How Drivers Understand Safe Behaviour and Perceive Risks at Passive Railway-Road Level Crossings

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Abstract: This study was designed to investigate how drivers assess safety issues at passive railway-road level crossings. The study was limited to traditional and relatively inexpensive safety measures. Fifty-six car and van drivers were interviewed after passive level crossings with low traffic volume. Both key requirements of safe behaviour (i.e. decrease of speed and looking for trains) were indicated by 36-71% of drivers depending on the classification of responses. This result suggests that a substantial percentage of drivers have no proper concept of safe behaviour at level crossings. Another important result was that drivers found the crossing of main roads to be more difficult than crossing passive railway-road level crossings — despite the fact that they considered the latter to be more dangerous. This suggests that the drivers estimated the crash risk at railway-road level crossings to be relatively low, although they know that it is dangerous in general. Furthermore, the drivers suggested that the conspicuity of level crossings could be improved by increasing lateral visibility early enough and with advance warning signs. The drivers also suggested that caution could be increased with the use of STOP signs, improving the visibility of road signs and increasing the lateral visibility of tracks. The results suggest that there are several potential safety measures that could support drivers.

Keywords: Railway-road grade crossing, drivers, traffic safety, behaviour, interviews.

1. INTRODUCTION

In Finland, the annual number of railway-road crashes has recently been 40-60 with 5-10 fatalities [1]. Given that those figures represent less than 1% of all police-reported road crashes and 1-3% of all road fatalities, one could assess that these figures are relatively low. In railway-road crashes, however, there is always the risk of a major crash with a high number of fatalities or substantial environmental damage.

Approximately 80% of railway-road crashes in Finland have occurred at passive railway-road level crossings (i.e. crossings with no active warning devices) [1]. The majority of passive railway-road level crossings are located on roads with low traffic volume (typically less than 20 vehicles per day) and drivers are usually familiar with those crossings. This is the case in Finland and in many other countries as well [2,3,4].

The safety of level crossings is a typical area of the transport system for which it is reasonable to apply the approach of shared responsibility [5]. Specifically, those involved in the design of the transport system need to accept responsibility for the safety of the system, and those that use the system need to accept responsibility for complying with the rules and constraints of the system. First, the road and railway authorities are responsible for enabling a safe crossing (e.g. marking of crossings, sufficient sight distances etc.), which as such is frequently challenging [2, 4]. In addition, the current system safety approach suggests that the authorities have to take into account that drivers are prone to (unintentional) errors. The contributing factors of level crossing accidents frequently include errors in direction of attention, detection of train, estimation of train speed, performance of specific tasks etc. (for a review see [4]). Consequently, the driver should be supported so that the number of these types of errors are minimised if level crossings cannot be removed. Secondly, the driver is expected to follow given rules and guidelines. Overall, the driver must give way to trains. Therefore, he or she must approach the level crossing cautiously and look for the train. Such a speed must be used that the vehicle can be stopped before the tracks.

One basic requirement of human-centred design is that the driver should understand safe behaviour at level crossings and what specific tasks this requires. However, earlier studies have shown, for example, that the precise meaning of signs used at level crossings and the action required are frequently misunderstood [6], which suggests that there might be other deficiencies as well. In addition, the driver should have a realistic concept about the risks involved at crossings. For example, if drivers estimate that the risks are very low compared with somewhat similar traffic situations (e.g. the crossing of main roads), it suggests that their risk assessment is unrealistic. Consequently, this study was designed to investigate how drivers assess safe behaviour at passive railway-road grade crossings and how they estimate the risk of crossing.

2. METHOD

2.1. Interview

The main data were collected using a roadside interview after passive railway-road level crossings with low traffic

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volume. Vehicles were stopped for the interview at a distance of 100 m after the level crossing. With a few exceptions all drivers were willing to participate in the interview. A couple of drivers were too hurried and drivers approaching the site after they had already been interviewed were excluded. The interviewer wrote down the drivers' answers. The interview lasted approximately 5 minutes.

In the first questions drivers were asked to describe the characteristics of safe behaviour at passive railway-road level crossings. Specifically, concepts of safe behaviour were requested by the open question, "Please tell in your own words how one should behave when crossing a passive railway-road level crossing, according to the traffic rules." This question was supplemented with, "Does anything else come to mind?"

Secondly, the risk of crossing was assessed by two questions making comparisons with the crossing of a major road. Specifically, the drivers were asked to rate on a five-point scale (a) the dangerousness and (b) the difficulty of crossing passive railway-road level crossings compared with crossing main roads. These two questions were based on Fuller's study, in which he argues that task difficulty and feelings of risk appear to have a high positive correlation, but feelings of risk and ratings of statistical risk are unrelated [7]. Consequently, Fuller concludes that task difficulty is a surrogate for risk assessment. Furthermore, one might assume that the rating of statistical risk might be difficult as the statistical risk is quite abstract and includes various elements, such as accident probability and severity of accident. In contrast, task difficulty is assumed to be more specific and therefore easier to assess.

Finally, the drivers were asked to provide suggestions for improving the conspicuity of railway-road grade crossings and increasing caution while crossing. For the first question no specific alternatives were given, while the question dealing with measures to increase caution included 13 alternatives. In both cases, however, the suggestions were limited to traditional and relatively inexpensive safety measures; measures such as removal of level crossings, active warning devices and technologies based on Intelligent Transportation Systems (ITS) were excluded, because large-scale implementation of such expensive measures was not considered feasible at level crossings where traffic volumes are low.

2.2. Speed Measurement

The approaching speed of the vehicles of interviewed drivers was measured by radar at distances of 50 m and 10 m before the tracks. These measurements were designed to show how much the driver decreased his or her speed before crossing the tracks. However, it is acknowledged that a speed at a distance of 50 m is not necessarily representative of the typical speed used on that road, as it may already be within the influence sphere of the crossing.

2.3. Sites

The data were collected in the vicinity of six level crossings. Each railway-road level crossing fulfilled the following criteria: (a) it was on a gravel road with a minimum width of 5 m, (b) traffic volume was 100 vehicles per day or less, (c) 2-15 trains per day, (d) there was only one railway track (but trains could come from either left or right) and no active warning devices, (e) there was no STOP sign, (f) the speed limit was 80 km/h or less, (g) the sight distance to the tracks (left or right or both) was limited until very close (about 8 m) to the crossing. Fig. (**1**) shows an example of the sites.

The data were collected on working days between 08:00 and 16:00. There was no active precipitation or water on the road surface. The drivers were not able to see the interviewer or speed measurer before the level crossing.

Fig. (1).

3. RESULTS

3.1. Drivers

Totally 56 drivers were interviewed. Eighty-four percent of them drove by car and 16% by van. Thirty-four percent of the drivers were women, which is somewhat more than the average in Finland (29%) [8]). The interviewer assessed the age of drivers and categorised them as follows: 18-24 years 4%, 25-44 years 32%, 45-64 years 46% and 65 years or more 18%. Fifty-two percent of the drivers indicated that they crossed the level crossing daily and 75% crossed the level crossing 2-6 times a week or more frequently.

3.2. Approaching Speed and Caution

The speed results showed that the mean speed was 42 km/h at a distance of 50 m before the tracks and 19 km/h at 10 m. The corresponding standard deviations were 8.5 km/h and 7.5 km/h, respectively. In addition, all vehicles with a few exceptions decreased in speed after the second speed measurement and practically stopped before approaching the tracks. These results suggest that, overall, the interviewed drivers crossed the tracks cautiously. These results were supported by the responses: 93% of the drivers indicated that they had crossed the tracks cautiously.

3.3. Concepts of Safe Behaviour at Passive Railway-Road Level Crossings

The responses were classified as given in Table **1**. Two aspects of the responses were evaluated: did the response show that the driver had understood (1) that one must observe whether a train is approaching and (2) that one must use such a speed that one can stop the vehicle before the track if necessary? The results given in Table **1** show that

80% of the drivers indicated that one must observe whether a train is approaching (categories a and b). On the other hand, the responses in category c show clearly that 41% of the drivers understood that one must use such a speed that one can stop one's vehicle before the track if necessary. In addition, the responses in categories d (one must stop) and e (one must almost stop) suggest roughly the same, but the interpretation is not straightforward. If categories c through e are assumed to indicate that the driver has understood the speed requirement, the proportion of drivers who responded correctly is 91%. Other responses were assessed to show more or less useful actions. However, they do not show any understanding of key requirements of crossing passive railway-road level crossings.

Table 1. How One Should Behave when Crossing a Passive Railway-Road Level Crossing According to the Traffic Rules

	Response Category	Proportion of Drivers (%)
a	Look right and left	67.9
b	Check on trains	12.5
c	Reduce speed so that it is possible to stop if necessary	41.1
d	Stop	37.5
e	Almost stop	14.3
f	Exercise caution	19.6
g	Shift to a lower gear	14.3
h	Stop if there is a STOP sign	3.6
i	No passing	1.8
j	Have a brief look at the tracks	1.8
k	Open the window	1.8

In addition to the investigation of a single requirement, it was analysed how many drivers indicated both key requirements. The results showed that both key requirements of safe behaviour (i.e. decrease of speed and observation of potential trains) were indicated by 36-71% of drivers depending on the classification of responses (in addition to category a or b, 35.7% of drivers indicated category c, 7.1% indicated category d and 28.6% indicated category e). Overall, this result suggests that a substantial percentage of drivers have no proper concept of safe behaviour at passive railway-road level crossings.

3.4. How Drivers Perceive Risk at Passive Railway-Road Level Crossings

Fig. (**2**) shows that drivers rated the crossing of main roads to be more difficult than crossing passive railway-road level crossings. In contrast, they considered the latter to be more dangerous.

3.5. Measures to Increase the Conspicuity of Passive Railway-Road Level Crossings

Drivers were asked to suggest how the conspicuity of the level crossing shown in Fig. (**1**) could be improved. No specific alternatives were given. Most drivers (75%) suggested increasing the lateral visibility early enough, followed by the use of advance warning signs (66%). Forty-six percent of the drivers indicated both measures. Other measures were indicated by very few drivers.

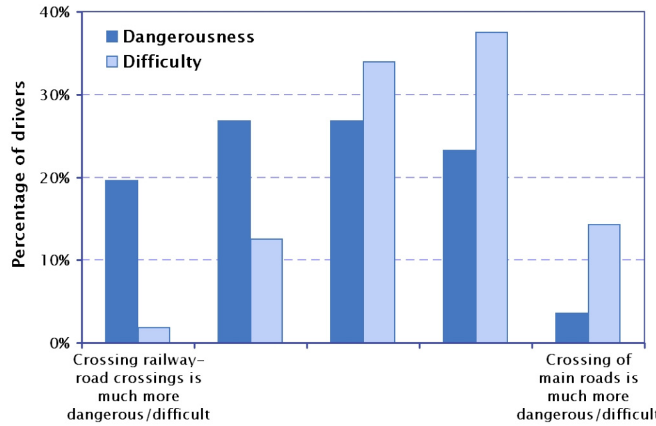

Fig. (2).

3.6. Measures to Increase Caution when Crossing Passive Railway-Road Level Crossings

A question with the specific alternatives shown in Table **2** asked for suggestions on how to increase caution when crossing passive railway-road level crossings. The drivers were asked to select three alternatives. The drivers most frequently selected the use of STOP signs, followed by improving the visibility of railway-road crossing signs and increasing the lateral visibility of tracks.

Table 2. Measures to Increase Caution when Crossing Passive Railway-Road Level Crossings

Measure	Percentage of Responses (%)
STOP sign	22
Improved visibility of railway-road crossing signs	18
Increased lateral visibility of tracks	16
Illumination of level crossing	8
Mirrors to improve the visibility of trains	7
Implementation of manually operated gate	7
Bumps	7
Level crossing signs with improved contrast against background	7
Speed limits for road vehicles	4
Increased width of road	2
Paving of road	1
Creating impression of narrowing road	1
Chicane to decrease vehicle speed	1
Total	**100**

4. DISCUSSION

This study was designed to investigate how drivers assess various safety issues of crossing passive railway-road level crossings. The study focused on traditional and relatively inexpensive safety measures. Both key requirements of safe behaviour (i.e. decrease of speed and observation of potential trains) were indicated by 36-71% of drivers depending on the classification of responses. The relatively large range results from responses that were open to interpretation. However, the result must be interpreted cautiously as it could be that some drivers were not able to convey their thoughts very clearly, although extensive answers were supported by an additional question. Nevertheless, this result suggests that a substantial percentage of drivers have no proper concept of safe behaviour at railway-road level crossings. The result is also supported by the results of earlier studies [6].

Another important result was that drivers found the crossing of main roads to be more difficult than crossing passive railway-road level crossings — despite the fact that they considered the latter to be more dangerous. Based on Fuller's theory [7], this difference suggests that the drivers estimated the crash risk (feeling of risk) at railway-road level crossings to be relatively low, although they know that it is dangerous in general (statistical risk). Consequently the driver task should be supported more effectively, because current practice leaves drivers with too many alternative ways to behave while approaching passive crossings, some of which are potentially dangerous. Measures such as the use of STOP signs or low speed limits could improve driver behaviour, depending on how much they decrease actual speeds. However, the effects of STOP signs may vary depending on the characteristics of crossings. Specifically, stopping may result in substantially delayed crossing if there is an ascent before the track, which is frequently the case at low-traffic crossings in Finland. In addition, the benefits of both kinds of road signs are likely to be smaller than expected because drivers frequently neglect the information, either intentionally or unintentionally.

Furthermore, the drivers suggested that the conspicuity of level crossings could be improved by increasing lateral visibility early enough and with advance warning signs. They also suggested that caution could be increased with the use of STOP signs, improving the visibility of road signs and increasing the lateral visibility of tracks. The results suggest that there are several potential safety measures that could support drivers. These measures can be strengthened by safety campaigns that provide information on correct behaviour at passive crossings. For example, Savage [9] found that the number of railway-road collisions can be reduced by public information campaigns. The campaigns are most effective if they are combined with engineering measures. An overall evaluation of the effects of these measures should be carried out. Overall, the problem needs further research that should be based on the concept of a self-explaining road [10] that emphasises driver support in road design.

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