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Personality and behavioral predictors of traffic accidents: testing a contextual mediated model

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Abstract

A contextual mediated model was proposed to distinguish the distal (i.e. personality factors) and proximal (i.e. aberrant driving behaviors) factors in predicting traffic accident involvement. Turkish professional drivers ($N = 295$) answered a questionnaire including various measures of personality factors, driver behaviors, and accident history. Results of the latent variable analysis with LISREL indicated that latent variables in the distal context (i.e. psychological symptoms, sensation seeking, and aggression) predicted at least one of the proximal elements (i.e. aberrant behaviors, dysfunctional drinking, and preferred speed) with relatively high path coefficients. While aberrant driver behaviors yielded a direct effect on accident involvement, psychological symptoms yielded an indirect effect mediated by driver behaviors. Further analyses revealed that personality factors had an impact on road accidents via their effects on actual driving-related behaviors although the path coefficients in predicting accidents were relatively weaker than those predicting risky driving behaviors and habits. Results were discussed considering the implications for classifying the accident correlates in a contextual framework and binominal-poisson distribution of self-reported accidents.
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Keywords: Contextual model; Personality; Driver behavior; Accidents

1. Introduction

Road-traffic accidents are a leading cause of death in Turkey. According to the Traffic Safety Project Report (2001) commissioned by the Turkish General Directorate of Highways, about 9000 people were killed in road crashes in 1999 and thousands were injured, and the cost of road crashes in 1999 was about US$ 3 billion to Turkish economy. Majority of the fatalities belong to the professional drivers and passengers of coaches (United Nations, 1999). Research on traffic accidents indicates that human factors are a sole or a contributory factor in approximately 90% of road-traffic crashes (Lewin, 1982). In the earlier studies taking an "individual differences" approach, human factors were studied in relation to "accident proneness" hypothesis, which emphasizes the role of accident-prone personality in explaining accident involvement. This hypothesis, however, was criticized from methodological, statistical, and theoretical perspectives and evolved into new concepts, such as "differential accident involvement" (McKenna, 1983). From a methodological viewpoint Evans (1991) argued that accident proneness hypothesis inherently compares those with above and below the average crash rate in a population assuming that there is a distribution of propensity to crash in the population. As indicated by Evans, contrary to this assumption some drivers with above average propensity to crash may be crash free and others with below average propensity to crash may have multiple crashes. Therefore, the mere comparison of the personality characteristics of the drivers with high and low propensity to crash would not yield a clear picture about the relationships. Although accident proneness hypothesis has been criticized, the causal factors that are internal to the driver in accident involvement have started to re-emerge (Haight, 2000) and the driver characteristics including dispositional factors have been the main focus in driving behaviors in the recent literature (Sivak, 1997).

Past research studying the role of personality characteristics on accident involvement provided equivocal results or yielded relatively weak associations between accident involvement and certain personality characteristics, such as risk taking, sensation seeking, and aggressive tendencies (for comprehensive reviews see Beirness, 1993; Elander et al., 1993; Lawton and Parker, 1998). In an excellent review on the behavioral correlates of accident involvement, Elander and his colleagues provided a useful framework in understanding the personality correlates of crash involvement as

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well as understanding the conflicting findings in this area and also suggested a number of plausible explanations for why only a small amount of the variance in crash rate is explained by personality factors. First, these authors made a distinction between driving style (i.e. behavior) and skills (i.e. performance) and implied that driver style is rather a more proximal factor to accident causation. Consistent with this distinction, they documented that driving style is associated with certain personality characteristics, such as Type A behavior and antisocial attitudes, and it is influenced by driving-related attitudes and beliefs as well as general needs and values. Second, they suggested that the interaction between stable personality factors and more transient elements, such as stressful life events, drinking and driving, or fatigue might play a critical role in crash causation. Third, they identified certain skills (e.g. reaction time and attention switching), cognitive abilities, and personality factors as extrinsic factors, and thus, placed them in the distal context of crash causation. Fourth, they proposed that the unexamined moderator and mediator variables contribute to the observed weak relationships and mixed findings in predicting road crashes in previous research. Finally, considering the mediational nature of the links between personality and crash involvement, they have called for testing well-structured models depicting both direct and indirect effects in predicting accidents considering methodological constraints, such as measurement errors.

Similarly, in his review article, Beirness (1993) concluded that "... personality does not account for a unique portion of the variance... rather, personality is merely viewed as more distal to crash involvement than many other factors. Personality can interact with other, more proximal, elements as well as situational factors to increase the risk of crash involvement" (p. 139). Parallel to these suggestions, recently, comprehensive mediated models, which link more general distal factors to accident involvement, were proposed and tested. For instance, Lajunen (1997) proposed that more general factors (driving experiences, personality factors, and general attitudes) lead to drivers' self-view about safety, driving skills, and driver attitudes, and these factors, in turn, predict driving style (violation). He further stated that safety margins mediate the link between driving style and accident involvement. Incorporating the past models, including Lajunen's model, Stradling and his friends (Parker and Stradling, 2001; Stradling and Meadows, 2000) developed a detailed model of driver crash involvement behavior. In this model, distal and proximal influences on accident involvement were distinguished and besides demographic characteristics, personality factors (e.g. risk taking), life style demands and choices (e.g. time pressure), and general attitudes (e.g. competitiveness, compliance) were treated as the distal or peripheral factors, and driving specific attitudes, styles, and safety margins were seen as the proximal or mediating factors.

Several attempts have also been made to test potential mediators of the personality-accident association. For example, West et al. (1993) asserted that the effects of personality traits on accident involvement were mediated by their effects on "driving style", and supporting this assertion they found that the association between social deviance and accidents was partially mediated by faster driving speed. Rimmö and Åberg (1999) proposed a mediational model assuming that aberrant driving behaviors mediate the relationship between sensation seeking and accidents. They found that sensation seeking had significant indirect effects on accident involvement via driving behaviors (i.e. violations and mistakes) although it did not have any direct effects. Similarly, in a study predicting severe crash and injury outcome, Kim et al. (1995) found that driver behavior and alcohol or drug use mediate the link between driver characteristics (i.e. age and sex) and crash type and injury severity. Using multiple predictors of motor vehicle accidents from characterological, situational, and behavioral risk areas, Norris et al. (2000) showed that a combination of factors could largely explain accident involvement and especially the accompaniment of certain personality (e.g. high hostility and low self-esteem) and behavioral factors (e.g. failure to obey traffic rules) may constitute a lethal combination. Although a number of studies have shown that accident involvement could be predicted by a variety of personality factors and driving behaviors, there is still a need for a structural model in which predictors and/or correlates of accident involvement are classified on the basis of their proximal and distal role in accident causation.

1.1. Contextual mediated model

In this study, to better understand the relative contributions of personality factors and driving behaviors in accident involvement, I propose a more general contextual model[1] considering the methodological limitations and suggestions made by Elander et al. (1993) and more recent formulations. The main purpose of the proposed contextual model is to distinguish the distal and proximal contextual factors that are related to accident involvement in a mediating framework and classify the correlates of risky driving according to their contextual closure to accident involvement. Contextual classification of causal factors is also expected to help researchers construct casual models in examining the predictive power of personality and behavioral variables. As

[1] The term contextual model was basically borrowed from Bradbury and Fincham's (1988) contextual model of close relationships explaining the dynamic interplay between distal and proximal features in predicting a specific outcome. Contextual model can also be discussed on the basis of ecological validity by using different theoretical perspectives. For example, Brunswik's organism-environment model, which places the organism (could be conceptualized as "driver" in contextual model) in the center of model and in an interactionist framework, assumes that organism is directly influenced by proximal region as a part of near environment (placed in input side and near to organism) and also indirectly influenced by distal region as a part of environment which is in a middle-sized distance away from the organism (see Wolf (2000) for a detailed description of the model).

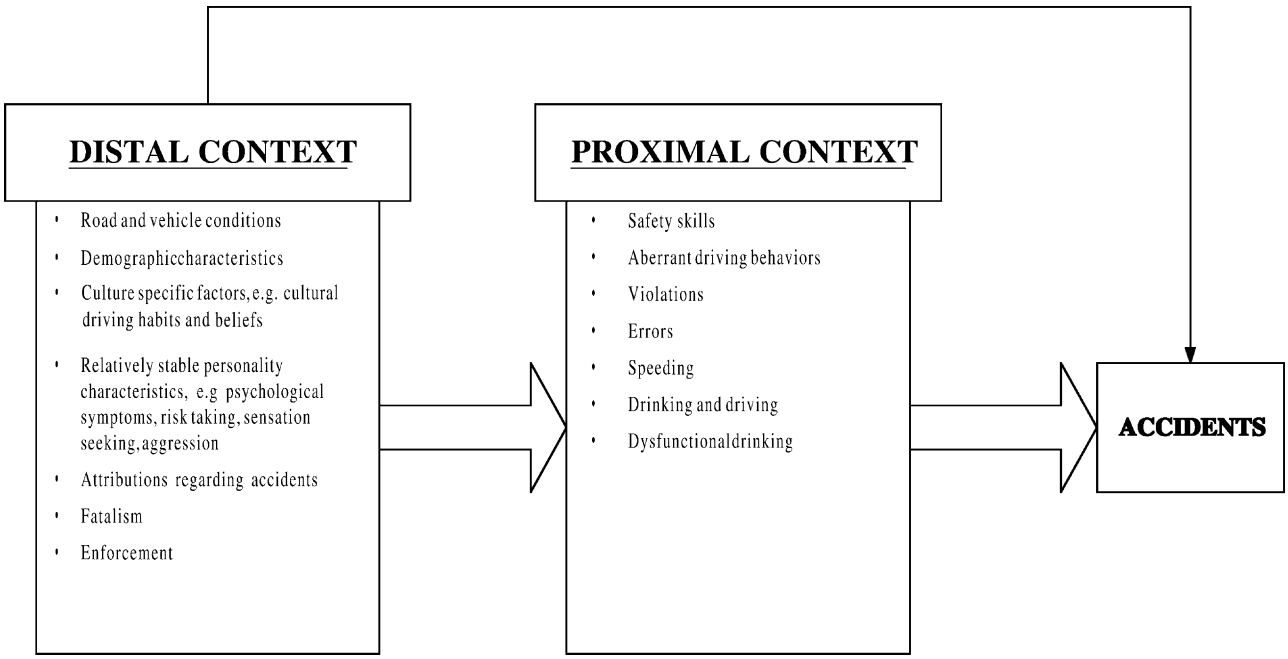

Fig. 1. Contextual mediated model.

depicted in Fig. 1, on the basis of the past studies, I assumed that the proximal context includes both stable and transitory factors, which are closely related to accident tendency. The stable driving style-related elements (e.g. speed choice, traffic errors, violations, and overtaking tendency), and critical attitudinal/behavioral factors (e.g. antisocial or dangerous drinking) as well as certain transitory factors (e.g. drinking and driving), which directly increases the risk of crash could be classified under the proximal context. Similar to Lajunen's general factors (1997), the distal context, however, consists of a number of extrinsic elements, ranging from more general cultural factors (e.g. safety attitudes, political and enforcement environment); socio-demographic factors (e.g. as age of driver and type of driver, road, vehicle and other environmental factors);[2] relatively stable personality factors, attitudes and beliefs (e.g. sensation seeking, risk taking, psychopathology, aggression, and fatalism) to cognitive factors (e.g. attributions regarding accident causation), which indirectly contribute to accident causation and predict accidents via proximal factors.

Briefly, I argue that distal factors create a generalized tendency in drivers to have high levels of risky driving behaviors (i.e. proximal factors), and in turn, these behaviors predict the actual accident involvement. Moreover, given both the distance between crash involvement and the distal context and the poisonous distribution of crash frequency (e.g. Elander et al., 1993; Haight, 2000), the link between the distal and proximal contexts is expected to be stronger than the link between the proximal context and crash frequency. Consistently, it is plausible to suggest that the elements in the distal context either do not predict or poorly predict traffic accidents, while they are expected to have significant indirect effects.

1.2. Proposed model

The aim of this paper was to test the proposed contextual mediated model. As depicted in Fig. 2, I hypothesized that the three typical dispositional elements of the distal context, namely, sensation seeking, aggression, and psychological symptoms, strongly predict widely studied elements of the proximal context; driver behaviors, speed choice, and alcohol consumption-related attitudes, and these variables, in turn, are expected to directly predict the number of accidents involved. In addition, distal variables were expected to have an indirect effect on the outcome variable via their effects on the proximal latent variables, while their direct effects were expected to be insignificant or weak. In the following section a selective review of literature regarding the constructs located in the distal and proximal context is presented to provide a rationale for including these variables.

1.2.1. Sensation seeking

Sensation seeking, which is defined as "a trait describing the tendency to seek novel, varied, complex, and intense sensations and experiences and the willingness to take risks for the sake of the experience" (Zuckerman, 1994, p. 27), is one of the most commonly studied personality factors in traffic and safety arena. Consistent with the premises of

[2] Culture, road, vehicle, and other environmental factors are also assumed to be distal to the driver and to accident causation. The categorization and elaboration of these factors, however, are beyond the scope of this paper.

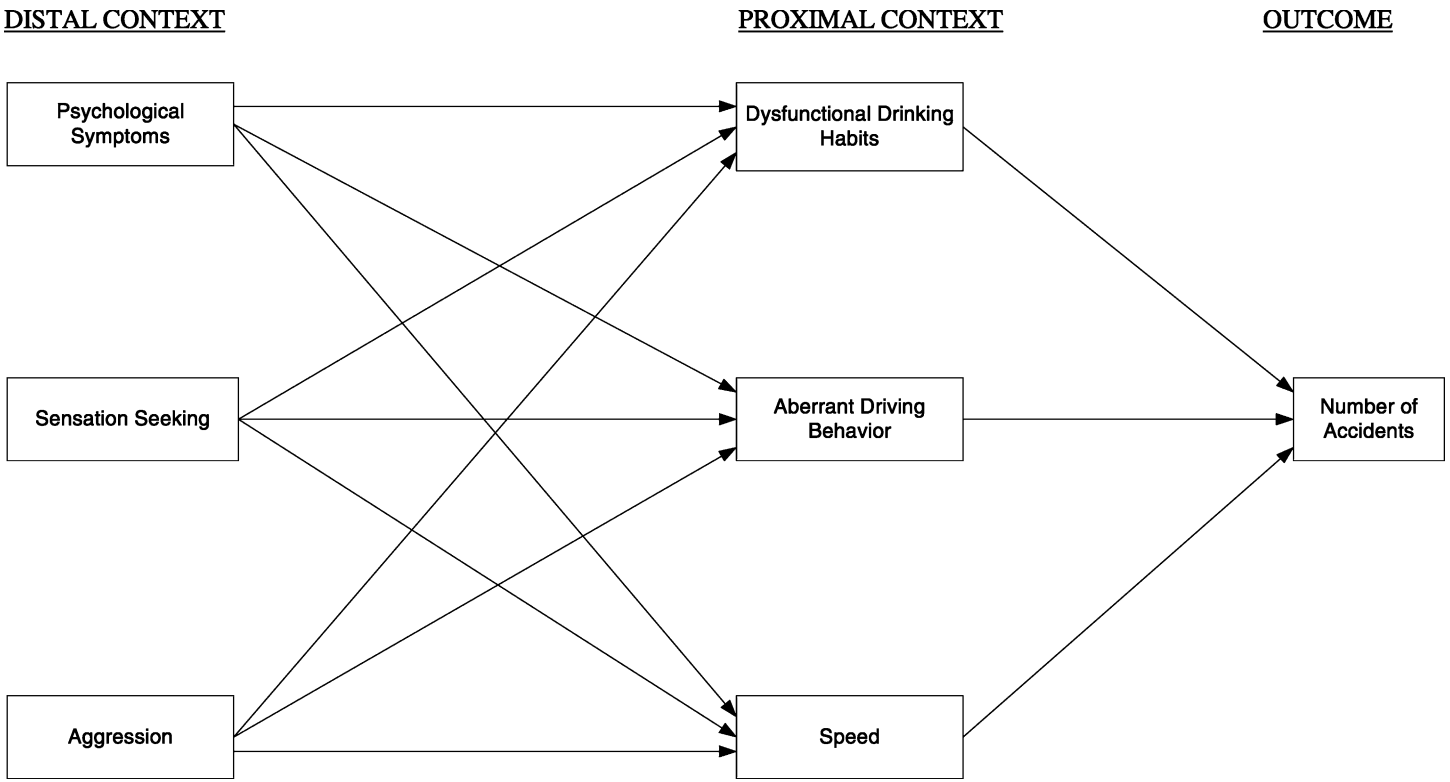

Fig. 2. Proposed contextual mediated model.

the contextual model, sensation seeking has been strongly associated with various elements of proximal context, such as high speed (Horvath and Zuckerman, 1993), frequent overtaking, and lane changing (McMillen et al., 1989), and driver behaviors, especially with violations (Rimmö and Åberg, 1999). In his review Jonah (1997) reported that the correlation between sensation seeking and different measures of risky driving behaviors ranged from 0.30 to 0.40. Jonah concluded that sensation seeking also influences risky driving behaviors and alcohol consumption, which in turn, have an effect on heightened collision rate.

1.2.2. Psychological symptoms

A number of studies have investigated the role of psychological symptoms on risky driving and/or accident involvement (e.g. Finch and Smith, 1971; Norris et al., 2000) since Tillman and Hobbs' (1949) early study comparing accident free and accident-prone taxi drivers on a number of psychopathological symptoms and demonstrating that accident repeaters were also socially deviant. Although some past studies revealed that those with high levels of psychopathological symptoms were more likely to involve in both traffic and other types of accidents (McDonald and Davey, 1996), other studies did not reveal a significant relationship or showed very week associations. Tsuang et al. (1985) concluded that although the findings considering the link between psychopathological symptoms and accidents involvement were mixed because of the methodological problems in the studies, people with high personality disorders (or psychological symptoms) seemed to be more vulnerable to accidents. As stated by Elander et al. (1993), although many studies examining the link between psychological symptoms and risky driving used clinical method and hence subject to bias, supporting the contextual mediated model, it can be concluded that " crash risk is consistently related to social deviance ... and this relationship *is mediated partly* by faster driving or more frequent violations" (p. 290 italics added).

In their literature review, McDonald and Davey (1996) found that the prevalence of personality disorders, especially antisocial personality disorder and hostility, was greater in accidents victims than it was for the general population. Contrary to the expectations, however, they found that anxiety and repressive disorders were not common among accident victims, although stress, as the natural correlate of these disorders, was found to be strongly associated with accident involvement. It seems that there is no clear evidence suggesting that specific psychological symptoms cause road crashes. However, past studies have not examined whether general psychopathological state including various symptoms such as anxiety, depression, and hostility has an effect on accident involvement via its effects on more proximal risky driving behaviors. Therefore, psychological symptoms were included as a distal element in this study.

1.2.3. Aggression

Aggression as the final distal-context variable of this study has been extensively studied in relation to traffic accidents. Majority of these studies seem to support the assumption that aggressive people are also aggressive drivers (e.g. Lajunen and Parker, 2001; Underwood et al., 1999). Aggressive driving has also been found to be associated with feelings of anger, frustration, hostile appraisals of other drivers (Gulian et al., 1989), and driving while intoxicated (Donovan and Marlatt, 1982). Briefly, empirical evidence suggests that aggressiveness increases driving risk, and therefore, general aggression appears to be one of the typical elements of the distal context, which may elicit risky driving behaviors affecting accident involvement.

1.2.4. Proximal elements

The proposed model included three proximal constructs, which have been shown to be strongest correlates of risky driving and accident involvement: driver behaviors, speeding and overtaking tendency, and dysfunctional drinking habits. Conceptually, aberrant driving behaviors are assumed to directly influence accident risk (Elander et al., 1993; Evans, 1991). Reason and his colleagues (1990) developed a self-report measure of driver behaviors and demonstrated that aggressive and ordinary violations, errors, and lapses were the fundamental dimensions of risky driving. This tripartite structure of driving behavior was replicated in other cultures (e.g. Blockey and Hartley, 1995), and violations were found to be the best predictor of road crashes (e.g. Parker et al., 1995). In a recent study on Swedish drivers, Rimmö and Åberg (1999) found that aberrant driver behaviors could be classified into four (violations, mistakes, inattention errors, and inexperience errors) rather than three factors. However, consistent with the pervious studies, they found that violations were the most stable predictor of accidents and traffic offenses. Furthermore, supporting the premises of the contextual model, these authors showed that violations and mistakes mediated the association between sensation seeking and accidents/offenses.

Alcohol consumption, drinking and driving, and the behaviors associated with drinking are the well-documented predictors of accident risk. Alcohol plays the most critical role in traffic safety than any other single factor, and about 47% of fatalities from traffic accidents would not occur were it not for alcohol (Evans, 1991). Several studies have shown that, in addition to its psychopharmacological effects, alcohol interacts with existing personality factors, such as hostility, resulting in a greater expression of aberrant behaviors, and hence, increases the risk of accidents (Beirness, 1993; Donovan et al., 1983; McDonald and Davey, 1996). Consistently, problem drinkers and alcoholics were found to drive more recklessly after drinking than social drinkers (Tsuang et al., 1985) and drinking habits and attitudes were found to be stable determinants of drunken driving (Åberg, 1993). Hence, in the present study, dangerous and

antisocial drinking habits were assumed to be one of the typical elements of the proximal context.

Finally, speed choice and actual speed driven in both residential area and intercity roads have documented as the stable predictors of accidents (Evans, 1991) in both simulation studies (e.g. Horswill and McKenna, 1999) and actual driving (e.g. Cooper, 1997). Thus, the speed habit was considered to be a proximal concomitant of accident involvement.

Several researchers suggested that correlative nature of the past studies and measurement errors in self-report measures usually attenuate the relationships between personality variables, driver behaviors, and accident involvement (e.g. Elander et al., 1993; Rimmö and Åberg, 1999). Thus, there is a need for methodologically sound studies in which potential confounding effects of personality traits and driver behaviors, as well as measurement errors are minimized. This can partly be accomplished by the use of structural equation modeling (SEM), which allows for multiple indicators of latent variables and hence controls for measurement errors that may attenuate or overestimate the relationships between variables (Hoyle, 1995). SEM was employed in the present study considering its advantages over traditionally used methods.

2. Method

2.1. Participants

The data reported in this study were collected as a part of an extensive questionnaire survey on the personality traits and accident involvement among mainly professional drivers. Initially the sample consisted of 321 professional and amateur drivers working in Ankara in Turkey. Considering the recommendations of Elander et al. (1993), questions on accident involvement were limited to the last 3 years and therefore, 29 drives with less than 3 years of driving experience were excluded from the sample, leaving 295 participants for the analyses. Participants were contacted by using different sources. Half of the heavy truck and intercity bus drivers were approached in a professional training seminar organized by the Association for Professional Drivers in Ankara. These drivers completed the questionnaire in small groups before the seminar. The remaining drivers were selected randomly from different private transportation companies in Ankara. Taxi and innercity minibus drivers were randomly selected from various waiting stations in Ankara. Drivers who were in the waiting list in the station were approached individually by a trained research assistant and asked to be a volunteer in a confidential study on driver behavior and traffic accidents. Only those who agreed to fill out the questionnaire were included in the study. Drivers, who accepted to participate in the study, either completed the questionnaire during their waiting period in their station or they were given appointment and visited later to collect the questionnaires. Amateur drivers were randomly selected among the university staff (except faculty members) and students holding a drivers license. Questionnaires were read by a male research assistant for some of the heavy truck drivers who were not fluent in reading and writing. The rest of the participants filled out the questionnaire individually. It took 40–90 min to fill out the questionnaire. About 70% of the contacted drivers agreed to fill out the survey.

Among the participants, 41 were amateur (13.8%), 94 were taxi (31.8%), 42 were minibus and service (14.2%), 51 were intercity bus (17.2%), and 67 were heavy truck (22.7%) drivers.[3] Participants had a mean age of 35.74 years (S.D. = 9.80) and had held a driver's license for a mean period of 14.37 years (S.D. = 9.08). On average, participants had 9.18 years of education (S.D. = 3.43). The mean km driven per year was 102,467 km (S.D. = 104,739).

In this study, accident was defined as any type of crash in the last 3 years caused by the person or the other drivers in the traffic. Those who had any accident were directed to another section in the questionnaire and asked to give a detailed description of the accident(s). Outcome of each crash for both the vehicle (as the degrees of damage) and the drivers or passengers (as injury, severe injury or human lost) was reported. While 49% of the drivers reported no accidents, 32% had only one crash, and 19% reported two or more crashes in the last 3 years. Almost all of the crashes (96%) had some damage on the vehicles, and 16 people were injured and 9 people were severely injured or lost their lives in these accidents.

2.2. Instruments

The questionnaire consisted of two sections. First section included questions assessing demographic characteristics, driving experience, and traffic accident history as well as traffic offenses within the last 3 years. Second section included the measures of personality traits and driver behaviors. In the demographics section, participants were also asked to complete single item measures of overtaking tendency, average speed both within and intercity roads, the frequency of alcohol consumption, and to give detailed descriptions of the reported accidents. To measure overtaking tendency, drivers were asked to chose one of the three options best describing their overtaking behavior, "(1) I tend to overtake less often than other drivers, (2) the frequency of my overtaking and others overtaking me is almost equal, (3) I tend to overtake more often than other drivers". Participants were also asked what their speed on average innercity city

[3] Comparison of driver groups using ANCOVA controlling age and exposure to driving (km driven in a year) indicated that taxi drivers reported significantly higher number of accidents than bus drivers. Contrary to the public belief, however, there was no significant difference among driver groups on the driving behaviors, skills, and personality variables with the exception of sensation seeking. Post hoc analyses indicated that heavy truck drives reported lower levels of sensation seeking tendency than amateur drivers, suggesting that similarities among driver groups were more common than the differences.

and intercity roads was when the weather and road conditions are "normal".

Since some of the measures used in this study were employed first time on a Turkish sample, initially the scales were translated into Turkish and then back translated to English by two individuals who are fluent in both languages.

2.2.1. Sensation seeking-risk taking

The Arnett Inventory of Sensation Seeking (AISS) (Arnett, 1994) including 20 items was used to measure the two dimensions of sensation seeking, each having 10 items: novelty (e.g. I like to travel to places that are strange and far away) and intensity (e.g. when I listen to music, I like it to be loud). One of the items on the novelty subscale stating "I do not like extremely hot and spicy foods" was excluded from the scale because of the common use of hot and spicy food in the Turkish culture. Risk taking was measured using five item thrill-seeking/risk-taking subscale of the Multidimensional Self-Destructiveness Scale (e.g. I crave excitement) developed by Persing and Schick (1999). All items were scored on a five point scale from "describes me very well" to "does not describe me at all". A principle component analysis[4] with varimax rotation on the 19 items of the AISS together with the five items of the risk-taking scale yielded three interpretable components, representing the two subscales of the AISS and risk-taking scale, and explaining 34% of the variance. Using 0.35 cut-off points for item loadings, first component included five items from the novelty subscale, explaining 19% of the variance. Second component consisted of the five items of thrill-seeking/risk-taking scale and explained 8% of the total variance. The third component tapped eight items from the intensity subscales, explaining 7% of the variance. Remaining items either did not load on any of the factors or highly cross-loaded on at least two components. The novelty, intensity, and risk-taking variables were created using corresponding items in the principal component analysis. Although these variables included relatively few items, internal consistency coefficients (α) were acceptable (0.62, 0.65, and 0.68, respectively).

2.2.2. Psychological symptoms

The four subscales (depression, anxiety, hostility, and psychoticism) of the Brief Symptom Inventory (BSI) (Derogotis, 1993) were used to assess psychological symptoms. The BSI was translated and adopted into Turkish by Sahin and Durak (1994). A five-point scale format from "not at all" to "extremely" was used asking for a time frame of the past week. The subscales had satisfactory reliability coefficients: depression with six items (e.g. feeling blue, hopeless, $\alpha = 0.82$); anxiety with six items (e.g. feeling tense, nervous, $\alpha = 0.84$), hostility with five items (e.g. easily getting angry, $\alpha = 0.84$), and psychoticism with five items (e.g. feeling no closeness to anybody, $\alpha = 0.62$).

2.2.3. Aggression

The aggression questionnaire (Buss and Perry, 1992) with four subscales was used to assess aggressive tendencies as a personality trait. All items were scored on a five-point scale, from "does not describe me at all" to "describes me very well". Physical aggression subscale comprised nine items (e.g. If somebody hits me, I hit back), verbal aggression five items (e.g. I often find myself disagreeing with people), hostility eight items (e.g. I wonder why sometimes I feel so biter about things), and anger seven items (e.g. when frustrated, I let my irritation show). Supporting Buss and Perry's findings, a factor analysis with promax rotation yielded four factors taping the four subdimensions of the questionnaire, explaining 38% of the total variance. However, as reported by Buss and Perry, some of the items on the anger, hostility, and verbal aggression subscales cross-loaded and three items had low loadings in this sample. These items were maintained and variables for the four subscales were created considering the original grouping of the items. Reliability analyses for the subscales revealed acceptable α consistency coefficients (ranging from 0.72 to 0.77) with the exception of verbal aggression subscale (0.58).

2.2.4. Driver behaviors

Twenty items from the driver behavior questionnaire (DBQ) (Reason et al., 1990) tapping two types of aberrant driver behaviors, namely violations (e.g. Disregard the speed limit on a residential road) and errors (e.g. Brake too quickly on a slippery road, or steer the wrong way in a skid), were used. Items measuring lapses in the original scale were excluded. Nine new items representing typical violations and errors observed among Turkish drivers (e.g. warning the car in front by honking to cross a junction as soon as the traffic lights turn to yellow) were also included, totaling 28 items. Participants responded to the DBQ items indicating how often they commit each of the given behaviors using a four-point scale from "never" to "nearly all the time". A principal component analysis with varimax rotation revealed two interpretable factors corresponding violations and errors, explaining 39% of the total variance. The first extracted factor, named violation, consistent of 17 items and accounted for 31% of the variance, the second factor, named as errors, consisted of 11 items and accounted for 8% of the variance. One of the newly added items ("warning the drivers in the front by signaling") did not load on any of the factors, and thus, was excluded. Violation and error subscales created on the basis of factor analysis had satisfactory internal consistency coefficients (0.84 and 0.85, respectively).

2.2.5. Antisocial and dangerous drinking

Two subscales from the Multidimensional Self-Destructiveness Scales were employed to assess risky drinking

[4] Factor structure of newly adapted measures into Turkish was examined in detail. Interested researcher may require these results directly from the author.

behaviors. The antisocial drinking subscale comprised six items (e.g. I have destroyed property accidentally while drunk) and the dangerous drinking subscale comprised five items (e.g. I have driven while drunk or high). Participants responded to these items considering how they generally behaved in the past while drinking and/or drunk by using a five-point scale format from "does not describes me at all" to "describes me very well". Although these two scales had relatively few items, they had acceptable α coefficients (0.69 and 0.76, respectively).

2.2.6. Data analysis

The model depicted in Fig. 2 was tested via LISREL 8.3 (Jöreskog and Sörbom, 1993) by employing the two-stage approach suggested by Anderson and Gerbing (1988). In this approach, the first step involves testing a measurement model via confirmatory factor analysis and the second step involves testing a series of structural models including the hypothesized model. The purpose of a measurement model is to describe how well the observed or measured variables (indicators) serve as measurement instruments for the underlying latent variables. The measurement model also estimates the nondirectional relationships (correlations) among the latent variables. The purpose of a structural model is to test a general model that prescribes the relationships among the latent variables. Considering the role of confounding factors in accident frequency (Elander et al., 1993) a partial correlation matrix (Table 1) was used as the input, controlling for exposure and age.

3. Results

Prior to analyses all of the major variables were checked for missing data. With the exception of alcohol-related variables, all of the variables had missing values <5% (ranging from 2 to 11 cases) and these cases were replaced with the mean of the given variable. However, 42 participants reported that they had never consumed alcohol, and hence did not respond to the scales of antisocial and dangerous drinking. Because of the concerns about the sample size, missing values were replaced with series means in the SEM analyses. A comparison of the correlations with and without missing values replaced indicated that correlations between these alcohol-related variables and the other major variables were relatively reduced after the replacement, probably because of the increased homogeneity of distributions. However, the reduction was minimal ranging from 0.02 to 0.04.

3.1. Evaluation of fit

There is no consensus among researchers concerning how best to evaluate the extent to which a proposed model fits the data. Based on the recent publications in this area (e.g. Hu and Bentler, 1995; Jöreskog and Sörbom, 1993), a set of fit indices were used in this study. Of the absolute indices, the Chi-square (χ^2) goodness of fit index and the χ^2/degrees of freedom ratio, the root mean square (RMS), and adjusted goodness-of-fit index (AGFI) were utilized. Fit measures that are based on χ^2 statistics typically estimate the "badness of fit" and optimal fit is indicated by a value of zero with increasing values indicating greater departure of the implied (estimated) covariance matrix from the observed covariance matrix (Hoyle, 1995). Therefore, nonsignificant or smaller χ^2 values are desired. In addition, model fit is judged to be good if the χ^2 is not too large relative to the degrees of freedom. It has been suggested that χ^2:d.f. ratios of 2:1 to 5:1 indicate an acceptable fit (Marsh and Hocevar, 1988).

3.2. Measurement model

Means, standard deviations, α coefficients, and partial correlations between the observed variables are presented in Table 1. Inspection of the partial correlations, controlling exposure to driving and age revealed that they were all in the expected direction, and overall, the correlations between the indicators of the same construct (indicated with bolded correlations) were higher than the correlations between the measures of different constructs. Although the correlations between the variables of distal and proximal contexts were moderately high, both contexts had relatively weak correlations with the number of accidents.

As illustrated in Fig. 3, the measurement model consists of seven latent constructs, which are represented in the figure by rectangles with curved edges. The indicator variables are represented by traditional rectangles. The three distal-context variables represent the latent exogenous (independent) variables. Four indicators measured the psychological symptoms: anxiety, depression, hostility, and psychoticism. The sensation seeking latent variable was measured by three indicators: risk taking, novelty, and intensity. The four subscales of the aggression questionnaire measured the aggression latent variable. Alcohol, aberrant driving behaviors, speed, and accidents constituted the endogenous (dependent) variables. Frequency of alcohol consumption, antisocial drinking, and dangerous drinking were used when estimating the dysfunctional drinking. Errors and violations were used for aberrant driving behaviors, and finally, the speed latent variable was measured by three indictors: overtaking tendency, speed within and intercity roads. Self-reported number of accidents within the last 3 years was used as the single indicator of the outcome latent variable, number of accidents. The error variance of accidents was fixed to zero in these analyses.

Correlations between the latent variables are conventionally shown with double-headed arrows on the figure. However, these correlations were given in Table 2 for the sake of clarity. As can be seen in Fig. 3, all of the observed variables loaded significantly on the appropriate latent variables (ranging from 0.33 for the alcohol consumption to 0.93 for anxiety. Besides alcohol consumption, overtaking tendency (0.44) and novelty (0.39) seemed to be relatively

Table 1
Partial correlations among major variables, means, standard deviations, and internal consistency coefficients

Variables[a]	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1 Anxiety	(**0.84**)																			
2 Depression	**0.81**	(0.82)																		
3 Hostility	**0.79**	**0.68**	(0.83)																	
4 Psychotisizm	**0.77**	**0.77**	**0.70**	(0.62)																
5 Risk taking	0.03	0.06	0.09	0.04	(0.68)															
6 Novelty	0.08	0.17	0.07	0.08	**0.30**	(0.62)														
7 Intensity	0.24	0.25	0.32	0.23	**0.40**	**0.28**	(0.65)													
8 Anger	0.38	0.32	0.45	0.37	0.36	0.18	0.38	(0.77)												
9 Physical aggression	0.30	0.26	0.39	0.29	0.28	0.19	0.35	**0.57**	(0.72)											
10 Verbal aggression	0.14	0.11	0.22	0.16	0.12	0.09	0.07	**0.46**	**0.33**	(0.58)										
11 Hostility	0.39	0.37	0.38	0.37	0.26	0.18	0.32	**0.63**	**0.54**	**0.46**	(0.76)									
12 Errors	0.57	0.57	0.57	0.50	−0.06	−0.08	0.19	0.21	0.25	0.17	0.30	(0.85)								
13 Violations	0.51	0.49	0.57	0.46	0.09	0.13	0.32	0.32	0.33	0.22	0.34	**0.67**	(0.84)							
14 Alcohol consumption	0.17	0.15	0.19	0.09	0.22	0.04	0.19	0.21	0.21	0.09	0.24	0.11	0.21	(–)						
15 Anti-social drink	0.35	0.27	0.48	0.33	0.05	0.00	0.33	0.32	0.33	0.19	0.28	0.41	0.44	**0.21**	(0.69)					
16 Dangerous drink	0.42	0.35	0.45	0.36	0.08	0.07	0.31	0.35	0.30	0.18	0.30	0.29	0.41	**0.29**	**0.61**	(0.76)				
17 Overtake	0.00	0.01	0.04	0.06	0.14	0.13	0.22	0.12	0.07	0.09	0.07	0.10	0.17	0.03	0.07	0.09	(–)			
18 Speeding in city	−0.03	0.03	0.06	−0.03	0.21	−0.01	0.18	0.13	0.15	0.11	0.11	0.08	0.18	0.14	0.01	−0.00	**0.30**	(–)		
19 Speeding interaction	0.00	0.05	0.03	0.02	0.27	0.12	0.22	0.09	0.07	0.02	0.06	0.05	0.18	0.04	0.03	0.01	**0.22**	**0.42**	(–)	
20 No. of accidents	0.21	0.23	0.18	0.20	−0.02	0.05	0.18	0.14	0.11	0.01	0.20	0.18	0.23	0.07	0.13	0.16	0.01	0.07	0.07	(–)
Mean	1.65	1.77	1.62	1.79	3.25	3.83	2.83	2.41	2.11	3.16	2.64	1.30	1.56	2.11	1.29	1.82	1.48	56.45	96.13	0.75
Standard deviation	0.68	0.76	0.76	0.70	0.81	0.76	0.65	1.03	0.75	0.87	0.91	0.39	0.43	0.73	0.59	0.82	0.71	13.35	19.24	0.90

[a] Age and annual mileage were controlled. Values on the diagonal within the parentheses indicate α values for multi-item measures. Bolded values show the correlations among the indicators of the same latent variable. Correlations above 0.12 are significant at $P < 0.05$, above 0.17 are significant at $P < 0.01$, and above 0.19 are significant at $P < 0.001$.

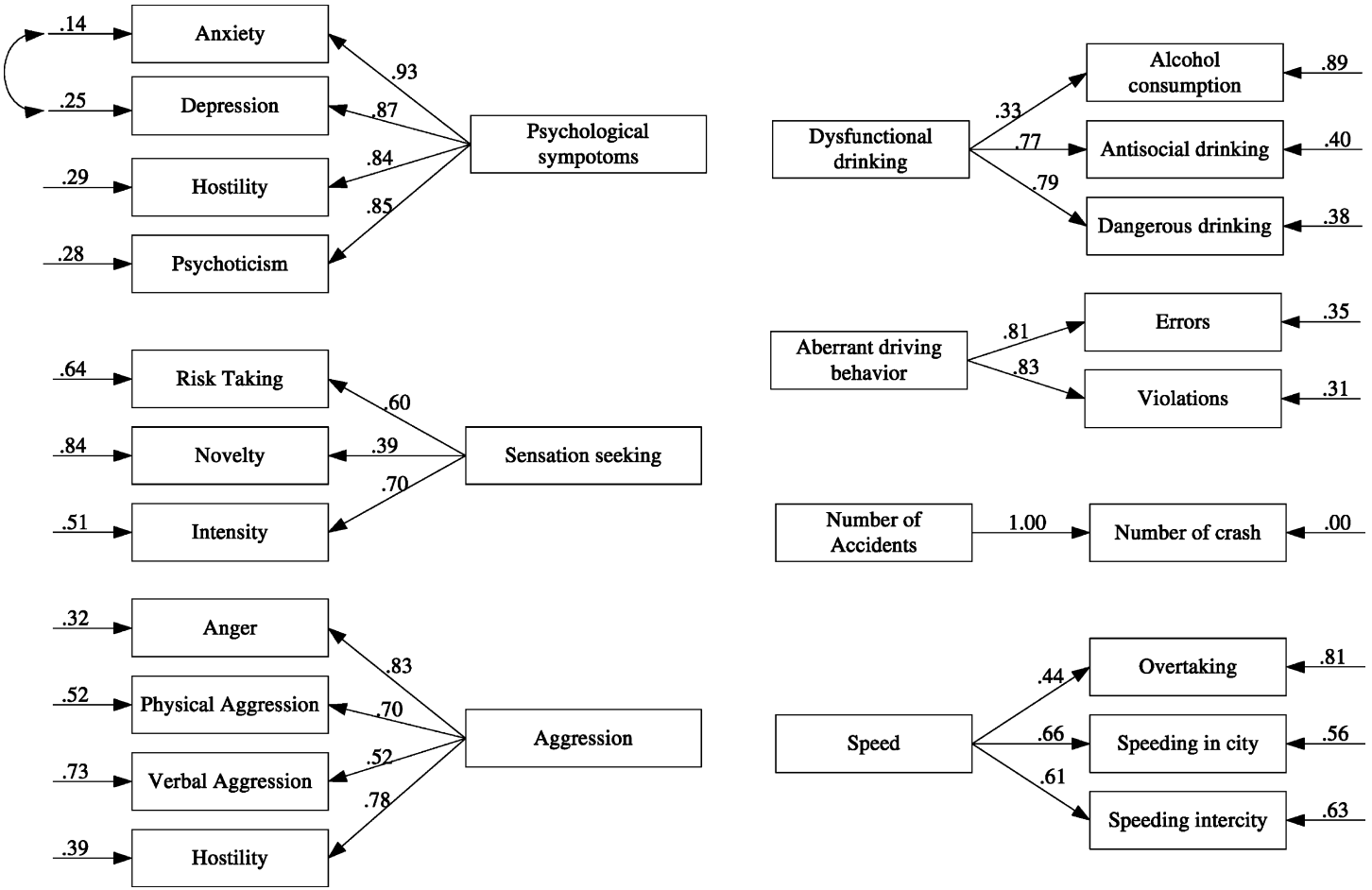

Fig. 3. Confirmatory factor analysis on the distal, proximal, and outcome variables: measurement model.

Table 2
Structural correlations among latent variables presented in the measurement model

Latent variables	1	2	3	4	5	6
1 Psychological symptoms	–					
2 Sensation seeking	0.29[a]	–				
3 Aggression	0.51	0.61	–			
4 Aberrant driving behaviors	0.73	0.28	0.46	–		
5 Dysfunctional drinking	0.54	0.40	0.52	0.61	–	
6 Speed	0.02[b]	0.50	0.22	0.26	0.07[b]	–
7 No. of accidents	0.24	0.15	0.18	0.25	0.19	0.10[b]

[a] Correlations above 0.13 are significant at $P < 0.05$.
[b] ns: not significant.

weak indicators of their latent variables. However, all loadings were statistically significant, and modification indices suggested minor modifications regarding the original specification of the model. The measurement model provided reasonable fit to the data [χ^2 (150, $N = 295$) = 312.80, $P < 0.001$, RMSEA = 0.06, AGFI = 0.87, NNFI = 0.91, CFI = 0.93]. Although the χ^2 statistic indicated significant differences between the observed and the estimated matrices, the χ^2:d.f. ratio was well below the suggested 5:1 ratio. This indicated that all of the latent variables were reliably measured by the observed variables.

As seen in Table 2, as expected, latent variables in the distal context were strongly correlated with those in the proximal context. Especially, psychological symptoms strongly correlated with aberrant driving behaviors (0.73) and dysfunctional drinking (0.54), although it was not associated with speed. Investigation of within context correlations revealed that the highest correlation was between sensation seeking and aggression (0.61) in the distal context, and between aberrant driving behavior and alcohol in the proximal context (0.61). Finally, confirming the relationship between personality/driving behaviors and accidents, latent variables in both contexts significantly correlated with accidents except speed (0.10), although the size of the correlations was relatively small. Of those links, the highest correlations were with aberrant driving behaviors (0.25) and psychological symptoms (0.24).

3.3. The structural model

The measurement model indicated that the latent variables necessary for testing the proposed model were estimated successfully from the observed variables. Evaluation of a structural equation model requires comparing the goodness of fit indices of several nested models in order to clearly identify where lack of fit arises within a model. As suggested by Mulaik and James (1995), a series of nested models were estimated before testing the proposed model. As expected, the results of all the nested model analyses indicated that although the null and uncorrelated factors models yielded a very poor fit [χ^2 (190, $N = 295$) = 2589.58, $P < 0.001$], and [χ^2 (170, $N = 295$) = 915.60, $P < 0.001$, RMSEA = 0.13, AGFI = 0.70, NNFI = 0.72, CFI = 0.75], respectively, the saturated model yielded a relatively good fit to the data [χ^2 (153, $N = 295$) = 344.81, $P < 0.001$, RMSEA = 0.07, AGFI = 0.86, NNFI = 0.90, CFI = 0.92]. This finding suggested that the latent variables were sufficiently related so that the proposed model could be tested. The single factor model also provided a very poor fit to the data, indicating that the common method variance cannot fully explain the observed pattern of the data [χ^2 (170, $N = 295$) = 1366.35, $P < 0.001$, RMSEA = 0.16, AGFI = 0.61, NNFI = 0.61, CFI = 0.64]. Specifically, the self-reported nature of the data does not appear to cause a substantial problem in this study. Briefly, nested model analyses indicated that measurement assumptions were met and that the latent variables were sufficiently related to test the hypothesized associations.

The proposed contextual mediated model was tested next by fixing all of the direct paths from distal context to accidents to zero. As depicted in Fig. 4, (X1 to X11 represent the indicators of the exogenous variables and Y1 to Y9 represent the indicators of the endogenous variables, as described earlier for the measurement model), the model provided reasonable fit to the data [χ^2 (156, $N = 295$) = 347.20, $P < 0.001$, RMSEA = 0.07, AGFI = 0.86, NNFI = 0.90, CFI = 0.92]. Although the χ^2 statistic was significant (indicating a significant difference between the observed and reproduced matrices), the χ^2:d.f. ratio was below the suggested 5:1 ratio. Investigation of the structural path parameters indicated that four out of nine possible paths from the distal context to the proximal context were significant. While psychological symptoms did not predict speed, its direct effects on both alcohol (path coefficient = 0.39) and aberrant driving behaviors (path coefficient = 0.69) were significant. Sensation seeking displayed a significant effect on speed (path coefficient = 0.60). Aggression also directly increased negative alcohol habits (path coefficient = 0.24). Partially supporting the expectations, while aberrant driving behaviors significantly predicted the number of accidents (path coefficient = 0.21), neither alcohol (despite its significant correlation in measurement model) nor speed significantly predicted accidents. Supporting the mediated model, the relationship between psychological symptoms and accidents was mediated by aberrant driving behaviors (path coefficient for indirect effect = 0.17, $P < 0.05$) while sensation seeking and aggression did not have significant indirect effects (0.07 and 0.03, respectively). The three distal variables accounted for 57% of the variance in aberrant driving behaviors, 40% in alcohol, and 28% in speed. While direct effects of the proximal variables accounted for 7% of the variance in accidents, distal context added about 3% to the explained variance via aberrant driving behaviors. Finally, in a modified model, nonsignificant paths in the proposed model were omitted and the model was re-estimated.

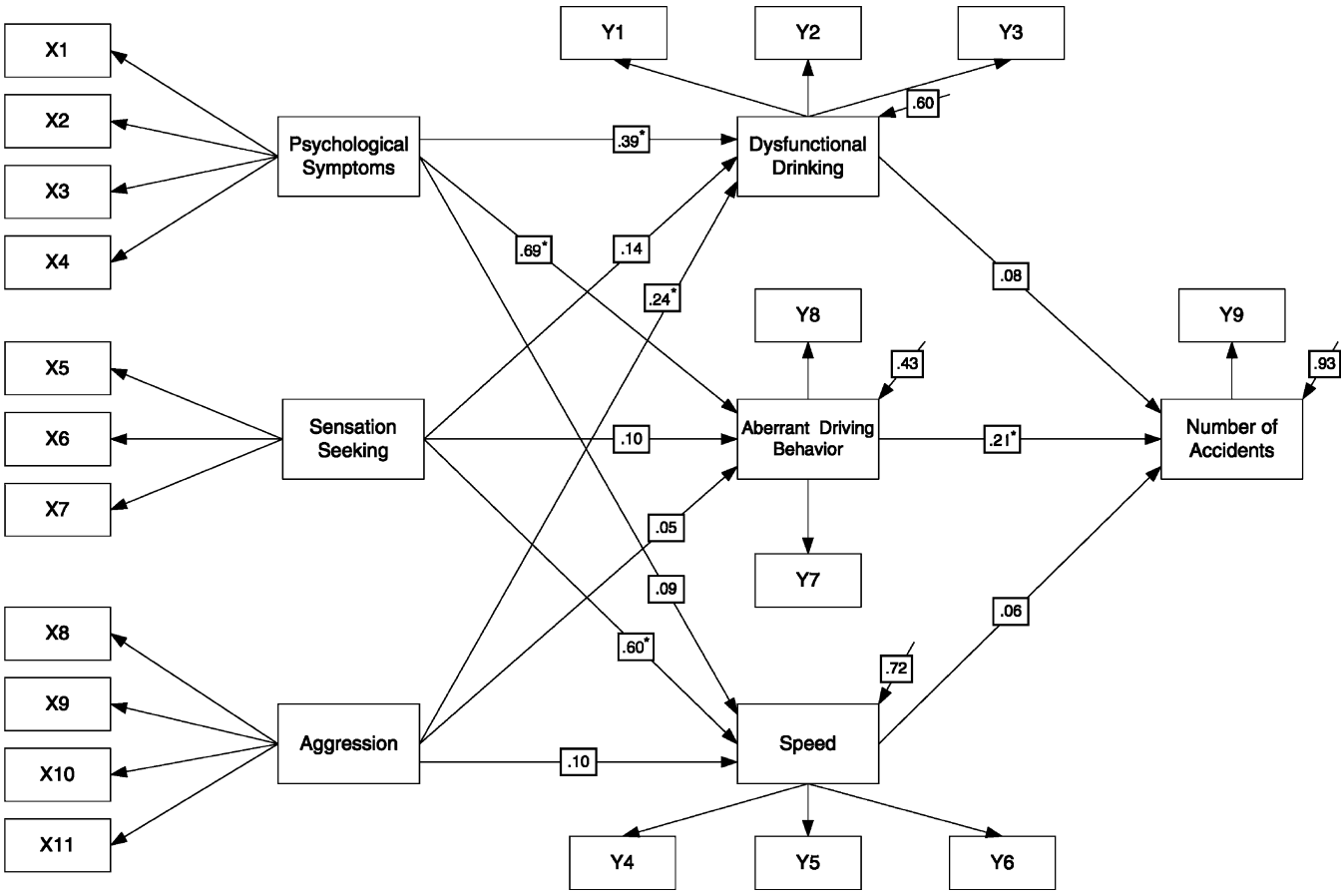

Fig. 4. Structural analysis on the proposed model: structural model, $^{*}P < 0.05$.

Although there was no significant difference between the proposed and modified models, the path coefficient of aberrant driver behaviors predicting accidents increased to 0.26.

4. Discussion

This research examined certain personality and behavioral correlates of accident involvement in a contextual mediated model distinguishing distal and proximal factors. The results of the measurement model analyses indicated that all of the indicators loaded highly on the appropriate latent constructs, suggesting that the latent constructs under consideration were reliably assessed. Since these loadings can also be interpreted as validity coefficients (Jöreskog and Sörbom, 1993), findings have some implications for the construct validity of the observed measures. Observed low loading of alcohol consumption (0.30) on the latent variable of dysfunctional drinking, as compared to antisocial (0.77) and dangerous drinking (0.79), was consistent with the previous findings indicating that attitudes against drunken driving and drinking habits are critical predictors of drinking and driving, rather than sheer amount of alcohol consumed (e.g. Åberg, 1993; Norström, 1983). Findings of the study replicated the well-documented association between certain personality constructs and risky driving behaviors (e.g. Kim et al., 1995; Tsuang et al., 1985), and the magnitude of the correlations and the effects were in fact greater than those reported in previous research. This improvement could have stemmed partially from using SEM estimating structural correlations among latent variables, which are free of measurement errors of observed variables, attenuating the correlations between variables.

4.1. Associations among latent constructs

The correlations among the latent variables in the measurement model revealed that levels of psychological symptoms were strongly associated with aberrant driving, moderately associated with dysfunctional drinking, and weakly but significantly linked with accidents. Although earlier studies documented such associations by using correlative designs similar to this study (e.g. Donovan et al., 1985), employing latent variable analysis seemed to offer a clearer and more consistent picture of the assumed associations. This study also replicated some of the previous findings in the literature. For example, similar to past research, moderately strong associations between sensation seeking

and the proximal context variables, especially with preferred speed and dysfunctional drinking, were found (Arnett et al., 1997; Jonah et al., 2001). Consistent with past research, aggression was found to be related to both aberrant driving behaviors and dysfunctional drinking (Arnett et al., 1997; Lajunen and Parker, 2001; Parker et al., 1998). As expected, the majority of both the distal and proximal context variables weakly but significantly correlated with accidents. The highest correlations of accidents were with the aberrant driving behaviors ($r = 0.25$) and psychological symptoms ($r = 0.24$), indicating the importance of these factors in accident involvement.

4.2. Contextual mediated model

Overall, the results of SEM in testing the proposed model provided support for the contextual mediated model. However, investigation of the path parameters revealed a partial support demonstrating that only one of the proximal variables (i.e. aberrant driving behaviors) directly and one of the distal variables (i.e. psychological symptoms) indirectly predicted the number of accidents. Examination of the predictive relationships between the distal and proximal variables, however, yielded support for the contextual model and were consistent with the previous findings (e.g. Rimmö and Åberg, 1999). While aberrant driving behaviors were strongly predicted by psychological symptoms only, dysfunctional drinking was predicted by psychological symptoms and aggression, and finally preferred speed was strongly predicted by sensation seeking. Psychological symptoms having direct effects on both aberrant driving behaviors and dysfunctional drinking and an indirect effect (via these behaviors) on the number of accidents appeared to be the strongest predictors among the three latent independent constructs. These results clearly underscore the strong role of aberrant driving behaviors in predicting accidents.

As observed from the correlations among the latent variables, psychological symptoms were significantly correlated with both sensation seeking ($r = 0.29$) and aggression ($r = 0.50$), suggesting a partial overlap between these variables. This may have resulted in a nonsignificant effect of sensation seeking and/or aggression on mediators and outcome variables. To test this possibility, another structural equation model in which paths from psychological symptoms to other variables were fixed to zero was tested. The results revealed that both sensation seeking and aggression had significant direct effects on aberrant driving behaviors (path coefficient = 0.23, 0.31, respectively) in addition to their previously mentioned effects on other variables. Furthermore, aggression had an indirect effect on accidents via aberrant driving behaviors (indirect effect = 0.09). Unlike the previous studies showing either weak or mixed associations between personality variables and traffic accidents (e.g. Tsuang et al., 1985), one of the most compelling findings of this study was that a relatively large percentage of variance in the proximal mediators representing risky driving behaviors was accounted for by the three personality variables suggesting a strong association between personality traits and driving style.

Given that a very large portion of variance in aberrant driving behaviors (57%) was explained by the distal factors and that these behaviors only mediated the bond between symptoms and accidents, the role of psychological symptoms (or well-being) should receive more attention in future studies employing powerful methodologies such as prospective designs. Consistent with the past research (e.g. Elander et al., 1993), in the present study, explained variance in accidents did not exceed the most commonly detected limit of 10%. Only 7% of the number of accidents drivers involved in the last 3 years was directly accounted for by proximal variables, and indirect effects of the psychological symptoms added some to this portion. One of the plausible reasons for not being able to explain a large portion of the variance in accident involvement could be related with the use of multiple regression model on accident data, which have indeed a negative binominal distribution. Recently, by using a very comprehensive method, Abdel-Aty and Radwan (2000) demonstrated that overall Poisson regression gives better results than the conventional multiple regression model, and in case of over dispersion (having a variance greater than the mean) negative binominal regression is superior and more appropriate approach in analyzing accident data. The fact that half of the drivers (49%) in the present study reported no previous accidents (accident mean = 0.75, and S.D. = 0.89), which resulted in a very skewed binominal distribution may partially be responsible for the weak correlations between accidents and other variables. Therefore, the true relationships between potential predictors and accident involvement in the population may be underestimated.

Similar to the contextual mediated model tested in this study, previous studies developed and tested mediated models on the basis of both theoretical and empirical frameworks. One of the most commonly employed theoretical mediated perspective in the driver behavior arena has been the theory of planned behaviors, which assumes that the immediate cause of a given behavior is not attitudes, but rather, behavioral intentions mediating the link between attitudes and actual behaviors (Ajzen, 1991). Past studies provided evidence indicating that a number of risky driving behaviors corresponding to the intention component of the model, such as exceeding the speed limits (Parker et al., 1996), aggressive violations (Parker et al., 1998), and intention to drink and drive (Åberg, 1993), form proximal predictors of a variety of outcome behaviors including accident involvement. Consistent with the findings of this study, Lajunen (1997) found that personality characteristics, especially sensation seeking, predicted perceptual motor skills and safety skills, and they in turn, predicted preferred speed.

Although the contextual mediated model seems to offer a conceptual argument for categorizing some of the correlates of accidents in a causal mediated framework, a more sophisticated examination of personality factors, driving skills, and behaviors is needed. For example, while driver behaviors,

especially violations, can be safely classified as an element of the proximal context, driving skills seem to be vague in this sense. Consistent with Evans (1991) and Elander et al.'s (1993) arguments, much of driving and driving-related skills could be categorized under distal context, whereas some other skills, such as hazard perception (Deery, 1999) appear to be highly proximal factors. Supporting this argument, Elander and his friends asserted that driving-related skills including the ability to detect hazards were directly related to driving, while information processing-related driving skills were extrinsic factors. Lajunen (1997) included both driving and safety skills and the mediating (proximal) factors in his model, and showed that these factors predict some risky driving behaviors (e.g. speeding) and indirectly predict accidents via exposure factors. Furthermore, the association between skills and risky driving may not be linear and better driving performance may not always lead to reduced crash risk. As indicated by Evans (1991), compared to average skilled drivers, racing drivers may have high rates of crash and violations independent of their skills. Future studies need to investigate the contextual links among unexamined variables based on more comprehensive conceptual arguments.

4.3. Limitations of the study

There are some limitations on the conclusions that may be drawn from the findings of this study. First, the sample used in this study was not representative of the Turkish drivers as a whole. Although four groups of professional and one group of amateur drivers were employed, both the number of the groups and some of the demographic characteristics (especially age) were very heterogeneous. Moreover, these professional groups may have differential rate of exposure to driving experiences. For example, while taxi drivers have more near accidents and rear-end collisions than the other driver groups, heavy truck and lorry drivers involve in more severe accidents. Because of their limited speeding capacity heavy truck drivers may also have reported low levels of overtaking tendency. Future research needs to test the proposed model within each group of drivers and check the cross-validity of the findings. Drivers in general have a very complex combination of risk and protective factors and some of these factors are malleable and others are more stable (Norris et al., 2000). Using different driver groups seems to add further complexity to these factors. The second limitation was that all of the reported accidents were treated into the same accident category ignoring the type of accidents. Past studies showed that accident types, such as active and passive accidents, may be related to certain driving behaviors and personality characteristics (Parker et al., 1995). Third, the data collected in this study, which were based on the self-report of the participants, were in some respect indirect and hence, they are partially subject to bias and measurement errors. Although latent variable analyses with multiple indicators partially control for measurement errors of the measures (Hoyle, 1995), this was not the case at least for accidents since the number of accidents was used as the sole outcome variable, and hence, its error variance was statistically fixed to zero in all of the tested models in this study. Furthermore, certain personality variables may have also interacted with the measurement error of accidents. For example, it is a possibility that high sensation seekers may be partially incorrect in reporting all the crashes they have been involved. In either case, there may be a portion of measurement error, which was not handled by the tested models.

The forth limitation concerns the replacement of missing data. Since 42 drivers reported that they did not consume alcohol at all, they were not able to respond to the items on drinking habits. However, considering the sample size restriction, missing values for these cases were replaced with group means. To test the impact of missing replacement, the same models were tested with 253 drivers by excluding these 42 drivers. Results yielded fit indices similar to the full-sample model except the AGFI which was reduced to 0.83 from 0.86 due to the shrinkage in the sample size. However, path parameters changed in both magnitude and significance regarding sensation seeking in the reduced sample. Sensation seeking significantly predicted all of the proximal latent variables (0.24 for aberrant driver behaviors, 0.19 for dysfunctional drinking, and 0.88 for speed) in the reduced sample model while it predicted speed only in the full-sample model, suggesting that those who did not consume alcohol at all were also low in sensation seeking. These findings demonstrated that missing replacement slightly influenced the parameter estimations in the analyses by reducing the observed correlations.

4.4. Suggestions for further studies

The contextual mediated model tested in this study seems to be an effective tool to better understand the underlying dynamics of both risky driving behaviors and road-traffic crash involvement. Potential role of other distal-context elements, such as attitudes, fatalism, and attributions regarding accident causation and other proximal context variables, such as hazard perception latency, need to be examined in future studies using more representative samples. Considering methodological limitations, multiple measurements of observed variables should be included by using more direct measures of proximal and outcome variables. Socio-economic development level and culture specific characteristics of a given country should also be taken into account in studying both casual factors and correlates of accidents. Finally, alternative methods such as Poisson or negative binominal regression can be used to clarify the relative role of distal and proximal variables in predicting accidents. Given the very high human and economic cost of traffic accidents in Turkey as compared to the other European countries (United Nations, 1999), examination of psychological and social determinants of traffic accidents will contribute to the establishment of a sustainable "traffic safety culture" in Turkey.

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