RESEARCHES ON THE REACTION OF A PEDESTRIAN STEPPING INTO THE ROAD FROM THE RIGHT SIDE FROM BEHIND AND AN OBSTACLE REALIZED ON THE TRACK

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Abstract

The paper presents the results of the behaviour of drivers in emergency/risk situations caused by a pedestrian entering the driving lane from the right. They were carried out on Kielce Track in Miedziana Góra. 100 drivers were tested in various age groups at different value risk times behind 0,5s - 3,0 s. The drivers have the opportunity to perform variant defensive manoeuvres: braking, bypassing or braking with bypassing. The researchers used a specially designed, safe model-up a pedestrian, moving on the path of a car from behind the curtains limiting the visibility of the model. The paper presents and analyses the results of measurements of the reaction times of drivers in a risk time function (mental reaction time, psychomotor reaction time while "braking", motor reaction time when braking psychomotor reaction time). The presented results of drivers reaction time confirm the thesis about the influence the risk time on reaction time. Drivers' reaction times confirm the thesis on the influence of the risk time on reaction times, both when turning and braking and also indicate a trend to shorten reaction times in difficult situations. The research method allowed for the capture of many of these disturbances though the fact of such a capture itself does not mean the possibility of their unambiguous interpretation.

Keywords: *reaction time, researches of drivers, driver behaviour*

1. Introduction

Road traffic accidents involving pedestrians are the group of accidents that most frequently occur. Therefore, they should be the best known and developed group of road accidents. The collection of these accidents is extremely diverse in terms of facts and course of events. Variety of situations involving pedestrians makes an additional difficulty for the driver who should respond adequately to the arising risks and within a reasonable time. Each driver's manoeuvre is preceded by a time in which he decides on a defensive manoeuvre on the basis of available information, primarily a visual one. In situations involving pedestrians, it is important to notice a pedestrian and the way a pedestrian moves. In specialist literature, addressed primarily to experts, the reaction times are given for road studies. The first such a survey was conducted in 1931 on the racetrack in Germany and included a group of sixty drivers and concerned reactions to the "stop" command [7]. As a statistical average value 1s was adopted then, although the entire range of the results included a range of 0.3 - 2.5 s [7]. Literature also published results of research carried out in a testing stand or in driving simulators. During measuring the reaction times are very important conditions and methods of research and those carried out on the road or a testing ground using a car seems the most reliable, though the attitude of a tested driver to a reaction in a certain way (awareness of participation in such studies) and in a certain place, are inevitable "interference" in relation to real and often unexpected traffic situations. Possible reasons for the discrepancies in published values of reaction times of drivers are discussed at length in papers [2] and [3]. Acceptance of the driver's reaction time in developing the opinion of the judiciary authorities is inevitable and often does not take into account the risk time. This has an impact on the accuracy of reconstructing a pre-accident situation and the results of the space-time analysis of events within the existence or inability to avoid it.

In the years 2007-2010, a very extensive research was carried out by a team from the Kielce University of Technology (with the participation of teams of Technical University of Cracow and Warsaw). One of the objectives of this work was to verify the driver's reaction time depending on the risk time (in some Western publications referred to as a TTC (Time to Collision). Our results enrich and update existing literature data.

Three simulated risk cases have been investigated: two of them related to the situation occurring at the crossroads where a car or lorry suddenly enters from a side road from the right side [2]. In the third situation, a pedestrian entered the road from the right shoulder (the pavement). In each of these situations, lateral view of the road and the pedestrian were limited, and the "obstacles" appeared unexpectedly at random. Furthermore, in a scenario involving a passenger car, a van approached the crossroads from the opposite direction, also making the situation more difficult by limiting the range of possible defensive manoeuvres for a tested driver. Each of these scenarios was to provide the specificity of the particular road situation, also in terms of the corresponding impact on the psyche of the driver. For example, in the case of a passenger car, as it has been already mentioned, the place to make a defensive manoeuvre by avoiding could be in varying degrees, limited by the van. In the scenario with a large lorry (tractor-trailer), it was not possible to make an avoidance manoeuvre - the driver could only brake with the relevant, established by himself intensity in order to avoid the impact of such a large obstacle.

2. Characteristics of scenario with a pedestrian entering the road

Description of the test polygon, prepared and organized on Kielce Track has been included in [5] with a detailed description of the construction of models and equipment and implementing mechanisms that performed obstacle movements as well as a description of a test car equipment.

Fig. 1. General view of the stand performing a pedestrian model movement

Figure 1 shows a view of the above-mentioned stand performing obstacle movements. A pedestrian model appeared at random from behind the curtains, on the right side of the track vehicle movement (Fig. 2). According to the assumption adopted for the entire study (all scenarios), the tests were carried out on the track for risk times in the range from 0.5 to 3.6 s. Such a large range of variation of this parameter could cause that when approaching a model of pedestrian barriers could be present in the left lane, in the middle of the road, or in the right lane. Then it would be possible to implement various manoeuvres. For example, during some tests the most preferred could be an avoidance manoeuvre from the left side, and in others to make way for a pedestrian and bypassing from the right side. Accordingly, despite the apparent similarity, accident situations would differ among themselves. This would be an introduction of an additional factor hindering the comparison of results. In this respect, as a general principle for all the tests, when the car reaches the height of an obstacle, a dummy should be placed around the centre of the right lane. In this way, a common feature of all tests was the ability to choose only one of three manoeuvres: brake, bypass from the left side or brake slowly in connection with bypassing from the left. The location of the dummy should prevent bypassing it on the right side, even in tests with a high risk time.

Fig. 2. View of one of the tests

To achieve this, you had to take a different speed for a man figure movement. For five shortest risk times on the track the speed was 4.5 m/s - which corresponds to fast running of young people. For subsequent tests, there were performed speeds of 2.25 and 1.25 m/s, and for three longest risk times - the speed 0.8 m/s - which corresponds to free or normal walking of elderly people [7].

Table 1 summarized data for each test. Significant variation of risk times in subsequent tests and the introduction of two "empty" rides aimed at including a surprise factor, and a required part of several hundred meters between the attempts in some way calmed down tested drivers.

Tab. 1. Characteristic parameters of the "pedestrian" scenario

Vehicle speed km/h	Distance m	Risk time s	Pedestrian speed km/h	Test no.
36	10	1	2.8	1
60	20	1.2	2.8	2
40	empty			3
40	10	0.9	2.8	4
45		0.8		5
60	50	3.0	0.9	6
50		3.6		7
50	40	2.88	0.9	8
60		2.4		9
40	30	2.7	0.9	10
50	20	1.44	1.5	11
36		2.0		12
40		1.8		13
50	30	2.16	1.5	14
60		1.8		15
36	5	0.5	4.5	16
60	empty			17
60	10	0.6	4.5	18
50		0.72		19

3. Analysis of results

Based on recorded signals from an accelerator pedal position sensor, a brake pedal and steering wheel, and a signal from the light barrier activating model movements by radio, times from the appearance of obstacles within the driver's visibility to the beginning of the change in the position of the above-mentioned elements that control the car have been determined. As a result of compiling data for the entire population of drivers, the following reaction times values have been achieved:

- mental reaction time, understood as the time from the appearance of an obstacle to the start of taking a leg from the accelerator pedal, hereinafter referred to briefly: reaction time, "acceleration pedal";
- psychomotor reaction time when braking, determined as the time from appearance of an obstacle to emergence of force on the brake pedal, hereinafter referred to briefly: reaction time, "brake";
- motor reaction time when braking, determined as the time from start removing the leg from the accelerator pedal to the onset of force on the brake pedal;
- psychomotor reaction time during a turn, determined as the time from the emergence of an obstacle to the onset of force on the steering wheel, hereinafter referred to briefly: reaction time - "turn."

For each of the above-mentioned times average values and standard deviations have been calculated for the entire study population of 100 drivers and for each of the 17 tests carried out indicated in Table 1. These values in a risk time function characterise given tests shown in the following figures.

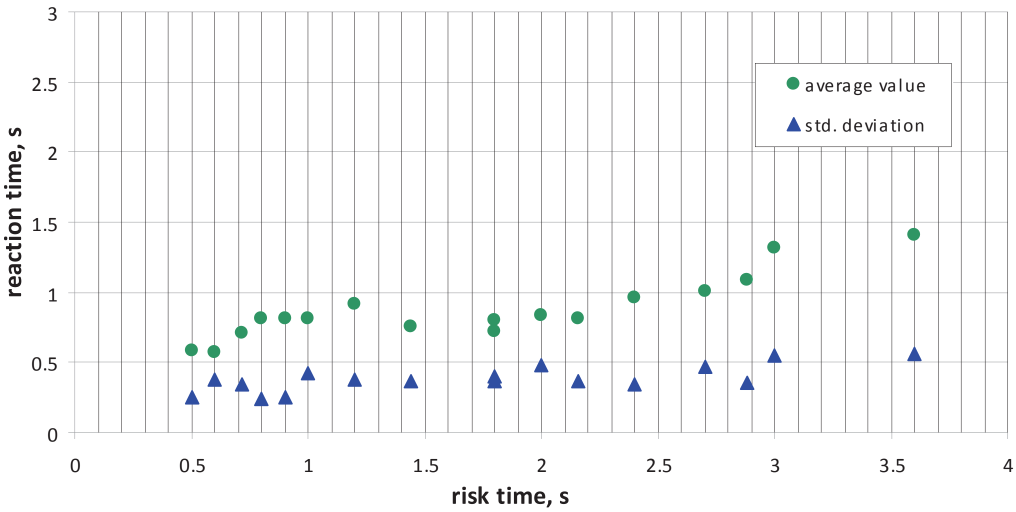

Fig. 3. The course of statistical parameters for brake reaction time

The average values of reaction times by a foot brake, as shown in Figure 3, change for the analysed range of risk times in the range from approximately 0.6 to approximately 1.4 s. It should be noted that this is a large - almost 2.5 - fold range of variation. We can therefore talk about a strong dependence on reaction times from risk times. Characterizing the general trend, it can be noted that despite some deviations, analysed reaction time decreased throughout the range with the decreasing risk time. This means that in more difficult situations tested drivers reacted quicker, that is, they analysed the situation and made a decision faster and performed it.

The standard deviation of reaction times, which change on the graph from about 0.55 for the longest risk times to around 0.25 seconds for the shortest ones, also show an overall downward trend, in line with decreasing risk time. This means that with decreasing risk time not only the average value decreases, but also the concentration of distribution increases - the drivers in the overall tested population reacts more uniformly.

It should also be noted that in comparison to the reaction times obtained in earlier studies conducted for 1 scenario [6], currently achieved average reaction times' values are much shorter. There, for the shortest risk times, an average reaction time of a foot brake stabilized at around 1.0 s.

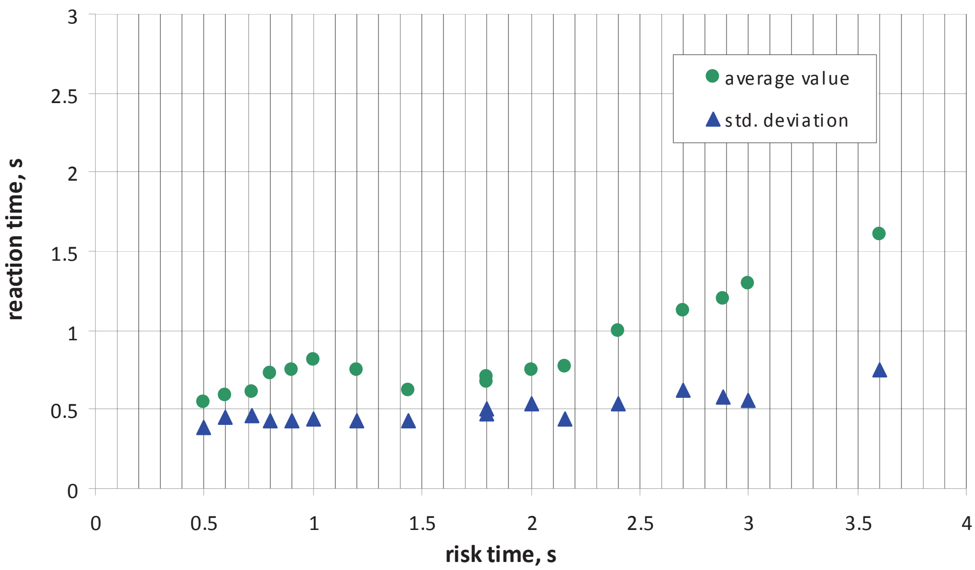

Fig. 4. The course of statistical parameters for the reaction time when turning the steering wheel while trying to avoid an obstacle

Similar trends - that is, a reduction in average reaction time values together with a decrease of risk time, may be observed for reaction times while turning - Figure 4. Similar is also the range of variation of average values, which varies from about 0.6 s to approximately 1.6 s. The standard deviations of reaction times while turning are in the range from about 0.4 to about 0.75 s and are slightly larger (by about 0.1-0.2 s) than the standard deviations for the reaction shown previously when braking.

Very interesting is the fact that in contrast to the brake reaction times, in the case of reaction times when turning, the average reaction time values obtained in studies of this scenario are very similar to those obtained in the first scenario [6].

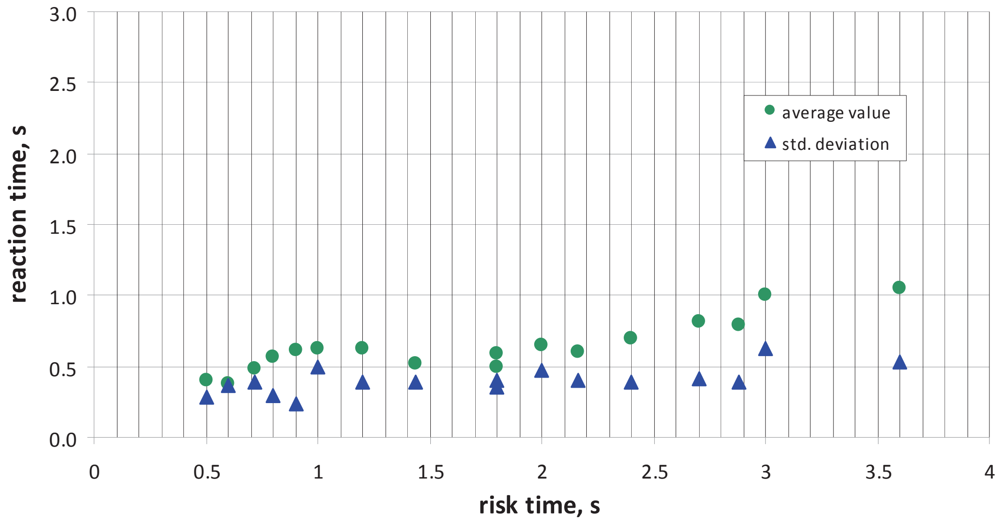

Fig. 5. The course of statistical parameters for the "acceleration pedal" reaction time

Analysis of the "acceleration pedal" reaction, as shown in Figure 5, indicates that with the shortening of risk time from greatest values (3.6 s) to about 2.2 - 2.4 s, average reaction time decreases almost linearly from value of about 1.1 sec to about 0.6 - 0.7 s. In the range of risk time from approximately 2.2 to approximately 0.8 s "acceleration pedal" reaction times take the values of about 0.6 s, and at even shorter risk times there is a noticeable trend to shorten the reaction time to about 0.4 s. In general, despite some deviations, the analysed reaction time decreased throughout the range in line with the decrease of risk time.

A similar overall regularity can be formulated for the standard deviations that changes on the chart from approximately 0.55 to approximately 0.25 seconds.

In the case of standard deviations it is worth paying attention to the two tests of risk times. In both cases, the standard deviation is significantly higher than for tests adjacent to the chart, implying a higher dispersion of the measured response times for individual drivers. It can be interpreted that these attempts have posed a problem for some drivers. In the case of 1.0 s risk time, the explanation may be the fact that this test was carried out first (see Table 1). The test of 3.0 s risk time was performed on two similar tests of risk time less than one second so an additional element of surprise could function here that is an obstacle appeared so early. It is interesting that this phenomenon is revealed so clearly in the graph of psychological reaction during braking, while the previous two graphs it is not so clearly visible.

Shown in Figure 6 the average motor response time values are within the narrow range from about 0.18 to about 0.38 s. Starting with the longest risk times, these values first decrease, reaching minimum values for risk times in a wide range of about 0.5 - 2.7 s. Values higher than average in this range were obtained for times 1.2 and 2.4 s. The standard deviations do not exceed 0.2 s for risk times no longer than 3 s and the distribution focus is nearly constant in the risk time range from 0.5 to 2.88 s.

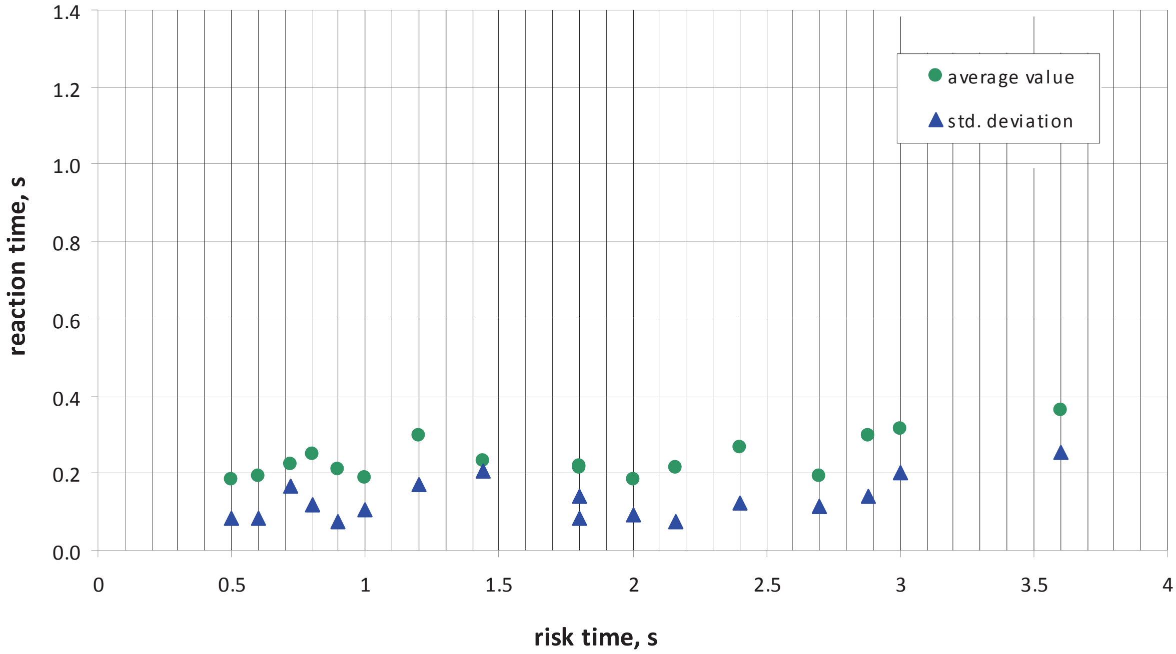

Fig. 6. The course of statistical parameters for the motor reaction time

4. Conclusions

The presented results of the drivers' reaction times confirm the thesis about the influence of the risk time on reaction times, both when turning and braking and also indicate a trend to shorten reaction times in difficult situations, i.e. with the decreasing risk time that characterises a particular situation [1], [4]. A similar trend characterises not only determined average values but also the standard deviations shown in the graphs. This means that with decreasing risk time decrease average values of all analysed reaction times but the focus of their distribution increases - the drivers in the overall study population react more uniformly.

Expert opinions on accidents involving pedestrians usually take reaction times for a manoeuvre to change driving direction with an attempt to avoid a pedestrian and a braking manoeuvre. A wide range of changes in the average drivers' reaction times (from about 0.6 to about 1.4 s for braking with a foot brake and from about 0.6 s to about 1.6 s for turning) shows that the analysis of accidents should take into consideration estimation of the risk time that characterises a particular situation and select reaction times adequate for the assessed risk time value. In this way, it would be reasonable to adopt in the analysis of one accident the risk time, for example, of a 0.7 s value and for another accident, the correct value may be, for instance, the reaction time of 1.4 s. It should be remembered that tested drivers should know that they participate in the research of an accident situation. For real traffic conditions, obtained values should be increased by time associated with the effect of surprise, which in various publications, is estimated at about 0.2-0.3 s. These times can of course increase other factors, which in the presented research have not been considered, such as long-term driving fatigue, alcohol, driving at night, etc.

In the conclusions, it is worth paying attention to the tests indicated in the analysis, for which parameter values deviating from a predominant trend have been observed (see comments on the standard deviations of acceleration reaction time in the tests of 1.0 and 3.0 s risk times). Despite averaging reaction times for the population of 100 surveyed drivers (usually averaging process "loses and rounds" minor interferences), minor factors identified in the analysis (a sequence of tests) exemptions visible on the graphs. It is worth emphasizing because this proves the diligence with which the concepts of such experiments should be conducted in order to obtain reliable results and to prevent small random factors from influencing obtained results.

In the following research the method of their realization allowed for the capture of many of these disturbances though the fact of such a capture itself does not mean the possibility of their unambiguous interpretation.

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