

Factors for Representing In-Vehicle Roominess

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Abstract. Car drivers or passengers tend to perceive the interior space of motor vehicles as a psychological space rather than a physical space. Even though cars have the same or similar volumes of the interior space, car users may perceive different in-vehicle roominess according to the characteristics of the interior space of the cars. In this study, we aim to investigate factors that represent in-vehicle roominess as psychological dimensions. 7 experts participated in collecting 105 psychological expressions for in-vehicle roominess, and the experiments were conducted with 15 participants and 7 diverse motor vehicles. Through factor analysis and multiple linear regression, we found 10 factors and 3 most influential factors in the in-vehicle roominess: namely, ‘space completeness’, ‘narrowness’ and ‘dullness’. We anticipate utilizing these factors for designing the interior space of motor vehicles in terms of psychological dimensions.

Keywords: Interior Roominess of Vehicles, Psychological Dimensions, In-vehicle Roominess Factors.

1 Introduction

In everyday life, people spend lots of time in motor vehicles. While riding the motor vehicles, car drivers and their companies perceive and feel the interior space of the motor vehicles and get a variety of subjective evaluations based on the space sense, including narrow/wide, small/big and so forth. So far, the interior space of the motor vehicles has been treated as a physical space, and studied using the measures based on mechanical dimensions. However, car drivers or users tend to perceive the interior space of the motor vehicles as a psychological space rather than a physical space, and thus, they express their perceptions and feelings for it in various ways. Even though several cars have the same or similar volumes of the interior space of the motor vehicles in physical or mechanical dimensions, car users may perceive different, so-called, ‘in-vehicle roominess’, according to the characteristics of the interior space of the cars in psychological dimensions.

Until now, regarding the design of interior space of motor vehicles and driver’s or user’s perception, there have been three research streams. The first research stream

focused on how efficiently the interior spaces of cars were designed and evaluated. These studies mainly relied on technological developments, and physical dimensions of interior space of cars were focused on. For example, virtual vehicle interiors were rendered using CAVE display and evaluated [2]. The second research stream belonged to the studies of user's perceptions on physical attributes of interior space of cars. These studies dealt with user's perceptions and satisfaction about interior space of cars, but still relied on the physical attributes [1]. The third research stream employed emotional measures to evaluate the interior image of cars. For example, Kansei engineering was applied to evaluate vehicle interior image [3]. These studies used emotional measures for evaluation, but targeted only on several parts of vehicle interior images, instead of considering the whole psychological space of vehicle interior.

In this study, we focus on the whole interior space of the motor vehicles as a psychological space, and aim to investigate factors that represent in-vehicle roominess in psychological dimensions.

2 Methods

In order to find psychological dimensions or factors that represent the interior roominess of vehicles, we employed the two-staged approach: First, we collected psychological expressions (i.e., adjectives) that described the feelings of 'in-vehicle roominess' through brain-storming. Second, we conducted experiments to measure the in-vehicle roominess based on the psychological expressions developed from the first stage.

2.1 Psychological Expressions for In-Vehicle Roominess

Before selecting the appropriate psychological dimensions or factors that represent the interior roominess of vehicles, at the first step, we need to collect psychological expressions (i.e., adjectives) that describe the feelings of 'in-vehicle roominess' as many as possible. Seven experts (2 HCI experts, 2 car-related experts, 3 interior design experts) used the brain-storming method to collect the psychological expressions related to the feelings of 'in-vehicle roominess' without time limitation.

At the second step, the collected expressions were elaborated by the experts grouping similar expressions and eliminating irrelevant expressions. From these two steps, we could collect appropriate psychological expressions enough to find psychological dimensions or factors that represent the interior roominess of vehicles at the next stage.

2.2 Experiments for Measuring In-Vehicle Roominess

We conducted experiments to measure the in-vehicle roominess based on 105 psychological expressions developed from the first stage. In the experiments, 15 participants took part in measuring the interior roominess of vehicles. The participants were 23~29 years old (mean: 24.5, stdev.: 1.64), and 12 males and 3 females. They had 0~10 years of driving experience (mean: 4.4, stdev.: 4.07). Seven motor vehicles were used for the experiments: Benz S500L, Benz E350, BMW 5, Nissan Maxima,

Nissan Altima, Hyundai Genesis and Lexus ES. These motor vehicles were selected on the basis of diversity of psychological space. Seven experts evaluated these motor vehicles, and concluded that they gave diversified impressions of interior roominess.

Every participant was asked to answer the level of agreement, based on 7-point scale, on each of 105 psychological expressions and overall in-vehicle roominess, after experiencing interior roominess of each of seven vehicles from the driver seat. The order of experiencing interior roominess of vehicles was randomized.

3 Results

We collected 105 psychological expressions (i.e., adjectives) that described the feelings of ‘in-vehicle roominess’ through brain-storming by 7 experts, and during the experiments for evaluating interior roominess of vehicles, based on 105 psychological expressions and overall in-vehicle roominess, each of 15 participants evaluated each of 7 motor vehicles. The data from the experiments was analyzed using factor analysis and multiple linear regression.

Factor analysis was used to find psychological dimensions or factors for representing in-vehicle roominess from the collected 105 psychological expressions, and multiple linear regression was employed to select factors that influenced in the in-vehicle roominess most.

3.1 Factor Analysis

We conducted the principal component factor analysis with varimax rotation and derived 10 factors, such as ‘space completeness’, ‘freshness’, ‘openness’, ‘softness’, ‘dullness’, ‘narrowness’, ‘heaviness’, ‘comfort’, ‘closeness’ and ‘perspective’, as shown in Table 1. 63.6% of total variance from the data was explained by 10 factors.

‘Space completeness’ includes such feelings of interior roominess as well-balanced, harmonious, enough, impressive, delicate, elegant, and so on. ‘Freshness’ represents feelings such as bright, neat, cute, magnificent, dynamic, lively, rhythmic, and so on. ‘Openness’ includes feelings such as high, vast, big, refreshing, pleasant, cleared, and so on. ‘Softness’ represents feelings such as tender, smooth, round, and so on. ‘Dullness’ includes feelings such as blunt, lumpy, voluminous, stumpy, and so

Table 1. Factors and their internal consistency indices

Factors	Cronbach's alpha
Space completeness	0.86
Freshness	0.80
Openness	0.84
Softness	0.74
Dullness	0.76
Narrowness	0.73
Heaviness	0.53
Comfort	0.59
Closeness	0.70
Perspective	0.70

on. ‘Narrowness’ represents feelings such as cramped, somber, stuffy, and so on. ‘Heaviness’ includes feelings such as weighty, awakening, square and level, and so on. ‘Comfort’ represents feelings such as cozy, nice, slim, friendly, conventional, and so on. ‘Closeness’ includes feelings such as dense, complex, rugged, and so on. ‘Perspective’ represents feelings such as deep, long, far-away, and so on.

Table 1 shows internal consistency of each factor’s measures based on Cronbach’s alpha index. All factors except ‘heaviness’ and ‘comfort’ indicated acceptable levels (above 0.7) of internal consistency in their measures. The measures for ‘heaviness’ and ‘comfort’ factors, however, need to be investigated further in terms of reliability.

3.2 Multiple Linear Regression

We conducted multiple linear regression with overall in-vehicle roominess as a dependent variable and the above 10 factors as independent variables. Based on the step-wise selection method, three factors were selected as the factors that influence in the in-vehicle roominess most: ‘space completeness’, ‘narrowness’ and ‘dullness’ as shown in Table 2. The linear regression line with these three factors explains about 52% of the total variability from data.

As shown in Table 2, ‘space completeness’ and ‘dullness’ have positive relationship with the overall in-vehicle roominess, whereas ‘narrowness’ have negative relationship with the overall in-vehicle roominess.

Table 2. Results of multiple linear regression

Factors	Parameter Estimates	Significance
Space completeness	0.56	$p < .0001$
Narrowness	-0.41	$p < .0001$
Dullness	0.20	$p = 0.0692$

4 Conclusions and Discussion

We derived 10 factors for representing the in-vehicle roominess, and found 3 most influential factors in the in-vehicle roominess. ‘Space completeness’ represents how harmonious/well-balanced the elements in the interior space of vehicles are, and ‘narrowness’ represents how cramped/stuffy the elements in the interior space of vehicles are, and ‘dullness’ represents how blunt/voluminous the elements in the interior space of vehicles are. So we can expect that the in-vehicle roominess would be increased if the elements in the interior space of vehicles are located in harmonious/well-balanced ways, are not cramped/stuffy, and give blunt/voluminous feelings to drivers. Therefore, we can measure the in-vehicle roominess as a psychological space through the above factors, and we can utilize those factors to design the new interior space of the motor vehicles and/or to compare the alternative designs of the motor vehicle interior space in terms of the in-vehicle roominess.

For further study, we need to investigate how the above three most influential factors can be applied to designing sub-interior spaces of vehicles, in the practical aspects. And also, the relationships between the above three most influential factors and the physical dimensions of interior space in vehicles need to be investigated.

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References

1. Petiot, J.-F., Salvo, C., Hossoy, I., Papalambros, P.Y., Gonzalez, R.: A Cross-Cultural Study of Users' Craftsmanship Perceptions in Vehicle Interior Design. *International Journal of Product Development* 7, 28–46 (2009)
2. Smith, R.C.: Shared Vision. *Communications of the ACM* 44, 45–48 (2001)
3. Tanoue, C., Ishizaka, K., Nagamachi, M.: Kansei Engineering: A Study on Perception of Vehicle Interior Image. *International Journal of Industrial Ergonomics* 19, 115–128 (1997)