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Physiological and Psychological Performance Measurement for the Practical Driving Test

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ABSTRACT

As technology advances, new driver assistance systems and innovations in road traffic are making driving easier for people. The era of autonomous driving for everyone is also drawing ever closer. In view of this, the practical driving test is still a major obstacle to accessing road traffic. In 2022, 37% of candidates failed this test, and according to the ADAC, this failure rate has stagnated around this level for 10 years. Modern driving schools invest heavily in the training of their learner drivers. Several mobile apps and simulators are available for initial driving training. With the help of a multimodal measurement of the physiological and mental state of the learner driver in the simulator and the real driving lesson, a database is built up of events that occur during the training session. This database will then be used to draw conclusions about the causes of failing the driving test in comparison with the data from the test drive. The individual learner drivers are evaluated from the time they register, through the driving lessons, to the practical driving test. The starting point is a personality test based on a questionnaire. In the further course of each simulator driving lesson, the subjective assessments of the learner driver before and after, as well as their physiological stress, are recorded. In the real driving lessons, the assessment of the respective driving instructor and a standardized driving log are added to record special events and behavior during the driving lesson. The special events are also recorded via a video recording and synchronized with the data from the learner driver's stress measurement. The stress level is recorded using a combination of various established measurement methods. These include heart rate variability, skin resistance, eye tracking and validated questionnaires. Various wearables are used to record the data. The collected information is then synchronized and evaluated centrally via their time stamps. Particular attention is paid to anomalies in the stress measurement at special events and locations in road traffic, such as turning at junctions or schools located on the route. The aim is to identify patterns that are associated with failing the practical driving test. With the knowledge gained, the training of learner drivers is to be optimized and the failure rate in the practical driving test reduced.

Keywords: Human factors in transportation, Driving school survey, Mental stress detection, Physiological signals, Wearable sensor

INTRODUCTION

In terms of road traffic hazards, young drivers and novice drivers in particular represent a major statistical safety risk. Most recently, this age group, which includes all driving license holders under the age of 25, was involved in around 20% of fatal road accidents. (Jannusch, 2023) In the 18–24 age group, an increased willingness to take risks, overconfidence, overconfidence and lack of experience lead to a dangerous starting point in road traffic (IM-NRW, 2024). To prepare for road traffic and gain initial practical driving experience, every driver must pass theoretical and practical driving tests. In 2017, 1.80 million theoretical and 1.66 million practical driving tests were carried out in Germany (Janson, 2019). If you look at Figure 1, you can see that 28.1% of practical driving tests taken in Germany in 2017 were failed.

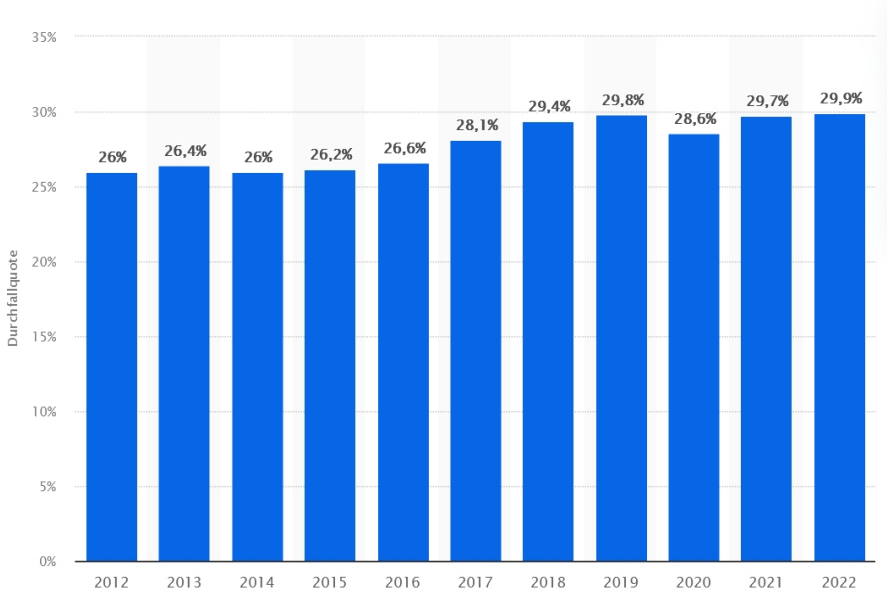

Figure 1: Failure rate for the practical driving test in Germany (KBA, 2023).

In 2022, the failure rate is even higher at 29.9%. One factor in these high figures may be that the training is still largely based on concepts from the 1970s and 1980s and is therefore no longer up to date in an increasingly changing road traffic environment (Bredow, 2016). As a comparative value, we use the figures from Switzerland, which perform even worse with 66.5% of practical driving tests passed in 2022 (Vereinigung der Strassenverkehrsämter, 2023). If we interpret these figures, we come to the conclusion that almost one in three learner drivers were unable to pass the practical driving test during their training at driving schools. Nowadays, learner drivers have a wide range of information and technical support at their disposal in driving schools to prepare them for the test and for road traffic in general (Mörl, 2020). Much of the theoretical and some of the practical training now takes place digitally in apps and driving simulators (Vohle, 2012). In practice, too, driving simulators are already available in

many driving schools and modern vehicles are equipped with a variety of Advanced Driver Assistance Systems (ADAS) that make driving easier for the driver (Schramm, 2020). Examples include Hill Hold Control (HHC) and traffic sign recognition. Driving schools can now draw on decades of experience in training and the continuous improvement of technical aids for these technical aids. The question remains: how can safe and responsible driving be taught? This includes a detailed consideration of the actual driving task and the associated skills that a novice driver must have (Grattenthaler, 2009). But also the influence of the actual learning process, which includes not only the result but also the individual personality profile of each learner driver. It can therefore be concluded that there are other factors besides learning to drive that prevent learner drivers from passing their driving test. In our study, we want to get to the bottom of possible psychological issues that may also be related to the personality profile of individual learner drivers. We also plan to evaluate and validate these studies, which are mostly based on questionnaires, using physiological indicators from stress research.

Research Background

The Uwe Hübner Driving School and the Smart Health Lab (SHL) of the University of the Bundeswehr Munich have joined forces to clarify the research questions raised. The driving school has two branches in Schwarzenberg and Aue with a total catchment area of around 38,000 inhabitants. In 2023, there were around 750 learner driver registrations, which are supervised by 15 driving instructors and 5 office staff. Three of the driving instructors are still in training. The company uses the most modern permitted options available from a technical perspective to train learner drivers. For example, the learner drivers are prepared for participation in road traffic with three different learning apps and driving simulators. Figure 2 shows the simulator and the interfaces of the apps used.

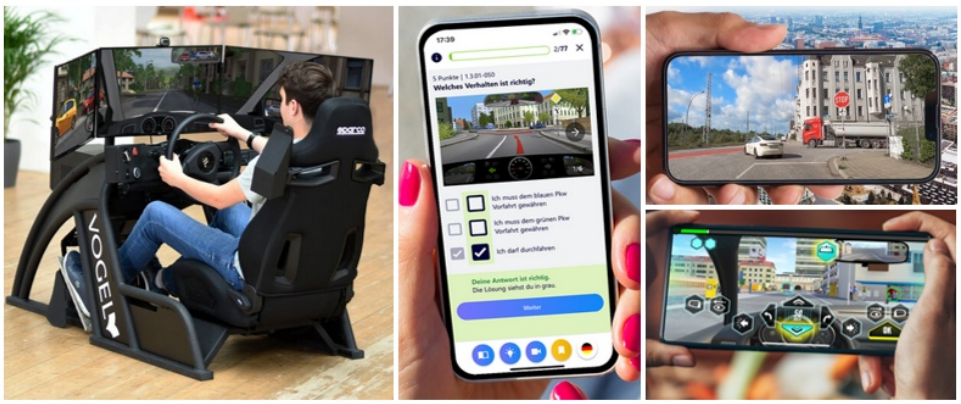

Figure 2: State-of-the-art technology for driving school training (Vogel, 2024).

While the focus of self-learning programs was initially only on training facts and theoretical test tasks, they are increasingly being used to develop

practical traffic awareness and hazard avoidance (Weiß, 2009). Driving simulators enable driving schools to adapt their training content precisely to the learning level of the individual learner driver. In addition, the learning success of learner drivers can be objectively recorded and driving performance can be clearly visualized for learning purposes (Genschow, 2013). Motor sequences, such as shifting gears, can be practiced and the reaction to dangerous situations that do not necessarily occur in practical driving lessons can be trained (Weiß, 2009). The learning effectiveness of virtual scenarios was already established by Regan et al. in 2000. Looking at the learner driver training regulations, it is clear that only minor changes have been made to the framework plans and subject areas in the last 20 years. This means that every driving instructor is free to ensure that the content of their training is complete (Sturzbecher, 2022). Measures for continuous improvement in the implementation of practical driving training are listed in the "Manual on the driving license examination system (practice)" (TÜV, 2019). Even when using the current possibilities of new concepts and technologies for the training of learner drivers, driving schools cannot ensure that learner drivers will pass the practical driving test. However, a prerequisite for admission to the practical driving test is a positive assessment by the supervising driving instructor (Sturzbecher, 2022). In addition to the factual consideration of knowledge for participation in road traffic, there are also minimum psychological requirements for test candidates. Adequate performance of the learner driver is required in the following 5 areas for driving aptitude: Orientation ability, concentration ability, attention, reaction ability and resilience. Other dimensions, such as intelligence, sustained attention or vigilance, can be taken into account if necessary by referring to the assessment guidelines for driving aptitude (Gräcmann, 2022). Table 1 compares the performance areas with the necessary assessment criteria (Brenner-Hartmann, 2023).

Table 1. Psychological driver requirements (Brenner-Hartmann, 2023).

Requirements	Evaluation Guidelines
load capacity	sufficient attention capacity even under stress and prolonged strain
orientation	- fast and reliable perception of visual information - reasonably fast target orientation in the visual environment (traffic area)
concentration	uninterrupted concentration
attention	adequate distribution of attention
ability to respond	- timely onset of motor response - safe and appropriate reactions to the situation - balance between speed and caution

Driving instructors and driving examiners are thus confronted with psychological issues whose assessment goes far beyond the content of their own training. The term stress, which appears here, could offer a way of technically validating the subjective assessment of driving instructors. Stress can be understood as the heavy strain placed on an organism by internal or external

stimuli. Current stress research is based, on the one hand, on the biological explanatory model of the physician Hans Selye and, on the other, on the psychological stress management model of the psychologist Richard Lazarus. In the biological model, stress is seen as a reaction and stress factors outside the body are linked to internal reaction processes in a measurable way. The psychological model describes stress as an interaction between the effect of stressors and the coping options available (Ernst, 2022). Stress research makes use of a whole range of self-assessment questionnaires, but stress can also be assessed via the resulting physiological activation. Cardiovascular stress indicators in particular, such as heart rate, heart rate variability, blood pressure and electrodermal activity, are technically relatively easy to measure (Kasten 2018). Studies have shown that heart rate (HR), blood pressure (BP), respiratory rate (RR) and skin conductance (GSR) increase during stress, while heart rate variability (HRV) and skin temperature (ST) decrease. These biological values can now be recorded using commercially available, wearable sensors that can also be worn while driving (Gedam, 2021). In combination with classic psychological questionnaires and personality tests, these measured values should provide an insight into the stress level of learner drivers during practical driving school training. This data can enable the driving instructor to respond individually to a high level of stress among learner drivers. Based on this, the planned study will focus on answering the following interdisciplinary research questions:

Q: Is there a correlation between learner drivers' state of stress while driving and passing the practical driving test?

Q: How can physiological stress data during driving be correlated with the psychological stress recordings and the personality profile of learner drivers?

Q: How do the training of learner drivers and the working environment of driving instructors change as a result of continuous stress measurement during practical driving training?

Method

The study is currently still in the conceptual preparation phase. In the planning phase, the main contents of the study are defined in the preliminary meetings and the course of the study is determined. Due to the methodical collection of personal data from learner drivers, a tested data protection concept is essential. This must also include all questionnaires and sensors used and can therefore only be drawn up after the questionnaires have been created and the sensors have been finally selected. In the first steps, the data already available at the driving school from handwritten logs and from the simulator must also be recorded and evaluated. Based on this, standardized online surveys are used. The task here is to develop a system for data collection and to define the corresponding interfaces. This system must be able to record and correlate the different data from the questionnaires, the protocols, the simulator and the physiological sensors. Added to this is the information from the personality profile of the individual learner drivers, as well as the vehicle data, which must be recorded at the same time as the stress states

obtained. The staggered procedure for the study is divided into individual work packages and can be seen in Figure 3.

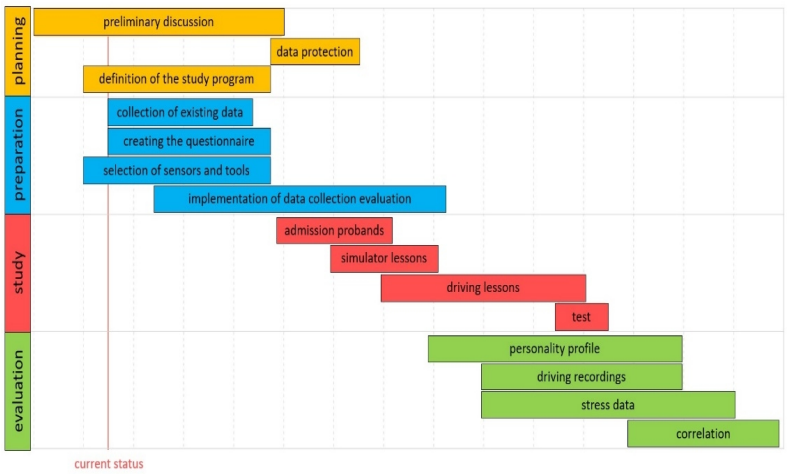

Figure 3: Procedure model of the study.

The actual study involves collecting data on the personality profile and stress levels of individual learner drivers in four different situations. These result from the course of practical driving training at the driving school. The first data is already collected during registration after the learner driver has given their consent to participate in the study and to the data protection concept. The actual driving training then starts parallel to the theory lessons in the driving simulator. In addition to the data collection that begins here with the help of the sensors, an assessment of the stress level before and after the simulator driving lesson is also collected. This assessment is made both by the test person themselves and by the responsible supervisor via the learner driver. The same procedure is planned for the subsequent practical driving lessons in the car. Here, the data collected is supplemented with the driving data of the vehicle and a report by the driving instructor on the procedure and special events during the driving lesson. Every learner driver must first complete several simulator driving lessons in order to qualify for the practical driving lessons. At least a prescribed number of driving lessons must be completed and admission to the driving test is only granted once the driving instructor has additionally assessed that the learner driver has mastered all the necessary training content. The driving test with an external examiner can also be used as a data source for the test report, which was prepared as proof of performance. The procedure is the same for all learner drivers and Figure 4 shows the data collections that are assigned to the individual training sections.

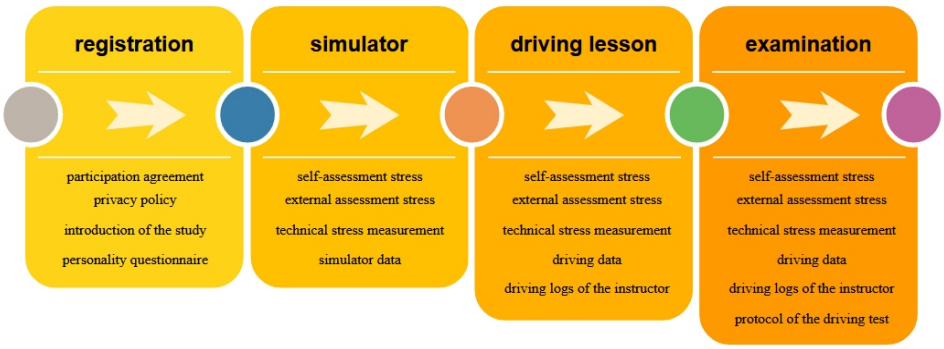

Figure 4: Data capture during the study.

CONCLUSION

Technological progress and modern approaches enable stress research to open up new perspectives, particularly in areas of training. If stress states are a significant factor in failing examinations, the foundations for improved stress resilience can be laid during training and methodical action can be trained to enable the examinee to better control their stress state. This also changes the training content and tasks of the trainers to some extent. Taking practical driving training as an example, the psychological aspects of failing the test are obvious, as admission is only granted if all the necessary behaviors have been practiced and carried out correctly. The extent to which psychological stress can be correlated with the technically recorded stress levels of learner drivers has yet to be evaluated in this study.

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