IR was found for rotary control-semi circular display and lowest IR was found for Horizontal rocker switch-electric light unit. For rural female subjects the highest IR was found for Vertical rocker switch-electric light and lowest IR was found for Horizontal rocker switch-electric light unit. For urban male subjects the highest IR was found for

Rotary control –semicircular display and the lowest IR was found for Horizontal rocker switch-electric light unit. For urban female subjects highest IR was found for Vertical rocker switch-electric light and lowest IR was found for Horizontal rocker switch-electric light unit.

It was noted that the IR values were greater in urban male subjects for all control-display configurations than that of rural male subjects. The same findings were also shown in case of female subjects. It may be pointed out that the magnitude of IR was weak in case of horizontal rocker switch and light intensity display in both rural and urban areas.

Table 6.7 E represented the percent difference of IR of all the adult rural and urban subjects for all the control-display units. It was noted that there was percent difference of IR up to 21.31% between rural and urban subjects. It was revealed the magnitude of IR among the urban male subjects was greater than that of the male subjects of rural areas by about 1.4% to 11.9% in different configurations of controls and displays. In case of female subjects rural-urban difference was greater in comparison to their male counterpart. The percentage difference was greater in urban subjects by about 9.5% to 21.3% in different control-display units.

Table 6.9 D. Comparison of the index of reversibility (IR) of rural and urban subjects for all the control-display configurations tested in this study

Control-display configurations	Index of reversibility			
	Male (n=2600)		Female (n=2628)	
	Rural (n=1300)	Urban (n=1300)	Rural (n=1314)	Urban (n=1314)
Rotary control –horizontal display	0.629	0.708	0.563	0.605
Rotary control –vertical display	0.614	0.692	0.602	0.662
Rotary control –semicircular display	0.713	0.723	0.600	0.664
Rotary control-light intensity testing display	0.623	0.686	0.569	0.694
Horizontal rocker switch-electric light	0.533	0.579	0.506	0.518
Vertical rocker switch-electric light	0.653	0.713	0.650	0.805

Table 6.9 E: Percentage (%) difference of IR of rural and urban subjects for all the control-display configurations tested

Percent (%) difference of IR between rural and urban subjects		
Control-display configurations	**Rural male vs. urban male**	**Rural female vs. urban female**
Rotary control –horizontal display	11.82%	7.19%
Rotary control –vertical display	11.94%	9.49%
Rotary control –semi circular display	1.39%	10.13%
Rotary control-light intensity testing display	9.63%	19.79%
horizontal rocker switch-electric light display	8.27%	2.34%
vertical rocker switch- electric light display	8.78%	21.31%

The mean Response Time of the rural and urban male and female subjects for the operation of all the control-display units was represented in **Table 6.9 F.** It was found that rural male showed mean response initiation time of 720.1 ms while rural females had mean response initiation time of 824.3 ms. There was a significant (P<0.001) difference between rural male and female. In case of urban male subjects the response time was 714.5 ms and the female subjects had the mean response initiation time of 819.2 ms. There was also a significant (P<0.001) difference in response time between two groups of subjects. Rural male and urban male also had significant (P<0.001) difference in mean response initiation time. The urban male subjects had better response time than that of rural male subject. The same trend of results was seen among rural female and urban female subjects.

Table 6.9 F: Mean Response Time (ms) of the rural and urban subjects for the operation of all the control display units

Mean Response Initiation time (ms)			
Male (n=2600)		**Female (2628)**	
Rural (n=1300)	Urban (n=1300)	Rural (n=1314)	Urban (n=1314)
720.1 ±11.02	714.5 ±12.12***	824.3 ±10.22	819.2 ±9.33###

***P<0.001 w.r.t rural male, ### w.r.t rural female

Discussion: From the results it was noted that the strength of stereotype, index of reversibility (IR) and response initiation time of rural and urban subjects (for both sexes) were found to be significantly (P<0.01 or less) different for almost all the control display unit operation. Such differences might be due to difference in socioeconomic status of the subjects, environmental condition, educational level, and facilities for day to day life. We know that motion stereotype is related to the cognitive function and it was evident from previous studies that respondents residing in urban areas performed better than the rural subjects for different cognitive domains (Saenz et al., 2017), living in rural areas might differ from the urban dwelling in different ways including lesser educational opportunities and poorer educational attainment (Wong & Palloni, 2009), lesser access to health care systems (Salinas et al., 2010), lesser use of precautionary care (Wong and Díaz, 2007). So, the rural people are underprivileged in numerous indicators of socioeconomic position throughout their life (Scott, 2010). Educational attainment has established a strong relationship with cognitive function across many studies (Fors et al., 2009; Jefferson et al., 2011; Lee et al., 2003; Singh-Manoux, 2005). Educational opportunities and quality of education in rural areas have over and over again found to be lagged behind urban areas (Wong & Palloni, 2009). Previous research suggested that employment in complex, cognitively stimulating occupations may help preserve cognitive function throughout working years and into later life (Andel et al., 2007). A better socio economic position and more stimulating cognitive surroundings in childhood have small but significant effects on absolute level of cognitive function throughout life (Everson-Rose et al., 2003). In addition, research studies from Portugal have also reported a higher occurrence of cognitive impairment in case of rural populations compared to urban populations (Nunes et al., 2010). In an another study on Indian population showed comparable test scores by urban population on most cognitive parameters as compared to rural population (Das et al, 2006). The shortage of opportunities which are common in rural perspective could be considered as the high threat issues for proper cognitive growth, like lesser access to public services, community health, and capital (Foulkes and Mori, 2009; Miller and Votruba-Drzal, 2013; Gouin et al., 2015; Morgan, 2015; Robinson, 2017), poorer quality of teaching, educators with lesser income and lower level of training, lesser access to primary level of education (Castro and Rolleston, 2015; Gouin et al., 2015), less years of parental schooling (Nadel and Sagawa, 2002; Foulkes et al., 2008; Foulkes and Mori, 2009; Mykerezi et al., 2014; Tine, 2017), and notably less familiar encouragement at home (Burchinal et al., 2008; Miller and Votruba-Drzal, 2013; Förster and Rojas-Barahona, 2014).

6. 10 Application of motion stereotype in interface modification and design

Motion stereotype pattern of a population has implication on using various equipment and appliances. The most compatible man-machine interface could be made by using population stereotype. Compatibility of an interface could assure safety, productivity and comfort of the user. Error could be reduced up to a reasonable magnitude by using a compatible interface. In the present investigation the principle of motion stereotype has been evaluated for the control unit of the commonly used gas burner oven. Gas stove is a quite simple domestic device for cooking and other purposes. A conventional gas stove is consisted of gas supply pipe, gas valve, gas injector jet, regulator, throat, gas mixing pipe, burner head, burner knobs, utensil supports and body frame.

In the present study the gas oven was modified considering the motion stereotype of the users, as discussed below. The experiments were conducted on two groups of subjects – (i) regular users of gas oven burner and (ii) non-users who were not habituated with gas oven burner. The non habituated subjects were not trained to use the gas oven so they could show their natural motion stereotype without any bias due to practice. The habituated users were included in this study because the intention of modification of gas oven knob was targeted for the benefit of the user population.

Table 6.10 A depicted the **g**ender distribution (frequency and percentage) of the subjects who volunteered for the study. It may be pointed out that a total of 420 subjects took part in the study among them 100 subjects never used gas oven before and 220 subjects were regular gas oven users. Among the non-users 50% were male and 50% were female. Among the gas oven users 49% were male and 55.45% were female.

Table 6.10 A: Gender distribution (frequency and percentage) of the subjects volunteered for the study

Non user of Gas oven (n=200)		**User of gas oven (220)**	
Male (n=100)	**Female (n=100)**	**Male (n=98)**	**Female (n=122)**
50 (%)	50 (%)	49 (%)	55.45 (%)

The conventional gas oven system:

In the conventional gas oven the gas knob is designed in such a way that it can be moved anti clockwise to increase the gas flow and the gas flow becomes the maximum when the knob reaches at the vertical position. From the maximum flow position, the knob can be moved further anticlockwise to the horizontal position to decrease the gas flow to the minimum ("sim"), as shown in Fig. 6.10.1

Limitation of the system: The main limitation of the conventional system was that the gas flow can be decreased by moving the knob both anticlockwise direction towards 'sim' position and clockwise direction towards off/ on position. Similarly, the gas flow can be maximized by moving the knob clockwise from 'sim' position and anticlockwise from on/ off position. Moreover, when the user requires stopping (off) the gas flow from 'sim' position he/she is compel to pass through vertical causing a maximum flow of the gas. Thus, it can be said that there are two principles of motion stereotype have been applied to design conventional gas oven, which are "anticlockwise to increase the gas flow" and "anticlockwise to decrease the gas flow". So the same type of motion (anticlockwise) does two opposite job i.e., increase and decrease the gas flow here in this interface, which may create confusion among the users who were not trained or habituated and operation error may be caused during using the gas oven.

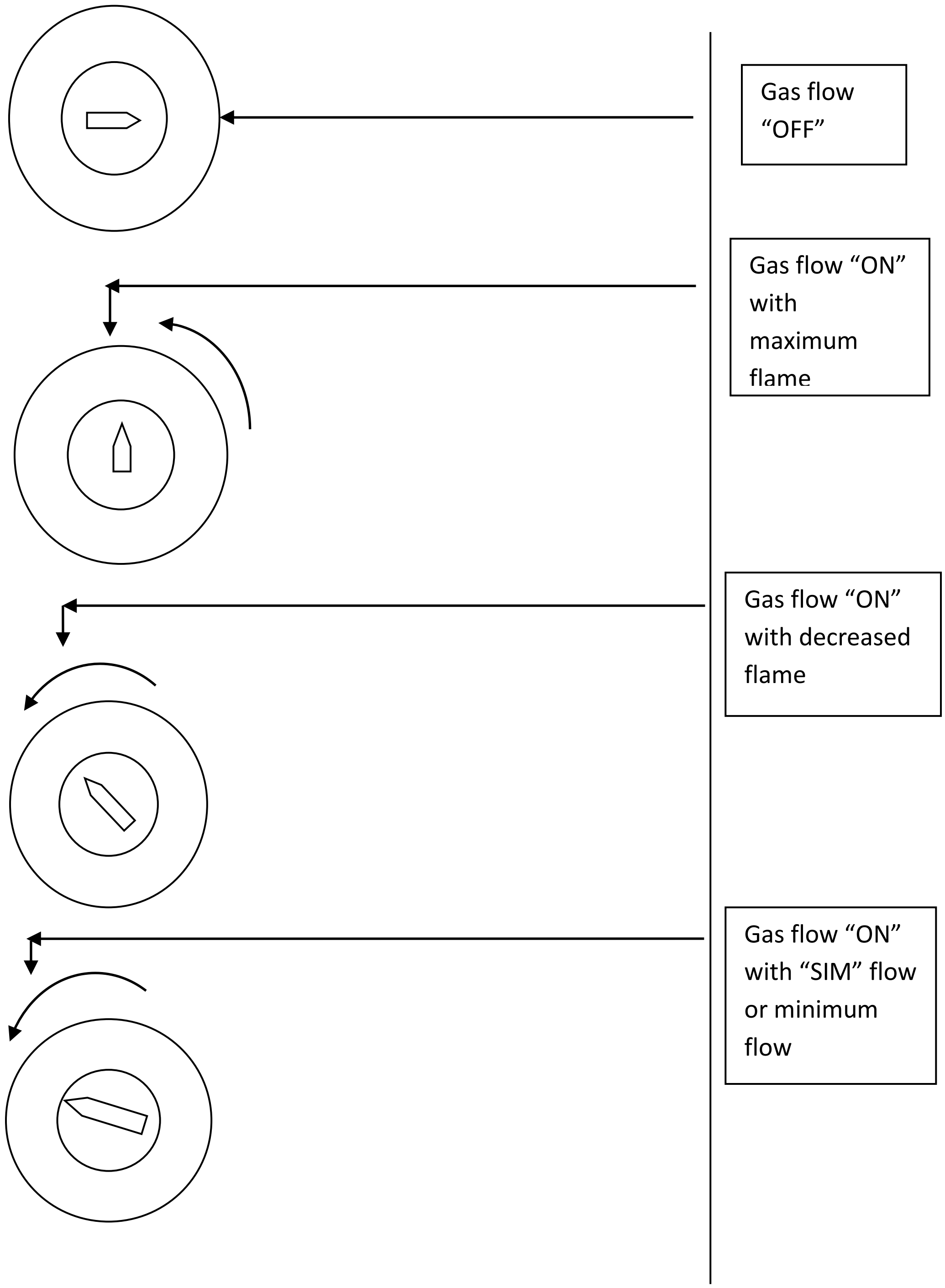

Fig 6.10.1: Schematic representation of the conventional two burner gas knob operation system (based on anticlockwise to increase and anticlockwise to decrease principle in one control)

The direction of motion of the subjects (%) for operating the gas oven has been represented in **Table 6.10 B**. It was noted that for executing the instruction “on the gas oven” 68% of the male non users and 64% of the female non users moved the gas knob in anti-clockwise direction whereas 100% of the regular users of both sexes moved the knob in anticlockwise direction. For “maximizing the flame” 52% male nonusers and 50% female nonusers moved the gas oven knob in anticlockwise direction and among gas oven users all the subjects moved the knob in anticlockwise direction. For “minimizing the flame” among gas oven, 50% of the male non users and 52% of the female non users moved the gas knob clockwise direction while in case of regular gas oven users 52.04% of the male and 53.29% of the female moved the knob in anticlockwise direction. For the instruction “off the gas oven” 62% of the male nonusers and 60% of the female nonusers moved the gas knob in clockwise direction while all the regular gas oven users (100%) moved the gas knob in clockwise direction.

It appeared from the results that the direction of motion (anticlockwise) for making the gas oven on was the same in cases of regular gas oven users and nonusers. But the percentage of respondents in cases of nonusers was much lower than that of regular users. During making gas flow off male and female subjects of both groups showed clockwise motion of the control knob. Like former case the percentage of respondents in cases of nonusers was much lower than that of regular users. However, in case of maximizing the flame there was no clear stereotype both in regular user and nonusers of both sexes. It may be stated that there was confusion among the subjects regarding operation of control knob to maximize the gas flow. The strength of stereotype was also weak in first two cases among the nonusers.

Table 6.10 B: Direction of motion stereotype (%) of all the subjects for completing the tasks assigned to them

Task assigned to the subjects	Response preference of Gas oven *non users* for conventional two burner gas oven operation				Response preference of Gas oven *regular users* for conventional two burner gas oven operation			
	Moving the knob Clock wise %		Moving the knob Anticlockwise %		Moving the knob Clock wise %		Moving the knob Anti clockwise %	
	Male (n=100)	Female (n=100)	Female (n=100)	Male (n=100)	Male (n=98)	Female (n=122)	Male (n=98)	Female (n=122)
"On" the gas oven	32.00 (32)	36.00	68.00	64.00	0.00	0.00	100.00	100.00
"Maximize" the flame	48.00 (48)	50.00	52.00	50.00	0.00	0.00	100.00	100.00
"Minimize" the Flame	50.00 (50)	52.00	50.00	48.00	47.96	46.71	52.04	53.29
"Off" the gas oven	62.00	60.00	38.00	40.00	100.00	100.00	0.00	0.00

Table 6.10 C represented the response initiation time (ms) of all the subjects for completing the tasks assigned to them. It was noted that mean response initiation time (ms) of the gas oven nonusers ranged between 816.1 to 828.4 ms while in case of gas oven users it ranged from 696.2 to 720.3 ms. the results indicated that regular users had quicker initiation time than that of nonusers

It appeared that the interface for conventional gas oven might have the problem of compatibility with population motion stereotype. Efforts have made to modify the interface design of conventional gas oven.

Table 6.10 C: Response initiation time (ms) of all the subjects for completing the tasks assigned to them

Mean Response initiation time (ms) of Gas oven non users		Mean Response initiation time (ms) of gas oven regular users	
Male (n=100)	**Female (n=100)**	**Male (n=98)**	**Female (n=122)**
816.1 ±42.33	828.4 ±48.14	710.5 ±22.12***	712.3 ±33.22###

814.2 ±48.13	824.1 ±44.22	700.1 ±36.33***	706.8 ±30.12###
818.1 ±44.23	820.4 ±44.32	720.3 ±28.22***	718.5 ±29.22###
813.7 ±48.22	824.2 ±42.43	696.2 ±24.34***	702.2 ±28.42###

***P<0.001 w.r.t male gas oven non users, ### P<0.001 w.r.t female gas oven non users

Modification of the two burner Gas oven knob:

The conventional gas oven operation system could make the user confuse to operate it because the interface follows two opposite motion stereotype principles, i.e., “anti clockwise to increase” and “anticlockwise to decrease”. Basically to increase and to decrease the gas flow the direction of motion is same in the conventional system.

Perfect reversibility happens while the response to 'increasing the flow' is opposite to the response of 'decreasing the flow’. It is a crucial feature in view of motion compatibility. Designers of man-machine interface should use motion stereotype with a sound quantity of reversibility to trim down puzzlement and boost effectiveness and safety. So, to eliminate or reduce the probable confusion and for better man-machine compatibility of the conventional gas oven, population stereotype was used.

To test the preference of modification of the control-display unit of the conventional gas burner oven a study was conducted and the results have been presented in Table 6.10 D. The results depicted the response (%) of all the subjects for the questions asked to them for modification of conventional gas oven. It was noted that 86% of the nonusers and 52.27 % of the regular users of gas oven opined for the modification of the existing gas oven interface. 82% non user and 56.36% user of gas oven were confused with the operation system of the existing gas oven. About 78% non user and 69.09% user of gas oven said that they will be comfortable with the shortening of the movement range of the existing gas knob.

Table 6.10 D: Response (%) of the subjects for the questions asked to them for modification of conventional gas oven control

Sl. No.	Questions asked to the subjects	Response %			
		Gas oven non users		Gas oven users	
		Yes	No	Yes	No
1.	Do you want any modification of the existing gas oven knob?	86.00	14.00	52.27	47.73
2.	Do you have any confusion with the operation of the existing gas oven control?	82.00	18.00	56.36	43.64
3.	Will it be comfortable with the shortening of the movement range of the existing gas oven control?	78.00	22.00	69.09	30.91

Criteria selected to modify the conventional two burner gas oven:

Based on the response to the questionnaire for modification of conventional gas oven control four criteria were selected.

1. The rage of movement of the gas knob was shortened.
2. "Anticlockwise to increase the flow" and "clockwise to decrease the flow" principles of motion stereotype was used in the modified gas oven.
3. "Anti clockwise to decrease the flow" principle for gas flow which is conventionally used in gas oven was eliminated from the internal design of the gas oven burner to minimize the confusion of the users.

The modified gas oven functions: In the modified gas oven the control knob function was modified on the basis of selected criteria (based on response of the subjects) and population stereotype. **Fig 6.10.2** represented the modified gas knob system. In the proposed interface, the control knob could be moved anticlockwise from the "on/off" position (horizontal right) to get the desired flow of gas gradually from minimum to maximum flow. The internal system of the control knob was modified in such a way that the knob stops moving at the vertical position where it yielded the maximum flow. From the vertical position the knob could be moved in clockwise direction to decrease the gas flow and ultimately to be stopped (off). Thus the principle of motion stereotype “anticlockwise to increase the flow” and “clockwise to decrease the flow” were used in this interface. By this modification the “anticlockwise to decrease” system of the conventional system was eliminated from this interface. This modification might solve the problem of the confusion regarding the gas oven operation.

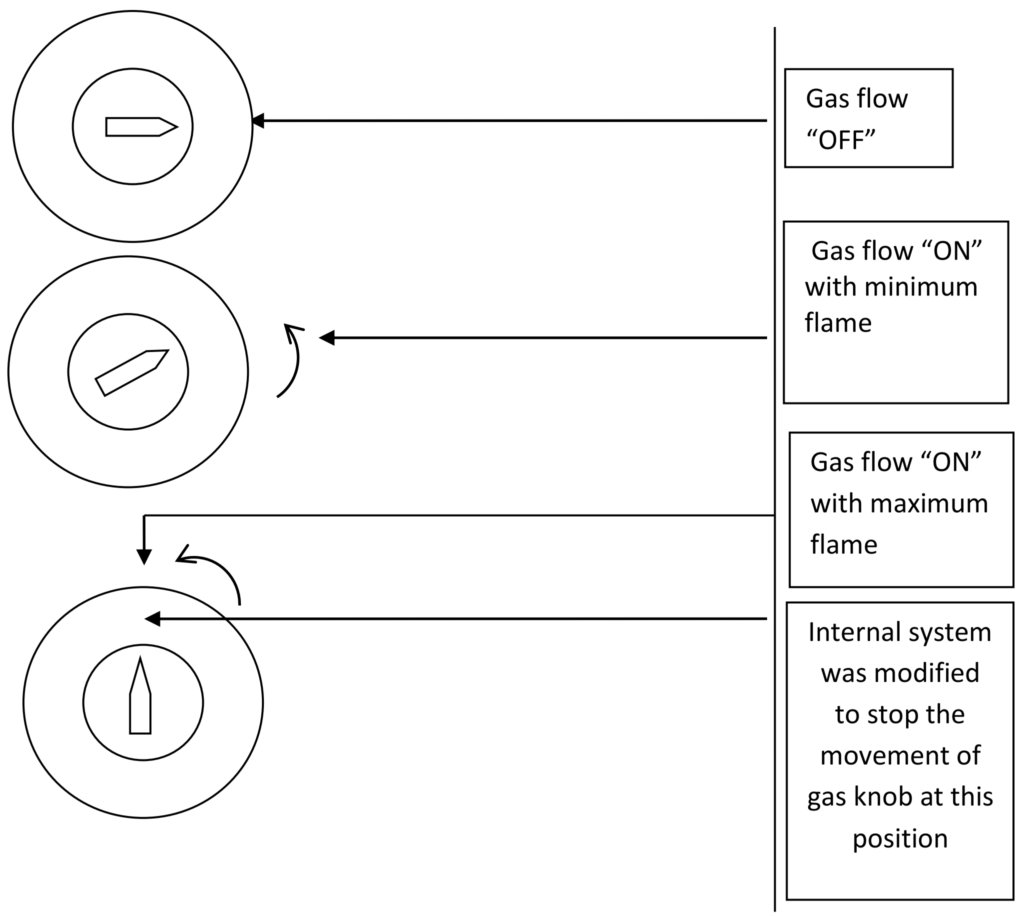

Fig 6.10.2 Schematic diagram of modified gas knob positions for operating gas oven (based on “anti clockwise to increase flow” principle)

Evaluation of the modified gas oven system:

The modified gas knob system was evaluted with the help of the same grop of subjects (n=200) who were participated in the test for evaluating the user interface of conventional gas oven burner. They were asigned with some specific tasks regarding to the gas oven operation. **Table 6.10 E** depicted the comparison of direction of motion of the subjects (%) for operation of conventional and modified gas oven burner. It was observed that for "on the gas oven" task 70% of the male and 68% of the female subjects moved the modified gas burner knob in anticlockwise direction. There was no significant difference found in strength of stereotype for the operation of conventional and modified gas knob system. For the instruction "maximize the flame", 66% of the male and 64% of the female moved the gas knob in anticlockwise direction. There was significant ($P<0.01$) difference found in strength of stereotype for the operation of conventional and modified gas oven control system. It was found that 64% of the male and 67% of the female participants moved the gas control knob in clockwise direction to decrease the gas flow. There was significant ($P<0.01$) difference found in strength of stereotype for the operation of conventional and modified gas oven control system. To make gas oven "off" 64% of the male and 60% of the female subjects moved the modified gas knob in clockwise direction, there was no significant difference found in strength of stereotype for the operation of conventional and modified gas oven control system.

Table 6.10 F represented the response initiation time (ms) of the subjects for operation of conventional and modified gas oven operation. It was showed that in case of modified gas oven, the mean response initiation time (ms) of the male subjects was 778.2 ms and of the female subjects was 798.1 ms for "on the gas oven" task, and it was 792.1 ms for the male subjects and

800.4 ms for the female subjects for maximizing the gas flame. To decrease the gas flame, the mean response initiation time (ms) was 800.1 ms and 812.4 ms for the male and the female subjects respectively whereas to make the gas oven "off" it was 800.3 ms and 817.2 ms for the male and the female subjects respectively. It was found that operation of modified gas oven (for all the task) showed significantly (P<0.01 or less) lesser mean response initiation time than that of conventional gas oven.

Gas flow on with maximum flow

Gas flow on with minimum flow

Gas flow on

Fig 6.10.3: operation of modified gas oven

Table 6.10 E: Comparison of Direction of motion stereotype (%) for the gas oven nonusers for operation of conventional and modified gas oven operation

Task assigned to the subjects	Conventional gas oven operation				Modified gas oven operation			
	Response (%)							
	Moved the knob Clock wise		Moved the knob Anti clockwise		Moved the knob Clock wise		Moved the knob Anti clockwise	
	M (n=100)	F (n=100)	M (n=100)	F (n=100)	M (n=100)	F (n=100)	M (n=100)	F (n=100)
"On" the gas oven	32.00 (32)	36.00 (36)	68.00 (68)	64.00 (64)	30.00 (30)	32.00 (32)	70.00 (70)	68.00 (68)
"Maximize" the flame	48.00 (48)	50.00 (50)	52.00 (52)	50.00 (50)	34.00 (34)	36.00 (36)	66.00 (66)**	64.00 (64)##
"Minimize" the Flame	50.00 (50)	52.00 (52)	50.00 (50)	48.00 (48)	64.00 (64)**	66.00 (66)##	36.00 (36)	34.00 (34)
"Off" the gas oven	62.00 (62)	60.00 (60)	38.00 (38)	40.00 (40)	64.00 (64)	60.00 (60)	36.00 (36)	30.00 (30)

**P<0.01w.r.t conventional gas oven operation by male, ##P<0.01 w.r.t conventional gas oven operation by female

Table 6.10 F: Comparison of Response initiation time (ms) of the non user of gas oven for operation of conventional and modified gas oven operation

Task assigned to the subjects	Response initiation time (ms)			
	Conventional gas oven operation		Modified gas oven operation	
	M (n=100)	F (n=100)	M (n=100)	F (n=100)
"On" the gas oven	816.1 ±42.33	828.4 ±48.14	778.2 ±44.12 ***	798.1 ±49.32###
"Maximize" the flame	814.2 ±48.13	824.1 ±44.22	792.1 ±47.33 **	800.4 ±45.33###
"Minimize" the Flame	818.1 ±44.23	820.4 ±44.32	800.1 ±44.23 **	812.4 ±43.12##
"Off" the gas oven	813.7 ±48.22	824.2 ±42.43	800.3 ±46.13 *	817.2 ±44.22#

*P<0.05 w.r.t. conventional gas oven operation by male, **P<0.01 w.r.t conventional gas oven operation by male, ***P<0.001w.r.t conventional gas oven operation by male,

#P< 0.05 w.r.t conventional gas oven operation by female, ## P< 0.01 w.r.t conventional gas oven operation by female, ###P<0.001 w.r.t conventional gas oven operation by female

Table 6.10 G represented the comparison of direction of motion stereotype (%) of the regular users of gas oven for the operation of conventional and modified gas oven. From the results it was noted that significant (P<0.01) difference in stereotype strength was found between the operation of conventional and modified gas oven for both sexes in case of "minimize the flame" task.

Table 6.10 G: Comparison of Direction of motion stereotype (%) of the regular users of gas oven for the operation of conventional and modified gas oven burner

Task assigned to the subjects	Conventional gas oven operation				Modified gas oven operation			
	Response (%)							
	Moved the knob Clock wise		Moved the knob Anti clockwise		Moved the knob Clock wise		Moved the knob Anti clockwise	
	M (n=98)	F (n=122)	M (n=98)	F (n=122)	M (n=98)	F (n=122)	M (n=98)	F (n=122)
"On" the gas oven	0.00	0.00	100.00	100.00	0.00	0.00	100.00	100.00
"Maximize" the flame	0.00	0.00	100.00	100.00	0.00	0.00	100.00	100.00
"Minimize" the Flame	47.96	46.71	52.04	53.29	72.45**	75.41##	27.55	24.59
"Off" the gas oven	100.00	100.00	0.00	0.00	100.00	100.00	0.00	0.00

**P<0.01w.r.t conventional gas oven operation by male, ##P<0.01 w.r.t conventional gas oven operation by female

Table 6.10 H represented comparison of response initiation time (ms) of the regular users of gas oven for the operation of conventional and modified gas oven burner. It was noted that for instructions "minimize the flame" and "off the gas oven" the gas oven users showed significant (P<0.01) decrease in response initiation time during operation of modified gas oven for both sexes in comparison to conventional burner.

Table 6.10 H: Comparison of Response initiation time (ms) of the regular users of gas oven for operation of conventional and modified gas oven burner

Task assigned to the subjects	Response initiation time (ms)			
	Conventional gas oven operation		Modified gas oven operation	
	M (n=100)	F (n=100)	M (n=100)	F (n=100)
"On" the gas oven	710.5±22.12	712.3±33.22	711.3±26.33	712.4±36.54
"Maximize" the flame	700.1±36.33	706.8±30.12	703.2±22.43	708.4±31.33
"Minimize" the Flame	720.3±28.22	718.5±29.22	698.4±31.35**	690.3±34.22##
"Off" the gas oven	696.2±24.34	702.2±28.42	680.22±32.43**	684.2±32.12##

** $P<0.01$ w.r.t conventional gas oven operation by male, *** $P<0.001$ w.r.t conventional gas oven operation by male #$P<0.05$ w.r.t conventional gas oven operation by female, ## $P<0.01$ w.r.t conventional gas oven operation by female, ##$P<0.001$ w.r.t conventional gas oven operation by female

So from the above results it can be said that the modification of gas oven which was fabricated on the basis of population stereotype showed significant ($P<0.01$) increase in strength of stereotype of the both regular users and nonusers of gas oven and also exhibited significantly ($P<0.01$) decreased response initiation time.

Operation errors may be caused if there is incompatibility between population stereotype and interface design. A study on the error analysis was made during operation of conventional as well as modified gas burner oven. The subjects were given different tasks for operating the gas oven control and the direction of motion of the control knob was noted. Any deviation of the desired direction of motion for a given instruction was taken as the operation error. An analysis of error was made after experiment was over.

Table 6.10.I represented the comparison of percentage (%) of error during conducting the assigned tasks between conventional gas oven users and modified gas oven users. It was noted that male gas oven nonusers showed 42.5% mean error for all the tasks, while their female counterparts showed 45% mean error for operation of conventional gas oven. The male gas oven users showed 47.48% mean error and female gas oven users showed 46.67% mean error. In case of operation of modified gas oven both users and non users (for both sexes) showed decrease in mean error percentage.

Table 6.10.I: Comparison of % of error during completing assigned tasks of gas oven operation between gas oven users and gas oven non users for conventional and modified gas oven

Task assigned to the subjects	**Percentage of error**							
	Conventional gas oven operation				**Modified gas oven operation**			
	Gas oven non users		**Gas oven users**		**Gas oven non users**		**Gas oven users**	
	M (n=100)	**F (n=100)**	**M (n=98)**	**F (n=122)**	**M (n=100)**	**F (n=100)**	**M (n=98)**	**F (n=122)**
"On" the gas oven	32%	36%	0%	0%	30%	32%	0%	0%
"Maximize" the flame	50%	52%	0%	0%	34%	36%	0%	0%
"Minimize" the Flame	50%	52 %	47.48%	46.67%	36%	34%	27.66%	24.85%
"Off" the gas oven	38%	40%	0%	0%	36%	30%	0%	0%
Mean error percentage	42.5	45	47.48	46.67	34	33	27.66	24.85

Discussion: Results suggested that the modified gas oven showed significantly better (P<0.01 or less) strength of stereotype than that of the conventional gas oven in all most all the tasks related to the gas oven operation. Response initiation time also found to be significantly (P<0.01 or less) decreased in case of modified gas oven operation for both group. Mean Error percentage also found to be decreased in case of modified gas oven operation. The findings clearly showed that modified interface of a gas oven burner had better compatibility with the users in comparison to the conventional one. Thus application of motion stereotype in man-machine interfaces might reduce the occurrence of error and improve the productivity. Earlier many investigators (Kang and Seong, 2001; Chan and Chan, 2007) suggested that appropriate compatibility should be considered for designing interface in relation to the motion stereotype. Compatibility refers to the relationship of stimuli and responses to human expectations, and as such is a central concept in human factors designs. The greater the degree of compatibility, the less recoding must be done to process the information, this in turn results in faster response times, fewer errors and reduced mental workload (Sanders and McCormick, 1987). Compatibility and stereotype may be resulting from common spatial relationships like eye-hand coordination (Gibbs, 1951) or from principles established in a particular culture (Loveless, 1962). A long ago Bergum and Bergum (1981) proposed the concern of operational explanation and the quantification of stereotype. We know that human are steady in their preference in choosing one response against a stimulus amongst a set of options (Fitts, 1951). To establish whether any response preference or stereotype is present, the bulk proportion of responses in a testing condition is the quantity of the strength of stereotype (Yu and Chan, 2004). The population stereotype and compatibility are the two vital concerns in human factors and engineering psychology (Yu and Chan, 2004). Neglecting these two key factors would unsurprisingly cause inadequate interface design which needed the burden of more training and technical backup to use the interface. Smith (1981) quoted: "Compatibility is a state of congruence between environmental inputs to the individual and the responses resulting. As such it is a primary principle and criterion in establishing effective matches between environmental inputs and the individual's psychological, physiological and anatomical response". For design overlooking response preferences, it is doubtful that a user will accomplish the intensity of performance achieve with a compatible setup, even after long term practice. There may be a trend to "revert" to the compatible association, particularly under any stressful situation (Yu and Chan, 2004). Stereotypes and compatibility were found to be different in different population like Chinese subject showed some stereotypes which were not found in U.S. subjects (Courtney, 1994). So in the present study the modification of conventional gas oven was done to get a more compatible gas oven interface for specially the studied population (Bengali, Indian) which was redesigned on the basis of their response preferences.