

Abstract – The paper describes a test design to evaluate the braking behaviour in the course of the driver education. The results show that the braking capabilities increased during the driver education and the learning effects are the same for males and females. The evaluation limit is set to 6 m/s². At the beginning of education, 50% of the drivers do not reach this limit, although the driver education car is equipped with an emergency brake assist, which is regularly installed in all vehicles since 2009. After the education, 100% of the drivers can reach the limit. The results are mapped to a collision avoidance scenario.

NOTATION

a_1	Deceleration of vehicle 1
a_2	Deceleration of vehicle 2
v_{01}	Velocity of vehicle 1
v_{02}	Velocity of vehicle 2
t_{reac}	Reaction time of vehicle 1
t_{safe}	Safety distance to vehicle 2

DRIVER EDUCATION AND TEST DESIGN

The new driver education concept in Germany enables young people to obtain a driving license at the age of seventeen. The license allows novice drivers to drive a vehicle with an educated adult. The positive results of this new education process can be shown by [1]. [2] shows that the education of the emergency braking is established but that driver education tests do not include this important issue in the driving test. The rate for testing is less than 10%. In this context the questions arise,

- whether the novice driver is able to handle the emergency braking conveniently and
- how the learning progress of the participants in driving schools is

Regarding these questions, special testing and investigation was carried out with support from a driving school in Osterode/ Germany and its driving instructor.

The test is designed as follows. The driving instructor gives a practical driving lesson of 90 minutes duration. The novice driver is required to conduct 45 minutes of regular driving within this lesson. After this time he drives to a place where he can safely perform an emergency braking. The place where the emergency braking is performed is used for all emergency brakings for all driving lessons. The first braking is done without any instructions to the participant. After the first braking the driving instructor gives educational remarks to the participant. Then the driving instructor decides how many times the participant has to repeat the emergency braking manoeuvre. The number of emergency brakings is limited to five per driving lesson. Additionally, it is of interest, how many lessons are necessary in total to give sufficient emergency competence.

RESULTS

To gather relevant data from the test, the driving school vehicle (VW Golf VI Plus) is equipped with an accelerometer which can easily be installed behind the front window.

The first results of the learners of emergency braking competence are pointed out in figure 1. The plot indicates on the one hand that the minimal number of emergency decelerations in the first driving lesson should be minimally four and on the other hand that the minimal number of driving lessons with an emergency braking topic should be three.

After this experience, the driving instructor has to decide on his own if there are further lessons needed. The development of this capability is shown in figure 2. It can be shown that there is a difference between the braking performances of male and female participants. First, the figure reveals that there are no major differences by male and female learners in the first driving lesson. The male

subjects could be well performers ($> 6\text{ m/s}^2$) or less well performers ($< 6\text{ m/s}^2$). The same holds for the female subjects in the first driving lesson. This is an important issue, even though the male subjects are slightly better less well performers in the first driving lesson. In the last driving lesson all participants can reach a braking performance up to 7 m/s^2 or higher. It is important to see that the female and male participants can reach comparable results.

Number of decelerations per driving lesson

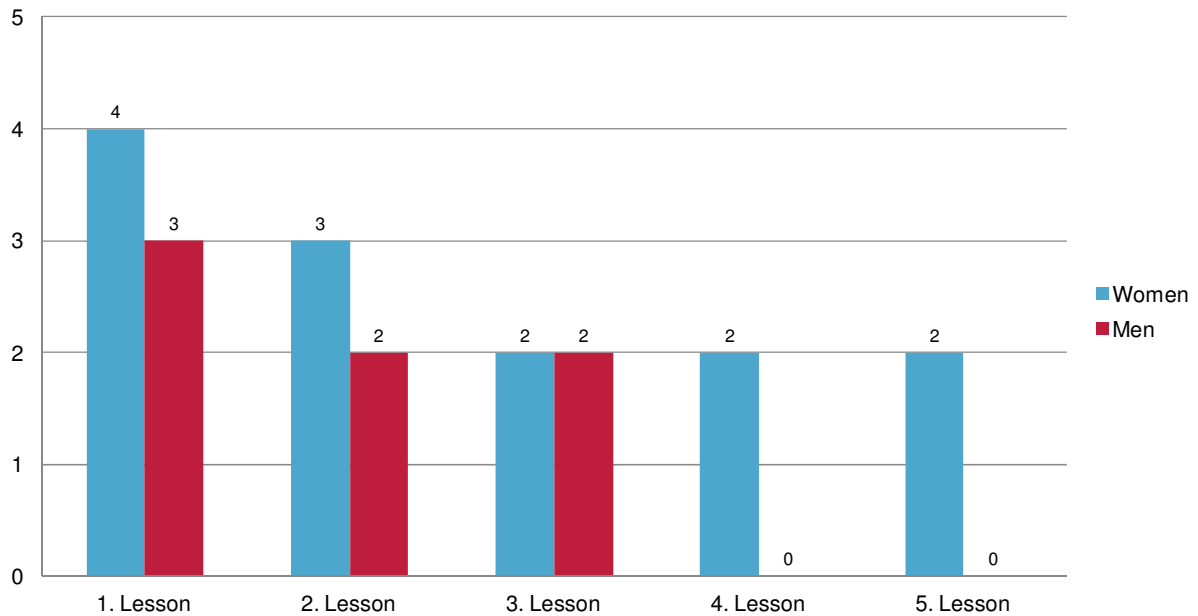


Figure 1: Number of decelerations per driving lesson.

Compare 1. and last lesson by increasing capability

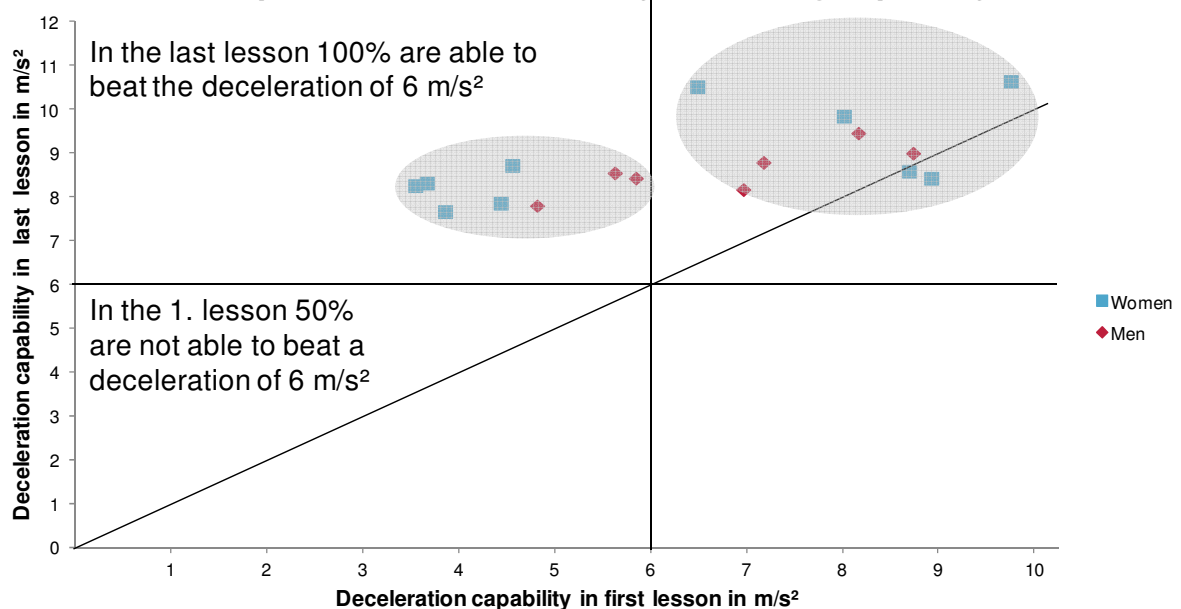


Figure 2: Comparison between the first and the last driving lesson

We applied these findings to an obvious and characteristic scenario of two following vehicles (1 and 2) with the following assumptions:

- i) stationary driving (figure 3)
- ii) both vehicles move with a velocity of 100 km/h

- iii) both vehicles move within the relative braking distance (equation 1.1)
- iv) vehicle 1 follows vehicle 2 with a clearance time of 1.6 seconds
- v) vehicle 2 has an emergency braking system which can brake with maximum deceleration in case of an occurring collision
- vi) the driver of vehicle 2 might not know that the vehicle in the front will perform such a strong deceleration
- vii) vehicle 2 does not have such a braking system on board
- viii) the driver in vehicle 1 can only decelerate with 6.4 m/s^2

Under these conditions and in accordance with equation 1 a table can be derived to rate the possibilities to avoid the collision in this scenario (table 1).
 Formula 1 is given by the relative braking distance and is converted to vehicle 1 in case of stationary following of vehicle 2.

$$a_1 = - \frac{v_{01}^2}{2 \left(\frac{v_{02}^2}{2a_2} + v_{01} * (t_{safe} - t_{reac}) \right)} \quad [1]$$

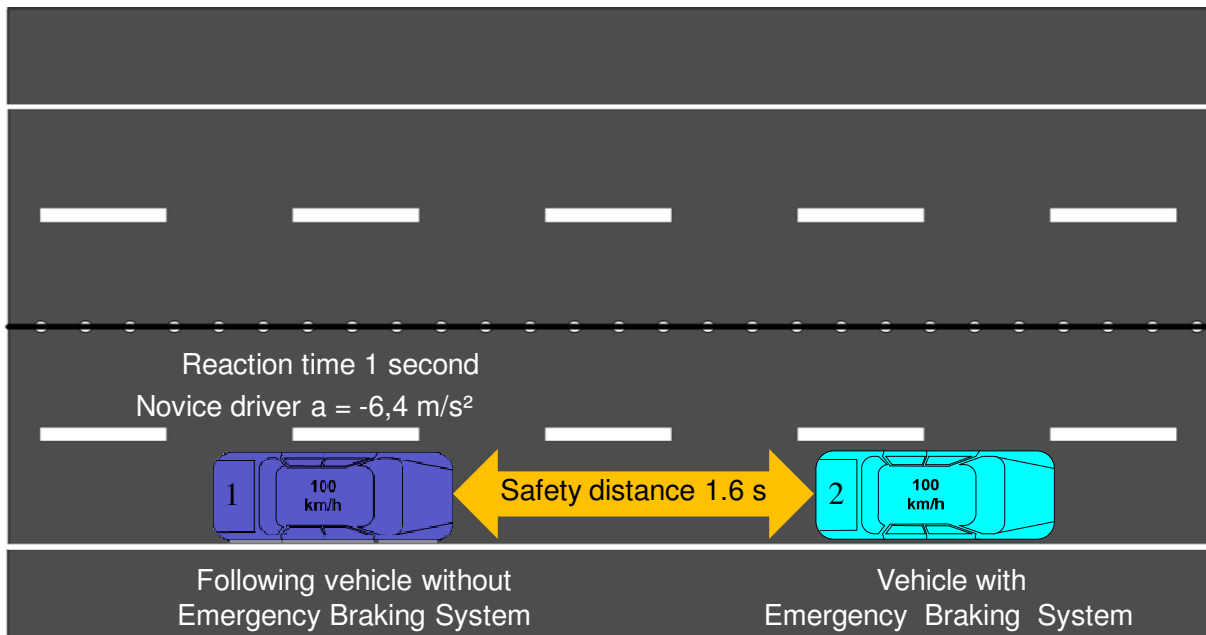


Figure 3: Scenario with two vehicles in a stationary following behaviour

Table 1: Mapping between clearance time, velocity and braking behaviour

		Deceleration value from vehicle 2 [m/s ²]									
		0	1	2	3	4	5	6	7	8	9
Deceleration value from vehicle 1 [m/s ²]	1										
	2				vmax 20 kph	vmax 10 kph	vmax 10 kph	vmax 10 kph	vmax 10 kph	vmax 10 kph	vmax 10 kph
	3					vmax 50 kph	vmax 30 kph	vmax 30 kph	vmax 20 kph	vmax 20 kph	vmax 10 kph
	4						vmax 80 kph	vmax 50 kph	vmax 40 kph	vmax 30 kph	vmax 30 kph
	5							vmax 120 kph	vmax 70 kph	vmax 50 kph	vmax 40 kph
	6								vmax 180 kph	vmax 100 kph	vmax 70 kph
	7									vmax 240 kph	vmax 130 kph
	8										
	9										

After a calculation of braking curves based on formula 1, several maximum speeds can be derived according to the given clearance time in figure 3. With the results in figure 2 in accordance with table 1 several areas can be derived. For the emergency braking capability at the beginning of the driving education a value of 6 to 7 m/s² can be derived. At the end values of 8 to 9 m/s² can be derived. If we put these values to table 1 these values are the emergency braking behaviour of vehicle 1 in the scenario. We can show, that accidents are able to occur by greater speeds than 70 kph. If we put the values which are reached at the end of the driving education as braking capability of vehicle 1, we can show in table 1 that no accident would occur at any speed.

For the interpretation of the results according to table 1, it is important to keep in mind that there are small gender differences and the results are obtained with a vigilant driver, in a given clearance time.

CONCLUSION

The emergency braking capability is important for driving a vehicle in critical situations. The results show that a good education can change a less well performer to a well performer. This means that 50% of possible accidents can be avoided by a good education.

If we look in the official accident statistic [3] it can be shown that 19% of young drivers (18 to 24 years old) had accidents with high speed. One reason for the severity of the accidents could be a low emergency braking capability based on insufficient driver education.

To find an answer to this our institute observes a driver safety training with a reference vehicle. The first results show that 20% of the participants are not able to reach the activation level of the emergency braking system of the driving school vehicle.

REFERENCES

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