Accident Analysis and Prevention 215 (2025) 107992

Contents lists available at ScienceDirect

Accident Analysis and Prevention

journal homepage: www.elsevier.com/locate/aap

Riding with distraction: Exploring the intention and behaviour of smartphone use while riding among motorcyclists in Vietnam

Ha Hoang [a,b], Mehdi Moeinaddini [c], Mario Cools [a,d,e,*]

[a] Local Environment Management & Analysis (LEMA), Urban and Environmental Engineering (UEE), University of Liège, Quartier Polytech 1, Allée de la Découverte 9, Liège, 4000, Belgium
[b] University of Economics - The University of Danang, 71 Ngu Hanh Son, Danang, 550000, Viet Nam
[c] Centre for Public Health, Queen's University Belfast, University Rd, Belfast, BT7 1NN, UK
[d] Faculty of Business Economics, Hasselt University, Agoralaan Gebouw D, Diepenbeek, 3590, Belgium
[e] Department of Mathematics, Education, Econometrics and Statistics (MEES), KULeuven Campus Brussels, Warmoesberg 26, Brussels, 1000, Belgium

ARTICLE INFO

Keywords:
Smartphone use while riding
Distracted driving
Road safety
Motorcyclists
TPB
SOR

ABSTRACT

The pervasive use of smartphones has significantly contributed to distracted driving, a leading cause of road traffic accidents globally. This study investigates the behavioural intentions and patterns of smartphone use while riding among motorcyclists in Vietnam, integrating the Theory of Planned Behaviour (TPB) with the Stimuli-Organism-Response (SOR) framework to encompass factors such as riding exposure and time pressure. A questionnaire survey was conducted, gathering data from 1,051 young motorcyclists. Using Partial Least Squares Structural Equation Modelling (PLS-SEM), the study identifies high levels of smartphone engagement during riding, driven primarily by Perceived Behavioural Control (PBC), which exhibited a stronger influence on behaviour than Attitudes and Social Norms. Notably, time pressure significantly enhanced the intention to use smartphones, suggesting that riding under time constraints could exacerbate the risk of distracted riding incidents. The findings highlight critical implications for road safety interventions and policy formulation, emphasising the need for targeted educational programmes and stricter enforcement measures to mitigate smartphone-induced distractions among motorcyclists at a higher risk of traffic accidents. The study contributes to understanding distracted riding behaviours in motorcycle-dominant regions, providing a foundation for future research and preventive strategies.

1. Introduction

Distracted road use has become a primary contributor to traffic accidents worldwide, with the pervasive nature of distraction leading to its classification as a public health crisis (Olson et al., 2009; Wilson and Stimpson, 2010; Swedler et al., 2015; Parr et al., 2016; McDonald et al., 2018; Montuori et al., 2021; Garsten, 2023). Among the various sources of distraction, smartphone use while driving (SWD) stands out as a particularly significant factor, contribution to traffic accidents across both developed and developing contexts (Olson et al., 2009; Madden and Rainie, 2010; Koppel et al., 2011; Farmer et al., 2015; WHO, 2018; Truong and Nguyen, 2019). Approximately two-thirds of adults engage in phone conversations while driving, further highlighting the ubiquity of smartphone distraction on the road (Ortiz et al., 2017; Shaaban et al., 2020). Despite substantial research on SWD among car drivers (McEvoy et al., 2006; Ishigami and Klein, 2009; Backer-Grøndahl and Sagberg, 2011; Holland and Rathod, 2013; Stavrinos et al., 2013; Dingus et al., 2016; Brown et al., 2019), the body of literature addressing smartphone use while riding (SWR) among motorcyclists is still limited (Islam, 2021). This gap is particularly notable given that motorcyclists face distinct risks compared to drivers, such as increased exposure to traffic elements and the absence of protective barriers (National Center for Statistics and Analysis, 2018). Motorcyclists' vulnerability to road injuries highlights the urgency of dedicated SWR research (Gunson et al., 2019), especially among young riders who are frequently high adopters of mobile technology (Ortiz et al., 2018).

SWD and SWR share similarities in their impact on user attention. Research indicates that the motivations and cognitive distractions associated with smartphone use show significant similarities across different modes of transport. For example, Ichikawa and Nakahara (2008) examined phone use among cyclists, while Truong et al. (2017, 2019) investigated motorcyclists, and Lennon et al. (2017) explored phone

* Corresponding author at: Local Environment Management & Analysis (LEMA), Urban and Environmental Engineering (UEE), University of Liège, Quartier Polytech 1, Allée de la Découverte 9, Liège, 4000, Belgium.
E-mail address: mario.cools@uliege.be (M. Cools).

https://doi.org/10.1016/j.aap.2025.107992
Received 1 May 2024; Received in revised form 12 February 2025; Accepted 4 March 2025
Available online 14 March 2025

Table 1
Summary of research on smartphone use while riding in Vietnam.

Study	Sample, Method	Objectives	Key factors
Truong and Nguyen (2019)	549 motorcycle taxi riders; Binary logistic regression	Explored the correlation between SWR and crashes	Motorcycle type, SWR, crashes
Nguyen et al. (2020)	291 motorcyclists; CB-SEM	Investigated motorcyclists' SWR intention and behaviour	TPB, habits, health motivation
Nguyen-Phuoc et al. (2020)	529 motorcyclists, 328 car drivers; SEM	Examined attitudes, beliefs, and perceived risks associated with SWR	SWR, attitudes, beliefs, perceived risk
Nguyen et al. (2024)	558 motorcycle delivery riders; PLS-SEM and ANN	Assessed SWR determinants in delivery riders using the Job Demands-Resources (JD-R model)	JD-R model attributes, socio-economic factors
This study	1051 young motorcyclists; PLS-SEM	Analyse the impact of driving exposure and time pressure on SWR behaviour	TPB, Stimulus-Organism-Response (SOR) framework, time pressure, riding exposure

use among pedestrians. The findings from these studies reveal that behaviours and risks related to smartphone distraction are consistent across various types of road users, with cognitive distractions impacting essential driving functions in similar ways across modes (National Safety Council, 2012; Topolšek and Ojsteršek, 2017; Nguyen-Phuoc et al., 2020). However, SWR poses unique challenges, particularly in environments with high motorcycle prevalence and mixed traffic flows. Thus, this study addresses an important gap in road safety literature by examining SWR specifically among young motorcyclists, a demographic that displays distinct behaviour and exposure patterns (Lesch and Hancock, 2004; Walsh et al., 2008; Hossain et al., 2023).

Vietnam provides an especially pertinent context for studying SWR due to its unique traffic environment, with motorcycles accounting for over 60% of road fatalities and the highest motorcycle ownership and usage rates globally (WHO, 2018; Truong and Nguyen, 2019; Bui et al., 2022). The high prevalence of motorcycles, combined with a rapidly growing young population of smartphone users (Do et al., 2018), amplifies the risks associated with SWR. Vietnam, along with other Southeast Asian countries, has undergone rapid digital adoption, where mobile technology has become an integral part of daily life, including road usage. This swift integration of smartphones has transformed the road environment, creating new safety concerns that demand immediate attention (Yannis et al., 2007; Regev et al., 2018). Examining SWR in Vietnam sheds light on how mobile technology adoption impacts road safety in developing countries and provides critical insights for designing targeted interventions in similar contexts globally. By focusing on Vietnam, this research contributes valuable insights into the broader implications of digital integration in traffic systems where vulnerable users, such as motorcyclists, dominate.

A review of prior research on smartphone use while riding (SWR) in Vietnam underscores the growing attention to this issue among motorcyclists (Table 1), yet also highlights important research gaps. For instance, Truong and Nguyen (2019) analysed the correlation between SWR and crashes among 549 motorcycle taxi riders using binary logistic regression, finding a significant association between SWR and increased crash risk, particularly concerning the type of motorcycle used. Nguyen et al. (2020) employed covariance-based structural equation modelling (CB-SEM) with a sample of 291 motorcyclists to examine factors influencing SWR, incorporating the Theory of Planned Behaviour (TPB) and factors like health motivation and habitual use. Nguyen-Phuoc et al. (2020) expanded on this by comparing 529 motorcyclists and 328 car drivers, utilising structural equation modelling (SEM) to study attitudes, beliefs, and perceived risks related to SWR, particularly emphasising differences in risk perception between vehicle types.

In the latest study, Nguyen et al. (2024) focused on 558 motorcycle delivery riders, applying partial least squares-SEM and artificial neural networks (ANN) within the Job Demands-Resources (JD-R) model to explore how job demands and socio-economic factors drive SWR. Despite these contributions, none of these studies addressed the situational factors that may affect SWR, such as time pressure and riding exposure in mixed-traffic environments. Our study fills this gap by examining SWR among 1051 young motorcyclists using a unique combination of TPB and the Stimulus-Organism-Response (SOR) framework, with a specific focus on time pressure and driving exposure—factors not previously explored. Through this approach, we build on and expand existing knowledge by incorporating situational pressures into a theoretical framework, offering a comprehensive understanding of SWR behaviour in a complex traffic environment.

This study adopts an innovative approach by integrating situational factors like time pressure and riding exposure within the TPB and the Stimulus-Organism-Response (SOR) framework, marking the first application of these theories in a SWR context. The TPB, which has been widely used to predict behavioural intentions based on attitudes, subjective norms, and perceived behavioural control (Ajzen, 1991; Kong et al., 2021; Montuori et al., 2021; Qu et al., 2020; Wang et al., 2020), is complemented here by the SOR framework, which considers environmental stimuli and emotional responses in influencing behaviour (Jacoby, 2002). By incorporating time pressure and riding exposure into these frameworks, this study adds a unique layer of analysis to existing SWR research, providing insights into the interplay of psychological and situational factors that drive SWR behaviour. This methodological innovation strengthens the study's contribution to the literature by offering a nuanced view of SWR that considers both internal motivations and external pressures in high-risk, mixed-traffic environments. Riding under time pressure is linked to various recognised factors like speeding and road rage, yet research exploring its connection with SWR remains limited (Parker et al., 1995; Stern, 1999; Fuller et al., 2009; Cœugnet et al., 2013a; Rendon-Velez et al., 2016).

Vietnam's mixed-traffic environment, characterised by dense interactions among cars, motorcycles, bicycles, and pedestrians, mirrors traffic patterns increasingly found in many rapidly urbanising cities across Asia, Africa, and Latin America. Such environments are becoming more common in urban settings worldwide, particularly in low- and middle-income countries where motorcycles serve as a primary transportation mode. This study's findings offer valuable insights for understanding the risks and behaviours associated with SWR in similarly complex traffic contexts globally. Furthermore, young motorcyclists are often early adopters of technology and exhibit different risk profiles compared to older drivers (Lesch and Hancock, 2004; Walsh et al., 2008; Hossain et al., 2023), which may predict trends in SWR behaviour as smartphone use among motorcyclists grows worldwide. By analysing SWR among young Vietnamese riders, this research also emphasises the importance of early interventions targeted at young motorcyclists, whose high rates of smartphone use and risk-taking behaviour underline the need for proactive measures in preventing SWR-related incidents. This study's insights are broadly applicable to other regions where motorcycles dominate road usage and provide critical perspectives on SWR's impact on traffic safety in mixed-traffic settings worldwide.

2. Theoretical framework, literature review and hypothesis development

Section 2 elaborates on the theoretical frameworks and the empirical groundwork that underpin our study. This section is structured into two primary subsections: the theoretical framework that introduces the adapted models and a comprehensive literature review that supports our hypothesis formulation.

2.1. Theoretical framework

2.1.1. Theory of planned behaviour (TPB)

The theory of planned behaviour is a theory used to predict and understand behaviours. It posits that behaviours are immediately determined by behavioural intentions, which in turn are determined by a combination of three factors: attitude towards the behaviour, subjective norms, and perceived behavioural control (Ajzen, 1991). The Theory of Planned Behaviour (TPB) is a widely employed predictive model for social behaviour, finding application in diverse fields (see, e.g., Rozenkowska (2023) and Zhang and Li (2020)). The TPB has also garnered considerable attention in traffic behaviour research. It has evolved into a prevalent framework in road safety, employed to elucidate the intricate decision-making processes of drivers (Subhan et al., 2021). Numerous investigations attest to the efficacy of TPB in forecasting the intentions and conduct of drivers across diverse road safety scenarios, including speeding (Chen and Chen, 2011; Cristea et al., 2013), distracted driving (Prat et al., 2015; Swedler et al., 2015), fatigued driving (Jiang et al., 2017; Watling, 2014), drink-driving (Moan and Rise, 2011; Potard et al., 2018), and aggressive driving (Forward, 2009; Iversen, 2004). The Theory of Planned Behaviour (TPB) model has found extensive application in forecasting the conduct of drivers using mobile phones. In a study examining motorcyclists in Vietnam, Nguyen et al. (2020) extended the TPB by incorporating additional variables such as habit and health motivation to assess their influence on intentions and behaviour related to smartphone use while riding. Scholars acknowledge the model's effectiveness in explicating intentional behaviours within this context (Brandt et al., 2022; Gauld et al., 2014b; Qu et al., 2020).

Despite the widespread application of the TPB in the domain of road safety, scholars have underscored the inadequacy of exclusively relying on traditional TPB constructs (with three cognitive variables) to thoroughly explicate the intentions and behaviours of drivers (Gauld et al., 2016; Murphy et al., 2020; Walsh et al., 2008). Ajzen (2002) and Armitage and Conner (2001) have emphasised the adaptability of the TPB framework, enabling the integration of additional predictors to improve its prediction and understanding. Consequently, many studies have expanded the TPB model by incorporating additional constructs such as descriptive norm (Waddell and Wiener, 2014), phone addiction and distraction perception (Jiang et al., 2019), and habit (Zhou et al., 2009) to explain drivers' SWD and SWR behaviour.

2.1.2. Stimulus – Organism – Response (SOR) theory

The Stimulus-Organism-Response (SOR) theory serves as a theoretical framework that explains human behaviour by analysing the interaction between environmental stimuli, the inside psychological development of individuals, and their behavioural reactions (Jacoby, 2002). This theory has gained attention and application across various fields, as evidenced in research on consumer purchasing behaviour (Chang et al., 2011; Li et al., 2021), peer-to-peer payment system usage behaviour (Irimia-Diéguez et al., 2023), and travel experiences (Chen et al., 2022). This theory allows for a nuanced comprehension of human behaviour, particularly when combined with the Theory of Planned Behaviour (TPB) (Liu et al., 2023). From this theory, external stimuli, such as situational elements and the environment, impact an individual's cognitive processes and feelings, thereby shaping their behavioural reaction. The SOR theory highlights the role of psychological conditions and processes as intermediaries between stimuli and responses. It accentuates the crucial need to comprehend cognitive and emotional mechanisms as the foundational underpinnings of behaviour.

However, using the SOR framework to explain traffic behaviour remains relatively limited despite its proven impact and foundation in various other research domains (Jacoby, 2002; Laato et al., 2020). Integrating the SOR framework in this study allows for an investigation into specific external stimuli, individual psychological factors, and situational contexts that contribute to mobile phone use while riding, particularly factors like riding frequency and time pressure. Time pressure is a prevalent issue in modern life, where everyone aims to accomplish as much as possible with limited time. This integration aims to examine the relationship between these external factors (e.g., time pressure) and behavioural responses, providing more nuanced insights into the underlying influences on behaviour.

While the TPB primarily focuses on psychological determinants, such as attitudes, subjective norms, and perceived behavioural control, the SOR model enhances the explanatory power of TPB by incorporating environmental stimuli (e.g., time pressure and driving exposure) and examining their psychological impact on individuals (organism), which ultimately leads to behavioural responses. This addition enables a deeper exploration of how external stimuli influence behaviour through psychological processes, especially for motorcyclists, where environmental distractions can significantly affect behaviour. The SOR model thus offers a framework for understanding how external stimuli shape perceptions and behaviours—an area that TPB alone may not fully address, as previous researchers have noted (Liu et al., 2023; Haq et al., 2024; Shi et al., 2024). This is particularly relevant in the context of distracted driving, where external pressures like time constraints and situational distractions may strongly influence motorcyclists' behaviours.

By integrating the SOR model, the study aims to capture these external factors more effectively, allowing for a richer and more comprehensive understanding of the ways in which perceptions and behaviours are shaped, thereby enhancing the study's explanatory scope. Therefore, the knowledge gained from this research is expected to support the development of interventions and policies to reduce this risky behaviour and promote safer driving practices.

2.2. Literature review and formulation of hypotheses

Having outlined the theoretical foundations with TPB and SOR, we now turn to a critical examination of existing literature. This review not only contextualises our study within current research but also highlights gaps that our hypothesis seeks to address.

2.2.1. Riding exposure

"Driving exposure", defined as the frequency with which individuals participate in traffic and the potential for traffic-related incidents, is influenced by factors such as urbanisation and the consequent increase in commuting distances (Carroll, 1973; Huang et al., 2023). This trend leads to more time spent travelling each day, significantly raising the likelihood of encountering traffic events and, consequently, accidents. The primary metrics for assessing driving exposure include total vehicle distance and time spent driving, which are directly linked to the probability of experiencing traffic incidents (Chipman et al., 1992). High driving exposure increases the risk of accidents due to frequent travel and longer commuting times.

In the context of motorcyclists, "riding exposure" similarly serves as a measure of the frequency and duration of motorcycle use in traffic and the potential hazards encountered. Riding exposure may increase the risk for motorcyclists compared to other types of vehicles, as motorcyclists face unique vulnerabilities on the road (Teschke et al., 2013). By incorporating riding exposure into our study, we aim to examine its relationship with risky behaviours, such as mobile phone use while riding. Research suggests that individuals with greater exposure to traffic are more inclined to engage in phone use, driven by factors such as congestion and time pressure from delays or unexpected disruptions, which may amplify their perception of time constraints (Baikejuli et al., 2023; Pöysti et al., 2005). Such conditions may prompt road users, especially motorcyclists, to use mobile devices in an effort to keep up with time commitments.

Based on the preceding paragraphs, we formulate the following hypothesis:

H1: Increased riding exposure intensifies perceived time pressure.

2.2.2. Time pressure

Time pressure is the sense of urgency an individual experiences when they do not have enough time to complete a task or achieve a goal. It reflects a state of urgency when there is a discrepancy between what an individual wants or feels they should do and what can realistically be accomplished before a temporal deadline (Svenson and Benson, 1993; Cœugnet et al., 2013a). The Scalar Expectancy Theory (Gibbon et al., 1984) posits that when individuals are under time pressure, they may overestimate the time that has passed, leading to emotional responses and impulsive or risky actions. The more emotionally charged the situation is, the more likely people will misjudge time. This helps explain why, in high-stress or time-sensitive situations, individuals often make poor decisions regarding time management.

When individuals face discrepancies between their desired actions or obligations and what can realistically be achieved within a temporary deadline, they often experience time pressure, leading to multitasking and time optimisation to cope with daily life demands and directly impacting their driving behaviours (Maule and Svenson, 1993; Singleton, 2020). However, there is limited research applying time pressure to understand the risky behaviours of motorcyclists. A study by Sharma et al. (2024) on motorcyclists in India found that time pressure contributes to an increase in over-speeding behaviour.

Time pressure has been documented as a crucial factor for dangerous driving behaviour, significantly influencing how individuals drive and contributing to aggressive and risk-accepting behaviours, such as speeding and sudden braking, as consistently shown in driving simulator studies (Dhoke and Choudhary, 2023; Fitzpatrick et al., 2017; Ge et al., 2022; Pawar and Velaga, 2020, 2021; Pawar et al., 2020; Santos et al., 2005; Zhang et al., 2020b; Zheng et al., 2019). The increasing time pressure affects vehicle control and drivers' reaction times and increases the crash risk and the likelihood of overtaking dangerously (O'Brien et al., 2004).

As shown in the questionnaire in Appendix A, the indicators for time pressure are framed from a long-term perspective rather than triggered solely by specific situational contexts. In today's fast-paced world, time pressure is not just a temporary factor but can become a more persistent issue, particularly with the growing urbanisation that often requires longer travel times to work or school. This perspective is supported by previous research (Li et al., 2013; Zheng et al., 2019; Quy Nguyen-Phuoc et al., 2022). Moreover, Cœugnet et al. (2013b) have emphasised the emotional impact of time pressure. When under time pressure, motorcyclists are more likely to adopt lenient or risk-tolerant attitudes towards behaviours such as speeding or using a smartphone while driving. In the Theory of Planned Behaviour (TPB), attitudes, perceived behavioural control (PBC), and social norms are considered key factors that influence an individual's intentions, which then guide their behaviour. The role of time pressure in shaping attitudes, PBC, and social norms is theoretically sound, as these psychological constructs directly affect how an individual intends to act.

Under time pressure, riders are compelled to update their travel estimates and react to minimise delays continuously. This often leads to riskier behaviours, including the use of communication tools to inform others of their expected arrival times, as well as multitasking activities such as using smartphones, which are perceived as necessary to manage tasks under tight schedules, fostering a perception that such multitasking is socially acceptable (Ge et al., 2022; Maule and Svenson, 1993; Peer, 2011; Singleton, 2020).

This perception enhances riders' confidence in their ability to manage the complexities of riding while using a smartphone, influencing their behavioural intentions (Walsh et al., 2008). Understanding how time pressure impacts driving behaviours and attitudes is crucial for developing strategies to mitigate its effects. There is a notable gap in the literature on the relationship between time pressure, increased accident risks, and aggressive riding behaviours, highlighting the need for further research (Cœugnet et al., 2013b). By integrating time pressure into our model, we can better understand how external influences may drive an individual's decision to use a smartphone while operating a vehicle.

Based on the preceding discussion, this study proposes the following hypotheses with respect to time pressure:

H2: Time pressure increases the attitude about using a smartphone while riding (ATT).

H3: Time pressure increases the social norm perception regarding the behaviour of using a smartphone while riding.

H4: Time pressure has an increasing effect on perceived behavioural control about using a smartphone while riding (PBC).

2.2.3. Relationship between TPB factors and smartphone use while riding

The Theory of Planned Behaviour (TPB) suggests that an individual's behaviour is influenced by their behavioural intention, which is determined by three socio-psychological factors: attitude, subjective norm, and perceived behavioural control (Ajzen, 1991, 2002). These elements are crucial in understanding the psychological drivers of behaviours in various contexts, including road traffic safety.

Studies have demonstrated a link between TPB factors and mobile phone use while driving, such as texting and calling (Sullman et al., 2018; Zhou et al., 2012). Detailed investigations have explored specific practices like concealed texting (Gauld et al., 2014a). However, each TPB factor's exact impact and influence on these behaviours is not fully understood. For instance, Nemme and White (2010) found that intention strongly predicts texting behaviours, but perceived behavioural control does not play a significant role. Conversely, attitude has been identified as a key predictor of mobile phone use for communication while driving, whereas subjective norm has shown a crucial influence under time pressure but a significant negative association with texting (Sullman et al., 2018; Walsh et al., 2008).

Studies have demonstrated a link between TPB factors and mobile phone use while driving, including behaviours such as texting and calling (Sullman et al., 2018; Zhou et al., 2012). Detailed investigations have explored specific practices, such as concealed texting (Gauld et al., 2014a). However, the exact impact and influence of each TPB factor on these behaviours is not fully understood. For example, Nemme and White (2010) found that intention strongly predicts texting behaviours, while perceived behavioural control does not play a significant role. Conversely, attitude has been identified as a key predictor of mobile phone use for communication while driving, whereas subjective norm shows a crucial influence under time pressure but a significant negative association with texting (Sullman et al., 2018; Walsh et al., 2008). Further illustrating the predictive power of an extended TPB framework, Nguyen et al. (2020) demonstrated in their study on motorcyclists in Vietnam that incorporating additional factors such as habit and health motivation effectively forecasts smartphone use behaviour among motorcyclists. This extended model highlights the value of considering broader motivational aspects when examining risky mobile phone use in different driving contexts.

The rising popularity of mobile applications like Zalo, Facebook, Twitter, and TikTok has introduced new hazards for road users (Hou et al., 2022; Qu et al., 2020). Given these considerations, our study

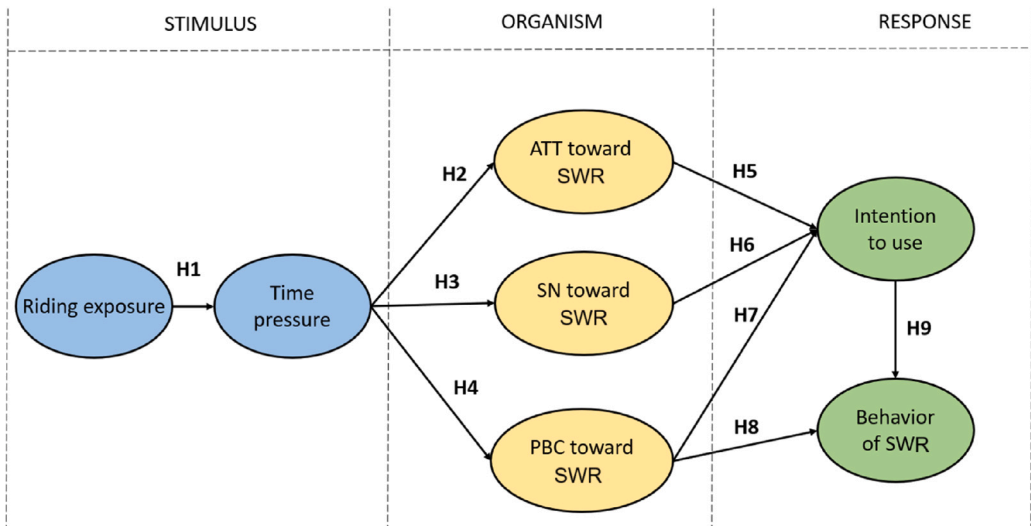

Fig. 1. Conceptual framework *Note:* ATT: Attitudes, SN: Social norms, PBC: Perceived behavioural control, SWR: smartphone use while riding.

examines SWR behaviours, including making calls, texting, navigating, taking photos, and recording videos while driving a motorbike. Building on the established TPB framework, the following hypotheses are formulated to investigate the TPB factors influencing SWR among motorcyclists:

H5: Attitudes about using a smartphone while riding increase the behavioural intention to use a smartphone while riding.

H6: Social norms influence the behavioural intention to use a smartphone while riding.

H7: Perceived behavioural control influences the behavioural intention to use a smartphone while riding.

H8: Perceived behavioural control increases the actual behaviour of using a smartphone while riding.

H9: Behavioural intention positively influences the actual behaviour of using a smartphone while riding.

2.3. Conceptual research model

The diagram in Fig. 1 presents a comprehensive conceptual framework comprising eight key variables. Utilising the TPB model as its theoretical foundation, the framework includes social norms (SN), perceived behavioural control (PBC), and attitudes (ATT) towards SWR as primary factors. Additionally, independent variables such as driving exposure and time pressure are incorporated within the model. All independent variables explore the mechanisms impacting SWR within the SOR theoretical framework. The model's dependent variables are behavioural intention and observable SWR behaviour. This structured framework facilitates analysis and understanding of the intricate relationships influencing driving behaviour, particularly regarding SWR and allows the testing of the nine hypotheses that we have formulated.

3. Methodology

3.1. Data collection

This research targets individuals aged 18–24 who primarily rely on motorcycles for transportation. We focus on this demographic because they represent a significant proportion of motorbike users and demonstrate higher mobility and a greater risk of road accidents than any other age group (European Commission, 2021). Additionally, being native to the smartphone era, they are more likely to use smartphones while driving (Jannusch et al., 2021).

The University of Danang's ethics committee approved the study, and data collection was conducted by a specially trained team of 15 students in various urban and rural public spaces. We gathered data using questionnaires, a cost-effective method validated by Hatakka et al. (1997) for its predictive ability regarding driving violations and accidents. Participants could win prizes valued at 100,000 VND (about $4 USD), and all research protocols maintained anonymity and confidentiality with informed consent.

The questionnaire was translated from English and validated by language and field experts to adapt the questionnaire to the Vietnamese context. Initial tests with 50 face-to-face surveys refined content clarity and, following the random sampling method outlined by Valliant et al. (2018) surveys were distributed to young drivers in both urban and rural areas in Vietnam, ensuring a sufficiently large sample size (more than 200 respondents) for Structural Equation Modeling (SEM), as recommended by Hadiuzzman et al. (2017).

3.2. Construct and measurement items

The survey instrument consists of three sections: the first introduces the study and outlines respondents' rights and confidentiality commitments; the second collects demographic information such as gender, driving licence status, and residence characteristics; and the third contains 7 measurement scales with 28 indicators in a Likert-5 format, adapted from prior research, to test the hypotheses. Respondents rate statements from 1 (totally disagree) to 5 (totally agree).

Measurement scales include Time pressure (e.g., "I am always in a hurry to be on time") drawn from studies by Li et al. (2013), Quy Nguyen-Phuoc et al. (2022), and Zheng et al. (2019); Riding exposure (e.g., "How many hours in a day do you ride?") based on Shen et al. (2020) and Vance et al. (2006); Attitudes towards smartphone use while riding (e.g., "Smartphone use while riding should be allowed") from Baikejuli et al. (2023), Nemme and White (2010), and Swedler et al. (2015); Social norms (e.g., "Important people approve of my smartphone use while riding") and Perceived behavioural control (e.g., "My riding is unaffected by smartphone use"), sourced from Chan et al. (2010), Nemme and White (2010), and Swedler et al. (2015). Intention to use (e.g., "I will use my smartphone while riding when possible") and (self-reported) Behaviour of using a smartphone while riding (e.g., "I use social media when riding") are measured based on Chan et al. (2010), and Baikejuli et al. (2023) and Ogden et al. (2022), respectively. Details and references for these scales are listed in Appendix A.

Table 2
Demographic characteristics of respondents.

Characteristic	Value	Frequency	Percentage
Gender	Male	342	32.5
	Female	709	67.5
Age	18–20	592	56.3
	21–24	459	43.7
Licence	Yes	652	62.0
	No	399	38.0
Residential characteristics	Urban	362	34.4
	Rural	689	65.6
Riding experience	Less than 2 years	302	28.7
	From 2 to 5 years	598	56.9
	Over 5 years	151	14.4
Crashes in the last 12 months	0	738	70.2
	1–2	275	26.2
	3 or more	38	3.6
Near-crashes in the last 12 months	0	409	38.9
	1–2	503	47.9
	3 or more	139	13.2
Offences	0	790	75.2
	1–2	205	19.5
	3 or more	56	5.3

3.3. Data analysis

After receiving all responses, we thoroughly reviewed all responses and excluded those with missing information or uniform responses across multiple questions to ensure data quality. Furthermore, we identified and eliminated outliers, which can significantly distort statistical analysis and hypothesis testing outcomes (Aguinis et al., 2013; Hoang and Le Tan, 2023). After outlier removal, 1051 observations remained for in-depth analysis. The detection method recommended by Kock et al. (2021) was applied to ensure that common method bias (CMB) did not bias the results. Exploratory Factor Analysis (EFA) confirmed that the extracted factor's variance was under 50%, indicating minimal CMB impact.

Structural equation modelling (SEM) was chosen to efficiently examine the interdependencies among latent variables, analysing multiple dependent variables and paths concurrently (Gefen et al., 2000). Given the exploratory nature of our hypotheses, partial least squares-based SEM (PLS-SEM) (Hair et al., 2021) was used, employing a two-stage process via SmartPLS. This approach involved first establishing the discriminant and convergent validity of the instruments (measurement model) before evaluating the theoretical relationships (structural model).

4. Results

4.1. Demographic characteristics

The demographic analysis in Table 2 showed that the study sample consists of 1051 participants. In terms of gender, 67.5% were female, and 32.5% were male. Concerning driving licences, 62% possessed a licence, while 38% did not. In Vietnam, individuals aged 16 and above can ride electric motorcycles or motorcycles under 50cc without a licence, explaining the significant number of unlicensed motorcyclists. Regarding driving experience, 56.9% had 2–5 years, 28.7% had less than two years, and 14.4% had over five years of experience. In the past year, 70.2% reported no crashes, 26.2% had one or two, and 3.6% had three or more. For near-crashes, 38.9% reported none, 47.9% had one or two, and 13.2% had three or more. Concerning offences, 75.2% reported none, 19.5% had 1–2, and 5.3% had three or more. Finally, 34.4% of participants were urban residents, and 65.6% were rural.

4.2. Measurement model evaluation

The assessment of reflective measurement models' quality typically involves three criteria: internal consistency reliability, convergent validity, and discriminant validity (Hair et al., 2013). In the PLS-SEM approach, internal consistency is assessed using Cronbach's Alpha and composite reliability (CR), with CR values ranging from 0.857 to 0.969 and Cronbach's Alpha from 0.752 to 0.957 (Table 3), both exceeding the recommended thresholds (Henseler et al., 2009; Bonett and Wright, 2015).

Convergent validity, evaluated through outer loadings and average variance extracted (AVE), shows all items meet (Chin, 1998)'s acceptable thresholds, with AVE values between 0.667 to 0.887 (Table 3), surpassing the recommended 0.5 (Hair et al., 2013). These results confirm the models' strong internal consistency and convergent validity.

Discriminant validity, assessed using the Fornell-Larcker or the Heterotrait-Monotrait (HTMT) criterion, favours HTMT due to its higher effectiveness in ensuring accurate causal interpretations in the modelling analysis (Ab Hamid et al., 2017; Henseler et al., 2015). The HTMT values are all below 0.9 (Table 4), confirming adequate discriminant validity (Hair et al., 2021). Multicollinearity, assessed using the variance inflation factor (VIF), was well below 10 in all cases, indicating that path coefficient estimates are accurate (Al-Ashkar et al., 2021; James et al., 2023).

4.3. Structural model evaluation

In this research, we utilised the standardised root mean square residual (SRMR) to assess the fit of the PLS-SEM model, achieving an SRMR value of 0.069, below the recommended threshold of 0.08 (Henseler et al., 2016), indicating a strong fit. The model's predictive performance was evaluated using the coefficient of determination (R-squared) and the Stone-Geisser Q-squared (cross-validated redundancy), which measure predictive accuracy and relevance, respectively (Hair et al., 2013). The model effectively explained the intention and behaviour constructs, with R-squared values ranging from 61.1% to 74.1%. Additionally, Q-squared values, calculated using blindfolding in SmartPLS, were 0.593 for intention and 0.435 for behaviour, indicating large predictive relevance (Hair et al., 2021), confirming the model's high predictive capability.

A bootstrapping procedure with 5000 replications was conducted to assess the significance of the path relationships within the proposed model. All path coefficients were significant at a 5% significance level, indicating that all the hypotheses we formulated in the research model are supported (Table 5). This implies that driving exposure significantly influences time pressure ($\beta = 0.362$, $p < 0.001$). Time pressure then impacts ATT, SNO, and PBC, with the largest effect on PBC ($\beta = 0.351$, $p < 0.001$). These factors, in turn, significantly enhance INT, with PBC having the strongest influence ($\beta = 0.475$, $p < 0.001$), more than double that of ATT and SNO. Finally, both INT and PBC positively affect MUD, with INT's direct impact ($\beta = 0.569$, $p < 0.001$) being 2.3 times greater than that of PBC ($\beta = 0.243$, $p = 0.001$).

5. Discussion

5.1. Behavioural insights and model efficacy

George et al. (2018) emphasised that targeted interventions should account for the diverse phone functions used during driving. Understanding why drivers use smartphones is essential for preventing associated dangers (Gras et al., 2007). Recognising the importance of smartphone use while riding for road safety, this study aims to develop a comprehensive framework by integrating the traditional Theory of Planned Behaviour (TPB) variables with riding exposure and time

Table 3
Measurement model evaluation.

Dimension	Item	Outer loading	Cronbach's Alpha	CR	AVE
Attitudes	ATT1	0.910	0.938	0.955	0.842
	ATT2	0.935			
	ATT3	0.915			
	ATT4	0.911			
Social norms	SNO1	0.903	0.957	0.969	0.887
	SNO2	0.954			
	SNO3	0.956			
	SNO4	0.954			
Perceived behavioural control	PBC	0.904	0.940	0.957	0.847
	PBC2	0.921			
	PBC3	0.931			
	PBC4	0.924			
Intention	INT1	0.906	0.919	0.943	0.806
	INT2	0.932			
	INT3	0.919			
	INT4	0.832			
Behaviour (Smartphone use while riding)	BEH1	0.810	0.902	0.928	0.72
	BEH2	0.880			
	BEH3	0.889			
	BEH4	0.821			
	BEH5	0.840			
Time pressure	TPR1	0.849	0.850	0.891	0.672
	TPR2	0.793			
	TPR3	0.830			
	TPR4	0.805			
Riding exposure	DEX1	0.780	0.752	0.857	0.667
	DEX2	0.815			
	DEX3	0.854			

Table 4
Heterotrait-monotrait ratio (HTMT).

	ATT	DEX	INT	BEH	PBC	SNO
ATT						
DEX	0.219					
INT	0.844	0.271				
BEH	0.788	0.282	0.845			
PBC	0.849	0.252	0.890	0.774		
SNO	0.872	0.219	0.834	0.764	0.838	
TPR	0.311	0.455	0.369	0.406	0.338	0.270

Table 5
Structural model evaluation.

Hypothesis	Direction	Path coefficient	Standard deviation	*t*	*p*-values	Conclusion
H1	DEX → TPR	0.362	0.031	11.635	<0.001	Supported
H2	TPR → ATT	0.329	0.030	10.930	<0.001	Supported
H3	TPR → SNO	0.300	0.031	9.709	<0.001	Supported
H4	TPR → PBC	0.351	0.030	11.850	<0.001	Supported
H5	ATT → INT	0.219	0.052	4.232	<0.001	Supported
H6	SNO → INT	0.225	0.051	4.398	<0.001	Supported
H7	PBC → INT	0.475	0.044	10.875	<0.001	Supported
H8	PBC → BEH	0.243	0.048	5.037	<0.001	Supported
H9	INT → BEH	0.569	0.046	12.414	<0.001	Supported

pressure, thereby enhancing the understanding of both external and internal factors shaping this behaviour among motorcycle riders. Notably, this study is one of the first to incorporate these two novel variables into the TPB framework while also integrating the Stimulus-Organism-Response model. This combined approach provides new insights into the formation of intentions and behaviours regarding smartphone use among young motorcyclists in a developing context like Vietnam.

Ajzen (1991) noted the TPB's flexibility in incorporating additional explanatory variables if they significantly enhance the model beyond standard TPB variables. The results from the extended TPB-based model, incorporating riding exposure and time pressure, demonstrated effectiveness with an R-squared of 74.1% for the intention to use a smartphone and 61.1% for the behaviour of using a smartphone, indicating a robust representation of construct relationships and underscoring the model's relevance and validity. These insights inform the development of effective road safety policies and initiatives. The findings provide evidence on factors influencing the intention and behaviour of using mobile phones while riding, underscoring the necessity for interventions to address mobile phone-related distractions and promote safer driving practices, as Rozario et al. (2010) advocated.

The results support the hypothesis that riding exposure creates a heightened awareness of time pressure, aligning with previous research showing that riders with higher mileage are more prone to frequent mobile phone use (Baikejuli et al., 2023; Brusque and Alauzet, 2008; Pöysti et al., 2005). Motorcycle riders may feel urgency and stress related to time management, especially when compensating for time lost due to slow traffic or unfavourable conditions. This understanding helps develop targeted interventions to enhance road safety and reduce time-related stress, promoting a more efficient and mindful riding culture.

Time pressure's influence on behaviours such as speeding, tailgating, and road rage is well-established (Cœugnet et al., 2013a; Fuller et al., 2009; Parker et al., 1995; Rendon-Velez et al., 2016; Stern, 1999). This study contributes to understanding how time pressure impacts the intention and behaviour of using smartphones while driving, particularly showing that perceived behavioural control (PBC) is most affected. Singleton (2020) supported the idea that time pressure might lead drivers to view smartphones as necessary for multitasking, fostering a positive attitude towards their use as a coping mechanism.

This pressure creates a cognitive justification for smartphone use as a necessary trade-off between time efficiency and safety, potentially reinforcing societal norms that view smartphone use while driving as acceptable under time constraints. For young motorcyclists, who often encounter significant time pressure while on the road, adjusting their schedules – such as starting earlier or staying later – could help alleviate stress without resorting to smartphone use while riding to manage tasks. Establishing guidelines for maximum daily driving or riding time is also advisable, particularly as many young riders now work for delivery companies and often work extended hours. Such measures may help reduce reliance on smartphones for time management, promoting safer practices and potentially reducing accident risks.

Among the TPB factors, PBC is most significantly influenced by time pressure. PBC refers to the drivers' perceived ability to manage risks associated with distracted driving, potentially enhanced by using hands-free devices or increased vigilance. Chajut and Algom (2003) suggested that time pressure helps concentrate on important tasks by reducing distractions, thus boosting confidence in smartphone use while riding despite potential risks. Consequently, Zhang et al. (2020a) proposed that periodic mandatory training and education on the dangers of smartphone use while driving could be particularly beneficial for experienced drivers. Such interventions may reduce riders' overconfidence in their riding abilities, which can otherwise lead to unsafe behaviours involving smartphone use.

This study reveals significant connections between TPB variables and the intention to use a smartphone while driving, providing additional evidence among young motorcycle riders that PBC is a strong predictor of this intention ($\beta = 0.475$), surpassing attitudes (ATT) ($\beta = 0.219$) and social norms (SNO) ($\beta = 0.225$). These findings align with earlier research showing that three TPB factors significantly predict individuals' intentions to engage in smartphone usage while driving (Gauld et al., 2017; Murphy et al., 2020; Rozario et al., 2010; Waddell and Wiener, 2014). Notably, Sullman et al. (2018) found attitude to be the most influential TPB factor in different contexts, reflecting variations between motorcycle riders and car drivers in terms of manual challenges. When riders believe they can use their phones without significant risk to their performance, they are more likely to engage in phone use while riding. This suggests that riders are particularly inclined towards this behaviour if they perceive it as safe. Therefore, a direct intervention could focus on altering riders' perceptions of the safety of smartphone use while riding. Educational and awareness programmes could highlight the serious risks and dangerous consequences of distracted riding, aiming to reduce rider's unwarranted confidence in their ability to ride safely while distracted. Regulatory agencies should also implement stricter measures and penalties to minimise PBC regarding phone use intentions and actual behaviours. Given that individuals are more likely to engage in behaviours they perceive as beneficial (Yang et al., 2018), future interventions should work to discourage positive attitudes towards SWR among motorcycle riders. This could involve a deterrence-based approach that combines enforcement with education, challenging the perceived benefits of this behaviour to reduce SWR effectively, as suggested by Rozario et al. (2010).

Furthermore, implementing and enforcing laws prohibiting mobile phone use while riding can alter users' attitudes and intentions and influence social norms and perceived behavioural control. In China, detection systems have been installed at intersections to capture the faces of (e-bike) riders using mobile phones and display their images on screens (Yang et al., 2022). Previous studies have confirmed that strict law enforcement measures, such as increased fines or penalties, can significantly reduce the recurrence of mobile phone use while riding (Olsson et al., 2020). However, without effective promotional programs, these enforcement measures may lose their impact, and the behaviour may return to pre-enforcement levels (McCartt and Geary, 2004). If these systems were enhanced to include financial penalties, they could potentially lead to changes in behaviour.

This study also found a positive correlation between social norms and the intention to use a mobile phone while riding a motorcycle. Consistent with the findings of De Gruyter et al. (2017), the influence of social relationships is believed to be linked to mobile phone use while riding, particularly between friends and partners. An intervention solution could involve launching public awareness campaigns to change societal norms regarding smartphone use while riding. Educational messages should emphasise community responsibility and the negative impact this behaviour can have on others, raising awareness that using a smartphone while riding is unacceptable. These interventions should actively promote new, positive habits for riders, helping them avoid repeating the SWR behaviour.

The intention to use a smartphone significantly influences motorcycle riders' behaviour, with strong intentions leading to actual behaviour despite potential risks ($\beta = 0.545$, $p < 0.001$). It reinforces findings from previous studies where many have demonstrated that individuals expressing a strong intention to use smartphones while driving are more likely to follow through with it (Backer-Grøndahl and Sagberg, 2011; Murphy et al., 2020; Pöysti et al., 2005). Addressing this intention is crucial for developing interventions and campaigns to reduce SWR and promote safer road practices.

5.2. Road safety intervention strategies

The current research examined the inclination of young drivers to use smartphones while riding, utilising a research model based on the Theory of Planned Behaviour (TPB). This framework has proven effective for developing road safety campaigns aimed at behaviours like speeding (Stead et al., 2005) and could inform impactful messages addressing smartphone use while riding.

Currently, in Vietnam, penalties for mobile phone use while riding a motorcycle are largely ineffective, as fines remain minimal and lack a meaningful deterrent effect. Additionally, certain behaviours legally fall into a grey area, for example, motorcyclists using phone mounts to view maps, which is not explicitly regulated by law despite its potential to cause distraction. The study by Nguyen et al. (2020) similarly observed that police sanctions for mobile phone use while riding or driving in Vietnam are inadequate for deterrence. Fines are modest, around US$10 for motorcyclists and US$35 for car drivers, and do not include more impactful legal measures, such as licence suspension, which has been shown in other jurisdictions to influence driver behaviour positively. Moreover, enforcement of penalties for motorcyclists using mobile phones is almost non-existent in Vietnam, which may unintentionally reinforce riders' Perceived Behavioural Control (PBC), as they feel unlikely to face penalties from the police.

There is also a need to consider expanding regulations to address other potentially distracting behaviours, such as using hands-free devices or fixing phones on mounts that allow riders to view screens while in motion. This remains a grey area in Vietnam, with no specific regulation governing the practice. To improve road safety, it would be prudent to prohibit these behaviours and introduce penalties similar to those for texting, making calls, or using a phone while riding.

Enforcement challenges arise from the widespread use of smartphones, prompting law enforcement to adopt alternative approaches, such as educational messages (Rudisill et al., 2019). Indeed, the results of this study could underpin public education campaigns that disseminate knowledge about the hazards and distractions of driving. Historical data supports the effectiveness of such campaigns: Elliot's meta-analysis showed a 7.5% reduction in target behaviours like drunk driving or seat-belt non-compliance (Elliott, 1993), while Delhomme's study noted an 8.5% decrease in crashes during campaigns that increased to 14.8% upon completion (Delhomme et al., 1999). Delaney et al. (2004) found that theory-based campaigns reduced crash frequency by an average of 20%, highlighting the importance of a solid theoretical foundation (Lewis et al., 2016).

The impact of instrumental attitudes on the tendency to use smartphones while riding is notable. Educational programs should, therefore, emphasise the dangers of smartphone use while riding, the severe legal penalties involved, and the minimal benefits compared to the substantial risks. Messages and factual information on the dangers of mobile phone use should be widely disseminated, particularly highlighting the impact on riding abilities, such as reduced reaction times and delayed responses. Integrating these points into traffic safety education programmes can raise awareness and promote safer riding behaviours. Campaigns can further strengthen social norms by demonstrating how individual actions influence others, encouraging motorcyclists to protect their own lives and those of others on the road. School-based education and parental involvement are crucial as they shape the social norms of children and young individuals. Additionally, social media platforms like Facebook and TikTok can be leveraged to effectively promote the cessation of smartphone use while riding, reaching younger audiences and reinforcing positive behavioural messages.

Furthermore, since Perceived Behavioural Control (PBC) is the most important predictor of intention, campaigns should focus on altering drivers' perceptions about the risks of smartphone use while driving. Therefore, campaigns should emphasise mobile phone usage's cognitive impairments and dangers. By addressing the beliefs surrounding PBC, public awareness campaigns are likely to achieve more favourable outcomes in mitigating risky phone usage among young drivers (Murphy et al., 2020).

The use of technology could play a crucial role in identifying mobile phone use behaviour among motorcyclists and making this information accessible to the public, which may enhance awareness and deterrence. Additionally, the increasing reliance on smartphones for navigation could be addressed by implementing alternative technical solutions, such as integrating speakers into motorcycles to provide audio guidance. This would allow riders to follow directions without needing to look at or operate their phones, thereby minimising distractions while maintaining effective navigation support. Another approach, inspired by the report by Hill et al. (2015) on mobile phone use in cars, could be adapted for motorcyclists. This would involve using apps or developing smartphone features that block incoming calls, text messages, and notifications while riding. Such tools could help reduce the temptation to use mobile phones and promote safer riding practices.

6. Conclusion

This study examined smartphone use while riding (SWR) among motorcyclists in Vietnam, extending the Theory of Planned Behaviour (TPB) by incorporating riding exposure and time pressure within the Stimulus-Organism-Response (SOR) framework. By integrating situational and psychological factors, the study provides a novel perspective on the mechanisms influencing SWR intention and behaviour. The findings highlight that perceived behavioural control (PBC) is the strongest predictor of SWR intention, followed by attitudes (ATT) and social norms (SNO). Additionally, time pressure significantly increases the likelihood of engaging in SWR, reinforcing prior findings that external constraints intensify risk-taking behaviours on the road. These insights contribute to a broader understanding of distracted riding, particularly among young motorcyclists who are part of the 'connected generation' for whom smartphones are deeply embedded in daily life.

Beyond its theoretical contributions, the study has practical implications for road safety interventions and policy development. Given that PBC strongly influences SWR intention, awareness campaigns should focus on challenging riders' perceived ability to use smartphones while riding. Educational initiatives should emphasise the cognitive impairments and reaction delays caused by SWR, making riders more aware of the associated dangers. Additionally, since time pressure exacerbates SWR, interventions should address commuter stress and urban mobility inefficiencies. Governments and transport planners may consider measures such as optimised traffic flow, dedicated motorcycle lanes, and improved public transportation to mitigate time-related pressures on riders. From a regulatory standpoint, stricter enforcement of phone-use restrictions, increased penalties, and technology-based deterrents – such as blocking notifications while riding – could help reduce risky riding behaviours.

Despite its contributions, the study has several limitations. First, it did not account for personality traits and descriptive norms, which could further shape SWR behaviour. Future research integrating these psychological constructs could enhance the explanatory power of the TPB-SOR model. Second, like many survey-based studies, this research relied on self-reported data, which may introduce social desirability bias, affecting response accuracy. To address this, we implemented anonymity measures, pre-testing, outlier removal, and Common Method Bias (CMB) detection. However, future research could employ objective behavioural tracking methods, such as naturalistic riding studies or smartphone usage monitoring. These approaches could validate self-reported data and provide deeper insights into real-world riding behaviours.

Future research should explore longitudinal designs to assess how SWR behaviours evolve over time, especially in response to technological advancements or policy changes. Cross-cultural studies could also examine whether these findings generalise to other motorcycle-dominant regions, such as Southeast Asia, Latin America, and Africa. As smartphone technology and road safety policies continue to evolve, understanding the intersection of digital connectivity and traffic safety remains critical for developing evidence-based interventions.

CRediT authorship contribution statement

Ha Hoang: Writing – review & editing, Writing – original draft, Visualization, Software, Methodology, Investigation, Formal analysis, Conceptualization. **Mehdi Moeinaddini:** Writing – review & editing. **Mario Cools:** Writing – review & editing, Writing – original draft, Validation, Supervision, Project administration, Funding acquisition, Conceptualization.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Acknowledgements

This work was supported by grant obtained from Wallonie-Bruxelles International (WBI), Belgium for the project 2.17 (Renforcement des compétences en matière de recherche, d'enseignement et de consultance dans le domaine de la logistique) and by the FNRS, Belgium fund supporting the sabbatical leave of Mario Cools.

Appendix A. Questionnaire

See Table A.6.

Data availability

Data will be made available on request.

Table A.6
Questionnaire.

Dimension	Item	Description	Sources
Attitudes (ATT)	ATT1	For me smartphone use while riding would be right.	Baikejuli et al. (2023)
	ATT2	For me, smartphone use while riding would be reasonable.	Nemme and White (2010) and Swedler et al. (2015)
	ATT3	For me, smartphone use while riding should be allowed.	
	ATT4	For me, smartphone use while riding would be necessary.	*Authors*
Social norms (SNO)	SNO1	People who are important to me would want me to use a smartphone while riding.	Nemme and White (2010) and Swedler et al. (2015)
	SNO2	People who are important to me would approve of me for smartphone use while riding.	
	SNO3	People who are important to me think I should use a smartphone while riding.	
	SNO4	People who are important to me think smartphone use while riding is reasonable.	*Authors*
Perceived behavioural control (PBC)	PBC1	I believe I have the ability to use a smartphone while riding.	Chan et al. (2010)
	PBC2	I believe my riding performance will not be affected if I use a smartphone while riding.	
	PBC3	How difficult is it for you to use a smartphone while riding? (1: very easy – 5: very difficult)	
	PBC4	I believe my riding skill is good enough to use a smartphone while riding.	
Behavioural intention (INT)	INT1	Do you agree that you plan to use a smartphone while riding in the future?	Chan et al. (2010)
	INT2	Do you agree that you will use a smartphone while riding in the future?	
	INT3	I will use my smartphone while riding whenever I have the opportunity.	
	INT4	How likely are you to use a smartphone while riding in the future? (1: extremely unlikely – 5: extremely likely)	
Behaviour (BEH)	BEH1	How often do you use a smartphone while riding a motorcycle?	Baikejuli et al. (2023) and Ogden et al. (2022)
	BEH2	When using a smartphone while riding, I often go on social media.	
	BEH3	When using a smartphone while riding, I often text.	
	BEH4	When using a smartphone while riding, I often make phone calls.	
	BEH5	When using a smartphone while riding, I often record videos and take photos.	
Time pressure (TPR)	TPR1	I am always in a hurry to be on time.	Li et al. (2013), Quy Nguyen-Phuoc et al. (2022) and Zheng et al. (2019)
	TPR2	I often think about the penalty for being late.	
	TPR3	I often worry about being late because of the time limit.	
	TPR4	I always want to spend less time on more things, even when riding.	
Riding exposure (DRE)	DRE1	How many hours in a day do you ride a motorcycle on average? (1: <1 h; 2: 1 h-1 h 30; 3: 1, 5 h-2 h; 4: 2 h-2, 5 h; 5: >2, 5 h	Shen et al. (2020) and Vance et al. (2006)
	DRE2	How many days a week do you ride a motorcycle on average? (1: 1 day – 5: 7 days)	
	DRE3	What is the distance you typically ride? (1: <3 km; 2: 3–5 km; 3: 5–8 km; 4: 8–10 km; 5: >10 km)	

References

Ab Hamid, M.R., Sami, W., Sidek, M.H.M., 2017. Discriminant Validity Assessment: Use of Fornell & Larcker criterion versus HTMT Criterion. J. Phys.: Conf. Ser. 890 (1), 012163. http://dx.doi.org/10.1088/1742-6596/890/1/012163.

Aguinis, H., Gottfredson, R.K., Joo, H., 2013. Best-practice recommendations for defining, identifying, and handling outliers. Organ. Res. Methods 16 (2), 270–301. http://dx.doi.org/10.1177/1094428112470848.

Ajzen, I., 1991. The theory of planned behavior. Organ. Behav. Hum. Decis. Process. 50 (2), 179–211. http://dx.doi.org/10.1016/0749-5978(91)90020-T.

Ajzen, I., 2002. Perceived behavioral control, self-efficacy, locus of control, and the theory of planned behavior. J. Appl. Soc. Psychol. 32 (4), 665–683. http://dx.doi.org/10.1111/j.1559-1816.2002.tb00236.x.

Al-Ashkar, I., Ibrahim, A., Ghazy, A., Attia, K., Al-Ghamdi, A.A., Al-Dosary, M.A., 2021. Assessing the correlations and selection criteria between different traits in wheat salt-tolerant genotypes. Saudi J. Biol. Sci. 28 (9), 5414–5427. http://dx.doi.org/10.1016/j.sjbs.2021.05.076.

Armitage, C.J., Conner, M., 2001. Efficacy of the theory of planned behaviour: A meta-analytic review. Br. J. Soc. Psychol. 40 (4), 471–499. http://dx.doi.org/10.1348/014466601164939.

Backer-Grøndahl, A., Sagberg, F., 2011. Driving and telephoning: Relative accident risk when using hand-held and hands-free mobile phones. Saf. Sci. 49 (2), 324–330. http://dx.doi.org/10.1016/j.ssci.2010.09.009.

Baikejuli, M., Shi, J., Qian, Q., 2023. Mobile phone use among truck drivers: The application and extension of the theory of planned behavior. Accid. Anal. Prev. 179, 106894. http://dx.doi.org/10.1016/j.aap.2022.106894.

Bonett, D.G., Wright, T.A., 2015. Cronbach's alpha reliability: Interval estimation, hypothesis testing, and sample size planning. J. Organ. Behav. 36 (1), 3–15. http://dx.doi.org/10.1002/job.1960.

Brandt, R.K., Haustein, S., Hagenzieker, M., Møller, M., 2022. Cyclists' handheld phone use and traffic rule knowledge. Transp. Res. F: Traffic Psychol. Behav. 86, 121–130. http://dx.doi.org/10.1016/j.trf.2022.02.004.

Brown, P.M., George, A.M., Rickwood, D., 2019. Perceived risk and anticipated regret as factors predicting intentions to text while driving among young adults. Transp. Res. F: Traffic Psychol. Behav. 62, 339–348. http://dx.doi.org/10.1016/j.trf.2019.01.014.

Brusque, C., Alauzet, A., 2008. Analysis of the individual factors affecting mobile phone use while driving in France: Socio-demographic characteristics, car and phone use in professional and private contexts. Accid. Anal. Prev. 40 (1), 35–44. http://dx.doi.org/10.1016/j.aap.2007.04.004.

Bui, H.T., Saadi, I., Torfs, K., Moeinaddini, M., Cools, M., 2022. Understanding the growing role of driving anger in the risk of traffic incidents involving Vietnamese motorcyclists. Traffic Inj. Prev. 23 (5), 215–220. http://dx.doi.org/10.1080/15389588.2022.2056598.

Carroll, P.S., 1973. Classifications of driving exposure and accident rates for highway safety analysis. Accid. Anal. Prev. 5 (2), 81–94. http://dx.doi.org/10.1016/0001-4575(73)90017-1.

Chajut, E., Algom, D., 2003. Selective attention improves under stress: implications for theories of social cognition. J. Pers. Soc. Psychol. 85 (2), 231–248. http://dx.doi.org/10.1037/0022-3514.85.2.231.

Chan, D.C., Wu, A.M., Hung, E.P., 2010. Invulnerability and the intention to drink and drive: An application of the theory of planned behavior. Accid. Anal. Prev. 42 (6), 1549–1555. http://dx.doi.org/10.1016/j.aap.2010.03.011.

Chang, H.-J., Eckman, M., Yan, R.-N., 2011. Application of the stimulus-organism-response model to the retail environment: the role of hedonic motivation in impulse buying behavior. Int. Rev. Retail. Distrib. Consum. Res. 21 (3), 233–249. http://dx.doi.org/10.1080/09593969.2011.578798.

Chen, C.-F., Chen, C.-W., 2011. Speeding for fun? Exploring the speeding behavior of riders of heavy motorcycles using the theory of planned behavior and psychological flow theory. Accid. Anal. Prev. 43 (3), 983–990. http://dx.doi.org/10.1016/j.aap.2010.11.025.

Chen, G., So, K.K.F., Hu, X., Poomchaisuwan, M., 2022. Travel for affection: A stimulus-organism-response model of honeymoon tourism experiences. J. Hosp. Tour. Res. 46 (6), 1187–1219. http://dx.doi.org/10.1177/10963480211011720.

Chin, W.W., 1998. The partial least squares approach to structural equation modeling. In: Marcoulides, G.A. (Ed.), Modern Methods for Business Research. In: Methodology for business and management, Psychology Press, New York, pp. 295–336. http://dx.doi.org/10.4324/9781410604385.

Chipman, M.L., MacGregor, C.G., Smiley, A.M., Lee-Gosselin, M., 1992. Time vs. distance as measures of exposure in driving surveys. Accid. Anal. Prev. 24 (6), 679–684. http://dx.doi.org/10.1016/0001-4575(92)90021-A.

Cœugnet, S., Miller, H., Anceaux, F., Naveteur, J., 2013a. How do time pressured drivers estimate speed and time? Accid. Anal. Prev. 55, 211–218. http://dx.doi.org/10.1016/j.aap.2013.02.040.

Cœugnet, S., Naveteur, J., Antoine, P., Anceaux, F., 2013b. Time pressure and driving: Work, emotions and risks. Transp. Res. F: Traffic Psychol. Behav. 20, 39–51. http://dx.doi.org/10.1016/j.trf.2013.05.002.

Cristea, M., Paran, F., Delhomme, P., 2013. Extending the theory of planned behavior: The role of behavioral options and additional factors in predicting speed behavior. Transp. Res. F: Traffic Psychol. Behav. 21, 122–132. http://dx.doi.org/10.1016/j.trf.2013.09.009.

De Gruyter, C., Truong, L.T., Nguyen, H.T.T., 2017. Who's calling? Social networks and mobile phone use among motorcyclists. Accid. Anal. Prev. 103, 143–147. http://dx.doi.org/10.1016/j.aap.2017.04.010.

Delaney, A., Lough, B., Whelan, M., Cameron, M., 2004. A Review of Mass Media Campaigns in Road Safety. Technical Report 220, Monash University Accident Research Centre, Victoria, Australia, URL https://www.monash.edu/_data/assets/pdf_file/0012/217200/A-review-of-mass-media-campaigns-in-road-safety.pdf.

Delhomme, P., Vaa, T., Meyer, T., Goldenbeld, C., Jaermark, S., Christie, N., Rehnova, V., 1999. Evaluated Road Safety Media Campaigns: An Overview of 265 Evaluated Campaigns and Some Meta-Analysis on Accidents (GADGET Project Deliverable 4). Technical Report, INRETS, Arceuil, France.

Dhoke, A., Choudhary, P., 2023. Is there a relationship between time pressure and pedestrian non-compliance? A systematic review. Transp. Res. F: Traffic Psychol. Behav. 93, 68–89. http://dx.doi.org/10.1016/j.trf.2023.01.001.

Dingus, T.A., Guo, F., Lee, S., Antin, J.F., Perez, M., Buchanan-King, M., Hankey, J., 2016. Driver crash risk factors and prevalence evaluation using naturalistic driving data. Proc. Natl. Acad. Sci. 113 (10), 2636–2641. http://dx.doi.org/10.1073/pnas.1513271113.

Do, T.T.T., Le, M.D., Van Nguyen, T., Tran, B.X., Le, H.T., Nguyen, H.D., Nguyen, L.H., Nguyen, C.T., Tran, T.D., Latkin, C.A., Ho, R.C.M., Zhang, M.W.B., 2018. Receptiveness and preferences of health-related smartphone applications among Vietnamese youth and young adults. BMC Public Health 18 (1), 764. http://dx.doi.org/10.1186/s12889-018-5641-0.

Elliott, B., 1993. Road Safety Mass Media Campaigns: A Meta Analysis. CR 118, Federal Office of Road Safety, Canberra, Australia, URL https://www.infrastructure.gov.au/sites/default/files/migrated/roads/safety/publications/1993/pdf/Edu_Media_1.pdf.

European Commission, 2021. European road safety observatory: Facts and figures Young people. Technical Report, European Commission, Directorate General for Transport, Brussels, URL https://road-safety.transport.ec.europa.eu/system/files/2022-01/F%26F_young_people_20211221.pdf.

Farmer, C.M., Klauer, S.G., McClafferty, J.A., Guo, F., 2015. Relationship of near-crash/crash risk to time spent on a cell phone while driving. Traffic Inj. Prev. 16 (8), 792–800. http://dx.doi.org/10.1080/15389588.2015.1019614.

Fitzpatrick, C.D., Samuel, S., Knodler Jr., M.A., 2017. The use of a driving simulator to determine how time pressures impact driver aggressiveness. Accid. Anal. Prev. 108, 131–138. http://dx.doi.org/10.1016/j.aap.2017.08.017.

Forward, S.E., 2009. The theory of planned behaviour: The role of descriptive norms and past behaviour in the prediction of drivers' intentions to violate. Transp. Res. F: Traffic Psychol. Behav. 12 (3), 198–207. http://dx.doi.org/10.1016/j.trf.2008.12.002.

Fuller, R., Gormley, M., Stradling, S., Broughton, P., Kinnear, N., O'Dolan, C., Hannigan, B., 2009. Impact of speed change on estimated journey time: Failure of drivers to appreciate relevance of initial speed. Accid. Anal. Prev. 41 (1), 10–14. http://dx.doi.org/10.1016/j.aap.2008.07.013.

Garsten, E., 2023. Smartphone use leading to more distracted driving deaths, safety officials say. URL https://www.forbes.com/sites/edgarsten/2023/04/28/addictive-smartphone-use-leading-to-distracted-driving-deaths-safety-officials-say/.

Gauld, C.S., Lewis, I., White, K.M., 2014a. Concealed texting while driving: What are young people's beliefs about this risky behaviour? Saf. Sci. 65, 63–69. http://dx.doi.org/10.1016/j.ssci.2013.12.017.

Gauld, C.S., Lewis, I., White, K.M., 2014b. Concealing their communication: Exploring psychosocial predictors of young drivers' intentions and engagement in concealed texting. Accid. Anal. Prev. 62, 285–293. http://dx.doi.org/10.1016/j.aap.2013.10.016.

Gauld, C.S., Lewis, I., White, K.M., Fleiter, J.J., Watson, B., 2017. Smartphone use while driving: What factors predict young drivers' intentions to initiate, read, and respond to social interactive technology? Comput. Hum. Behav. 76, 174–183. http://dx.doi.org/10.1016/j.chb.2017.07.023.

Gauld, C.S., Lewis, I.M., White, K.M., Watson, B., 2016. Young drivers' engagement with social interactive technology on their smartphone: Critical beliefs to target in public education messages. Accid. Anal. Prev. 96, 208–218. http://dx.doi.org/10.1016/j.aap.2016.07.041.

Ge, Y., Liu, X., Shen, B., Qu, W., 2022. Does a prosocial attitude reduce risky driving behaviour under time pressure? Transp. Res. F: Traffic Psychol. Behav. 84, 1–8. http://dx.doi.org/10.1016/j.trf.2021.11.018.

Gefen, D., Straub, D., Boudreau, M.-C., 2000. Structural equation modeling and regression: Guidelines for research practice. Commun. Assoc. Inf. Syst. 4 (1), http://dx.doi.org/10.17705/1CAIS.00407.

George, A.M., Brown, P.M., Scholz, B., Scott-Parker, B., Rickwood, D., 2018. "I need to skip a song because it sucks": Exploring mobile phone use while driving among young adults. Transp. Res. F: Traffic Psychol. Behav. 58, 382–391. http://dx.doi.org/10.1016/j.trf.2018.06.014.

Gibbon, J., Church, R.M., Meck, W.H., 1984. Scalar timing in memory. Ann. New York Acad. Sci. 423 (1), 52–77. http://dx.doi.org/10.1111/j.1749-6632.1984.tb23417.x.

Gras, M.E., Cunill, M., Sullman, M.J., Planes, M., Aymerich, M., Font-Mayolas, S., 2007. Mobile phone use while driving in a sample of spanish university workers. Accid. Anal. Prev. 39 (2), 347–355. http://dx.doi.org/10.1016/j.aap.2006.08.006.

Gunson, H.P., Beanland, V., Salmon, P.M., 2019. Road-related anger in motorcyclists versus car drivers. Transp. Res. F: Traffic Psychol. Behav. 62, 327–338. http://dx.doi.org/10.1016/j.trf.2019.01.006.

Hadiuzzman, M., Das, T., Hasnat, M.M., Hossain, S., Rafee Musabbir, S., 2017. Structural equation modeling of user satisfaction of bus transit service quality based on stated preferences and latent variables. Transp. Plan. Technol. 40 (3), 257–277. http://dx.doi.org/10.1080/03081060.2017.1283155.

Hair, J.F., Ringle, C.M., Sarstedt, M., 2013. Partial least squares structural equation modeling: Rigorous applications, better results and higher acceptance. Long Range Plan. 46 (1–2), 1–12. http://dx.doi.org/10.1016/j.lrp.2013.01.001.

Hair, Jr., J.F., Hult, G.T.M., Ringle, C.M., Sarstedt, M., Danks, N.P., Ray, S., 2021. Partial Least Squares Structural Equation Modeling (PLS-SEM) Using R: A Workbook, first ed. In: Classroom Companion: Business, Springer, Cham, http://dx.doi.org/10.1007/978-3-030-80519-7.

Haq, M.D., Tseng, T.-H., Cheng, H.-L., Chiu, C.-M., 2024. An empirical analysis of eWOM valence effects: Integrating stimulus-organism-response, trust transfer theory, and theory of planned behavior perspectives. J. Retail. Consum. Serv. 81, 104026. http://dx.doi.org/10.1016/j.jretconser.2024.104026.

Hatakka, M., Keskinen, E., Katila, A., Laapotti, S., 1997. Self-reported driving habits are valid predictors of violations and accident. In: Rothengatter, T., Vaya, E.C. (Eds.), Traffic and Transport Psychology: Theory and Application. Pergamon/Elsevier Science Inc, Amsterdam, Netherlands, pp. 295–303.

Henseler, J., Ringle, C.M., Sarstedt, M., 2015. A new criterion for assessing discriminant validity in variance-based structural equation modeling. J. Acad. Mark. Sci. 43 (1), 115–135. http://dx.doi.org/10.1007/s11747-014-0403-8.

Henseler, J., Ringle, C.M., Sarstedt, M., 2016. Testing measurement invariance of composites using partial least squares. Int. Mark. Rev. 33 (3), 405–431. http://dx.doi.org/10.1108/IMR-09-2014-0304.

Henseler, J., Ringle, C.M., Sinkovics, R.R., 2009. The use of partial least squares path modeling in international marketing. In: Sinkovics, R.R., Ghauri, P.N. (Eds.), New Challenges to International Marketing. In: Advances in International Marketing, Vol. 20, Emerald Group Publishing Limited, Leeds, pp. 277–319. http://dx.doi.org/10.1108/S1474-7979(2009)0000020014.

Hill, L., Rybar, J., Styer, T., Fram, E., Merchant, G., Eastman, A., 2015. Prevalence of and attitudes about distracted driving in college students. Traffic Inj. Prev. 16 (4), 362–367. http://dx.doi.org/10.1080/15389588.2014.949340.

Hoang, H., Le Tan, T., 2023. Unveiling digital transformation: Investigating technology adoption in Vietnam's food delivery industry for enhanced customer experience. Heliyon 9 (9), e19719. http://dx.doi.org/10.1016/j.heliyon.2023.e19719.

Holland, C., Rathod, V., 2013. Influence of personal mobile phone ringing and usual intention to answer on driver error. Accid. Anal. Prev. 50, 793–800. http://dx.doi.org/10.1016/j.aap.2012.07.004.

Hossain, M.M., Zhou, H., Das, S., Sun, X., Hossain, A., 2023. Young drivers and cellphone distraction: Pattern recognition from fatal crashes. J. Transp. Saf. Secur. 15 (3), 239–264. http://dx.doi.org/10.1080/19439962.2022.2048763.

Hou, M., Chen, S., Cheng, J., 2022. The effect of risk perception and other psychological factors on mobile phone use while crossing the street among pedestrians. Accid. Anal. Prev. 170, 106643.

Huang, S.-Z., Sadiq, M., Chien, F., 2023. Dynamic nexus between transportation, urbanization, economic growth and environmental pollution in ASEAN countries: does environmental regulations matter? Environ. Sci. Pollut. Res. 30 (15), 42813–42828. http://dx.doi.org/10.1007/s11356-021-17533-z.

Ichikawa, M., Nakahara, S., 2008. Japanese high school students' usage of mobile phones while cycling. Traffic Inj. Prev. http://dx.doi.org/10.1080/15389580701718389.

Irimia-Diéguez, A., Liébana-Cabanillas, F., Blanco-Oliver, A., Lara-Rubio, J., 2023. What drives consumers to use P2P payment systems? An analytical approach based on the stimulus-organism-response (SOR) model. Eur. J. Manag. Bus. Econ. ahead-of-print (ahead-of-print), http://dx.doi.org/10.1108/EJMBE-12-2022-0374.

Ishigami, Y., Klein, R.M., 2009. Is a hands-free phone safer than a handheld phone? J. Saf. Res. 40 (2), 157–164. http://dx.doi.org/10.1016/j.jsr.2009.02.006.

Islam, M., 2021. The effect of motorcyclists' age on injury severities in single-motorcycle crashes with unobserved heterogeneity. J. Saf. Res. 77, 125–138. http://dx.doi.org/10.1016/j.jsr.2021.02.010.

Iversen, H., 2004. Risk-taking attitudes and risky driving behaviour. Transp. Res. F: Traffic Psychol. Behav. 7 (3), 135–150. http://dx.doi.org/10.1016/j.trf.2003.11.003.

Jacoby, J., 2002. Stimulus-organism-response reconsidered: an evolutionary step in modeling (consumer) behavior. J. Consum. Psychol. 12 (1), 51–57. http://dx.doi.org/10.1207/S15327663JCP1201_05.

James, G., Witten, D., Hastie, T., Tibshirani, R., 2023. An Introduction to Statistical Learning: with Applications in R, second ed. In: Springer Texts in Statistics, Springer, New York, http://dx.doi.org/10.1007/978-1-0716-1418-1, Corrected printing.

Jannusch, T., Shannon, D., Völler, M., Murphy, F., Mullins, M., 2021. Smartphone use while driving: an investigation of young novice driver (YND) behaviour. Transp. Res. F: Traffic Psychol. Behav. 77, 209–220. http://dx.doi.org/10.1016/j.trf.2020.12.013.

Jiang, K., Ling, F., Feng, Z., Wang, K., Shao, C., 2017. Why do drivers continue driving while fatigued? An application of the theory of planned behaviour. Transp. Res. A: Policy Pr. 98, 141–149. http://dx.doi.org/10.1016/j.tra.2017.02.003.

Jiang, K., Yang, Z., Feng, Z., Yu, Z., Bao, S., Huang, Z., 2019. Mobile phone use while cycling: a study based on the theory of planned behavior. Transp. Res. F: Traffic Psychol. Behav. 64, 388–400. http://dx.doi.org/10.1016/j.trf.2019.05.020.

Kock, F., Berbekova, A., Assaf, A.G., 2021. Understanding and managing the threat of common method bias: Detection, prevention and control. Tour. Manag. 86, 104330. http://dx.doi.org/10.1016/j.tourman.2021.104330.

Kong, X., Das, S., Zhou, H., Zhang, Y., 2021. Characterizing phone usage while driving: Safety impact from road and operational perspectives using factor analysis. Accid. Anal. Prev. 152, 106012. http://dx.doi.org/10.1016/j.aap.2021.106012.

Koppel, S., Charlton, J., Kopinathan, C., Taranto, D., 2011. Are child occupants a significant source of driving distraction? Accid. Anal. Prev. 43 (3), 1236–1244. http://dx.doi.org/10.1016/j.aap.2011.01.005.

Laato, S., Islam, A.N., Farooq, A., Dhir, A., 2020. Unusual purchasing behavior during the early stages of the COVID-19 pandemic: The stimulus-organism-response approach. J. Retail. Consum. Serv. 57, 102224. http://dx.doi.org/10.1016/j.jretconser.2020.102224.

Lennon, A., Oviedo-Trespalacios, O., Matthews, S., 2017. Pedestrian self-reported use of smart phones: Positive attitudes and high exposure influence intentions to cross the road while distracted. Accid. Anal. Prev. 98, 338–347. http://dx.doi.org/10.1016/j.aap.2016.10.028.

Lesch, M.F., Hancock, P.A., 2004. Driving performance during concurrent cell-phone use: are drivers aware of their performance decrements? Accid. Anal. Prev. 36 (3), 471–480. http://dx.doi.org/10.1016/S0001-4575(03)00042-3.

Lewis, I., Watson, B., White, K.M., 2016. The step approach to message design and testing (SatMDT): A conceptual framework to guide the development and evaluation of persuasive health messages. Accid. Anal. Prev. 97, 309–314. http://dx.doi.org/10.1016/j.aap.2015.07.019.

Li, F., Jiang, L., Yao, X., Li, Y., 2013. Job demands, job resources and safety outcomes: The roles of emotional exhaustion and safety compliance. Accid. Anal. Prev. 51, 243–251. http://dx.doi.org/10.1016/j.aap.2012.11.029.

Li, X., Zhou, Y., Wong, Y.D., Wang, X., Yuen, K.F., 2021. What influences panic buying behaviour? A model based on dual-system theory and stimulus-organism-response framework. Int. J. Disaster Risk Reduct. 64, 102484. http://dx.doi.org/10.1016/j.ijdrr.2021.102484.

Liu, Y., Cai, L., Ma, F., Wang, X., 2023. Revenge buying after the lockdown: Based on the SOR framework and TPB model. J. Retail. Consum. Serv. 72, 103263. http://dx.doi.org/10.1016/j.jretconser.2023.103263.

Madden, M., Rainie, L., 2010. Adults and Cell Phone Distractions. Technical Report, Pew Research Center, Washington, DC, URL https://www.pewresearch.org/internet/wp-content/uploads/sites/9/media/Files/Reports/2010/PIP_Cell_Distractions.pdf.

Maule, A.J., Svenson, O., 1993. Theoretical and empirical approaches to behavioral decision making and their relation to time constraints. In: Svenson, O., Maule, A.J. (Eds.), Time Pressure and Stress in Human Judgment and Decision Making. Springer, Boston, MA, pp. 3–25. http://dx.doi.org/10.1007/978-1-4757-6846-6_1.

McCartt, A.T., Geary, L.L., 2004. Longer term effects of New York State's law on drivers' handheld cell phone use. Inj. Prev. 10 (1), 11–15. http://dx.doi.org/10.1136/ip.2003.003731.

McDonald, C.C., Kennedy, E., Fleisher, L., Zonfrillo, M.R., 2018. Factors associated with cell phone use while driving: A survey of parents and caregivers of children ages 4-10 years. J. Pediatr. 201, 208–214. http://dx.doi.org/10.1016/j.jpeds.2018.06.003.

McEvoy, S.P., Stevenson, M.R., Woodward, M., 2006. Phone use and crashes while driving: a representative survey of drivers in two Australian states. Med. J. Aust. 185 (11).

Moan, I.S., Rise, J., 2011. Predicting intentions not to "drink and drive" using an extended version of the theory of planned behaviour. Accid. Anal. Prev. 43 (4), 1378–1384. http://dx.doi.org/10.1016/j.aap.2011.02.012.

Montuori, P., Sarnacchiaro, P., Nubi, R., Di Ruocco, D., Belpiede, A., Sacco, A., De Rosa, E., Triassi, M., 2021. The use of mobile phone while driving: Behavior and determinant analysis in one of the largest metropolitan area of Italy. Accid. Anal. Prev. 157, 106161. http://dx.doi.org/10.1016/j.aap.2021.106161.

Murphy, G., Gauld, C., Lewis, I., 2020. Predicting the monitoring/reading of communications on a smartphone among young drivers using an extended theory of planned behaviour. Accid. Anal. Prev. 136, 105403. http://dx.doi.org/10.1016/j.aap.2019.105403.

National Center for Statistics and Analysis, 2018. Motorcycles: 2016 Data (Updated, Traffic Safety Facts. Report No. DOT HS 812 492). Technical Report, National Highway Traffic Safety Administration, Washington, DC, URL https://crashstats.nhtsa.dot.gov/Api/Public/Publication/812492.

National Safety Council, 2012. Understanding the Distracted Brain: Why Driving While Using Hands-Free Cell Phones Is Risky Behavior. White Paper, National Safety Council, URL https://www.nsc.org/getmedia/2ea8fe8b-d7b7-4194-8ea5-306d30a73972/cognitive-distraction-white-paper.pdf.

Nemme, H.E., White, K.M., 2010. Texting while driving: Psychosocial influences on young people's texting intentions and behaviour. Accid. Anal. Prev. 42 (4), 1257–1265. http://dx.doi.org/10.1016/j.aap.2010.01.019.

Nguyen, M.H., Nguyen-Phuoc, D.Q., Nguyen, N.A.N., Oviedo-Trespalacios, O., 2024. Distracted on duty: A theory-based exploration of influences leading to mobile phone distracted riding among food delivery workers. Accid. Anal. Prev. 202, 107538. http://dx.doi.org/10.1016/j.aap.2024.107538.

Nguyen, D.V.M., Ross, V., Vu, A.T., Brijs, T., Wets, G., Brijs, K., 2020. Exploring psychological factors of mobile phone use while riding among motorcyclists in Vietnam. Transp. Res. F: Traffic Psychol. Behav. 73, 292–306. http://dx.doi.org/10.1016/j.trf.2020.06.023.

Nguyen-Phuoc, D.Q., Oviedo-Trespalacios, O., Su, D.N., De Gruyter, C., Nguyen, T., 2020. Mobile phone use among car drivers and motorcycle riders: The effect of problematic mobile phone use, attitudes, beliefs and perceived risk. Accid. Anal. Prev. 143, 105592. http://dx.doi.org/10.1016/j.aap.2020.105592.

O'Brien, S., Tay, R., Watson, B., 2004. Situational factors contributing to the expression of aggression on the roads. IATSS Res. 28 (1), 101–107. http://dx.doi.org/10.1016/S0386-1112(14)60097-2.

Ogden, J., Brown, P.M., George, A.M., 2022. Young drivers and smartphone use: The impact of legal and non-legal deterrents. J. Saf. Res. 83, 329–338. http://dx.doi.org/10.1016/j.jsr.2022.09.007.

Olson, R.L., Hanowski, R.J., Hickman, J.S., Bocanegra, J., 2009. Driver Distraction in Commercial Vehicle Operation. Technical Report FMCSA-RRR-09-042, US Department of Transportation, Washington, DC, URL https://www.fmcsa.dot.gov/sites/fmcsa.dot.gov/files/docs/DriverDistractionStudy.pdf.

Olsson, B., Pütz, H., Reitzug, F., Humphreys, D.K., 2020. Evaluating the impact of penalising the use of mobile phones while driving on road traffic fatalities, serious injuries and mobile phone use: a systematic review. Inj. Prev. 26 (4), 378–385. http://dx.doi.org/10.1136/injuryprev-2019-043619.

Ortiz, C., Ortiz-Peregrina, S., Castro, J.J., Casares-López, M., Salas, C., 2018. Driver distraction by smartphone use (WhatsApp) in different age groups. Accid. Anal. Prev. 117, 239–249. http://dx.doi.org/10.1016/j.aap.2018.04.018.

Ortiz, N.C., Ramnarayan, M., Mizenko, K., 2017. Distraction and road user behavior: An observational pilot study across intersections in Washington, D.C.. J. Transp. Heal. 7, 13–22. http://dx.doi.org/10.1016/j.jth.2017.05.362.

Parker, D., Reason, J.T., Manstead, A.S.R., Stradling, S.G., 1995. Driving errors, driving violations and accident involvement. Ergonomics 38 (5), 1036–1048. http://dx.doi.org/10.1080/00140139508925170.

Parr, M.N., Ross, L.A., McManus, B., Bishop, H.J., Wittig, S.M.O., Stavrinos, D., 2016. Differential impact of personality traits on distracted driving behaviors in teens and older adults. Accid. Anal. Prev. 92, 107–112. http://dx.doi.org/10.1016/j.aap.2016.03.011.

Pawar, N.M., Khanuja, R.K., Choudhary, P., Velaga, N.R., 2020. Modelling braking behaviour and accident probability of drivers under increasing time pressure conditions. Accid. Anal. Prev. 136, 105401. http://dx.doi.org/10.1016/j.aap.2019.105401.

Pawar, N.M., Velaga, N.R., 2020. Modelling the influence of time pressure on reaction time of drivers. Transp. Res. F: Traffic Psychol. Behav. 72, 1–22. http://dx.doi.org/10.1016/j.trf.2020.04.017.

Pawar, N.M., Velaga, N.R., 2021. Investigating the influence of time pressure on overtaking maneuvers and crash risk. Transp. Res. F: Traffic Psychol. Behav. 82, 268–284. http://dx.doi.org/10.1016/j.trf.2021.08.017.

Peer, E., 2011. The time-saving bias, speed choices and driving behavior. Transp. Res. F: Traffic Psychol. Behav. 14 (6), 543–554. http://dx.doi.org/10.1016/j.trf.2011.06.004.

Potard, C., Kubiszewski, V., Camus, G., Courtois, R., Gaymard, S., 2018. Driving under the influence of alcohol and perceived invulnerability among young adults: An extension of the theory of planned behavior. Transp. Res. F: Traffic Psychol. Behav. 55, 38–46. http://dx.doi.org/10.1016/j.trf.2018.02.033.

Pöysti, L., Rajalin, S., Summala, H., 2005. Factors influencing the use of cellular (mobile) phone during driving and hazards while using it. Accid. Anal. Prev. 37 (1), 47–51. http://dx.doi.org/10.1016/j.aap.2004.06.003.

Prat, F., Gras, M.E., Planes, M., González-Iglesias, B., Sullman, M.J.M., 2015. Psychological predictors of texting while driving among university students. Transp. Res. F: Traffic Psychol. Behav. 34, 76–85. http://dx.doi.org/10.1016/j.trf.2015.07.023.

Qu, W., Ge, Y., Guo, Y., Sun, X., Zhang, K., 2020. The influence of WeChat use on driving behavior in China: A study based on the theory of planned behavior. Accid. Anal. Prev. 144, 105641. http://dx.doi.org/10.1016/j.aap.2020.105641.

Quy Nguyen-Phuoc, D., An Ngoc Nguyen, N., Nguyen, M.H., Ngoc Thi Nguyen, L., Oviedo-Trespalacios, O., 2022. Factors influencing road safety compliance among food delivery riders: An extension of the job demands-resources (JD-R) model. Transp. Res. A: Policy Pr. 166, 541–556. http://dx.doi.org/10.1016/j.tra.2022.11.002.

Regev, S., Rolison, J.J., Moutari, S., 2018. Crash risk by driver age, gender, and time of day using a new exposure methodology. J. Saf. Res. 66, 131–140. http://dx.doi.org/10.1016/j.jsr.2018.07.002.

Rendon-Velez, E., van Leeuwen, P.M., Happee, R., Horváth, I., van der Vegte, W.F., de Winter, J.C.F., 2016. The effects of time pressure on driver performance and physiological activity: A driving simulator study. Transp. Res. F: Traffic Psychol. Behav. 41, 150–169. http://dx.doi.org/10.1016/j.trf.2016.06.013.

Rozario, M., Lewis, I., White, K.M., 2010. An examination of the factors that influence drivers' willingness to use hand-held mobile phones. Transp. Res. F: Traffic Psychol. Behav. 13 (6), 365–376. http://dx.doi.org/10.1016/j.trf.2010.07.002.

Rozenkowska, K., 2023. Theory of planned behavior in consumer behavior research: A systematic literature review. Int. J. Consum. Stud. 47 (6), 2670–2700. http://dx.doi.org/10.1111/ijcs.12970.

Rudisill, T.M., Baus, A.D., Jarrett, T., 2019. Challenges of enforcing cell phone use while driving laws among police: a qualitative study. Inj. Prev. 25 (6), 494–500. http://dx.doi.org/10.1136/injuryprev-2018-042931.

Santos, J., Merat, N., Mouta, S., Brookhuis, K., de Waard, D., 2005. The interaction between driving and in-vehicle information systems: Comparison of results from laboratory, simulator and real-world studies. Transp. Res. F: Traffic Psychol. Behav. 8 (2), 135–146. http://dx.doi.org/10.1016/j.trf.2005.04.001.

Shaaban, K., Gaweesh, S., Ahmed, M.M., 2020. Investigating in-vehicle distracting activities and crash risks for young drivers using structural equation modeling. PLoS One 15 (7), e0235325. http://dx.doi.org/10.1371/journal.pone.0235325.

Sharma, I., Gupta, M., Mishra, S., Velaga, N.R., 2024. Exploring the impact of time pressure on motorized two-wheeler riders' over-speeding behavior. Transp. Lett. 1–17. http://dx.doi.org/10.1080/19427867.2024.2368348.

Shen, S., Benedetti, M.H., Zhao, S., Wei, L., Zhu, M., 2020. Comparing distance and time as driving exposure measures to evaluate fatal crash risk ratios. Accid. Anal. Prev. 142, 105576. http://dx.doi.org/10.1016/j.aap.2020.105576.

Shi, J., Hua, W., Si, H., Cheng, L., 2024. How to stimulate users' ridesharing intention and behavior? Evidence from structural and multi-group analyses. Travel. Behav. Soc. 37, 100858. http://dx.doi.org/10.1016/j.tbs.2024.100858.

Singleton, P.A., 2020. Multimodal travel-based multitasking during the commute: Who does what? Int. J. Sustain. Transp. 14 (2), 150–162. http://dx.doi.org/10.1080/15568318.2018.1536237.

Stavrinos, D., Jones, J.L., Garner, A.A., Griffin, R., Franklin, C.A., Ball, D., Welburn, S.C., Ball, K.K., Sisiopiku, V.P., Fine, P.R., 2013. Impact of distracted driving on safety and traffic flow. Accid. Anal. Prev. 61, 63–70. http://dx.doi.org/10.1016/j.aap.2013.02.003.

Stead, M., Tagg, S., MacKintosh, A.M., Eadie, D., 2005. Development and evaluation of a mass media Theory of Planned Behaviour intervention to reduce speeding. Health Educ. Res. 20 (1), 36–50. http://dx.doi.org/10.1093/her/cyg093.

Stern, E., 1999. Reactions to congestion under time pressure. Transp. Res. C: Emerg. Technol. 7 (2), 75–90. http://dx.doi.org/10.1016/S0968-090X(99)00013-3.

Subhan, F., Zhao, S., Diop, E.B., Ali, Y., Zhou, H., 2021. Public intention to pay for road safety improvement: A case study of Pakistan. Accid. Anal. Prev. 160, 106315. http://dx.doi.org/10.1016/j.aap.2021.106315.

Sullman, M.J.M., Hill, T., Stephens, A.N., 2018. Predicting intentions to text and call while driving using the theory of planned behaviour. Transp. Res. F: Traffic Psychol. Behav. 58, 405–413. http://dx.doi.org/10.1016/j.trf.2018.05.002.

Svenson, O., Benson, L., 1993. Framing and time pressure in decision making. In: Svenson, O., Maule, A.J. (Eds.), Time Pressure and Stress in Human Judgment and Decision Making. Springer US, Boston, MA, pp. 133–144. http://dx.doi.org/10.1007/978-1-4757-6846-6_9.

Swedler, D.I., Pollack, K.M., Gielen, A.C., 2015. Understanding commercial truck drivers' decision-makin process concerning distracted driving. Accid. Anal. Prev. 78, 20–28. http://dx.doi.org/10.1016/j.aap.2015.02.004.

Teschke, K., Harris, M.A., Reynolds, C.C.O., Shen, H., Cripton, P.A., Winters, M., 2013. Exposure-based traffic crash injury rates by mode of travel in British Columbia. Can. J. Public Heal. 104 (1), e75–e79. http://dx.doi.org/10.1007/BF03405659.

Topolšek, D., Ojsteršek, T.C., 2017. Do drivers behave differently when driving a car or riding a motorcycle? Eur. Transp.- Trasp. Eur. 66, 7, URL http://www.istiee.unict.it/europeantransport/papers/N66/P07_66_12_2017.pdf.

Truong, L.T., De Gruyter, C., Nguyen, H.T., 2017. Calling, texting, and searching for information while riding a motorcycle: A study of university students in Vietnam. Traffic Inj. Prev. 18 (6), 593–598. http://dx.doi.org/10.1080/15389588.2017.1283490.

Truong, L.T., Nguyen, H.T.T., 2019. Mobile phone related crashes among motorcycle taxi drivers. Accid. Anal. Prev. 132, 105288. http://dx.doi.org/10.1016/j.aap.2019.105288.

Truong, L.T., Nguyen, H.T.T., De Gruyter, C., 2019. Mobile phone use while riding a motorcycle and crashes among university students. Traffic Inj. Prev. 20 (2), 204–210. http://dx.doi.org/10.1080/15389588.2018.1546048.

Valliant, R., Dever, J.A., Kreuter, F., 2018. Practical Tools for Designing and Weighting Survey Samples, second ed. In: Statistics for Social and Behavioral Sciences, Springer, Cham, http://dx.doi.org/10.1007/978-3-319-93632-1.

Vance, D.E., Roenker, D.L., Cissell, G.M., Edwards, J.D., Wadley, V.G., Ball, K.K., 2006. Predictors of driving exposure and avoidance in a field study of older drivers from the state of maryland. Accid. Anal. Prev. 38 (4), 823–831. http://dx.doi.org/10.1016/j.aap.2006.02.008.

Waddell, L.P., Wiener, K.K.K., 2014. What's driving illegal mobile phone use? Psychosocial influences on drivers' intentions to use hand-held mobile phones. Transp. Res. F: Traffic Psychol. Behav. 22, 1–11. http://dx.doi.org/10.1016/j.trf.2013.10.008.

Walsh, S.P., White, K.M., Hyde, M.K., Watson, B., 2008. Dialling and driving: Factors influencing intentions to use a mobile phone while driving. Accid. Anal. Prev. 40 (6), 1893–1900. http://dx.doi.org/10.1016/j.aap.2008.07.005.

Wang, X., Xu, R., Asmelash, A., Xing, Y., Lee, C., 2020. Characteristics of driver cell phone use and their influence on driving performance: A naturalistic driving study. Accid. Anal. Prev. 148, 105845. http://dx.doi.org/10.1016/j.aap.2020.105845.

Watling, C.N., 2014. Sleepy driving and pulling over for a rest: Investigating individual factors that contribute to these driving behaviours. Pers. Individ. Differ. 56, 105–110. http://dx.doi.org/10.1016/j.paid.2013.08.031.

WHO, 2018. Global Status Report on Road Safety: Summary. Technical Report WHO/NMH/NVI/18.20, WHO (World Health Organisation), Geneva, URL https://iris.who.int/bitstream/handle/10665/277370/WHO-NMH-NVI-18.20-eng.pdf.

Wilson, F.A., Stimpson, J.P., 2010. Trends in fatalities from distracted driving in the United States, 1999 to 2008. Am. J. Public Health 100 (11), 2213–2219. http://dx.doi.org/10.2105/AJPH.2009.187179.

Yang, H., Liu, X., Su, F., Cherry, C., Liu, Y., Li, Y., 2018. Predicting e-bike users' intention to run the red light: An application and extension of the theory of planned behavior. Transp. Res. F: Traffic Psychol. Behav. 58, 282–291. http://dx.doi.org/10.1016/j.trf.2018.05.027.

Yang, Y., Yin, D., Easa, S.M., Liu, J., 2022. Attitudes toward applying facial recognition technology for red-light running by E-bikers: A case study in Fuzhou, China. Appl. Sci. 12 (11), 211. http://dx.doi.org/10.3390/app12010211.

Yannis, G., Golias, J., Spyropoulou, I., Papadimitriou, E., 2007. Mobility patterns of motorcycle and moped riders in Greece. Transp. Res. Rec. 2031 (1), 69–75. http://dx.doi.org/10.3141/2031-09.

Zhang, Z., Guo, Y., Fu, R., Yuan, W., Yang, G., 2020b. Do situational or cognitive factors contribute more to risky driving? A simulated driving study. Cogn. Technol. Work. 22 (4), 759–767. http://dx.doi.org/10.1007/s10111-020-00630-3.

Zhang, Y., Huang, Y., Wang, Y., Casey, T.W., 2020a. Who uses a mobile phone while driving for food delivery? The role of personality, risk perception, and driving self-efficacy. J. Saf. Res. 73, 69–80. http://dx.doi.org/10.1016/j.jsr.2020.02.014.

Zhang, Y., Li, L., 2020. Intention of Chinese college students to use carsharing: An application of the theory of planned behavior. Transp. Res. F: Traffic Psychol. Behav. 75, 106–119. http://dx.doi.org/10.1016/j.trf.2020.09.021.

Zheng, Y., Ma, Y., Guo, L., Cheng, J., Zhang, Y., 2019. Crash involvement and risky riding behaviors among delivery riders in China: The role of working conditions. Transp. Res. Rec. 2673 (4), 1011–1022. http://dx.doi.org/10.1177/0361198119841028.

Zhou, R., Rau, P.-L.P., Zhang, W., Zhuang, D., 2012. Mobile phone use while driving: Predicting drivers' answering intentions and compensatory decisions. Saf. Sci. 50 (1), 138–149. http://dx.doi.org/10.1016/j.ssci.2011.07.013.

Zhou, R., Wu, C., Patrick Rau, P.-L., Zhang, W., 2009. Young driving learners' intention to use a handheld or hands-free mobile phone when driving. Transp. Res. F: Traffic Psychol. Behav. 12 (3), 208–217. http://dx.doi.org/10.1016/j.trf.2008.11.003.