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Mobile phone use while driving indicators based on naturalistic driving data

Indicadores do uso do telefone celular ao volante com base em dados naturalísticos de direção

Thiago Noriyuki Kubo[1], **Arthur Hideio Noguti**[1,2], **Jorge Tiago Bastos**[1]
[1]Universidade Federal do Paraná, Curitiba, Paraná, Brasil
[2]Observatório Nacional de Segurança Viária, São José dos Campos, São Paulo, Brasil

Contact: thiago.kubo@ufpr.br, (TNK); arthur.noguti@onsv.org.br, (AHN); jtbastos@ufpr.br, (JTB)

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ABSTRACT
The use of mobile phones while driving is a known risk factor for road crashes. Little is known about the characteristics of mobile phone use as a secondary task while driving in Brazil. The aim of this study was to derive road safety performance indicators related to mobile phone use while driving from Brazilian naturalistic driving data. The methodology involved an observational study analyzing video footage from 32 drivers in Curitiba and the Metropolitan Region. The most common type of use was checking/browsing: 44.96% of all instances. The average frequency of use was 8.71 uses per hour, with an average duration of 55.34 seconds per use. On average, drivers reduced their speed by 6.32 km/h after initiating use, and increased it by 5.11 km/h after completing the task. Checking/browsing was the type of use associated with the greatest speed adaptation, showing an average reduction of 7.39 km/h at the start, and an average increase of 3.55 km/h at the end. In conclusion, speed adaptation during mobile phone use was related to the complexity of the activity, based on the required manual, visual, and cognitive demands. However, drivers did not perceive the increased risk of making a call or sending a voice message, highlighting the need for more effective measures to reduce engagement in secondary tasks while driving.

RESUMO
O uso do telefone celular ao volante é fator de risco reconhecido para a ocorrência de sinistros de trânsito. Pouco ainda se conhece sobre as características de uso do telefone celular como tarefa secundária à condução no Brasil. O objetivo deste estudo foi produzir e analisar indicadores de desempenho da segurança viária relacionados ao uso do telefone celular ao volante a partir de uma base de dados naturalísticos de direção. A metodologia consistiu em um estudo observacional com a análise de vídeos obtidos a partir do monitoramento da atividade real de condução de 32 condutores em Curitiba e Região Metropolitana. O uso mais comum foi para verificar/navegar – 44,96% dos usos. A frequência média de uso foi de 8,71 usos/h e a duração de 55,34 segundos por uso. Em média, os condutores reduziram a velocidade em 6,32 km/h após o início do uso e aumentaram em 5,11 km/h após a conclusão. Verificar/navegar foi o tipo de uso com maior adaptação de velocidade, apresentando uma redução média de 7,39 km/h ao iniciar o uso e um aumento médio de 3,55 km/h ao fim do uso. Em conclusão, a adaptação da velocidade para o uso do telefone celular foi relacionada à complexidade da atividade, conforme os níveis de demanda manual, visual e cognitiva. No entanto, os condutores não perceberam o acréscimo de risco nas ligações ou envio de mensagens de voz, evidenciado a necessidade de medidas mais efetivas para reduzir o engajamento na tarefa secundária de uso do telefone celular ao volante.

1. INTRODUCTION

Using a mobile phone while driving has a direct impact on the driver's actions, as well as on the performance of their driving task (Atwood et al., 2018; Backer-Grøndahl and Sagberg, 2011;

Bastos et al., 2020; Christoph, Wesseling and van Nes, 2019; Morgenstern, Schott and Krems, 2020; Oviedo-Trespalacios et al., 2018; Phuksuksakul, Kanitpong and Chantranuwathana, 2021; Schneidereit et al., 2017; Wijayaratna et al., 2019; Young and Lenné, 2010). This type of secondary task can lead to attention diversion and manual-visual distraction, which affects performance due to the repetitive shift in focus, the physical constraints of handling the device, and the redirection of the visual field within the vehicle (Atwood et al., 2018). Mobile phone use (MPU) while driving is currently recognized as one of the most dangerous road distractions (Young and Lenné, 2010).

Brazilian Traffic Law (Law No. 9,503 of September 23, 1997, Article 252, as amended by Law No. 13,281 of 2016) classifies driving with one hand as a serious infraction, except when signaling, changing gears, or activating vehicle equipment. However, holding or handling a mobile phone while driving elevates this to a very serious infraction. Despite these legal restrictions, MPU while driving remains a growing risk factor in Brazil (Bastos et al., 2020).

In Brazil, the 2019 National School Health Survey (IBGE, 2019) revealed that 38.10% of students aged 13 to 17 had ridden in a vehicle where the driver used a mobile phone in the past 30 days. The state of Paraná reported a slightly higher percentage at 39.40%, while Curitiba recorded 47.2%, the seventh-highest rate among Brazilian capitals.

Christoph, Wesseling and van Nes (2019) observed that before initiating an MPU event, most drivers were already engaged in an MPU-related subtask. According to the authors, a driver may wait for the 'right moment' to use a mobile phone if they hold it for an extended period. Driver engagement in MPU depends on the situation and environment. In more complex situations, drivers typically avoid secondary activities and maintain greater visual focus on the road (Ismaeel et al., 2020). Factors such as the presence of vehicles ahead, oncoming traffic, speed, and passengers influence this precaution (Tivesten and Dozza, 2014; Bastos et al., 2021). Morgenstern, Schott and Krems (2020) observed higher mobile phone use in low-speed situations and in vehicles stopped at red lights (2020).

After analyzing naturalistic data from the Second Strategic Highway Research Program Naturalistic Driving Study (SHRP 2 NDS), Schneidereit et al. (2017) identified 192 MPU events involving typing, with an average duration of 180 seconds, based on a selected portion of the database. Using the same database, Atwood et al. (2018) found an average of 1.6 text messages and 1.2 calls per hour. The study found that, on average, the risk of traffic crashes increased by 6.46% for each text message sent per hour. Kreusslein et al. (2020) analyzed mobile phone calls using the previously mentioned SHRP 2 NDS database and found that calls lasted an average of 549.6 seconds, with the handling stages before and after the call posing the highest risk.

To evaluate the effects of MPU at signalized intersections, Eldessouki and Almaneea (2023) found that this behavior reduced saturation flow at traffic lights due to a delay in vehicle departure when the light changed from red to green. This suggests that visual and auditory cues should be implemented to minimize departure delay. Ziakopoulos, Kontaxi and Yannis (2023), using naturalistic data from a mobile phone application, found that drivers used a mobile phone at least once in approximately 26.6% of trips.

Because the mobile phone interface is small due to the typical display size, users require greater focus (both visual and mental) to perform this task. This caused the user to become distracted while driving, which can lead to sudden changes in speed, braking, lane position, incorrect touches, and a loss of attention on the road (Khan et al., 2021). Additionally, the study noted that 15% of drivers used voice assistants (such as Google Assistant), 5% used Head-Up Displays, and 80% used the traditional mobile phone interface.

Variations in the assimilation of information acquired through peripheral vision — that is, information within the driver's field of vision but not necessarily processed — can be caused by cognitive distractions (Saifuzzaman et al., 2015). One of the most common adjustments drivers make is reducing speed to compensate for the additional cognitive demand (Törnros and Bolling, 2005). Wijayaratna et al. (2019) suggested, through a naturalistic study, a 2% to 5% reduction in speed during manual-visual MPU; while activities related to vocal engagement (calling or audio messages) did not cause variations in speed.

Reinforcing the concept of risk adaptation, Morgenstern, Schott and Krems (2020), based on a naturalistic study, compared instantaneous speeds 10 seconds before (I_1) and 10 seconds after (I_2) the beginning of message typing events ($\Delta_I = I_2 - I_1$), as well as the speeds 10 seconds before (C_1) and 10 seconds after (C_2) the conclusion of the events ($\Delta_C = C_2 - C_1$). Drivers reduced their speed by an average of 2.12 km/h during the initial interval (Δ_I), and increased their speed by an average of 2.14 km/h during the conclusion interval (Δ_C).

Based on this, the general objective of this paper was to derive road safety performance indicators related to mobile phone use while driving from Brazilian naturalistic driving data. The specific objectives of this work included: classifying mobile phone uses; computing the percentage of travel time spent on secondary mobile phone use activities (%); calculating the average speed during mobile phone use (km/h); determining the frequency of use (uses/h); measuring the average usage time (s); and determining whether using a phone while driving leads to a decrease in speed (as a form of risk compensation).

2. MATERIALS AND METHOD

2.1. Brazilian Naturalistic Driving Study

The "minimum viable prototype" principle and instrumentation from drivers' private vehicles guided the development of the Brazilian Naturalistic Driving Study. he study used three cameras – two facing outside the car (1 and 2) and one facing inside (3), as shown in Figure 1 – a laptop, a power inverter, and a GPS receiver to enable data collection. Image, positioning and speed data were recorded every second of the journey, without audio recording, to ensure a certain level of privacy for the driver.

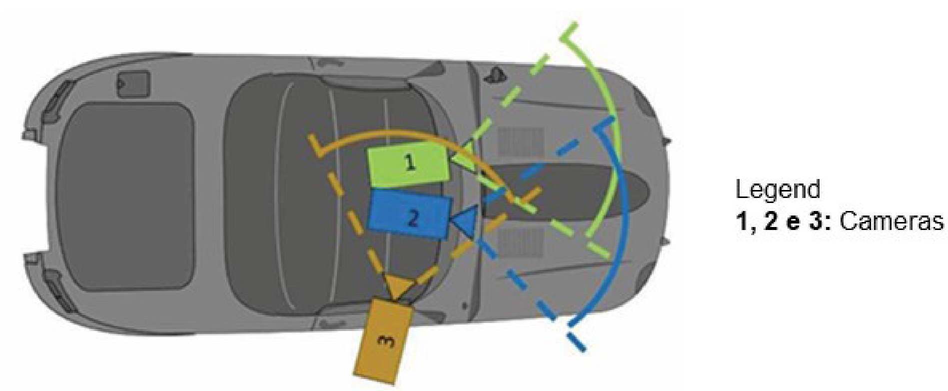

Figure 1. Position of cameras in the vehicle.

The study recruited 32 drivers, who completed a total of 924 trips. The trips took place in the metropolitan region of Curitiba, Paraná, Brazil. The first trip of each driver was discarded to allow for an acclimation period to the monitoring system procedures, and only valid times were used in the analysis. Out of a total of 381.45 hours of travel, 299.08 hours were considered valid. To classify each second of travel as valid time, the data must meet the following criteria: video images and GPS data must be provided; the vehicle must be running; and the handbrake must be deactivated (lowered).

The participating drivers consisted of 14 males and 18 females, with ages ranging between 20 and 62 years. Of the total sample, 29 drivers used the vehicle for conventional purposes, while three were mobility app drivers. The average driving time ranged from seven to fourteen days for each driver; however, mobility app drivers had a shorter data collection period due to their higher number of trips.

2.2. Mobile phone use analysis (MPU)

Analysis of videos from the vehicle's internal camera allowed the identification of mobile phone use while driving. MPU events were classified into 6 categories:

a) Typing: starts when the driver moves their hands towards the mobile phone, then touches the screen with one or both hands several times consecutively, ending when the driver releases the device and regains visual contact with the road or starts another secondary activity;

b) Calling/voice message: starts when the driver moves his/her hands towards the mobile phone, then uses it to make calls or listen to/send audio messages on applications, ending when the driver releases the device and resumes visual contact with the route or start another secondary task;

c) Holding: starts when the driver moves his/her hand towards the mobile phone, then keeps it in his/her hands without viewing or using the device, ending when the driver releases the device and regains visual contact with the road or starts another secondary task;

d) Using on-holder: it starts when the driver moves his/her hands towards the mobile phone, then uses it while held by a support fixed to the vehicle dashboard, ending when the driver finishes manual contact with the device and resumes visual contact with the device or starts another secondary task;

e) Checking/browsing: starts when the driver moves his/her hands towards the mobile phone, then touches the mobile phone screen and maintains visual and/or manual contact with the device to view content, ending when the driver releases the device and resumes visual contact with the road or begins another secondary task;

f) Other: begins when the driver moves his/her hands towards the mobile phone, then uses it for any purposes other than those previously described, such as taking a picture or using the device's flashlight, ending when the driver releases the device and resumes visual contact with the road or initiates another secondary task.

By manually coding the behaviors identified in the videos, this study recorded 3,620 MPU events. These events generated six indicators for analysis: average mobile phone usage time (overall and by category) (s); percentage of trips involving mobile phone use (%); percentage of time spent using a mobile phone (overall and by category) (%); frequency of MPU events (uses/h); average instantaneous speed during MPU (overall and by category) (km/h); and variation in average instantaneous speed by MPU category compared to the baseline (without mobile phone use) (km/h). Because each use occurred under specific conditions—such as the driver's attention level, mood, conversation content, time of day, traffic, and driving environment—MPU events were treated as independent.

To analyze speed adaptations as a form of risk compensation, this study considered four average speeds for each event: the average speed between 8 and 10 seconds before the start of MPU (S_1), the average speed between 8 and 10 seconds after the start of MPU (S_2), the average speed between 8 and 10 seconds before MPU completion (S_3), the average speed between 8 and 10 seconds after MPU completion (S_4). The speeds S_1, S_2, S_3 and S_4 correspond to the average of the three instantaneous speeds within each considered interval. Figure 2 shows the speeds S_1, S_2, S_3, and S_4 arranged along a timeline (seconds).

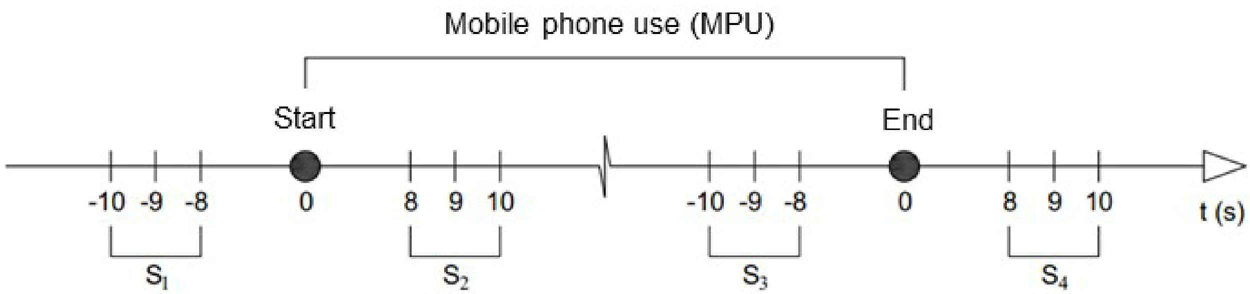

Figure 2. Speeds for adaptation analysis.

The procedure to verify speed adaptation involved comparing speeds S_1 and S_2 and between speeds S_3 and S_4 for each MPU event. Any MPU event lasting less than 20 seconds was excluded from this analysis. In cases where the interval between the end of one event and the beginning of the next was less than 10 seconds, the previous event interfered with the S_1 of the following event. Therefore, the following event was discarded to eliminate any S1 speeds that contained MPU data. After applying these filters, of the 3,620 MPU events identified in the study, 1,104 events remained for analysis of speed adaptation as a risk compensation strategy.

To statistically validate the comparison data, this study first applied the Anderson-Darling normality test to classify the data as normally or non-normally distributed. The Kruskal-Wallis non-parametric test was used with a significance level of 5%, as none of the data sets followed a normal distribution.

3. RESULTS

3.1. Classification of mobile phone use while driving

In total, this study recorded 25.35 hours of mobile phone use while driving, which accounted for 8.61% of the total valid driving time. When analyzed by trip, the average mobile phone usage per trip was 7.31%. This means that for every 14 minutes of travel, drivers engaged in secondary mobile phone activities for approximately 1 minute. Checking/browsing was the most common type of use (839 uses and total duration of 18,799 seconds), followed by using on-holder (695 uses and total duration of 17,149 seconds). Table 1 details the distribution of uses, as well as the total duration for each type of MPU.

Table 1: Number of mobile phone uses by duration and category

Type of use	Number of uses	Porcentage of uses (%)	Time using (s)	Time using (%)
Calling/voice message	41	2.20%	7,655	13.72%
Holding	183	9.81%	7,406	13.27%
Checkin/browsing	839	44.96%	18,799	33.69%
Using on-holder	695	37.25%	17,149	30.73%
Typing	95	5.09%	4,332	7.76%
Others	13	0.70%	459	0.82%
Total	1,866	100.00%	55,800	100.00%

3.2. Duration and frequency of mobile phone uses

After analyzing all valid trips, the average frequency of MPU events was 8.71 uses per hour, meaning drivers engaged in an MPU event approximately every 7 minutes of travel. For trips with recorded MPU events, the average duration per use was 56.34 seconds. Among the different types of use, the 'calling/voice message' category had the longest duration, averaging 3.11 minutes (186.71 seconds) per use. In comparison, Funkhouser and Sayer (2012) found that the average duration of calling/voice message events in the United States was 2.60 minutes. In Sweden, Tivesten and Dozza (2014) recorded an average typing duration of 55.20 seconds for text messages. The nearly one-minute duration of each mobile phone use event presents a significant road safety hazard. At an average speed of 17.06 km/h (the general average speed during MPU events), this equates to 267 meters traveled with divided attention.

3.3. Average speeds and speed variation for mobile phone use

According to Table 2, each type of MPU had a different average speed, which varied depending on the complexity of the secondary task and the traffic conditions encountered while performing it. The average speed variation (%) represents the ratio of the average speed variation for each type of use (km/h) to the average speed without MPU (km/h), allowing for comparison of variations under the same baseline.

Table 2: Average speeds and average speed variation for MPU, by type of use

Type of use	Average speed (km/h)	Average speed variation	
		(km/h)	(%)
Calling/voice message	21.04	-5.31	-20.45%
Holding	18.06	-8.47	-32.60%
Checkin/browsing	14.99	-11.00	-42.34%
Using on-holder	21.58	-4.34	-16.71%
Typing	10.25	-13.27	-51.10%
Others	13.23	-7.99	-30.75%
Without MPU	25.97	-	-

During MPU events related to checking/browsing and typing, drivers tended to reduce their average speed more significantly (reduction of 42.24% and 51.10%, respectively). In terms of absolute values for average speeds, typing was the type of use with the lowest average (10.25 km/h), which may indicate a more significant cognitive, visual and manual demand for engaging in this secondary task; checking/browsing also required similar demands, resulting in relatively low average speeds (14.99km/h). Calling/voice messages, which required low or no visual demand or loss of visual contact with the traffic lane, and using on-holder, which required low manual demand, reached average speeds exceeding 20km/h.

Figure 3 contains the box-plot graph of average speeds according to the type of MPU discarding the uses that occurred with the vehicle speed equal to zero. All medians were below 20 km/h, although some uses occurred at speeds exceeding 70 km/h. Statistical analysis using the Kruskal-Wallis non-parametric comparison test – H (N = 736) = 54.11, $p \leq 0.001$ – indicated that the average speeds during MPU were statistically different (considering a 5% significance level). The speed while texting on a mobile phone was lower than that for all other types of use, whereas the speed during calls or voice messages was higher than for any other use.

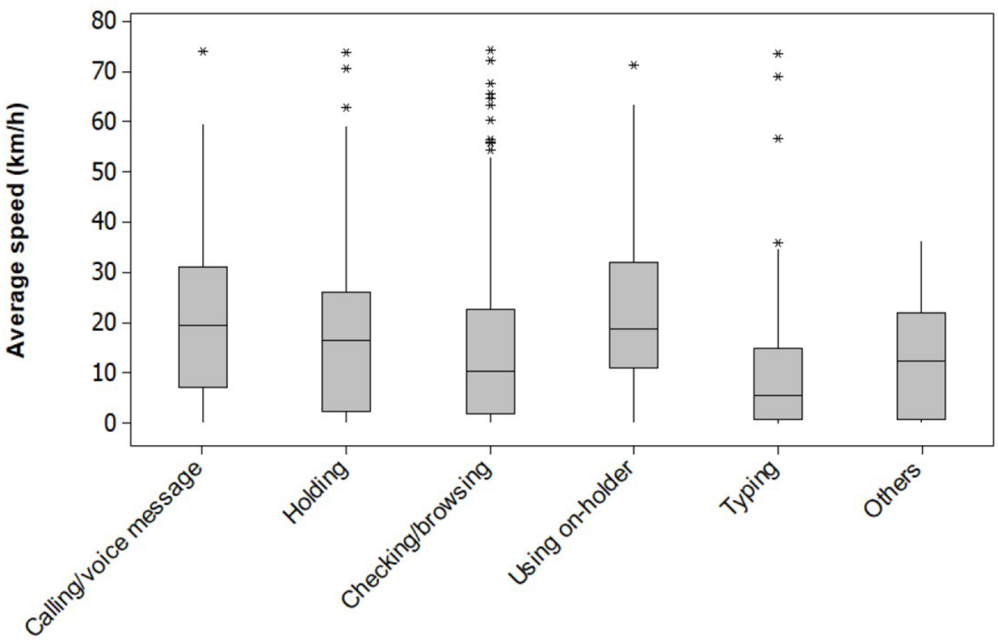

Figure 3. Box-plot graph of average speeds by type of MPU.

3.4. Speed adaptation as a form of risk compensation

In order to analyze the potential speed adaptation as a way to compensate for the increased cognitive, visual, and manual demands associated with MPU, this study examined 1,104 MPU events. Table 3 details the average speeds evaluated, as well as the variations between S_1 and S_2, and between S_3 and S_4 speeds.

Checking/browsing and typing, both of which involve visual distraction, resulted in significant speed reductions (-7.39 km/h and -9.94 km/h, respectively) immediately after mobile phone use began. This suggests drivers instinctively compensate for the increased risk. Similarly, the 'others' category, which may include tasks requiring visual or cognitive effort, showed the largest speed decrease (-13.56 km/h).

Table 3: Average speeds before and after the start and end of a MPU event

Type of use	S_1 (km/h)	S_2 (km/h)	S_3 (km/h)	S_4 (km/h)	S_2–S_1 (km/h)	S_4–S_3 (km/h)
Calling/voice message	20.63	21.52	22.02	22.92	+ 0.88	+ 0.90
Holding	22.53	16.58	13.21	17.01	- 5.95	+ 3.80
Checkin/browsing	21.18	13.79	10.27	13.82	- 7.39	+ 3.55
Using on-holder	22.75	17.80	14.93	18.01	- 4.96	+ 3.08
Typing	17.16	7.22	9.40	12.85	- 9.94	+ 3.45
Others	16.75	3.19	6.91	21.92	- 13.56	+15.02
Average	20.62	14.29	14.23	19.33	- 6.32	+ 5.11

Calling/voice message did not result in a reduction in speed when starting the task, nor a significant increase in speed after completing the task. his suggests that this type of MPU did not influence the driver's decision to adjust speed as a form of risk compensation. In contrast, checking/browsing, using on-holder, holding and typing showed similar increases (approximately 3 km/h) after completing the secondary task (S_4–S_3), indicating that drivers tended to gradually return to their baseline speeds (when not using the mobile phone).

In general, the speed reduction between S_1 and S_2 averaged 6.32 km/h, while the speed increase between S_3 and S_4 averaged 5.11 km/h. With the exception of calling/voice message uses, drivers tended to reduce their speed after starting the MPU event and increase their speed after completing the MPU event. This may indicate a speed adaptation strategy aimed at compensating for the increased risk. Table 4 presents the descriptive statistics for the speeds S_1, S_2, S_3, and S_4.

Table 4: Descriptive statistics of speeds S_1, S_2, S_3 and S_4

Speed interval	Average (km/h)	Std. Dev. (km/h)	Min. (km/h)	Q1 (km/h)	Median	Q3 (km/h)	Max. (km/h)
S_1	22.09	21.01	0.00	1.03	19.61	36.46	137.60
S_2	16.89	20.13	0.00	0.14	8.11	30.93	142.59
S_3	16.61	20.52	0.00	0.15	5.50	31.05	126.49
S_4	21.08	20.85	0.00	0.43	18.24	35.52	125.85

Beyond average speed comparisons, the data revealed factors influencing speed reduction during mobile phone use (MPU). Although speeds exceeding 100 km/h were occasionally observed at the beginning and end of MPU events, these instances were too infrequent to establish a clear pattern. Maximum speeds across the analyzed intervals (S_1–S_4) ranged from 14.59 km/h to 125.85 km/h. For the full sample, which included all types of MPU, statistical analysis using the non-parametric Kruskal-Wallis test – $H (N = 1{,}104) = 46.22$, $p \leq 0.001$ – indicated that the values of S_1 were statistically higher than S_2 values at a 5% significance level. This suggests that drivers compensated for the increased risk associated with engaging in the secondary task by reducing their speed, or possibly waited for slower traffic conditions before using their devices. Additionally, for the same sample, statistical analysis using the Kruskal-Wallis test – $H (N = 1{,}104) = 40.68$, $p \leq 0.001$ – indicated that the S_3 values were statistically lower than S_4 values at a 5% significance level. This result suggests that drivers either resumed higher speeds after the MPU ended or maintained their speed reduction until they reached a new speed increase.

Table 5 presents the results of the Kruskal-Wallis non-parametric comparison test, applied at a 5% significance level, for each type of mobile phone use. The results indicated that: (i) for calling/voice message, the values of S_1 were not statistically higher than those of S_2, and the values of S_3 were not statistically lower than those of S_4; (ii) for holding, S_1 was not statistically higher than S_2, but S_3 was statistically lower than S_4; (iii) for checking/browsing and using on-holder, S_1 was statistically higher than S_2, and S_3 was statistically lower than S_4; and (iv) for typing, S_1 was statistically higher than S_2, but S_3 was not statistically lower than S_4.

Table 5: Results of the Kruskal-Wallis non-parametric test by MPU classification

Type of use	Hypothesis	n	H	p-value	α	Statistically significant
Calling/voice message	$S_1 > S_2$	37	0.18	0.668	0.05	No
Calling/voice message	$S_3 < S_4$	37	0.30	0.581	0.05	No
Holding	$S_1 > S_2$	63	2.74	0.098	0.05	No
Holding	$S_3 < S_4$	63	5.89	0.015	0.05	Yes
Checking/browsing	$S_1 > S_2$	337	33.73	≤0.001	0.05	Yes
Checking/browsing	$S_3 < S_4$	337	20.24	≤0.001	0.05	Yes
Using on-holder	$S_1 > S_2$	142	4.20	0.040	0.05	Yes
Using on-holder	$S_3 < S_4$	142	3.92	0.048	0.05	Yes
Typing	$S_1 > S_2$	60	19.74	≤0.001	0.05	Yes
Typing	$S_3 < S_4$	60	1.68	0.195	0.05	No

Similar to the methodology applied by Kreusslein et al. (2020), Morgenstern, Schott and Krems (2020) compared speeds 10 seconds before and after the start and end of text message sending events. In general, drivers tended to reduce speed at the start of the event, while they tended to increase speed as the event concluded.

The results of this study (NDS-BR) were compared with those obtained in international studies regarding the uses for calling/voice messages and typing, as shown in Tables 6 and 7.

Table 6: Comparison of speed adaptation with international studies for calling/voice message

Study	Hypothesis 1	Variation (km/h)	Hypothesis 2	Variation (km/h)	Statistically significant
NDS-BR (ONSV, 2025)	$S_1 > S_2$	+ 1.82	$S_3 < S_4$	+ 2.88	No (1) / No (2)
Kreusslein et al. (2020)	$I_{-10} > I_{+10}$	–0.17	$C_{-10} < C_{+10}$	+ 0.47	No (1) / No (2)
Kreusslein et al. (2020)	$I_{-20} > I_{+20}$	+ 1.41	$C_{-20} < C_{+20}$	+ 0.97	No (1) / No (2)

Table 7: Comparison of speed adaptation with international studies for typing

Study	Hypothesis 1	Variation (km/h)	Hypothesis 2	Variation (km/h)	Statistically significant
NDS-BR (ONSV, 2025)	$S_1 > S_2$	–10.80	$S_3 < S_4$	+ 3.55	Yes (1) / No (2)
Morgenstern, Schott and Krems (2020)	$I_{-20} > I_{+20}$	–2.12	$C_{-20} < C_{+20}$	+ 2.14	Yes (1) / Yes (2)

CONCLUSION

The Brazilian Naturalistic Driving Study (NDS-BR) provided mobile phone use indicators by analyzing data from 32 drivers across 299.08 valid hours of driving. This analysis allowed for the identification of drivers' behavioral characteristics when engaging in mobile phone use events (MPUs). The category with the highest frequency and duration of use was checking/browsing, followed by using the phone on a holder. Calling/voice messages had the longest duration per use, which, along with the speed adaptation data, suggested that drivers did not perceive the risk of engaging in calling/voice message tasks while driving. When compared to results from international studies, the average duration of calling/voice messages in this study was longer, while texting events were shorter.

The comparison of speeds during the initiation and completion of MPU secondary tasks allowed for the calculation of indicators that, in general, demonstrated speed adaptations as a way to compensate for the risks associated with engaging in MPU secondary tasks while driving. Through statistical tests with a 5% significance level, this study found that drivers tended to reduce their speed when starting a mobile phone-related secondary task or, in some cases, waited for lower-speed situations before engaging in the task. Similarly, at the end of the MPU, drivers generally returned to higher speeds or continued using the mobile phone until their speed increased again.

The speeds observed during each type of MPU can be linked to the complexity of the secondary task, depending on the manual, visual, and cognitive demands involved. The calling/voice message category did not result in a statistically significant variation in speed, which is concerning as it suggests that drivers may not perceive the risk associated with this task. This highlights the need for more effective measures to encourage safer driving behaviors. In contrast, the checking/browsing and using on-holder categories showed statistically significant reductions in speed when starting the MPU and increases in speed when completing it, indicating an adaptation strategy as a form of risk compensation.

The results regarding mobile phone use for calling/voice messages and speed adaptation were consistent with those found in international studies, where differences in speeds evaluated during risk compensation analysis were not statistically significant. Consequently, there was no evidence of speed adaptations while engaging in calling/voice messaging.

Although this study recorded 3,620 instances of mobile phone use, it included only 32 drivers, which is a relatively small sample size. The primary recommendation is to expand the sample size to achieve more representative results. Additionally, including drivers from other cities across Brazil would enable the extrapolation of findings to a national level and potentially reflect the behavior of Brazilian drivers more accurately. By increasing the sample, it would also be possible to analyze indicators categorized by factors such as gender, age, and/or years of driving experience, as well as to explore the frequency of mobile phone use based on the time of day and/or day of the week.

It is also important to note that using computer vision technology to identify mobile phone use can be an effective strategy for optimizing naturalistic studies. This technology is capable of automating repetitive tasks, significantly reducing the time required for manually coding mobile phone use events.

AUTHORS' CONTRIBUTIONS

TNK: Conceptualization, Writing – original draft, Writing – review & editing, Investigation, Methodology, Visualization; AHN: Writing – original draft, Writing – review & editing, Investigation; JTB: Project administration, Formal analysis, Funding acquisition, Conceptualization, Data curation, Writing – original draft, Writing – review & editing, Investigation, Methodology, Resources, Supervision, Validation, Visualization.

CONFLICTS OF INTEREST STATEMENT

The authors declare that there is no conflict of interest.

USE OF ARTIFICIAL INTELLIGENCE-ASSISTED TECHNOLOGY

The authors declare that no artificial intelligence tools were used in the research reported here or in the preparation of this article.

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