공학석사 학위논문

Characterizing driver seat position-preference relationship and evaluating utility of self-selected driver seat positions

– 자동차 시트 위치–운전 선호도 관계의 특성 파악 및 자가 선택 시트 위치의 효용성 평가 –

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ABSTRACT

Vehicle ergonomics has been extensively researched in the field of ergonomics. Previous research has defined and measured drivers' most preferred seat positions, and utilized this data to conduct various observations and analysis about driving posture prediction, the relationship between anthropometric measures and preferred component arrangement, the optimal adjustment range of components, and population accommodation.

However, there exist two limitations of previous research. First, not much research has been conducted about the relationship between driver preference ratings and seat positions other than the most preferred seat position (MPSP) of the driver. Second, the previously used self-selection method of defining and determining MPSP has been used in various research studies without proper validation. Thus, it is difficult to determine if this self-selection method is useful in identifying the driver's most preferred seat position, and whether or not other seat positions with similar preference ratings exist. Therefore, the objectives of this study were to: 1) characterize the driver seat position-preference relationship across the entire seat adjustment range and 2) verify the utility of the self-selected MPSP method. To do so, individual drivers' preference maps were empirically developed using an interpolation method.

The study collected the data of 20 participants and 9 trials of their self-selected MPSP, in addition to the preference ratings of 34 seat positions. Four characteristics (unimodality, individuality, asymmetry, pointedness) were observed in the relationship between seat position and driver preference. Also, stature found to influence the relationship.

In addition, participants' self-selected preferred seat positions generally had high preference scores with an average equal to the 94.6th percentile of all preference rating values obtained. However, on average, 10 percent of the MPSP had relatively low preference scores below the 88th percentile. Furthermore, the limitations of the self-selection method were evident as the participants on average only identified 41% of the entire region of seat positions with high preference ratings equal to or higher than the average of the preference scores of his/her MPSP.

This study discovers the relationship between driving preference and seat positions across the entire seat adjustment range, and evaluated the utility of the self-selection method. The results of this study are expected to be utilized in more accurately evaluating the level of the driver population accommodation in relation to the seat adjustment range and aiding in designing vehicle interiors.

Keywords: vehicle ergonomics, vehicle seat positions, driver preference map, most preferred seat position, self-selected seat position

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1. INTRODUCTION

The primary goal of ergonomics is to increase safety, performance, and user satisfaction during human-system interaction. Thus, an extensive amount of research has been done in relation to vehicles within the field of Ergonomics (Dunk and Callaghan 2005). Previous research has reported that an ergonomically designed vehicle interior brings about feelings of comfort and satisfaction, and in contrast, an inadequately designed interior incurs negative effects on the driver. Driving for long periods of time in an uncomfortable posture has been shown to result in biomechanical load and musculoskeletal diseases (Rajput and Abboud 2007; Gyi 1996). In addition, inadequate vehicle design may cause fatigue and poor operating performance and ultimately jeopardize the driver's safety (Kim et al. 2013).

Numerous vehicle ergonomics studies have focused on the measuring and analysis of driving posture, the relationship between anthropometric measurements and component arrangement preference, and accommodation range and population accommodation calculation. Reed et al. (2000), Park et al. (2014), Park et al. (2016) developed posture prediction models by grouping preferred driving postures by driver stature, gender, age, and preferred upper/lower posture for different vehicle types. Peng et al. (2018) reported the effect of a driver's anthropometric dimensions on his or her preferred vehicle seat position. Gragg et al. (2011) proposed a model to determine the seat adjustment range that accommodates both the 95th percentile male and 5th percentile female in terms of stature. Park (2012) used a vehicle mock-up to collect drivers' seat and steering wheel preference data and developed a new index (Q-index) and methodology to measure and evaluate the accommodation level of each component's adjustment range. Another study investigated the optimal truck cabin layout for a driver's preferred seat location (Parkinson et al. 2006). Likewise, previous studies defined, measured, and analyzed the drivers' most preferred seat position (MPSP) data.

However, the existing studies have two main limitations. First, existing research focuses on the MPSP that is measured and defined in each study but fails to explore other vehicle seat positions other than the initially defined MPSP. Despite the general acceptance of the hypothesis that the driver's driving preference is affected by the seat location, only a small number of studies have addressed the relationship between the seat position and driving preference, in addition to its characteristics. One such study is that of Kyung et al. (2007), which investigated the effect of driver characteristics (gender, age, stature) on MPSP sensitivity by comparing the driver's preference of his or her MPSP and 20 nearby seat positions. Though the study did consider the preference of seat positions in the vicinity of the MPSP, the range for consideration was very limited (a region measuring 6 cm. horizontally and 3 cm. vertically). In addition, the 100-point scale data was simplified and coded into levels 0 through 5, and therefore only basic observations were made such as "the preferred range was large/small", or "the preference of each seat position was high/low/similar". This made it difficult to accurately depict the change in driver preference according to seat position. In addition, there are no studies on the relationship between driving preference and seat positions across the entire seat adjustment range, to the author's best knowledge. As it is widely accepted that the seat position has largest effect on seat posture (Asano et al. 1989), it is necessary to investigate the exact characteristics that affect the relationship between driver preference and seat positions across the entire seat adjustment range in order to further the research field of vehicle ergonomics.

The second limitation is that the current method of defining MPSP has been used without verification. The general method used to determine the MPSP is by instructing the driver to self-select his or her preferred seat position. This method either results in a MPSP based on the driver's selection after driving practice and seat adjustment (Kyung et al. 2007; Park et al. 2014; Park et al. 2015;), or a defined region of MPSP by collecting and combining various preferred seat positions (Kim et al. 2014; Park 2012; Porter and Gyi 1998). This driver self-selection method of defining MPSP is the most simple and intuitive method, as the driver is able to select his or her own preferred seat position. However, there are some questionable aspects of this method, such as whether the MPSP selected by the driver is indeed the most preferred seat position out of all possible seat positions, and whether the driver is able to select the whole area of preferred seat position through self-selection (that is, how large or small the self-selected MPSP region is compared to the entire region with a similar preference rating as the self-selected region), which have not yet been validated. The first concern is due to the possibility of the driver being satisfied by an initial, mediocre seat position, due to the additional time and effort needed to discover a better seat position, which may include the most preferred seat position. In such cases, the driver's postures and other variables may then be based on a seat position that is not the most preferred seat position, thus resulting in findings that do not align with the goal of the research. In addition, even if the driver was able to select his or her most preferred seat position by self-selection, there is the possibility of another seat position or region of seat positions with the same or higher preference as the self-selected seat position. In this case, the complete area of preferred seat positions would not have been covered by driver self-selection, which would make it difficult to collect and analyze the entire data set related to the preferred seat position. This may result in an underestimation of the accommodation level of the calculated seat adjustment range. Therefore, it is necessary to compare the driver preference and preference distribution of seat positions in addition to the self-selected seat positions, and do so over the entire region of the seat adjustment range.

This study examines the relationship between driver preference and seat position over the complete seat adjustment range, and validates the driver self-selection method that was widely used in previous studies. The preference score for 24 (6 by 4) grid points across the area of the seat adjustment range was collected and analyzed by visual inspection and various indices, to examine the differences according to overall characteristics and stature. In addition, the collected preference scores were interpolated to generate a preference map of the driving preference across the entire seat adjustment range, and the utility of this map was validated. Lastly, the study aims to shed some light on the two concerns mentioned above (the utility of MPSP) by comparing the generated interpolation map and driver self-selected MPSP.

2. METHOD

2.1 Data collection

2.1.1 Participants

20 participants, 10 male and 10 female, were recruited for the study. The participants were between 20 and 35 years old, with the average age being 28.3 years (St. Dev. = 4.20), and all had a valid driver's license. To understand the effect of stature on the relationship between seat position and driver preference, the participants were grouped into Short (below 40th percentile), Medium (40th-80th percentile), and Tall (above 80th percentile). The percentile groups were determined based on the anthropometric data from the SizeKorea 7th investigation of anthropometric dimension, which provide the anthropometric measurements of the Korean population. The statistics of the three groups are shown in Table 1.

Table 1. Summary of the stature groups

Stature Group	Short	Medium	Tall
Number of participants	n=7 (M=0, F=7)	n=7 (M=4, F=3)	n=6 (M=6, F=0)
Stature (cm)	161.9 (157.0-164.5)	169.9 (166.0-174.0)	181.9 (177.0-190.6)
Age (years)	27.1 (23-31)	29.6 (20-38)	28.2 (24-33)
Driving experience (years)	4.2 (0-13)	3.9 (0-15)	5.4 (0-14)

Note : The values in parentheses indicate range. 'M' and 'F' denote male and female, respectively.

2.1.2 Apparatus

The experiment was conducted on a driving simulator that consisted of an adjustable vehicle mock-up and three large monitors (Figure 1). The adjustable indoor vehicle mock-up was used and consisted of the seat, steering wheel, acceleration and brake pedals, and the gear stick, and all parts were from a commercial sedan. In order to minimize external influence of the self-selected MPSP or seat position preference rating, the acceleration and brake pedals, and the gear stick were fixed in the same location as a commercial sedan, and the angle of the seat board was set parallel to the floor at 0°. The angle of the seat backrest and steering wheel were initially adjusted to each participant's preferred angle and then fixed at this angle for all trials thereafter. The seat position is expressed by coordinates on the x-axis (-x is the forward direction and +x is backward direction) and z-axis (+z is the upward direction and –z is the downward direction) from the seat's side view, with the origin located at a point on the floor which makes a perpendicular line to the middle of the brake pedal surface. The coordinates were measured with a tape measure attached to the apparatus. The UC-win / Road ver.10 driving simulation software was used to reenact a realistic driving scenario during the study.

Figure 1. An adjustable vehicle mock-up and driving simulation software

2.1.3 Experimental design

Participants were instructed to rate their preference for a total of 24 seat positions (located at grid points consisting of 6 columns by 4 rows) shown in Figure 2. These positions were selected by dividing up the seat's adjustment range (35 cm x 21 cm) into a grid, with 6 columns (Columns 1-6) created with 7 cm of space between the columns along the x-axis, and 4 rows (Rows A-D) created with 7 cm. or similar distance between the rows along the z-axis. Due to the seat operation range, there exists a slight difference in the distance between the four seat positions in Rows A and D. These 24 seat positions sufficiently cover the entire seat adjustment range of a sedan, and will henceforth be called "grid point position". Figure 2 and Table 2 describe the grid point positions in more detail.

The seat preference was rated on a scale of 0 to 10 (Score of 0: highly non-preferred, score of 10: highly preferred). The participants were instructed to rate the seat position preference in increments of 0.5, and to assume a daily driving situation (Figure 3).

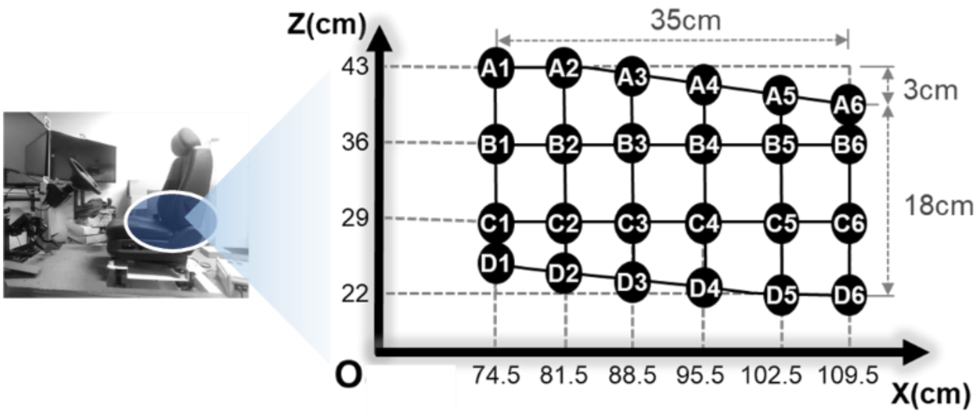


Figure 2. The schematization of grid point positions

Table 2. X and Z-axis coordinates of the grid point seat positions

Grid point positions code	X (cm)	Z (cm)
A1	74.5	43
A2	81.5	43
A3	88.5	42.7
A4	95.5	41.8
A5	102.5	40.9
A6	109.5	40
B1	74.5	36
B2	81.5	36
B3	88.5	36
B4	95.5	36
B5	102.5	36
B6	109.5	36
C1	74.5	29
C2	81.5	29
C3	88.5	29
C4	95.5	29
C5	102.5	29
C6	109.5	29
D1	74.5	25
D2	81.5	24.1
D3	88.5	23.2
D4	95.5	22.3
D5	102.5	22
D6	109.5	22

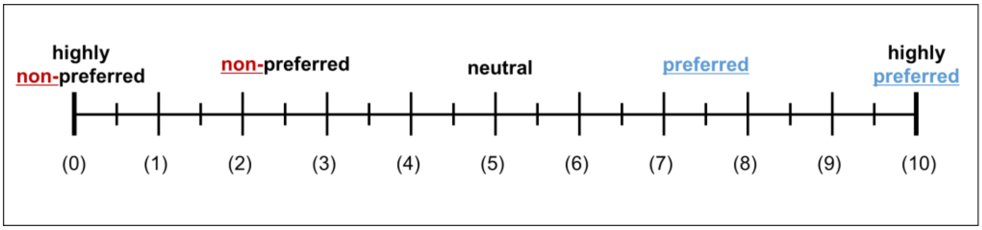


Figure 3. The preference rating scale

2.1.4 Procedure

The three parts of the experiment were as follows: Part 1) Fixing the steering wheel and backrest angle, Part 2) Study A: determine the self-selected preferred seat position, Part 3) Study B: preference rating collection for various seat positions

In Part 1, participants were instructed to select their preference for (a) steering wheel angle, (b) seat backrest angle, (c) seat position on the x-axis, and (d) seat position on the z-axis. At this time, participants were given enough time to get accustomed with the driving simulator through driving practice. After participants got accustomed to the driving simulator, their preference for factors (a)-(d) were recorded, of which (a) steering wheel angle and (b) seat backrest angle were kept constant for Study A and B.

In Part 2, Study A, participants were given the task of adjusting the seat to their most preferred position, as done in previous studies to measure MPSP. During the selection of preferred seat position, participants were given a postural guide to put both hands on the steering wheel, place the left foot on the floor or footrest, place the right foot on the acceleration or brake pedal, and lean against the seat backrest while selecting their most preferred seat position. The x and z-axis coordinates of the seat position were recorded, and the seat position was adjusted to one of the initial seat positions. The initial seat positions consisted of the four corners of the grid (A1, A6, D1, D6; two times for each grid point position), and the center of the seat adjustment range ((92 cm, 32.5cm); one time) for a total of 9 times, and two minutes of rest were given between each trial.

In Part 3, Study B, participants rated their driving preference according to seat position. Participants were seated in a pre-positioned seat and instructed to freely drive around on the simulator. Afterwards, participants rated their preference of the pre-positioned seat on a scale of 0 to 10. One set of preference rating consisted of a total of 34 seat positions (24 grid point positions, 1 seat position from Step 1, and 9 self-selected seat positions from Study A) were rated. This process was repeated three times with 10 minutes or more rest time in between the sets, and the order of seat positions was randomized for each set. The driving posture guide provided in Study A was also provided in Study B.

After all three parts, participants were given a simple survey about their general driving experience, driving frequency, factors that affected their preference, etc.

2.2 Data analysis

2.2.1 Indices for characterizing seat position-driver preference relationship

The following data visualization methods were used to depict the different characteristics that were observed in the relationship between driving preference and seat position.

(1) Color map

As each seat position for each grid point was rated three times, the average of the scores were defined as the preference rating of the grid point. Then, this preference score was recorded on a 6 x 4 chart, in accordance to the grid point position. The higher preference scores were color coded in red, and the 'grid point of highest preference' was indicated with bolded outline of the cell (Figure 4). The color maps of 20 participants visualize the characteristics of the driving preference and seat position relationship.

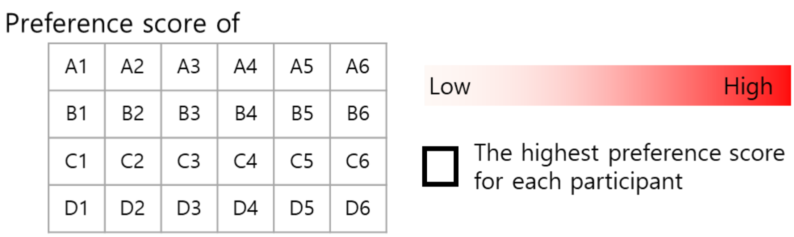


Figure 4. The expression of color map of the grid point seat position-driving preference score

(2) Direction of the largest preference reduction from the maximum preference seat position

The direction of the preference reduction from the maximum preference grid seat position was investigated. The directions are expressed by ±X or ±Z. This direction of preference reduction was examined and compared for each of the 20 participants and the different stature groups.

(3) Bivariate skewness of X and Z axis[1)]

Hong and Sung (2017)'s bivariate skewness was used as an index to express the amount of direction of the distribution's skewness. This index is complementary to the Mardia skewness index (Mardia, 1970), which is generally used to represent the skewness of multivariate distributions, and is calculated as a 2-dimensional vector, as follows.

$$\text{Bivariate skewness} = \left(\frac{E[Z_X Z_Y^2]}{|\Sigma|^{3/2}}, \frac{E[Z_X^2 Z_Y]}{|\Sigma|^{3/2}}\right)$$

The first component represents the direction and amount of skewness based on the X axis, and the second component represents the same information based on the Z axis. A perfectly symmetric distribution has a value of 0. If the skewness is positive, the distribution has a long tail in the positive direction, and if the skewness is negative, the distribution has a long tail in the negative direction.

The directional skewness of the X and Z axis were calculated for all participants for the preference ratings of the grid points, and the amount and direction of skewness of the participants and stature groups were examined and compared.

[1)] A more detailed explanation of bivariate skewness, see Hong and Sung (2017) "Bivariate skewness, kurtosis and surface plot"

(4) Bivariate kurtosis

Hong and Sung (2017)'s bivariate kurtosis was used as an index to express the thickness of the tail of the distribution, that is the pointedness of the distribution. This index complements the Mardia skewness index (Mardia, 1970), which is generally used to represent the pointedness of multivariate distributions, and is calculated as follows.

$$\text{Bivariate kurtosis} = \frac{E\left[Z_X^2 Z_Y^2\right]}{|\Sigma|^2}$$

The bivariate kurtosis has a value of 1 when the distribution is a bivariate normal distribution. If this value is larger than 1, the distribution is pointier than the normal distribution, and if the value is less than 1, the distribution is flatter than the normal distribution.

The kurtosis of each participant's grid point preference ratings were calculated, and the pointedness of the participants' and stature groups' distributions were examined and compared.

(5) Maximum preference rating and average preference rating

The maximum and average preference ratings were calculated from the grid point preference scores of each participant. The two values were compared for the participants and stature groups to observe how high the maximum preference score is compared to the average preference score, that is, how pointy the distribution is.

2.2.2 Driver seat position-preference map

This section explains the method designed to create and validate the accuracy of the 'preference map' by interpolating the preference scores at the grid points, in order to predict the preference scores for the entire seat adjustment range.

To generate the preference map, the Matlab 2017a software was used, and the 'v4' method of the 'griddata' function was used to interpolate the scatterplot data using biharmonic spline interpolation. Biharmonic spline interpolation is not triangulation-based, as other interpolation methods, and performs the same calculation regardless of location, thus no distortion of the interpolation surface occurs near the boundaries (Sandwell 1987). This method was used to generate the 'preference map' across the entire seat adjustment area.

Ten seat positions (one self-selected seat position from the steering wheel and seat backrest angle setting step, and nine self-selected seat positions from Study A) per each participant were used to validate the accuracy of the preference map. The preference score predicted by the 'preference map' based on the ten seat positions and the actual preference score expressed by the participant in Study B were compared using the paired t-test.

Additionally, the accuracy of the preference map was verified by calculating the error of the preference score prediction from the preference map. This was done by comparing the absolute error between the participant's preference rating and preference rating interred from the preference map, and the inter-individual deviation during data collection (the standard deviation between the three repeated ratings of each seat position).

2.2.3 Evaluating utility of self-selected MPSP

To validate the preference level of the self-selected MPSP, the preference score of each seat position was interpolated by dividing the preference map with 0.1 cm spacing, and these scores were combined and defined as the entire set of preference scores. Then, the percentile of the self-selected MPSP was inferred from the interpolation of the entire set of preference scores, for each participant.

In addition, to analyze whether the entire preference region was defined through the self-selection method (that is, how large or small the self-selected MPSP region is compared to the region with a similar preference rating as the self-selected region), the ‘preferred region’ and ‘self-selected region’ was visualized on each participant’s preference map. The ‘preferred region’ is defined by the area on the preference map where the seat positions have a higher rating than the average preference score of the nine self-selected MPSP. The ‘self-selected region’ is defined as the inner region of the convex-hull that is created by the nine self-selected MPSP on the preference map. The ratio of the area of ‘self-selected region’ in comparison to the ‘preferred region’ was calculated for each participant, and this value was used to compare the size of the two regions.

3. RESULTS

3.1. Characteristics of the relationship between seat position and driving preference

To understand the general characteristics of the relationship between driver preference and seat position, the color map of the seat position preference scores (of the grid points) is provided for the 20 participants in Figure 5. In addition, the calculation of the analysis indices (section 2.2.1) of each participant's preference about the grid point positions is provided in Table 3.

Participant 1

0.0	1.3	4.0	6.7	3.7	1.7
0.7	3.7	6.0	7.0	6.0	2.0
1.3	3.7	5.7	7.0	5.7	2.0
0.0	2.0	3.0	3.7	3.3	1.7

Participant 2

2.7	4.2	2.7	0.7	0.0	0.0
6.2	8.5	6.7	2.8	0.3	0.0
5.8	8.7	6.8	4.2	1.5	0.2
6.5	6.0	4.8	3.7	1.2	0.0

Participant 3

0.0	1.8	3.7	4.3	2.0	0.8
0.7	3.3	5.0	4.3	3.7	1.0
0.5	3.2	4.3	3.8	2.3	1.8
0.7	2.7	2.8	3.0	2.8	2.2

Participant 4

3.8	5.2	2.7	0.0	0.0	0.0
4.8	8.2	5.0	0.5	0.0	0.0
2.7	4.8	4.2	1.8	0.0	0.0
0.8	1.5	1.3	0.0	0.0	0.0

Participant 5

2.7	3.3	4.5	2.5	1.8	0.7
5.2	5.3	6.3	3.7	2.2	0.7
4.8	8.2	7.5	4.2	2.5	1.0
4.0	7.7	4.2	2.3	1.0	0.7

Participant 6

2.3	4.3	4.2	3.0	1.0	0.0
4.0	8.7	6.3	5.2	1.3	0.0
5.3	7.7	6.8	5.0	1.7	0.0
3.0	3.5	5.2	3.3	2.8	0.0

Participant 7

0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.3	0.0
0.3	0.7	5.8	3.3	2.7	0.0
0.7	2.7	7.7	5.0	1.0	0.0

Participant 8

0.0	1.7	5.7	4.7	0.0	0.0
4.2	9.2	9.0	6.2	1.7	0.0
7.0	8.5	7.0	5.0	1.3	0.0
4.5	4.7	5.3	4.3	1.3	0.0

Participant 9

2.5	2.8	0.0	0.0	0.0	0.0
2.5	6.2	7.8	0.3	0.0	0.0
3.5	7.7	7.7	3.3	0.0	0.0
2.3	6.7	6.5	4.8	1.2	0.0

Participant 10

0.3	0.5	0.0	0.0	0.0	0.0
2.7	8.2	3.3	0.3	0.0	0.0
2.7	7.5	5.0	0.5	0.0	0.0
0.8	2.3	2.7	0.8	0.0	0.0

Participant 11

3.8	5.8	4.5	2.2	0.3	0.0
5.8	8.7	6.8	3.0	0.7	0.0
4.0	3.7	4.5	2.5	0.7	0.3
2.3	2.5	2.5	1.7	1.0	0.0

Participant 12

0.0	0.0	1.3	1.7	0.5	0.0
0.0	3.8	5.0	3.2	2.3	0.3
1.7	5.2	7.5	5.5	2.5	0.3
2.0	5.2	6.3	5.5	2.3	0.0

Participant 13

0.0	1.0	4.3	7.0	2.7	1.0
0.7	3.7	6.7	8.7	4.0	1.0
1.3	4.7	7.7	8.0	5.7	1.3
2.0	4.0	4.3	4.3	4.0	1.0

Participant 14

0.0	0.0	0.7	2.7	2.8	0.0
0.0	0.2	4.7	5.8	3.7	0.0
0.0	0.5	4.3	9.2	5.5	0.0
0.0	0.5	3.2	3.5	1.8	0.0

Participant 15

0.5	2.0	1.3	0.3	0.0	0.0
2.7	7.3	8.0	5.0	0.5	0.0
2.5	6.8	8.0	4.2	0.3	0.0
1.0	3.8	4.7	2.5	0.0	0.0

Participant 16

1.0	3.3	0.0	0.0	0.0	0.0
4.0	9.3	6.0	1.2	0.0	0.0
3.0	7.0	4.7	0.7	0.0	0.0
2.3	3.3	2.7	1.0	0.0	0.0

Participant 17

0.0	0.0	6.3	6.3	2.5	1.0
3.3	4.0	8.7	9.3	4.3	2.0
3.2	4.0	6.7	6.8	4.3	3.2
2.5	3.2	4.3	3.7	3.7	2.3

Participant 18

1.0	2.3	1.0	0.0	0.0	0.0
3.0	6.3	8.0	1.3	0.0	0.0
2.3	3.7	4.0	1.0	0.7	0.0
1.7	1.7	1.3	1.0	0.3	0.0

Participant 19

3.0	1.8	1.7	0.7	0.5	0.0
3.5	7.3	3.7	1.8	0.3	0.3
3.7	6.0	5.2	2.2	0.2	0.0
3.2	4.3	4.3	4.0	0.2	0.0

Participant 20

0.0	0.0	5.7	8.3	5.0	1.7
0.0	5.0	8.7	9.7	4.3	2.7
1.0	5.0	5.3	8.3	5.3	2.3
0.0	2.3	4.7	3.7	4.0	1.3

Figure 5. Color maps for each participant

Table 3. Indices for characterizing seat position-driver preference relationship

Participant no.	Stature group	Number of peak points or areas	Direction of the largest preference reduction	Bivariate skewness of		Bivariate kurtosis	Max. score	Avg. score
				X	Z			
1	Medium	1	-Z	0.07	(0.10)	0.89	7.0	3.4
2	Short	1	-Z	0.01	(0.21)	1.01	8.7	3.5
3	Tall	1	-X	0.08	(0.19)	0.98	5.0	2.5
4	Short	1	-X, -Z	(0.01)	(0.14)	1.03	8.2	2.0
5	Tall	1	-X	0.02	0.03	0.97	8.2	3.6
6	Short	1	-X	0.13	(0.13)	1.08	8.7	3.5
7	Tall	1	-X	0.42	0.22	1.15	7.7	1.3
8	Medium	1	+Z	0.25	(0.18)	0.92	9.2	3.8
9	Short	1	+Z	(0.17)	(0.26)	1.62	7.8	2.7
10	Short	1	+Z	0.11	(0.2)	1.34	8.2	1.6
11	Medium	1	-Z	0.1	(0.21)	1.14	8.7	2.8
12	Medium	1	+Z	0.24	(0.06)	0.86	7.5	2.6
13	Medium	1	+X	0.08	(0.21)	0.92	8.7	3.7
14	Tall	1	-Z	0.06	(0.06)	1.01	9.2	2.0
15	Medium	1	+Z	(0.00)	0.04	0.92	8.0	2.6
16	Medium	1	+Z	(0.01)	(0.19)	1.06	9.3	2.1
17	Tall	1	+X	0.13	(0.25)	0.85	9.3	4.0
18	Short	1	+Z	0.01	(0.34)	1.21	8.0	1.7
19	Short	1	+Z	0.05	0.06	1.19	7.3	2.4
20	Tall	1	+X	0.1	(0.17)	0.86	9.7	3.9
Short group mean		1	+Z	0.02	(0.17)	1.21	8.1	2.6
Medium group mean		1	+Z	0.10	(0.13)	0.96	8.3	3.0
Tall group mean		1	-X	0.14	(0.07)	0.97	8.2	2.9
Total mean		1	+Z	0.08	(0.13)	1.05	8.2	2.8

Note : The values in parentheses indicate negative.

The color map revealed that though most participants had one position with the highest preference, some participants (participants 1 and 15) gave highest preference ratings to two proximate seat positions, resulting in a mountain peak shape (Figure 5). Double or multiple peaks were not observed. The seat positions with high preference scores all seem to occur near the seat position with the highest preference score, and there was a trend of the preference scores decreasing with increased distance from the seat position with the highest preference score.

The preference score from the seat position with the highest preference score showed a dramatic decrease in different directions according to stature group. The preference score data for the Short and Medium groups dramatically decreased mainly in the upper direction (+Z), but in the Tall group, the preference scores decreased in the forward direction (-X).

The bivariate skewness in the direction of the x-axis is on average 0.08 and mostly positive, and in the direction of the z-axis, the skewness is on average -0.13 and mostly negative (Table 3). There were no statistically significant differences in the skewness of the x and z-axis between the stature groups (Table 4).

The total average for the bivariate kurtosis was 1.05, with the average of the Short, Medium, and Tall stature groups being 1.21, 0.96, and 0.97, respectively. ANOVA analysis and post hoc analysis was conducted for the different stature groups' average difference in kurtosis determined that the Short and Medium groups had significantly larger kurtosis values compared to the Tall group ($p<0.05$). This data is presented in Table 4.

In terms of the maximum and average preference scores, the average preference score of the entire preference map was low at 2.79 out of 10 (standard deviation=0.82, minimum value=1.3, maximum value=4). The average of the participants' maximum preference scores was 5.42 points higher than the average at 8.21 out of 10 (standard deviation=1.02, minimum value=5.0, maximum value=9.7).

Table 4. ANOVA analysis and post hoc analysis for the different stature groups' average difference in bivariate skewness and kurtosis

(a) The result of ANOVA analysis in bivariate skewness and kurtosis

		Sum of squares	**DOF**	**Mean squares**	**F**	**p-value**
Skewness of X	Between-group	.049	2	0.025	1.880	.183
	Within-group	.222	17	0.013		
Skewness of Z	Between-group	.035	2	0.018	1.104	.384
	Within-group	.297	17	0.017		
Kurtosis	Between-group	.281	2	0.140	5.981	.011(*)
	Within-group	.399	17	0.023		

Note : * < .05

(b) The result of post hoc analysis in bivariate kurtosis

Dependent variable	**Group (A)**	**Group (B)**	**Average difference (A-B)**	**Standard error**	**p-value**
Kurtosis	Short	Medium	.25340*	.08191	.017(*)
		Tall	.24229*	.08525	.029(*)
	Medium	Short	-.25340*	.08191	.017(*)
		Tall	-0.1112	.08525	.991
	Tall	Short	-.24229*	.08525	.029(*)
		Medium	.01112	.08525	.991

Note : * < .05

3.2 Generation and validation of the preference map

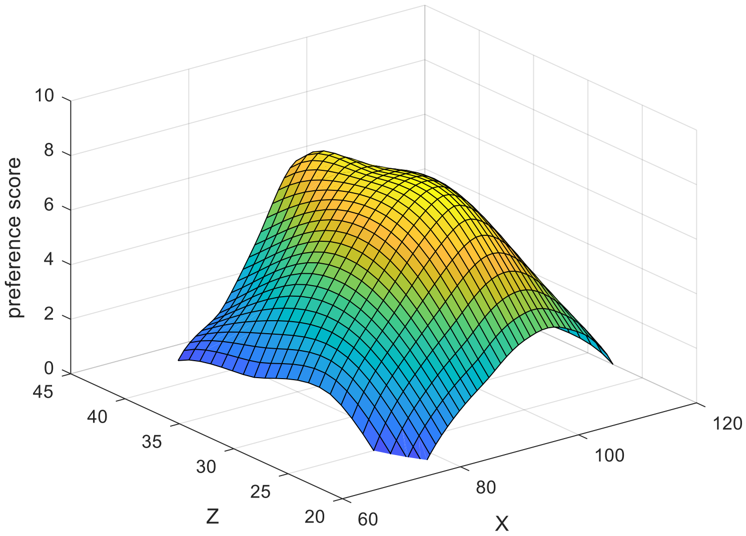
The visualization of the preference map using the preference ratings of the grid point positions and biharmonic spline interpolation is shown in Figure 6.

A paired t-test of the participants' response of preference scores and predicted preference scores did not show any statistically significant difference between the two score groups (Table 5, $p>0.025$ (two-sided test)).

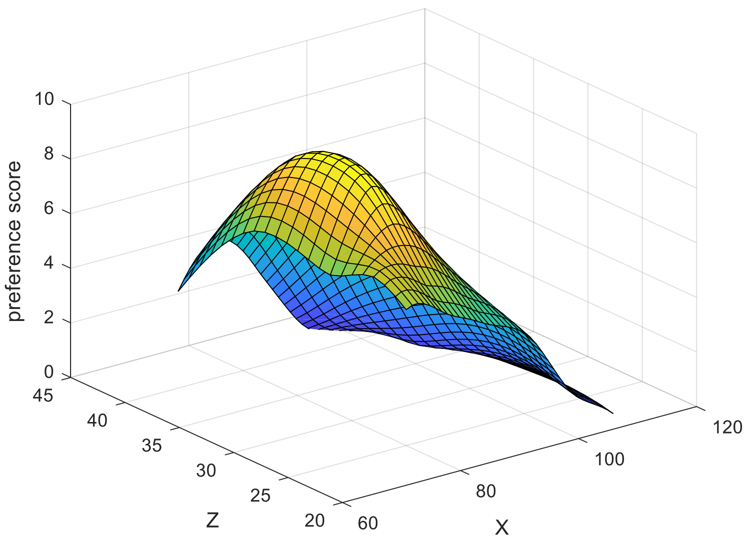
Table 5. The result of paired t-test between the participants' response of preference scores and predicted preference scores

	Paired difference				
	Mean	**Standard deviation**	**Standard error of the mean**	**t**	**p-value (two-sided)**
(participants' response of preference scores) – (predicted preference scores)	.12034	.76146	.05384	2.235	.027

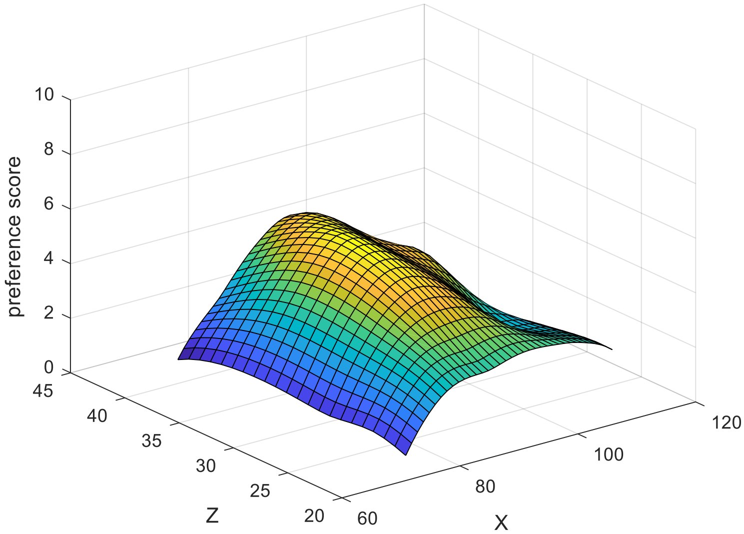
In addition, the mean average error between the predicted score from the 'preference map' and the measured preference score was 0.6014, which was a smaller value than the participants' inter-individual difference of preference ratings from the data collection, which was 0.66967. However, the difference was not statistically significant ($p=0.174$).



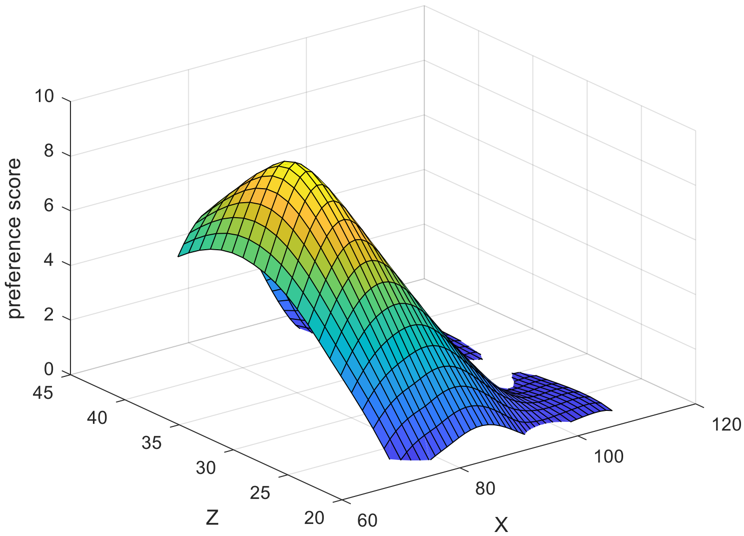
(a) Participant 1



(b) Participant 2



(c) Participant 3



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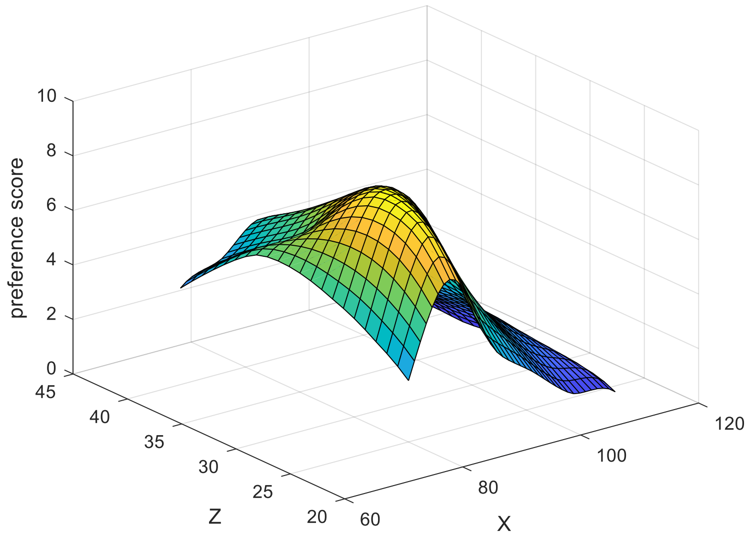
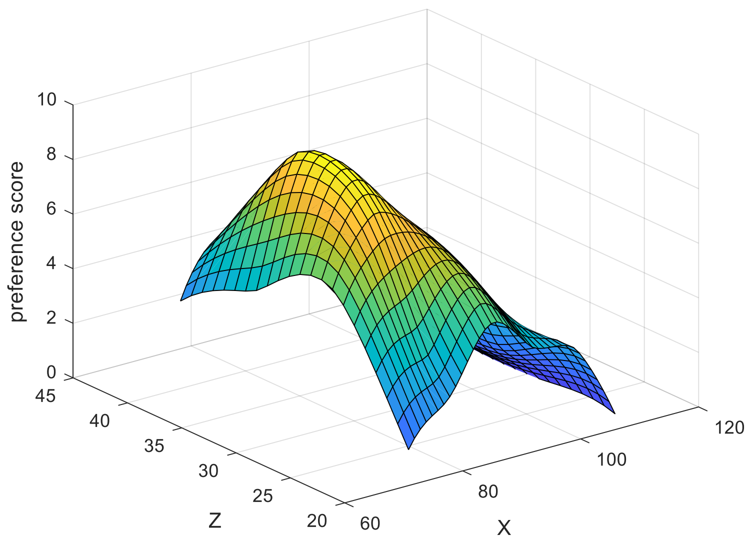


(e) Participant 5



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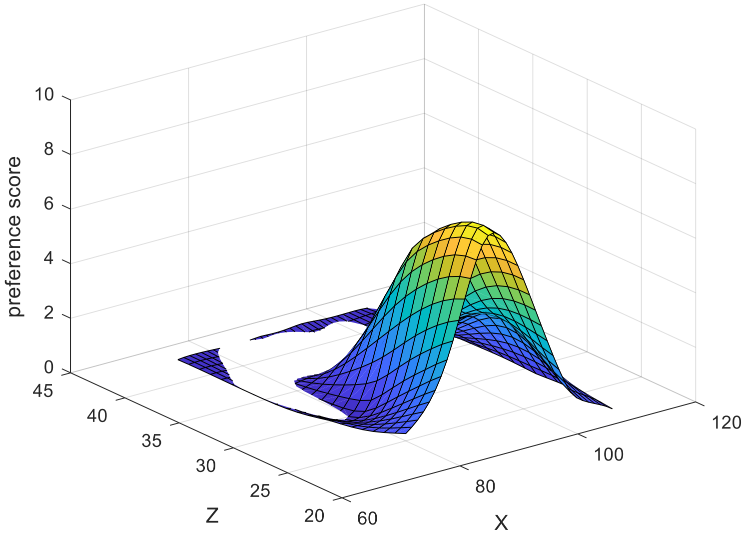
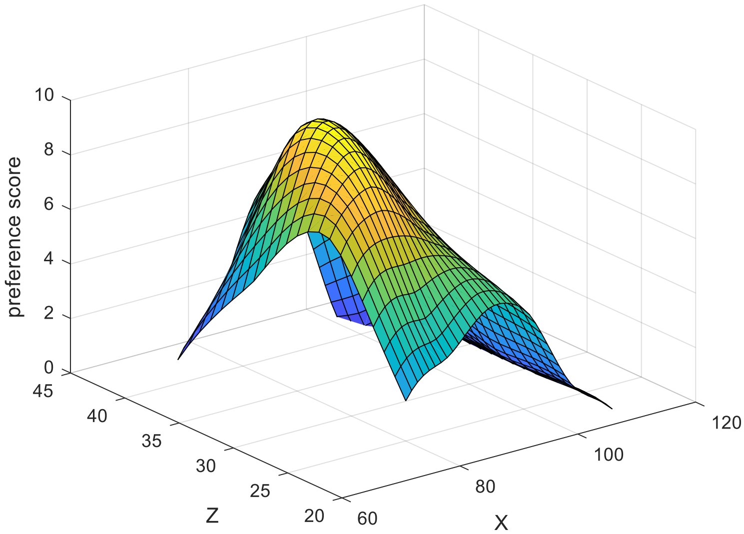


(g) Participant 7



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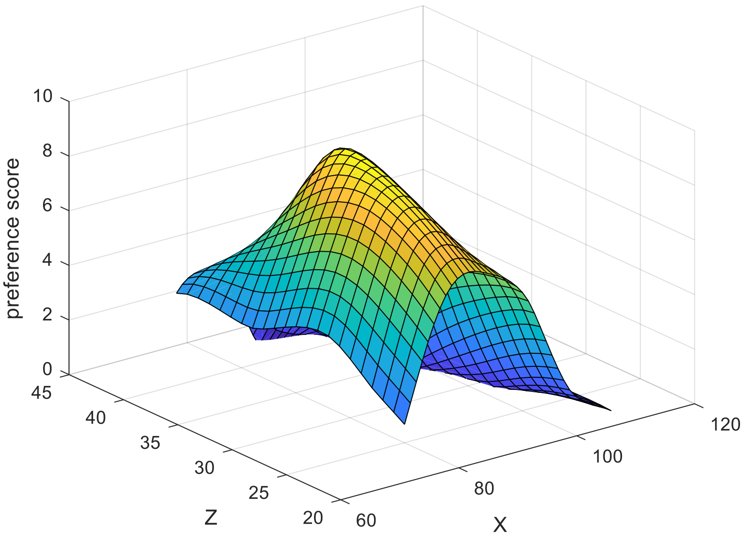
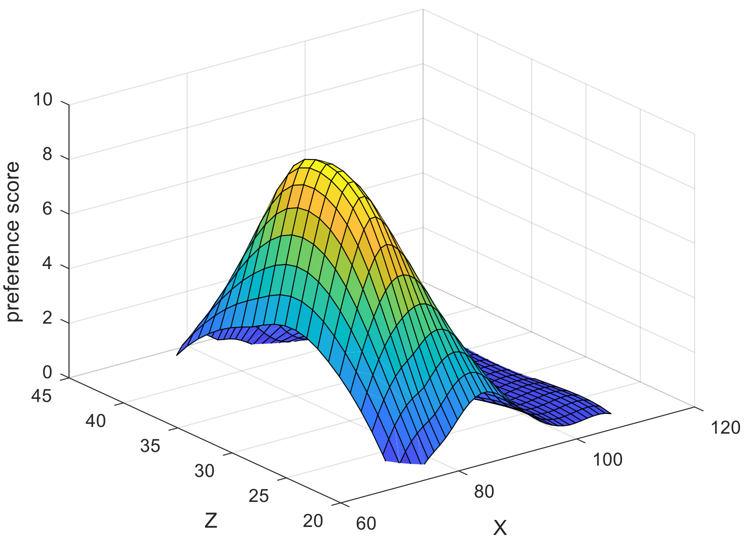


(i) Participant 9



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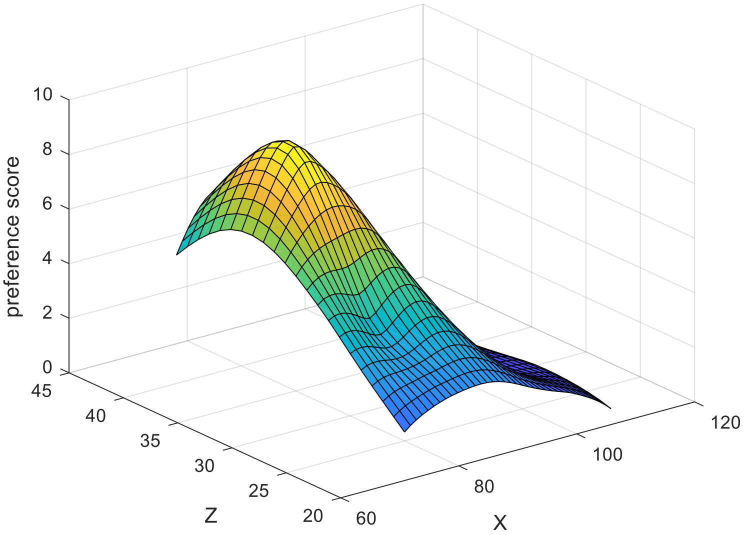

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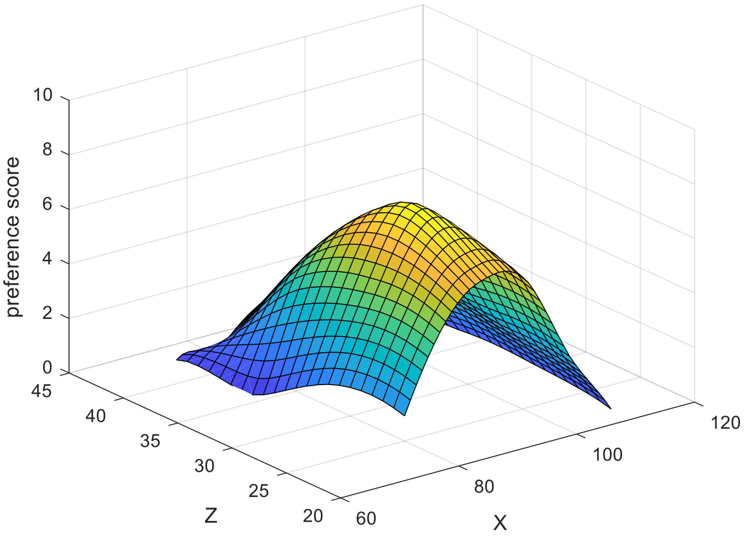

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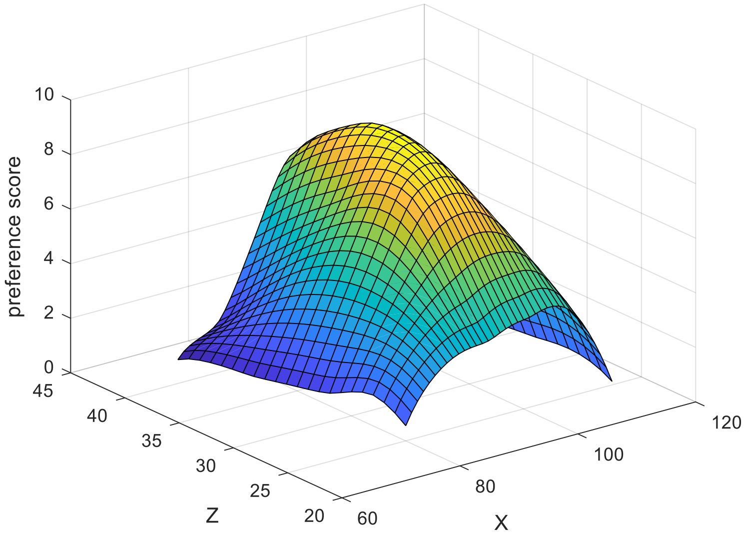
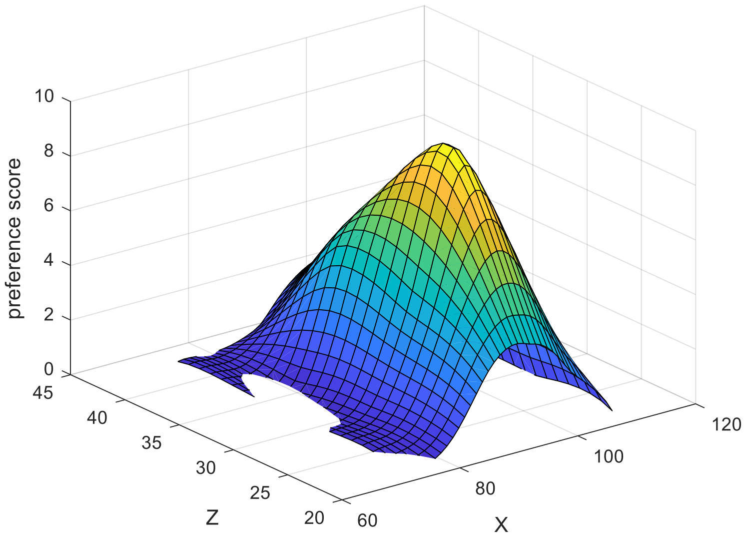
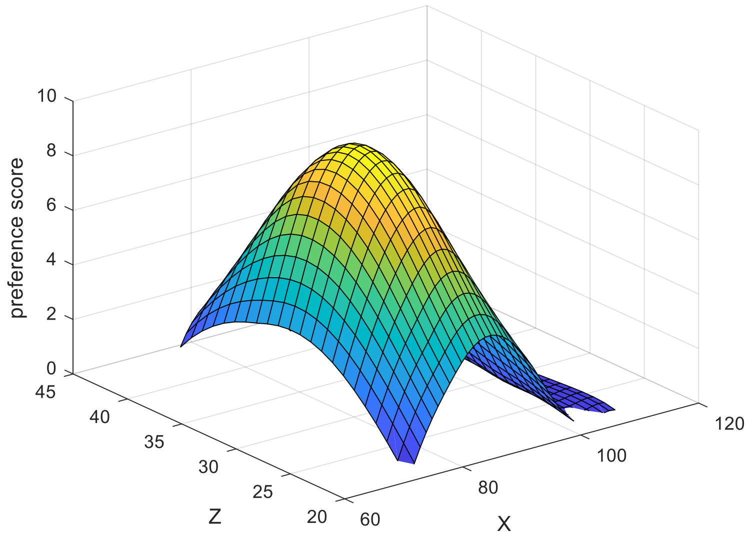


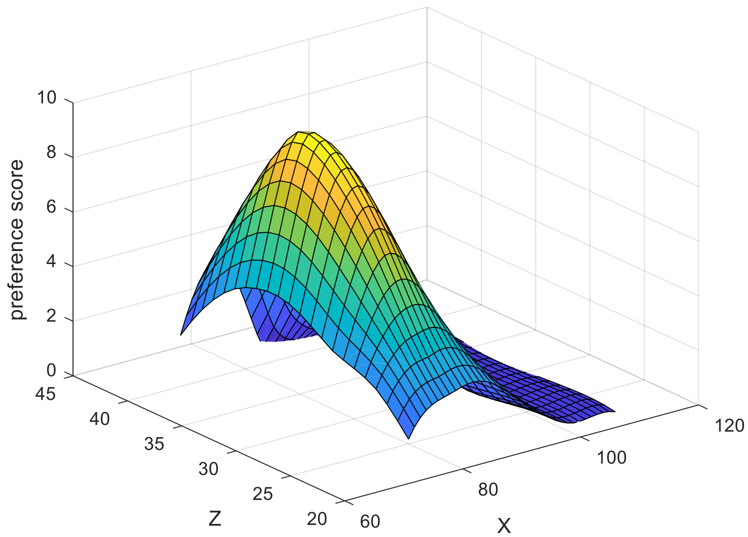
(m) Participant 13



(n) Participant 14



(o) Participant 15



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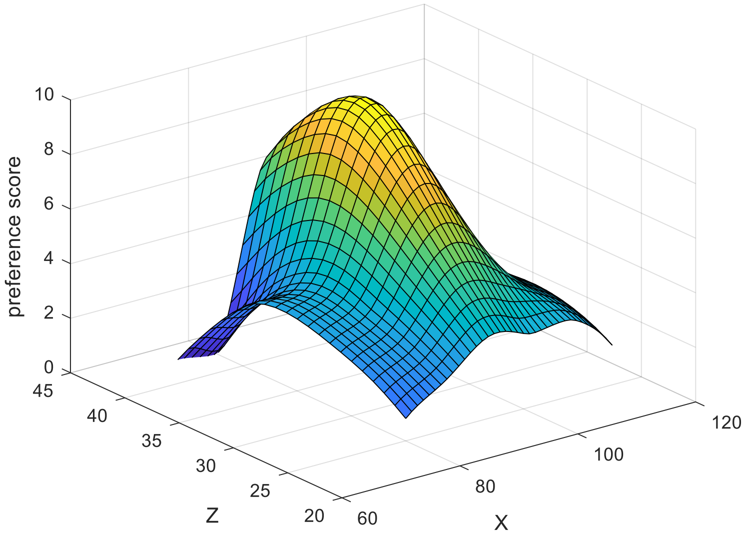
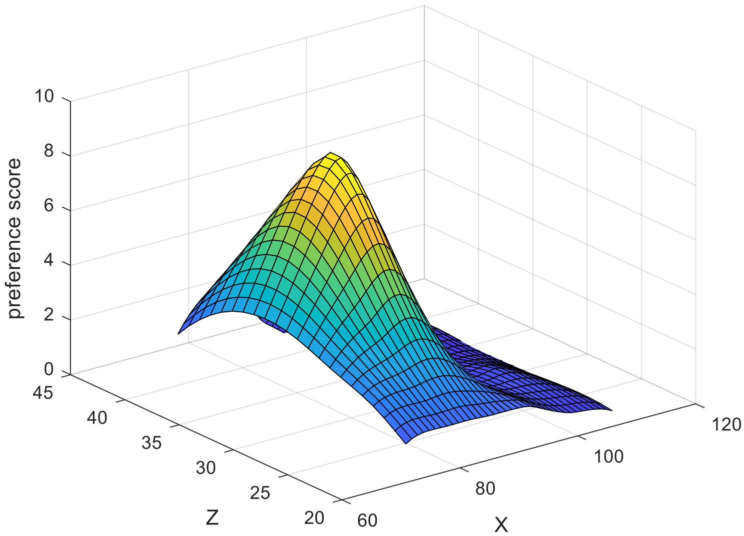
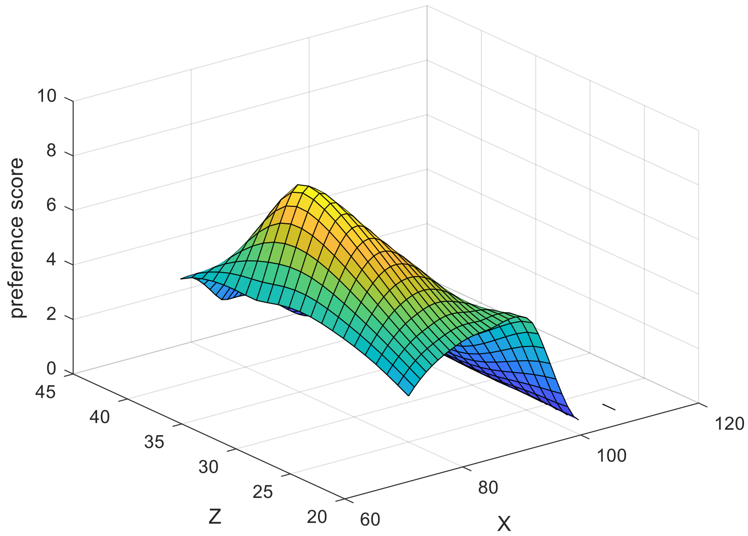


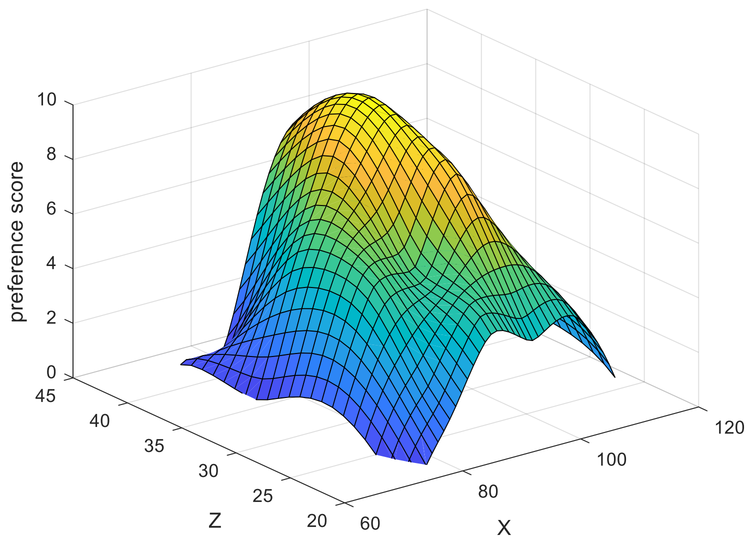
(q) Participant 17



(r) Participant 18



(s) Participant 19



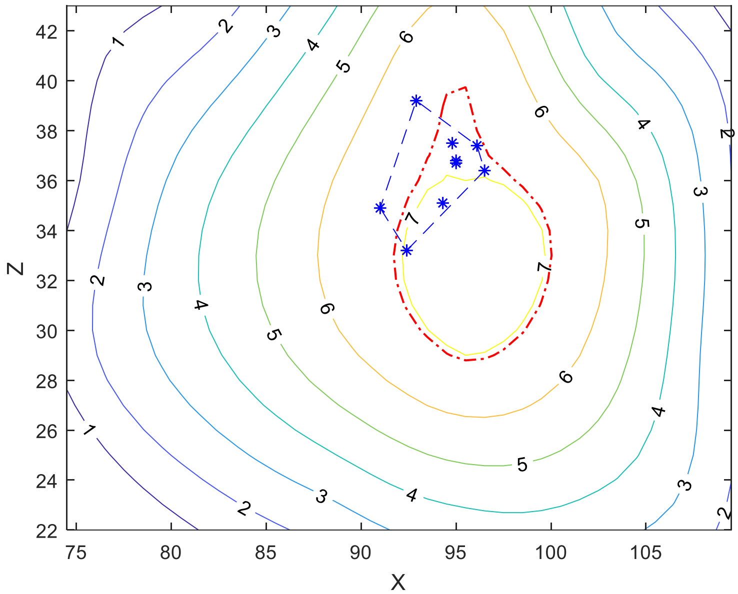
(t) Participant 20

Figure 6. The visualization of the preference map using biharmonic spline interpolations for each participant

3.3 Comparison of the preference map and self-selected MPSP

In order to confirm that the participant's self-selected MPSP had a high preference score, the percentile of each participant's self-selected MPSP was inferred by interpolation, and is shown in Table 6. Participants placed their self-selected MPSP in a region with a preference score above the 90^{th} percentile for an average of 7.7 out of the 9 trials, and participants' self-selected preferred seat positions generally had high preference scores with an average equal to the 94.6^{th} percentile of all preference rating values obtained.

The region with preference ratings higher than the average rating for the participant's preference rating of the 9 self-selected MPSP was defined as the preferred region, and the convex-hull of the 9 self-selected MPSP on each participant's preference map is defined as the self-selected region. Figure 7 depicts each participant's preference distribution as a contour map, in which the self-selected MPSP is marked with an asterisk (*), and the preferred region and self-selected region marked with red and blue dotted lines, respectively. After calculating the area of the preferred region and self-selected region individually, the ratio of the preferred region to the self-selected region was calculated (Table 7). With the exception of participant 4, all participants had a larger preferred region compared to the self-selected region. Participant 4's preferred and self-selected region were similar in size (preferred region area of the preferred region= 37.16 cm^2, area of the self-selected region =39.85 cm^2). The size of the self-selected region was, on average, 41% the size of the preferred region.



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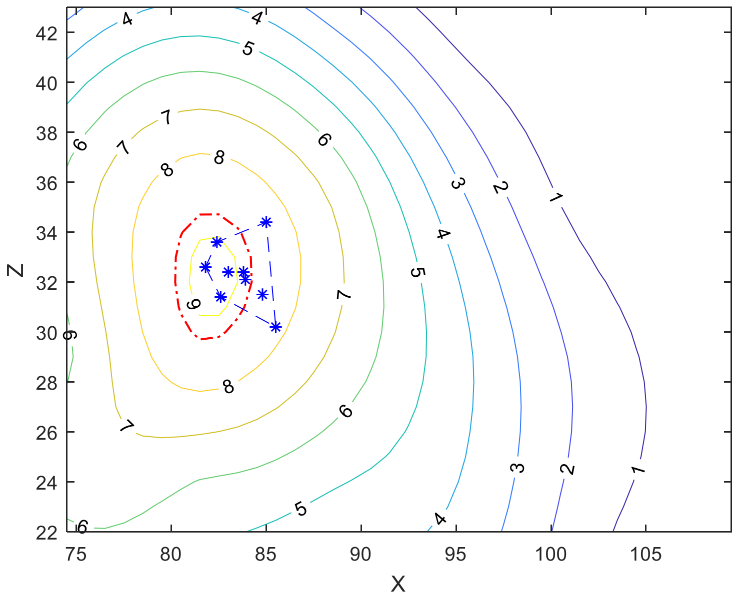
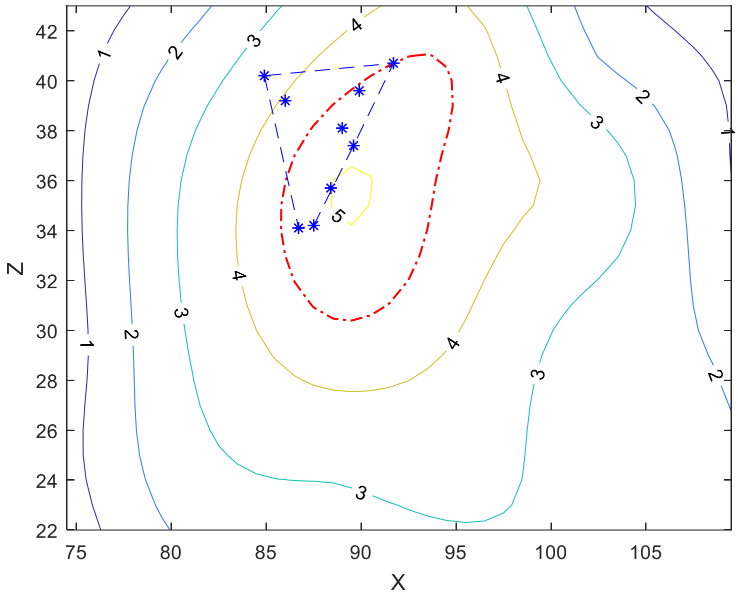
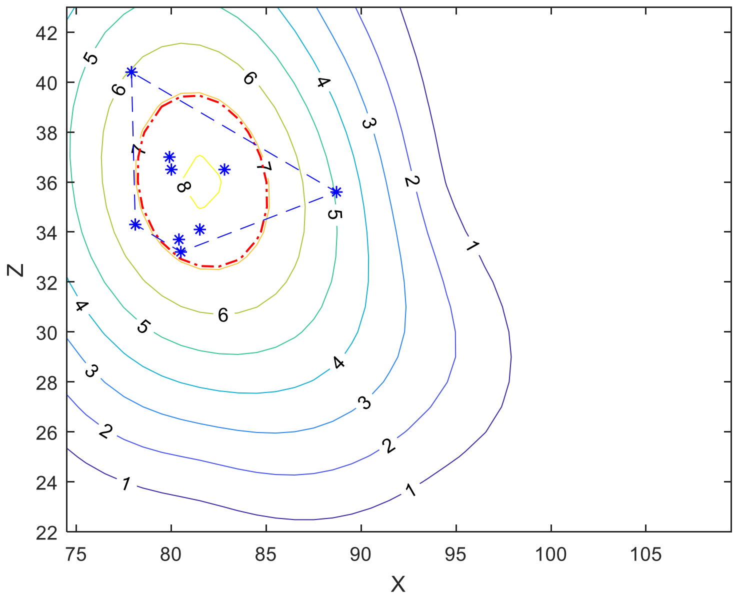


(b) Participant 2



(c) Participant 3



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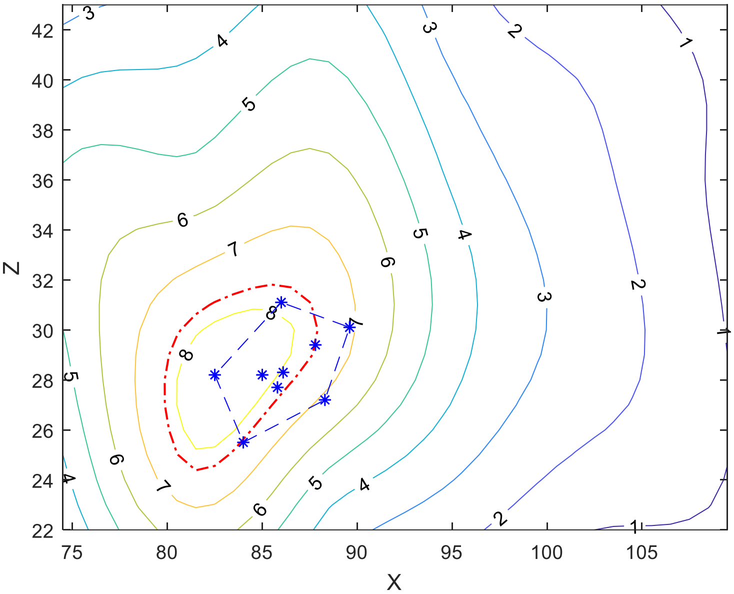
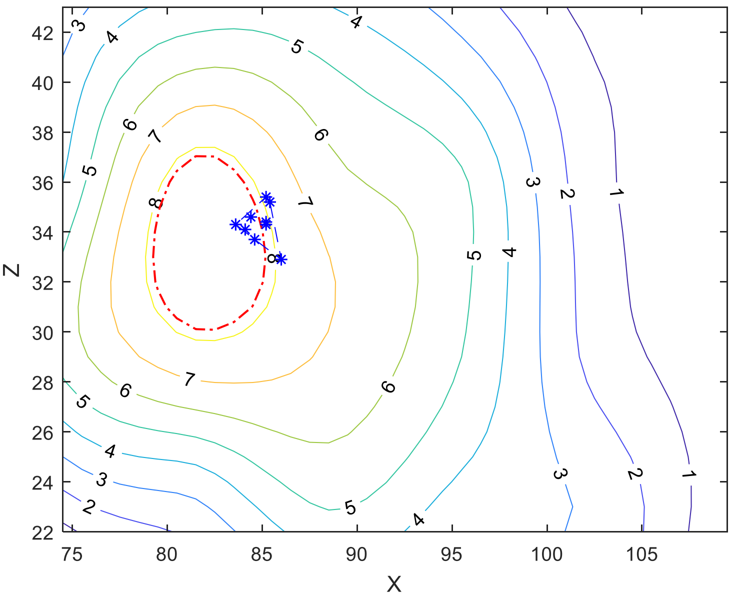
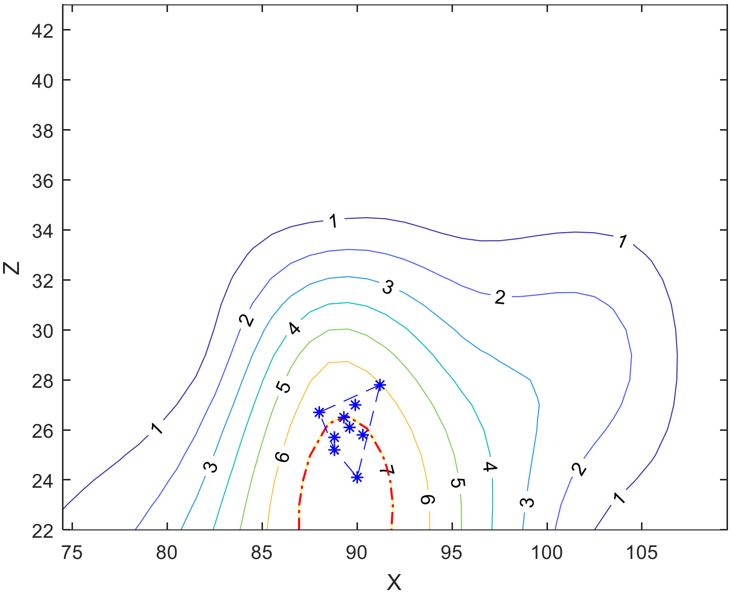


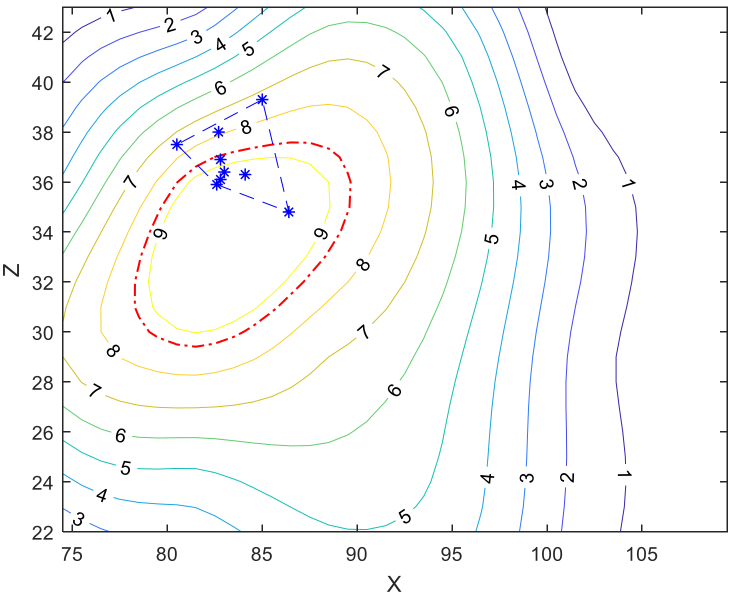
(e) Participant 5



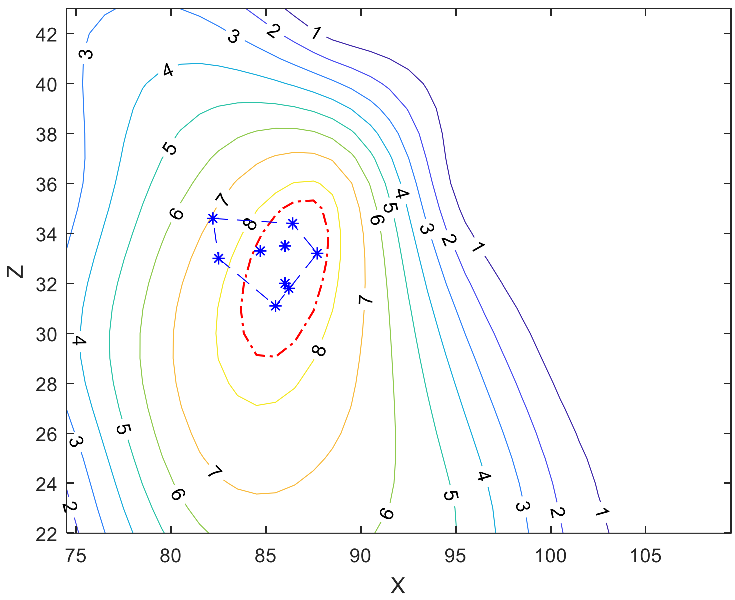
(f) Participant 6



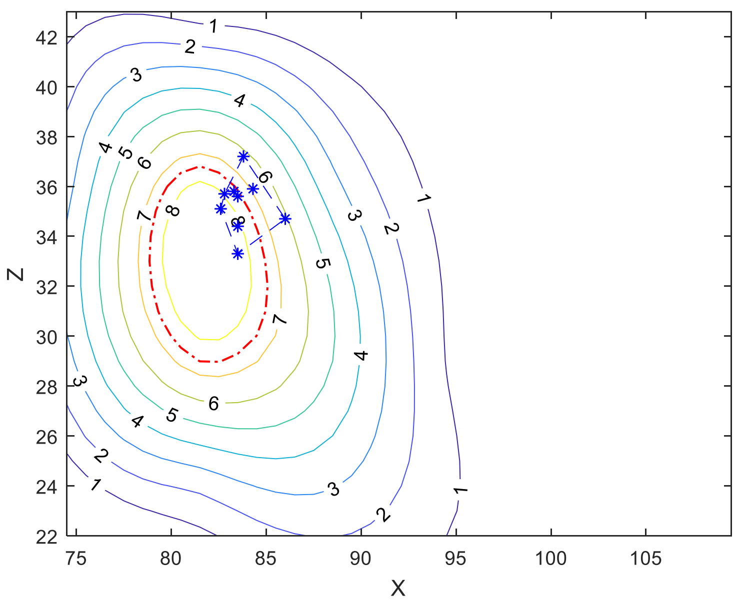
(g) Participant 7



(h) Participant 8



(i) Participant 9



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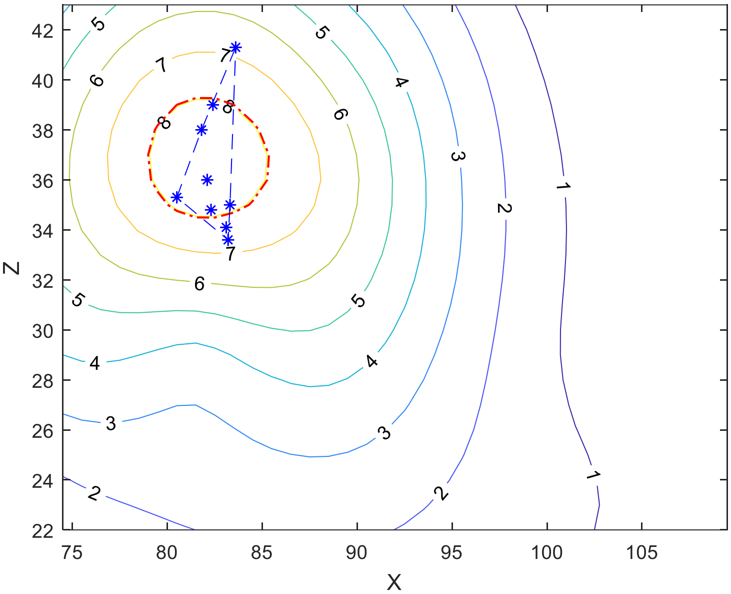
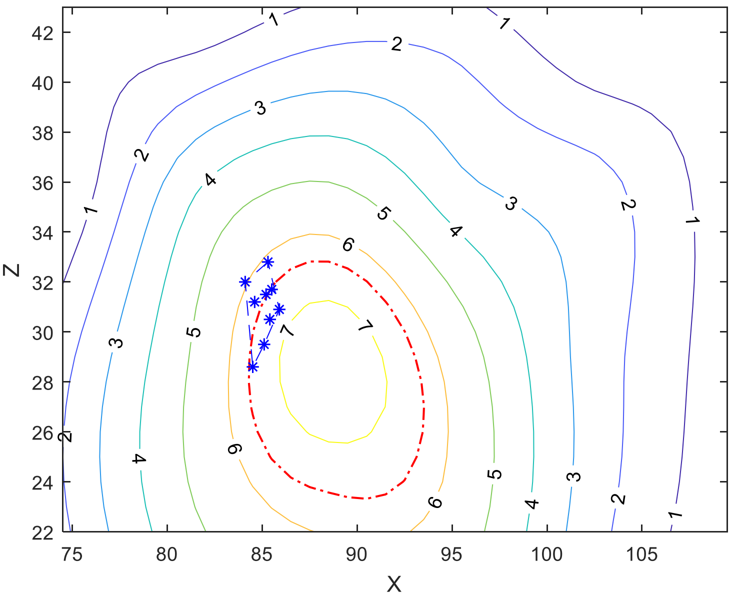
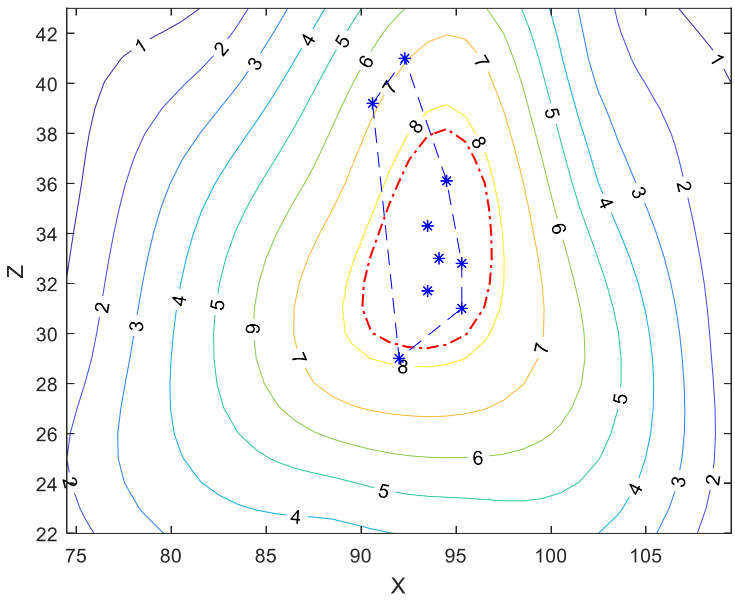


(k) Participant 11



(l) Participant 12



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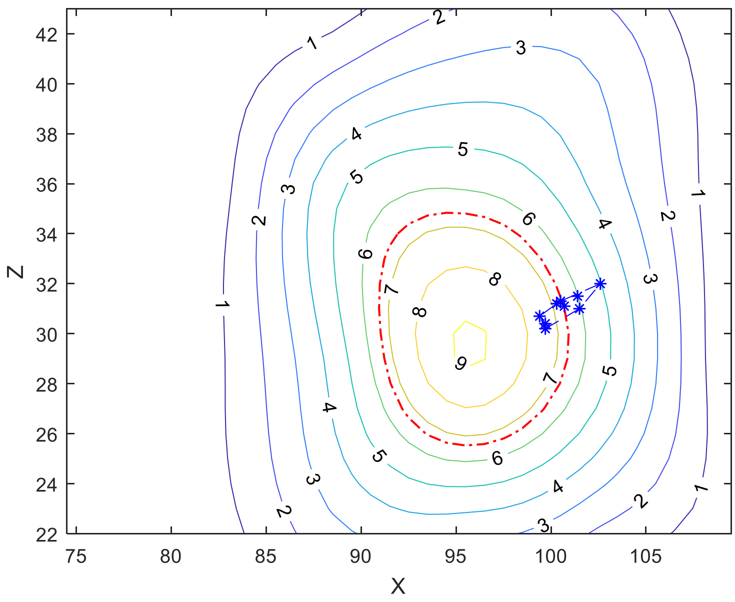
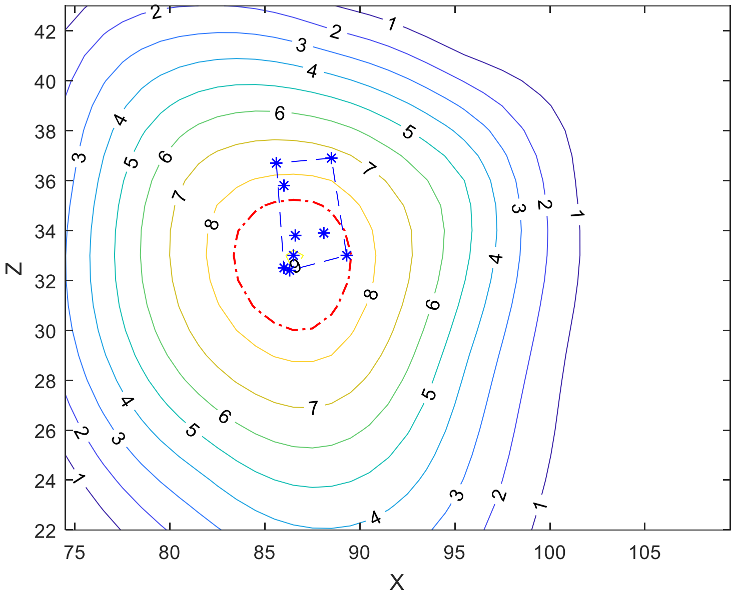
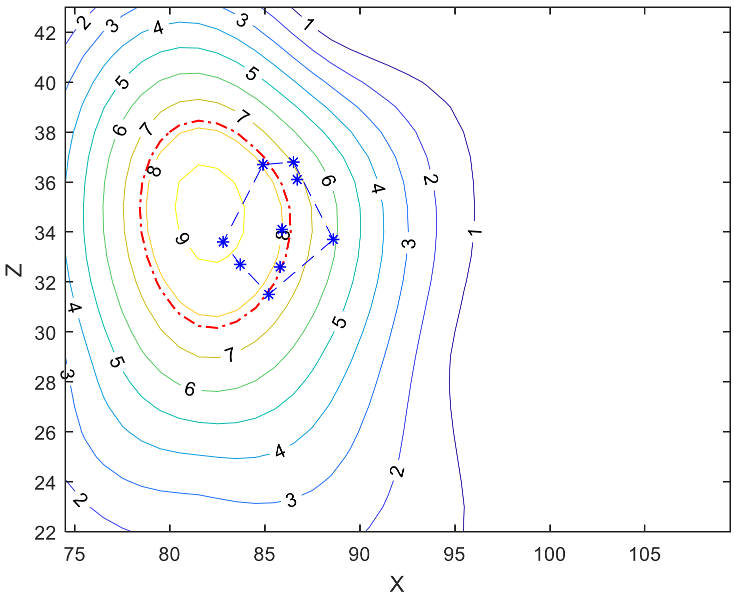


(n) Participant 14



(o) Participant 15



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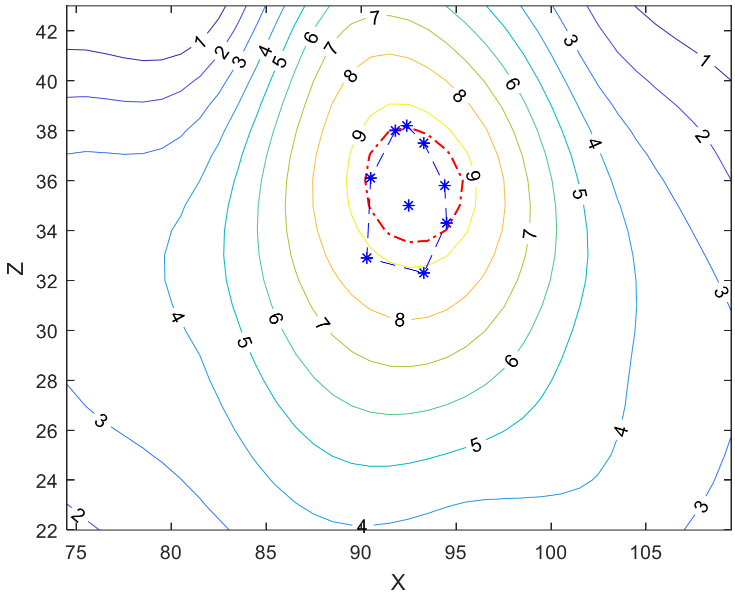
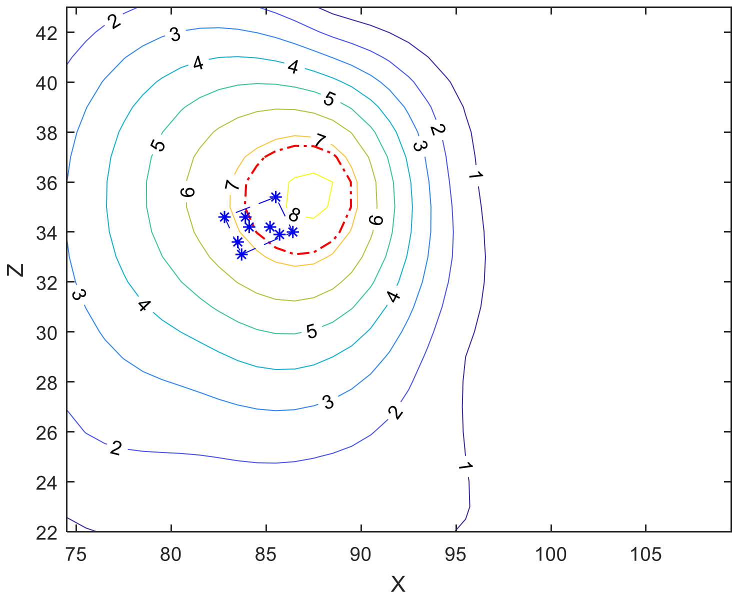
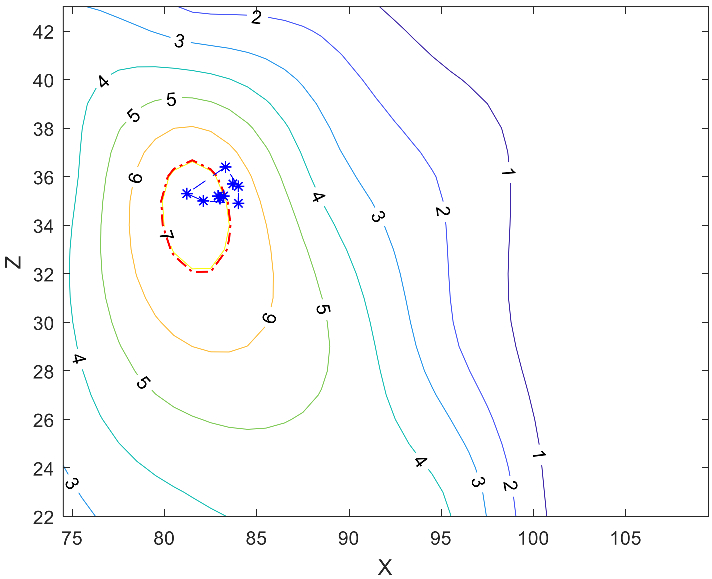


(q) Participant 17



(r) Participant 18



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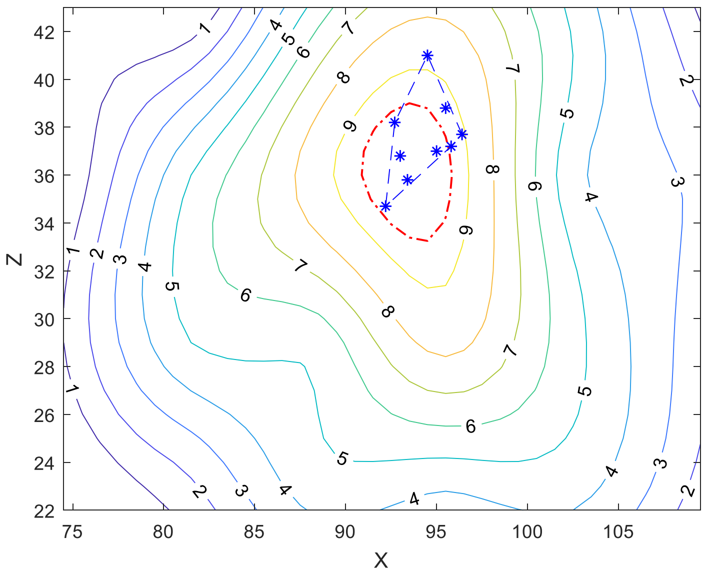


(t) Participant 20

Figure 7. Each participant's preference distribution as a contour map.

Note : The self-selected MPSP is marked with an asterisk (*). The preferred and self-selected region marked with red and blue dotted lines, respectively.

Table 6. Percentile of preference score of the self-selected MPSP from each participants' preference map

Participant No.	Percentile of each trial of the determining self-selected MPSP									Average percentile
	1	2	3	4	5	6	7	8	9	
1	87.7	87.1	93.8	95.0	95.7	93.6	93.8	93.9	92.7	92.6
2	99.9	99.3	94.7	98.6	98.4	99.6	99.7	96.3	92.8	97.7
3	64.0	77.7	96.0	95.0	97.5	92.1	90.9	99.4	98.4	90.1
4	88.3	98.5	98.4	95.8	92.7	78.2	96.8	99.2	98.9	94.1
5	96.1	94.7	99.9	86.3	96.5	89.1	98.2	94.2	95.8	94.5
6	93.2	94.9	93.5	94.8	98.5	93.5	96.7	96.7	97.6	95.5
7	98.0	94.2	99.4	97.6	98.0	98.3	96.8	98.7	96.5	97.5
8	96.9	97.1	77.6	79.5	83.3	96.3	95.1	96.0	92.2	90.4
9	91.7	85.9	99.7	99.8	99.6	98.0	99.1	98.8	99.2	96.9
10	95.4	92.4	88.9	98.2	95.4	98.2	96.7	89.7	97.3	94.7
11	97.4	88.6	97.7	95.2	97.7	99.8	99.1	98.1	93.0	96.3
12	86.3	84.4	93.5	91.6	93.7	88.8	91.0	94.3	90.6	90.5
13	78.5	79.7	99.8	92.3	98.8	99.6	98.5	98.4	96.4	93.6
14	94.0	78.7	90.3	89.9	86.6	94.5	91.1	86.2	93.9	89.5
15	100.0	90.6	94.7	99.9	97.1	98.5	88.1	99.8	99.5	96.5
16	84.5	89.1	93.5	93.0	94.5	97.5	94.1	90.3	99.2	92.8
17	97.9	97.6	99.6	94.1	94.6	98.4	97.3	98.0	99.2	97.4
18	94.9	98.3	98.8	95.5	97.2	97.1	98.3	99.1	95.5	97.2
19	98.4	95.9	96.6	99.9	96.3	98.8	96.8	98.9	99.8	97.9
20	98.1	91.5	95.4	97.9	99.9	99.7	96.7	94.1	98.7	96.9
Total average percentile										94.6

Note : The shaded regions in Table 6 indicate relatively low preference score below the 88^{th} percentile.

Table 7. The area of the preferred region and self-selected region

Participant No.	The area of		The ratio of the area of self-selected region in comparison to the preferred region (B/A)
	Preferred region (cm^2, A)	Self-selected region (cm^2, B)	
1	58.27	17.37	30%
2	17.20	9.49	55%
3	68.69	23.69	34%
4	37.16	39.85	107%
5	40.36	23.11	57%
6	32.95	2.63	8%
7	18.43	5.72	31%
8	67.05	13.27	20%
9	21.47	11.82	55%
10	38.43	6.84	18%
11	24.82	11.13	45%
12	69.31	4.28	6%
13	44.99	33.80	75%
14	74.57	1.71	2%
15	25.97	13.01	50%
16	50.67	17.82	35%
17	19.06	18.05	95%
18	20.07	4.68	23%
19	14.11	2.45	17%
20	22.10	12.38	56%
Avg.	38.28	13.65	41%

4. DISCUSSION

4.1. Characteristics of the relationship between seat position and driving preference

Four main characteristics were observed in the color map and 5 indices that represent the relationship between seat position and driving preference.

(1) Unimodality: A unimodal shape was observed in the analysis, as the highest preference score occurred in one or two proximate seat positions, and the preference score decreased as distance increased from the position(s) with the highest preference score(s). Dual or multiple peaks was not observed (Figure 5). This trend of unimodality observed in the preference distribution can be interpreted in terms of biomechanics. It is widely known that the middle range of a joint's range of motion is the most favorable. A driving posture is comprised of a combination of various joint angles, and thus the optimal driving posture is likely to be composed of joint angles that lie within the middle range of a joint's range of motion. In addition, it is expected that the driving preference will decrease as the driving posture deviates further from this optimal posture or postures.

(2) Individuality: Individual differences were observed in terms of the preference score distribution according to the driver's seat position (Figure 5).

(3) Pointedness: The average preference score of the most preferred seat position was noticeably higher compared to the average preference score. This signifies the close proximity of the high preference scores. The preferred seat

position is concentrated in one region, and the reason for the pointed shape of the preference map may be a result of participants using various standards used to evaluate the seat position. The survey conducted after the study revealed that participants considered many factors in deciding their preferred seat position. These factors include but are not limited to how comfortable the posture was when seated, the distance between the steering wheel and the body, whether the motion of stepping on the pedals extended to the ends of the ankle's range of motion, the range of vision when seated, and whether the posture was familiar. Therefore, the region that satisfied all of the participant's conditions and ultimately given a high preference score, was only a small number out of the entire range of seat positions. In addition, analysis the stature groups' bivariate kurtosis (Table 4b) revealed the Short group exhibiting a significantly pointy distribution compared to the Medium and Tall group. Taking into consideration the shorter limb lengths of the participants in the Short group, there are only a limited number of seat positions with adequate accessibility to the steering wheel and pedals. Thus, it could be predicted that high preference ratings could only be given to seat positions in a limited region. Furthermore, it can be interpreted that the Short group may have a smaller preferred region, as the postures that can be expressed by a combination of the more advantageous joint angles is smaller compared to other stature groups, due to shorter limbs.

(4) Asymmetry: Asymmetry along the x-axis (front back) and z-axis (up and down) were observed by calculating the bivariate skewness of the seat positions' preference score distribution (Table 3). The skewness along the x-axis was mostly positive, as the distribution is mostly skewed towards the –x direction and has a long tail in the positive direction along the x-axis. The skewness along the z-axis is mostly positive, as the distribution is skewed in the +z direction and

have long tails along the –z axis. It is difficult to precisely pinpoint the reason for asymmetry, but may be explained by the geometric relationship between the driver's body and other components of the vehicle (dashboard, steering wheel, etc.). For example, interference may occur with the steering wheel and the upper body when the seat is adjusted in the forward direction, but this would not occur if the seat was adjusted in the backward direction. Another index used was the direction of decrease in preference score. The ratings decreased as distance increased from the most preferred position in different directions for the Short and Medium groups (upward direction, +z) and Tall group (forward direction, -x). This trend demonstrates the difference in stature groups in terms of factors considered when deciding seat preference. For example, the Short and Medium groups may consider the contact stress between the front of the seat and back of the thigh as a primary consideration factor, causing a dramatic decrease in preference score when the seat position is adjusted upward. On the other hand, the participants in the Tall group have longer limbs than the other two groups, and thus may mainly consider the interference between the knees and the dashboard, resulting in a dramatic decrease in preference ratings in the forward direction.

4.2. Evaluation of the utility of self-selected MPSP

A comparison of the self-selected MPSP and generated preference map revealed that though individual differences exist, participants were able to self-select seat positions with a high enough preference. Thus, the widely-used method of driver self-selection in defining the MPSP, as used in many existing works (Reed et al. 2000; Gragg et al. 2011; Park 2012; Park et al. 2014; Park et al. 2016; Peng et al. 2018), is valid as shown by in Table 6.

However, there exist limitations in defining the driver's preferred region with the sole use of the self-selected method. First, not all participants placed their self-selected MPSP in their preferred region, and on the contrary, on average of 10 percent of the MPSP had relatively low preference scores below the 88th percentile (Table 6). In addition, even participants who accurately placed the self-selected MPSP in a region with a high preference score only defined 41% of their preferred region (above average preference score) with the 9 self-selection trials (Table 7). It is expected that increasing the number of trial repetitions may result in finding a larger preferred area, but is not ideal as additional costs occur. Thus, this is one of the limitations in defining the entire preference region using the self-selected MPSP method.

Various reasons may exist for these limitations of the self-selected MPSP method. First, many cognitive resources (memory, decision making, operation, evaluation, etc.) are required in finding the driver's most preferred seat position. For example, this method may require the participant to complete a complicated cognitive process of calculating the preferred seat position region through the initial position, adjusting the seat after deciding the direction of adjustment, and evaluating the resulting seat position, comparing it to nearby seat positions. Thus, it may be difficult for drivers to select an accurate MPSP. In addition, Cook and Woods (1994) states that a tendency of "cognitive tunneling" exists, which makes it difficult to explore various alternatives due to the initial hypothesis. Despite the existence of other seat positions of similar preference, participants may attempt to match the seat position to their daily seat position or to one of the initial seat positions. Therefore, there is a possibility of participants not being able to find all of their preferred seat positions, and instead only exploring a small region of the preferred seat positions. Though an increased number of trials in the self-selection method may offer a solution to this problem, this requires additional time and effort during the study.

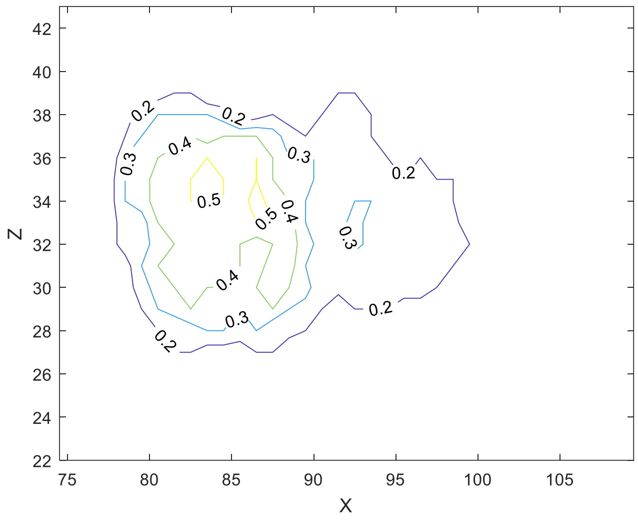
4.3 Contributions and implications

This study was the first step in exploring the relationship between the seat positions and driving posture preference in regards to the entire seat adjustment range of a vehicle. The experiment process and analysis method used in this study may be of use in exploring the relationship between other vehicle interior factors and driver preference. Preference maps offer information about not only the location of the MPSP but information of the preference region such as the area, shape, skewness, rate of preference score decrease in each direction, and personal preference distribution. Therefore, this method may be applied to future related works about interior design of vehicles in thoroughly exploring the trends of preference distribution according to the vehicle seat position.

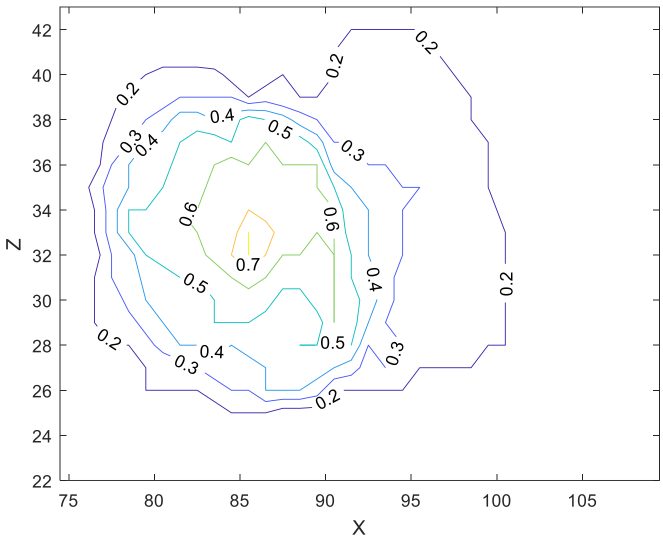
The results suggest that the self-selected MPSP represents a seat position that generally is of high preference, and that the self-selected MPSP is useful in designing vehicle interiors. However, the sole use of the self-selected MPSP was inadequate in defining the entire region of seat positions with high preference. Therefore, solely using the self-selection MPSP to calculate accommodation level of the seat adjustment range may not be accurate.

Additionally, the generated preference map allows for an accurate calculation of the accommodation level. The calculated population accommodation with the use of a preference map as opposed to a few self-selected MPSP will result in a much more accurate estimate, as the self-selected MPSP method of calculating accommodation is likely to underestimate the accommodation level.

Moreover, the generated preference map may be used to calculate the accommodation level about various accommodation standards, thus allowing for more flexibility during design. The designer will have the choice to decide a 'target preference score (or percentile)' according to the situation, and afterwards generate an accommodation level map of the drivers who meet these requirements. For example, a comparison of the accommodation level map of participants whose preference ratings are 6 and 7 at a certain seat position (Figure 8) shows that the accommodation level increases as the standards are eased. As this method offers a larger amount of information compared to the existing method of defining the seat adjustment range with the sole use of self-selected MPSP, it may be a practical analysis tool in future research.



(a) Accommodation level of preference score over 7 (max accommodation level = 0.55)



(b) Accommodation level of preference score over 6 (max accommodation level = 0.8)

Figure 8. A comparison of the accommodation level map of participants whose preference ratings are 6 and 7 at a certain seat position

4.4 Limitations

This study utilized a vehicle mock-up and a driving simulation program, and there may be a difference in the preferred seat position and driving preference evaluation due to a few factors, such as 1) the vehicle mock-up does not have a roof, 2) the field of vision may be insufficient, and 3) other psychological factors.

In addition, the vehicle mock-up used in this study was of a sedan and the simulated driving situation was of a short distance drive in a city environment. Thus, results may vary for other types of vehicles (SUV, truck, etc.) and other driving environments (countryside, long distance driving, etc.).

5. CONCLUSION

This study examined relationship between driving preference and seat positions across the entire seat adjustment range, and verified the genera method of self-selection used in previous studies. There were four characteristics (unimodality, individuality, asymmetry, pointedness) observed. Short and Medium groups showed different trends compared to the Tall group in terms of the direction of reduction in preference rating, as the former showed a reduction in the upper direction (+z), and the latter in the forward direction (-x). In addition, the Short group had a pointier distribution compared to the Medium and Tall group.

On the other hand, the self-selected MPSP method was evaluated. Examination of the utility of self-selected MPSP showed that participants' self-selected preferred seats generally had a high preference rating, located at seat positions with high preference score with an average equal to the 94.6th percentile of all preference rating values obtained. However, on average, 10 percent of the MPSP had relatively low preference scores below the 88th percentile. Also, limitations of the method were evident in that participants on average only identified 41% of the entire region of seat positions with high preference ratings with the self-selection method.

There is a possibility that the self-selection method is not adequate in finding the region of MPSP. This may affect the analysis and conclusions that are made with the assumption of the credibility of the method. Additionally, the preference map utilized in this study offers a systematic method to find the preferred region, and results in a larger number of preference data compared to the self-selection method. Therefore, further development of this study may bring about tools to accurately calculate the accommodation level of the seat adjustment range, in addition to aiding the design process of vehicle interiors.

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APPENDIX A: Simulation road map

APPENDIX B: Survey format

설문

1. 이름: ______________ 나이(만) : ______________ 운전경력: ______________
2. 평소 운전하는 차 : 모델명 ________ ☐ 경차 ☐ 세단 ☐ SUV ☐ 기타 ☐ 없음
3. 평소 운전 빈도 : ☐ 하루 1회 이상 ☐ 1주일 1~5회 ☐ 1달 1~4회 ☐ 거의 안함
4. 1회 운전시 평균 주행 시간 : ☐ 1시간 미만 ☐ 1~2시간 ☐ 2시간 초과 ☐ 거의 안함
5. 평소 운전시 자세의 불편함을 민감하게 느껴 시트 위치를 자주 바꾸는 편입니까?
   ☐ 전혀 그렇지 않다 ☐ 그렇지 않다 ☐ 보통이다 ☐ 그렇다 ☐ 매우 그렇다
6. 일상적인 운전이 가능한 시트의 위치는 선호도 몇 점 이상입니까? (0-10점) ________점
7. 선호도 점수를 매기거나 운전 가능 여부를 판단할 때 고려한 점은 무엇이었는지 자유롭게 서술하시오. ______________________________

ABSTRACT

Characterizing driver seat position-preference relationship and evaluating utility of self-selected driver seat positions

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Vehicle ergonomics has been extensively researched in the field of ergonomics. Previous research has defined and measured drivers' most preferred seat positions, and utilized this data to conduct various observations and analysis about driving posture prediction, the relationship between anthropometric measures and preferred component arrangement, the optimal adjustment range of components, and population accommodation.

However, there exist two limitations of previous research. First, not much research has been conducted about the relationship between driver preference ratings and seat positions other than the most preferred seat position (MPSP) of the driver. Second, the previously used self-selection method of defining

and determining MPSP has been used in various research studies without proper validation. Thus, it is difficult to determine if this self-selection method is useful in identifying the driver's most preferred seat position, and whether or not other seat positions with similar preference ratings exist. Therefore, the objectives of this study were to: 1) characterize the driver seat position-preference relationship across the entire seat adjustment range and 2) verify the utility of the self-selected MPSP method. To do so, individual drivers' preference maps were empirically developed using an interpolation method.

The study collected the data of 20 participants and 9 trials of their self-selected MPSP, in addition to the preference ratings of 34 seat positions. Four characteristics (unimodality, individuality, asymmetry, pointedness) were observed in the relationship between seat position and driver preference. Also, stature found to influence the relationship.

In addition, participants' self-selected preferred seat positions generally had high preference scores with an average equal to the 94.6th percentile of all preference rating values obtained. However, on average, 10 percent of the MPSP had relatively low preference scores below the 88th percentile. Furthermore, the limitations of the self-selection method were evident as the participants on average only identified 41% of the entire region of seat positions with high preference ratings equal to or higher than the average of the preference scores of his/her MPSP.

This study discovers the relationship between driving preference and seat

positions across the entire seat adjustment range, and evaluated the utility of the self-selection method. The results of this study are expected to be utilized in more accurately evaluating the level of the driver population accommodation in relation to the seat adjustment range and aiding in designing vehicle interiors.

Keywords: vehicle ergonomics, vehicle seat positions, driver preference map, most preferred seat position, self-selected seat position

Student Number: 2017-28718

국문 초록

자동차는 오랫동안 인간공학의 주요 연구 대상 중 하나로 자리매김해왔다. 자동차 인간공학의 여러 분야에서 운전자가 가장 선호하는 시트의 위치를 정의 및 측정하였고, 이를 활용하여 운전자의 운전 자세 예측 및 분석, 인체 치수와 선호 부품 배치의 관계 도출, 최적 부품 조절 범위 결정, 그리고 인구 집단의 수용도 계산 등의 다양한 분석이 시도되어왔다.

하지만 기존 연구들에서는 다음과 같은 두 가지 한계점이 존재한다. 첫째, 운전자의 최고 선호 시트 위치(Most preferred seat position, MPSP) 외 다른 시트 위치와 운전 선호도의 관계의 특성을 밝힌 기존 연구가 매우 드물다. 둘째, 기존에 MPSP를 측정하는데 가장 보편적으로 사용되어온 자가 선택 방식 는 운전자가 선택한 지점이 실제로 가장 선호되는 지점인지, 운전자가 선택한 지점과 비슷한 선호도를 갖는 다른 지점은 존재하지 않는지의 효용성을 검증하지 않은 채 사용되어왔다. 따라서 본 연구에서는 실험을 통해 자동차 시트 조절 범위 전역에 대한 시트 위치-운전 선호도 관계의 특징을 밝히고, 보간법을 사용한 '선호도 지도'를 생성하여 자가 선택 MPSP 방식의 효용성을 검증하였다.

본 연구에서는 총 20명의 피실험자를 대상으로 9번의 자가 선택 MPSP 측정과 34개의 시트 위치의 선호도 점수 수집이 이루어졌다. 수집된 데이터를 통해 자동차 시트 위치-운전 선호도 관계에서 4가지

특징(단봉성, 개별성, 비대칭성, 첨성)을 도출하였으며, 키집단(Short, Medium, Tall)별 특성을 비교하였다. 또한 피실험자들이 자가 선택한 시트의 위치는 평균 백분위수 94.6 으로 높은 선호도를 보이는 것으로 나타났으나, 9번의 측정 중 0.9번 정도는 선호도가 낮은(백분위수 88 미만) 영역을 선택하며, 같은 선호도를 갖는 모든 선호 영역의 면적 대비 41%에 해당되는 영역만을 선택함을 발견하여 자가 선택 방식이 한계점을 갖는다는 사실을 확인하였다.

본 연구는 자동차 시트 조절 범위 전역에서의 시트 위치와 운전 선호도 관계의 특성을 밝힌 첫 번째 연구이며, 기존에 보편적으로 사용되어왔던 자가 선택 MPSP 방식의 효용성을 검증했다는 점에서 의의를 갖는다. 이 연구 결과는 자동차 시트 조절 범위에 대한 인구집단의 수용도를 정확히 계산하는 것 뿐만 아니라 자동차 실내 패키징의 설계 자유도를 높일 수 있는 새로운 도구로 활용될 수 있을 것으로 기대한다.

주요어: 자동차 인간공학, 자동차 시트 위치, 운전자 선호도 지도, 최고 선호 시트 위치, 자가 선택 시트 위치

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