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Beside and Behind the Wheel: Factors that Influence Driving Stress and Driving Behavior

Víctor Corcoba Magaña [1,*], Xabiel García Pañeda [1], Roberto Garcia [1], Sara Paiva [2] and Laura Pozueco [1]

[1] Department of Computer Science, University of Oviedo, 33003 Oviedo, Spain; xabiel@uniovi.es (X.G.P.); garciaroberto@uniovi.es (R.G.); pozuecolaura@uniovi.es (L.P.)

[2] Escola Superior de Tecnologia e Gestão, Instituto Politécnico de Viana do Castelo, 4900-347 Viana do Castelo, Portugal; sara.paiva@estg.ipvc.pt

* Correspondence: corcobavictor@uniovi.es; Tel.: +34-985-182-277

Abstract: A large percentage of traffic accidents are due to human errors. Driving behavior and driving stress influence the probability of making these mistakes. Both are influenced by multiple factors, among which might be elements such as age, gender, sleeping hours, or working hours. The objective of this paper is to study, in a real scenario and without forcing the driver's state, the relationship between driving behavior, driving stress, and these elements. Furthermore, we aim to provide guidelines to improve driving assistants. In this study, we used 1050 driving samples obtained from 35 volunteers. The driving samples correspond to regular commutes from home to the workplace. ANOVA and ANCOVA tests were carried out to check if there are significant differences in the four factors analyzed. Although the results show that driving behavior and driving stress are affected by gender, age, and sleeping hours, the most critical variable is working hours. Drivers with long working days suffer significantly more driving stress compared to other drivers, with the corresponding effect on their driving style. These drivers were the worst at maintaining the safety distance.

Keywords: driving behavior; driving stress; safe driving; sleeping; working hours

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1. Introduction

Traffic accidents are one of the most important causes of premature death [1,2], and driving behavior undoubtedly has an influential role on traffic [3,4]. According to several works, an aggressive driving style, characterized by intense and abrupt use of the vehicle's pedals, increases the probability of suffering traffic accidents and their severity [5]. Drivers who exhibit this driving style have less time to react to unforeseen events, and their actions are less predictable. The consequence is increased stress for all concerned. Stress during driving depends on a multitude of factors [6–8], such as driving workload, quality of sleep, personality, and lifestyle. In this work, we focus on four factors that can influence both driving behavior and driving stress: age, gender, sleeping hours, and working hours.

In several studies, age is highlighted as an important factor in traffic accidents. On the one hand, younger drivers behave more antisocially and perceive hazards less quickly due to their inexperience [9] or their lack of ability to regulate their emotions [10]. On the other hand, older drivers are more likely to engage in unsafe behaviors in controlling speed, steering, and changing lanes. In [11], the authors conducted a study involving 140 people to assess the influence of age and experience on road safety. To do this, the drivers completed a driver behavior questionnaire (DBQ) designed to statistically analyze driver behavior responses to perceived road safety issues. The problem with this study is that it compared very similar age ranges: 18–21 years and 21–25 years. It also categorized the participants into two groups: one composed of drivers with less than 1 year of experience and the other made up of drivers with 1 or more years of experience. The study did not analyze the cases of middle-aged drivers or older drivers.

In [12], the researchers carried out an analysis of the effects of age and gender on driving style, using an adaptation of the Multidimensional Driving Style Inventory (MDSI). In total, 1153 volunteers participated in this study. The authors found that young drivers manifested more hostile and anxious behavior than middle-aged and older drivers. They observed a negative correlation between driving experience and aggressiveness, distraction, and anxiety. Furthermore, experienced drivers tended to take the least risks. Regarding gender, men obtained higher scores in aggressive and risky driving styles. For their part, women obtained high scores in the careful driving style and the anxious driving style. As we can see, most of the studies have focused on conducting surveys, collecting data on traffic accidents, or performing specific tasks such as responding to a phone call [13]. In [14–16], we find some similar studies.

There are many instances in the literature that analyze gender differences in cognitive tasks such as mental rotation, spatial orientation, and verbal memory [17]. However, very few studies focus on driving, which is an activity that demands high cognitive capacity. Some studies show that men are more likely to adopt a risky driving style [18]. For their part, women may have more problems handling the vehicle and managing traffic situations [19]. Everything seems to indicate that the psychological differences between men and women could also cause a difference in driving behavior [20].

In [21], the authors analyzed the behavior of drivers at a roundabout. They observed that women drove more slowly than men in this scenario. However, they also use the brakes more. Twenty volunteers participated in this study. In [22], the researchers conducted a study to evaluate the driving behavior on s-curved roads. The authors concluded that female nonprofessional drivers had the largest speed standard deviation and lane position standard deviation on this type of road. A high value in these variables is associated with a greater probability of suffering an accident.

In [23], the authors investigated the differences in driving and visual behavior when the driving workload is high. In the tests, they realized that women show better attention than men. However, the impact of the driving workload is higher. The strategy to cope with a high driving workload also differs. Females adopt a more conservative coping strategy to compensate for the higher workload. In contrast, men are less aware of the increase in driving workload. This is manifested by less mirror-checking and an increase in gaze concentration. These results match those obtained by [24].

In the case of sleep, there are numerous studies where it has been found that a lack of sleep degrades vehicle control and the perception of risk situations [25] and can cause the same effects as driving under the influence of drugs [26]. In these articles, the main drawback we find is that they focus solely on analyzing specific scenarios, such as a monotonous road, and a limited set of parameters, such as reaction time or standard deviation of vehicle speed. In addition, they are not performed in real driving environments. For example, in [27], the researchers conducted an experiment involving 24 volunteers. Drivers had to carry out two driving tests. In one of the tests, the participant had slept well. In the other test, he was completely deprived of sleep for one night. The driving test consisted of driving for 1 h on a monotonous highway. EEG and lateral standard deviation (SDLP) were monitored during the test. The results demonstrated the effect of fatigue on driving. However, this study evaluated driving based on a single parameter, the SDLP. In addition, it did not take into account the possibility that the driver slept for a few hours or the quality of sleep was not adequate. It also focused on a single scenario, a highway.

Regarding the effects of work on driving, we found very few articles, and most refer to professional drivers [28]. However, the relationship between working hours, fatigue, and the risk of traffic accidents is clear [29]. There are many workers who are not professional drivers but use their vehicles to travel to work. Commuting is especially dangerous because it often takes place after the driver has been awake for a long period of time, where both the physical and cognitive demands of the job may have caused fatigue [30]. In [31], researchers analyzed the connection between working conditions and the risk of traffic accidents. They used data obtained from a survey of employees in France, in which

46,962 people participated. This survey included data on road risk exposure at work, socio-occupational factors, and working conditions. The analysis of the data revealed that long working hours, uncertainty in working schedules, and working at night have strong effects on the risk of road accidents [32–34].

In conclusion, in the literature, there are many studies where the influence of the drivers' state and their characteristics on driving have been verified. However, most of them are based on questionnaires such as the DBQ (Driver Behavior Questionnaire) [35] or traffic accident reports from institutions [36], but not vehicle telemetry. Unsafe driving behavior does not always lead to a traffic accident. Therefore, focusing only on traffic accidents might underestimate the impact of some factors on driving safety. In addition, the few works that consider vehicle telemetry make use of driving simulators and artificially force the driver's state (e.g., fatigue, drowsiness). This could imply that the results are not realistic. Our main contribution in this study is to analyze whether the characteristics associated with the driver, such as age, gender, hours of sleep, and hours worked, alter driving behavior in a real driving environment.

In this paper, we focus on how the drivers drive and what stress they feel, taking into account the following four factors: age, gender, sleeping hours, and working hours. The specific objectives are:

- To check if the driving behavior is influenced by age, gender, sleeping hours, and working hours.
- To check if there is a relationship between the stress experienced by the participants while driving and their characteristics (age, gender, sleeping hours, and working hours).
- To carry out the study in a real driving environment without artificially forcing the driver's condition (e.g., sleepy, tired).
- To draw conclusions that allow us to customize driving assistants and properly prioritize their advice.

2. Design and Methodology

2.1. Materials and Instruments Used

Three elements are used in this study: a personal diary, a survey, and a smartwatch. In the personal diary, participants annotated driving stress, sleep quality, sleeping hours, and working hours for each trip. Driving stress and sleep quality were reported subjectively using a Likert scale (Table 1). The participants employed these data to complete the survey shown in Table 2 with the average values obtained during the driving tests. In this survey, the participants are also asked about their age, gender, number of years driving, and kilometers driven in 2018.

Table 1. Likert scale used to report driving stress and sleep quality.

Score	Driving Stress	Sleep Quality
1	No stress	Very Poor
2	Mild stress	Poor
3	Moderate Stress	Normal
4	A lot of Stress	Good
5	Extreme stress	Very Good

The driving was monitored using a Huawei Watch 2 smartwatch. This device runs Android Wear 2.0 and has the following sensors: 6-axis A + G sensor, 3-axis compass, heart rate sensor (PPG), barometer, capacitive sensor, ambient light sensor, and GPS + Glonass. Its CPU is Qualcomm Snapdragon 2100, and it has 768 MB of RAM. We have developed an application for this watch that obtains the vehicle's speed, its geolocation, and the heart rate of the driver, with a sampling frequency of 1 s. The heart rate data were discarded as it was not accurate enough to perform a heart rate variability analysis (HRV). For this reason, driving stress was evaluated subjectively by the driver.

Table 2. Survey completed by the participants.

Question	Type of Answer
Age	Number
Gender	Female or Male
Number of years driving	Number
Kilometers driven in 2018	Number
Average sleeping hours during tests	Number
Average sleep quality during tests	Likert Scale (1–5)
Average working hours during tests	Number
Average driving stress during test	Likert Scale (1–5)

2.2. Driving Behavior

There is a lot of diversity and different perspectives in the studies and proposals on driving behavior. Accordingly, there is no consensus on its definition. In our proposal, the term driving behavior fits the concept proposed by [37]. These authors describe driving behavior as "an abstract concept characterized by an event or a set of events that occur while driving". We have defined a set of patterns and variables to detect situations during driving that adversely affect safety. They model dangerous situations such as aggressive driving style, failure to maintain a safe distance, and a lack of ability to predict traffic flow. They were designed by a mechanical engineer who is an expert in driving behavior, and they are based on previous work [38,39]. They are used to evaluate driving and analyze if there is a relationship between the characteristics of the drivers, their driving behavior, and their stress levels. Figure 1 shows the driving patterns used to evaluate the driving. The red dots indicate the beginning and end of the pattern. Table 3 summarizes the conditions of the driving patterns.

- Brake-Brake: It is defined as the number of times per 100 km that the driver brakes sharply twice or more in a 10-s time window. This pattern is related to an inadequate speed. The intensity of deceleration must be equal to or lower than $-1.5\ \mathrm{m/s^2}$. It has been demonstrated in many works that a deceleration value equal to or higher than this threshold significantly increases fuel consumption and emissions [40,41]. In the example shown in Figure 1a, the driver brakes twice sharply. Firstly, he brakes sharply after four seconds, and the speed decreases from 90 to 83 km/h. Later, he suddenly brakes again after 10 s, and the vehicle speed is reduced from 71 to 65 km/h.
- Brake-Acceleration: It is defined as the number of times per 100 km that the driver brakes abruptly ($\geq -1.5\ \mathrm{m/s^2}$) and then accelerates ($\geq 0.8\ \mathrm{m/s^2}$) in one of the next two seconds. A low value is associated with the keeping of an adequate safety distance and better use of the energy produced by the engine. In Figure 1b, the driver brakes sharply. The vehicle speed decreases from 49 to 43 km/h. After one second, he speeds up again.
- Acceleration-Brake: It is defined as the number of times per 100 km that the driver accelerates strongly and brakes almost immediately (the time window is two seconds). The acceleration must be equal to or higher than $2.5\ \mathrm{m/s^2}$ [41]. A low value of this variable is correlated to a good ability to anticipate traffic flow. In Figure 1c, the driver accelerates strongly after two seconds. The vehicle speed is increased from 52 to 61 km/h. Immediately after, the driver has to make speed corrections.
- Positive Kinetic Energy (PKE): This variable measures the aggressiveness of driving [42,43]. Its value depends on the intensity and frequency of the accelerations. If it is high, it means that the driver accelerates sharply and frequently. This driving style has a negative impact on stress levels. The driver has to make quick decisions in order to avoid accidents. The PKE is estimated over a period of time, as follows:

$$\mathrm{PKE} = \frac{\sum \left(v_i^2 - v_{i-1}^2\right)}{d};\ v_i > v_{i-1} \quad (1)$$

where ν_i and υ_{i-1} are, respectively, the final and initial speeds (in m/s) at each time interval, for which $\upsilon_i - \upsilon_{i-1} > 0$, and d is the total distance traveled (in m).

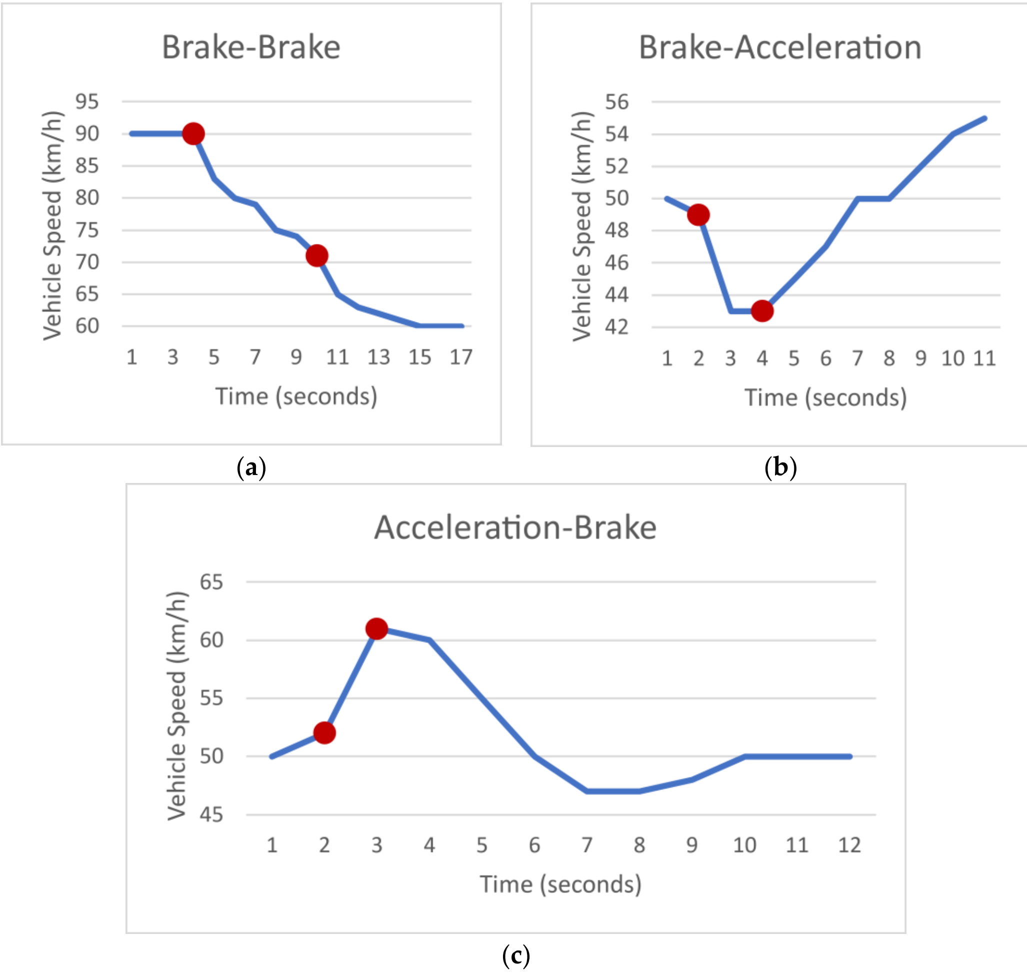


Figure 1. Description of driving patterns: (**a**) Brake-Brake pattern; (**b**) Brake-Acceleration pattern; (**c**) Acceleration-Brake pattern.

Table 3. Conditions of the driving patterns.

Driving Pattern	Condition
Brake-Brake	$a \leq -1.5\ m/s^2 \rightarrow (t \leq 10\ s)\ a \leq -1.5\ m/s^2$
Brake-Acceleration	$a \leq -1.5\ m/s^2 \rightarrow (t \leq 2\ s)\ a > 0.8\ m/s^2$
Acceleration-Brake	$a \geq 2.5\ m/s^2 \rightarrow (t \leq 2\ s) \rightarrow a \leq -0.8\ m/s^2$

3. Case Study

In this section, we describe the setting of the experiment. The objective is to build a realistic scenario in order to analyze the influence of nondriving factors on driving behavior and driving stress. In particular, we examined the following relationships:

- age, gender, sleeping hours, and working hours vs. driving behavior.
- age, gender, sleeping hours, and working hours vs. driving stress.

3.1. Participants

In total, 37 drivers participated in the study. Two were discarded as they did not complete the driving test. Thus, the final number of participants was 35 (21 males and 14 females). The average age of the participants was 42.85 ± 12.98 years (min: 23, max: 65).

Table 4 shows their driving experience, taking into account the number of years of driving. We can see that all participants drove a similar number of kilometers in 2018.

Table 4. Driving experience of the participants.

Driving Experience (Years)	Number of Drivers	Average Age	Kilometers Driven in 2018
1–5	1 man, 2 women	23.66 ± 0.58	9329 ± 1040
6–10	5 men, 1 woman	26.17 ± 3.25	9453 ± 1526
11–20	1 man, 5 women	40.50 ± 2.43	10304 ± 2480
>20	14 men, 6 women	51.45 ± 8.46	9830 ± 1640

The drivers were recruited voluntarily, and they did not receive any payment or benefit for the tests. The selection criteria were that the subject was healthy, with no history of heart-related diseases, and had good vision. We requested that they not consume drugs, alcohol, or other beverages and medications during the experimental period. Furthermore, they all had intellectual and skilled work that does not require physical effort.

3.2. Procedure

Each driver completed 30 trips. The routes correspond to a daily commute to the workplace and are located in Asturias and Granada (Spain). Therefore, the itineraries are well known, and the driving stress might not be as high as driving on unknown roads. Subjects used their own vehicles to complete the driving test. Drivers were requested to start their journey with plenty of time in advance in order to avoid time pressure. Furthermore, they kept a personal diary to annotate driving stress, working hours, sleep quality, and sleeping hours for each day. Driving stress and sleep quality were scored by the driver using a Likert scale between 1 and 5. At the end of the experiment, the participants reported the mean values after completing the survey. In the case of driving patterns, they were obtained using the smartwatch. Figure 2 describes this process.

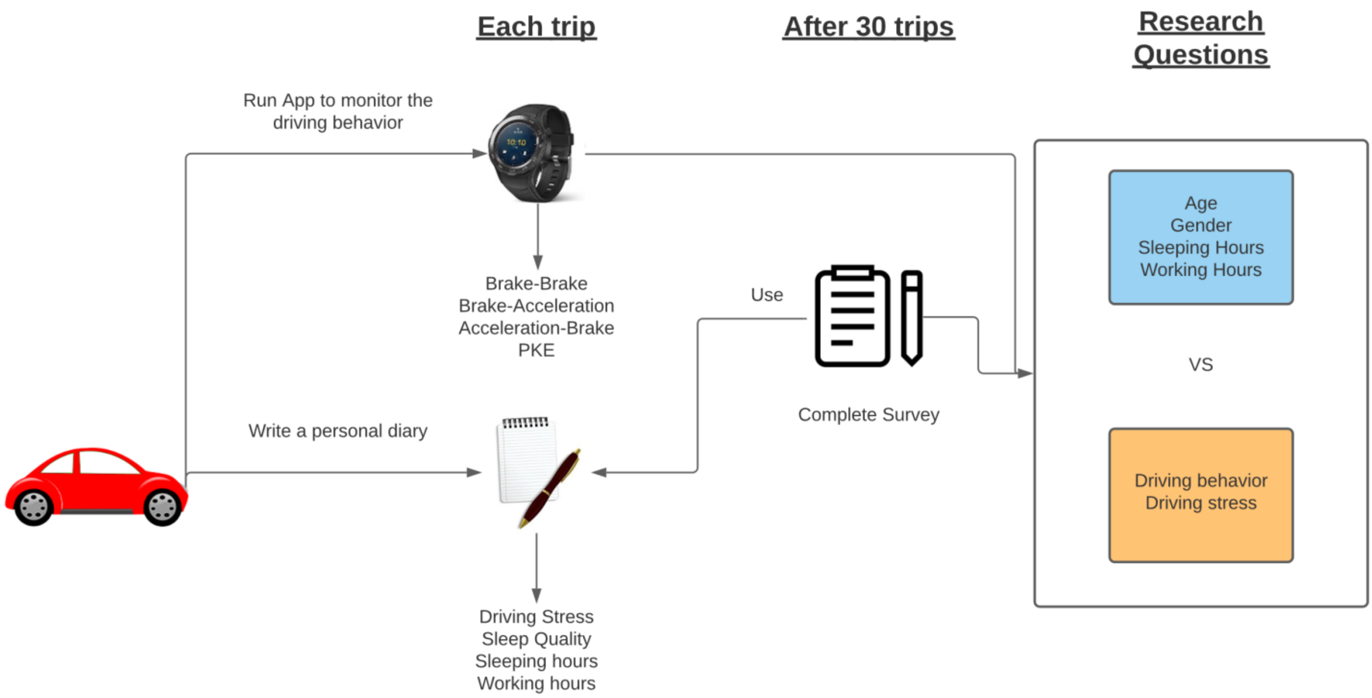


Figure 2. Description of the experiment.

Table 5 shows the characteristics of the routes. The drivers repeated their route 30 times on different days, from Monday to Friday, but at the same time each day. On all routes, the drivers were driving on the highway most of the time. Furthermore, there were almost no traffic delays, according to Google. There was only a traffic delay of 0.077% (±0.06%) of the route on average and a medium amount of traffic in 1.82% (±1.08) of the route. The level of traffic was very low because the drivers set out early in the morning (average start time = 7:02:21 ± 00:23:28). The drivers drove without any driving assistance except the use of power steering. After 30 trips, the drivers completed the previously described survey on their age, gender, sleeping quality, sleeping hours, working hours, and driving stress using their annotations.

Table 5. Route characteristics.

Feature	Average Value per Trip
Distance (km)	39.37 ± 6.86
Travel time (min.)	33.9 ± 3.83
Driving on highways (km)	32.39 ± 8.61
Driving on extra-urban road (km)	3.85 ± 3.57
Driving on urban road (km)	3.12 ± 1.53

3.3. Ethics Statement

The study was conducted in accordance with the code of ethics on human experimentation established by the Declaration of Helsinki (1964) and amended in Seoul (2008) [44]. The data were saved following Organic Law 15/1999 of 13 December 1999 on the Protection of Personal Data from Spain [45]. All participants were volunteers, and they were informed of the study's goals and procedures.

4. Results

In this section, we present the results of the experiment. The data were analyzed with one-way analysis of variance (ANOVA) to determine if there were significant differences between the groups according to the age of the participants. In addition, we used Tukey's posthoc test to identify which groups showed significant differences. In the rest of the study, the ANCOVA test was used, setting age as a covariate. We used this method in order to avoid that the differences found between the groups can be influenced by age. Average values are described as mean ± standard deviation. The statistical tests were performed with IBM SPSS 25. A significance level of $p < 0.05$ was fixed for all statistical tests.

4.1. Influence of Age on Driving Behavior and Driving Stress

In this subsection, we aim to analyze if there is any relationship between age, driving behavior, and driving stress. We clustered the drivers into three different groups according to their ages. Table 6 describes the clusters.

Table 6. Descriptions of clusters.

Set	Age	Number of Driving Samples
A	$18 \leq x \leq 32$	9
B	$32 < x \leq 55$	17
C	$x > 55$	9

4.1.1. Driving Behavior

Table 7 shows the results of the ANOVA test for the variables related to driving behavior (driving patterns and PKE). In this table, *df* represents the degrees of freedom, *F* is the ratio calculated as the between-groups variance divided by the within-group variance, and *p*-value indicates the likelihood of finding a particular set of observations if the null hypothesis is true. Table 8 presents the *p*-values obtained by Tukey's posthoc test.

Table 7. Results of the ANOVA test for driving behavior.

Variable	Df	F	*p*-Value
Brake-Brake	1047	26.255	0.001 *
Brake-Acceleration	1047	2.841	0.059
Acceleration-Brake	1047	6.854	0.001 *
PKE	1047	41.074	0.001 *

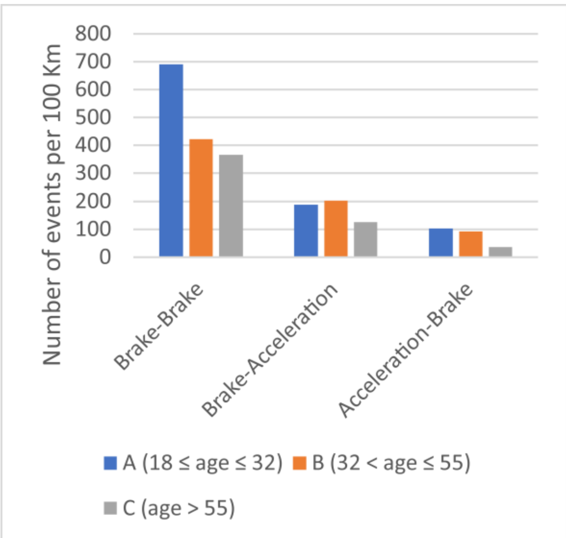
Note: * indicates *p*-value smaller than 0.05.

Table 8. *p*-values of Tukey's posthoc test for driving behavior.

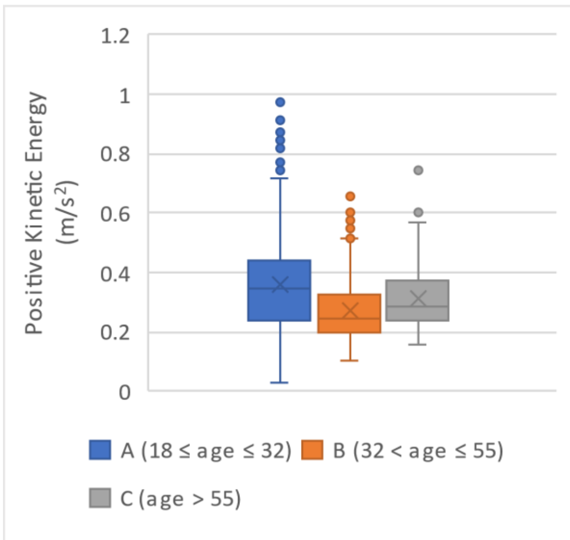
Set		Brake-Brake	Brake-Acceleration	Acceleration-Brake	PKE
A (18 ≤ age ≤ 32)	B	0.001 *	0.913	0.834	0.001 *
	C	0.001 *	0.208	0.004 *	0.001 *
B (32 < age ≤ 55)	A	0.001 *	0.913	0.834	0.001 *
	C	0.384	0.050	0.004 *	0.001 *
C (age > 55)	A	0.001 *	0.208	0.003 *	0.001 *
	B	0.384	0.050	0.004 *	0.001 *

Note: * indicates *p*-value smaller than 0.05. Gray background is for improving the readability of the table.

Figure 3 captures driving behavior grouped by age. For the Brake-Brake driving pattern, Group A obtained a value 63.44% higher than Group B and 88.78% higher than Group C. On the other hand, there were no significant differences between Group B and Group C. For the Brake-Acceleration driving pattern, no significant differences were found between the three groups of drivers. In the Acceleration-Brake driving pattern, older drivers had the best results. The value obtained was 64% lower than the result obtained by Group A and 60% lower compared to Group B. There were no significant differences between young drivers (Group A) and middle-aged drivers (Group B).



(**a**)



(**b**)

Figure 3. Driving behavior grouped by age. (**a**) Driving patterns; (**b**) positive kinetic energy (PKE).

Finally, the youngest drivers obtained the worst results in the positive kinetic energy category. The value obtained by Group A was 29% higher than the average value obtained by Group B and 16% higher than the result obtained by Group C. Tukey's posthoc test showed significant differences between all groups.

4.1.2. Driving Stress

Table 9 shows the results of the survey completed by the participants on driving stress. This survey was conducted using a Likert scale, where 1 meant no stress and 5 meant extreme stress. There were significant differences (F (2, 1047) = 93.321, $p < 0.05$) according to the ANOVA test. Table 10 presents the results of Tukey's posthoc test. The youngest group of drivers suffered the most stress. The value reported by these participants was 39% higher than that of middle-aged drivers and 24% higher than that of older drivers. Middle-aged drivers reported feeling the least stress.

Table 9. Results of the survey on driving stress grouped by age.

Set	Average Driving Stress
A (18 ≤ age ≤ 32)	2.22 ± 0.63
B (32 < age ≤ 55	1.59 ± 0.69
C (age > 55)	1.78 ± 0.41

Table 10. *p*-values of Tukey's posthoc test for driving stress.

Set		Average Driving Stress
A (18 ≤ age ≤ 32)	B	0.001 *
	C	0.001 *
B (32 < age ≤ 55)	A	0.001 *
	C	0.001 *
C (age > 55)	A	0.001 *
	B	0.001 *

Note: * indicates *p*-value smaller than 0.05. Gray background is for improving the readability of the table.

4.2. Influence of Gender on Driving Behavior and Driving Stress

In this subsection, we aim to analyze if there is any relationship between gender, driving behavior, and driving stress. Twenty-one men and fourteen women participated in the study.

4.2.1. Driving behavior

Table 11 shows the results when applying an ANCOVA test, setting age as a covariate and gender as a fixed factor. Figure 4 compares the driving patterns and positive kinetic energy obtained for both women and men.

Table 11. Results of ANCOVA grouped by gender.

Variable	Result
Brake-Brake	F (1, 1047) = 122.973, $p < 0.05$ *
Brake-Acceleration	F (1, 1047) = 31.965, $p < 0.05$ *
Acceleration-Brake	F (1, 1047) = 41.790 $p < 0.05$ *
PKE	F (1, 1047) = 171.605, $p < 0.05$ *

Note: * indicates *p*-value smaller than 0.05.

We can observe that for the three driving patterns, men obtained worse results. In the case of the Brake-Brake pattern, the average number of events per 100 km obtained by women was 52.67% lower than the value obtained by men. In the case of the Brake-Acceleration pattern, the value obtained was reduced by 62.15%. Finally, in the Acceleration-Brake pattern, the result decreased by 72.48%. The same happened with positive kinetic energy; men obtained a value 32% higher than women. In all these cases, the differences were significant.

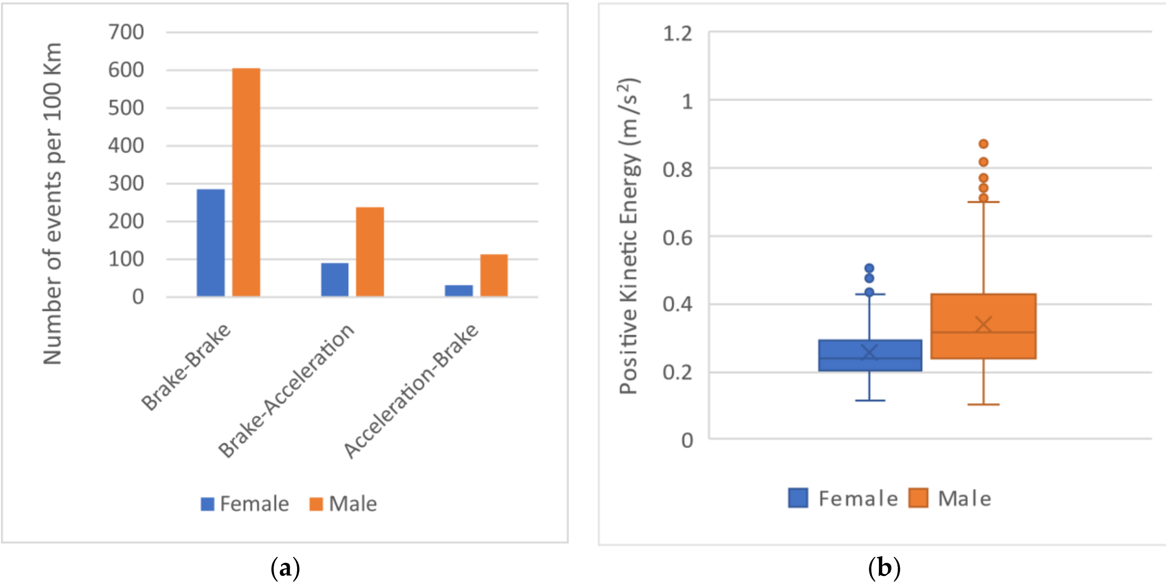


Figure 4. Driving behavior grouped by gender. (**a**) Driving patterns; (**b**) positive kinetic energy (PKE).

4.2.2. Driving Stress

Table 12 presents the results of the survey on driving stress, grouped by gender. The results obtained indicate that men feel more stress than women. In addition, the differences between both groups were significant (F (1, 1047) = 158.695, $p < 0.05$) according to the ANCOVA test.

Table 12. Results of the survey on driving stress grouped by gender.

Set	Average Driving Stress
Female	1.57 ± 0.62
Male	1.95 ± 0.65

4.3. Influence of Sleep on Driving Behavior and Driving Stress

In this subsection, we analyze if there is any relationship between sleeping hours, sleep quality, driving behavior, and driving stress. Table 13 shows the sleep quality score clustered by the number of hours of sleep. Drivers rated sleep quality using a Likert scale, where 1 means that their sleep quality is very poor and 5 means it is very good. The results show that drivers who sleep less than seven hours also report poor sleep quality. The difference between drivers who sleep less than seven hours and those who sleep seven hours or more is significant, F (1, 1047) = 3713.515, $p < 0.05$.

Table 13. Sleep quality grouped by sleeping hours.

Set	Sleep Quality Score
Group A (<7 h)	2.10 ± 0.45
Group B (≥7 h)	4.20 ± 0.40

Consequently, we grouped the drivers into two groups in order to analyze driving behavior and stress. The first set (A) was composed of drivers who sleep less than 7 h. The second set (B) was made up of drivers who sleep 7 h or more. Group A had 10 drivers, while Group B was comprised of 25 drivers.

4.3.1. Driving Behavior

Table 14 shows the results obtained when applying an ANCOVA test, setting the age as a covariate and sleeping hours as a fixed factor. Figure 5 captures the results of the driving patterns by grouping participants according to the number of hours they sleep.

Table 14. Results of ANCOVA grouped by sleeping hours.

Variable	Result
Brake-Brake	F (1, 1047) = 28.163, $p < 0.05$ *
Brake-Acceleration	F (1, 1047) = 0.465, $p > 0.05$
Acceleration-Brake	F (1, 1047) = 5.760 $p < 0.05$ *
PKE	F (1, 1047) = 66.801, $p < 0.05$ *

Note: * indicates *p*-value smaller than 0.05.

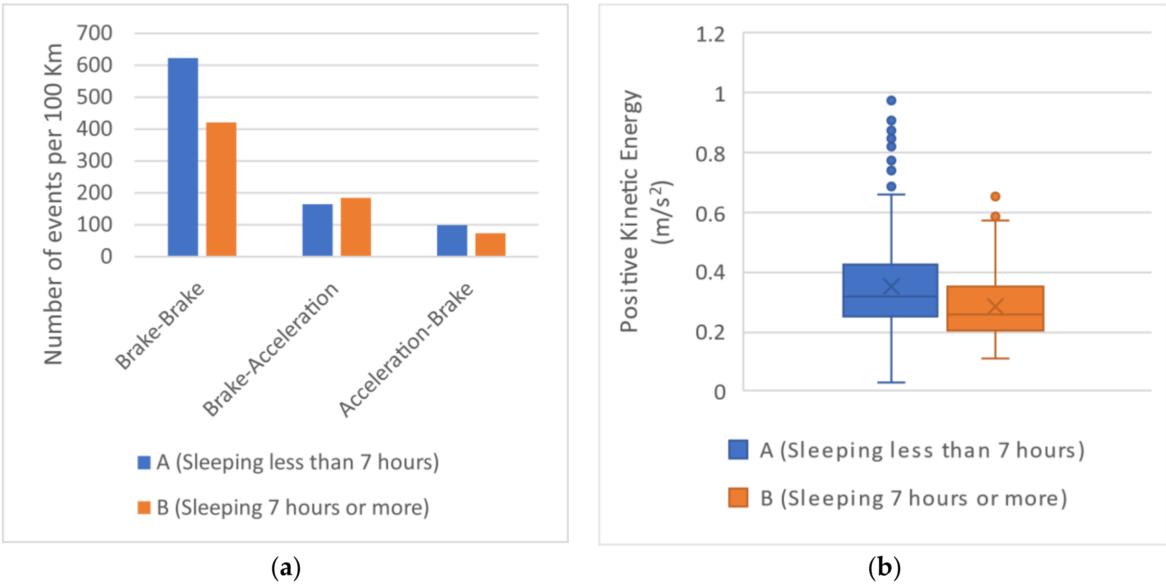


Figure 5. Driving behavior grouped by sleeping hours. (**a**) Driving patterns; (**b**) positive kinetic energy (PKE).

The first group (drivers who sleep less than 7 h) demonstrated less safe driving behavior. In the Brake-Brake pattern, the group composed of drivers who sleep less obtained a value 32.46% higher than that of drivers who sleep more. Regarding the Brake-Acceleration pattern, there were no significant differences between the groups. In the case of the Acceleration-Brake pattern, the drivers of Group A obtained a value 26.23% higher than the drivers of Group B.

Finally, the PKE value obtained by Group A drivers was significantly higher (25%) than that of Group B drivers. Lack of sleep implies an increase in the number and intensity of accelerations.

4.3.2. Driving Stress

Table 15 captures the results of the survey on the level of subjective driving stress. The results indicated that drivers who sleep fewer hours suffered 16% more stress than drivers who sleep the recommended number of hours. In addition, the differences between both groups were significant (F (1, 1047) = 43.623, $p < 0.05$), according to the ANCOVA test.

Table 15. Results of the survey on driving stress grouped by sleeping hours.

Set	Average Driving Stress
Group A (<7 h)	2.00 ± 0.45
Group B (≥7 h)	1.72 ± 0.72

4.4. Influence of Working Hours on Driving Behavior and Driving Stress

In this subsection, we analyze if there is any relationship between working hours, driving behavior, and stress. The participants were classified into two groups. The first set (A) consisted of drivers who work more than 8 h (13 drivers). The second set (B) included drivers who work a maximum of 8 h (22 drivers). This threshold was set because the standard working day in Spain is eight hours.

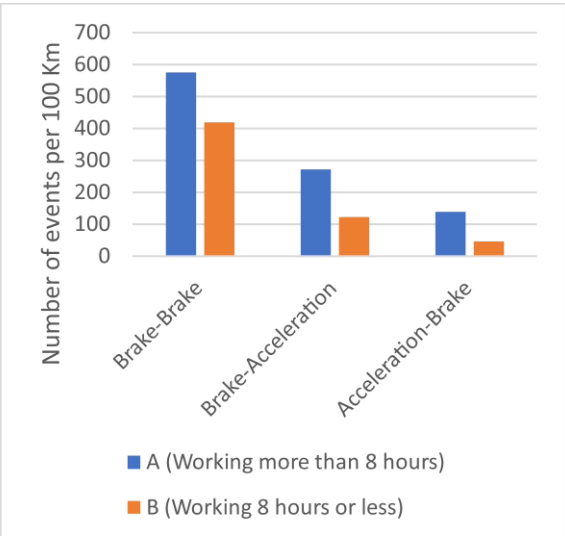
4.4.1. Driving behavior

Table 16 shows the results obtained when applying an ANCOVA test, setting age as a covariate and working hours as a fixed factor. Figure 6 captures the results of driving patterns by grouping the participants according to working hours.

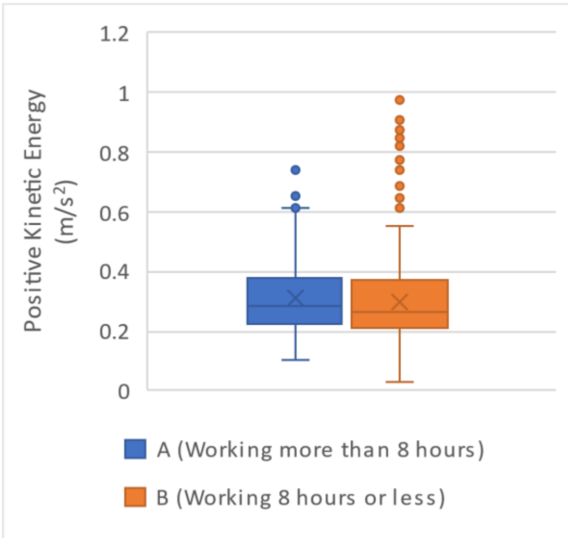
Table 16. Results of ANCOVA grouped by working hours.

Variable	Result
Brake-Brake	F (1, 1047) = 48.010, $p < 0.05$ *
Brake-Acceleration	F (1, 1047) = 35.678, $p < 0.05$ *
Acceleration-Brake	F (1, 1047) = 60.105 $p < 0.05$ *
PKE	F (1, 1047) = 8.443, $p < 0.05$ *

Note: * indicates *p*-value smaller than 0.05.



(**a**)



(**b**)

Figure 6. Driving behavior grouped by working hours. (**a**) Driving patterns; (**b**) positive kinetic energy (PKE).

The first group (drivers who work more than 8 h) manifested less safe driving behavior according to the three driving patterns. The difference between the two groups was particularly relevant in the Acceleration-Brake pattern that is associated with the ability to anticipate traffic flow. In this case, the value of Group A was almost three times higher than the value obtained by Group B. Regarding PKE values, the drivers who work the most hours are those who obtained the worst results. The PKE value obtained by Group A was 3.12% higher than that obtained by Group B.

4.4.2. Driving Stress

Table 17 shows the results of the survey on the level of subjective driving stress. The results indicate that drivers who work more than 8 h suffer 35% more stress than drivers who work 8 h or less. In addition, the differences between both groups were significant ($F(1, 1047) = 468.071$, $p < 0.05$), according to the ANCOVA test.

Table 17. Results of the survey on driving stress grouped by working hours.

Set	Average Driving Stress
Group A (>8 h)	2.15 ± 0.43
Group B (≤8 h)	1.59 ± 0.65

5. Discussion of the Results

The results obtained in this study show differences in driving behavior according to age. Young drivers obtained the worst results in the Brake-Brake and Acceleration-Brake driving patterns. The same is true for the PKE variable. These results are consistent with the conclusions of the European Conference of Ministers of Transport [46]. Younger drivers are less aware of driving risk than their older counterparts, and they often suffer from euphoria. In addition, they have less driving experience. As a result, they show a more aggressive driving style. Regarding levels of stress, they are the age group who suffers the most stress while driving, according to the survey carried out.

Middle-aged drivers performed well in the Brake-Brake driving pattern and the PKE variable. This means that their driving is characterized as smooth and that they drive at an appropriate speed. However, they have difficulties in maintaining a safe distance and anticipating traffic flow. Regarding driving stress, they were the group who reported suffering less. This could be due to their smooth driving style, high driving experience, and good physical condition.

Older drivers were the best performers in all three driving patterns. These drivers have a greater ability to predict traffic flow owing to their experience [47]. However, we observed a slightly more aggressive driving style than the middle-aged drivers, although not as aggressive as the young drivers. In terms of the value of driving stress, these drivers have a higher value than middle-aged drivers. In this case, the progressive deterioration of cognitive skills could involve an increase in driving workload that contributes to driving stress.

Regarding gender, we encountered very significant differences between men and women in driving behavior. In all the driving patterns, women obtained better results, likewise with the PKE variable. Women present a smoother driving style than men, allowing them to anticipate the flow of traffic and, thus, avoid sudden accelerations and decelerations, leading to better use of energy and safer driving. Their behavior is more predictable so that other road users can make decisions in advance and with greater accuracy. This driving behavior also implies less stress while driving, as can be seen from the survey carried out. In conclusion, in this experiment, men revealed a more unsafe and aggressive driving style than women. These results are in line with the conclusions obtained in other studies [48] that were carried out using driving simulators.

In the sleep analysis, drivers who sleep less than 7 h presented a more aggressive driving style, in which abrupt accelerations and decelerations proliferated, as well as a lack of maintenance of the safety distance. Drowsiness causes a decrease in the ability to anticipate the flow of traffic. Decision-making, vigilance, and hazard perception become worse [49,50]. This behavior has negative effects on both fuel consumption and safety. Likewise, these drivers show higher driving stress values than the drivers who sleep 7 h or more. Fatigue due to sleep deprivation leads to impaired driving skills [51].

Finally, we also detected an effect of working hours on driving behavior. In both the PKE variable and the three driving patterns, the drivers who work the most hours are those who obtain the worst results. This means that they drive at inappropriate speeds, accelerate and brake frequently and harshly, and are unable to anticipate traffic flow. Overworking has a major impact on the driver's cognitive abilities [52] and increases anger, hostility, and stress [53,54], resulting in more aggressive driving behavior in which sudden accelerations proliferate. In our experiment, overworking was the factor that had the most influence on obtaining poor results in the Brake-Acceleration driving pattern. Regarding driving stress, there were significant differences depending on working hours. Drivers who work more report more stress.

6. Conclusions

In this work, we analyzed how driving behavior and driving stress are influenced by a set of factors (age, gender, sleeping hours, and working hours). Driving was monitored using a smartwatch that recorded the heart rate and vehicle speed. Stress, sleeping hours, and working hours were reported by the participants through a survey. In total, 35 volunteers participated in the study, each completing 30 trips.

The results show that too little sleep and too many hours of work lead to a worsening of driving skills and driving stress. The WHO recommends that a healthy adult should sleep between 7 and 8 h a day [27]. Drivers who fall outside this category present an aggressive driving style, characterized by the frequent and abrupt use of the accelerator and brake. In addition, they have difficulty concentrating and predicting traffic flow. Drivers with long working hours were the most stressed in this study.

Age is another element that has affected the results. Young drivers have less skill behind the wheel, which causes them to feel greater stress while driving. Middle-aged drivers are the best performers, reporting that driving does not cause them high stress. Older drivers have extensive experience. The downside is that they may be overconfident, and their cognitive skills will gradually deteriorate.

Finally, gender seems to be linked to driving style. Women have a smooth driving style, characterized by gradual use of the pedals. This maximizes energy use and improves safety. Conversely, men show a more aggressive driving style that also causes higher stress while driving.

One of the main limitations of this study is that we have not analyzed the personality and mental state of the participants, factors which could influence both stress and driving behavior. As future work, we aim to include a test that allows us to determine the driver's character. Furthermore, it should be taken into account that the findings in this study relate only to the routes of the driving test, the population sampled, and the other underlying conditions stated in the paper. However, the results are aligned with those obtained by other authors using driving simulators.

Lastly, although drivers from two different regions of Spain (Asturias and Granada) took part in the experiment, all the participants were Spanish. We would like to compare the results with those obtained by drivers from other countries in order to analyze cultural differences. The results of this research could be used to improve driving assistants, adapting them more closely to driver profiles and their state.

7. Guidelines for Driving Assistants

Based on the results, we propose the following ideas to improve and customize driving assistants:

- Young Drivers: Driving assistants should be focused on improving their driving style, evaluating the actions of these types of drivers and offering advice to smooth their driving style. However, the feedback provided by these systems should be positive, aimed at encouraging the drivers to improve and taking into account their personality.
- Middle-aged drivers: It would be very useful for driving support systems to provide information about any changes in the driving environment in order to anticipate any event, for example, the intention of a driver ahead of them to change lanes. In the literature, we find many proposals on the prediction of driving behavior [53,54]. These solutions are based on artificial intelligence algorithms and the use of sensors to

obtain information about the environment and the driver. However, it is still an open problem as, to date, the prediction horizon is very limited.

- Older drivers: It is difficult to change their habits. Driving assistants should use gamification techniques to encourage drivers to improve. In addition, these drivers tend to show worse response times to unexpected events. The driving assistants should provide support to elderly drivers in places where a short response time is required, such as crossroads and roundabouts. Furthermore, they could advise drivers not to use the vehicle when weather conditions are not appropriate. Weather events such as rain or ice demand a rapid response time from the driver due to lack of grip.
- Fatigue due to lack of sleep or excessive working hours: These drivers show a deterioration in their driving skills and are less alert. Both manufacturers [51] and researchers [55] have designed solutions to detect fatigue during driving. These technologies could be improved if they also consider what is happening before the driver gets behind the wheel. The drivers could use a wearable device to analyze their sleep patterns and level of stress even before entering the vehicle. Driving assistants could suggest using public transport if the driver's condition is not optimal or propose an alternative route to the destination that requires less cognitive ability.

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References

1. Caiazzo, F.; Ashok, A.; Waitz, I.A.; Yim, S.H.L.; Barrett, S.R.H. Air Pollution and Early Deaths in the United States. Part I: Quantifying the Impact of Major Sectors in 2005. *Atmos. Environ.* **2013**, *79*, 198–208. [CrossRef]
2. Norheim, O.F.; Jha, P.; Admasu, K.; Godal, T.; Hum, R.J.; Kruk, M.E.; Gómez-Dantés, O.; Mathers, C.D.; Pan, H.; Sepúlveda, J.; et al. Avoiding 40% of the Premature Deaths in Each Country, 2010–2030: Review of National Mortality Trends to Help Quantify the UN Sustainable Development Goal for Health. *Lancet Lond. Engl.* **2015**, *385*, 239–252. [CrossRef]
3. Haque, F.; Abas, M.A. Review of Driving Behavior Towards Fuel Consumption and Road Safety. *J. Mek.* **2018**, *41*, 59–68.
4. Meiring, G.A.M.; Myburgh, H.C. A Review of Intelligent Driving Style Analysis Systems and Related Artificial Intelligence Algorithms. *Sensors* **2015**, *15*, 30653–30682. [CrossRef]
5. Ma, C.; Hao, W.; Xiang, W.; Yan, W. The Impact of Aggressive Driving Behavior on Driver-Injury Severity at Highway-Rail Grade Crossings Accidents. *J. Adv. Transp.* **2018**, *2018*, e9841498. [CrossRef]
6. Gnardellis, C.; Tzamalouka, G.; Papadakaki, M.; Chliaoutakis, J.E. An Investigation of the Effect of Sleepiness, Drowsy Driving, and Lifestyle on Vehicle Crashes. *Transp. Res. Part F Traffic Psychol. Behav.* **2008**, *11*, 270–281. [CrossRef]
7. Mamcarz, P.; Droździel, P.; Madleňáková, L.; Sieradzki, A.; Droździel, P. Level of Occupational Stress, Personality and Traffic Incidents: Comparative Study of Public and Freight Transport Drivers. *Transp. Res. Procedia* **2019**, *40*, 1453–1458. [CrossRef]
8. Wang, K.; Murphey, Y.L.; Zhou, Y.; Hu, X.; Zhang, X. Detection of Driver Stress in Real-World Driving Environment Using Physiological Signals. In Proceedings of the 2019 IEEE 17th International Conference on Industrial Informatics (INDIN), Helsinki, Finland, 22–25 July 2019; Volume 1, pp. 1807–1814.
9. Machin, M.A.; Sankey, K.S. Relationships between Young Drivers' Personality Characteristics, Risk Perceptions, and Driving Behaviour. *Accid. Anal. Prev.* **2008**, *40*, 541–547. [CrossRef]
10. Navon-Eyal, M.; Taubman-Ben-Ari, O. Can Emotion Regulation Explain the Association between Age and Driving Styles? *Transp. Res. Part F Traffic Psychol. Behav.* **2020**, *74*, 439–445. [CrossRef]

11. Farooq, D.; Juhasz, J. Statistical Evaluation of Risky Driver Behavior Factors That Influence Road Safety Based on Drivers Age and Driving Experience in Budapest and Islamabad. *Eur. Transp. Eur.* **2020**, 1–18. [CrossRef]
12. Padilla, J.-L.; Castro, C.; Doncel, P.; Taubman-Ben-Ari, O. Adaptation of the Multidimensional Driving Styles Inventory for Spanish Drivers: Convergent and Predictive Validity Evidence for Detecting Safe and Unsafe Driving Styles. *Accid. Anal. Prev.* **2020**, *136*, 105413. [CrossRef]
13. Shinar, D.; Tractinsky, N.; Compton, R. Effects of Practice, Age, and Task Demands, on Interference from a Phone Task While Driving. *Accid. Anal. Prev.* **2005**, *37*, 315–326. [CrossRef]
14. Nagamatsu, L.S.; Munkacsy, M.; Liu-Ambrose, T.; Handy, T.C. Altered Visual-Spatial Attention to Task-Irrelevant Information Is Associated with Falls Risk in Older Adults. *Neuropsychologia* **2013**, *51*, 3025–3032. [CrossRef]
15. Maciokas, J.B.; Crognale, M.A. Cognitive and Attentional Changes WithAge: Evidence from Attentional Blink Deficits. *Exp. Aging Res.* **2003**, *29*, 137–153. [CrossRef]
16. Lee, T.-Y.; Hsieh, S. The Limits of Attention for Visual Perception and Action in Aging. *Aging Neuropsychol. Cogn.* **2009**, *16*, 311–329. [CrossRef] [PubMed]
17. Moè, A.; Hausmann, M.; Hirnstein, M. Gender Stereotypes and Incremental Beliefs in STEM and Non-STEM Students in Three Countries: Relationships with Performance in Cognitive Tasks. *Psychol. Res.* **2021**, *85*, 554–567. [CrossRef] [PubMed]
18. Butters, J.; Mann, R.E.; Wickens, C.M.; Boase, P. Gender Differences and Demographic Influences in Perceived Concern for Driver Safety and Support for Impaired Driving Countermeasures. *J. Saf. Res.* **2012**, *43*, 405–411. [CrossRef] [PubMed]
19. Özkan, T.; Lajunen, T. What Causes the Differences in Driving between Young Men and Women? The Effects of Gender Roles and Sex on Young Drivers' Driving Behaviour and Self-Assessment of Skills. *Transp. Res. Part F Traffic Psychol. Behav.* **2006**, *9*, 269–277. [CrossRef]
20. Hole, G.J. *The Psychology of Driving*; Psychology Press: London, UK, 2014; ISBN 978-1-317-77810-3.
21. Teo, S.H.; Gan, L.M. Speeding Driving Behaviour: Age and Gender Experimental Analysis. *MATEC Web Conf.* **2016**, *74*, 00030. [CrossRef]
22. Li, X.; Yan, X.; Wong, S.C. Effects of Fog, Driver Experience and Gender on Driving Behavior on S-Curved Road Segments. *Accid. Anal. Prev.* **2015**, *77*, 91–104. [CrossRef]
23. Yang, Y.; Wong, A.; McDonald, M. Does Gender Make a Difference to Performing In-Vehicle Tasks? *IET Intell. Transp. Syst.* **2014**, *9*, 359–365. [CrossRef]
24. Holland, C.; Geraghty, J.; Shah, K. Differential Moderating Effect of Locus of Control on Effect of Driving Experience in Young Male and Female Drivers. *Personal. Individ. Differ.* **2010**, *48*, 821–826. [CrossRef]
25. Bener, A.; Yildirim, E.; Özkan, T.; Lajunen, T. Driver Sleepiness, Fatigue, Careless Behavior and Risk of Motor Vehicle Crash and Injury: Population Based Case and Control Study. *J. Traffic Transp. Eng. Engl. Ed.* **2017**, *4*, 496–502. [CrossRef]
26. Williamson, A.M.; Feyer, A.M. Moderate Sleep Deprivation Produces Impairments in Cognitive and Motor Performance Equivalent to Legally Prescribed Levels of Alcohol Intoxication. *Occup. Environ. Med.* **2000**, *57*, 649–655. [CrossRef] [PubMed]
27. Mahajan, K.; Velaga, N.R. Effects of Partial Sleep Deprivation on Braking Response of Drivers in Hazard Scenarios. *Accid. Anal. Prev.* **2020**, *142*, 1–14. [CrossRef]
28. Centers for Disease Control and Prevention (CDC) Ambulance Crash-Related Injuries among Emergency Medical Services Workers—United States, 1991–2002. *MMWR Morb. Mortal. Wkly. Rep.* **2003**, *52*, 154–156.
29. McCartt, A.T.; Rohrbaugh, J.W.; Hammer, M.C.; Fuller, S.Z. Factors Associated with Falling Asleep at the Wheel among Long-Distance Truck Drivers. *Accid. Anal. Prev.* **2000**, *32*, 493–504. [CrossRef]
30. Caponecchia, C.; Williamson, A. Drowsiness and Driving Performance on Commuter Trips. *J. Saf. Res.* **2018**, *66*, 179–186. [CrossRef] [PubMed]
31. Fort, E.; Ndagire, S.; Gadegbeku, B.; Hours, M.; Charbotel, B. Working Conditions and Occupational Risk Exposure in Employees Driving for Work. *Accid. Anal. Prev.* **2016**, *89*, 118–127. [CrossRef] [PubMed]
32. Fort, E.; Pourcel, L.; Davezies, P.; Renaux, C.; Chiron, M.; Charbotel, B. Road Accidents, an Occupational Risk. *Saf. Sci.* **2010**, *48*, 1412–1420. [CrossRef]
33. Andrea, H.; Bültmann, U.; Beurskens, A.J.H.M.; Swaen, G.M.H.; van Schayck, C.P.; Kant, I.J. Anxiety and Depression in the Working Populationusing the HAD Scale. *Soc. Psychiatry Psychiatr. Epidemiol.* **2004**, *39*, 637–646. [CrossRef] [PubMed]
34. Dembe, A.E.; Erickson, J.B.; Delbos, R.G.; Banks, S.M. Nonstandard Shift Schedules and the Risk of Job-Related Injuries. *Scand. J. Work. Environ. Health* **2006**, *32*, 232–240. [CrossRef] [PubMed]
35. de Winter, J.C.F.; Dodou, D. The Driver Behaviour Questionnaire as a Predictor of Accidents: A Meta-Analysis. *J. Saf. Res.* **2010**, *41*, 463–470. [CrossRef] [PubMed]
36. Hu, L.; Bao, X.; Wu, H.; Wu, W. A Study on Correlation of Traffic Accident Tendency with Driver Characters Using In-Depth Traffic Accident Data. *J. Adv. Transp.* **2020**, *2020*, e9084245. [CrossRef]
37. Vilaca, A.; Cunha, P.; Ferreira, A.L. Systematic Literature Review on Driving Behavior. In Proceedings of the 2017 IEEE 20th International Conference on Intelligent Transportation Systems (ITSC), Yokohama, Japan, 16–19 October 2017; pp. 1–8.
38. Rionda, A.; Pañeda, X.G.; García, R.; Díaz, G.; Martínez, D.; Mitre, M.; Arbesú, D.; Marín, I. Blended Learning System for Efficient Professional Driving. *Comput. Educ.* **2014**, *78*, 124–139. [CrossRef]

39. Pozueco, L.; Tuero, A.G.; Pañeda, X.G.; Melendi, D.; García, R.; Pañeda, A.G.; Rionda, A.; Díaz, G.; Mitre, M. Adaptive Learning for Efficient Driving in Urban Public Transport. In Proceedings of the 2015 International Conference on Computer, Information and Telecommunication Systems (CITS), Gijon, Spain, 15–17 July 2015; pp. 1–5.
40. Smith, L. Reducing the Environment Impact of Driving-Effectiveness of Driver Training. 1999, pp. 48–55. Available online: https://trid.trb.org/view/695276 (accessed on 22 April 2021).
41. Ericsson, E. Independent Driving Pattern Factors and Their Influence on Fuel-Use and Exhaust Emission Factor. *Transp. Res. Part Transp. Environ.* **2001**, *6*, 325–345. [CrossRef]
42. André, M. *Driving Cycles Development: Characterization of the Methods*; SAE Technical Paper: Warrendale, PA, USA, 1996.
43. Andrieu, C.; Pierre, G.S. Comparing Effects of Eco-Driving Training and Simple Advices on Driving Behavior. *Procedia Soc. Behav. Sci.* **2012**, *54*, 211–220. [CrossRef]
44. Jonkman, L.J.; Nonyel, N.P.; Law, M.G.; Drame, I. An Ethics-Based Approach to Research in Global Health: A Call to Action for Pharmacists. *Res. Soc. Adm. Pharm.* **2020**, *16*, 1569–1573. [CrossRef]
45. Corvo López, F.M. Data Protection in the Internet: National Report Spain. In *Data Protection in the Internet*; Moura Vicente, D., de Vasconcelos Casimiro, S., Eds.; Ius Comparatum—Global Studies in Comparative Law; Springer International Publishing: Berlin/Heidelberg, Germany, 2020; pp. 371–395, ISBN 978-3-030-28049-9.
46. European Conference of Ministers of Transport Young Drivers: The Road to Safety. 2006. Available online: https://www.oecd.org/itf/37556934.pdf (accessed on 22 April 2021).
47. Horberry, T.; Anderson, J.; Regan, M.A.; Triggs, T.J.; Brown, J. Driver Distraction: The Effects of Concurrent in-Vehicle Tasks, Road Environment Complexity and Age on Driving Performance. *Accid. Anal. Prev.* **2006**, *38*, 185–191. [CrossRef]
48. Witt, M.; Kompaß, K.; Wang, L.; Kates, R.; Mai, M.; Prokop, G. Driver Profiling—Data-Based Identification of Driver Behavior Dimensions and Affecting Driver Characteristics for Multi-Agent Traffic Simulation. *Transp. Res. Part F Traffic Psychol. Behav.* **2019**, *64*, 361–376. [CrossRef]
49. Harrison, Y.; Horne, J.A. The Impact of Sleep Deprivation on Decision Making: A Review. *J. Exp. Psychol. Appl.* **2000**, *6*, 236–249. [CrossRef]
50. Smith, S.S.; Horswill, M.S.; Chambers, B.; Wetton, M. Hazard Perception in Novice and Experienced Drivers: The Effects of Sleepiness. *Accid. Anal. Prev.* **2009**, *41*, 729–733. [CrossRef] [PubMed]
51. Sikander, G.; Anwar, S. Driver Fatigue Detection Systems: A Review. *IEEE Trans. Intell. Transp. Syst.* **2019**, *20*, 2339–2352. [CrossRef]
52. Blanco, M.; Hanowski, R.J.; Olson, R.L.; Morgan, J.F.; Soccolich, S.A.; Wu, S.-C.; Guo, F. The Impact of Driving, Non-Driving Work, and Rest Breaks on Driving Performance in Commercial Motor Vehicle Operations. 2011, pp. 1–99. Available online: https://vtechworks.lib.vt.edu/handle/10919/55114 (accessed on 22 April 2021).
53. Nishikitani, M.; Nakao, M.; Karita, K.; Nomura, K.; Yano, E. Influence of Overtime Work, Sleep Duration, and Perceived Job Characteristics on the Physical and Mental Status of Software Engineers. *Ind. Health* **2005**, *43*, 623–629. [CrossRef] [PubMed]
54. Proctor, S.P.; White, R.F.; Robins, T.G.; Echeverria, D.; Rocskay, A.Z. Effect of Overtime Work on Cognitive Function in Automotive Workers. *Scand. J. Work. Environ. Health* **1996**, *22*, 124–132. [CrossRef]
55. Gaspar, J.G.; Schwarz, C.W.; Brown, T.L.; Kang, J. Gaze Position Modulates the Effectiveness of Forward Collision Warnings for Drowsy Drivers. *Accid. Anal. Prev.* **2019**, *126*, 25–30. [CrossRef] [PubMed]