Kansei and Ergonomic Consideration on Slanted and Horizontal Car Seat Levers

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Abstract

The purpose of the study was not only to determine an easy-to-operate lever angle but also to discover relationships in the comfortable/uncomfortable lever angle between low-torque occupants (females and older people) and high-torque occupants (males). The lever angles and positions on the sides of the car seats were set in the experimental apparatus (two-dimensional coordinate). A Kansei evaluation was performed via two lever angles and five Kansei evaluation selected in a preliminary experiment, and the relationship between the comfort and control lever design parameters (Lever angle, lever position height, and horizontal distance). They were investigated via ANOVA and LOESS. Significant differences were observed between the lever angles and genders in the relationships between the positions and Kansei scores (Comfort/Discomfort). The high Kansei score positions for females at the mounting angle of 25 degrees have moved far up relative to the horizontal angle, but the area was considerably narrower than that of males. When the lever mounting angle was slanted, High Kansei scores are observed wide changes, and the reachable range was considerably wider regardless of gender. We also found a significant trend toward improved Kansei scores. Keywords: kansei engineering, ergonomics, car seat, lever position, automotive.

1 Introduction

Car seats have included some control levers to adjust the seating position. The position of these levers is not necessarily comfortable and easy to operate for all passengers and drivers [4]. For people with a wider range of body sizes, the requirement for ergonomic considerations becomes important. Many of these levers control for comforts, such as height, position, and reclining. Additionally, Kurita et al. (2013) have conducted a biomechanical analysis of force perception characteristics and reported it affects steering wheel operability [5].

Studies investigated the effects of the comfortable operation of vertical lever grips (Pull/Push) and lever position (Height/Distance) [6]. Furthermore, there are studies examined the operation of the vertical grip (Push/Pull) [7], and manual transmission shifter lever [4]. Groenestein (2009) had obtained subjective evaluations on the comfort of the lever operation. In that study, participants (both males and females) focused on seat adjustment and comfort [8]. In that study, 70% of the participants reported that comfort seat adjustment was one of the decision factors of "Likes/Dislikes".

For the many cars, the levers located on the side of the seat used for adjusting the seat-backrest angle. It is known that the adjusting angle of the seat-backrest is the spine load decreases [9]. The mounting angle and installation position of the seat levers are determined by mechanical and interior design limitations, and they have determined mainly with males data.
The role of the seat lever mounting angle regarding operability was not well investigated. Furthermore, there is absent that a real industry standard. In the study, we conducted a Kansei evaluation on the relationship between the mounting angle and the operability of the lever of car seats. It is considered that changing the mounting angles of the lever reduces the wrist abduction angle, and that increases the work efficiency of the musculoskeletal. The purpose of the study was to determine an optimum seat lever mounting angles, and that considering the physical properties of occupants such as body size and upper arm force. The goal can be achieved with Kansei engineering methodology. The purpose of the research does not just research, but to find a concrete seat lever design methodology that can be operated by anyone.

2 Methods
2.1 Participants
A total of 47 healthy participants, including adults and university students (31 males, 16 females), participated in the evaluation experiment. They are unpaid for participation. Participants had no symptoms that interfere with lever operation. All the participants were right-handed. The average age of males corresponded to 25.1 years and the average height was 170.2 cm. The average age of females corresponded to 29.1 years and the average height was 158.7 cm. It covers a range of heights between the 5th and 95 percentile of surveys by the Research Institute of Human Engineering of Quality Life (HQL) from 2004 to 2006 [10] (Fig. 1).

![Fig. 1 Height of Participants in the Statistical Distribution of Japanese](image)

2.2 Equipment and procedure
Fig. 2 shows the position of the lever grip point on the experiment apparatus. The twenty-five positions were set for evaluation. These were selected from both preliminary experimental results and the participant reachable mounting angles and positions. The lever positions are termed as 1 ~ 10 in the rows and A-U in columns. The experiment lever mounting angles have two that horizontal (0 °) and 25 °. The distance from the leftmost pivot point to the grip point was 120 mm. The lift moves 30 mm with the grip. The initial pull-up force at the grip point was set to 39 N for both angles.

The physical set-up is shown in Figs. 2 and 3. These Kansei evaluation to the operation of the seat lever selected from the preliminary experiment (Fig. 4). In the study, the order of lever mounting angle and position has been changed randomly. During the evaluation, participants were instructed to use their upper limbs to operate the lever. They were
also instructed not to use the trunk to the maximum possible extent. Operating postures were recorded with cameras from the frontal, sagittal, and transversal planes.

Fig. 2 Experimental apparatus for the research (Mounting lever angle: 0° and 25°)

Fig. 3 Measurement/evaluation position diagram

Fig. 4 Kansei evaluation for Lever operation (Kansei words: SD method, five levels)

### 3 Analysis of experimental results

#### 3.1 ANOVA on relations between Kansei evaluations and lever angle/gender difference.

The Kansei score results were collected from all 47 participants. Statistical analysis was performed with JMP ver. 8 (SAS Software) and R. 3.6. 2 (R Development Core Team).

We analyzed how the angle of the lever and gender affect the Kansei scores. Prior to ANOVA, the homoscedasticity of the variance was examined. Because we found the substantial gender difference in the preliminary study, the evaluation results were separately done for male and female data.

The Kansei evaluation scores of the influence of lever position at each angle were all homoscedasticity. In the study, participants (both males and females), the two Kansei scores of "wrist comfort" and "ease of exertion" were homoscedasticity. For male participants, the "wrist comfort" showed a significant difference in the lever position at the lower $p$-value than 0.01, and also "ease of exertion" showed the difference with the lower $p$ than 0.01. Female participants showed a significant difference in the wrist ($p < 0.05$), arm ($p < 0.01$), and shoulder ($p < 0.01$) of the upper extremity. "ease
of exertion” also showed difference ($p < 0.01$).

Then, we have further analysis of the Kansei score "Wrists comfort", which have homoscedasticity, by ANOVA and LOESS.

(a) ANOVA results of the Kansei scores according to the mounting angle.

**Fig. 5** shows the results of the all participants measurement position where the lever mounting positions are common both mounting angles that were horizontal (0°) and oblique angle of 25°. The Kansei scores of the lever operations were clearly changed with the lever mounting angles. The high Kansei score positions were moved from left to right, and better at the mounting angle 25° than horizontal. ($p < 0.01$).

![Kansei evaluation (Wrist comfort)](image)

**Fig. 5 Kansei score (Wrist comfort) of Lever mounting angles (All Participants, 0° and 25°)**

(b) High Kansei score positions

**Fig. 6** shows the results for male participants for the Kansei score "Wrists comfort". The high Kansei score positions for the mounting angle 0° was 07M (Average of 3.7), followed by 06J (3.6), 07K (3.5), 05I * (3.4), 06H (3.4), 08L (3.4), and 05K (3.3). The high Kansei score position from the 1st to 9th, they have rated the average of all or more. At the mounting angle 25°, the best-rated position was 08N (Average of 4.4), followed by 09o (4.1), 08L (4.0), 09M (4.0), 10 P (4.0), 09Q (3.9), and 07K (3.5). The 1st to 10th positions were the average of all or more.

The results for females showed that high Kansei scores of the mounting angle 0° were 09K (Average of 3.5), and followed by 07K (3.4), 08L (3.4), 07M (3.3), 06J (3.2), 08J (3.2), and 7I * (3.1). From the 1st to the 8th position, Kansei scores were the average of all or more. At the mounting angle 25°, the highest position evaluated was 08N (Average of 3.9), followed by 09M (3.9), 10 N (3.9), 08L (3.8), 09o (3.6), 10 P (3.6), and 07M (3.5). From the 1st to the 7th position, Kansei scores were the average of all or more.

For the effects to Kansei score in the lever mounting angle of 0° to 25°, the best Kansei score position for the 0° of males was 07M, for the 25°, the same position had been slightly better than the average of all, *(Fig. 6).* The best Kansei score position for the 0° of females was 09K, for the 25°, the same position had been low than the average of all.

The Kansei scores were more investigated with the posthoc test by Tukey’s HSD test. The HSD test results show six groups at mounting angle 0° and two groups at the mounting angle 25° for the results for males. The results for females show two groups at mounting angle 0° and one group at the mounting angle 25°. When the lever mounting angle was slanted, Multiple comparisons of average tended to results in fewer groups, regardless of gender. The mounting angle 0° has not included the high Kansei score position rated +1SD or higher, regardless of gender. At the mounting angle 25°, 08N was a very high score position for males (+1SD or higher). The high Kansei score positions for females did not show such that.
Fig. 6 Results of the average value multiple comparison Tukey's HSD tests (males, Kansei score: “wrist comfort”, top: 0 °, bottom: 25 °).

(c) Gender effect.

For the average of all Kansei scores for all mounting angles for all participants, were 3.1 with the standard deviation which was 1.2. As shown in Fig. 7, the results for males, in the Kansei score "Wrist comfort", the mounting angle 0 ° was the Kansei score: 2.9 (SD: 1.1, p < 0.01), the mount 25 ° was the Kansei score: 3.3, and SD was 1.1 (p < 0.01). For the results for females, the mounting angle 0 ° was the Kansei score: 2.8 (SD: 1.2, p < 0.01), the mounting angle 25 ° was the Kansei score: 3.1 and the SD was 1.3 (p < 0.01).

Fig. 7 Results of ANOVA by Lever Mounting Angle (average and standard deviation)

At the mounting angle 0°, males rated higher than the average of all (the two mounting angles and all lever positions) for the three (Can be manipulated with one hand, Comfortable posture, Shoulder comfort) of the five Kansei evaluation, while females had no positions that have a higher score than the average of all. For the effect of lever
mounting angles 25 °, males rated more than the average of all Kansei scores. The results of the females indicated that the four Kansei scores were higher than the average of all. (Can be manipulated with one hand, Ease of exertion, Shoulder comfort, Wrist comfort). The tendency of females was considerably weaker than that of males, but there was a significant tendency to improve with changes in the mounting angle.

3.3 LOESS on relations between Kansei evaluations and lever angle/gender difference.

In order to utilize the research results as a design index, we illustrated the positions where the high Kansei scores are obtained in the two-dimensional map. LOESS (Locally Estimated Scatterplot Smoothing), which is an optimal smoothing method [11], was used to map the High Kansei score positions for the effect of lever mounting angles. LOESS has been used in morphometric studies [12]. Fig. 8 shows a local regression using a cubic function of Xj adjacent to Xi as the weighted kernel expression (Eq. (1)).

\[
(1 - \frac{|X_i - X_j|}{\text{distance to the furthest neighbor}})^3
\]

Fig. 8 Overview of Local Regression with LOESS Weighted Kernel[11]

LOESS analysis was performed on the Kansei evaluation scores from segmented body parts of the upper limbs (Wrist, arm, or shoulder) for the effects of two mounting angles (0° and 25°).

(a) Results of lever mounting angle (0 °).

LOESS analysis was performed on Kansei score “Wrist comfort” with good homoscedasticity regardless of gender. The high Kansei scores position of males was wider in the shape of the egg-shape horizontally, and females have vertically slender shape, and its area was considerably narrower than that of males. The high Kansei score area for females was smaller and was included in that of males. (Fig. 9).

Fig. 9 The high Kansei scores area of “Wrist comfort” on lever mounting angle: 0°, left: male, right: female.

(b) Results of Lever mounting angle (25 °).

As shown in Fig. 10, the high Kansei score positions for the mount 25° were different from that of the angle 0° for both males and females. We found a similar tendency that high Kansei score positions for females are included in that of males. The Kansei scores were also higher in males than in females. For high Kansei scores of the other upper limbs.
(shoulder or others), The high Kansei score positions for females were also included in that of males. Males had higher Kansei scores than that of females (Fig. 11, Table 1).

For the results for females of Kansei score “Ease of exertion”, unlike the others, the area of +1SD or higher Kansei score was wider than males. These results were similar to those obtained by analysis of variance (p < 0.01) (Table 1).

![Fig. 10 The high Kansei scores area of “Wrist comfort” on lever mounting angle 25°, left: male, right: female.](image)

![Fig. 11 The high Kansei scores area of “Shoulder comfort” on lever mounting angle 25°, left: male, right: female.](image)

![Fig. 12 The high Kansei scores area of “Ease of exertion” on lever mounting angle 25°, left: male, right: female.](image)

| Table 1. The numbers of high Kansei score lever positions (One-way ANOVA, +1SD or moreover). |
|-----------------------------------------------|----------------|----------------|----------------|
| Kansei evaluation                            | 0°            | 25°            |                |
|                                              | male | female | male | female |
| Shoulder comfort                             | 0    | 0      | 1    | 0      |
| Wrist comfort                                | 0    | 0      | 1    | 0      |
| Ease of exertion*                            | 0    | 0      | 1    | 2      |
| Can be manipulated with one hand             | 0    | 0      | 4    | 2      |
| Comfortable posture                          | 0    | 0      | 3    | 0      |
4 Conclusion.

The results of the study show that changes in the lever mounting angles of 0° and 25° made a shift in the higher Kansei score positions. The high Kansei score positions for males and females were almost the same.

In Kansei scores by dividing the upper limbs (Wrist, arm, or shoulder), the high Kansei score positions for females were included in that of males. Kansei scores were also significantly lower in females than that of males as shown in Fig. 11 (p < 0.01). As shown in Fig. 12 and Table 1, in the case of the females, there were more +1SD or more Kansei score positions for the overall muscle development without arm segmentation than in the males (p <0.01) (Kansei score “ease of exertion”). The result of females was tended to have high Kansei scores on the whole of the upper limb muscle exercises than that of males.

The results of a map using LOESS, which has been used in morphometric studies, showed that the high Kansei score positions were almost the same as the ANOVA results (Figs. 9 to 12).

The future work includes measuring the muscle activity by the EMG evaluation. The results can be applied to the design index of the lever arrangement on the side of a chair.

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