# Analysis of Usage Characteristics of Premium Bus Passenger Using Video Observation Method

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**Abstract**

This study analyzes user behavior patterns to suggest the improvement direction of premium bus using video observation method. Premium bus offers a variety of convenience features compared to conventional buses, thus enhancing user comfort. However, there are customer needs for location improvement of provided convenience features. The optimal location of the premium bus convenience can be determined by analyzing the usage pattern based on the observation of passenger behavior. Action camera was installed on the front and rear side of the passenger. Tasks and preferences posture were taken during the bus ride for 3 hours. The subjective task frequency and usage frequency of convenience were evaluated through questionnaire evaluation for 30 minutes after boarding the bus. Ten participants (male: 5, female: 5) were recruited. Observation of user behavior showed that smartphone usage (36%) and sleeping (29%) were high when boarding a premium bus. In the subjective evaluation, the sleeping result (8.2) and the use of a smartphone (7.3) were high. In this study, the tasks performed by the premium bus passengers were identified, and the frequency of task usage was quantitatively and qualitatively identified.

## INTRODUCTION

For the convenience of the passengers, the seat of the express bus, which runs for a long time needs ergonomic design considering posture, human body characteristics, and usage characteristics. More than 34 million Koreans have used express buses for long distance travels from 2002 to 2017 (Ministry of Land, Infrastructure and Transport, 2017). Bus passenger seats, which do not take into account the user characteristics such as human body characteristics, seating position, and usage characteristics, can cause fatigue and inconvenience to passengers on board for a long time. Therefore, bus passengers need ergonomic design to reduce passenger fatigue and improve comfort.

A variety of ergonomic studies have been conducted to improve the usability and convenience of bus sheets (Cheng et al., 2010; Choi et al., 2013; Jung et al., 1998; Kim et al., 2010; Zhao et al. 1994). Park et al. (2015) proposed an ergonomic passenger seat evaluation scale and method to analyze the influence of the shape of the bus seat on the seating feeling. Jung et al. (2017) identified the preferred design characteristics of armrests of length, height, width, and shape based on ergonomic evaluation to improve the usability of the bus passenger seat armrests and proposed an improved design. To design the ergonomic shape of the seat, Cheng et al. (2010) measured the seat pressure of 30 adults and calculated the seat pressure value as the height value on the 3D coordinate system to calculate the seating position corresponding to the rider's hip and thigh

Recently, to improve the convenience of express bus passengers, a premium bus seat having a wide space and a variety of convenience specifications has been developed. However, further study is needed to optimize convenience specifications. Premium bus seats can extend the seat pitch and width of existing seats to provide a relatively large space and create a separate space for each seat to enhance passenger comfort. The premium bus seat offers a variety of convenience features such as adjustable headrests, footrests, legrests, reading light, folding tables and entertainment systems to enhance passenger comfort, but some features require improvements in form, position and size (Kim et al., 2018). Also, there is a lack of research that suggests convenient ergonomic design by analyzing the utilization behavior of the changed passengers due to the application of various convenience specifications.

The purpose of this study is to observe bus passengers and analyze the characteristics of convenience usage by applying video observation method for optimum design of premium bus. The premium bus passenger observation was conducted for 3 hours using the action camera for the premium bus passengers between Seoul and Pohang. Using the results of the passenger observation and the questionnaire evaluation, we derive the types of tasks that appear when the premium bus passengers use the convenience and evaluate the subjective and objective utilization frequency.

## MATERIALS AND METHODS

*Participants*

Ten Koreans (Male: 5, Female: 5) participated in this experiment. The average age of participants was 27.8 years, and participants from 20s to 50s participated. The body size of the subjects participating in this experiment is similar to the average human body size of Korea (2010), so it is statistically appropriate to represent Korean population. This experiment was approved by the IRB of POSTECH (PIRB-2017-E069). The height of the participant was measured after completing the participation agreement of the participant.

*Apparatus*

User behavior observation was performed by installing two action cameras on the front and rear of the passenger, as shown in Figure 1. The location of the camera is selected so that it does not affect the behavior of passengers when boarding the bus.

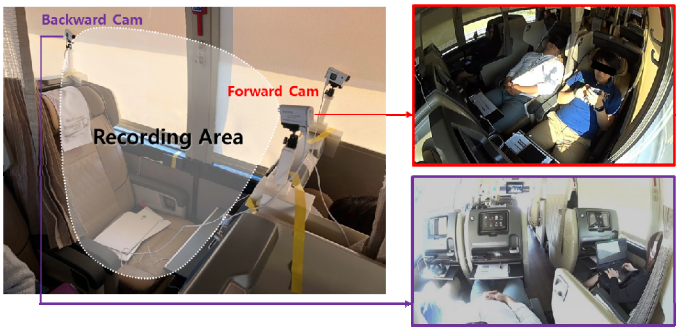



Figure 1. Example of camera attachment

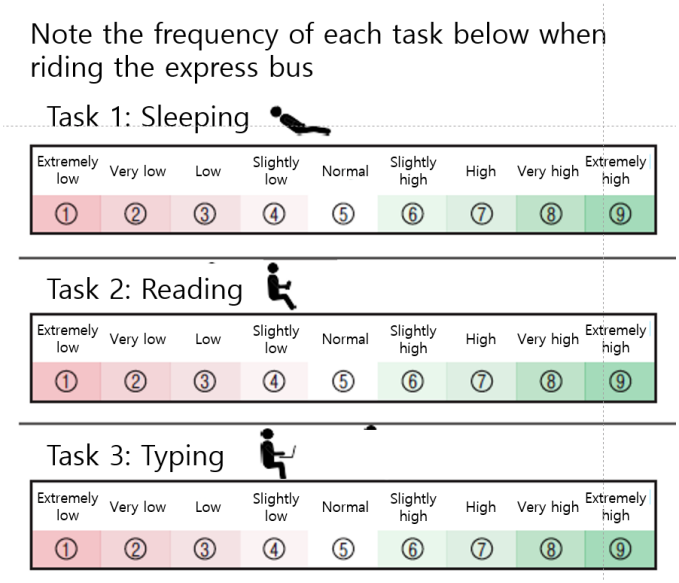



Figure 2. Questionnaire example

The subjective task performance frequency of the rider after 3 hours of bus ride was evaluated. The evaluation was conducted through a subjective evaluation paper consisting of 9 points as shown in Figure 2. The frequency of task performed on 9 tasks of sleeping, smart phone, drinking, eating, watching tv, writing note, typing, reading, laptop video watching was evaluated. Task performance frequency was rated as 9 points (1 point: extremely low, 9 points: extremely high)

*Experimental procedure*

User behavior observation was performed through three steps: (1) preparation for the experiment, (2) observation of behavior during boarding, and (3) questionnaire evaluation. Before starting the experiment, participants were asked to fill out the agreement after describing the experiment. Subjective evaluation exercises and camera installation were carried out inside the bus. Passengers were recorded for three hours after the bus departed. The subjective frequency of task was evaluated for 30 minutes after boarding the bus.

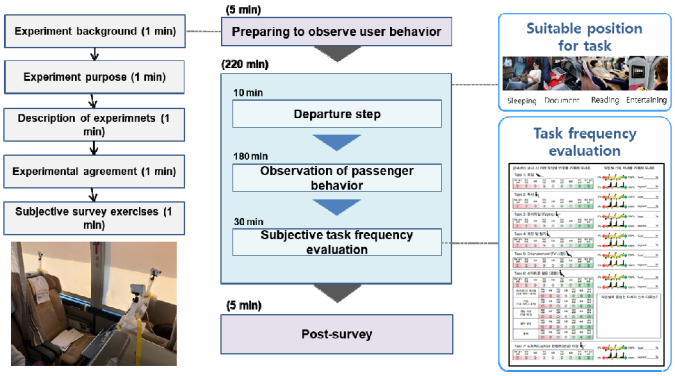



Figure 3. Experimental procedure

*Analysis*

The user behavior observation was analyzed after excluding the starting stage and the subjective evaluation period to confirm the natural behavior. Task sequences of three types (Departure, Ride, and Arrival) were derived according to task frequency and convenience specification utilization to analyze participants' convenience utilization patterns when sitting in a premium bus. In the departure phase, the task was temporarily carried out after boarding, but the specification utilization of the premium seat was low. In the riding phase, all tasks were performed in a fixed posture for a long period, and the availability of the premium seat was high. Arrival stage was performed temporarily before arriving, and convenience utilization of premium seat was low.

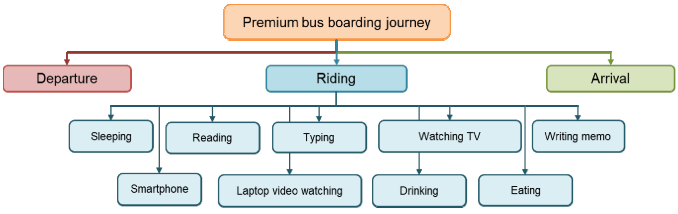


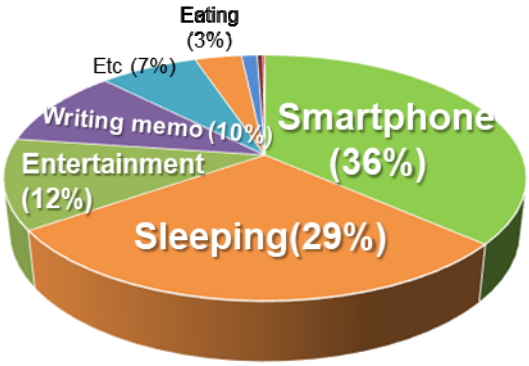

Figure 4. Task classification during bus ride

Task was selected from three pilot tests (sleeping,

smart phone, drinking, eating, watching tv, writing a note, typing, reading, laptop video watching).

The recorded video was analyzed by comprehensive time logging. We mark the time of the task change of the passenger as an event and calculate the duration of the task using the start and end time information of each event.

Task analysis results were divided into three phases according to their importance. Subjective questionnaire results were divided into top for 7.0(high) and above, medium for 4.0(slightly low) and above, and low for below 4.0. Objective results were divided into top for more than 20%, middle for more than 10%, and low for less than 10%.




| Task | S1 | S2 | S3 | S4 | S5 | S6 | S7 | S8 | S9 | S10 | Average | Ratio |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Sleeping | 0:40 | 1:10 | 0:00 | 0:23 | 2:30 | 0:50 | 0:39 | 1:07 | 1:02 | 0:51 | 0:55 | 29% |
| Smartphone | 2:29 | 0:32 | 2:43 | 1:10 | 0:28 | 0:40 | 1:21 | 0:03 | 1:17 | 0:54 | 1:09 | 36% |
| Drinking | 0:00 | 0:00 | 0:01 | 0:01 | 0:00 | 0:02 | 0:01 | 0:02 | 0:01 | 0:00 | 0:00 | 0% |
| Eating | 0:00 | 0:00 | 0:00 | 0:09 | 0:11 | 0:08 | 0:08 | 0:03 | 0:20 | 0:07 | 0:06 | 3% |
| Watching TV | 0:00 | 1:27 | 0:00 | 0:38 | 0:03 | 0:31 | 0:00 | 1:07 | 0:00 | 0:00 | 0:22 | 12% |
| Writing memo | 0:00 | 0:00 | 0:00 | 0:17 | 0:24 | 0:21 | 0:14 | 0:53 | 0:32 | 0:37 | 0:19 | 10% |
| Typing | 0:00 | 0:00 | 0:00 | 0:00 | 0:00 | 0:00 | 0:00 | 0:00 | 0:00 | 0:00 | 0:00 | 0% |
| Reading | 0:00 | 0:00 | 0:00 | 0:00 | 0:00 | 0:03 | 0:00 | 0:00 | 0:00 | 0:00 | 0:00 | 0% |
| Laptop video watching | 0:21 | 0:00 | 0:00 | 0:00 | 0:01 | 0:00 | 0:00 | 0:00 | 0:00 | 0:00 | 0:02 | 1% |
| Etc. | 0:00 | 0:00 | 0:00 | 0:15 | 0:00 | 0:28 | 0:22 | 0:08 | 0:09 | 0:57 | 0:13 | 7% |
| Sum | | | | | | | | | | | 3:11 | 100% |

Figure 5. Examples of image analysis methods

## RESULTS

During the bus ride, participants repeatedly performed three tasks: smartphones, sleeping, and watching TV. The frequency of posture change was lower than that of task change, and posture was maintained and various tasks were performed. Passengers commonly use 'smartphone → sleeping → smartphone' pattern was confirmed.

As shown in Figure 6, the frequency of each task on the premium bus ranks in the order of sleeping, smartphone usage, drinking, watching TV, and eating. Among them, the top task of 7.0 points or more was found to be sleeping 8.2 and using smartphone 7.3, and it was found to be 5.2 points for watching TV and 4.6 points for entertainment with medium task of 4.0 or more.

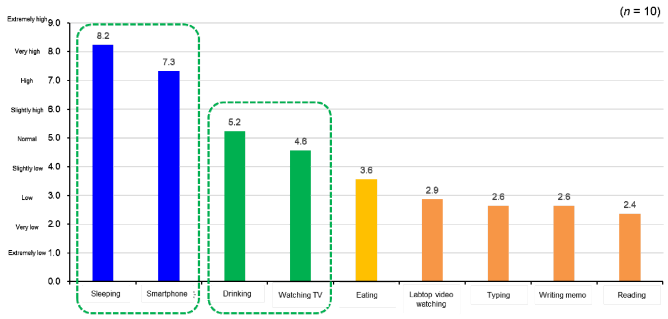
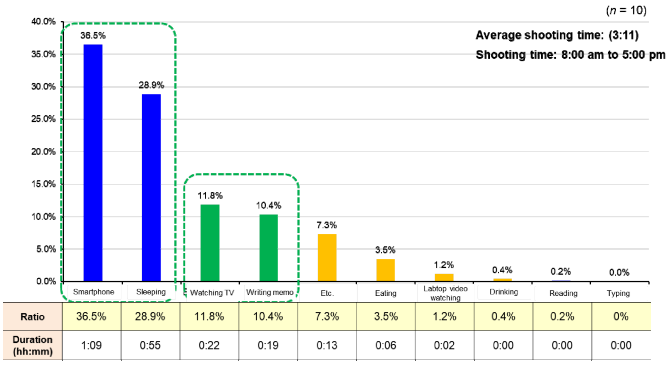



Figure 6. The subjective evaluation analysis result




| | Smartphone | Sleeping | Watching TV | Writing memo | Etc. | Eating | Laptop video watching | Drinking | Reading | Typing |
|---|---|---|---|---|---|---|---|---|---|---|
| Ratio | 36.5% | 28.9% | 11.8% | 10.4% | 7.3% | 3.5% | 1.2% | 0.4% | 0.2% | 0% |
| Duration (hh:mm) | 1:09 | 0:55 | 0:22 | 0:19 | 0:13 | 0:06 | 0:02 | 0:00 | 0:00 | 0:00 |

Figure 7. Video analysis result

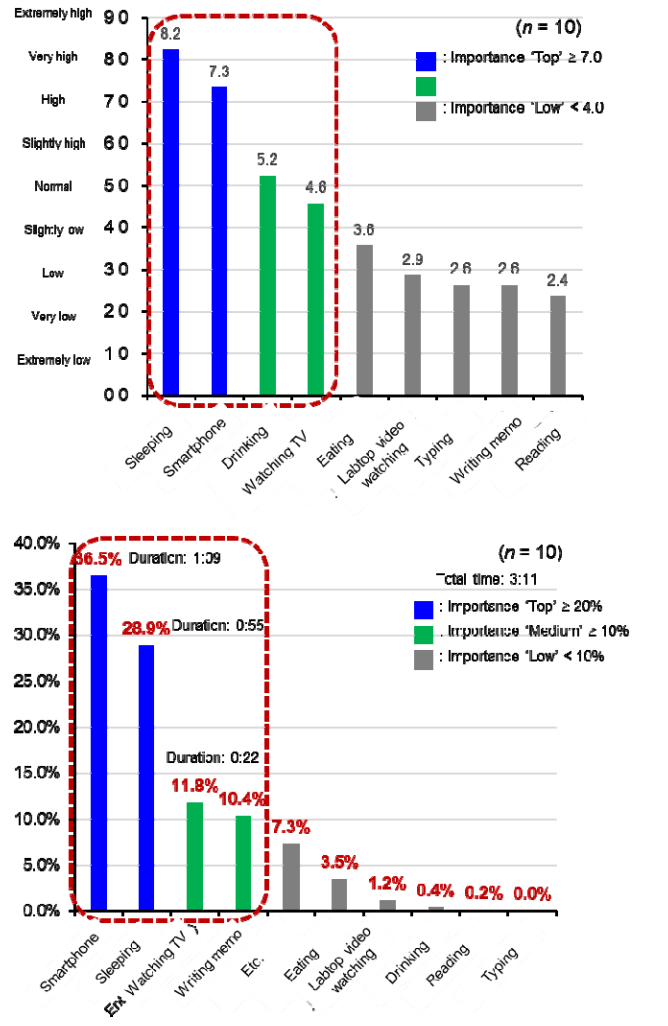



Figure 8. Comparison of subjective evaluation and video

analysis results

As shown in Figure 7, the frequencies of objective task analyzed by video when boarding a premium bus were in the order of smartphone, sleeping, watching TV, and writing a note. Among the above tasks, more than 20% of the tasks were smartphone 36.5%, sleeping 28.9%, 11.8% of watching TV and 10.4% of writing a note. The duration was also measured, and the smartphone and sleeping at the top task lasted 1h 9m and 55m, respectively.

As shown in Figure 8, subjective evaluation and image analysis showed that sleeping and using smartphone were selected as top tasks at the same time, and entertainment was commonly selected as medium task. In the subjective evaluation, sleeping (8.2) was the most frequent, but image analysis showed the highest frequency of using smartphone (26.5%, cumulative time: 1h 9m). The subjective evaluation showed that drinking was the third highest frequency, but image analysis showed a low frequency of 3.5%.

## DISCUSSION

In this study, the main riding tasks of passengers during bus ride were analyzed through the observation of premium bus passengers and the subjective evaluation. Through the observation of passengers, three types of tasks were classified as riding, boarding, and arriving. Also, we identified the main tasks performed by the premium bus passengers while sleeping, sleeping, eating, laptop video watching, watching TV, typing, writing a memo, and reading. Also, upper, middle, and lower tasks were divided according to frequency. The top tasks were using smart phones and sleeping, while the medium tasks were entertainment, drinking, notes and handwriting. Observation of the participants during the bus ride confirms the needs of the bus users. Also, it can be applied to the bus improvement design through analysis of the frequency of task use or convenience frequency of passengers

In this study, the video taken during the bus ride were processed by a comprehensive method, and the time required for each task was quantitatively analyzed. The time required for tasks was analyzed based on the time of task change of the premium bus passenger. As a result, it was confirmed that the sum of the tasks of smart phone (36.5%), sleeping (28.9%), watching TV (11.8%) and writing memo (10.4%) accounted for 87.6% .

Analysis of main task performance according to passengers' journey was made. Behavioral pattern analysis was performed based on participants' task and attitude change. We confirmed that three main tasks (sleeping, smartphone, watching TV) are repeatedly performed. The frequency of posture change was lower than task change.

It can be used to optimize bus convenience position and shape through subjectively and objectively analyzed results of duration time analysis of each task. Both of behavior pattern analysis and questionnaire evaluation showed high frequency of use of smartphone, but currently there is no convenience related to smart phone on premium bus. Also, it was confirmed that improvement of convenience features such as table and cup holder to support entertainment, beverage preparation, memo, and handwriting corresponding to the middle task is required. Suggestions for design reference can be made through user behavior pattern analysis. It is necessary to provide convenience specifications to support major tasks such as smartphone utilization. Also, it is necessary to improve the usability of table and cup holder supporting upper and middle task.

In the result part, there is a difference between the subjective evaluation and the result of objective evaluation about sleeping. This is because the experiment was conducted only during the day to observe the passenger behavior, so the participants performed less sleeping relatively. Also, since the experiment was conducted on a total of 10 people, sufficient data could not be collected. Also, tasks such as drinking are not long, but they have frequently used tasks and can affect the actual frequency of use. Therefore, additional analysis of the frequency is needed.

This study was conducted for daytime passengers to apply the video shooting technique, but it is necessary to analyze the user observation and behavior type for more experimental participants. It is necessary to measure and analyze the detailed usage posture of the premium bus passenger to grasp the preferred attitude of each task.

## ACKNOWLEDGEMENTS

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