Recent Topics on Human Science Research and Future Prospects

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Human Science in the railway field is a scientific discipline aimed at solving problems and proposing the countermeasures which will improve the safety, ease of use and comfort of railways. This is achieved through insights acquired by measuring, evaluating and analyzing the psychological, physical, physiological and behavioral characteristics of people, such as passengers using railways and workers operating them. This paper outlines recent topics examined in the area of human science research in education and training, and improvements to the on-board and station environment, before finally outlining possible future prospects.

Keywords: human science, education and training, on-board environment, station environment

1. Introduction

From the railway perspective, human sciences form a field of study that aims to solve problems and come up with proposals to improve safety, practicality and comfort of railway systems based on knowledge, obtained through measurement, evaluation and analysis, of the psychological, physiological, physical and behavioral characteristics of passengers as well as those involved in the daily operation of railways. Studies on railway workers have included aptitude tests, education and training, human error analysis, organizational climates and measures to enhance in-cab design. Studies on passengers have covered proposals to improve interior design of cars and in the station environment. This paper primarily discusses education and training, and measures to improve the design of car and cab interior design, and the station environment.

2. Education and training

Prevention of human errors is an important issue in improving railway safety. There have been a number of studies on education and training of railway workers, especially crewmembers. Over recent years, an increasing number of studies have dealt with methods for encouraging railway workers to think by themselves and raise awareness. This new trend is due to a gradual shift in teaching methods from simply providing knowledge, which of course is essential, to higher levels of education largely aimed at raising worker awareness of issues, so that they can fully demonstrate their capabilities in the work place. A key part of this has been a focus on tools for education and training. One of the characteristics of recent studies is that they propose easy-to-use and effective teaching materials and sensory systems. Four representative studies are outlined below.

Traditionally, close-call experiences and ingenious actions to prevent accidents were shared among workers across different generations through conversations and after-hour gatherings. However, as lifestyles change, it is becoming increasingly difficult to share information in this way. In an attempt to counter this trend, the Accident round-table discussion method was developed [1]. The method involves bringing together a group of around four to ten people to discuss accidents, causes of the accidents and prevention measures which can be implemented in the work place. Through discussions, the participants share information and their awareness of safety is raised. The method and related points of importance are summarized in the ‘Accident round-table discussion method manual.’

To prevent future accidents and disruptions, it is essential to gather sufficient information about the behavior of those who have been involved in an accident and to understand how the accident occurred. Accordingly, on-site interviews are conducted with those involved in the accident. However, no standard method for this approach existed in the railways and investigation reports were often returned to the issuer for lack of information. Consequently, an interview method was developed which includes guidance on the appropriate attitude to adopt during the interview, and a checklist of points to consider by the interviewer when conducting interviews, based on techniques (cognitive interview, active listening, etc.) used in psychological research [2]. To help introduce the method, a 5-step education program was created that focuses on ways to motivate workers to take part in the program and share experiences. It was confirmed through monitoring that the interviewing method was highly effective.

Everyday reports are also an important source of information. Efforts have been made to identify factors that promote reporting on safety [3]. Where workers operate individually, voluntary reporting is an especially important source of information. At the same time, those who may have committed an error are likely to be reluctant to report their mistakes. With that background in mind, a survey was conducted to gain a better understanding of how voluntary reporting of mistakes works in practice, which was followed by a series of interviews, a web survey and psychological tests. Through the process, the following four factors were found to encourage reporting: 1) tendencies to think from the viewpoints of others, 2) tendencies to sympathize with others, 3) tendencies to respect self-evaluation of oneself and 4) high self-respect for one’s own profession. In addition, based on voluntary reports made in the past by field workers on the mistakes they made, teaching materi-
als aimed at enhancing voluntary reporting were proposed. Besides prevention of errors, studies have also been conducted into education and training methods. For example, in the event of suspension of train services due to an accident or for other reasons, user dissatisfaction can effectively be reduced by announcing the expected timing of resumption of services at an early stage. On the other hand, railway workers tend to be reluctant to do that as the expected timing can be modified repeatedly or updates can be delayed. With that in mind, audiovisual aids were developed (Fig. 1), highlighting the importance of early announcement to users and announcement techniques that are effective in minimizing user dissatisfaction, based on verified data on the psychological and behavioral impact of the announcement of expected service resumption timing on users [4]. Further review of the audiovisual aids led to a proposal for education and training methods for promoting service resumption announcements while lessening worker anxiety. Since the methods were launched for staff training, more workers than before have started proactively practicing the early announcement techniques learned while remaining aware that it is important to continue practicing the techniques.

### Chapter 1 What customers typically expect from announcements during train service suspension

#### Customer requests for improvement

1. Delayed announcement of expected service resumption timing
2. Inaccurate expected timing for service resumption
3. Lack of information on connecting lines
4. Lack of information on bypass routes
5. Lack of information on alternative transportation
6. Inappropriate frequencies of announcements
7. Inappropriate sound volumes
8. Other

![Fig. 1 Example of screens used in the audiovisual aids [4] - Presentation based on evidence -](image)

The most common request for improvement was to reduce the “delay in announcement of expected service resumption timing.”

#### 3. Support in designing cabins and cabs

The comfort and user-friendliness of railway cars are essential to provide a quality service. There have been a number of fact-finding surveys and experimental studies on train vibration, interior noise, thermal comfort, odor and other subjects from human science perspectives, based on which evaluation methods have been proposed for the design and improvement of cabins [5-8]. In addition, efforts are underway to develop evaluation methods for collision safety to mitigate car damage. Furthermore, an increasing number of voices have been raised to review the cab design, which has been undergoing a range of improvements, the introduction of various designs and other changes, from the perspective of what is essentially required for driving. This subject has also been studied. Some of the recent studies, such as “Method for Predicting Thermal Comfort in Commuter Trains in Summer,” “Development of a Human Model for Railway Collision on Numerical Simulation” and “How to Decide Specifications of Aural alerts in Train Cabs,” are outlined below.

Numerous complaints are reported every year about the air conditioning in commuter trains, and yet there is only limited knowledge about ideal temperature control in commuter trains, making correct evaluation difficult. With that in mind, the “Method for Predicting Thermal Comfort in Commuter Trains in Summer” was developed.
As part of the development process, an experiment was conducted with about 100 ordinary railway users in summer, the season with most complaints, to understand the relationship between thermal environment and on-board comfort. Based on the results of the experiment and known thermal characteristics of humans, methods were then proposed for predicting thermal comfort in summer commuter trains. It has been known that there are variations in temperature, humidity and air flow volume, and thus comfort, even in the same cabin. The prediction methods make it possible to estimate the spatial distribution of thermal discomfort in the cabin and can be used to design optimum air conditioning and to make necessary adjustments in the cabin during the summer season.

As part of the studies on cars with high collision safety for the mitigation of passenger injuries in collisions such as at level crossings, numerical analysis methods were developed to accurately predict passenger injuries. As part of these ongoing efforts, a numerical human model was developed for railway collision simulation. Dummy models (numerical models of crash test dummies) currently available for collision simulation are only designed for impact in specific directions: there are frontal impact dummy models, side impact dummy models, and so on. It is, therefore, necessary to selectively use these different dummy models depending on the directions of impact being evaluated. In addition, the current dummy models are built with the dimensions of typical Westerners, making it difficult to evaluate the safety of Japanese cars and to devise countermeasures. To overcome these issues and enable accurate evaluation of general and more specific in-car applications, a model (numerical human model based on finite element methods) of a Japanese build without limitations in impact direction was developed (Fig. 2) [9]. Using this all-directional model and a conventional model specifically designed for frontal, seated collisions, experiments were conducted in which these dummies sat in a transverse seat facing a table either squarely, at an angle or sideways on. It was found that the newly developed model was effective for evaluating injuries in all impact directions. Along with conventional dummy models, the new model will be utilized wherever appropriate in future efforts to improve the collision safety of interior fittings and car bodies.

Over the last 50 years, Japanese men have clearly become larger in build. At the same time, an increasing number of women are becoming drivers. As a result variation in driver build has grown. This calls for a review of current cab dimensions. With that in mind, tools have been developed to support the design of cabs that are easy to work in for various drivers with different builds. Among the tools developed are driving posture templates [10]. These templates are based on related experiments conducted on people of various builds, and can be easily laid over cab design drawings to indicate the average driving posture, the space in which buttons can be operated easily, the appropriate height of foot stands, and so on. These templates also show the positions of various parts of the driver’s body according to driving posture, from which appropriate ranges of seat adjustments and positions of devices can be determined.

With the advancement in driver support technologies and the diversification of safety systems, tones used in the cab are starting to diversify, which may offer some benefits to drivers but may also become a source of confusion or distraction. Thus, aural information design guidelines need to be established. To this end, methods for selecting new aural alerts were proposed as possible materials for design processes. Alert information that needs to be conveyed is classified into four levels (hazard levels) according to likelihood of the situation resulting in an accident, and classification criteria are defined for each level. Each level is assigned specific sound and voice information based on driver reaction to the aural alerts. The methods also propose a way of selecting sound and voice information based on how frequently they are to be used, while limiting the number of new sounds that can be confused with existing ones.

4. Improvement in station environment

Efforts made in recent years to improve station environments include “Layout of Tactile Walking Surface Indicators at the Bottom of Staircases,” “Research on Countermeasures to Reduce Unpleasant Odors in Toilets of Railway Stations” and “Improvement of Comfort of Station
Waiting Room by Greening by Aromatic Plants.” [11, 12, 13]

While their shapes are specified by JIS, Tactile Walking Surface Indicators (TWSIs) for the visually impaired have no other standards, including for installations in railway stations, with the result that different railway operators and regions are using different rules. Users have been requesting standardization of rules on the TWSIs. At the request of central government and other relevant organizations, a series of experiments were conducted to standardize the installation of TWSIs, and the results were used to revise the state guidelines on the installation of TWSIs on station platforms. Most recent efforts include a survey and review on methods for installing TWSIs on station stairs [11].

Among the odor-prone places found in stations, are toilets. To establish effective anti-odor measures, it is essential to identify the mechanisms generating odor. Accordingly, substances found in toilets were analyzed, and the results showed that ammonia was the main component of the odor. Based on the results, efforts were initiated to identify how ammonia is generated [12]. Among the bacteria found in toilets are those that dissolve urea into ammonia. It was found that ammonia generation primarily depends on the amount of bacteria, temperature, the volume of urea and the degree of ammonia permeation. Given these findings, laying photocatalyst antibacterial tiles on toilet floors was proposed. The proposal appears to be effective in deactivating bacteria.

In an attempt to improve customer experience, closed spaces in stations such as concourses are increasingly being greened. In order to maximize the effectiveness of greening measures in stations, a review was made to clarify the effects of plant aromas and establish effective greening methods based on appropriate amounts of plants introduced [13]. From among aromatic plants, those that appeared appropriate for installation at stations were selected; the required volume for each plant per area of given capacity for customers to be able to smell the aroma where it was to be introduced was calculated. The selected aromatic plants were then planted in appropriate volumes, based on the calculations, in closed spaces and a subjective evaluation was conducted by monitors who regularly used the stations. The results showed that about 40 % of the monitors sensed the aromas and felt relief from fatigue. It was also found that the impact of greening can be enhanced if targeted greening methods were used.

5. Future prospects

The only way to eradicate human errors is through perseverance. Miscommunication is considered a typical human error. While various measures have been taken to prevent this, miscommunication is still highlighted as the cause of accidents. “The Training Method of Communication Skills for Train Dispatchers in Abnormal Situations” featured in this RTRI REPORT is one piece of research which discusses education and training to reduce communication problems [14]. While the report specifically relates to dispatchers, poor communication can occur in any other place in the working environment, and for different reasons (due to specificities of the situation). Further work will be conducted in this field, to identify both common and specific features related to different working contexts and conditions.

Today, from a risk management point of view, events that used to be unthinkable are no longer unthinkable, and studies and other is being carried out to confront these new challenges. At present, railway workers are concerned with crisis aversion and handling of accidents and are highly stressed and prone to making human errors, to the extent that they need attention. Even in less stressful situations, railway workers are still required to be prepared to make sound judgments and take appropriate actions. Efforts will be continued to build decision making skills and incorporate these into staff education, which will enable workers to decide and act appropriately in circumstances that cause confusion or require flexible actions. In a related move, efforts will be made to develop methods for evaluating the mental and physical condition of those involved in decision making.

RTRI has been working on advancing driver support systems, such as a driver monitoring system in the cab that uses the latest image processing technologies to detect driver drowsiness, a roadway monitoring system to assist driver’s views of the line ahead, and ways to share any unusual occurrences that have been detected. From the human science point of view, efforts will continue to develop driver monitoring systems, to oversee their physical and mental condition and even drowsiness, in a way that supports driving and helps prevent accidents, while placing no pressure on the driver being monitored. This program will also consider the possibility of including the latest measurement techniques to monitor the physiological and psychological state of drivers.

Out of necessity, RTRI’s scope of research is being expanded beyond the field of railways. The “Study on the Behavior of Sika Deer Near Railway Tracks and the Effect of Alarm Calls” featured in this RTRI REPORT is a study on damage to railway transportation by animals [15]. The number of collisions between trains and deer that cross onto railways and the resultant delays in train operations has increased over recent years to the extent that preventive measures must be initiated. Operation to avoid a collision causes stress for drivers, and collisions generate extra work for track maintenance workers and causes inconvenience to passenger. A range of measures have been therefore taken by railway companies to prevent animals entering the tracks and collisions, such as putting up fences, slowing down trains in high-risk sections and so on. However, the number of collisions has been rising in part due to an increase in deer population. Efforts will be expanded to improve the situation.

Level crossing accidents are caused primarily by road traffic, a non-railway factor, and disrupt railway transport. All conceivable measures have been taken by railway companies to prevent accidents that include removing level crossings by building flyovers and installing obstruction detection devices that automatically detect vehicles stuck on the tracks. That said, there are too many level crossings in the system to equip them all with those preventive measures. Given the situation, additional ingenious measures need to be introduced. To that end, traffic through level
crossings will be analyzed more closely to come up with effective measures such as information sharing and displays to deter risky behavior at crossings and prevent collisions.

6. Conclusion

RTRI established a Masterplan RESEARCH 2020 which began implementation in FY2015. Under the theme "R&D for the future of railways," the Human Science Division will play a leading role, working with the Signaling & Transport Information Technology Division and the Vehicle Structure Technology Division, in tackling the main theme of "Improving safety for railway users." The program will look at raising the decision making skills of railway workers, improving level crossing safety and improving vehicle collision safety, all of which were mentioned in "5. Future prospects." All of these subjects are challenging and efforts will be made to come up with proposals for enhanced railway safety.

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