ABSTRACT

Evaluation of Motion Stereotype of Bengali (Indian) Population and its application in Interface design

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Introduction: Motion stereotypes are important factors which should be considered for each population with special care during man-machine interface design. Motion stereotypes are repetitive motion exhibited by users against specific stimulus for operation of a control-display configuration. Stereotypes are basically habituated reflexes that have become involuntary and 'automatic' by nature. Colour is something which is quite important in industrial design. It is one of the key factors in product semantics which is the study of symbolic characters of man-made forms in the perspective of their use and the application of this knowledge to the industrial design. Symbolic qualities represents psychological, social and cultural context of a product.

Aim and objectives: The main aim of this study was to evaluate the pattern of motion stereotype of Bengali (Indian) population. The objectives of the study were to determine the direction of motion stereotype, stereotype strength, response initiation time (RIT) and index of reversibility (IR) and to find the factors influencing the motion stereotype, viz, gender, handedness, socioeconomic status, place of habitation as well as to promote the application of motion stereotypic principle in designing man-machine interface.

Methods: To fulfill the aim of the study some suitable methods had been employed. About 5228 healthy adults (18-60 years) and 500 children (6-9 years) were selected from different

districts of West Bengal state, India on the basis of random sampling. This cross-sectional study was conducted according to the ethical standards of the institute.

To test the motion stereotype of the subjects total eleven sets of control-display units were fabricated which were given bellow in the table:

Table: control-display units fabricated and tested in the present study

Set 1	Horizontal display-rotary switch	Set 6	Electric light display-vertically aligned rocker switch
Set 2	Vertical display-rotary switch	Set 7	Analog display-spatially aligned rotary switch
Set 3	Semicircular display-rotary switch	Set 8	Digital display-spatially aligned rotary switch
Set 4	Intensity testing display (Light intensity)- rotary switch	Set 9	Digital display-rotary switch
Set 5	Electric light display-horizontally aligned rocker switch	Set 10	Digital display-vertically sliding switch
		Set 11	Digital display-horizontally sliding switch

The subjects were instructed to operate control to get a predefined response (say, increase the values of the display). The direction of motion of control attempted by the subject was recorded. The stereotype was determined by greater percentage of subjects operated a control in a particular direction (say, clockwise / anticlockwise of up / down) for a desired response. The strength of stereotype becomes increased as the percentage of subject responds to a direction is increased. A value of 50% indicated poor stereotype or no clear stereotype.

The colour stereotype of the subjects was tested for four sets of criteria by using a color chart with nine different colours. A digital timer was used for recording response initiation time (RIT) of the subjects. The handedness of the subjects was evaluated by measuring the strength of the

hand. Hand grip dynamometer was used to evaluate the hand strength. The hand with greater strength was regarded as dominant hand. The Socio-economic status of the subjects in this study was determined by Modified B.G. Prasad Scale. The resting and working heart rate of the subjects were measured by a heart rate monitor (Polar S610i).From the resting and working heart rates the cardiovascular stress index (CSI) was determined and the effect of the stress on motion stereotype was assessed. The Job related psychological stress was measured by a standard questionnaire (Srivastava and Singh, 1984) to assess the Occupational Stress Index (OSI) of the subjects. The thermal stress was determined by a highly sensitive digital Thermal Environmental Monitor (3M QUIEST-36). The effects of job related stress and heat stress on motion stereotype was assessed by dividing the subjects into different stress levels.

Results and Discussion: From the analysis of the results it was found that 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 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. The mean weight of the urban male children were significantly (P<0.05) higher than the rural male. The 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.

From the results the dominant patterns of motion stereotypes which were found in case of the Bengali (Indian) population were, "Clockwise to increase", "anticlockwise to decrease", "clockwise to up", "anticlockwise to down", "right to increase", "left to decrease", "up to

increase", "down to decrease", "right to on", "left to off", "down to on" and "up to off". The present study showed that there was no variation in direction of motion stereotype between adult male and female but the stereotype strength, index of reversibility and mean response initiation time were found to be significantly (P<0.05 or less) different.   The adult and children subjects (both male and female) showed significant difference in mean response initiation time and Index of Reversibility (IR) but for the other components of stereotypic responses (like direction of motion stereotype, strength of stereotype) they did not show much differences. The male subjects (both adult and children) in the present study took lesser time to respond to the stimulus than their female counterpart. The adult subjects took lesser time to respond to the stimulus than the children.

The population drawn in the present study showed that a very small percentage (11%) of the population was left handed. It was found that the direction of stereotype was the same in both right and left handed subjects. However, for all other aspects of motion stereotype (stereotype strength, index of reversibility and response initiation time) the left and right handed (both male and female) subjects showed significant variations (P<0.05 or less).

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 direction of stereotype was the same in the subjects of all levels of socioeconomic conditions and there was a significant association between the socioeconomic status (for both sexes) and stereotype strength. The mean response initiation time was also significantly different among the four social classes (for both sexes) and it was noted that the upper class has the shortest response initiation time and the lower middle class has the longest (for both sexes) RIT. The strength of stereotype was also found to be different among all social classes (for both sexes). The poorest compatibility was seen in case of

horizontal rocker switch-electric light display for both sexes and the best compatibility was noted for vertical rocker switch electric light (in case of females) and semicircular display with rotary switch (in case of males).

Results revealed that the higher level of education among male and female were associated with stronger motion stereotype. The response initiation time was significantly faster (P<0.01) among the subjects with higher level of education for both male and female subjects than that of lower level of education.

The present study indicated that red colour was found to be strongly associated with the "hot sensation", "danger", "off response" and "stop". Other than this green colour was found to be strongly preferred by the subjects for "on response", "safe area" and "go" criterions. 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. In cases of "cold sensation", "off response", "safe area" and "caution" no clear cut colour preference or colour stereotype was noted. There was no significant difference between the rural and urban subjects for stereotype strength or colour preference.

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 all the control display unit operation.

The results also suggested that the Y-Z^R plane (sagittal) was found to be the most compatible and suitable plane for positioning control in both digital and analog display units for studied population.

The Cardiovascular stress significantly altered the direction of motion stereotype in almost all the control-display units studied. Index of reversibility was also found to be significantly different. Heat stress showed significant ($p<0.01$ or less) impact on motion stereotype strength IR and RIT in most of the control display combinations but direction of motion stereotype did not changed due to heat stress. Job related psychological stress showed no impact on direction of motion stereotype and strength of motion stereotype but RIT and IR changed significantly ($P<0.01$) at different levels of job related psychological stress.

The principle of motion stereotype was used to modify a man-machine interface. A modification of conventional gas oven burner was done on the basis of motion stereotype of the subjects which was expected to be more compatible. In the modified gas oven the gas knob function was modified on the basis of four selected criteria (based on response of the subjects) and population stereotype. In the conventional gas oven burner there were some drawbacks from the view pots of motion stereotype. The intensity of gas flow could be reduced by moving the control knob in both clockwise and anticlockwise directions from the vertical position (maximum flow). This was beyond the common principle of motion stereotype – 'clockwise to decrease' and 'anticlockwise increase'. Attempts were taken to modify the conventional gas burner oven to avoid the confusion of the users. In this interface from the "off" position, the knob can be moved anticlockwise to get the desired flow of gas gradually from minimum to maximum flow. The knob cannot be moved further due to the modification. "Anticlockwise to increase the flow" and "clockwise to decrease the flow" principle of motion stereotype were used in this interface. Experimental study was conducted on two groups of subjects- regular users of gas oven and non-users of gas oven. Experimental results suggested that the modified gas oven showed significantly ($P<0.01$ or less) increased strength of stereotype than that of the conventional gas

oven in most of the given tasks during experiments. The response initiation time also found to be significantly (P<0.01 or less) decreased in case of modified gas oven operation for both groups of subjects. The mean error percentage also found to be decreased in case of modified gas oven operation. So it could be expected that the modified gas oven is more compatible for the users.

Conclusions: In the present study the motion stereotype of the Bengali (Indian) population has been established. From the results it may be concluded that clear-cut direction of motion stereotypes were found in the said population for operation of some common control display units. There was no variation in the direction of stereotype between male and female subjects. However, variations were noted in stereotype strength (SS), response initiation time (RIT) and Index of reversibility (IR). No adult-children variation was noted in motion stereotype strength but variation in IR and response initiation time (RIT) were found. Vertical rocker switch-electric light unit and Digital display-horizontally sliding switch unit were found to be the most compatible analog and digital displays respectively for the studied population. It may be concluded that the observed response of the participants will be helpful for fabricating the control –display for the target population.

An indication of colour stereotype was also noted for Bengali (Indian) population. In cases of "cold sensation", "off response", "safe area" and "caution" no clear-cut colour preference or colour stereotype was noted. A significant gender variation in colour preference was noted but no significant rural-urban variation was found in colour stereotype. These finding will also be helpful for rectifying the wrong colour coding of the controls as well as for introducing the proper colour coding for new control-display system where there is no colour coding at all.

In case motion stereotype there was a significant variation in stereotype strength (SS), IR and RIT between left handed and right handed subjects but direction of motion stereotypes were found to be the same in left handed and right handed male and female subjects. Therefore, the interface design would be same for both right and left handed people.

 Socioeconomic status and educational status of the subjects also had significant impacts on SS, IR and RIT but the direction of motion stereotypes were found to be the same for all the subjects of both sexes.

Impact of rural-urban variation on the strength of motion stereotype, IR and RIT was noted but direction of motion stereotypes was found to be the same in rural and urban subjects.

It was also concluded from the present investigation that the motion stereotype pattern might be altered under stress condition. Higher level of work related cardiovascular stress changed the direction of motion stereotypes significantly in almost all the control display operations. IR was also found to be changed due to cardiovascular stress. Heat stress caused significant variation in the stereotype strength (SS), RIT and IR. Job related psychological stress, however, had no significant impact on SS but IR and RIT were found to be changed significantly due to variation in job related psychological stress. Therefore, the design of interface should carefully be done where the control display operation is made under stressed condition.

Y-Z^R plane (sagittal) was found to be the most compatible and suitable plane for positioning control in both digital and analog display units for studied population. These findings will enable the interface designers to design the control display unit properly.

A modification of a conventional gas burner oven, a commonly used control-display unit, on the basis of the population stereotype was suggested in the present study. The modified gas burner

oven was analyzed and compared with the conventional gas burner oven. It was found that the modified gas burner oven showed more efficiency and human compatibility for operation among the users and it also created less confusion during operation than that of the conventional gas burner oven.

It may be stated that the direction of motion stereotype observed in the studied population may be implemented for common control display units so that errors in the operation can be lessened and productivity can be increased.