Recent Topics on Human Science Research

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The Human Science Division of the Railway Technical Research Institute comprises 4 laboratories: Safety Psychology, Ergonomics, Safety Analysis and Biotechnology, and has been conducting human scientific research to improve the safety/comfort of railways linked to issues such as psychological aptitude tests, human error prevention, driver support, abnormality/accident handling, ride comfort, risk assessment, and user environments. This paper outlines recent topics related to human science research of safety administration support, education and training, improvement of the on-board environment and other environmental investigations.

Keywords: human science, safety administration support, education and training, ride comfort, on-board safety, investigation of station environment

1. Introduction

The Human Science Division of the Railway Technical Research Institute (RTRI) inherited studies that were carried out by the Railway Labour Science Research Institute of the former Japan National Railways, expanding the scope of its research from labor science to human science; specifically the Division marked the 50th anniversary of their R&D last year. Currently the Division consists of four laboratories, namely Safety Psychology, Ergonomics, Safety Analysis, and Biotechnology, and is now tackling human science research aimed at making contributions to improve safety and ride comfort in railways, including research activities and studies on psychological aptitude tests, human error prevention, driver support, abnormality/accident handling, ride comfort, risk assessment, user environment, etc. With reference to past achievements, this paper introduces recent R&D efforts being pursued in the human science field.

2. Safety administration support

In 2006 the Act for the Partial Revision of the Railway Business Act, etc. for the Purpose of Improving Transportation Safety came into force, leading to a reinforcement of the Transportation Safety Management System. Accordingly, transport companies have adopted the concept of “Plan, Do, Check, and Act (PDCA) Cycle” to tackle the building of safety management systems. Meanwhile, the Railway Technical Research Institute has engaged in studies to support safety management, producing proposals such as the “Accident Round-table Discussion Method,” the “Human Factor Analysis Technique by RTRI,” and the “Evaluation Method of Safety Climate in Work Site” [1].” Previously, close-call experiences and ideas on how to prevent an accident were shared in an intergenerational manner through communications on informal occasions and informal conversations after office hours. However, along with a change in lifestyles, such sharing is now difficult. To address this issue, the “Accident Round-table Discussion Method” was developed. The method involves four to ten people who come together to discuss the causes of an accident in the workplace and measures to prevent it. And, the “Manual for the Accident Round-table Discussion Method” describes a method for improving safety awareness by allowing information to be shared naturally through discussions and indicates points to consider in implementing this method, in an organized manner. The “Human Factor Analysis Technique by RTRI” is a method for accurately analyzing the background factors of an accident or trouble causing small damage, including close-call cases. This Analysis Technique is effective for discovering hazards that might lead to a significant accident and applying measures to prevent an accident. A handbook was compiled to present the basic knowledge needed for this analysis and which gives examples of how it is applied, in a structured manner. The “Evaluation Method of Safety Climate in Work Site” is a method where staff have to reply to around 100 questions in a questionnaire, about their present state; then their answers are retrieved; individual factors related to the climate of safety are then evaluated while weighting each one according to the features of each job type and adding a relative evaluation made in another workplace under the same conditions. Based on the results of this process, a discussion is then held on the challenges in the workplace and about improvements which could be introduced for creating a better work environment.

The Human Science Division is also tackling research on a risk analysis needed by railway operators for managing risk. Recent studies include a “Calculation Method with Weighting on Risk according to Recognition by Railway Users” and a “Safety Assessment of Railroad Crossing in Snowy Cold Region,” which will be discussed below.

2.1 Calculation method with weighted risk according to recognition by railway users

The Division has so far offered a “Method to Support Management of Error Risk” where a degree of influence of error induction factors is added to a risk value that consists of a combination of a maximum influence and ease of occurrence of an error, with a view to facilitating risk management. This work further allowed confirmation
that there is a gap between real risk and risk perceived by railway users when their perception of risk in society was evaluated, for the purpose of risk management in relation to the need for railway operators to be trusted by the public. In order to reflect this real-to-perceived risk gap, a "Calculation Method with weighted Risk according to Recognition by Railway Users" was developed [2]. The real-to-perceived risk gap can be explained using two factors: "proximity" representing the possibility of a user encountering risk and "fear" that indicates a degree of danger. Converting the two factors into scores, the weight for risk perceived by railway users is calculated as the sum of the "proximity score" and "fear score." It is believed that further evaluation is necessary, but there is confidence that this kind of evaluation of the influence of social perception is useful in risk management in the railway business.

2.2 Safety assessment of railroad crossings in snowy cold regions

Accidents at level crossings account for a large share of all railway accidents. Railway operators have been studying measures to prevent level crossing accidents for many years. Though the number of level crossings per se has been falling through the increased construction of elevated railway lines etc., there are still more than 30,000 crossings in Japan today. Therefore, it is necessary to assign higher priority to developing and collecting the required information to plan measures for crossing to prevent further accidents. For this reason, the Railway Technical Research Institute has conducted research using statistical analysis to estimate the number of crossing accidents. The evaluation method which uses a prediction formula is called the "Level Crossing Safety Evaluation Method." The prediction formula so far obtained uses a regression formula which employs explanatory variables corresponding to each specification, such as a type of crossing, the number of tracks, the number of passing trains, road width, and traffic volume. However, in previous methods weather factors were not taken into consideration, therefore it was decided to propose, on this occasion, a "Method to Evaluate Safety at Crossings in Snow Zones or Cool Regions" which can reveal winter weather related conditions or events which lead to an accident in such cold or snowy areas [3]. This Method includes explanatory variables such as winter weather conditions and traffic conditions around a crossing. And it has been confirmed that estimation accuracy has been improved, since correlation between estimated result and real data increased after applying the Method to real crossings in cold or snow-prone regions.

3. Education and training

The Human Science Division in the past conducted a series of studies of education and training targeting railway workers and, especially, train crews. But recent years have seen an increase in the number of studies on teaching methods used to encourage voluntary thinking and realization by trainees themselves. Against this background, the division has sought to develop a teaching method which places an emphasis on enhancing trainee awareness of the issues at hand, targeting a higher level of education and training so that they can fully and steadily use their skills in the field, though it is, of course, necessary to provide guidance aimed raising their level of knowledge. For this purpose, it is important to take into account support tools to be used in tandem while providing guidance. Consequently, the common thread to the series of studies being conducted is to produce useful and easy to use course materials easy as part of a simulation system. One of the proposals made so far is the Practical System for Implementing Vocational Training Program for Improving Train Driver Abilities to Cope with Abnormal Situations, which is a driver education and training program where trainees can make their own psychological status and characteristics of their driving behavior reach their subconscious by experiencing virtually their mental processes in an emergency, following an emergency driving scenario, and, immediately after it, by objectively reviewing them based on data [4]. In 2012, the simulation option tool (Reflecting Back Support System) was successfully developed, which plays an important role in the functioning of this program. In addition, the division’s R&D has produced the following output: "Error Prevention Effects of Point and Call Checks," "Coaching Technique about Safety using Self-Assessment," and "The Efficacy of Audio-Visual Materials for In-Company Training on the Expected Restart of Railway Services."

3.1 Simulation software to see error prevention effects of Point and Call Checks

Point and Call Checks are widely used as a means for safety checking, but it is difficult for each staff member to continue to realize the effect the practice has on error prevention, and sometimes the practice loses its substance in actual scenes. In order to address such a problem and promote appropriate practice of Point and Call Checks, we have developed software to be used for training assignment where trainees can perceive an effect of Point and Call Checks through experiencing occurrence of an error that is given as a challenge in a personal computer. Experts think that there are five functions to prevent errors in Point and Call Checks. This software allows trainees to experience each effect. The paper "Error Prevention Effects of Point and Call Checks [5]" reported an underlying verification test on the error prevention functions of Point and Call Checks.

3.2 Safety coaching technique using self-assessment

Safety guidance is most effective when tailored to each trainee’s characteristics. To this end, the "Coaching Technique about Safety using Self-Assessment" is a safety education technique which allows trainees to check their attention ability for themselves and leverage feedback from results to voluntarily find and implement a measure that can prevent their actions from leading to an error due to personal characteristics they have concerns about [6]. This technique is unique since continuous coaching sessions support a trainee’s efforts to devise their own measures, and it includes steps to increase knowledge about the voluntary design of measures through prior group meetings.
Here it is assumed that the target audience are drivers, but we think it is possible for it to be applied to training in other work settings.

3.3 Audio-visual materials for in-company training on the expected restart of railway services

An effective means to reduce complaints from passengers when an accident or some other event forces train operations to stop, is to provide guidance on expected resumption of operations as early as possible after the event has occurred. However, a railway staff could be reluctant to provide such information for passengers too soon, since two or more changes in information on expected resumption and provision of information can be sometimes occurred. To address this problem, based on verified data concerning on the influence such guidance with information would have on expected operation resumption on the psychology and behavior of train users, the Human Science Division developed audio-visual aids that stress the importance of early provision of information and present effective guidance techniques to reduce complaints from train users. Moreover, studies were carried out on the follow-up training using this material; consequently it was proposed as a training method which could help reduce anxiety of a railway staff and encourage them to actively provide information on resumption of train operations. It was confirmed that the effect of this method was that more and more staff members understood the importance of early guidance and proactively providing information to passengers, and at the same time, this awareness remained present for a long time after the training [7].

4. Evaluation method to improve vehicle environments

Convenience on board a vehicle and ride comfort are important for enhancing service. The Human Science Division is actively engaged in investigating actual conditions on board trains and experimental research targeting various factors such as rolling, internal noise, thermal environment, smell, etc. from the human science point of view. Based on the results of investigations, a method for evaluating these elements was proposed. Further work is being undertaken now to develop a method aimed at evaluating safety in terms of on-board crashworthiness, focused on reducing damage, for example, in case of a train collision. Though recently convenience, ride comfort, and safety of railways have been enhanced, rail user expectations have risen. The factors which need to be studied to meet those expectations are many and varied. Furthermore, there is an additional need to be as accurate as possible in these evaluations to ensure that developments reflect reality as much as possible.

4.1 Evaluation of ride comfort

The Human Science Division is also researching methods to evaluate ride comfort and motion sickness in terms of rolling, which is central to improving ride comfort, with a focus on vibration in relatively high frequencies and rolling in lower frequencies that is specifically generated by inertial forces working in a curve. While a performance index already exists for different levels of ride comfort and motion sickness based on acceleration of a vehicle, efforts are being made to try to apply this index effectively with a view to raising the quality vehicle vibration control and train operations as well as track maintenance control. For example, if it is possible to identify areas causing poor ride comfort and sections often leading to motion sickness, it would be possible to then study measures tailored to the problem. Accordingly, attempts are being made to adjust and upgrade the indices to identify such locations and sections [8, 9]. Additionally, Unified Data-Indication System for ride comfort was developed which produces a ride comfort index, calculated per location, simultaneously with related components such as traveling environment and vibration acceleration (Fig. 1).

4.2 Comfort index for on-board thermal environment

Even today the thermal environment is a common source of complaint, though the environment has been significantly improved along with air-conditioning equipment widely introduced in trains. One of reasons is considered to be higher passenger expectations in relation to the thermal environment. In order to satisfy these expectations, it is necessary to conduct detailed investigations into actual
conditions and clarify the mechanisms which lead to user discomfort. The thermal environment was therefore measured on board a commuter train in summer and further tests were carried out through simulation of temperature change on board a commuter train. This provided insight into the factors which contribute to passenger comfort in relation to on board temperature [10]. Based on the results of these surveys and tests, an on-board comfort index was drawn up, making it possible to indicate precisely the degree of on-board discomfort due to the thermal environment, recorded during experiments. The plan is now to expand the scope of application of this proposed index so that it can facilitate improvements to the on-board thermal environment, based on confirmed real scenarios.

4.3 Driving Posture Template

There is no doubt that the physical size of the average male in Japan has increased over the past five decades. In addition, there are a growing number of women employed as train drivers. Consequently, the difference in physical size and shape of drivers is widening, which has led to the need to review the size and position of the driver’s desk. In parallel to this trend, research has been undertaken generally to review railway designs. Tests have been conducted using people to find optimal handrail designs, based on different body shape and size, and also to reset the position of overhead hand straps or handles.

Data obtained through these studies have led to proposals for more optimal design. In addition, the results and data from these studies can be leveraged for the present research into producing a design support tool which can help in redrawing the driver’s desk, which is suited to use by drivers of different builds.

The Driving Posture Template (Fig. 2) was one of the outcomes of this research, which now serves as blueprint for driver related design [11]. The Driving Posture Template was produced on the basis of results of experiments targeting people of various build. The blue print makes it easier to visualize the average driving posture, since it can be simply superimposed on a drawing of a driver’s desk.

The template also contains information such as a spatial range where a driver can push buttons easily and appropriate height of a foot stool. It also allows for example confirmation of the physical position of the driver in the driving posture enabling the study on a simpler scale, of how to adjust the movement range of a driver’s seat and the area in which equipment can be placed. The template is scheduled to be applied in practice.

4.4 Reduction in injury to passengers in accident

In order to improve the on-board environment of a train, the Human Science Division has identified that an essential part of its work should focus on how to support the design of safe and trouble-free vehicles. To this end, studies will typically investigate on-board safety using passenger behavior simulation to target measures at reducing injury to passengers in an accident, for example, in the case of a collision. A series of studies has revealed that passenger injury often stems from them colliding with interior fittings. Thus, a proposal was made for safer interior design based on for example introducing a partition of longitudinal seating, baggage racks, and hand rails [12]. Current research is seeking to design a new model to simulate human-body movement, specially designed for the railways. This is expected to broaden the scope of on-board safety evaluation, and contribute to safer overall vehicle design.

5. Other investigations to improve user environments

In addition to the developments described above, the Human Science Division is working on how to install Tactile Walking Surface Indicators (TWSIs) to enable barrier-free environment, evaluating the impact on health of magnetic fields generated in the railway environment, and researching odors on-board vehicles and inside stations, etc.

The shape of TWSIs is specified in the Japanese Industrial Standards (JIS). However, there are cases where different railway companies and regions apply these rules differently. Therefore, users have requested the harmonization of these specifications. Consequently, the Japanese Government and authorities concerned commissioned the Human Science Division at RTRI to work on this issue. The division conducted a series of experiments to harmonize TWSI installation techniques, thus contributing to the revision of guidelines issued by the Government on the installation of indicators on a platform. Recently, the Division has been engaged in research and investigation into an installation method to be applied to stairs and steps [13].

In 2012, regulations were introduced on magnetic fields having a commercial frequency component generated in the railway environment, since railways are regarded as a public space. However, there is almost no knowledge about the effects on health of a magnetic fields generated in the railway environment, especially, for the frequency range of several kHz to tens of kHz (including the intermediate frequency magnetic fields of between 300 Hz and 10 MHz) relating to the main traction converter of railway vehicles. The results of exposure tests using intermediate frequency magnetic fields so far, have revealed no significant effect either on genes, for example in the form of genetic mutation, or on cell differentiation. Nonetheless investigations are being pursued in this area. Further details on the subject were reported in the paper “Evaluation.
Toilets are often a source of customer complaints, since they cause unpleasant odors in stations. In order to find an effective remedy to this problem, it was necessary to gain insight into the causes of how such odors can become a nuisance. An analysis was therefore made of the substances found in Toilets. This revealed that the main source of bad odors was ammonia. The next step involved identifying the elements which generated ammonia [15]. The conclusion was that particular types of germs found in toilets produce ammonia when decomposing urea, which in turn generated amounts of bacteria depending on temperature, and the amount of urea and its dyeing amount are important factors. Based on these findings, a proposal was made to introduce photocatalyst tiles on the floors Toilets, which is believed will deactivate the bacteria.

6. Conclusions

As mentioned above, along with advance of technology and enhancement of the railway environment, users have higher expectations of this transportation mode. To respond to such expectations, those involved in human science research must resolve an ever increasing number of challenges. While new requests arrive, it is not uncommon for old problems of 30 or 40 years old, to come back as well, requiring new solutions, in order to cater to the new social, environmental and technological paradigm of today. Researchers in this field should advance their own studies based on well-planned strategies to meet such needs. The author thinks that one such strategy is actually to model a human to deal with each challenge. Effective human modeling needs to keep a sharp eye on people and then understand them fully. Based on such models, the Human Science Division intends to promote R&D with a view to being able to offer practical proposals to each of these issues.

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