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THE MEDIATING ROLE OF PERSONALITY IN THE RELATIONSHIP BETWEEN REACTION TIME AND TRAFFIC PERCEPTION IN YOUNG ADULTS

Summary. The objective of this research was to examine how personality acts as a mediator in the relationship between reaction time and traffic perception in young adults. Given the increase in the number of road accidents among this age group in the European Union, it is essential to understand the psychological determinants of risky driving behavior. A sample of 60 participants from Poland, Slovakia, and Lithuania was assessed using the Vienna Test System to measure personality, reaction time, time-movement anticipation, and traffic perceptions. The results indicate gender differences in self-control personality factor and motor reaction time, as well as a positive correlation between the sense of responsibility and time-movement anticipation. The proposed model was confirmed, demonstrating that mental stability mediates the relationship between reaction time and traffic perceptions. A driver with high mental stability can react faster to stimuli while accurately perceiving objects in road traffic. This study has implications for road safety policies and practices. Incorporating personality assessments into driver training programs can help develop interventions that target specific personality traits. Furthermore, interventions aimed at enhancing mental stability may help reduce the likelihood of accidents among young drivers. However, this study's limitations, such as the small sample size and narrow age range, should be considered in future research with other age groups and additional variables that directly impact traffic safety.

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1. INTRODUCTION

The number of people who died in road accidents in 2021 increased by 5% on average in the European Union. It is noteworthy that from 2019-2021 vehicle traffic was limited due to the COVID pandemic. The highest rates of people who died in traffic incidents per 1 million inhabitants were reached by Lithuania (90), Romania (85), Bulgaria (67), and Poland (65) [1]. In 2022, an increase in the number of accidents and fatalities was observed. In Poland alone, in three months in 2022, there were 4136 road accidents in which 418 people were killed and 4755 were injured.

Driving is a multitasking activity that requires high psychomotor performance [2]. It is a task in which the main modifier is the constantly changing situational environment. The number of elements occurring independently in a given period engages the multi-level resources of the individual [3]. Therefore, the driver is in a continuous process of decision-making ending in a response (R) dependent on the external situation (S), previous experiences, information acquired (E), and internal stimuli from the body (I).

$$R = f(S, E, I) \tag{1}$$

The most important factors explaining driver behavior in traffic are perception [4], reaction time [2], personality [5], memory, and intelligence [6]. This is not a complete list of variables affecting a driver's performance; however, these are the dimensions that have a direct relationship with the processes required to perform driving activities. Indirect factors may include age and experience, gender, emotions, attitudes, and temperament [7].

Personality is a complex system of information (experiences, sensations, attitudes) and the mental processes that organize this information (intelligence, aptitudes, abilities, temperament), forming a relatively constant cognitive, emotional, and behavioral pattern. Personality is connected with temperament, which is the organism's biological endowment, which is a type of nervous system (energy level and reaction time) [8]. The main personality dimensions that influence a driver's reactions in a traffic situation are extraversion, neuroticism/impulsivity, conscientiousness, openness to experience/risk aversion, and agreeableness [5]. Trait mapping allows the determination (prediction) of whether a given driver will make mistakes, behave aggressively, drive while fatigued, or engage in other risky behaviors [9]. It is worth noting that personality is often a compensation resource for deficits arising from psychobiological conditions. If a driver has decreased psychomotor performance, it can be compensated by caution, adherence to traffic rules, attention, emotional stability, and a sense of responsibility [10].

Perception of traffic elements requires the involvement of cognitive processes that enable the reception and interpretation of impressions through operations on perceptual information as conscious reactions of sensory apparatuses to external stimuli, which makes it possible to recognize objects (objects on the road), processes (acceleration, gear change), maneuvers (bypassing, overtaking), and atmospheric phenomena (intense rainfall, fog) in traffic [11].

The driver's actions are based on the perceptions formed after receiving stimuli from the traffic situation, which include visual, auditory, tactile, and kinesthetic information. These sensory inputs are processed by attentional resources to create a perception of sensations and perceptions. The driver then performs cognitive operations on this information by directing it to memory and further processing it through imaginative or thinking processes [6]. The outcome of these cognitive processes depends on the driver's intelligence, aptitudes, and mindset, as well as their personality, emotions, socialization, and psychomotor skills, all of which can influence their responses to the acquired information [12]. Each stage of this information processing has a significant impact on the driver's decision-making process, ultimately leading to a choice of action. The optimal outcome of these cognitive processes is the effectiveness and accuracy of the driver's reactions in the specific traffic situation at hand.

The detection of a stimulus triggers a reaction that may be involuntary (braking at every traffic signal) or conscious (braking after the perception of a red or, in a specific context, an amber light) [13]. The driver has to assess the information and then adjust their behavior accordingly. The parameter that allows for determining efficiency is the reaction time. This is the time from perceiving a stimulus to making the correct response based on the stimulus. An additional parameter is motor time, which begins with the initiation of movement response and ends with the return to the baseline state. Both parameters are related to perception and constitute traffic perception [4]. Navigating in dynamic settings requires correct rapid perception recognition and the accurate interpretation of stimuli. The cognitive process supporting the driver's performance is time-movement anticipation. This parameter is important not only when overtaking and passing objects on the road but also when estimating the distance to specific elements in the traffic environment [11].

The highest numbers of accidents and risky behaviors are reported among young adults. According to Erik Erikson, the age of people in this group ranges from 19 to 40 years old. Among young adults, law-breaking and dangerous driving behaviors, including speeding, phone use, and aggression, are observed more often than in other age groups [14]. This research project will describe the characteristics of the selected variables based on a sample of individuals from this age group. The relationship between psychomotor performance (X) and the perceptual accuracy of objects occurring in traffic (Y), which is mediated by personality (M_i), will be tested (see Fig. 1).

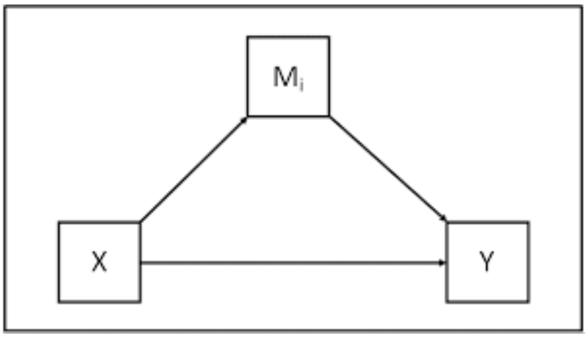

Fig. 1. Research model: Example

2. METHODS

2.1. Participants

Individuals who took part in the study were enlisted from three different universities (N=60): the University of Žilina (n=20), Vilnius Gediminas Technical University (n=20), and Lublin University of Technology (n=20). Recruitment was advertised among students and employees according to the following criteria: being aged 19-40 years, having a driving license for at least two years with driving experience, and consenting to participate in the study. The selection process was conducted such that a male and female population was obtained according to the distribution found in technical universities: 23.2% females (n=13) and 76.8% males (n=43). The average age of the group was 25.9 years, with a standard deviation of 3.72.

2.2. Apparatus and Measurements

The research tool used in the present study is the Vienna Test System software with a universal response panel (in and out device; see Fig. 2). The software was launched on a notebook with an INTEL i5 7gen 7200U, 4 GB RAM, Intel® HD Graphics 620 graphic card without dedicated graphics memory and operated on a 64-bit Windows 7 Professional operating system. The test screens were presented on a 15.6" LCD monitor (resolution 1366 x 768 pixels). A headset was used to separate the person from potential distractors and to increase the immersiveness of the trial in tasks with sound.

The ability to respond to simple choice stimuli was examined using the reaction test method (see Fig. 3). It is possible to measure reaction time for simple and multiple-choice responses using either light or sound stimuli. Additionally, there is a choice of three colors (red, yellow, or white) that can be used to create various stimulus combinations to calculate reaction time. The incorporation of a rest key and a reaction key enables the differentiation between motor and reaction times. The S3 test variant was used, by which a choice reaction was required in response to yellow/tone stimuli (reactions to critical stimulus combinations). This method can measure the following parameters: working time, mean motor time, mean reaction time, correct reaction, no reaction, and dispersion.

The accuracy of perceiving objects in road traffic was verified using the Adaptive Tachistoscopic Traffic Perception Test method (see Fig. 4). In this test, the screen displays pictures of traffic scenarios accompanied by a tone cue before each illustration. After each picture is displayed, the participant is prompted to identify its contents from a list of five potential answers. The answer options are the same for each item. This method can provide the following information: total score, incorrect answers, lower and upper limits of the true performance parameter, correct answers, and reliability.

Fig. 2. Vienna Test System: In and out device

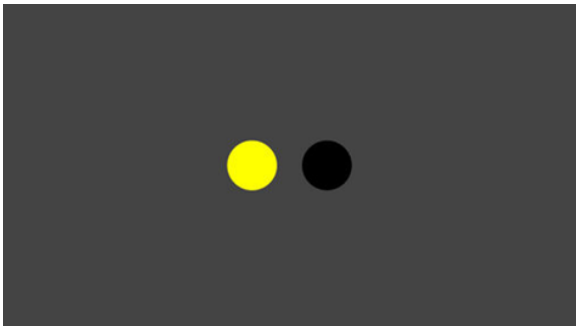

Fig. 3. Reaction test (RT): Screen example

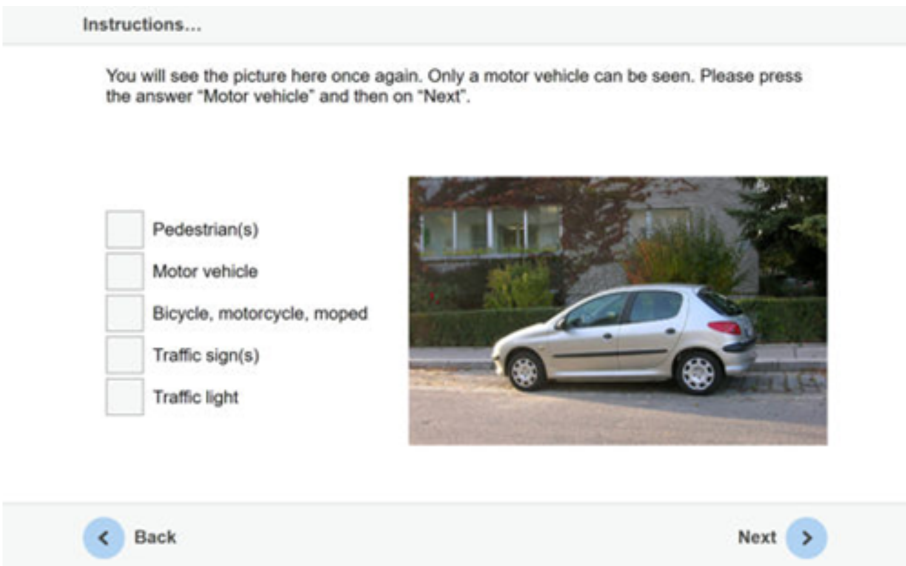

Fig. 4. Adaptive Tachistoscopic Traffic Perception Test: Task example

Personality was characterized using the Inventory of Driving Related Personality Traits (IVPE; see Fig. 5). This test evaluates personality traits that are relevant to traffic psychology, such as one's sense of social responsibility, self-control, mental stability, and risk avoidance. "Mental stability" pertains to the respondent's emotional resilience and susceptibility to stress. "Sense of responsibility" refers to an individual's adherence to societal norms and values. The self-control scale measures the level of conscientiousness, discipline, and impulsiveness. "Risk avoidance" relates to a respondent's tendency to avoid hazardous driving behaviors and instead adopt preventive driving practices.

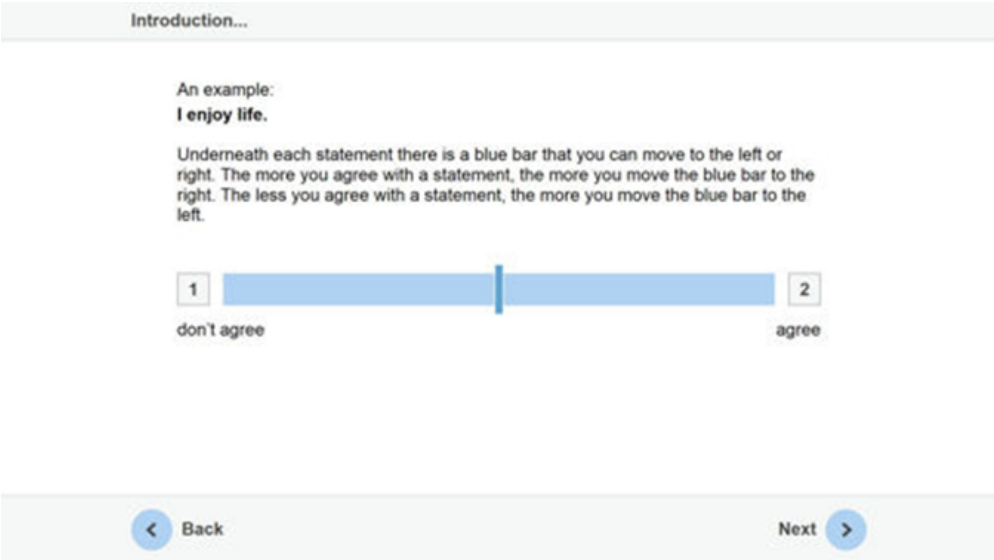

Fig. 5. Inventory of Driving-related Personality Traits (IVPE): Question example

Regarding transportation, the ability to predict and make time movements is crucial to positioning oneself in accordance with the movements of people or objects. An experiment involved a green ball that moved on a screen, with its speed and direction changing depending on the task. At an unexpected time, the ball disappeared, and participants were required to press a button when they thought the ball should have reached the target line; they were also to mark the point at which they think the ball would cross the target line. Two types of tasks were presented: one in which the ball moved from left to right and one in which it moved from right to left. Left anticipation is better developed in right-handed traffic. After the examination, the following data were obtained: number of exact estimations, number of overestimations, number of extreme over- and underestimations, and median deviation time from the left and right.

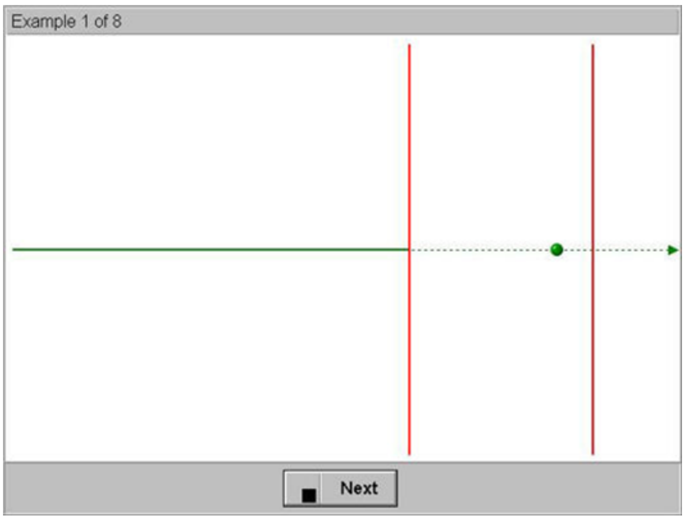

Fig. 6. Time Movement Anticipation (ZBA): Task example

2.3. Experiment procedure

The study was approved by the psychology department ethical review committee of the John Paul II Catholic University of Lublin. After reviewing the procedure information and agreeing to participate in the study, individuals were asked to complete a personal questionnaire confirming that they met the recruitment criteria and including questions about health status to exclude the persons with cognitive deficits or disorders affecting the experiment. Several participants did not proceed to the next stage. Then, in a specially prepared room (free of distractors), each individual was asked to take a seat facing the screen and the reaction panel and then put on the headphones. The experimenter supervising the study started the measurement procedure (RT → AVAVT → IVPE → ZBA). Each test was preceded by instructions and a training phase. Once the participant's understanding of the instructions was confirmed and they passed the training phase, the actual measurement phase was initiated. The experimenter observed the subject the whole time and was ready to interact with the person. The average time taken to complete all tasks was 35 minutes. After the measurement, the experimenter interviewed the subject to gain feedback about the experience. For four participants, the examiner determined that the obtained data were not suitable for further analysis (test interruption, third-party interference with the test, and attempted cheating).

3. RESULTS

The analyses were performed using IBM SPSS Statistics 25. Raw scores were converted into Z-scores in comparison to the normalization group (N=1000). The Z-score indicates the location of a raw score in relation to its distance from the mean. The rule of thumb was used to assess normality. Descriptive statistics (see Table 1) show that skewness for individual variables is between -2 and +2 and kurtosis is between -7 and +7, which allows the assumption of the normality of distribution. On this basis, parametric tests were applied.

Table 1

Descriptive statistics for the research sample (N=56)

	Mean (M)	Standard deviation (SD)	Skewness	Kurtosis
Mental stability	97.52	8.74	-0.79	0.04
Self-control	93.96	7.61	0.25	0.16
Risk avoidance	91.96	6.95	0.24	0.31
Sense of responsibility	93.45	7.03	0.51	1.38
Movement/time left	101.50	9.04	-0.22	1.92
Movement/time right	102.00	9.00	0.22	0.58
Traffic perception	98.36	11.65	0.00	0.05
Motor time	105.13	9.25	-0.23	-0.15
Reaction time	107.52	9.33	0.31	0.49

First, a Student's t-test was conducted to determine the differences between males and females regarding each of the study variables (see Table 2).

Statistically significant differences between males and females were identified in the personality factor *self-control* (p=.02) as well as *motor time* (p=.03). The females had significantly higher scores in self-control than males, meaning they better manage the impulses that arise in traffic, such as overtaking a vehicle due to impatience, speeding, and aggressiveness on the road. A tendency was also observed in *risk avoidance* (p=.06) and *time-movement anticipation left* (p=.06), which needs to be verified on a larger study sample. It is worth noting that females have higher risk avoidance and lower anticipation ability than males. There were no significant differences between males and females in *mental stability* (p=.33), *sense of responsibility* (p=.49), *movement/time right* (p=.32), *traffic perception* (p=.14), and *reaction time* (p=.77).

Table 2

Differences between females (n=13) and males (n=43) for each tested variable

	Females		Males		df	t	p
	M	SD	M	SD			
Mental stability	94.85	11.85	98.33	7.55	15	-1.00	.33
Self-control	98.23	4.78	92.67	7.87	54	2.41	**.02***
Risk avoidance	95.15	7.99	91	6.40	54	1.93	.06
Sense of responsibility	94.62	5.59	93.09	7.44	54	0.68	.49
Movement/time left	97.31	10.48	102.77	8.28	54	-1.96	.06
Movement/time right	99.77	9.15	102.67	8.95	54	-1.02	.31
Traffic perception	94.15	11.80	99.63	11.44	54	-1.50	.14
Motor time	100.31	6.74	106.58	9.48	54	-2.22	**.03***
Reaction time	106.85	12.36	107.72	8.38	54	-.29	.77

*. Correlation is significant at the 0.05 level (2-tailed).
**. Correlation is significant at the 0.01 level (2-tailed).

The data show that there are no sex differences in the main research variables (with the exceptions of *motor time* and *self-control*); thus, the females and males can be analyzed as one research group.

Secondly, ANOVA and post-hoc Tukey's test were also conducted to determine if there were differences between individuals by country of origin. The results showed no differences (p >.05), which indicates the consistency of the research group and allows for analyses to be conducted on the entire group.

Next, Pearson's r-correlation test was used to examine the relationship between the variables and verify the applicability of regression tests (see Table 3).

Table 3

Pearson Correlation Matrix

	1	2	3	4	5	6	7	8	9
Mental stability	1.00								
Self-control	-.03	1.00							
Risk avoidance	.10	.04	1.00						
Sense of responsibility	-.03	**.71****	-.03	1.00					
Movement/time left	-.17	.25	-.17	**.33****	1.00				
Movement/time right	-.17	.15	.13	**.28***	**.65****	1.00			
Traffic perception	**.27***	.00	-.09	.11	.09	-.13	1.00		
Motor time	.08	-.03	-.04	.04	-.06	-.08	.13	1.00	
Reaction time	**.32***	.12	.06	.12	-.19	-.11	-.07	**.32***	1.00

*. Correlation is significant at the 0.05 level (2-tailed).
**. Correlation is significant at the 0.01 level (2-tailed)

A strong significant correlation was found between the personality factors of *sense of responsibility* and *self-control* (r=.71. p>0.01), which indicates a high similarity of these variables. The same situation occurs in the case of *movement-time anticipation from the left* and *from the right* (r=.65, p>0.01). It is worth mentioning that the remaining significant correlations are weak, which, on the one hand, is sufficient to further analyze the existing relationships, and, on the other hand, indicates that different phenomena have been explored.

Stepwise regression analysis was conducted to identify predictors of traffic perception (see Table 4), as it is an efficient way to select suitable predictors after the elimination of multicollinearity. The tolerance statistic and the variance inflation factor was 1.

Table 4

Results of Stepwise Regression Analysis between Mental Stability, Reaction Time, and Traffic Perception

	Unstandardized Coefficients		Standardized Coefficients			95.0% Confidence Interval for B	
Model 1	B	Std. Error	Beta	t	Sig.	Lower Bound	Upper Bound
Constant	62.71	17.08		3.67	<.001	28.46	96.96
Mental Stability	.37	.17	.27	2.09	<.05	.02	.71
F(1,54)=65.76; p < .05 Traffic perception=62.71 + 0.37 x Mental stability							

Model 1 explains 27% of the variance, and mental stability as a predictor explains 7.5% of traffic perception. The results show that just one predictor was added to the model, and the R-squared value increased, indicating that the model adequately explains the variance of traffic perception. Reaction time was excluded from the model due to a lack of predictive significance. Mental stability had a positive coefficient (B=.37), indicating that higher levels of mental stability are associated with higher levels of the ability to correctly perceive objects in traffic. This relationship is statistically significant (p<.05) and has a moderate effect size (β=.27).

Using the expansion package PROCESS in SPSS software, path analysis with logistic regression was conducted to verify a research model in which mental stability (Mi) mediates the relationship between reaction time (X) and traffic perception (Y) – the correctness of perceiving the objects occurring in traffic.

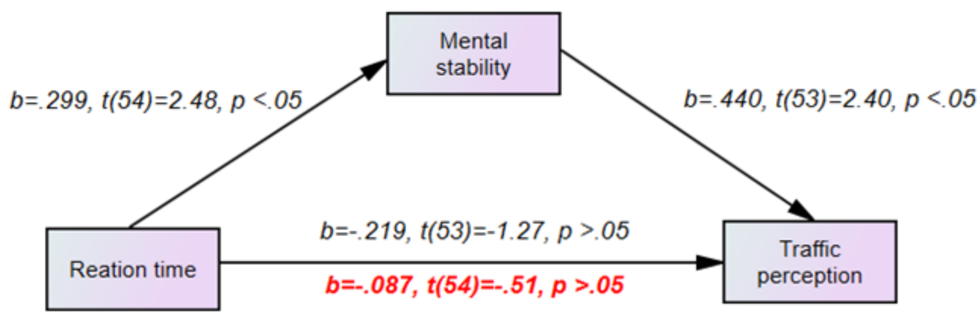

Fig. 7. Path analysis with logistic regression and the effect of mental stability (M) mediation on the relationship between reaction time (X) and traffic perception (Y) (N=56)

Finally, the results obtained for the indirect effect were as follows: Indirect Effect=.132, SE=.087, 95% CI [.005, .339], which means that mental stability mediates the relationship between reaction time and traffic perception. This result confirms the hypothesized model on the relationship between the variables.

4. DISCUSSION

Personality is a critical factor in predicting driver performance in road traffic. The present study showed that personality is related to cognitive and executive processes, such as time-movement anticipation, perception of objects in traffic, and reaction time. Other findings imply that personality can compensate for cognitive deficits, thus reducing the possibility of driver errors [15]. One reason this is significant is the fact that driver mistakes are a major contributor to car crashes [16].

Moreover, this study revealed that a driver's sense of responsibility positively influences their time-movement anticipation. A driver who has a pro-social attitude and follows traffic rules becomes more accurate when assessing the movement of another vehicle over time, especially before making an overtaking maneuver. Such a driver's decision is more appropriate for the overtaking situation and reduces the risk of colliding with a vehicle moving in another lane [6]. Therefore, how a driver behaves on the road can be significantly influenced by their personality, which can ultimately impact the safety of not only themselves but also other road users.

The obtained results confirm that a driver who has a low level of mental stability will react to a stimulus faster than other drivers and can lose the ability to correctly perceive objects in traffic. It is important to note that short reaction times are associated with errors in cognitive judgment [17]. Drivers with high mental stability are characterized by better judgment, as they are able to focus on a specific task, unlike those with high impulsivity [18]. Thus, we found that mental stability is a predictor of the ability to perceive objects in traffic. A possible explanation for this relationship is the strain of resource systems overload through emotions that limit cognitive abilities [19]. Drivers who experience stress may have limited decision-making abilities, reducing their effectiveness in a dynamic transportation environment [20].

Additionally, research has shown that there are significant differences in self-control and motor time between male and female drivers. Other variables did not present statistically significant differences. Studies have consistently found that females tend to score higher in traits related to conscientiousness and responsibility [21], while males score higher in traits related to risk-taking and sensation-seeking [22]. Females also tend to have higher levels of self-control and risk avoidance than males [23]. It is important to note that these differences are not absolute and may vary depending on individual factors such as age, cultural background, and driving experience [24].

It is crucial to determine which personality factors have direct effects and which have indirect effects on particular executive behaviors [25]. Not all personality factors examined in the present study are related to psychomotor phenomena, but this does not mean that they do not influence other processes relevant from a safety perspective. This study suggests that it is essential to expand the list of variables that have predictive properties from a psychological diagnostics perspective. It would be useful to replicate the current experiment with a larger sample and successively add mediators and moderators to create more sophisticated statistical models. These studies could help identify the most critical personality factors and their interactions with other variables in predicting driver behavior and safety.

While our study provides valuable insights into the relationship between personality and driver capabilities, there are several limitations that should be considered.

Firstly, the sample size used in the study may have impacted the lack of significance observed in mediation model paths c and c'. The experiment was conducted on a small sample size, which may limit the generalizability of the results. This could be addressed in future research by using a larger and more diverse sample of drivers to ensure that the findings are more robust and applicable to a wider range of individuals.

Secondly, the study relied on self-reported data for personality traits, which may be subject to bias and may not accurately reflect an individual's actual personality. Additionally, the cognitive tests used to measure psychomotor performance may not have fully captured all aspects of driving behavior and may not be perfect indicators of actual driving performance. Therefore, it is important to consider the limitations of self-reported data and the need for more objective measures of personality and driver performance in future research.

Lastly, this study focused on a limited set of personality traits and cognitive processes and, thus, may not have captured the full range of factors that influence driver behavior. Several other potentially important variables, such as driving experience, cultural background, and situational factors, were not considered in this experiment. Subsequent research should aim to explore a broader range of variables to provide a more comprehensive understanding of the complex factors that contribute to driver performance.

Furthermore, future studies could compare psychological test results with behavioral indicators obtained from people while driving in real-time. This approach would provide a more comprehensive understanding of how personality factors influence driving behavior in real-world settings. The use of technology, such as driving simulators, could help replicate real-world driving scenarios while monitoring driver behavior and performance. This approach could lead to the development of more effective interventions to improve driver safety, such as training programs tailored to specific personality traits.

5. CONCLUSIONS

This research underscores the importance of an individual's personality in anticipating their driving performance and safety on the road. According to the findings, a driver's personality can compensate for cognitive deficits and limit the possibility of driver error. Moreover, a pro-social attitude and a sense of responsibility positively influence time-movement anticipation, leading to appropriate decision-making, thus reducing the risk of accidents. Mental stability is also a critical personality factor that can influence reaction time without impairing the perception of objects in traffic. However, it is essential to determine the direct and indirect effects of personality factors on executive behavior to develop effective interventions for improving driver safety. Future studies should focus on expanding the list of variables with predictive properties and comparing psychological test results with behavioral indicators obtained from real-time driving.

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