Use of Driving Simulators for Teaching Shifting Competence in Driver Training

Key Results of IfA Driving School Survey | February 22, 2024

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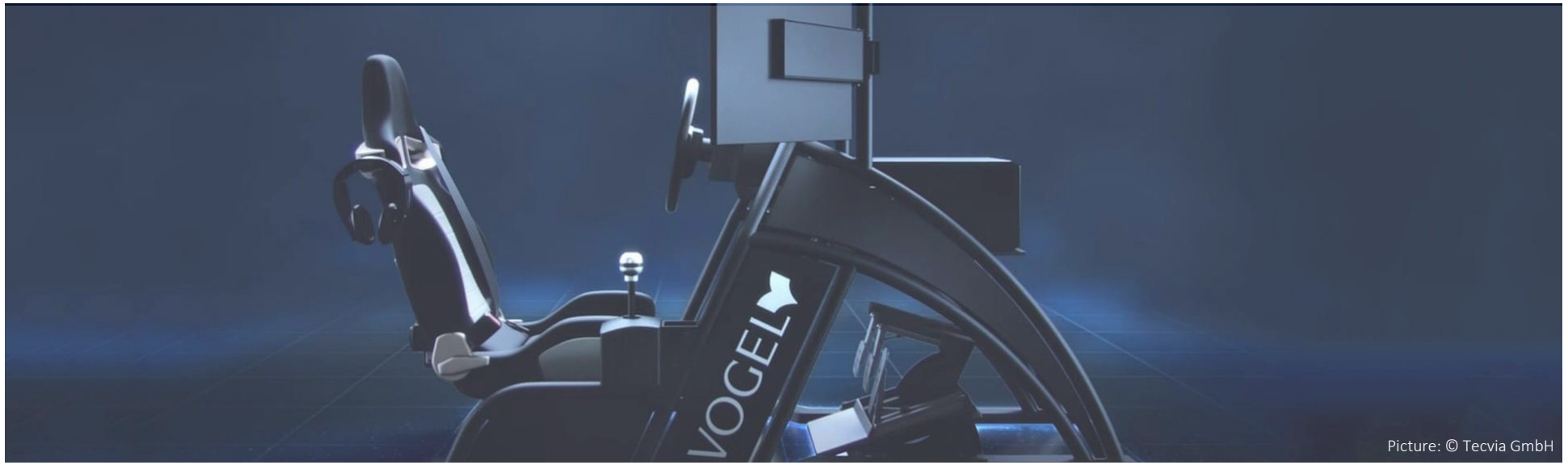

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Use of Driving Simulators to Teach Shifting Skills

Content

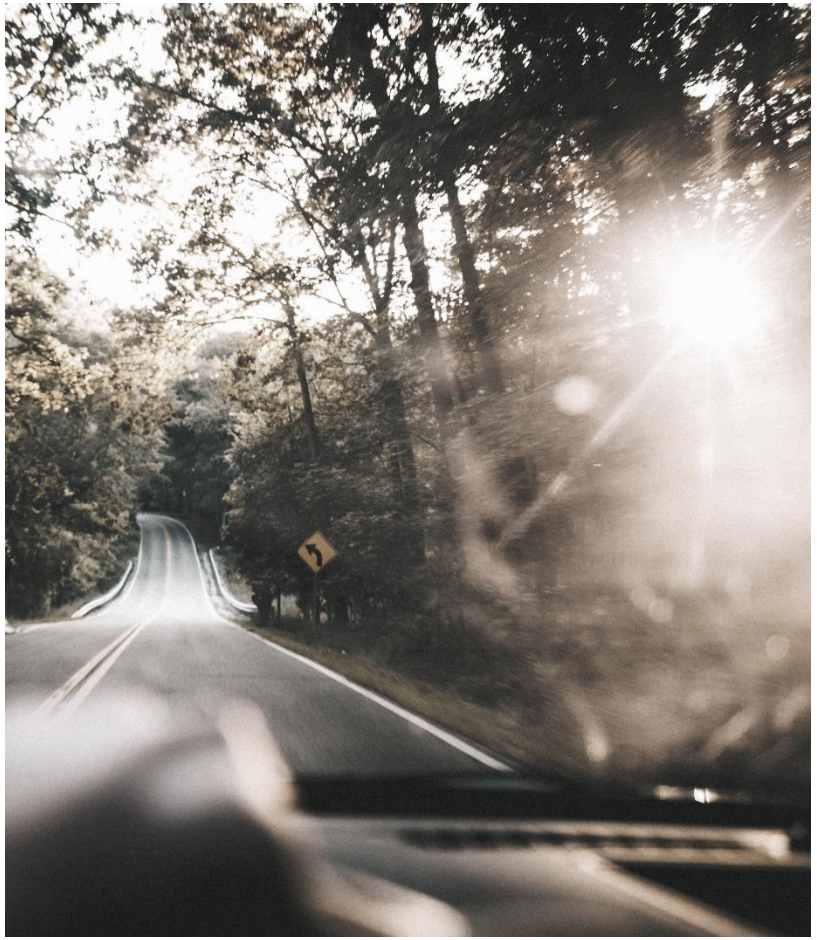
1 Initial situation | 3

2 Driving school survey | 7

3 Experimental study | 16

4 Implications and summary | 32

5 Contact | 35



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Initial Situation

Initial Situation

Identification of relevant drivers of change

Political

Politicians are focused strongly on implementing measures to meet climate protection targets. In this context, the promotion of electromobility is seen as a key lever.

Economical

There has been an increase in consumer prices in the German economy. Rising raw material prices and the CO_2 tax are also affecting fuel prices in particular.

Socio-cultural

Digitization is well advanced in all areas of society. Young generations demand highly flexible access to services over time and regard digitized processes as a hygiene factor.

Technological

In the passenger car sector, the market for electric vehicles, which are automatic vehicles due to their technical design, is growing strongly. Additionally, new (partially) autonomous driving assistance systems are often only available for automatic vehicles.

Ecological

Environmental and sustainability aspects are playing an increasing role in many sections of the population. In addition to public institutions, companies from the private sector are also positioning themselves more strongly as sustainable enterprises.

Juristical

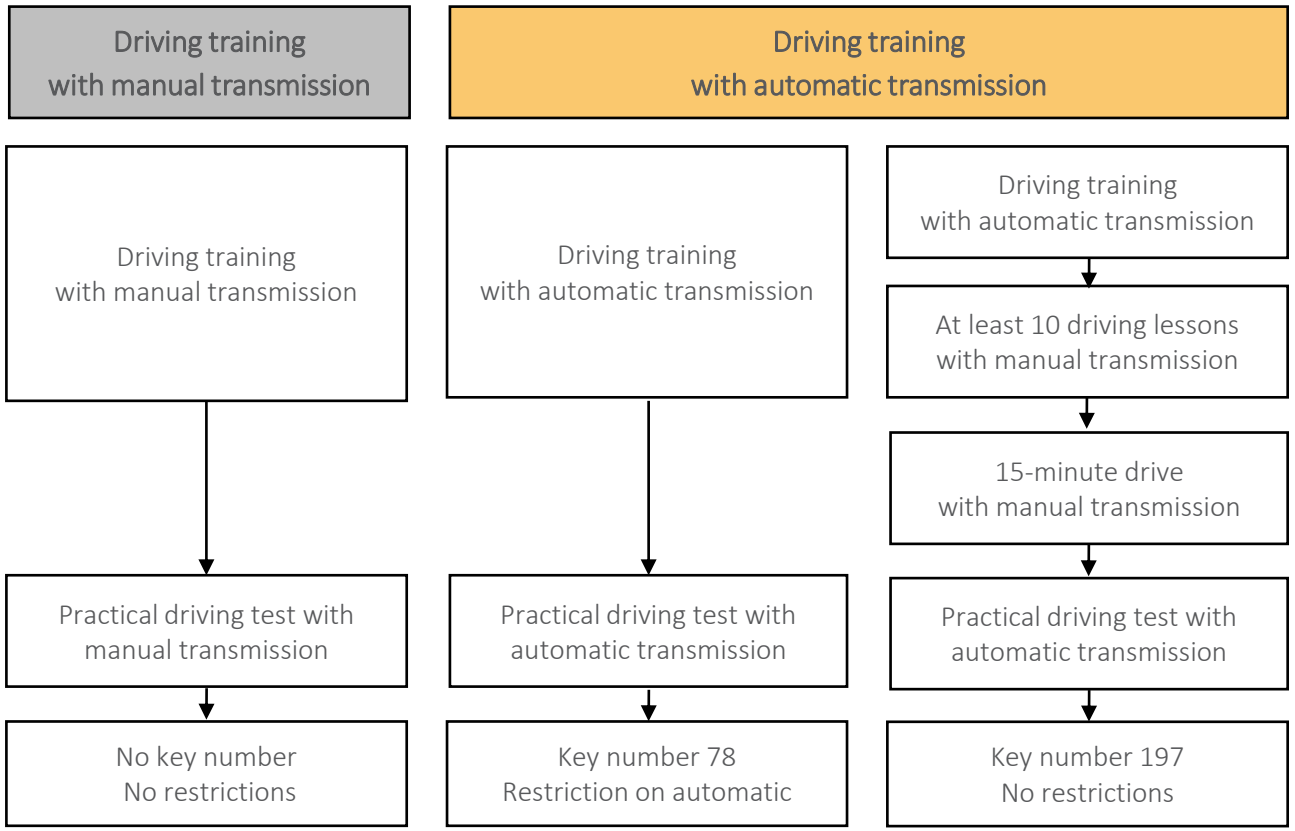
The new automatic transmission regulation makes it possible to take a driving test in a vehicle with an automatic transmission and at the same time obtain a driving license that allows you to drive vehicles with a manual transmission.

- The driving school sector in Germany, with its currently around 10,000 companies, is also confronted with the current drivers of change.
- Politically and legally motivated, environmental aspects and the new automatic regulation in particular lead to direct effects.
- From a technological perspective, new drive concepts and (partially) autonomous driving functions will force driving training companies to invest in the vehicle fleet in a medium term. At the same time, technically advanced driving simulators enable the integration of new training concepts into driver trainings.
- Customers are demanding innovations and digitized processes more than ever before.

Source: Institute for Automotive Research (IfA) 2023

Initial Situation

The automatic regulation from April 1st, 2021



- The "Automatic Transmission Regulation" restricts if the practical driving test was previously **completed on a driving school vehicle with automatic transmission**. In this case, the driving license is limited by the code number 78 and only applies to vehicles with automatic transmissions..
- The "Automatic Transmission Regulation" from April 1sr, 2021 stipulates that learner drivers complete **driving lessons on vehicles with automatic transmission**. However, **at least ten driving lessons** will be completed on a vehicle with a **manual transmission**. After a **15-minute drive**, (urban and extra-urban), the driving instructor assesses whether the learner driver has the competencies to drive a vehicle with manual transmission and certifies this. After that the **practical driving test** is taken on a **vehicle with automatic transmission**. The learner driver is issued with a driving license with the code number 197.

Source: Institute for Automotive Research (IfA) 2021
BR-Drs 579/20 from September 25, 2020

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Research Targets

Driving simulators to train shifting skills

To what extend can shifting competence also be taught in driving simulators?

Scientific evaluation of the teaching of shifting skills in driving trainings with driving simulator support.

Image sources: AutoScout24 GmbH & Institut für Automobilwirtschaft (IfA)

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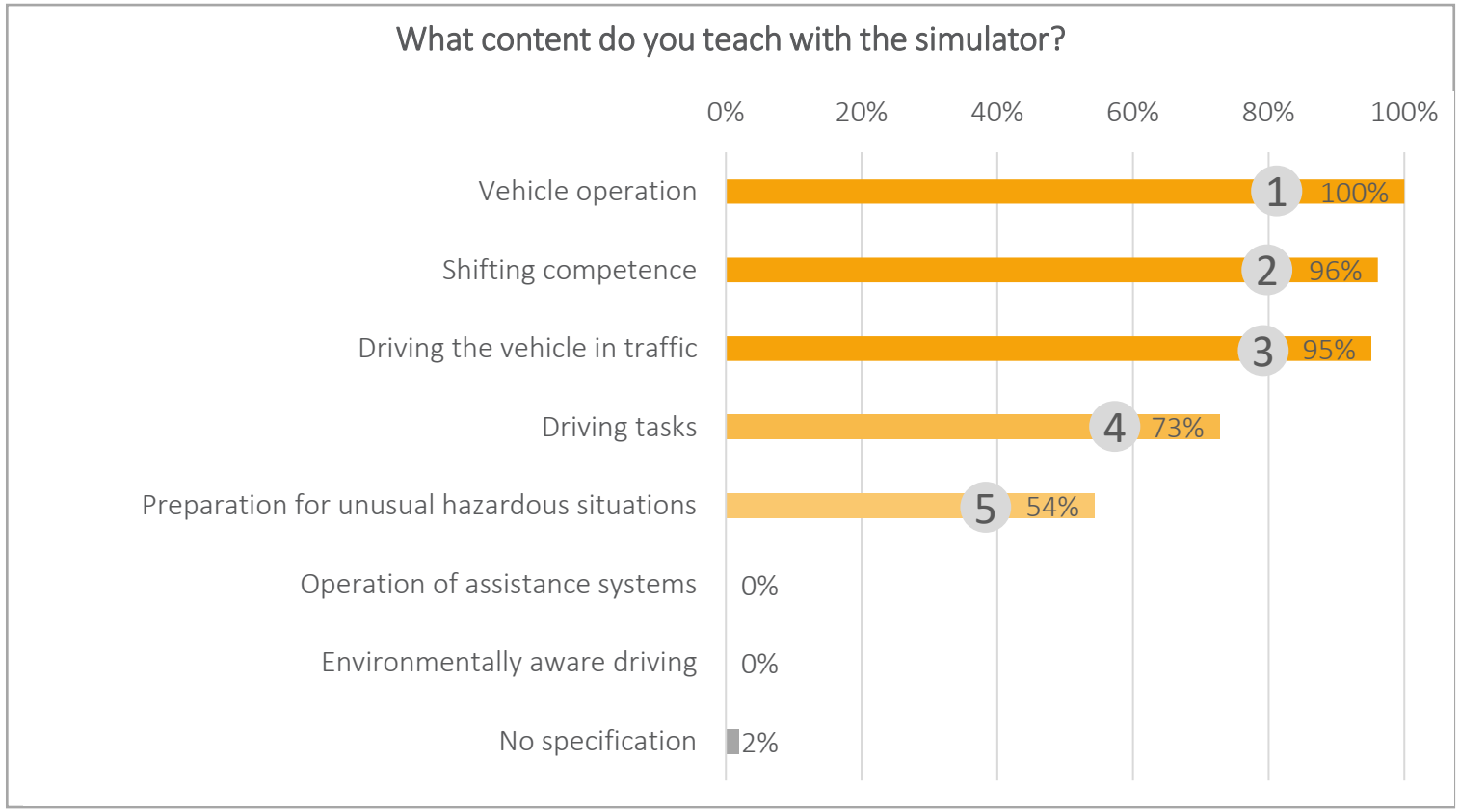
IfA Driving School Survey

IfA Driving School Survey

Teaching of specific training content with driving simulators



- All of the surveyed driving schools use the driving simulator to teach basic vehicle operation - for example, how to use the pedals or the direction indicator.
- 96 percent – that means nearly every driving school – uses the driving simulator to teach shifting skills (e.g. starting, changing gears, shifting up and down).
- The higher-level "driving the vehicle in road traffic" is also a central training content, 95 percent of which is taught by almost every driving school with the driving simulator.

Source: Institute for Automotive Research (IfA) 2021
Survey in the period from March 31 to May 26, 2021 | n = 103

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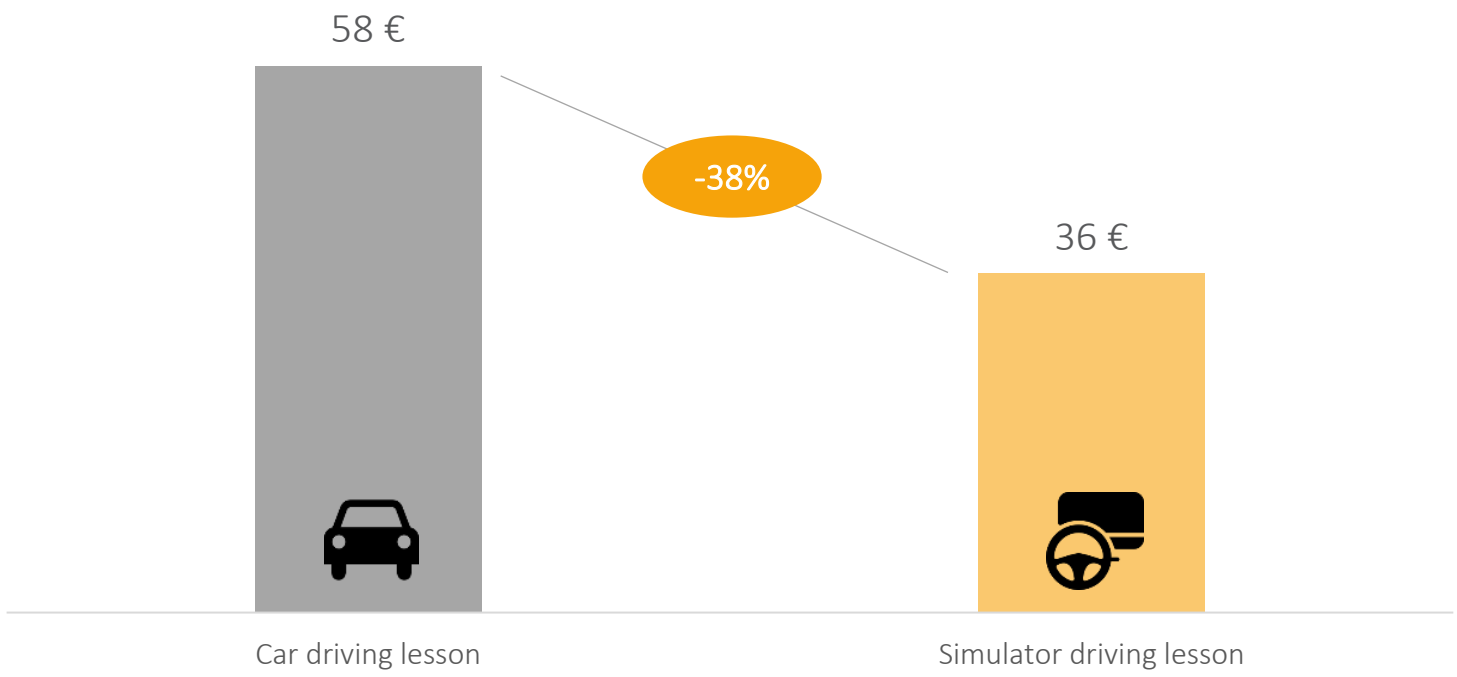
IfA Driving School Survey

Comparison of costs of individual driving lessons (customer perspective)

Comparison of costs for a driving lesson in a car vs. a driving simulator (gross prices)



- The offer prices of driving lessons by using a driving simulator are on average 38% lower than the offer price of "real" driving lessons with a driving school car.
- If driving simulators are consistently integrated into driver training and driving lessons in a car are replaced by simulator driving lessons, learner drivers get benefits from lower overall costs for obtaining a driver's license.
- Additionally, it can be assumed that driving schools benefit from higher contribution margins for driving simulator hours. The reasons for this are the lower personnel and operating costs compared to the use of passenger cars.

Source: Institute for Automotive Research (IfA) 2023 & MOVING 2023

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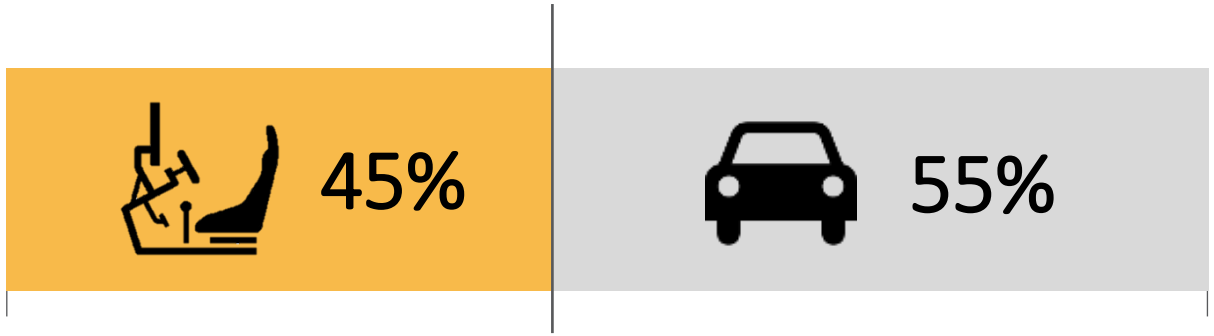
IfA Driving School Survey

Integration of driving simulators into practical driver training

Proportions of real driving hours and simulator hours



- Regarding the division of practical driving lessons into “real” driving lessons and simulator hours, it is first noticeable that the average of the driving schools surveyed clearly prefers combined training with practical training hours in the driving simulator and in the driving school car.
- Less than half of the training hours are completed with simulators - and 55 percent in the driving school car.
- The result also shows that driving schools have now firmly integrated the simulator into their training concept.
- Additionally, the result is a clear positioning of driving schools towards a combined training concept – using a simulator combined with car lessons.

Source: Institute for Automotive Research (IfA) 2021
Survey in the period from March 31 to May 26, 2021 | n = 105

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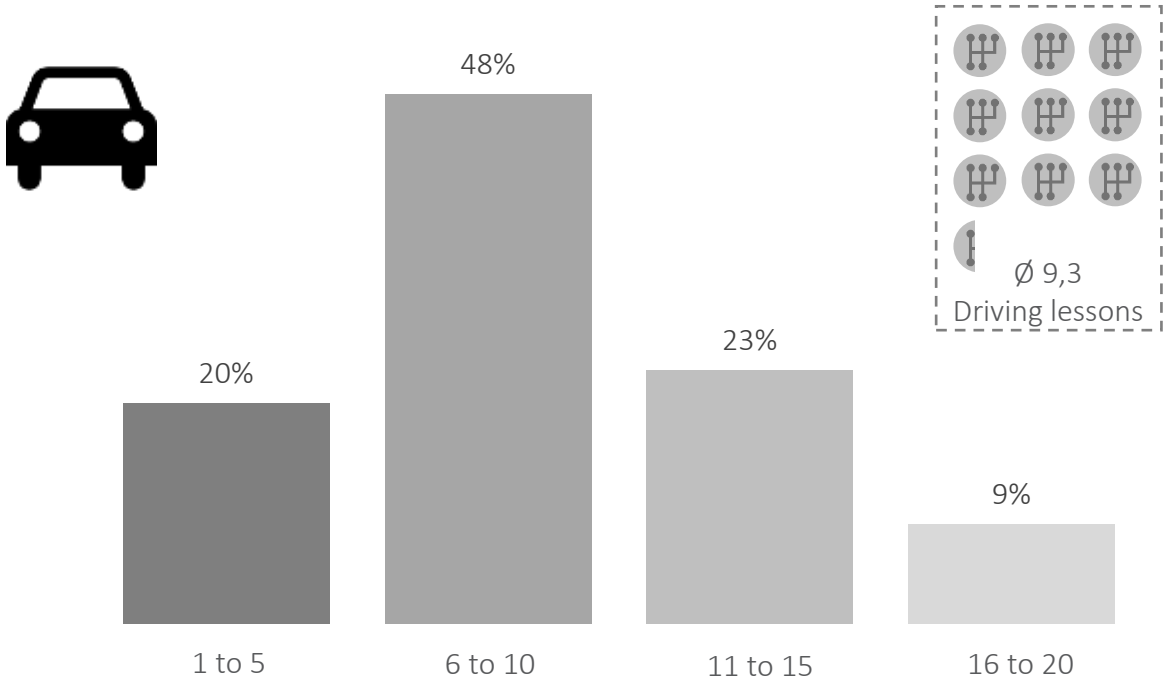
IfA Driving School Survey

Teaching shifting skills in the "real" driving school car

How many hours of hands-on driving in a driving school car does it take for the average learner driver to master "shifting skills"?



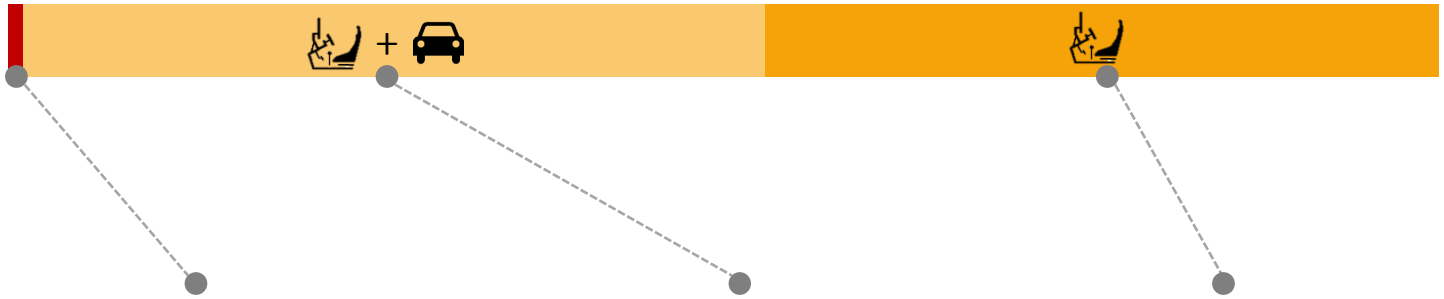
- Shifting competence is defined as the ability of a learner driver to perform operating tasks of a passenger car with a clutch pedal in a safe, responsible, and environmentally conscious manner.
- This definition includes pedal operation, starting up, gear shift control, upshifting, downshifting, proper gear selection, and maneuvering.
- According to the surveyed driving schools, learner drivers need an average of 9.3 driving lessons to achieve the required “shifting competence”, around two-thirds (68 percent) need no more than ten driving lessons before they can be assumed to have the "shifting competence“ to drive a vehicle safely.
- On the other hand, for obtaining driving license class B197 there are usually ten compulsory driving hours with a subsequent test drive on a vehicle with manual transmission necessary.

Source: Institute for Automotive Research (IfA) 2021
Survey in the period from March 31 to May 26, 2021 | n = 94

IfA Driving School Survey

Teaching shifting competence with driving simulators

Can a learner driver also use the driving simulator (instead of using a driving school car) to learn the necessary shifting competence to drive a car with a manual transmission?



No, shifting competence can only be learned in a driving school car.

0%

Partially, the simulator can support in conjunction with the driving school car.

52%

Yes, shifting competence can also be learned in the simulator.

48%

- 52 percent of those surveyed believe that the simulator can make a significant contribution to learn shifting skills.
- 48 percent of the surveyed people think that student drivers can learn shifting skills in the driving simulator.
- This result can be interpreted that driving schools attribute a high level of training quality to the simulators, even when it comes to teaching complex psychomotor skills such as shifting skills.
- The main advantage of the driving simulator is that different actions (e.g. starting, shifting up) can be repeated more frequently in the driving simulator and therefore trained more intensively.

Source: Institute for Automotive Research (IfA) 2021
Survey in the period from March 31 to May 26, 2021 | n = 99

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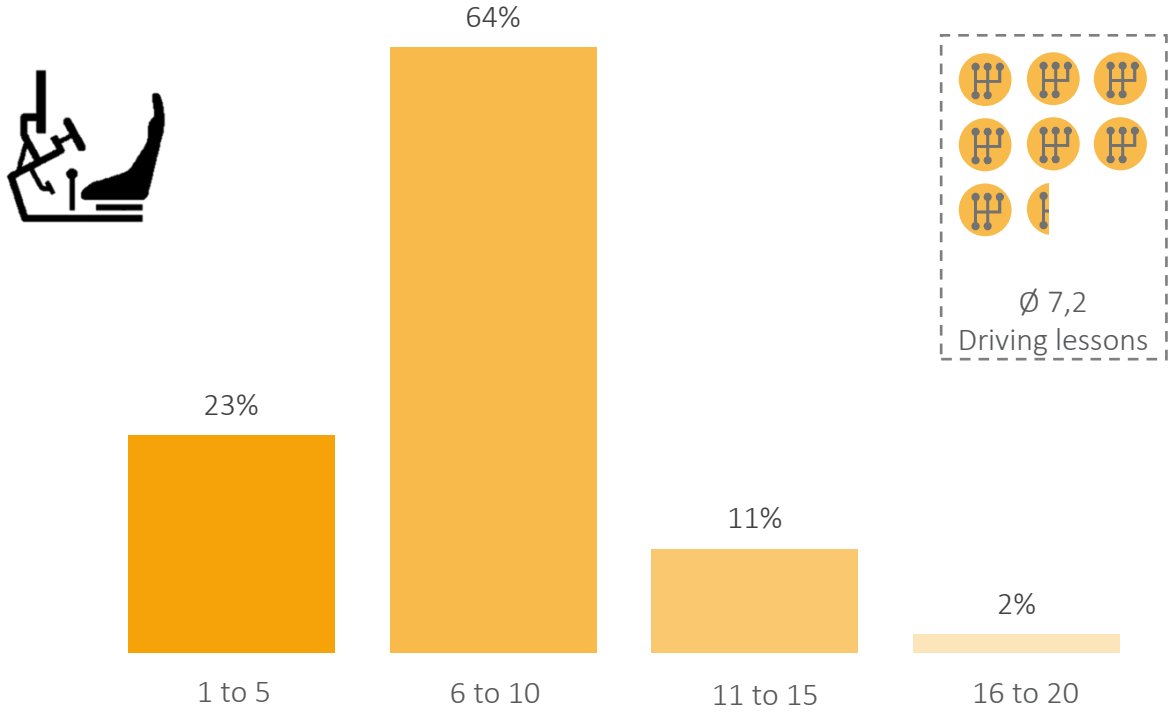
IfA Driving School Survey

Time required to teach shifting competence using a driving simulator

How many simulator hours does an average learner driver need?

(Answer only from driving schools that believe that learning the shifting experience is 100 percent possible in the driving simulator)



- Those driving schools that think it would be practical to teach shifting techniques exclusively using the simulator were also asked how many driving lessons would normally be required in the driving simulator.
- The surveyed driving schools told us an average of 7.2 driving hours.
- Compared to driving lessons in a real driving school car (Ø 9.3 driving hours), the driving simulator can lead to a faster learning success.
- This makes it clear that the respondents expect the driving simulator can increase their learning efficiency: Specific driving situations that are directly related to learning shifting skills (e.g. starting after a stop sign, changing gears when driving through an intersection) can be repeated more often in the simulator than in a real driving school car.

Source: Institute for Automotive Research (IfA) 2021
Survey in the period from March 31 to May 26, 2021 | n = 47

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IfA Driving School Survey

Functions of driving simulators in teaching shifting competence

How would you rate the driving simulator in terms of teaching shifting skills?

Basic requirements*	School grade**
Pedal control	2,02
Shifting up	2,10
Gearshift control	2,22
Startup/grinding point	2,26
Shifting down	2,28
Correct choice of gear	2,38

Action requirements*	School grade**
Fluid shifting operations	2,30
Smooth and fluid steering movements	2,39
Timely and appropriate acceleration	2,43
Acceleration capacity used depending on the situation	2,56
Suitable gear for acceleration	2,62

* Criteria from learning level documentation for key number B197 of the Bundesvereinigung der Fahrlehrerverbände e.V. (Federal Association of Driving Instructor Associations)

** German school grading system: 1=very good to 6=insufficient

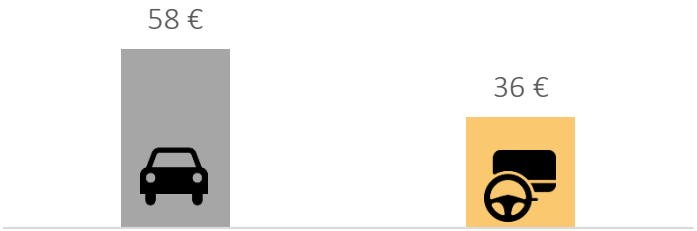
- For the driving training of class B with the key number B197, the shifting competence of the learner driver is assessed by the driving instructor in a 15-minute test drive.
- For the test drive, the Bundesvereinigung der Fahrlehrerverbände e.V. (Federal Association of Driving Instructor Associations) provides driving instructors with a catalog of tasks with basic requirements and specific action requirements regarding to vehicle operation and environmentally friendly driving.
- The driving schools participating in the survey evaluated the driving simulator in terms of teaching shifting competence based on the eleven different requirements with school grades.
- It can be noted that the simulator tends to be valued more highly when conveying basic requirements than when it comes to specific action requirements.

Source: Institute for Automotive Research (IfA) 2021
Survey in the period from March 31 to May 26, 2021 | n = 105 | n = 75

IfA Driving School Survey

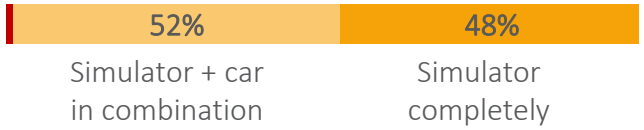
Key findings

Costs for a driving lesson



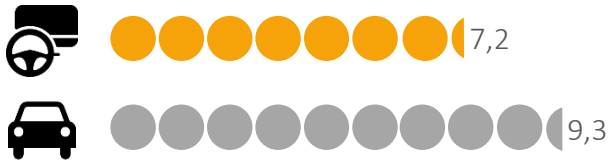
Driving simulators and switching competence

Ways to learn switching competences ...



Of the driver training companies surveyed, just under half believe that switching skills can be taught entirely through the driving simulator.

Speed of learning success



The driver training companies surveyed see faster learning success in teaching shifting skills through driving simulators.

Driving simulator functions

Evaluation of the simulator functions with regard to teaching switching competence

Top 3:	Worst 3:
+ Pedal control	– Startup/grinding point
+ Shifting up	– Shifting down
+ Gearshift control	– Correct choice of gear

- In summary, the result of the driving school survey can be seen as a clear positioning of the “Pro Simulator” driving schools in the teaching of shifting skills.
- By using driving simulators, driving schools can respond to the relevant drivers of change and make driver training ecologically sustainable and technically innovative.
- The use of simulators also enables driving schools to meet new customer requirements and stabilizes the “driving school” business model from a business perspective.
- When it comes to teaching shifting skills, driving schools see great potential in innovative and suitable simulators to impart the necessary training content, which results primarily from the high learning efficiency.
- The driving school survey also provides important impulses for the continuous development of driving simulators.
- In many driving schools, driving simulators are already firmly integrated into there training concepts. In order to fully exploit the potential of such technical innovations, legal initiatives are required that legally allows the use of simulators.

Source: Institute for Automotive Research (IfA) 2021

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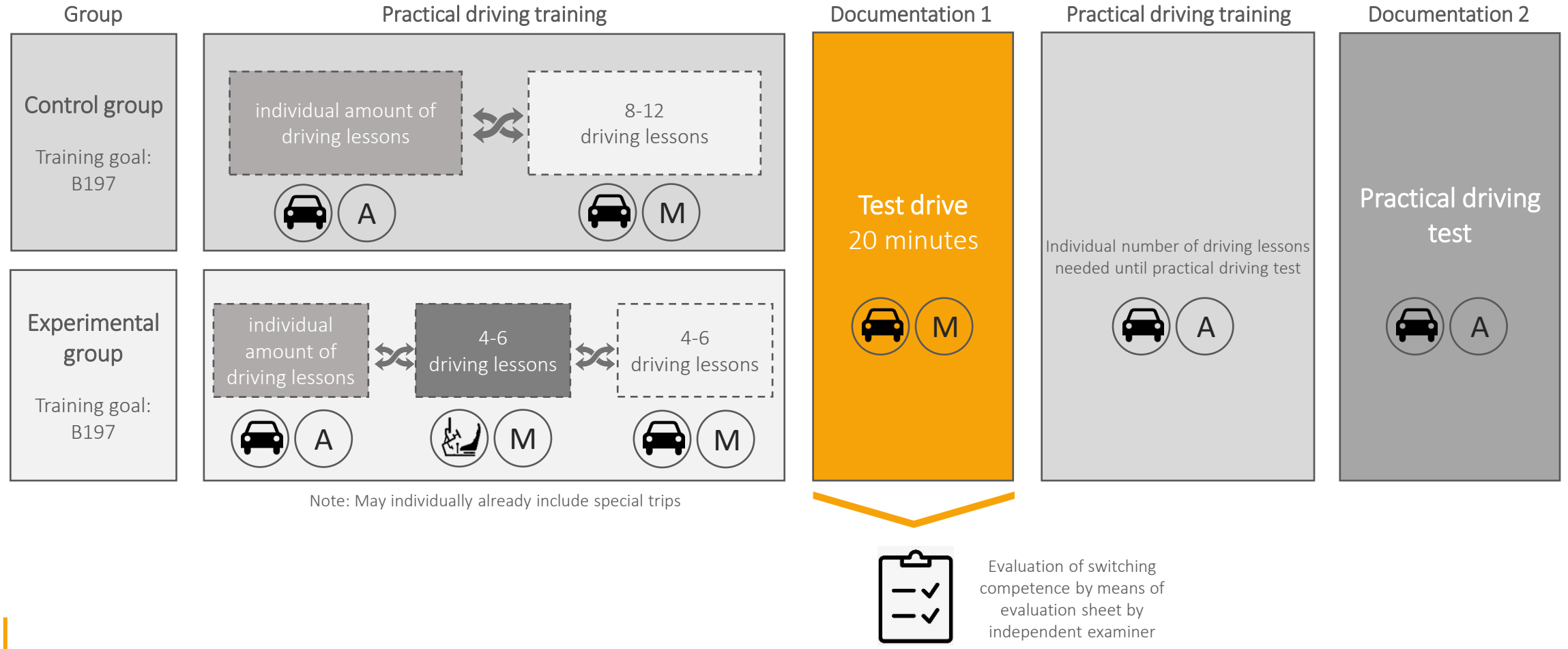
Experimental Study: Study Design

Experimental Study

Study design



Source: Institute for Automotive Research (IfA) 2023

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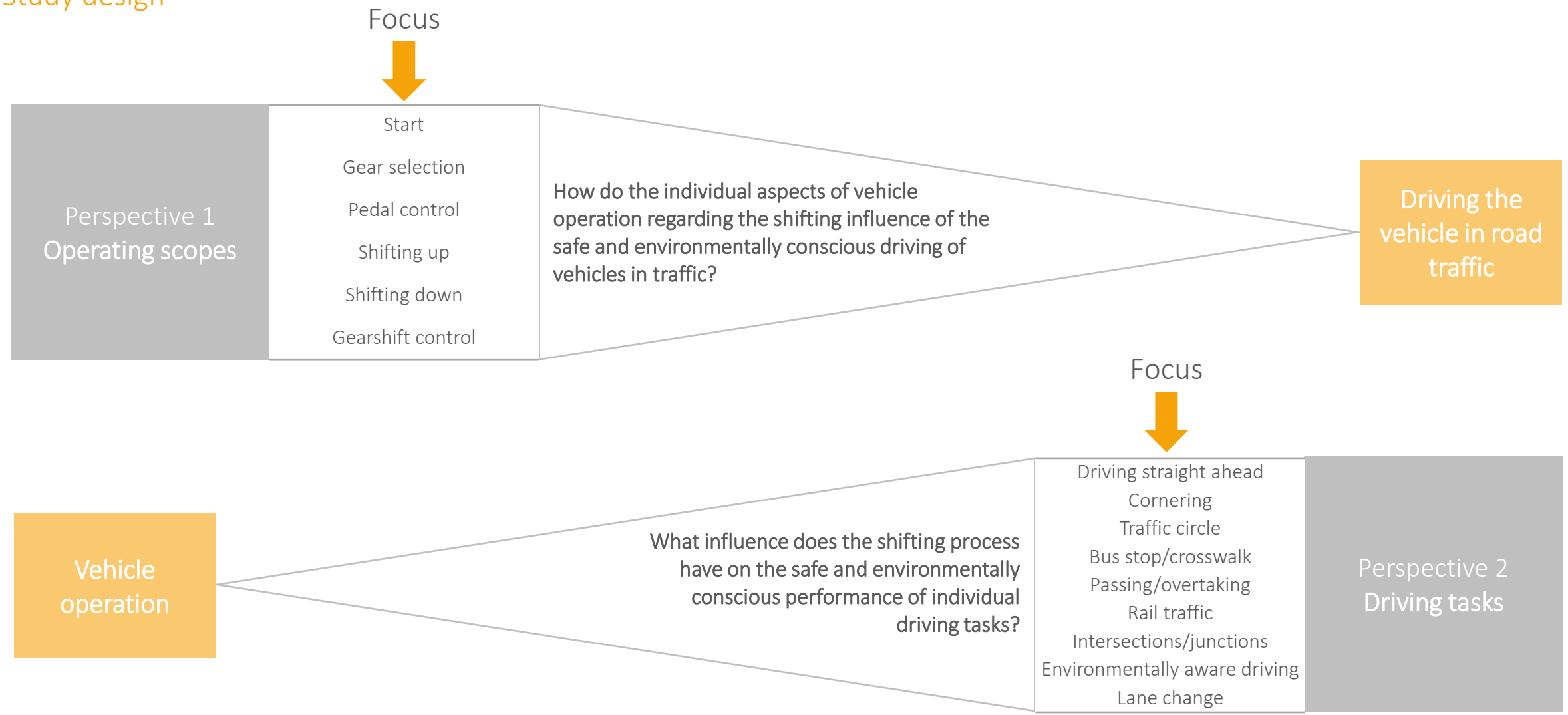
Experimental Study

Study design



Source: Institute for Automotive Research (IfA) 2023

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Experimental Study

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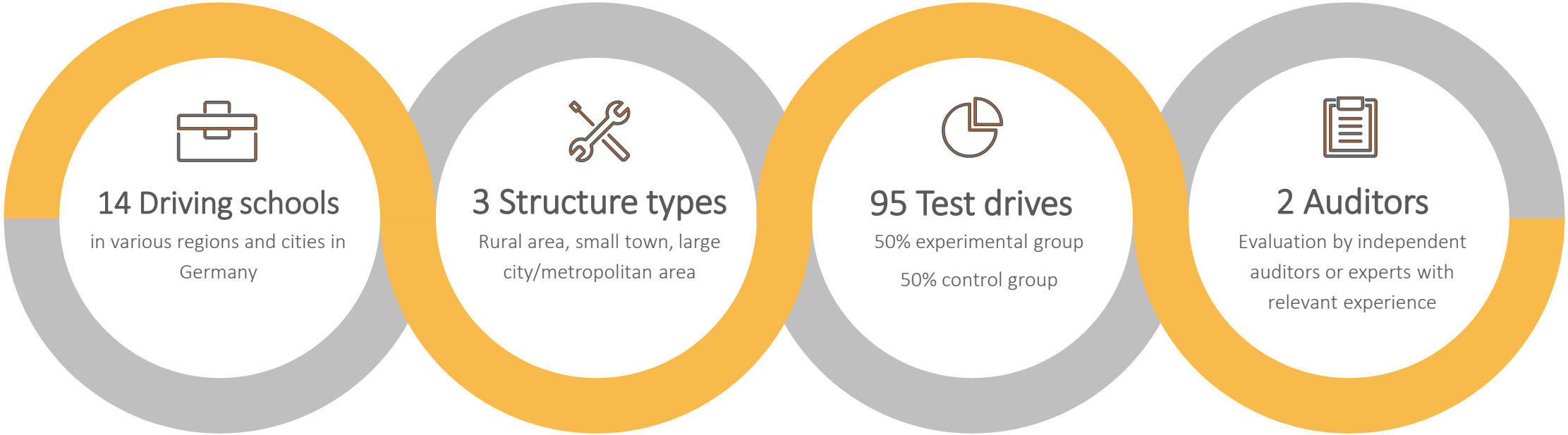
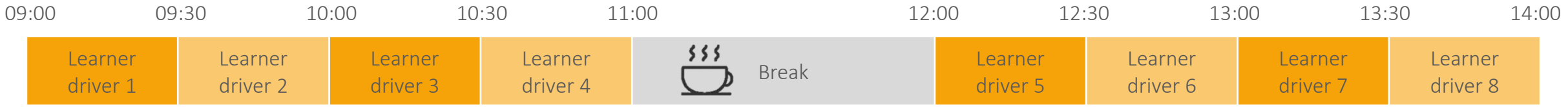
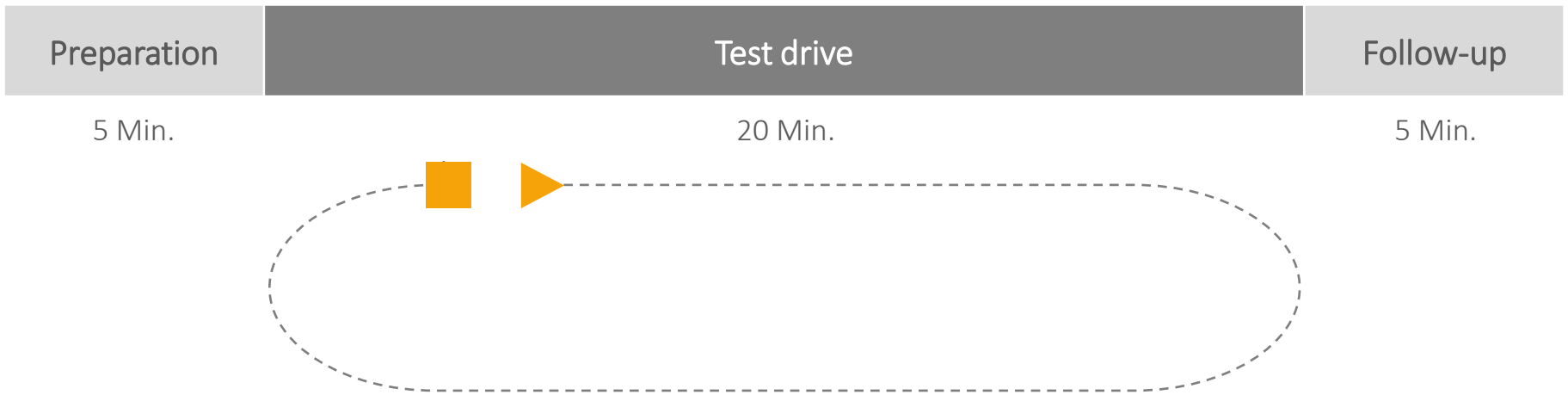


Source: Institute for Automotive Research (IfA) 2023

Experimental Study

Study design





Source: Institute for Automotive Research (IfA) 2023

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Experimental Study

Impressions

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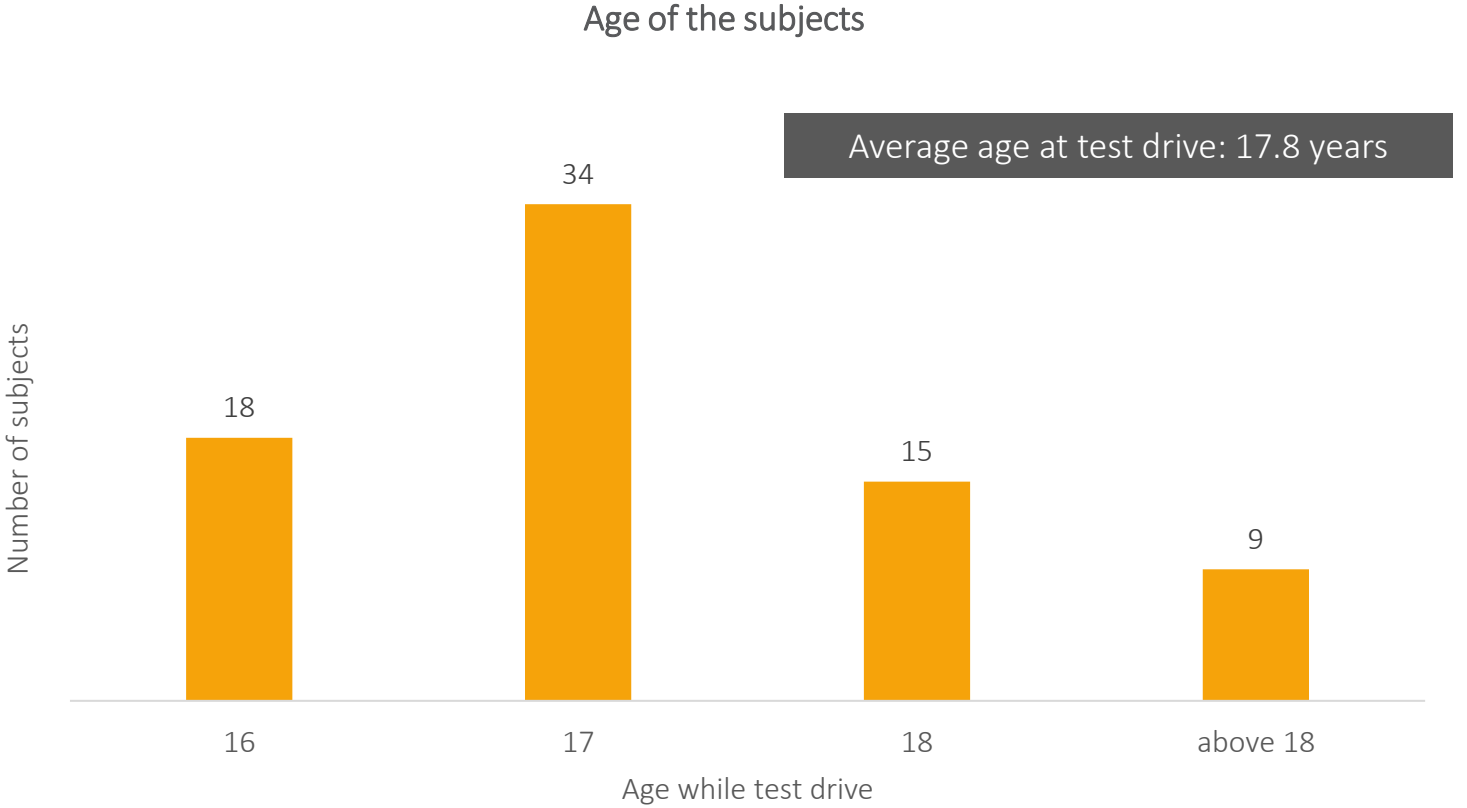
Experimental Study: Results

Experimental Study: Results

The sample: Age of the learner drivers

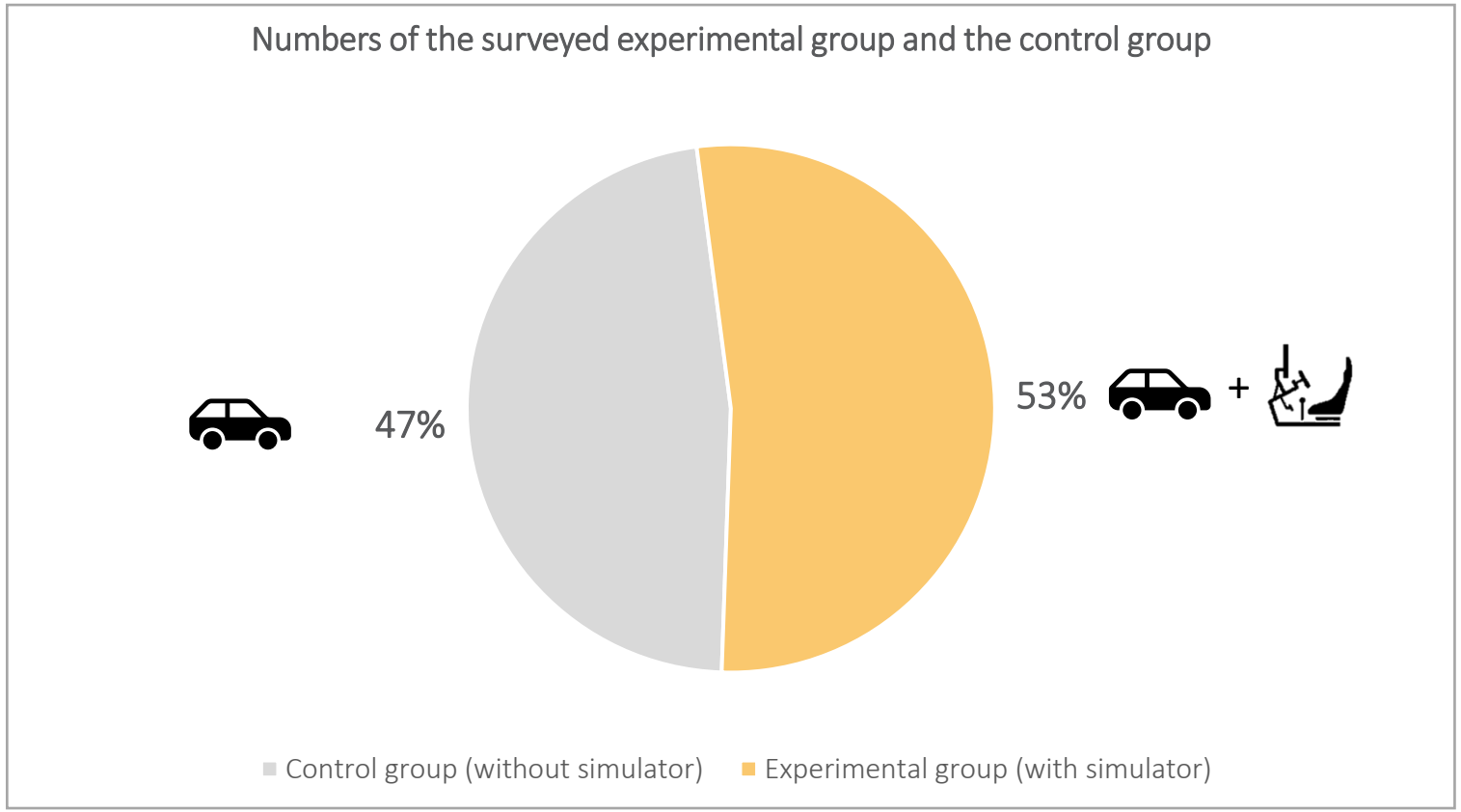


- A central goal of conducting the experimental study is to include only test learner drivers in an age range that typical of driver's license acquisition.
- The driver's license candidates who participated as subjects in the study were – on average – 17.8 years old.
- About 24% of the subjects participated in the study at the age of 16, and about 45% of the subjects were 17 years old at the time of the test drive.
- Just below 20% of the subjects were 18 years old at the time of the test drive, and only about 12% of the test subjects were older than 18.

Source: Institute for Automotive Research (IfA) 2023
Survey in the period from February 11 to July 18, 2023 | n = 76

Experimental Study: Results

The sample: Number of subjects and average number of driving hours

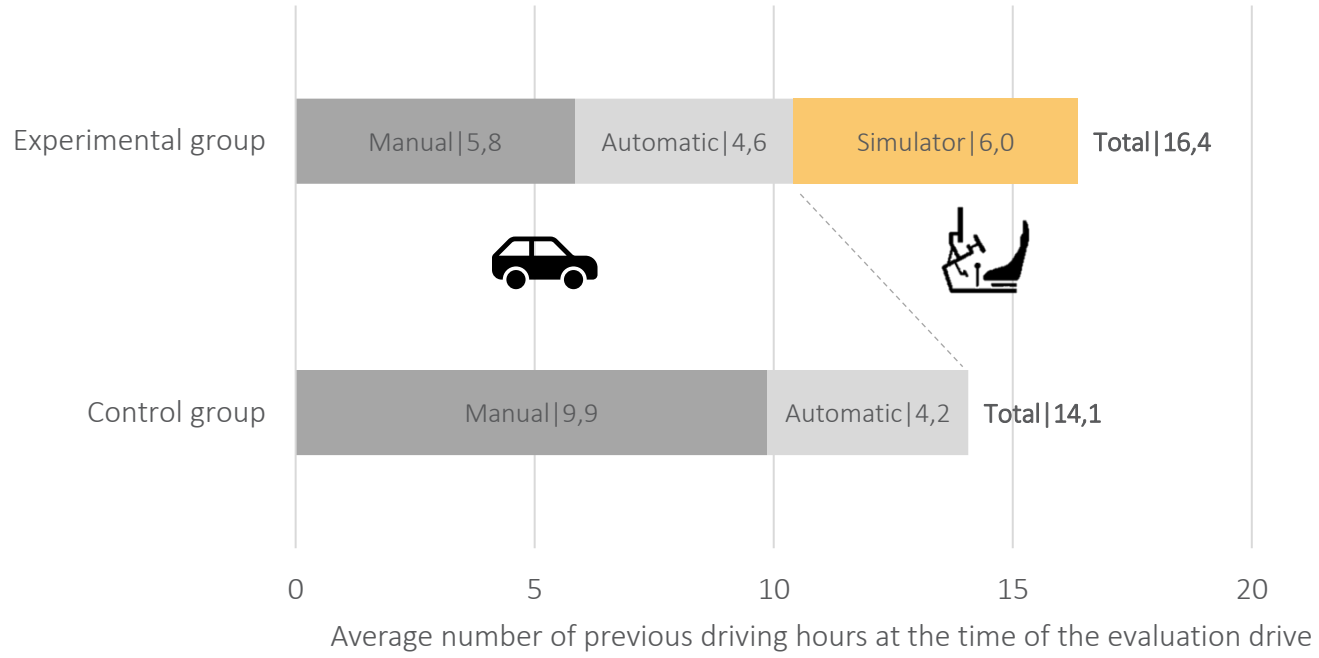


- The base for the evaluation is the raw data on the determined shifting competence levels of a total of 95 subjects.
- An experimental group with 48 subjects (driving training up to the test drive with simulator) and a control group with 47 subjects (driving training up to the test drive without simulator) were formed.
- The dataset was cleaned regarding to the characteristics "age of the test person at the time of the test drive" and "previous possession of a driver's license"; datasets with extreme characteristic values were also excluded. The result of the data cleansing is a dataset that represents a total of 76 datasets.
- While 36 subjects and thus about 47% belonged to the control group, the experimental group with 40 subjects comprises about 53%.

Source: Institute for Automotive Research (IfA) 2023
Survey in the period from February 11 to July 18, 2023 | n = 76

Experimental Study: Results

The sample: Number of subjects and average number of driving hours



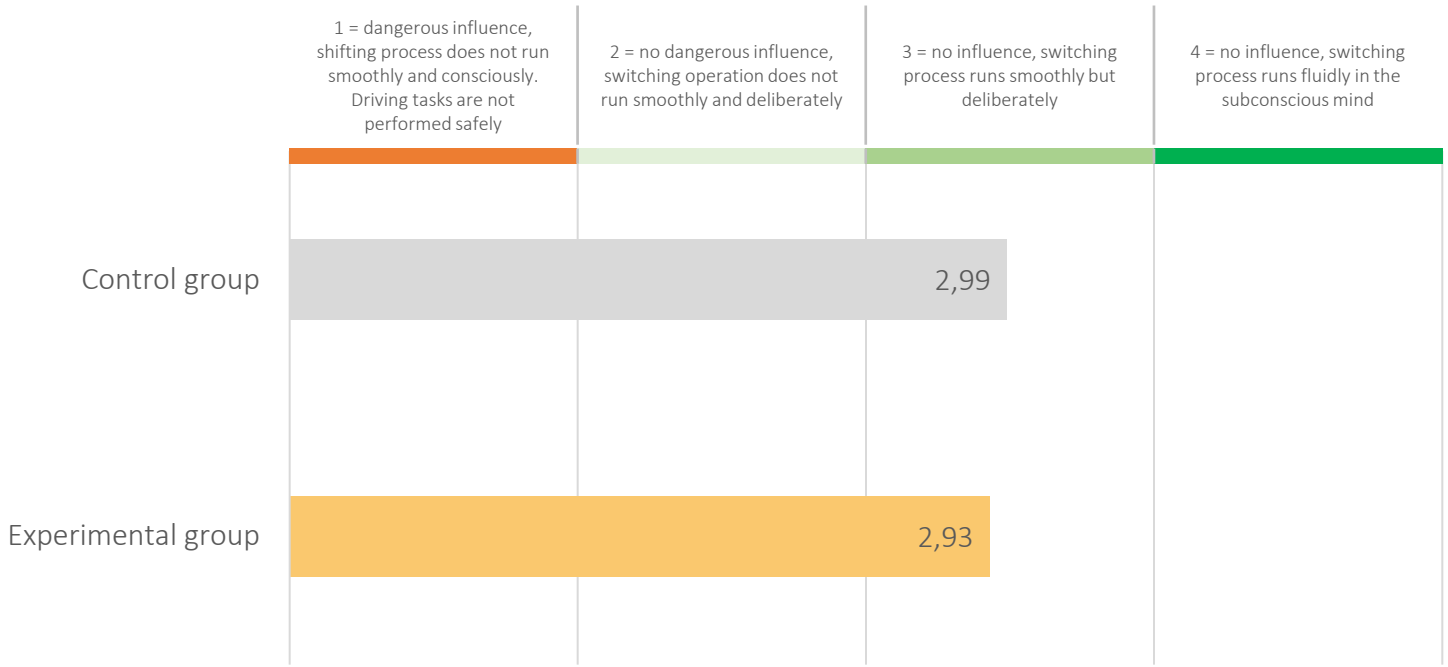
- On average, subjects from the experimental group completed 5.8 hours of driving in a passenger car with a manual transmission, 4.6 hours of driving with an automatic transmission, and 6 hours of driving on the simulator before the test drive.
- At the time of the test drive, the subjects in the control group had completed an average of 9.9 driving hours in a passenger car with a manual transmission and 4.2 driving hours in an automatic passenger car.
- In total, the subjects from the experimental group had 16.4 driving hours (45 min each) at the time of the test drive, while the subjects from the control group had 14.1 driving hours.

Source: Institute for Automotive Research (IfA) 2023
Survey in the period from February 11 to July 18, 2023 | n = 76

Experimental Study: Results

Focus: Scope of vehicle operation

To what extent do the scopes of vehicle operation in the context of shifting* influence the safe and environmentally conscious driving of the vehicle in road traffic?



*Circumstances of vehicle operation analyzed during the field test include:
Pedal operation, startup/grinding point, gearshift control, shift up, shift down, gear selection.

- The Scope **of vehicle operation** analyzed during the field test include:
  - Pedal control
  - Startup/grinding point
  - Gearshift control
  - Shifting up
  - Shifting down
  - Gear selection
- The subjects of the control group as well as of the experimental group reach the same shifting competence level
- The identified limitations for reaching the fourth and highest level in the practical test can be found in the fact that the processing of the operating tasks is not yet completely automated in the subconscious.

Source: Institute for Automotive Research (IfA) 2023
Survey in the period from February 11 to July 18, 2023 | n = 76

Experimental Study: Results

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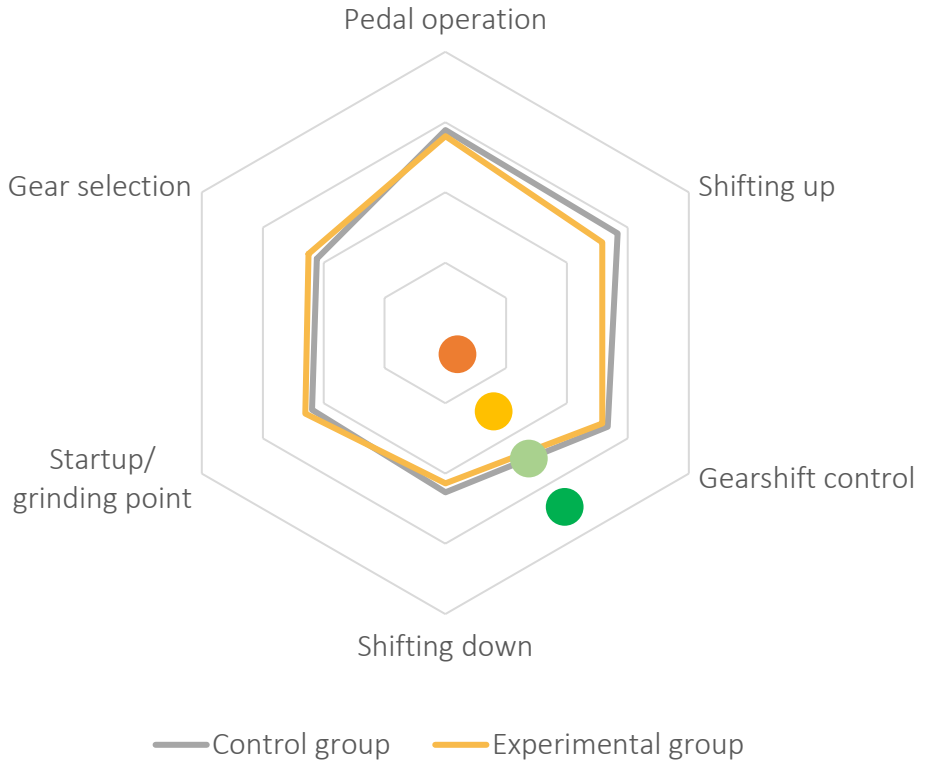
To what extent do the scopes of vehicle operation in the context of shifting influence the safe and environmentally conscious driving of the vehicle in road traffic?



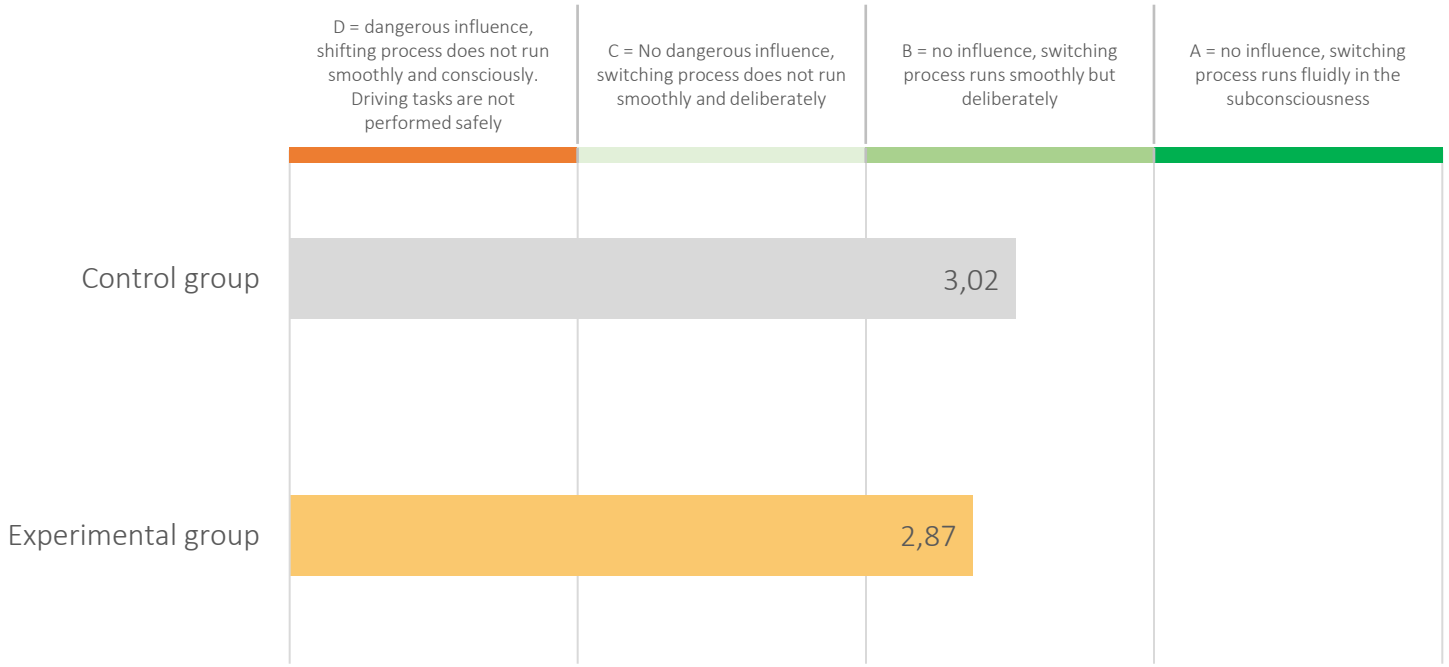
- The results of both study groups are at almost identical levels, both in terms of the overall average and within the six individual operating scopes.
- Both groups achieve the highest level of competence for "pedal operation" and the second-highest level for "shifting up".
- The "gear selection", "starting/grinding point" and "downshifting" scopes of operation show a poorer performance of the test subjects of both groups.
- It is striking that test subjects in the control group have the greatest advantage in competence over the experimental group regarding areas of upshifting and downshifting.
- In contrast, the test subjects in the experimental group achieved a higher level of shifting competence regarding the operating tasks "start/grip point" and "gear selection".

Source: Institute for Automotive Research (IfA) 2023
Survey in the period from February 11 to July 18, 2023 | n = 76

Experimental Study: Results

Focus: Completing the driving tasks

To what extent does vehicle operation in the context of shifting influence the safe and environmentally conscious completion of individual driving tasks*?



*Driving tasks analyzed as part of the field trial include:
Entering and exiting lanes/changing lanes, Cornering, passing/overtaking, intersections/junctions/entrances, traffic circles, rail traffic, bus stop/pedestrian crossing, straight ahead driving, environmentally aware driving.

- The anayized driving tasks include:
  - Entry and exit lanes/change of lanes
  - Cornering
  - Passing/overtaking
  - Intersections/junctions/entrances
  - Traffic circle
  - Rail traffic
  - Bus stop/crosswalk
  - Driving straight ahead
  - Environmentally aware driving
- The test persons in the control and experimental groups achieve again the identical shifting competence level. On average, safe and environmentally conscious completion is not influenced by vehicle operation in the context of shifting across all nine different driving tasks.
- The deficit in reaching the highest level can be found in the motor-cognitive movement sequences of the test persons, which are conscious and not completely automated. However, based on the average numbers, it can be deduced that the test persons in the control group performed slightly better.

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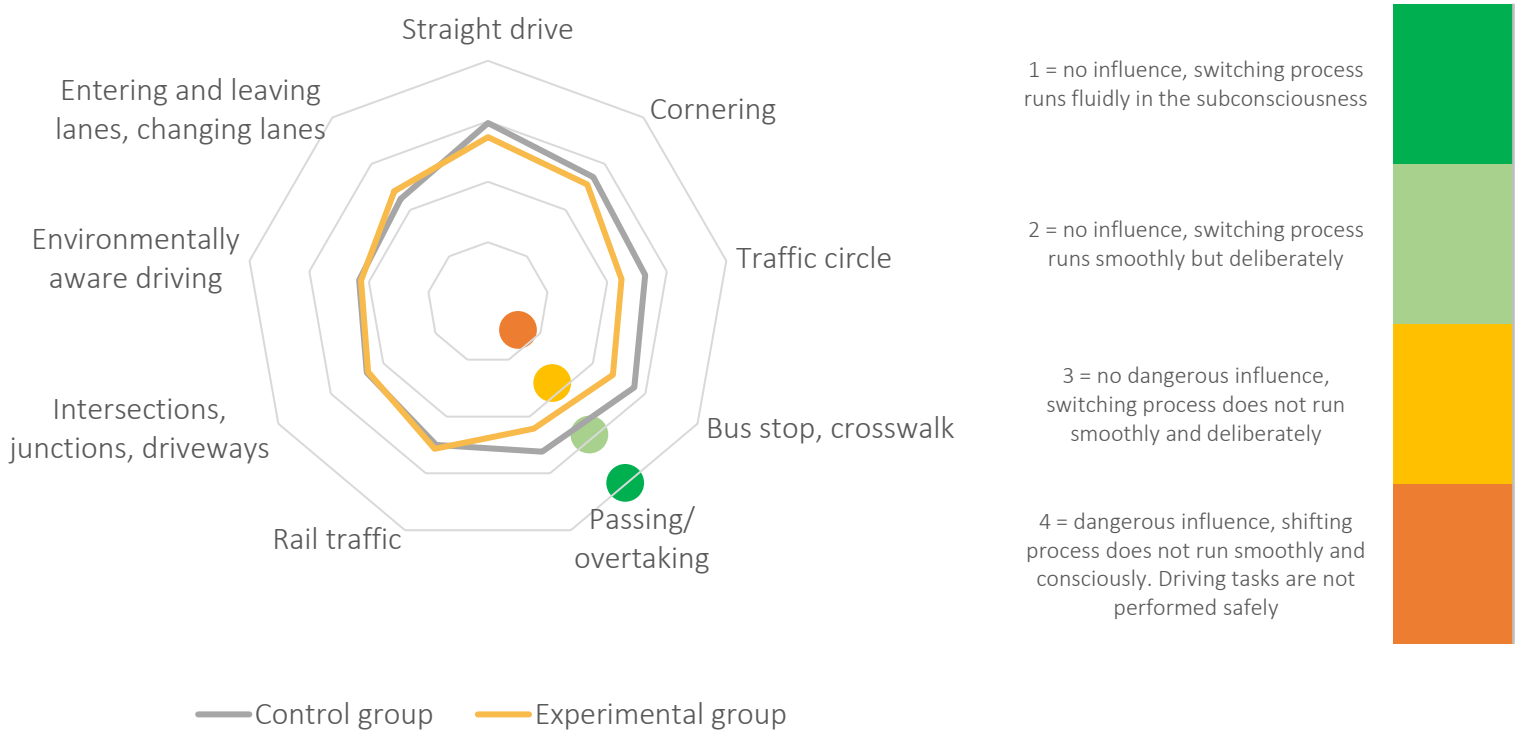
Experimental Study: Results

Focus: Completing the driving tasks

To what extent does vehicle operation in the context of shifting influence the safe and environmentally conscious completion of the respective driving task*?

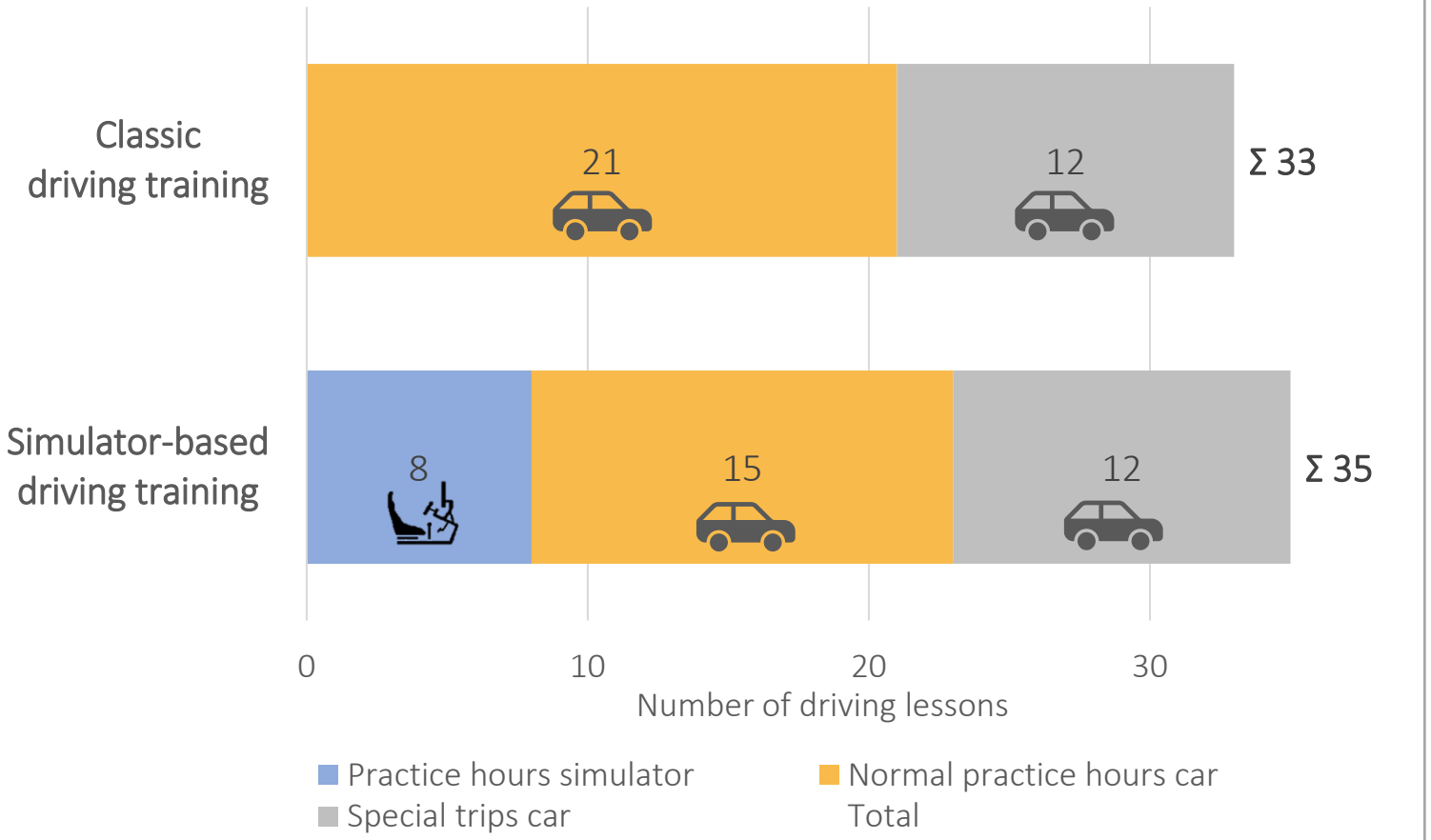


- There can be identified driving tasks in which the shifting competence levels achieved by the control and experimental groups are basically identical. On the other hand, individual driving tasks can be identified in which the determined shifting competence levels differ significantly.
- It is striking that the test persons in the control group performed better, particularly in driving tasks in which traffic dynamics tend to be higher and a larger number of other road users are involved.
- Obviously, such traffic situations in traffic roundabouts (traffic circles) or when overtaking cannot yet be simulated and trained sufficiently realistically in the driving simulator.

Source: Institute for Automotive Research (IfA) 2023
Survey in the period from February 2 to July 18, 2023 | n = 76

Experimental Study: Results

Integration of simulator lessons into practical driving training

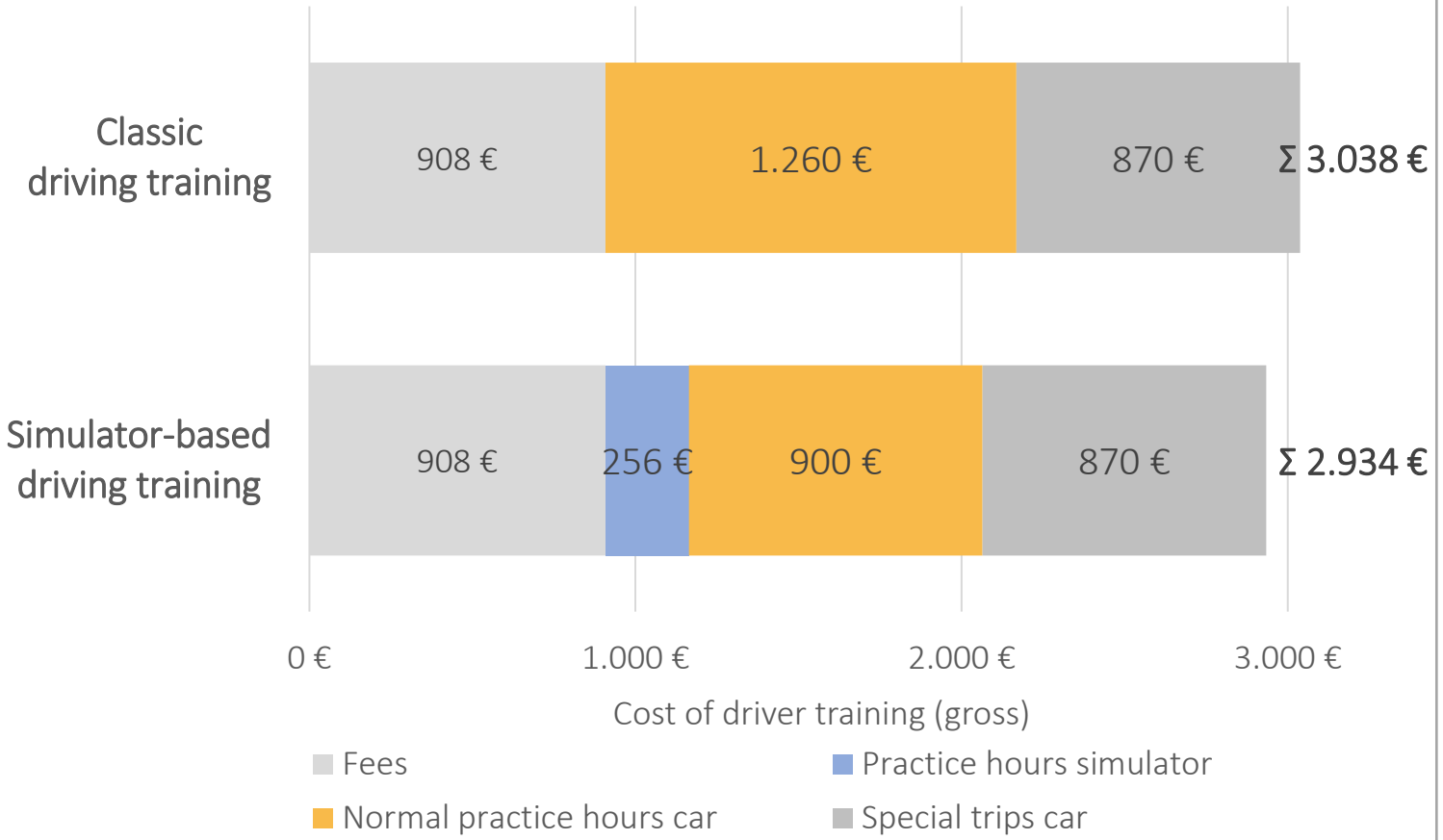


- Based on the analyses, it is recommended to conduct part sof the practical driving training in the driving simulator.
- Not least because simulators have been shown to be beneficial in teaching basic vehicle operation, they should be used primarily in the first half of driver training.
- In total, between seven and ten driving hours in the simulator are recommended. The intensity of the simulator integration always depends on the learning progress of the individual learner driver. “Learning-disabled” driving students benefit more from driving simulator lessons than the average, a higher number of driving simulator hours is also recommended for these driving students.
- Based on an average number of 33 driving hours before obtaining a driving license, between a quarter and a third of the total practical driving training can be replaced by simulator hours.

Source: Institute for Automotive Research (IfA) 2023 & MOVING 2023

Experimental Study: Results

Example: Impact on driving license costs from the learner driver's perspective.



- The implementation of driving simulators also has economic advantages for the learner drivers.
- Nevertheless, simulator-based driving training requires an average of two more driving hours than traditional driving training. However, these two hours are advantageous for the learner driver in terms of skills.
- The reasons for that are the different offer prices for driving lessons in the driving simulator.
- Based on an average driving school training, the cost advantage for the learner driver is around 100.00 euros.

Implications and Summary

Summary of Results

Overview

Position of the driving instructors	Teaching shifting competences with driving simulators	Qualitative aspects	Economic aspects
▪ The position of driving instructors regarding the use of driving simulators to teach shifting skills is generally positive and open-minded. ▪ The surveyed driving instructors rated the learning efficiency of driving training in the simulator as higher than that of conventional driving training exclusively in the car. ▪ Further arguments for using driving simulators include economic advantages and image reasons.	▪ The learner drivers trained combined with the simulator reach the identical shifting competence level as those learner drivers who were trained exclusively in the passenger car. ▪ At about the midpoint of the practical driving training, the learner drivers have the ability to carry out the circumferences of shifting gears in such a way that the safe and environmentally conscious driving of the vehicle in traffic is not affected.	▪ In summary, it can be deduced from the results of the study that driving simulators combined with practice hours in a passenger car are primarily suitable for teaching the basic perimeters of vehicle operation. ▪ Additionally, by using driving simulators, driving schools can respond to the relevant drivers of change by making driver training ecologically sustainable and technically innovative.	▪ The use of driving simulators also has economic advantages for learner drivers. ▪ Nevertheless, simulator-based driving training requires an average of two more driving hours than traditional driving training. However, these two hours are advantageous for the learner driver in terms of skills. ▪ The reasons for that are the different offer prices for driving lessons in the driving simulator and in the real car. ▪ Based on an average driving school training, the cost advantage for the learner driver is around 100.00 euros.

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Use of Driving Simulators for Teaching Shifting Competence in Driver Training

Key Results of IfA Driving School Survey | February 22, 2024

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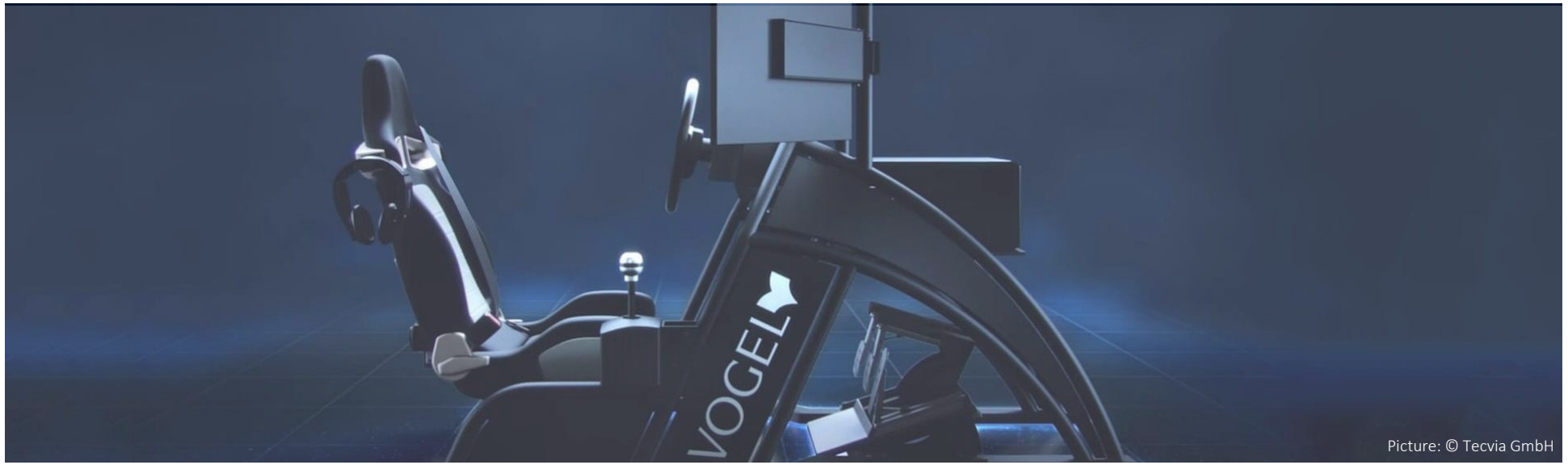

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