Passengers' Comfort in Railway Vehicles

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The previous studies on passengers' comfort in railway vehicles focused on the efforts to make the vibrations, noise, and thermal environments as close to "optimal" conditions as possible. Increasingly, there have been more and more efforts in recent years dedicated to creating "comfortableness", which is discussed in this report.

Past studies examined means of producing an "optimal" environment

Vibrations environment (motion sickness and riding comfort)

When it comes to vibrations, the corresponding perceptual organs of humans differ according to frequencies and directions. For instance, "shaking" , which is vibration with low frequency (under 1 Hz}, becomes the main cause of motion sickness. The results of the research involving passengers on a train running over a mountainous route have revealed that, of those experiencing motion sickness, the majority became ill in a section with frequent lateral motions of approximately 0.3 Hz. Even if the intensity of vibrations is the same, the perceived intensity will differ at the different frequencies. Therefore, in order to assess the vibrations, a weighting filter needs to be applied based on frequencies to conform to how humans feel. For measuring motion sickness, studies on seasickness aboard ships are ongoing where the indicator Motion Sickness Dose Value (MSDV) is defined in international standards. To apply this measurement system to trains, we have developed the indicator MSDV-y in which the lateral (y) vibration is added. Some trains running at high speeds in curved sections are equipped with car body tilting systems. This indicator is used to explore means of controlling car body tilting in a manner that reduces passengers' exposure to feelings of motion sickness.

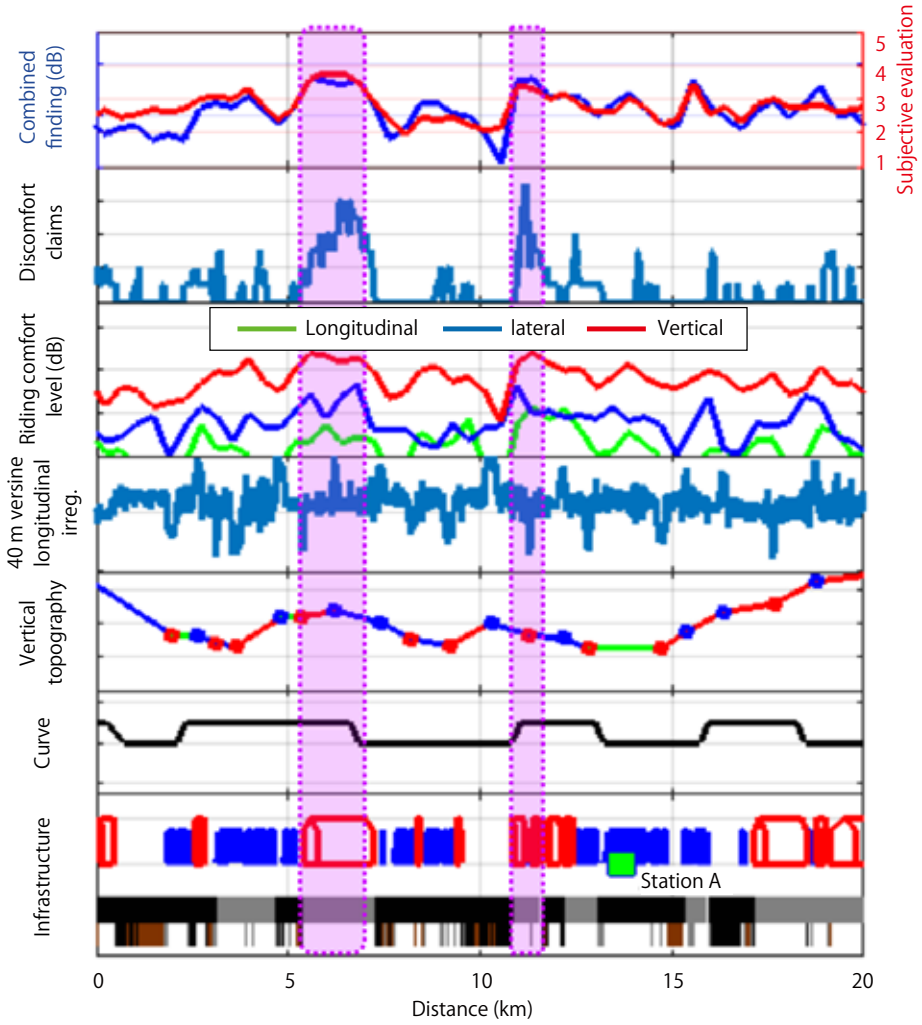
In the 0.5-60 Hz bandwidth, vibrations are highly impactive relative to "riding comfort". We have used this bandwidth to reflect the human perception sensitivity to vibrations and proposed a method of estimating the sensory ride comfort using the measured vibration acceleration data obtained by synthesizing the vertical, lateral, and longitudinal vibrations. We have also developed the "Integrated Display System for Riding Comfort Information" that enables the integrated display and understanding of these estimated values with vehicle, track, and other interdisciplinary information. Since use of this system allows us to intuitively determine what vibrations affect the riding comfort, the system is used to identify the factors deteriorating the riding comfort and take measures to improve them while validating the effects of the measures.

Noise environment

The vibration at 20 Hz or more is also perceived as noise. Again, the level of the sound loudness experienced is not proportional to how discomfort is felt. This is especially true when considering voices intended to provide important information during a conversation. It is difficult to decide whether they contribute comfort or discomfort by simply judging from their sound pressure or auditory perceptive characteristics. In our study, we have found that the chatter of the passengers sitting next to the study's subjects and the ringtones of mobile phones are felt more uncomfortable than the vehicle running noise at the same sound pressure. The reason is thought to be because the running noise is derived from the vibration

associated with traveling, which is deemed to be advantageous, and therefore tolerated considering that it cannot be avoided. Conversely, the neighboring chatter and mobile phone ringtones are nuisances without any associated benefit, which causes passengers to feel uncomfortable.

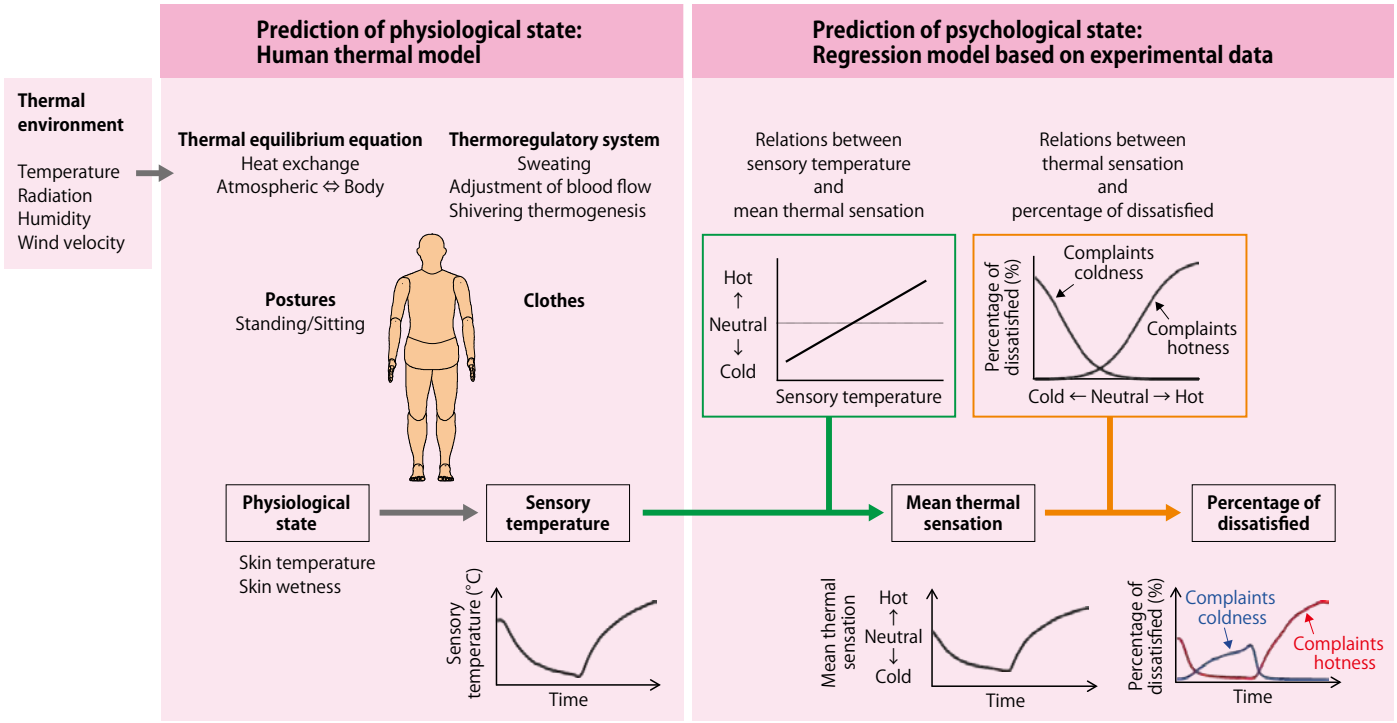
The mutual effects between the vehicle running noise and vibration were examined through an experiment using an in-car comfort simulator. It was concluded that the vehicle running noise creates the illusion that, as the sound volume decreases, the vibration also decreases. However, it has been verified that the opposite to those findings does not occur. If the running vibration decreases, we do not feel that the noise is reduced. Instead, if the noise is heard at a lower level, we feel the vibration has increased rather than the noise has decreased.



Displaying along distance structure of track, infrastructure and vehicle vibration data reflecting the human perception sensitivity to vibration, the causes for the vibrations can be multilaterally identified and analyzed. The combined findings estimating the sensory ride comfort, obtained by synthesizing the measured vertical, lateral, and longitudinal accelerations are in good agreement with the bodily sensation assessment in an experiment.

Thermal environment

Many of the complaints from passengers are related to the thermal environment. Such complaints have the common characteristic that it should be neither too warm nor too cool. The thermal environment is also greatly affected by such factors as the clothes, gender, and physiques of individuals. In addition, it is easy to produce temperature changes on trains by the opening/closing of doors and the loading/unloading of passengers. Particularly in commuter service, the temperature in railway vehicles is hard to control since they can fluctuate greatly depending on the number of passengers, frequent door openings, and the size of opening areas. Under the circumstances, we propose a method of predicting the thermal sensations experienced by passengers, which are difficult to quantify, through the use of the bodily sensation experiment data for the thermal environment in a railway vehicle. We are proceeding with the research to contribute to the realization of an in-vehicle thermal environment which is comfortable throughout the year.



RTRI propose a method of predicting the thermal sensations experienced by passengers, which is composed of two sections: physiological state prediction section and psychological state prediction section.

Recent efforts towards establishing "comfortableness"

In recent years, the railway passenger companies have been marketing campaigns advertising the enjoyment of "rail travel", such as on cruise trains. The in-vehicle information accessibility and information service are enhanced by installing monitors and providing power points and a WiFi environment. As such, there are only a few elements to be studied for "comfortableness". However, RTRI has studied the effect of odor (scent) and obtained the result that the sensory temperature varies according to the effect of scent.

Progressing towards future enhancement of passengers' comfort in railway vehicles

Considering the future enhancement of passengers' comfort in railway vehicles, one of its critical features will be the public nature of railways, that is, sharing the "place" and "time" with others in the age of the driving of autonomous cars. Since human beings are social animals, a place to share "comfortableness" with others while moving will bring about new value. Amid the population decline, it is more critical to promote the repeated use of railways. To achieve this target, it is possible to estimate the psychosomatic states of passengers from the image, audio, physiological, and other data and encourage them to act for the better and make a psychological change.