# Personality factors that induce drivers' vulnerability to stress: predictors for traffic behavior

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***Abstract*:** This study aims to predict traffic behavior using personality factors that induce drivers' vulnerability to stress (aggression, dislike of driving, proneness to fatigue, risk monitoring, sensation seeking) in accordance with the transactional model of stress and driver fatigue developed by Matthews (2001, 2002). 338 participants were asked to fill in the Driver Stress Inventory and the Driver Behavior Questionnaire. We aimed to achieve the best prediction models for behavior in traffic. The study results support the utility of the transactional model in predicting and explaining aberrant behaviors. It shows that by measuring personality traits in the specific context of behavior occurrence, one can capture other effects compared to those captured by a general predisposition toward a behavior.

***Keywords***: driver stress vulnerability, dislike of driving, aggression, proneness to fatigue, hazard monitoring, thrill seeking, Driver Stress Inventory, Driver Behavior Questionnaire

## Introduction

Each year road accidents kill about 35,000 people in the EU member states and severely injure more than 1.5 million people (CARE). While the causes of road accidents vary, most researchers consider human factors responsible for most of them (Mesken, 2006). It was even estimated that in 90-95% of traffic accidents, human action is a unique factor (Rumar, 1985). In this context, in the last decades researchers have become increasingly involved in the study of risky behaviors and road safety, particularly focusing on how personality factors influence emotional and driving behavior as well as the involvement in accidents (Rundmo & Iversen, 2002). In this study we aim to predict aberrant driving behavior using personality factors that induce drivers' vulnerability to stress, according to the transactional model of stress and driver fatigue developed by Matthews (2001, 2002).

## Theoretical background

*Aggression and anxiety as personality traits and general driving behavior*

Despite the large number of studies that have focused on the influence of different personality traits on traffic safety, the results are either contradictory or inconclusive (Iversnen and Rundmo, 2002). These inconclusive results may be explained by measuring the personality characteristics with general inventories, which do not include measurements of the specific behavior in question. As a result, the role of some traits is well demonstrated, for example the role of

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sensation seeking (Iversen & Rundmo, 2002; Ulleberg, 2002), while the role of other traits remains questionable or unclear. Among the personality factors affecting road safety, aggression and anxiety were investigated.

*Aggression and driving behavior*

It was argued that dispositional factors, such as aggression, make some individuals more prone to aggressive behavior in traffic than others (Shinar, 1998, Deffenbacher et al. 2003). Aggression was defined as "a general tendency to engage in acts of physical and verbal aggression, an anger proneness, or a predisposition towards hostile beliefs about other people" (Buss & Perry, 1992). Although numerous studies show that aggressive driving is associated with increased accidents (Mizell, 1997; Lajunen and Parker, 2001), the relationship between aggression as personality traits, or between aggressive driving and traffic accidents is still unclear (Nabi et al. , 2006). Older and newer studies report inconsistent results.

Donovan and Marlatt (1982) found that a group of drivers with a high rate of violations and accident involvement had higher scores on the Buss - Durkee hostility inventory. Similarly, Wilson and Jonah (1988) examined the relationship between risky and aggressive driving. They analyzed the history of accidents and traffic violations of the participants and found positive associations with the scores on aggressive tendencies subscales of the Buss - Durkee inventory of hostility. In addition, Arnett et al. (1997) showed that trait aggression was associated with risky driving behaviors, such as involvement in racing and overtaking in a restricted area.

However, other studies have failed to identify a significant association between traffic accidents and hostility, irritability, anger proneness and other factors related to aggression (Nabi, 2006).

Lajunen and Parker (2001) tested the reactions to traffic scenarios based on trait aggression and found that the "physical aggression" scale had a modest but direct effect on aggressive behavior, while the effect of "verbal aggression" was mediated by anger.

Nabi et al. (2006) conducted a study in a large cohort of French employees (11.754 participants) to determine if aggression / hostility are significantly associated with an increased risk of accident involvement. The results showed that the total score for aggression / hostility did not predict the risk of accident involvement. The authors concluded that aggressive traffic behavior and / or anger at the wheel go beyond the individual's general proneness for aggression.

*Anxiety and driving behavior*

There are relatively few studies on the influence of trait anxiety on driving behavior (Shahar, 2009).

Ulleberg (2002), using a cluster analysis, evaluated the effect of several personality traits, including anxiety. This analysis revealed six subgroups of young drivers that were different, based on several characteristics including attitudes towards traffic safety, risk perception, estimation of driving ability and involvement in accidents. The two groups were characterized by a high level of risk. One of these groups (including mostly men) was characterized by altruism and low anxiety, high levels of sensation seeking, irresponsibility and aggressive traffic behavior. The second risk group (composed mostly of women) was characterized by high levels of sensation seeking, aggression and anxiety and anger in traffic. The authors considered that the second profile indicated a low level of control over emotions. Therefore, this study suggests that both very low and a high level of anxiety may have adverse effects on traffic safety.

Ferreira et al. (2009) investigated the effect of several personality traits on risky behaviors: errors of commission, inattention and errors of omission. The results indicated that individuals with high levels of anxiety were more prone to distraction and errors of omission.

Shahar (2009) conducted a study on a sample of 120 drivers (men) that examined self-reported driving behavior based on trait anxiety (STAI). Regression analysis showed that trait anxiety had a direct positive significant effect on aberrant driving behavior (assessed using the Driver Behavior Questionnaire). This positive relationship between anxiety and aberrant behavior was found for both errors and lapses as well as for simple and aggressive violations. The positive relationship between aggressive violations and anxiety suggested low levels of emotional regulation among the individuals with a high level of anxiety.

However, other studies support the view that a high level of anxiety may have an effect of reducing risky traffic behaviors. A factor involved in producing this effect is the risk perception (Shahar, 2009). Indeed, anxiety is associated with higher levels of perceived risk (Mesken, 2006). At the same time, the perception of risk is associated negatively with risky behavior: drivers who perceive low risk of driving dangerously, while those who perceive a high level of risk in the same situation, drive with more caution (Harre, 2000).

Thus, while researchers agree that a high level of anxiety is associated with an increased frequency of errors in traffic, things are not as clear for the effects of anxiety on traffic violations; in this respect further studies are needed.

In the studies, which focused on the influence of aggression on driving behavior, the relationship between aggression and behavior was not always identified. In this respect, as stated by Nabi et al. (2006), it seems that aggression in traffic and / or anger at the wheel go beyond the individual's general proneness for aggression. Regarding anxiety, if its influence on errors is well documented, the same can be said about the influence of anxiety on traffic violations; in this respect there are two opposing perspectives in the literature.

It is possible that the lack of consistency in the results is due to the measurement approach of personality traits. Specifically, when measuring personality characteristics with general inventories, which do not include measurements of specific the behavior in question, the general context for the behavior is expected to be weaker and the relationships identified difficult to interpret. Attempts to link the general personality constructs with external criteria have more success when the measurement of these constructs is more specifically adapted to the targeted behavior (Montag & Comrey, 1987). Therefore, we consider the approach of personality factors in the context of driving most appropriate, as opposed to their approach as a general predisposition to certain behaviors.

Another issue concerning the effects of many studies which address personality factors in driving behavior is the lack of a theoretical model behind the research. Therefore, in this study, aggression and anxiety were addressed through the transactional model of stress and driver fatigue.

*The transactional model of stress and driver fatigue*

The transactional model of stress and driver fatigue was developed by Gerald Matthews (2001) and is based on principles set out in the Transaction Theory of Stress (Lazarus and Folkman, 1984) that the "stress" acts as a product of an ecological relationship between person and environment, supported by cognitions related to external requests. The basic premise of this model is that individuals perceive external situations in a wide range of ways depending on personality, experience and evaluation processes. Therefore, subjective interpretation of stressful situations is important in determining the resulting behavior (Rowden, 2006).

The transactional model distinguishes various constructs that interact dynamically, as shown in Figure 1.

Environmental stressors are external environmental factors which overwhelm one’s ability to fulfill personal goals, such as poor visibility, difficult driving conditions and obstacles caused by traffic. The psychological impact of stressors is moderated by personality factors that influence how external stimuli are interpreted depending on the personal concerns of the drivers. For example, a red traffic light may be seen as an obstacle by a driver prone to frustration, but has no effect on another driver. In the specific traffic circumstances, environmental stressors and personality factors interact to influence cognitive processes related to stress. These cognitive processes aim to assess the personal relevance of stimuli and coping processes that support the choice of action in order to manage the requests received. Cognitive processes related to stress have two types of results: subjective outcomes, such as anxiety, anger, fatigue and performance outcomes, such as damage control and psychomotor speed adjustment. These results interact

dynamically, changing environmental conditions. Often stressors are self-correcting for short periods of time. For example, a decrease in visibility that is assessed as threatening could be offset by reducing the speed of travel. The results of stress can affect safety even more when cognitive processes are substantially distorted and when this processing perpetuates non-adaptive or bad reactions to certain types of requests (Matthews, 2002).

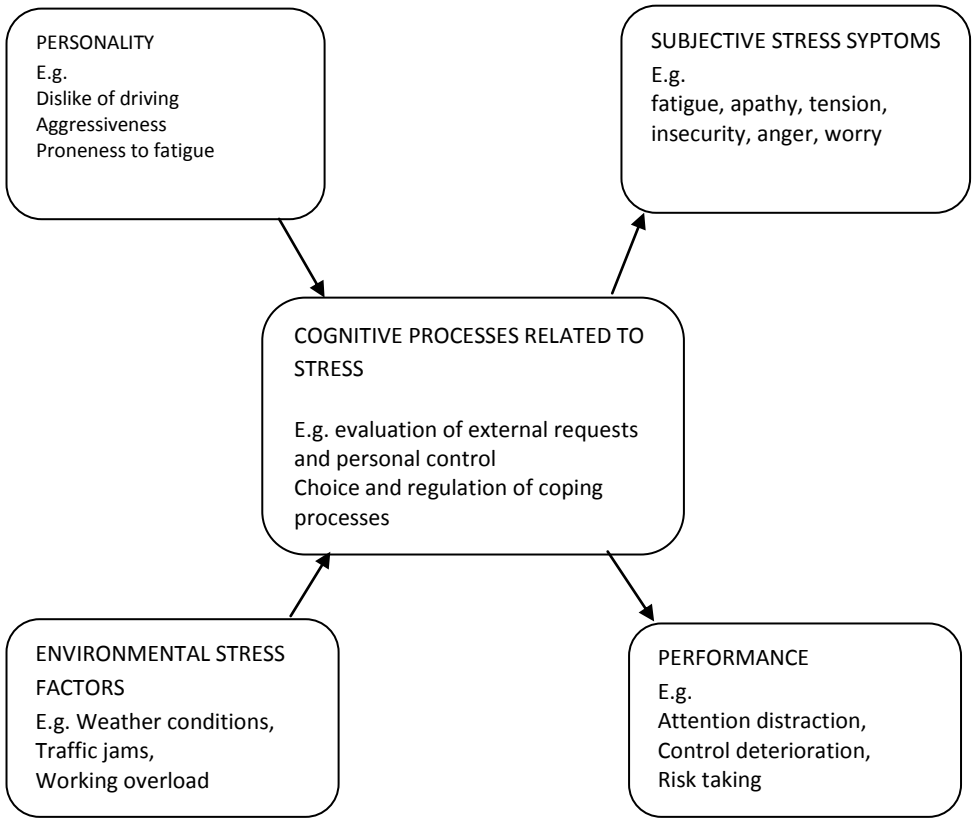


Figure 1. *Transactional model of stress and driver fatigue, Matthews (2002)*

It seems like that the aggressive drivers tend to misinterpret the intentions of other drivers especially in conflicting traffic situations. They evaluate the maneuvers made by other vehicles as hostile, such as blocking their way and respond to what they see in the same manner. They cope with aggressive actions such as insulting gestures or close following of the other vehicle. Negative evaluations and confrontation coping are dangerous.

Besides, they can also generate a vicious circle. A driver who is used to coping with aggressive behavior can cause hostile reactions from other drivers. In other words, the driver is vulnerable to environmental events, such as traffic

congestion, triggering a pattern of confrontation meetings with other drivers, with negative effects on safety.

Many of the studies conducted by Matthews were focused on assessing personality factors which induce different types of driver vulnerability to stress. Matthews (2002) distinguishes five personality traits measured in the context of driving and seen as dimensions of vulnerability to stress: dislike of driving, aggression, proneness to fatigue, hazard monitoring and thrill seeking. These dimensions are assessed using the Driver Stress Inventory.

*Dislike of driving* (the equivalent of trait anxiety as "standard" personality) – refers to feelings of self-doubt and anxiety; it is associated with negative self-evaluation and the use of an emotion-centered coping style, as such self-blame.

*Aggression* – refers to the tendency to easily get angry and choose a style of confrontation coping: risky behavior, intimidation or competition with other drivers.

*Proneness to fatigue* – refers to the tendency to reduce the degree of activation in response to physiological and environmental cues while driving (especially after a long drive).

*Hazard monitoring* – refers to the tendency to actively manage risks and behaviors associated with safety; the desire to prevent threats by vigilantly searching for danger.

*Sensation seeking* – refers to the pleasure of taking risks.

Although there are correlations between these dimensions and the "standard" personality traits, such as extraversion and emotional stability, the driver stress inventory dimensions are more predictive for driving behavior. The driver may have a "personality" in the context of specific driving that reflects fundamental beliefs about the meaning of the driving task and about the threats and challenges it offers. In this respect, the dislike of driving refers to the importance of maintaining a sense of personal competence; aggression refers to maintaining power over other drivers, and fatigue proneness refers to avoiding discomfort when the driver is feeling tired (Matthews, 2001).

The scales seem to adequately predict various criteria related to driving. Aggression, sensation seeking, and to some extent low hazard monitoring, predict self-reported involvement in accidents. Aggression, sensation seeking and low dislike of driving, correlate with penalties for violations, such as speeding and frequent self-reporting of violations. Higher rates of unintentional errors are associated with high aggression, high sensation seeking, dislike of driving and high fatigue proneness, as well as with low hazard monitoring. The dimensions of drivers' vulnerability to stress also seem to be universal for different cultures (Lajunen and Summala, 1995).

*Errors and violations in traffic*

The analysis of traffic violations and errors is based on the model proposed by Reason (1990), which supports the existence of two completely separate psychological determinants underlying the occurrence of road accidents. Reason (1990) argues that errors and violations are mediated by different psychological mechanisms. Violations require explanations in terms of social and motivational factors, while the errors could be explained by individual characteristics related to information processing (Reason, 1990). Errors were divided into lapses, omissions and mistakes; violations were divided into simple violations, aggressive violations, or non-intentional violations (Havârneanu, Hohn and Gheorghiu, 2010).

Based on the model of Reason, the Manchester University group of psychologists has created one of the most used tools for evaluating aberrant driving behavior – the Driver Behavior Questionnaire. DBQ is a widely used and validated tool (Gras et al. 2006). Although over time different factor structures have been achieved (three factors or four factors – to distinguish between errors, lapses, simple violations and aggressive violations, or even five or six factors (Ozkan, 2006a), the structure, with two factors that distinguishes between errors and violations, has proved to be the most stable in all studies in spite of the different identified structures (Ozkan, 2006b).

In terms of predictive ability, De Winter and Dodou (2010) have shown in a meta-analysis on the DBQ, that the violations predicted accidents with an average correlation of 0.13 based on Pearson's bivariate correlations and 0.07 based on reported effects in multivariate analysis. Errors predicted the accident involvement with 0.10 and 0.06, respectively. Also, the authors reported that the errors and violations were negatively correlated with the age and positively correlated with the mileage. In addition, men reported fewer errors and more violations compared to women.

Havârneanu et al. (2010) constructed a version of the DBQ questionnaire adapted for the Romanian population. The factor structure, which keeps the fundamental distinction between errors and violations, is somewhat different from that obtained by Reason (Havârneanu et al. 2010). More specifically, the results of the factorial analysis highlight three factors covering 41.85% of the variance. These factors are: factor 1 - human error (including lapses, slips and mistakes), factor 2 - very dangerous violations, factor 3 - dangerous deviations with reference to hurry, speed and impatience in traffic. Factor 2 and Factor 3 include both simple violations and aggressive violations. In this research we used the version of the DBQ adapted by Havârneanu et al. (2010).

## The empirical study

*Hypotheses*

The dimensions of vulnerability to stress (aggression, dislike of driving, hazard monitoring, sensation seeking, proneness to fatigue) predict aberrant driving behavior (slips, lapses, mistakes, errors, simple violations, aggressive violations, total violations, total DBQ score, factor 1 (human error), factor 2 (very dangerous violations), and factor 3 (dangerous violations with reference to hurry, speed, impatience in traffic).

*Sample*

The research was conducted on a total of 338 participants, 175 men and 163 women aged between 19 and 81 years (mean 37.43 and standard deviation 14.16). They had a driving license for an average of 11.75 years (standard deviation 10.96). 53.3% drove every day, 21% 2-3 times per week and 25.8% once a week or less. The number of km traveled is less than 8.000 km - for 40.8% of the participants, between 8.000 and 16.000 km - for 31.3% of participants from 16.000 to 25.000 km - for 11.5% of participants and over 25.000de km for 16.5%.

*Instruments*

We adapted the Driver Stress Inventory (DSI) developed by Matthews et al. (1997), aimed to measure the individual vulnerability to stress in the context of driving. It includes 48 items that measure five stable features on driving: Aggression - 12 items, dislike of Driving - 12 items, hazard monitoring - 8 items, sensation seeking) - 8 items, and fatigue proneness - 8 items.

The internal consistency of the instrument was estimated by calculating Cronbach's Alpha coefficient. The entire questionnaire (48 items) achieved a coefficient of 0.865. Analyzing the item - total score correlations we noticed that they were between -0.057 and 0.541. We eliminated the items that correlated poorly with the total score of the scale: item 26 [-0.057], item 10 [-0.042] and item 36 [-0.027]. Continuing the analysis with 45 items, we obtained an alpha coefficient of 0.876. Analyzing the internal consistency coefficients for each subscale we obtained the data presented in Table 1.

| Driver Stress Inventory | No. of Items | Alpha Coefficient | Items deleted | Final Alpha | Item – Total scores correlations |
|---|---|---|---|---|---|
| Aggression | 12 | 0.775 | items 11 and 19 | 0.792 [10 items] | between 0.339 – 0.555 |
| Dislike of driving | 12 | 0.793 | items 14 and 32 | 0.813 [10 items] | between 0,416 – 0.556 |
| Hazard monitoring | 8 | 0.620 | items 10, 26 and 36 | 0.720 [5 items] | between 0,380 – 0.569 |
| Sensation Seeking | 8 | 0.808 | no items were deleted | 0.808 | between 0,306 – 0.666 |
| Proneness to fatigue | 8 | 0.835 | no items were deleted | 0.835 | between 0,357 – 0.653 |

Table 1: *Initial Alpha coefficients for the five dimensions of the Driver Stress Inventory, minimum and maximum values of the correlations between items, and Alpha coefficient after deletion of items.*

It is noted that in general the alpha coefficients are high, indicating good internal consistency.

By reducing the 48 items of the Driver Stress Inventory into factors, using the principal components method and Varimax rotation five factors were retained; the inventory was constructed to measure five stable features. After rotation, the first factor covers 10.36% of the variance, the second factor 9.76% of the variance and the third factor 8.36% of the variance, the fourth factor 6.82% of the variance and the fifth factor 4.36% of the variance. Together, the five factors cover 39.68% of the variance.

The KMO coefficient of 0.829 and the Barlett coefficient of sphericity (1128) = 5653.41, $p < 0.001$ indicates that the items match the factorial model. The data reveals the factorial validity of the Driver Stress Inventory.

| ***Items*** | ***Factor saturation*** | | | | |
|---|---|---|---|---|---|
| | **$F_1$** | **$F_2$** | **$F_3$** | **$F_4$** | **$F_5$** |
| I15 Sensation seeking | **.730** | | | | |
| I9 Sensation seeking | **.723** | | | | |
| I24 Sensation seeking | **.720** | | | | |
| I20 Sensation seeking | **.666** | -.302 | | | |
| I38 Sensation seeking | **.568** | | | | |
| I6 Sensation seeking | **.498** | -.333 | | | |
| I12 Sensation seeking | **.408** | | | | |
| I8 Sensation seeking | **.394** | | | | |
| I4 Dislike of driving | | **.644** | | | |
| I2 Dislike of driving | | **.613** | | | |
| I1 Dislike of driving | | **.598** | | | |
| I17 Dislike of driving | | **.571** | | | |
| I33 Dislike of driving | | **.568** | | | |
| I22 Dislike of driving | | **.453** | | .307 | |

| *Items* | *Factor saturation* | | | | |
|---|---|---|---|---|---|
| | **$F_1$** | **$F_2$** | **$F_3$** | **$F_4$** | **$F_5$** |
| I7 Dislike of driving | | **.447** | | | |
| I37 Dislike of driving | | **.439** | | .370 | |
| I5 Dislike of driving | | **.376** | | .305 | |
| I27 Dislike of driving | | **.331** | | | |
| I41c Proneness to fatigue | | | **.732** | | |
| I41e Proneness to fatigue | | | **.731** | | |
| I41g Proneness to fatigue | | | **.714** | | |
| I41b Proneness to fatigue | | | **.692** | | |
| I 41h Proneness to fatigue | | | **.659** | | |
| I41d Proneness to fatigue | | | **.627** | | |
| I41a Proneness to fatigue | | | **.621** | | |
| I41f Proneness to fatigue | | | **.373** | | |
| I34 Aggression | | .322 | | **.621** | |
| I 5 Aggression | | | | **.523** | |
| I39 Aggression | | .350 | | **.516** | |
| I31 Aggression | | | | **.511** | |
| I28 Aggression | | | | **.499** | .300 |
| I16 Aggression | | | | **.474** | |
| I40 Aggression | | | | **.464** | |
| I13 Aggression | | | | **.395** | |
| I3 Aggression | | | | **.313** | |
| I21 Aggression | | | | **.333** | |
| I30 Hazard monitoring | | | | | **.645** |
| I18 Hazard monitoring | | | | | **.645** |
| I23 Hazard monitoring | | | | | **.615** |
| I29 Hazard monitoring | | | | | **.565** |
| 25 Hazard monitoring | | | | | **.541** |
| *Eigenvalue* | ***4.97*** | ***4.68*** | ***4.01*** | ***3.27*** | ***2.09*** |
| *% variance* | ***10.36*** | ***9.76*** | ***8.36*** | ***6.82*** | ***4.36*** |

Table 2. *The item loadings in five factors.*

Aberrant driving behavior was measured using the version of the Driver Behavior Questionnaire adapted by Havârneanu et al. (2010) for the Romanian population. As part of this research we only used the scale which measures the frequency of aberrant behaviors reported by the participants. We obtained a high alpha coefficient of 0.877. The analysis included all 37 items, and the correlations between the items and total score were between 0.218 and 0.538. No item was removed.

## Results

Table 3 displays the Pearson correlations between the variables investigated. There are significant correlations between the dimensions of vulnerability to stress and aberrant driving behavior, suggesting the possibility of predicting traffic behavior based on the dimensions of vulnerability to stress. The hypothesis was tested though the multiple regression analysis, stepwise method.

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
|---|---|---|---|---|---|---|---|---|
| **1. Aggression** | **1** | | | | | | | |
| **2. Dislike of driving** | **.439**** | **1** | | | | | | |
| **3.Hazard monitoring** | **.295**** | **.430**** | **1** | | | | | |
| **4.Sensation Seeking** | **.403**** | -.094 | .021 | **1** | | | | |
| **5.Proneness to fatigue** | **.370**** | **.478**** | **287**** | .049 | **1** | | | |
| **6.Slips** | **.315**** | **.273**** | .088 | .083 | **.214**** | **1** | | |
| **7.Lapses** | **.195**** | **.235**** | .001 | .077 | **.237**** | **.124*** | **1** | |
| **8.Mistakes** | **.238**** | **.306**** | .086 | .075 | **.206**** | **.153**** | **.159**** | **1** |
| **9. Errors** | **.308**** | **.321**** | .074 | .093 | **.258**** | **.193**** | **.146**** | **.291**** |
| **10.Simple violations** | **.282**** | -.057 | -.106 | **.440**** | .038 | **.373**** | -.072 | -.082 |
| **11.Aggressive violations** | **.500**** | .014 | .024 | **.474**** | .052 | **.613**** | .062 | .021 |
| **12.Total violations** | **.429**** | -.026 | -.049 | **.508**** | .050 | **.541**** | -.010 | -.037 |
| **13.Total DBQ score** | **.423**** | **.176**** | .016 | **.340**** | **.182**** | **.418**** | .082 | **.152**** |
| **14.Factor 1** | **.311*** | **.328**** | .067 | .098 | **.262**** | **.192**** | **.151**** | **.296**** |
| **15.Factor 2** | **.356**** | .035 | .093 | **.374**** | .094 | **.452**** | .039 | -.009 |
| **16. Factor 3** | **.386**** | -.066 | **-.145*** | **.493**** | .006 | **.486**** | -.044 | -.050 |

| | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 |
|---|---|---|---|---|---|---|---|---|
| **9. Errors** | **1** | | | | | | | |
| **10.Simple violations** | -.047 | **1** | | | | | | |
| **11.Aggressive violations** | **.157**** | **.173**** | **1** | | | | | |
| **12.Total violations** | .055 | **.122*** | **.498**** | **1** | | | | |
| **13.Total DBQ score** | .054 | **.134*** | **.812**** | **.665**** | **1** | | | |
| **14.Factor 1** | .033 | **.112*** | **.838**** | **.825**** | **.824**** | **1** | | |
| **15.Factor 2** | .013 | .101 | **.540**** | **.328**** | **.359**** | **.509**** | **1** | |
| **16. Factor 3** | .074 | **.110*** | **.355**** | **.252**** | **.323**** | **.375**** | | **1** |

Table 3. *Pearson correlations between the dimensions of vulnerability to stress and aberrant driving behaviors.*

*Prediction of errors and violations based on vulnerability to stress dimensions*

The total errors' score (the summed omissions, lapses and mistakes scores) are significantly predicted by dislike of driving ($\beta = 0.230$, $p < 0.01$) and aggression ($\beta = 0.207$, $p < 0.01$), fig. 2. Together, these two explain 13% of the total variance of errors ($F(2.335) = 26.62$, $p < 0.01$, Adjusted $R2 = 0.132$).

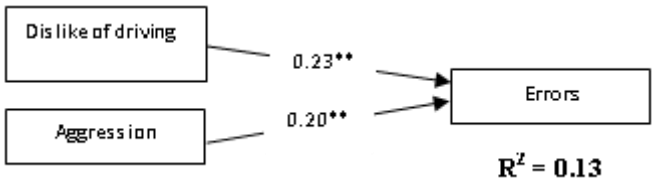


Figure 2. *The prediction of errors. The numbers on the arrows indicate the standardized β coefficients.*
* p<0.05, ** p<0.01

**The total score for violations** (simple and aggressive violations) had the following significant predictors: sensation seeking (β = 0.382, p <0.01), aggression (β = 0.319, p <0.01) and hazard monitoring (β = -0.152, p <0.01), Fig.3. They explained together 33% of the total variance of the violation scores (F (3.334) = 56.91, p <0.01, Adjusted R2 = 0.332).

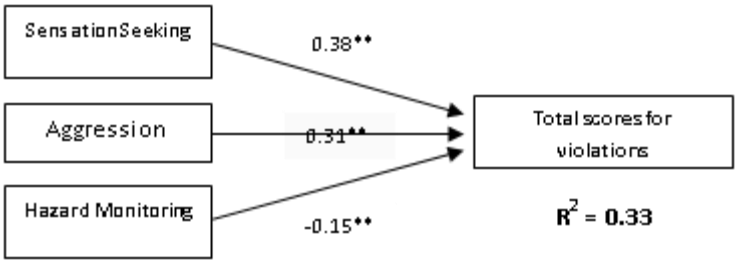


Figure 3. *The prediction of violations. The numbers on the arrows indicate the standardized β coefficients.*
* p<0.05, ** p<0.01

Then, we separately predicted the scores for simple and aggressive violations, and we obtained the following results.

**Simple violations** were predicted by the following variables: sensation seeking (β = 0.370, p <0.01), hazard monitoring (β = -0.168, p <0.01) and aggression (β = 0.182, p <0.01), Fig. 4. The model explains 22% of the variance of the total score for simple deviations (F (3.334) = 33.63, p <0.01, Adjusted R2 = 0.225).

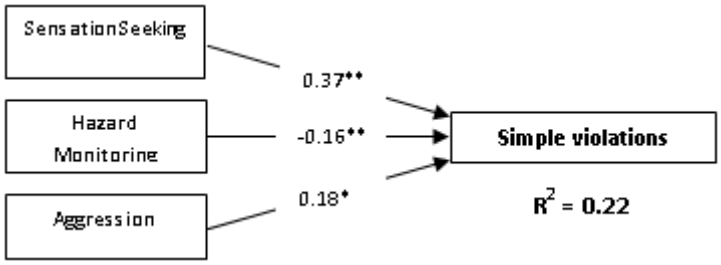


Figure 4. *The prediction obtained for simple misconduct. The numbers on the arrows indicate standardized β coefficients.*
* p<0.05, ** p<0.01

**Aggressive violations** were predicted by the following variables: aggression (β = 0.462, p <0.01), sensation seeking (β = 0.272, p <0.01), and dislike of driving (β = - 0.164, p <0.01), Fig. 5. The model explains 35% of the variance of the total score of aggressive violations (F (3.334) = 62.10, p <0.01, Adjusted R2 = 0.352).

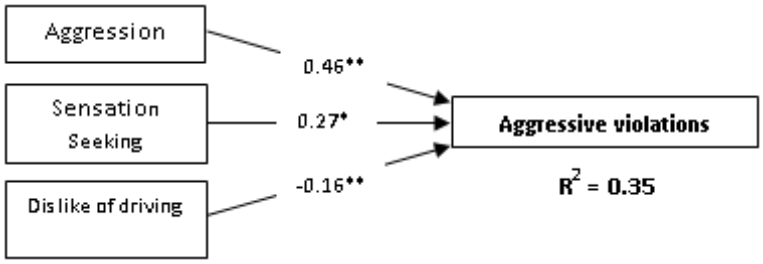


Figure 5. *The prediction obtained for aggressive violations. The numbers on the arrows indicate standardized β coefficients.*
* p<0.05, ** p<0.01

**Discussion**

Summarizing the results above we note that aggression is a significant predictor for both types of violations and for the errors made in the traffic; the dislike of driving is a significant positive predictor of errors and a significant negative predictor of aggressive misconduct; sensation seeking is a positive significant predictor of violations; hazard monitoring significantly predicts traffic violations, albeit to a lower extent (additional 2% of variance explained, R2change = 0.021).

As assumed by the transactional model of driver stress (Matthews, 2002) and supported by previous studies, aggression is associated with more frequent reporting of traffic violations. These results are in line with previous research (Matthews, 2001).

A possible explanation for this association is derived from the frustration – aggression theories (Dollard, 1939), and social information processing theory. Dodge & Coie (1987), and Shinar (1998), applied the frustration - aggression theory on driving behavior and conducted a series of studies to examine the effects of environmental stressors. Aggressive behaviors were associated with frustration caused by delays and traffic jams. Among them, most of the factors that generate frustration in traffic are represented by the behavior of other drivers. The frustrated driver's reaction depends at least partially on how the driver interprets the behavior of other drivers. Dodge and Coie (1987) suggest that interpreting this behavior as challenge is a major predictor for aggression and for its chances to be perpetuated. They postulate that aggression causes the attribution of hostile intentions. Therefore, aggressive drivers make hostile attributions for the behavior of other drivers, and tend to respond through aggressive behaviors. However, in a study conducted by Yagil (2001), this explanation was not empirically supported.

Another factor that explains the relationship between proneness towards aggression and aggressive driving behavior is the anger proneness; anger is associated with both simple and aggressive violations (e.g., Deffenbacher, 2003, Underwood et al., 1999; Lajunen et al., 1998). In this respect, Lajunen and Parker

(2001) investigated the relationship between driver anger, aggression proneness as well as aggressive driving behavior and suggested that the link between verbal aggression and aggressive driving behavior is mediated by anger.

The proneness of aggressive drivers to anger is linked to performing simple violations. Lerner and Keltner (2000) argue that emotions influence rational thinking and that affective states can be used as emotional information about the environment. Therefore, angry drivers could assess traffic situations as less risky, because anger is associated with a higher level of perceived control, and the low level of perceived risk increases the level of risk taking, including the performance of simple violations.

Aggression was a significant positive predictor for driving errors. This result is consistent with previous studies (e.g. Matthews et al., 1996). The transactional model (Matthews, 2001, 2002) considers aggression as a trait which induces vulnerability to stress. One of the most significant cognitive symptoms of stress is cognitive interference: the subjective expression of diverting attention from the internal task to internal thoughts and concerns (Sarason et al., 1988). In this respect, Desmond (1987) found a correlation between aggression and positive cognitive interference; the latter is conceptualized in this study as a state rather than a process and is evaluated as the presence of intrusive post-driving thoughts. Thus, the link between aggression and errors could be explained by cognitive interference – which is associated with a high number of errors. However, unlike the relation between aggression and violations, the relation between aggression and error is not well documented.

Dislike of driving was a significant positive predictor for errors and a significant negative predictor for violations.

The link between the dislike of driving and errors supports the adverse effects of anxiety on task performance. Specifically, researchers usually attribute the decreases in performance to a form of attention deficit (as proposed by the cognitive interference theory, Sarason, 1988), and to processing efficiency (Eysenck and Calvo, 1992). In spite of being different, both theories argue that in anxious individuals attention is diverted from the task to worries, which take on the processing resources. Matthews (2001) also claims that the effect of dislike of driving on errors is due to cognitive interference. Besides, this possibility is supported in a study conducted by Wilson et al. (2006), who showed that high anxiety had a negative effect on processing efficiency, measured by self-reporting, pupil response and gaze variability. In fact, the association between a dislike of driving / anxiety and errors is supported by a large number of studies (e.g. Shahar, 2009, Matthews et al., 1996; Mesken, 2006).

It seems that the more cautious behavior manifest in anxious individuals may explain the effects of the dislike of driving on the low frequency of violations. Indeed, anxiety is associated with higher levels of perceived risk, defined as the subjective experience of risk in potentially hazardous traffic situations (Elander et

al., 1993), and with lower levels of perceived control (Mesken, 2006), which in turn lead to greater caution in traffic.

It is somewhat surprising that the dislike of driving is a significant negative predictor for aggressive behavior and not for simple violations. In a study (Shahar, 2009) which looked at the effects that trait anxiety (measured by the State - Trait Anxiety Inventory, Spielberger, 1970) had on aberrant driving behaviors, anxiety was positively associated with aggressive self-reported violations; the authors explained this association thorough a low level of emotional control which is characteristic for anxious individuals. These different results could be explained by the fact that a dislike of driving leads to a more specific measure of anxiety in the context of driving and not to a general measure as in the above mentioned study. Thus, it appears that a dislike of driving has different effects on aberrant driving behavior, compared to anxiety as a personality trait.

These results support the findings of Matthews (2002): a dislike of driving has rather ambiguous effects on safety; drivers who do not like driving are at risk due to errors but are reluctant to risk-taking.

Sensation seeking was a significant positive predictor for both for simple and aggressive violations. These results are not at all surprising, given that sensation seeking is constantly associated with risk taking (e.g. Rimmo and Aberg, 1999; Ulleberg, 2002; Iversen and Rundmo, 2002). Horvath and Zuckerman (1993) argue that people with high levels of sensation seeking engage more frequently in risky activities as they value the rewards they will achieve more (i.e. finding the desired stimulation). Another factor involved in the association between sensation seeking and risk taking is the perception of risk. People with high levels of sensation seeking perceive less risk and therefore are more inclined to engage in risky behaviors (Rosenbloom and Tova, 2003). Likewise, Horvath and Zuckerman (1993) argue that people with high levels of sensation seeking tend to overestimate their own skills.

Hazard monitoring was a significant negative predictor for traffic violations. Providing it expresses a general orientation towards safety, it is expected to materialize into caution at the behavioral level and consequently into very few violations. This result is consistent with previous studies (Matthews, 2001).

*Prediction of dangerous and very dangerous behavior based on the dimensions of vulnerability to stress*

Factor 2 (very dangerous violations) was significantly predicted by sensation seeking ($\beta = 0.275$, $p < 0.01$) and aggression ($\beta = 0.245$, $p < 0.01$), Figure 6. They explained together 18% of the total variance ($F(2.335) = 39.28$, $p < 0.01$, Adjusted $R2 = 0.185$).

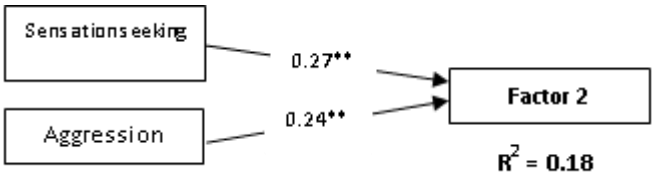


Figure 6. *The prediction of factor 2. The numbers on the arrows indicate the standardized β coefficients.*
* p<0.05, ** p<0.01

Factor 3 (dangerous violations with reference to hurry, speed, impatience in traffic) was successfully predicted by the following dimensions: sensation seeking (β = 0.374, p <0.01), aggression (β = 0.307, p <0.01) and hazard monitoring (β = -0.243, p <0.01), Fig. 7. The prediction model explained 33% of the total variance of factor 3 (F(3.334) = 56.87, p <0.01, Adjusted R2 = 0.332).

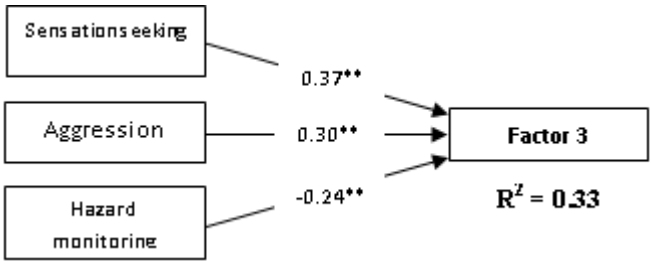


Figure 7. *The prediction of factor 3. The numbers on the arrows indicate the standardized β coefficients.*
* p<0.05, ** p<0.01

Factor 2 (very dangerous violations) and factor 3 (dangerous violations with reference to hurry, speed, impatience in traffic) are both significantly predicted by sensation seeking and aggression. However, factor 3 had hazard monitoring as an additional predictor. This result might be due to differences in the degree of risk included in the two factors. While hazard monitoring decreases the number of low and moderate risky violations, it is not sufficient enough to explain highly dangerous behaviors. Very risky violations may be explained by other factors, different from those used in the current study. This hypothesis is supported by the fact that very dangerous behaviors are worse predicted (18%) than the less risky behaviors (33%).

**Conclusions**

An important note about these results is that, although studies measuring aggression with general personality inventories usually fail to identify the

relationship between aggression and driving behavior (Nabi et al. 2006), more specific studies which measure aggression in the context of driving (as in the present study) have consistently found this relationship. As Matthews (2002) claims, the driver may have a "personality" that is unique in the context of driving, which reflects fundamental beliefs about the meaning of the driving task and about the threats and challenges it offers. Therefore the measurement of personality traits in the context of the targeted behaviors is likely to be predictive for driving behavior.

Moreover, when measuring personality traits in the specific context of behavior occurrence, one can capture other effects compared to those captured by a general predisposition toward a behavior. In this respect, in the current study, a dislike of driving was negatively associated with the aggressive violations, while in studies aimed at the effects of general anxiety, anxiety was positively associated with aggressive violations. These results represent an additional argument for measuring personality traits in a more specific way.

Another important observation is that aggression has negative consequences for safety, leading to a higher frequency of violations and errors. On the other hand, a dislike of driving has rather equivocal effects on safety: drivers who do not like driving are at risk due to errors but reluctant when it comes to risk-taking. Matthews (2002) found the same results.

This study supports the existence of the fundamental distinction between errors and violations. Thus, the violations and errors were predicted by different factors which support Reason's (1990) assumption that violations and errors have different psychological determinants, although they both contribute to accident risk. Violations require explanations in terms of social and motivational factors, while the errors could be explained by individual characteristics related to information processing. Besides, while errors were predicted to a quite low extent (the best predictive model explained 16% of the error variance), violations were better explained by our predictors (the best predictive model for aggressive violations explained 45% of the total violation variance). This finding can be explained again in terms of fundamental differences between the errors and violations. While violations are deliberate actions which deviate from the accepted norms and rules, errors are unintentional. Violations are therefore more likely to be predicted on the basis of stable dispositional predispositions.

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