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Research on the Error Prevention Skills Possessed by Experienced Drivers



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The job of operating a train is comprised of a variety of tasks and the risks of error differ with each task that is involved. Moreover, even with the same task, risks differ depending on the situation that is involved. In addition to compiling the errors which drivers consider as caution needed care and situations, the methods for preventing errors have also been compiled in this paper through interviews conducted among experienced drivers. As a result of this study, it was found that the errors that drivers think caution needed can be categorized into five types and the situations. Such errors may be categorized into three dimensions. With respect to the "schemes for preventing errors," operators take actions that are appropriate to the nature of each type of error. Moreover, it was assumed that experienced drivers possess two cycles for developing these skills to prevent error in an on-going manner, It is believed that the nurturing and strengthening of each cycle is an approach to providing effective education and training.

● Keyword : Human error, skills for preventing errors, drivers, interview survey, training method

1 Objective

In order to prevent human error on the part of drivers, multifaceted measures are required and education involving knowledge, training in skills through gaining experience, and education having to do with awareness such as understanding of the importance of safety are believed to be the measures that are related to education and training. This research initiative focused on the error prevention skills possessed by experienced drivers as an approach to education and training.

Experienced drivers operate trains in a manner that adapts to the time and place such as paying particular attention to signals that may easily be incorrectly perceived. Moreover, such drivers foresee situations in which a problem may occur and think about the measures that need to be taken in such a situation and thus prevent the impact of such a problem from increasing. In this way, it may be assumed that experienced drivers have mastered the skills that are needed to prevent diverse errors.

For this reason, in order that young and mid-level drivers may master the error prevention skills possessed by experienced drivers broadly and efficiently, interview surveys were conducted among the experienced drivers and in addition to analyzing their skills, development is being undertaken with respect to methods of enhancing their capability in implementing the required measures and preventing accidents by monitoring risks during the work situation (this will be referred to in this paper as 'risk monitoring capability'). This paper reports on the work conducted up to the results of the analysis of the error prevention skills possessed by the experienced drivers.

2 Methodology of the Interview Survey

2.1 Targeted District

In order that the operation environment of JR East as a whole may be covered, the places for conducting the interview survey were selected giving consideration to the following.

- Safety installation: ATS-P, ATC, ATS-Ps, ATS-SN
- Classification of trains handled: Electric train, diesel car, electric locomotive, diesel locomotive
- Frequency of operation: Tokyo metropolitan district, local districts
- Variety of the train classification: Variety of train types such as limited express, rapid service, ordinary service
- Method of operation: Two-man operation, one-man operation
- Weather conditions: Snow country, etc.

As a result of these considerations, four locations in the Tokyo metropolitan area, one location in the Sendai district, and one location in the Niigata district were selected for conducting the interview survey.

2.2 Targeted Personnel

The interviews were conducted principally among experienced drivers but also included highly skilled mid-level and young drivers. The target group was comprised of a total of 58 drivers who were recommended at the job site. The breakdown of this group was as

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follows:

- Experienced drivers (with 15 years or more of experience as a driver): 37 people
- Mid-level and young drivers: 21 people

2.3 Method of Conducting the Interviews

Two to three employees of the research center conducted interviews with each driver. The interviews were conducted in private rooms.

2.4 Details of the Interviews

Since it was believed that drivers would have a difficult time responding if they were asked directly about the error prevention skills that they possess, an attempt was made to extract information on their error prevention skills by asking questions about the following items.

(1) The tasks and situations that may easily cause error when the driver is flustered or absent minded;
(2) The points that require care for each task and the techniques for preventing errors (preparation for duty, roll call, reporting to the point of origin, operating a train on the main line, shunting operation in the compound, etc.);
(3) The concrete locations, tasks and tracks that require care;
(4) The background to having achieved understanding of the above points that require care;
(5) The things the driver would like to teach young drivers (mind set, pride, situations that require awareness of responsibility, etc.);

As seen from the above, effort has been made to grasp in detail the situations that require care in line with the concrete circumstances such as the district, tracks and train type involved in the work of each driver and what actions are being taken in such situations.
As a general trend, the more experienced the driver was (the longer the operator's experience as a driver), the more ingenuity was required in order to extract information on the skills possessed in a concrete manner. This is assumed to be due to the fact that young drivers are more actively aware of the points that require care while with experienced drivers, such points are, in a sense, a part of their "subconscious memory" and such drivers are able to put the requirements to practical use without the need for active awareness.

3 Results

3.1 Errors that Require Care and Methods for the Prevention of such Errors

The "errors that operators think require care" and "situations in which such errors are prone to occur" (hereafter referred to as "errors and situations that require care") that were identified through the interview have been analyzed. As a result, it has been found that errors that require care may be compiled into the following five types of errors.

(1) Being misled by ambiguous stimuli;
(2) Being ambiguous in confirmation;
(3) Forgetting to do things that need to be done;
(4) Mistaking one's current mode;
(5) Making errors of judgment.

Moreover, it has been found that drivers implement "schemes for preventing errors" that are in line with the mechanism of each type of error. Table 1 shows the basics of "schemes for preventing errors" for each of the five types of errors given above and at the same time, shows the concrete "situations that require care" in which such errors are prone to occur and the "schemes for preventing error" in such situations that may generate error.
In the following section, the error types will be reviewed.

3.1.1 Being Misled by Ambiguous Stimuli

(1) Nature of the error type
This is a type of error that occurs due to erroneous action that is taken as a result of the repetition of a task of the same pattern numerous times and being led to misinterpret stimuli that require different action from usual, and erroneously interpreting such stimuli to be the "usual stimuli one is accustomed to." This kind of action may also be called being misled, reflex action, or reacting in an impatient manner.
(2) Schemes for preventing such errors
Looking at the schemes for preventing this kind of error, a typical example is "taking action that acts as a buffer" or "leaving a time lag."
For example, looking at the first example in Table 1, upon commencing a shunting operation, it is necessary to confirm that the shunting signal indicates 'proceed' but if "opening of the switch" and "the shunting signal indicating 'proceed'" are always linked, particularly at a time when the driver is absent minded, operation

may inadvertently be initiated with only the opening of the switch. Experienced drivers are aware of this risk and in order to prevent being "misled" when they are being absent minded, they take "action that acts as a buffer" prior to starting the operation. For example, such action may involve leaving the driver's seat to confirm the signal.

3.1.2 Being Ambiguous in Confirmation

(1) Nature of the error type

After repeatedly experiencing the fact that the situation is in the prescribed state upon each confirmation, the depth of the level of confirmation may become slack. Looking at the example in Table 1, in the event the second and subsequent shunting signals up ahead that are confirmed after starting train operation almost always show 'proceed', on the rare occasions in which the confirmation has become slack, if the shunting signal just happens to indicate 'stop' when confirmation is slack, there is the risk of the train going past the signal. This may be called ambiguous confirmation or subconscious omission caused by familiarity.

(2) Schemes for preventing such errors

As a measure for preventing such errors, there is a method that leads to conscious confirmation. In the case of the example given above, if the confirmation is ambiguous, the driver may not look at the shunting signal or the driver may only look at the signal but confirmation of the state of the signal may be slack. For this reason, in order to ensure confirmation of the state of the signal, the scheme of pointing to the shunting signal itself and calling out the signal's state rather than vaguely confirming the signal is being implemented.

Moreover, there were examples in which "things that are different from the ordinary" are themselves considered to comprise a situation that requires care in order to control the level of consciousness of the operator. For example, in addition to the awareness that care must be taken regarding the state of the second and subsequent shunting signals up ahead after starting train operation, the drivers perceived precursors such as those that indicate the risk involving the state of such signals indicating 'stop' and used these precursors as triggers to control the level of consciousness. Precursors that were given as requiring care included, for example, a shunted train that is not usually seen being in the vicinity, the timing of the shunting signal indicating 'route clear' being faster (or slower) than usual or the state of the train schedule being irregular.

3.1.3 Forgetting to Do Things that Need to be Done

(1) Nature of the error type

This is an error that involves temporarily forgetting things that need to be done or causing a delay in the timing of the action due to becoming absent minded as a result of familiarity with the work or due to some interference that diverts attention from the job despite the fact that the action is recognized as being something that needs to be done. In the example given in Table 1, prior to the actual slow speed signal, a slow speed approach signal is installed in a section that requires temporary restriction of the speed due to such reasons as construction work that is being undertaken. However, in places where it is not possible to confirm the slow speed signal on a continuous basis even after having passed the slow speed approach signal, if there are other factors that divert attention, there is the possibility of temporarily forgetting the existence of the section that requires restriction of the speed. Since the driver needs to be aware of a variety of factors during operation, such a situation that may temporarily result in forgetfulness is recognized by the driver as a state that requires care.

(2) Schemes for preventing such errors

As schemes for preventing such errors, the matters that need to be confirmed may be made more conspicuous or image training may be conducted in advance on the method of operation at places that require care. The former involves having a personal trigger for returning attention to the work involved even if the driver becomes absent minded or the driver's attention is diverted as a result of some interference. In the example stated above, upon confirmation of slow speed approach signal, the brake may be applied very lightly even if the current speed does not require immediate braking in order for the brake lamp to light up or the feel of the operation changes so that even if awareness is diverted from the need to slacken the speed temporarily, the driver will be able to return awareness to the need for such speed restriction.

The latter method also involves concrete advance image training on the method of operation for a section that requires care in order to create a mind set that will naturally lead to operation that complies with the need for slackening the speed.

3.1.4 Mistaking One's Current Mode

(1) Nature of the error type

The term 'mode' used here in the context of the job of the driver refers to such factors as the number of cars in the train set and the type of train (limited express, rapid service, ordinary service, etc.) In the example of Table 1, in stations where trains with multiple types in terms of the number of cars in the train set stop, the position for stopping is determined by the number of cars for the sake of the

convenience of passengers. Moreover, depending on the train, division (partial split up of the train set) or merger (partial coupling of the train set) in mid-operation may be implemented. Were a train set to be split up in the course of a run, unless the driver is fully aware of this, there is the risk that the mode (number of cars in the set) prior to the split up will remain in the driver's mind and the driver will stop the train in a position that corresponds to what was the correct position prior to the split up. This is a typical error of mistaking one's current mode.

(2) Schemes for preventing such errors

As "schemes for preventing such errors," one method is making the factors that need to be confirmed conspicuous. Another way is to look at the actual situation or conduct image training in order to promote active switching of the mode in the mind. In the example given above, while this is an extremely simple method, a method that was used for promoting awareness of the change of modes was to view the split up work closely whenever a train set is split up. Moreover, since the first station at which the train stops after the split up is most prone to such an error, there were drivers who paid particular attention to such stations. These are extremely simple methods but are believed to be highly pertinent from the perspective of the human factor.

3.1.5 Making Errors of Judgment

(1) Nature of the error type

A typical case of making errors of judgment is illusion or being preoccupied by a mistaken conception as a result of the inadequacy of prior information or due to past work experience. In the example given in Table 1, if a train is operated relying on approximate recall regarding the section for slackening the speed, an error in mistaking the speed restriction is conceivable.

(2) Schemes for preventing such errors

There were examples in which this type of error was being prevented by investigating the factors to be judged in advance or having multiple methods for confirmation. Since the cause of this type of error was often the inaccuracy of information or knowledge that is required for forming a plan, as is only to be expected, information that is as accurate as possible was being compiled in advance and multiple methods of confirmation were being used in order to avoid illusions or preoccupations.

3.1.6 Compilation of the Error Prevention Skills of Drivers

From the above, the error types from Type 1 to Type 4 can be considered as skill-based errors under the categorization proposed by Rasmussen. The work of the driver is basically conducted in conformance with rules and train schedules and since the schedule of trains is relatively accurate, much of the work is pattern oriented. For this reason, when rare situations that are different from the norm occur, the driver may act in the same way as in normal situations and this may often cause slips (failure when attempting to execute plans correctly) or lapses (loss of plans during an operation). Such risks are well recognized by experienced drivers and it is believed that they are reflected in errors that require care, situations that require care, and schemes for preventing errors. The prevention of errors by drivers is, in a sense, a struggle with skill-based errors.

With respect to errors that can be envisioned in abnormal situations, mistakes in judgment (failure upon forming plans) that constitute the Type 5 error are believed to be relatively numerous, but through the interviews that were conducted, references to errors that occur in abnormal situations were not numerous. This is believed to be due to the fact that the occasions on which the driver encounters abnormal situations are not frequent and thus the ratio of errors that occur due to such situations is relatively low. Moreover, trains are operated in collaboration with the traffic dispatcher during abnormal situations and errors were not readily recalled as being the error of the individual driver. It is believed that this point will need to be more deeply researched as a future issue.

3.2 Dimensions of Understanding of Situations that Require Care

In the preceding section, the "situations that require care" for each type of error were considered and when the details of such situations were further examined, it was found that there are roughly the following three dimensions to the depth of awareness and understanding regarding the "situations that require care." (Examples are given in the column entitled "Examples of Situations that Require Care" in Table 1.)

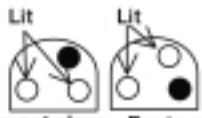
(1) Level 1- Simple and fixed situations that require care: The principal situations are those that are common and already clearly indicated at the work site as requiring care. For example, signals are generally installed on the left side of the tracks and in the case of signals that are installed on the right side due to the features of the terrain, in many cases education that such signals require care is already provided at the work site level.

(2) Level 2- Compound and case reliant situations that require care: The image and understanding of these situations are that they

require care as concrete cases and in contexts that are more in line with the actual work than in the case of Level 1. The differences from the situations of Level 1 are relative and in many cases, the points that require care for Level 2 are understood to be more dynamic situations. An example of this is the "second and subsequent shunting signals up ahead that ordinarily always indicate 'route clear.'"

(3) Level 3- Situations that require care that enable predicting errors: This is the case in which "things that are different from the norm" that may induce error are detected leading to the prevention of error. As shown in Table 1, this is the case in which a situation that requires care such as the fact that the "second and

Table 1: "Errors that Require Care" and "Schemes for Preventing Errors";
Examples of Concrete Situations that Require Care and Schemes for Dealing with such Situations

	Errors that require care	Schemes for preventing errors	Examples of situations that require care	Examples of concrete schemes for dealing with situations that require care
1	Being misled by ambiguous stimuli - Being misled, reflex action, reacting in an impatient manner	Schemes for preventing being misled - Take action that acts as a buffer, leave a time lag	[Level 1] There is the possibility of starting the train by reflex action as a result of having been misled by the closing of doors or the operation of the switch. [Supplementary Explanation] When moving to the pool track at the end of the line, the driver operates the master controller (accelerator) after confirming that the "lamp indicating closure of the door is lit" and that the "shunting signal is in 'route clear' state." There are some places where a switch that is immediately in front of the driver changes direction prior to the signal changing to 'route clear' state, and if this situation were to be repeatedly experienced on an everyday basis, the changing of the switch may act as a trigger leading to the reflex action of starting the train.	Prior to operation in the compound, the emergency brake is applied as the train enters the platform section. [Supplementary Explanation] When the driver is seated at the driver's seat with the master controller (accelerator) in a position where it may be easily grasped, there is the possibility of starting the train by reflex as a result of being misled by the closing of the door or the operation of the switch and for this reason, the driver should get out of the driver's seat when confirming the signal.
2	Being ambiguous in confirmation (confirmation is not made) - Ambiguous confirmation due to familiarity, subconscious omission	Schemes for preventing ambiguous confirmation - Devise methods of working that promote conscious confirmation	[Level 2] At places where the shunting signal is always in 'route clear' state, there is the possibility of confirmation being neglected due to the driver being absent minded. [Supplementary Explanation] At stations and in the compounds of depots, a shunting signal is designated for each branching of the tracks and it is necessary to confirm multiple shunting signals when shunting the train. Moreover, there are places where subsequent shunting signals up ahead usually indicate 'route clear' upon the first signal indicating 'route clear' and at such places the changing to 'route clear' state of the first shunting signal may lead to negligence in confirming the second and subsequent signals up ahead.	Upon confirmation by pointing to and saying the state of the signal aloud, physically point to the lamp of the shunting signal in order to confirm the state of the signal. [Supplementary Explanation] The shunting signal is comprised of three lamps and when open, the left lamp and right upper lamp are lit. By paying particular attention to these two lamps, clear confirmation of the state of the signal may be ensured.  Route not clear Route clear 'Route clear' state of the shunting signal
			[Level 3] If the shunting signal for a train changes to 'route clear' immediately after a different train exits the section, there is the possibility that the midway shunting signals are not in the 'route clear' state. [Supplementary Explanation] While places where the shunting signal is always in the 'route clear' state require care, in particular, if the shunting signal of a train changes to the 'route clear' state immediately after a different train exits the section, the state of the second and subsequent shunting signals farther ahead may be in the 'route not clear' state.	If it is forecast that the midway shunting signals may not be in the 'route clear' state, particular care is required and the speed should be reduced. [Supplementary Explanation] A "situation that is different from the norm" should be understood as a situation that requires care and even if the first shunting signal goes into the route clear state, the fact that the subsequent shunting signals up ahead may not be in the 'route clear' state should be assumed and by consciously reducing the speed, the awareness level should be controlled in order to raise the level of vigilance.
3	Forgetting to do things that need to be done	Scheme for not forgetting	[Level 2] At curves where the slow speed signal cannot be seen from the slow speed approach signal, there is the tendency to temporarily forget to slacken the speed.	When the slow speed approach signal is confirmed, the brake should be applied lightly so that the brake lamp lights up.

	Errors that require care	Schemes for preventing errors	Examples of situations that require care	Examples of concrete schemes for dealing with situations that require care
3	Becoming absent minded or forgetful due to some interference that diverts attention	- Ensure that matters that need to be confirmed are made conspicuous - Promote recall through image training	[Supplementary Explanation] There is a "slow speed approach signal" installed at a point 600 meters short of the section that requires restricting the speed and a "slow speed signal" installed at the start of the section itself. If the level of slackening that is required is insignificant and there is no need to apply the brakes immediately at the slow speed approach signal, there is the possibility of temporarily forgetting to restrict the speed due to attention being diverted by such matters that require care as signals, time, and the tracks prior to reaching the slow speed signal.	[Supplementary Explanation] During braking, the brake level lamp will be lit up. By having the brake lamp lit, the action that is forgotten may be recalled.
4	Mistaking one's current mode - One's own mode such as the type of train being operated or the number of cars in the train set is mistaken	Scheme for not mistaking the mode - Ensure that matters that need to be confirmed are made conspicuous - Look at the actual situation or conduct image training in order to promote active switching of the mode in the mind	[Level 2] If the fact that the number of cars in the train set has changed through split up or coupling is not clearly recognized, there is the possibility of absent mindedly stopping at a position that corresponds to what was the appropriate position prior to the change of modes. [Supplementary Explanation] There are cases in which the position for stopping a train differs according to the number of cars in the train set.	When a train is split up or coupled, the work of splitting up or coupling should be viewed first hand without fail in order to instill awareness with respect to the mode of the train (the driver should not wait inside the driver's cab.) [Supplementary Explanation] This is based on the experience that when the driver's cab changes as a result of a split up or coupling of a train set, errors do not occur with respect to the position for stopping the train, but when the driver's cab does not change, there have been chilling and unnerving situations and for this reason, steps were taken to confirm the split up and coupling work and this led to eradication of chilling and unnerving situations.
5	Making errors of judgment - Errors are made in judgment	Schemes for avoiding errors in judgment - Investigate the matters on which judgment is required in advance - Put multiple methods of confirmation in place	[Level 2] When approaching a section for slackening the speed with ambiguous recollection or perception, an error may be made in the speed restriction. [Supplementary Explanation] The driver judges whether or not the relevant slackening of speed applies to the work performed based on the time, the required level of slackened speed, and section for slackening the speed (distance from the point of origin in the district) and confirms the position on the railway diagram.	Prior to beginning the run, information on the approximate position for slackening the speed should be obtained from a driver who has already operated a train in the section. [Supplementary Explanation] In a section for slackening the speed that is encountered for the first time, it is difficult to identify the position of the slow speed approach signal from the railway diagram and for this reason, information on landmarks for the approximate position should be obtained from an operator who has already operated a train in the section.

subsequent shunting signals up ahead that are ordinarily always in 'route clear' state" is not only recognized but also by perceiving precursors (such as that there is a shunted train that is unfamiliar in the vicinity) the awareness level is controlled by using such precursors as the trigger.

3.3 Opportunities for Learning the Points Requiring Care

In the interview survey, the respondents were questioned on the triggers that led them to become aware of the above "errors that require care" and "situations that require care." The following is a compilation of these trigger mechanisms.

(1) Having abided by instructions provided by supervisory drivers and senior drivers (and having continued to abide by such instructions even 20 or 30 years after they were given)

(2) Having learnt from failure or chilling and unnerving experiences and having begun to implement schemes in order to avoid such situations

(3) Having thought about accidents at the work site and the cause for chilling and unnerving experiences and having begun to pay more attention to such situations

(4) Having begun to take appropriate action consciously as a result of an accident at the work site

(5) Having applied actions that were being taken by other drivers and districts

From these, it is believed that the triggers for learning the points that require care often have to do with "instructions from the supervising driver" or "one's own chilling and unnerving experience" and are the result of committing the "instructions from early in their career" and "personal experience involving close calls" deeply into one's memory and linking these to action.

Moreover, experienced drivers have a high level of "sensitivity" regarding the experience of others (object lessons) and it is apparent that these drivers absorb such experience as their own.

3.4 The Two Cycles for Developing Skills to Prevent Errors

When awareness of "errors that require care" and "situations that require care" and the "schemes for preventing errors" that are based on these as well as the process towards execution of these schemes

are analyzed, it can be concluded that experienced drivers have two cycles for developing skills to prevent errors (refer to Figure 1). Each of these cycles will be explained in the following sections.

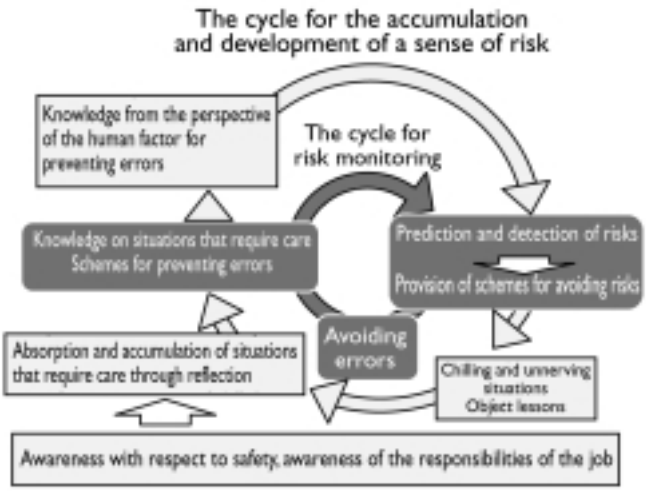


Fig. 1: Model for the Accumulation and Utilization of Skills by Drivers to Prevent Errors

(1) Cycle for Monitoring Risks

This is the cycle for avoiding risks through prediction of risks based on the accumulation of such factors as situations that require care in line with the condition of the task in order to avoid errors by ensuring that schemes for preventing such errors are in operation. This may be said to be a cycle that is always in operation during the actual work situation.

Risks while in work situations are constantly changing and in order for humans who are limited in resources available to concentrate their attention so that human error may be avoided, skills for paying attention in line with the risks involved are important. The cycle for monitoring risks as explained here is a base for the effective focusing of attention in order to avoid errors.

(2) Cycle for the Accumulation and Development of a Sense of Risk

This is a cycle that involves reflecting on one's own chilling and unnerving experiences and on the risk information provided by colleagues or of other workplaces and thinking about the causes for such situations or risks not only to gain understanding with respect to knowledge and background to situations that require care, but also to enable application of such understanding to the future prevention of errors. It may be described as a cycle for learning about risks in an autonomous and continuous manner. The base for this cycle is believed to be the level of awareness on matters of safety and of awareness of the responsibilities of the job.

Experienced drivers are not necessarily provided psychological education on human error in a systematic manner but they do understand situations in which errors may occur and take rational measures in order to prevent such errors. This is the result of instructions provided by supervisory or senior drivers or of learning from the driver's own experience in chilling and unnerving situations. In particular, with respect to the chilling and unnerving situations that the driver experiences, there are many cases in which learning comes from reflection on "why did I almost make an error in that situation" after their duty is done.

It is believed that there is a hint here for forming a cycle for the accumulation and development of a sense of risk. It is important that chilling and unnerving situations be openly reported and shared by all to the extent possible in order to prevent accidents. However even more than this, it is believed that what is more important is the extent to which the individual can learn from chilling and unnerving situations that are experienced. The difference in the level of learning is believed to relate significantly to the quality and amount of skills for preventing errors that the individual possesses.

4 Methodology for Education and Training on "Skills for Preventing Errors"

The methodology for education and training in order to raise the skills of drivers in preventing errors is believed to be comprised of the following two approaches that correspond to the two cycles described above.

4.1 Understanding and Mastery of the Details and Rationale of the "Errors and Situations that Require Care and Schemes for Preventing Errors"

This relates directly to teaching the factors that comprise the cycle for monitoring risks with respect to the part shown on the inner part of the diagram. Concretely, by teaching the reasons why "errors that require care" and "situations that require care" are risk factors and the rationale for the "schemes for preventing errors," these factors will be entrenched in the individual's memory and this will work towards preventing errors in the actual work situations.

4.2 Understanding and Learning of the Process for Autonomous Extraction and Entrenchment of "Errors and Situations that Require Care and Schemes for Preventing Errors"

This attempts to teach the cycle for the accumulation and development of a sense of risk that is the part shown on the outside of the diagram and does not involve the learning of individual items of knowledge, so to speak, but rather corresponds to "learning how to learn." For example, by having the individual understand the awareness gained through reflection and the method of reflection concerning the individual's experience in chilling and unnerving situations and on schemes for preventing errors, this method promotes the mastery of processes that enable autonomous and on-going development. If the individual becomes capable of digesting experience in chilling and unnerving situations, it will be possible to learn from object lessons and from the chilling and unnerving situations experienced by others, thus enabling extraction of new situations that require care brought about by such factors as a change in the railway schedule.

5 Future Direction

Through interviews with experienced drivers, a variety of skills for preventing errors has been compiled. Among these are diverse types and dimensions of error prevention. For this reason, it is not necessarily true that all of these are effective for all drivers. For example, for a novice driver, there may be other skills that need to be given precedence. Moreover, even mid-level and veteran drivers may have skills that are suitable for them and others that are not suitable for them.

Accordingly, it will be necessary in the future to review the appropriateness or otherwise of the nature of "errors that require care," "situations that require care" and "schemes for preventing errors" that have been compiled, to review the universality of application when sharing these with other drivers, and to review the steps that are required in applying these. There is a plan in place for reviewing these with supervisory drivers in a model work place in the future.

Moreover, as explained in this paper, in order to share these skills, understanding of the two cycles assumed to be possessed by experienced drivers will need to be deepened and debate will be required on how these skills may be developed into the concrete education and training method. For this again, concrete implementation will be attempted through debate and trials in a model workplace.

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References:

1) James Reason; Organizational Accidents, JUSE Press, April 1999

2) Safety Research Laboratory, East Japan Railway Company: Human Factor of Safety -- Towards Activation of Safety Activities in the Workplace with Human Factors as Base -- March 2004