



Impact of Environmental & Psychological Factors on Driver's Behavior and its Respective Effective Measures to be Taken in Terms of Improving Roadway Design and Policymaking

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Abstract. This study aimed to investigate the complex connection among environmental and psychological factors that impact driver behavior, with an emphasis on the effect of traffic heterogeneity and unfavorable pavement conditions on driving performance. The findings indicate that environmental stimuli and their processing by the human brain can have a significant impact on driver behavior. Drivers in heterogeneous traffic may uncertain to maintain their speed and may engage in more lane changes and overtaking, leading to increased visual and cognitive distractions. Moreover, the traffic performance is greatly impacted by the adverse road conditions resulting in the direct relationship in between road conditions and vehicle speed. These findings have significant implications regarding road design and traffic management, as they highlight the need to take measures for improving road conditions and effective traffic controls to ensure safe and sound driving. This current study is really helpful to policy makers, transportation engineers and road designers in developing traffic management strategies and informed decisions about road infrastructure to make certain the smooth traffic flow. Furthermore, risky driving behavior arbitrates the involvement of psychosocial factors in road traffic accidents. Implications of the findings have been discussed in terms of improving drivers' training curricula and enforcement of traffic laws.

Keywords: Environmental factors, Psychological factors, pavement condition, and road danger.

1 Introduction

Well-made transportation infrastructure is essential for effective and safe traffic activities. The network of road with good pavement (road surface) quality is needed for this. However, by the passage of time pavement conditions progressively deteriorate due to the factors such as overcrowding, environmental variables, and poor road construction [1,2].

Another significant factor is mental state of drivers also playing an important role in traffic safety due to some factors such as proper alignment of the road, low driving speeds, improve traffic safety services, and an increase of traffic interference issues on metropolitan roads. Meanwhile, familiarity with route has a major impact on a driver's psychological state when driving in a city [3]. Typically, when a road originally constructed it is in good condition. The pavement progressively deteriorates and deteriorates further with time and with constant application of traffic loads that has negative impact on psychological state of drivers. [4]

The safety and efficiency of roadway systems are critical for public transportation. The design of the roads and the management of traffic are essential factors that impact driver behavior and roadway safety. Traffic performance influenced by many factors that includes tire pressure, vehicle speed, traffic load, and traffic volume, psychological state of driver are considered as traffic variables that influence performance. [5] The condition of road surfaces has a profound impact on driver behavior and psychological state, influencing both safety and security on the roads. For instance, encountering broken pavement can lead to heightened stress and frustration, similar to how financial pressures, like rising inflation rates, can cause anxiety and alter behavior. Rough roads can increase cognitive load, making it harder to concentrate, much like financial worries can distract from daily tasks. Emotional responses to poor road conditions can manifest as anger or stress, potentially leading to aggressive driving behaviors. These psychological strains not only affect individual

Drivers but can also impact overall traffic safety and the likelihood of accidents. Subjective feelings of fatigue decreased performance [6]. It's also observed that stress in monotonous situations leads to increased fatigue, causing additional psychological issues in individuals performing repetitive tasks [7].

In terms of risk perception, drivers may choose alternate routes to avoid poorly maintained roads, much like individuals might alter their spending habits during economic uncertainty. Safety concerns are paramount, as rough pavement can lead to accidents and near-miss incidents, highlighting the need for effective road maintenance. Regular vehicle maintenance becomes more crucial as rough roads contribute to increased wear and tear. Finally, public opinion often calls for improved infrastructure to ensure safety, akin to calls for financial policies that stabilize the economy.

Addressing these issues requires comprehensive strategies that consider both the psychological and physical impacts on drivers.

The frequent lane changes in Karachi minimally impact vehicle speeds, especially for motorcycles weaving through traffic. This behavior is influenced by the psychology of conflict avoidance in motorcycle collisions. With limited insurance coverage for vehicles in Pakistan, collisions often result in immediate payments negotiated on the spot between parties. Despite motorcyclists usually suffering more severe injuries, they are often expected to bear the financial burden and legal consequences, influencing how other vehicle owners perceive collision risks.

Traffic complexity is influenced not only by vehicles but also by drivers, who possess diverse psychological traits and varying objectives. Consequently, imbalances can arise, leading to irrational driving behavior. The intricate interactions within traffic alter the specific behaviors of its participants. For safe traffic flow, each driver must consider the behaviors of others and be willing to adhere to common safety requirements without imposing their own behavior.

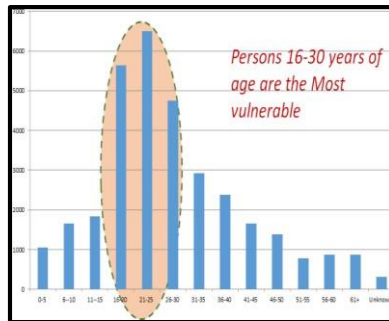


Fig.1. Vulnerable road users in Karachi, Pakistan

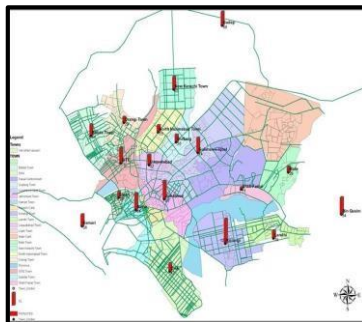


Fig. 2. Spatial Distribution of fatalities in various towns

This study involves the assessment of the involvement of environmental and psychological factors on the behavior of drivers, with a particular focus on pavement condition effects on vehicle speed.

2 Methodology:

2.1 Traffic Data Acquisition and Data Processing:

The data used in this study involves the traffic data which includes site details, trajectory dataset and vehicle dataset. Driving behavior depends on several external factors, such as road geometry and driving environment which play a significant role in accidents. To keep the driving environment (with respect to road geometry) uniform for all the participants, each participating driver was ensured that similar geometrical elements and other road infrastructure features were faced.

After the data is acquired, processing of data is carried out to determine any flaws or ambiguity present. Different environmental and psychological characteristics are determined using previous studies which play a major role in driver behavior analysis as highlighted in the figure. Correlations between environmental factors and vehicular speed are determined.

2.2 Collection of Data for Driver Behavior Survey:

A detailed research on the psychological and behavioral impacts of rough pavement conditions on drivers was conducted. An online questionnaire was conducted targeting the drivers having the age range 18 years to 38 years to determine the comprehensive insights into the psychological and behavioral impacts of rough pavement conditions on drivers, aiding researchers in understanding the broader implications for road safety and infrastructure enhancement.

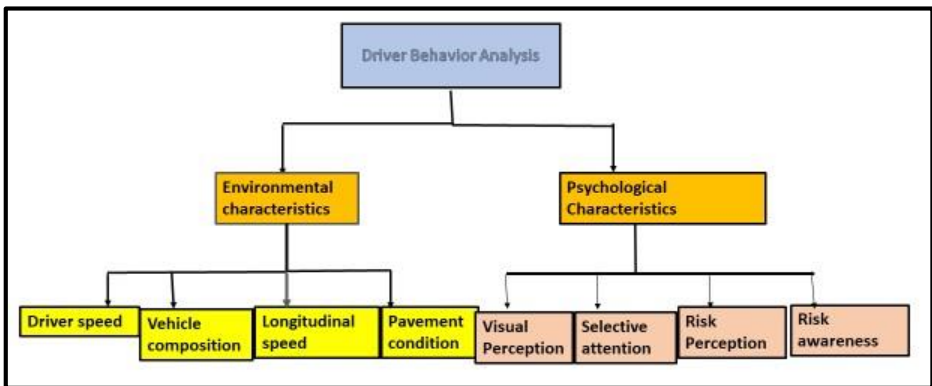


Fig.3. Visual presentation of aspects of Driver Behavior Analysis

3 Results and Discussion:

3.1 Effect of Pavement Distress on Vehicle Speed

Significant vehicle speed loss is the result of pavement distresses. For the purpose of estimating traffic performance, the relationship between Speed and PCI values in a free flow situation was used. We set out road sections with different kind of distresses. The sections were surveyed and the empirical result is investigated.

The empirical results from surveyed sites showed that the adverse conditions in pavement have significant impact on the traffic performance. There is direct relationship between the PCI (Pavement Condition Index) and speed of the vehicles. Some observations were outliers indicating an indirect relation between PCI values and speed which may be possible in real time. People may change their direction when there is distress in pavement with the same speed.

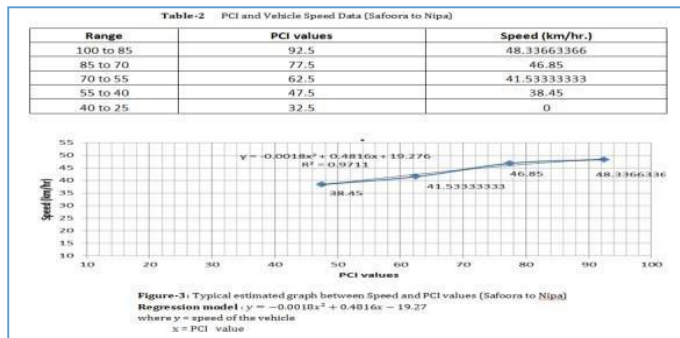


Fig. 4. Regression Model of PCI vs Vehicle speed

Gap versus speed

- Below graph shows the relationship between speed and longitudinal and lateral gaps.
- Both lateral and longitudinal gaps are less in less speed and increases when the speed increases.
- The increase in road width usage is due to the varying widths of the vehicles and their gap maintaining behavior.

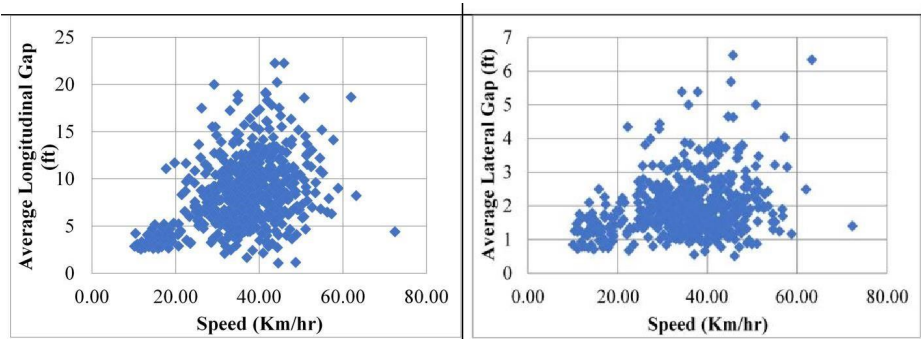


Fig. 5. Understanding of psychological and behavioral impacts of rough pavement conditions on driver Behavior

Psychology has gained significant scientific importance and serves as a fundamental tool for understanding and interpreting individual behavior both in solitary and social contexts. Individuals cannot socialize or communicate without perceiving, learning, and memorizing experiences. Drivers, in particular, rely on their senses—sight, hearing, and smell—to navigate and respond to their environment. [8] Learning is the process through which individuals adopt behaviors based on their experiences. For drivers, social learning theory suggests that behaviors observed on the road, such as yielding to pedestrians or navigating complex intersections, are often learned through watching and imitating other drivers. [9]

The findings of current research indicated that drivers must focus intensely on navigating potholes, cracks, and uneven surfaces, increasing cognitive load and potentially leading to mental fatigue. Focusing on road imperfections can distract drivers from critical tasks such as observing traffic signals and responding to other vehicles. Driver distraction is a well-recognized safety issue with significant consequences, as noted in various studies [10]. Numerous simulator studies have investigated the effects of cognitive distractions on driver behavior [11].

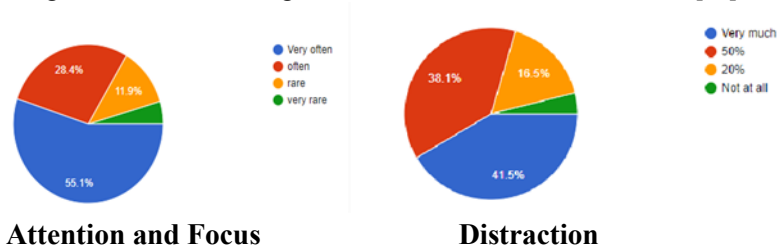


Fig. 6. Driver’s behavior (1)

Present research revealed that persistent exposure to poor road conditions can elevate stress levels, impairing decision-making and Frustration from rough pavements can lead to aggressive driving behaviors, including speeding and abrupt lane changes in addition to driver discomfort while currently riding on a road that may increasing the likelihood of accidents. That is also aligned with previous researches The condition of road infrastructure, including its geometric characteristics, plays a crucial role in shaping drivers' psychological states. This influence has been thoroughly documented in previous studies, which also offer several specific design recommendations [12,13]. Drivers may overreact to road imperfections by slowing down excessively or making sudden maneuvers, potentially causing collisions.

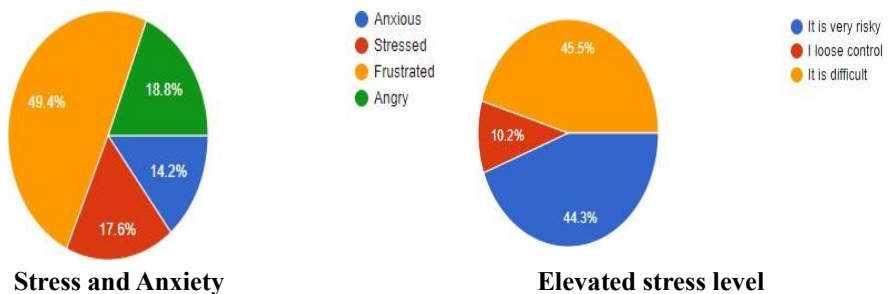


Fig. 7. Driver's behavior (2)

It also observed that conversely, some drivers may underestimate the impact of rough pavements, maintaining higher speeds or not adjusting their driving style appropriately. Driving on rough roads accelerates vehicle wear, leading to potential mechanical failures such as tire blowouts or suspension problems. Poor pavement conditions can compromise vehicle handling, making it harder to steer, brake, or accelerate smoothly, especially in emergency situations. Perception is a complex process, often demonstrated through phenomena like optical illusions. These perceptual phenomena significantly influence and sometimes mislead drivers. Misinterpretations of reality are more likely when a driver loses concentration, potentially leading to irresponsible behavior. [14]

Underestimation Mechanical Issues Reduced Maneuverability

These factors underscore the critical importance of maintaining good pavement conditions to enhance road safety and mitigate adverse effects on driver behavior. Rough pavement conditions can affect drivers psychologically by increasing their cognitive workload, stress levels, and altering their perception of risks. These factors contribute to unsafe driving behaviors and heightened safety risks on the road

4 Conclusion

In conclusion, traffic safety hinges greatly on understanding and addressing driver behavior, which is influenced by a range of psychological factors. When drivers take to the road, they are subjected to various psychological processes such as perception, learning, memory, emotions, and motivation [15]. These factors collectively shape their decisions and actions while driving, impacting their ability to navigate safely through traffic and respond effectively to changing road conditions. Therefore, exploring and comprehending these underlying psychological mechanisms are crucial for developing strategies that promote safer driving behaviors and reduce the likelihood of accidents. The analysis of data can be used for defining and classifying the vehicle undergoing maneuvers in mixed traffic condition. It has been found that the driver behavior in heterogeneous movement is significantly different from the homogeneous movement. Therefore, the different maneuvers need to be incorporated into the analysis and simulation of mixed traffic flow for making it more realistic and reliable. The results of the analysis would help policy makers in making decisions regarding over speeding of the vehicles and separate lanes for different vehicles in order to make driving convenient which would reduce accidents and improve the well-being of the road users. Also designing safety programs and safety education to drivers that take personality traits into account may also yield better results.

Acknowledgement. The authors acknowledge the financial support from Erasmus+ CBHE project BIOMED5.0, funded by the European Union (Project Number: 101129077). Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union. Neither the European Union nor the granting authority can be held responsible for them.

References

1. S. Bhandari, X. Luo, and F. Wang, "Understanding the effects of structural factors and traffic loading on flexible pavement performance," *International Journal of Transportation Science and Technology*, vol. 12, no. 1, pp. 258- 272, 2023.
2. D. Llopis-Castelló, T. García-Segura, L. MontalbánDomingo, A. Sanz-Benlloch, and E. Pellicer, "Influence of pavement structure, traffic, and weather on urban flexible pavement deterioration," *Sustainability*, vol. 12, no. 22, p. 9717, 2020.
3. H. Alizadeh *et al.* Frequent versus occasional drivers: A hybrid route choice model *Transportation Research Part F: Traffic Psychology and Behaviour* (2019)
4. Khan, I., Khattak, K., Khan, Z. H., & Gulliver, T. A. (2023). Impact of Road Pavement Condition on Vehicular Free Flow Speed, Vibration and In-Vehicle Noise. *Science, Engineering and Technology*, 3(1), 1-8.
5. Fernandes Junior, J. L., Pais, J. C., & Pereira, P. A. (2006). Effects of traffic loading on Portuguese and Brazilian Pavements Performance.

6. Lyznicki, J.M., Doege, T.C., Davis, R.M., Williams, M.A., 1998. Sleepiness, driving and motor vehicle crashes. *J. Am. Med. Assoc.* 279, 1908–1913.
7. Hancock, P.A., Warm, J.S., 1989. A dynamic model of stress and sustained attention. *Hum. Factors* 31, 519–537.
8. Dolfer, M. (2004). *Psicologia del traffico*, Mac Graw-Hill.
9. Bucchi, A. & Simone, A. (2000). *Il fattore umano nell'ingegneria della sicurezza nella circolazione stradale, Strade e Autostrade*, 1.
10. Strayer, D.L., Drews, F.A., Crouch, D.J., 2006. A comparison of the cell phone driver and the drunk driver. *Hum. Factors* 48, 381–391.
11. Strayer, D.L., Johnston, W.A., 2001. Driven to distraction: dual-task studies of simulated driving and conversing on a cellular telephone. *Psychol. Sci.* 12, 462–466.
12. Bucchi, A. & Lantieri, C. (2011). *Introduzione alla psicologia del traffico, Strade e Autostrade*, 1.
13. Bucchi, A. & Petretto, F. (2011). *Infrastruttura stradale e psicologia viaria, Strade e Autostrade*, 5.
14. Polmonari, A., Cavazza, N. & Rubini, M. (2002). *Psicologia sociale, Il Mulino*
15. Bucchi, A., Dondi, G., Simone, A. & Bonini, A. (1999). *Principi dell'ingegneria della sicurezza nei sistemi di trasporto, Trasporti europei*, 10.

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