Transportation Research Part F 15 (2012) 480–490

Contents lists available at SciVerse ScienceDirect

Transportation Research Part F

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

Drivers' subtypes in a sample of Italian adolescents: Relationship between personality measures and driving behaviors

Davide Marengo [a,*], Michele Settanni [a], Giulio Vidotto [b]

[a] Department of Psychology, University of Turin, Via Verdi 10, 10124 Turin, Italy
[b] Department of General Psychology, University of Padua, Via Venezia 8, 35131 Padua, Italy

ARTICLE INFO

Article history:
Received 23 December 2011
Received in revised form 6 April 2012
Accepted 7 April 2012

Keywords:
Adolescents
Dangerous driving
Personality
Cluster analysis
Riding simulator

ABSTRACT

Considering a limited number of relevant personality measures (e.g., sensation seeking, impulsivity, locus of control, anxiety and altruism), the present study aimed to identify subtypes of drivers in an Italian sample of 207 adolescents aged 14–15 (52.7% girls) with heterogeneous moped riding experiences. Subtypes were compared on the basis of both self-report driving behaviors and two measures extracted from students' performances on a moped simulator employing a specifically developed Rasch-based method. On the basis of cluster analysis, three subgroups were identified (profiles A, B, C). Profile B was characterized by high levels of sensation seeking and impulsivity, and low levels of altruism and anxiety. It showed high risk propensity considering both self-report and simulator measures. Profile A consisted of mostly females and was characterized by high levels of anxiety, externality and low levels of sensation seeking and altruism. While showing cautious driving behaviors, it did not differ from profile B in terms of crash involvement. Profile C was characterized by high levels of altruism and a more internal orientation; it showed the safest driving attitude.

A relevant feature of this study is the direct assessment of driving behaviors by means of simulation performances, which nonetheless showed high concordance with self-report data. Congruence of our findings with previous studies on older and more experienced samples is discussed, along with the use of simulation, in the light of future perspective for research.

1. Introduction

In Italy, as of today, involvement in road traffic accidents is the first cause of decease for young people under 30. While representing only 12% of the registered motor vehicles circulating in Italy, powered two-wheelers account for 52% of the traffic-related fatalities for people under 30 (ANIA, 2011); the percentage adds up to 67% for youngsters aged 15–17, the second largest proportion in EU 19 after Greece (ERSO, 2010). Concerning low-powered vehicles, 20% of the overall moped-related fatalities involves adolescents aged between 15 and 17 years old, of which 93% males (ISTAT, 2009).

Lack of experience and an often unrealistic evaluation of both their own driving skills and the traffic situation have been shown to characterize young novice drivers (Brown & Groeger, 1988; Gregersen, 1996; Horswill, Waylen, & Tofield, 2002; Liu, Hosking, & Lenné, 2009), putting them at a greater risk of being involved in a crash while driving in the streets than older, more experienced drivers. In a developmental view, authors suggests youngsters' self-serving biases and risky behaviors to be related to the adolescents' need to perceive themselves as autonomous and competent while actively involved in

* Corresponding author. Tel.: +39 0116702979.
E-mail address: davide.marengo@yahoo.com (D. Marengo).

1369-8478/$ - see front matter © 2012 Elsevier Ltd. All rights reserved.
http://dx.doi.org/10.1016/j.trf.2012.04.001

normative adult tasks (Bonino, Cattelino, & Ciairano, 2005; Jessor, Donovan, & Costa, 1991); risky driving behaviors have also been found to be enacted by adolescents as a mean to gain popularity within the group of peers (Allen & Brown, 2008; Gardner & Steinberg, 2005) and comply to gender-role expectations (especially for young males, Harré, Field, & Kirkwood, 1996).

In the last decades different types of intervention to increase driving safety have been proposed and carried out, often to unsatisfactory results within the younger cohorts. As discussed in the OECD report (2006), improvements in road safety measures targeted at general population have shown positive effects on young driver risk but ultimately have not been successful in reducing the gap between younger and older drivers' involvement in traffic-related fatalities.

On another side, skill-based training programs targeted at novice drivers have in some cases shown negative effects on drivers' crashing rates, supposedly as a result of an increase of confidence in their ability to manage dangerous traffic situations (Gregersen & Nyberg, 2003; Jones, 1993; Katila, Keskinen, Hatakka, & Laapotti, 2004). Moreover, due to the lack of evaluation studies and methodological heterogeneity (for a review, Engström, Gregersen, Hernetkoski, Keskinen, & Nyberg, 2003; OECD, 2006), school interventions in the form of educational campaigns have often failed to demonstrate direct effects in reducing youngsters' crash involvement and dangerous driving behaviors (McKenna, Yost, Muzenrider, & Young, 2000; Vernick et al., 1999; see also Elder et al. (2005) for a review). Still, according to some authors, lack of effectiveness is also related to a limited concern for individual differences, both in terms of personality and behavioral attitudes (Assailly, 2001; Ulleberg & Rundmo, 2003).

Indeed, several studies have found personality factors to differentiate young drivers in terms of risky driving propensity (Arnett, 1990; Iversen & Rundmo, 2002; Ulleberg & Rundmo, 2003) and accident involvement (Jonah, 1997; Sümer, 2003). As a whole, findings indicate that young drivers do not represent an uniform group.

For most studies, the usual methodological approach has been to focus the analysis on groups of relevant constructs and to test each variable's isolated influence on driving related measures. Sensation seeking, a personality trait which may be described as the desire to engage in stimulating experiences even at the expense of personal safety (Zuckerman, 1979), is one of the constructs which has been most consistently linked to dangerous driving behaviors and crash involvement, especially for what concerns male drivers (Arnett, Offer, & Fine, 1997; Cestac, Paran, & Delhomme, 2011; Dahlen & White, 2006; Jonah, Thiessen, & Au-Yeung, 2001; Zuckerman, 2007). In a similar way, impulsivity, which relates to a lack of perceived self-control in responding to stimuli, has been connected with driving anger, aggressive driving and driving under the influence of alcohol (Dahlen, Martin, Ragan, & Kuhlman, 2005; Deffenbacher, Lynch, Filetti, Dahlen, & Oetting, 2003; Stanford, Greve, Boudreaux, Mathias, & Brumbelow, 1996). Moreover, both sensation seeking and impulsivity have been reported to share a common peak in the years from early to mid-adolescence (Steinberg et al., 2008).

Low scores on altruism, which reflect a general lack of concern for others, have been related to enhanced risk taking while driving (Ulleberg & Rundmo, 2003) and speeding (Machin & Sankey, 2008; Vassallo et al., 2007).

Locus of control, a personality construct which reflects the extent to which people considers events that may affect them to be under their control (internality) or to be influenced by external forces (externality), has been linked to driving behaviors with mixed results. In 1987, Montag and Comrey found externality to increase drivers' likelihood of accident involvement, reportedly as a result of a lack of responsibility toward the driving situation, and internality to characterize people with a more cautious driving style; similar findings have been documented by following studies (Lajunen & Summala, 1995), while others have failed to find direct links with risky driving behaviors (Arthur & Doverspike, 1992; Iversen & Rundmo, 2002). More recent findings, on the other side, have reported associations between internality, self-report measures of accident involvement and violation of traffic laws (Özkan & Lajunen, 2005); concurrently, externality has been shown to favor driving errors and anxious-dissociative driving styles, and to be prevalent in the female group (Holland, Geraghty, & Shah, 2010).

On a related note, studies have also found high levels of anxiety to be related to aggressive driving behaviors, driving lapses, and crash involvement (Dula, Adams, Miesner, & Leonard, 2010; Shahar, 2009). Still, findings indicate that the link between anxiety and driving behavior does not follow a linear relationship (Oltedal & Rundmo, 2006; Ulleberg, 2002).

An alternative approach, shared by a growing number of studies, is to identify subtypes of novice drivers on the basis of patterns of personality and behavioral characteristics; this is generally achieved by means of cluster analysis techniques. Using this approach, Donovan, Umlauf, and Salzberg (1988) described three subtypes of drivers from a sample of young males who had been previously involved in traffic accident. Two of them showed high-risk characteristics: the first one was characterized by impulsivity, sensation seeking and aggressive behavior; the second group was characterized by depressive symptoms and externality.

Following studies generally have focused on gender-balanced samples. Deery and Fildes (1999) identified five subtypes of young novice drivers: two of them, labeled as high-risk drivers, were characterized by high scores on sensation seeking, hostility and involvement in risk driving behaviors; for both, the proportion of males was largely superior than in the other subgroups.

Ulleberg (2001) described six subtypes of novice drivers. Two high-risk subtypes were identified: the most deviant (Cluster 2, 80% males) was characterized by high scores on sensation seeking, low altruism and low anxiety; the other one (Cluster 5) showed a pattern of high scores on aggression, driving anger, and high anxiety. Compared to the other subgroups, both reported higher rates of crash involvement and risky driving behaviors; moreover, this subgroup was found to be the least responsive to a traffic-safety campaign.

More recently, Lucidi and colleagues (2010) have identified three personality subtypes within a sample of Italian novice drivers. One of them was very similar to highest-risk subgroup discussed by Ulleberg (Cluster 2), showing high scores on normlessness, excitement-seeking and driving anger measures, and low scores on anxiety and altruism. Drivers from this subgroup, prevalently males (74.5%), were labeled as ‘‘risky’’: Compared to the other subgroups they had the highest rates of accident involvement, driving errors and violation of traffic laws.

A medium-risk personality subtype was also described: drivers from this subgroup were characterized by high anxiety, hostility and low scores on sensation seeking and altruism. Similarly to ‘‘risky drivers’’, their locus of control was found to be externally oriented. Labeled as ‘‘worried drivers’’, they reported the highest scores on risk perception but also the largest number of lapses while driving.

Similar results have also been recently reported for a sample of young moped riders aged between 14 and 15 (Brandau, Daghofer, Hofmann, & Spitzer, 2011); authors identified four subgroups: one of them, characterized by a personality pattern of high scores on novelty seeking, impulsivity and risk taking, was found to be the most involved in risk driving behaviors and the most frequently injured while riding on the moped.

For most of these studies, driving related measures were mainly obtained by means of self-report questionnaires. The use of driving simulation in this kind of studies is less documented (Deery & Fildes, 1999); still, a feature of simulation which is of special interest in this field of research is the possibility to test young drivers yet to be licensed, thus allowing a direct assessment of driving behaviors otherwise impossible to obtain by means of self-report or observation. Concordance between self-report and simulation measures of driving behaviors is documented (Reimer, D'Ambrosio, Coughlin, Kafrissen, & Biederman, 2006). Moreover, some authors have reported findings which indicate that simulator measures can be predictive of real-world driving outcomes (i.e., de Winter et al., 2009; Lee & Lee, 2005), in some cases to a greater degree than on-road test (Lew & et al., 2005).

The present study is conducted in a sample of Italian adolescents with heterogeneous driving experience. The main aim of this study is to identify subtypes of drivers by using cluster analysis on a set of personality measures shown in literature to be linked with driving behaviors. We measured sensation seeking, impulsivity, altruism, anxiety and locus of control. We chose this set of instruments on the basis of their consistent relations with driving behaviors found by many (previously cited) studies. We expect to find similar patterns of relationship in our study. More extensive measures of personality (e.g., IPIP or BFI) were not employed because of their typically longer administration times and lower consistency of the links with driving behaviors and outcome, as found by several authors (e.g., Dahlen & White, 2006; Jovanović, Lipovac, Stanojević, & Stanojević, 2011).

In order to investigate differences, subtypes are compared on the basis of driving safety and accident involvement on moped simulator, self-report measures of risky driving, helmet use, past riding experience and gender. The assessment of driving behaviors through simulation allows testing of participants on common relevant traffic situations. This was particularly important for this study since we decided to deal with individuals who have limited or absent driving experience; for these individuals self-report measures on their driving habits are clearly inadequate. Thus, the use of simulation was instrumental for the investigation of risk driving profiles at earlier stages of driving experience than those usually documented by studies of this kind.

Methodological strengths and limitations of this approach are elaborated in the conclusive sections, along with implications for future perspectives of research and intervention.

2. Materials and methods

2.1. Participants

The study involved 207 students aged 14–15 years (108 females, 98 males), attending the first of year of high school in North-East area of Italy. Due to special constraint imposed by schools, selection of participants by randomization was not possible. Students' motivation for participation in the research was the opportunity to earn school credits that could be used in their final examination. Formal consent to take part in the research was obtained from both students and their parents. Response rate was 100%. Sample's inclusion criteria were age and the intention to ride a two-wheeled vehicle within the year following the study; participants' meeting of inclusion criteria was investigated with a screening questionnaire. At the time of their recruitment, 46% of the students reported past riding experience on moped prior to their involvement in the study, while 54% of them reported none. As a result, self-report measures about driving behaviors were not collected from participants who did not report past riding experiences.

2.2. The simulator

Students' riding behaviors were tested on the Honda Riding Trainer, a medium-to-low budget simulator for moped and motorcycle riding. The HRT runs from a desktop personal computer and is controlled by motorbike handlebars and pedals that are attached to a lightweight frame. The simulated riding environment consists of twelve full tracks, each including 7–8 hazard scenes, adding up to a total of 95 hazard events; typical hazard scenes included situation in which vehicles suddenly change lanes, as well as traffic jams or pedestrians crossing street without notice. The full testing procedure consisted of three riding sessions for each subject, conducted every 15–20 days. Each session included four tracks, with a small break in the middle of each session. The HRT simulator settings for this study were automatic transmission, small engine size (moped – 50 cc) and day light condition.

All students were tested on each of the twelve tracks; presentation order for the tracks was rendered unique for each student employing a Latin square randomization design (for a more in-depth analysis of the employed design see Vidotto, Bastianelli, Spoto, & Sergey, 2011). Computerized scoring were automatically determined by the simulator software at the end of each track on account of observance of speed limit, safety distance, correct lane position and the involvement in crash events. Score values range from (A), reflecting a perfect performance, (B) violation of driving code, (C) violation of safety distance limits (set at <50 cm); to (D), assigned in case of crash event involvement.

2.2.1. Riding behavior measures

Two measures were extracted from students' performances on simulator:

2.2.1.1. Crash involvement. For each subject, this measure represents the total number of crash occurrences (or score D) as observed in the three riding sessions on the simulator.

2.2.1.2. Safe driving index. This index is a measure of students' driving safety while riding on the simulator. Estimation of the measure was performed on performances' raw scores applying the Many-Facet model (Linacre, 1989), a politomic extension of Rasch dichotomous model for measurement, according to the methodology described by Miceli, Settanni, and Vidotto (2008). Along with Rasch typical conjoint estimation of person ability (e.g., students' ability on the simulator) and items difficulty (e.g., simulator's hazard scenes), the Many-Facet model allows estimation of the effect of different raters on test scores; in this study, this feature was employed to test the influence of track presentation order on the riding performances. Analysis was implemented using the Facets software (Linacre, 2008), and involved two phases. A preliminary estimation of the measures was performed on all the scores; a second run of the estimation procedure was then performed excluding the crash related scores from the analysis ("D" rated events) while anchoring item and track order difficulties at the previously estimated measures. This procedure allowed us to obtain a measure of riding ability statistically independent from crash involvement, while still heuristically related to students' riding performances on the simulator.

2.3. Questionnaire

Prior to any testing, participants were asked to fill a screening questionnaire investigating both socio-demographic characteristics and past riding experience; before each of the driving sessions they were also administered a short questionnaire investigating state-related psycho-physiological disposition to testing; finally students filled a general questionnaire containing state and trait personality measures and driving related behavioral scales. More specifically, the general questionnaire included the following personality measures:

2.3.1. Sensation seeking and impulsivity

These measures were assessed with the Dangerous Thrill Seeking and Impulsivity Thrill Seeking subscales, part of the Sensation Seeking Facets measure from the International Personality Item Pool (Hoyle, Stephenson, Palmgreen, Lorch, & Donohew, 2002); each subscale consists of 10 items in the form of statements regarding respectively the desire to be involved in dangerous activities and the sense of being emotionally out of control or unable to suppress the impulse of engaging in risky behaviors. Each item is structured as five-point Likert scale ranging from (1) "Strongly agree" to (5) "Strongly disagree". Example items for the Sensation Seeking subscale: "I would enjoy being out on a sailboat during a storm"; "Might enjoy a free fall from an airplane"; "I would fear walking in a high-crime part of a city". Example items for the Impulsivity subscale are "I do unexpected things"; "I am unpredictable, people never know what I am going to say"; "I am easily talked into doing silly things".

2.3.2. Driving locus of control

This scale is used to investigate the sense of personal responsibility as related to driving events they may get involved into or witness. Higher scores on this scale reflect a more external orientation of the locus of control, which reflects people's tendency to look at driving related events as result of luck or uncontrollable forces, thus minimizing the importance of drivers' personal contribution as a cause of possible outcomes. This scale is a part of the Cognitive-Behavioral Assessment Protocol (BG Version, Vidotto, Sica, & Baldo, 1995); it includes 12 items in the form of sentence to which participants have to rate their agreement to employing a five-point Likert scale from (1) "Strongly disagree" to (5) "Strongly agree. Example items are: "Expert drivers can do a lot of things to avoid getting involved in a crash"; "Even an expert driver could cause a serious accident"; "Accident-free drivers are just luckier than others".

2.3.3. Altruism

Other-centered personal values were investigated employing a subscale selected from the Personal Values' scale reported in Stattin and Kerr (2001). Principal Component Analysis was performed on the global scale, yielding a four and three factor solutions; the threefold latent structure was accepted as the most appropriate solution, each factor respectively identifying constructs related to other-centered, self-centered and hedonistic personal values; the sub-scale used in this study is comprised of six items underlying the other-centered values factor, each item structured as a five-point Likert scale, ranging from (1) "Not important" to (5) "Extremely important". Example items are: "My family"; "Helping others"; "Working with others for a better society".

2.3.4. Anxiety

This measure represent the average of the scores reported by participants prior to each of the three driving sessions on the State-Trait Anxiety Inventory (STAI-X1; Spielberger, Gorsuch, Lushene, Vagg, & Jacobs, 1983), a primary scale of the Cognitive-Behavioral Assessment Protocol (CBA 2.0). The scale accounts for 10 items each describing an emotional state related to anxiety to which students had to rate their accordance on a four-point Likert scale, ranging from (1) "Not at all" to (2) "Very much". Example items are: "I am tense"; "I feel pleasant"; "I am jittery".

2.3.5. Driving related scales

The following measures were extracted from the "Me and my health" questionnaire (Bonino et al., 2005):

2.3.5.1. Dangerous Driving. Students had to report on this scale about their past driving behaviors. This scale is based of 11 items, each describing a potentially harmful behavior related to driving; two subscales can be extracted: driving under the influence of psychoactive substances (2 items) and violations of traffic laws (9 items). Students had to rate the frequency of behaviors on a four-point scale from (1) "Never" to (4) "Always". Example items are: "Drive after you'd had three or more drinks of wine or cans of beer"; "Drive more than 30 km/h over the speed limit"; "Cut in front of another vehicle at full speed (so you could make a turn)".

2.3.5.2. Helmet use. Students had to rate the frequency of helmet use while riding in the street on their moped on a single item structured as four-point scale ranging from (1) "Every time" to (4) "Never". Variable was dichotomized (constant helmet use was scored as 1; none to seldom use as 0).

2.4. Data analysis

As the first step of data analysis we computed descriptive statistics and reliability (Cronbach's Alpha) for the employed scales, along with Pearson's correlation coefficients among the measures. Prior to cluster analysis, personality scores were standardized to permit direct comparison between scales; multicollinearity diagnostics were also preliminarily performed on the scales: the results allowed all measures to be included in the analysis. Classification of the students in subgroups on the basis of the personality scales was then carried out in two phases. Ward's hierarchical clustering method was initially used to look in the data for appropriate solutions. The chosen solution was then refined running the *K*-means partitional algorithm on the previously estimated cluster centroids in order to generate the final cluster membership configuration.

As a mean of external validation criteria for the personality subgroups, driving related scales and items were tested for differences controlling for cluster membership: analysis of variance was performed with Bonferroni post hoc analysis to test continuous variables, while χ^2-test was carried out for dummy categorical variables. Effect size of the cluster solution on dependent variables was calculated with the η^2 and Cramer's Phi coefficients. Test significance for rejecting the null hypothesis was set at the 0.5 level.

3. Results

3.1. Descriptive statistics and correlations between the scales

Table 1 shows descriptive statistics, intercorrelations and reliability coefficients for the employed measures. For all administered measures the reported Cronbach's Alpha was adequate ($\alpha > .60$). Analysis of correlation coefficients indicated

Table 1
Correlation, descriptive statistics, Cronbach's α of the personality scales and driving related behavioral measures.

		1	2	3	4	5	6	7	8	9	Range	Mean	S.D.	α
1	Anxiety	–									10–28	16.52	3.10	.82
2	Sensation seeking	−.14	–								10–49	23.39	7.79	.82
3	Impulsivity	.01	.67**	–							10–47	24.48	8.51	.89
4	Locus of control externality	.09	.16*	.19**	–						12–60	32.24	5.50	.62
5	Altruism	−.18*	−.12	−.28**	−.14*	–					6–30	23.09	3.42	.70
6	Safe driving (simulator)	.08	−.24**	−.20**	−.23**	.07	–				(−.42)–2.25	.96	.49	
7	Crash involvement (simulator)	.07	.19**	.11	.14**	−.05	−.59**	–			1–33	11.85	4.97	
8	Driving under the influence of substances	−.06	.30**	.22**	−.06	−.04	−.19*	−.12	–		2–8	2.5	1.06	.62
9	Violations of traffic laws	−.09	.40**	.34**	.18*	−.20**	−.19*	−.10	.64**	–	8–32	12.2	4.5	.86

* $p < .05$.
** $p < .001$.

the presence of significant links between personality measures. Sensation seeking and impulsivity showed a strong direct relation; both measures were also positively related to the externality of the locus of control. Altruism, on the other side, was negatively related to externality, impulsivity and anxiety measures.

Significant links between personality and driving related measures were also found. Sensation seeking was significantly correlated with both simulator and self-report driving measures. Impulsivity and externality showed a similar pattern of relations. Altruism was negatively related to self-report driving violations; anxiety, on the other side, was not significantly linked with the driving measures.

Concerning driving measures, significant correlation was found between participants' self-report dangerous driving behaviors and safe driving behaviors on the simulator. Correlations between self-report dangerous driving measures and crash involvement on simulator were not significant. Driving safety on the simulator, on the other side, showed a strong inverse correlation with crash involvement in the simulated environment.

3.2. Defining the cluster solution

The clustering process yielded two suitable configurations of respectively three and four clusters. Solutions were compared on the basis of inspection of the dendrogram tree of cluster hierarchy, the cluster distance coefficients and the pseudo-*F* statistic (for a review, Milligan & Cooper, 1985) reported for each step of the agglomeration schedule; the four cluster solution was found to be numerically more balanced than the three cluster structure, the latter unevenly composed of a large subgroup accounting for half of the sample, with the rest of the students equally distributed in two smaller clusters. Concurrently, analyses of variance for both personality and driving measures (self-report and simulation data) (see Tables 2 and 3) revealed the three clusters configuration to provide a more effectively differentiated grouping of the participants than the four clusters solution, thus leading to rejection of the latter as a non-adequately contrasting description of sample variability for the chosen criteria.

3.3. Personality profiles

Mean scores of the personality measures are presented for each cluster in Fig. 1 in z-standardized form (see also Table 2).

Personality profile for Cluster A was characterized by high scores on anxiety and externality, and low scores on altruism; significant differences on these measures were found between this profile and Cluster C. For Cluster A, scores on sensation seeking and impulsivity were significantly lower than those reported for Cluster B. Cluster A pattern of personality suggests students from this subgroup may feel apprehensive about performing on a new or unfamiliar driving task, while also not fully acknowledge the role of their personal conduct in controlling the riding situation. As a result, for this subgroup riding behaviors on the simulator were expected to be cautious, if not necessarily careful and competent.

Personality profile for Cluster B was characterized by high scores on the sensation seeking and impulsivity measures (over one standard deviation above the sample mean); significant differences with Cluster C were found on all personality measures. Compared to the other clusters, Cluster B scores on the anxiety measure showed an intermediate pattern. No significant differences were observed between this profile and Cluster A on the measures of locus of control and altruism. As whole, personality profile suggests participants from this subgroup to be more open to engage in risky and impulsive behaviors at the expense of both personal and other people's safety. As such, they were expected to show low compliance with traffic regulations and to be more easily involved in road accidents while riding in the simulated environment.

Lastly, the Cluster C subgroup was found to have the highest scores on the altruism scale (half a point of standard deviation over the sample mean) and the lowest scores on impulsivity and anxiety measures; it was also characterized by low scores on the sensation seeking scale and more internal orientation of the locus of control than reported for the other clusters. As previously reported, significant differences between this cluster and Cluster B were found on all measures; compared to the profile for Cluster A, major significant differences were observed on locus of control and anxiety measures. Students from this subgroup are characterized by good emotional adjustment and feelings of concern for other people's needs; compared to the other subgroups, they also appear more aware of their personal contribution in shaping traffic events; overall, they were expected to show high compliance of traffic laws and comparatively low crash rates while driving on the simulator.

Table 2
Cluster differences on personality scales: mean scores and standard deviation.

	Personality subgroups			F	η^2
	Profile A mean (SD) (n = 48)	Profile B mean (SD) (n = 48)	Profile C mean (SD) (n = 83)		
Anxiety	.93 (.90)$^{B**-C**}$	−.06 (.86)$^{A**-C*}$	−.46 (.70)$^{A**-B*}$	46.80**	.34
Locus of control externality	.58 (.82)^{C**}	.24 (1.09)^{C**}	−.50 (.81)$^{A**-B**}$	24.79**	.22
Sensation seeking	−.48 (.64)^{B**}	1.27 (.65)$^{A**-C**}$	−.42 (.70)^{B**}	114.02**	.56
Impulsivity	−.19 (.81)^{B**}	1.16 (.65)$^{A-C**}$	−.50 (.72)^{B**}	83.05**	.49
Altruism	−.22 (.84)^{C**}	−.60 (1.16)^{C**}	.46 (.79)$^{A**-B**}$	22.09**	.20

A–B–C: *Cluster differences significant at .05 level. **Significant at .001 level.

Table 3
Clusters' differences for demographic variables and driving related measures.

	Personality subgroups			χ^2	*Phi*
	Profile A (n = 48)	Profile B (n = 48)	Profile C (n = 83)		
% of the total	26.8%	26.8%	46.4%		
% Females	70.8%^{B*}	43.8%^{A*}	50.6%	7.894*	.21
% Rode a moped in the last 6 months	35.6%^{B*}	68.2%$^{A*-C*}$	42%^{B*}	11.110**	.26
% Always wearing a helmet while riding	14 (93.3%)^{B*}	18 (56.3%)^{A*}	25 (75.8%)	7.413*	.30
	Profile A mean (SD)	Profile B mean (SD)	Profile C mean (SD)	*F*	η^2
Driving under influence of substances	−.33 (.60)^{B**}	.50 (1.42)$^{A**-C**}$	−.09 (.86)^{B**}	8.467**	.09
Violations of traffic laws	−.27 (.85)^{B**}	.71 (1.27)$^{A**-C**}$	−.23 (.70)^{B**}	16.681**	.17
Safe driving (Simulator)	.095 (1.12)^{B*}	−.47 (.88)$^{A*-C*}$	15 (.95)^{B*}	6.62*	.07
Crash involvement (Simulator)	12.08 (5.01)	13.43 (5.65)^{C*}	11.11 (4.56)^{B*}	3.32*	.03

A–B–C: *Cluster differences significant at .05 level. **Significant at .001 level.

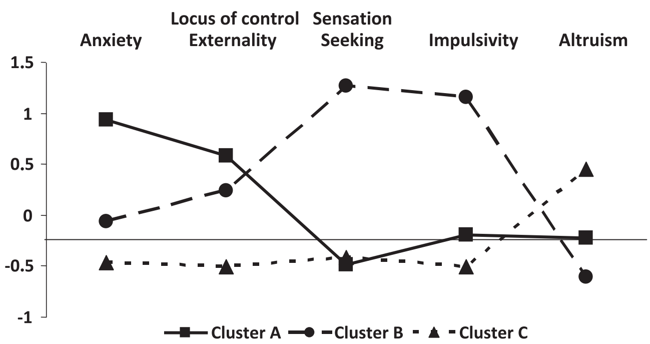

Fig. 1. Clusters' profile plot by personality measures mean scores (*Z*-scores).

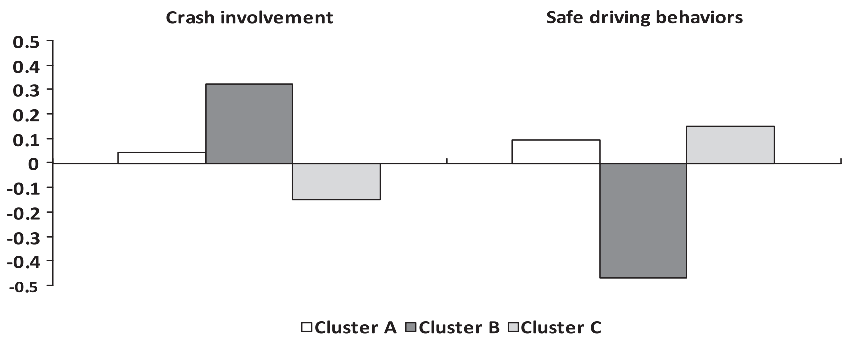

Fig. 2. Clusters' profile plot by simulator driving measures mean scores (*Z*-scores).

3.4. Demographic differences between clusters

Significant differences between clusters were found controlling for gender (see Table 3). A large prevalence of females (70.8%) was found in Cluster A, while Cluster B showed a more limited prevalence of males (56.2%). No difference in gender prevalence was found for the C subgroup.

3.5. Differences for driving related measures

Differences between subgroups were observed both in terms of riding experience and involvement in risk driving behaviors (see Table 3). Compared to other subgroups, Cluster B was characterized by a higher prevalence of experienced riders (68.2%, riding experience during the last 6 month). A large prevalence of inexperienced participants was found in Cluster A (64.4%); a similar but less contrasted situation was observed for Cluster C (58%).

Disparities between subgroups were also found concerning helmet use. Analysis only focused on experienced riders: the large majority of riders from Cluster A (93.3%) reported consistent helmet wearing while riding the moped. Compliance with helmet use was found to be more heterogeneous in Cluster B: almost half of the riders (43.7%) reported none or inconsistent wearing of helmet. Compared to the other subgroups, Cluster C showed an intermediate pattern.

No differences were observed between Cluster A and Cluster C concerning the self-report measures of dangerous driving; concurrently, compared to Cluster B, both subgroups were characterized by significantly lower involvement in dangerous driving behaviors such as driving under the influence of substances and violations of the traffic laws.

Investigation of clusters' differences on the measures extracted from students' performances on the simulator delineated a more contrasted situation (see Fig. 2). Significant discrepancies were observed between Cluster B and the other subgroups in terms of driving safety on the simulator, the former associated to a less cautious driving style than the latter. Cluster A and Cluster C were not found to be significantly different in terms of the overall safety of riding performances.

Cluster B was also characterized by the highest rate of crash involvement during the simulator performances, significantly diverging from Cluster C which in turn reported the lowest crash rate. On the other side, Cluster A was not found to be significantly different from both the other subgroups on this measure.

Additionally, the measures obtained from the moped simulator performances were controlled according to students' riding experience in real life: results (not reported in this study) indicated no differences between experienced and inexperienced students in terms of driving safety and crash involvement.

4. Discussion

The aim of the present study was to identify driver subtypes on the basis of both personality measures and driving behaviors. Relevant data was collected from a sample of adolescents aged 14–15 by means of self-report questionnaires and riding sessions on a moped simulator. The use of simulator measures allowed us to discriminate between driver profiles in a way otherwise impossible with adolescent with none to few driving experiences. Having collected self-report measures from adolescents with prior driving experiences, it was also possible to investigate concordance in the identified cluster between self-report assessment of real-world driving behaviors and direct assessment of their riding behaviors on the simulator.

We found significant negative relations between self-report dangerous driving behaviors and driving safety on the simulator; this is congruent with findings reporting consistency between self-report and simulator data on driving behaviors (Reimer, D'Ambrosio, Coughlin, Kafrissen, & Biederman, 2006). Links between self-report driving behaviors and crash involvement on the simulator, on the other side, were not significant. However, direction of the relations between self-report and simulator data indicated concordance between the measures.

Three subgroups of drivers were identified; each of them was characterized by different personality characteristics and driving risk patterns (profiles A, B, C).

Profile B, which showed the highest risk pattern, was characterized by high sensation seeking, impulsivity, and low scores on altruism and anxiety. It reported the highest rate of crash involvement and showed high-risk propensity both considering self-report and simulator driving measures. Profile B shares a similar pattern of personality measures with the "risky drivers" subtype identified by Lucidi and colleagues (2010) and one of the high-risk clusters described by Ulleberg (2001). The high scores on sensation seeking make it also comparable to the two deviant subgroups of drivers identified by Deery and Fildes (1999) and the Type 4 cluster reported by Brandau and colleagues (2011). Compared to the clusters described in these studies, however, the prevalence of males in profile B was decidedly less pronounced. Similarly to the high-risk subtype described by Lucidi and colleagues, we found experienced drivers to be over-represented in profile B; differences between clusters in terms of past driving experiences have also been reported by Ulleberg (2001). It is possible that some of the studied personality traits are linked in adolescence with more precocious driving experiences (e.g., individuals with higher levels on sensation seeking and impulsivity, due to a general risk-taking disposition, could be more prone to early driving). Drivers with this profile show a general lack of concern for both other people's well being and their personal safety and a peculiar openness to dangerous activities; as such, they are at great risk while riding in the streets.

Profile A was characterized by high scores on anxiety and externality and low scores on sensation seeking. While generally showing cautious driving behaviors, drivers from this profile did not differ from the high-risk subgroup (profile B) in terms of crash involvement on the simulator. Profile A shares key characteristics with the "worried drivers" subtype described by Lucidi and colleagues, as well as a similar medium-risk driving pattern; it can also be compared to one of the low-risk clusters reported in Ulleberg's study: both shares low sensation seeking and high anxiety scores, but differ on the altruism measure, which in profile A is substantially lower. This could be related to cultural differences between the samples. Similarly to the subtypes discussed in both these studies, females were largely prevalent in this subgroup. This is consistent with findings documenting a larger proportion of females in groups of drivers characterized by high anxiety scores (Lucidi et al., 2010; Ulleberg, 2001). Moreover, the discrepancy we observed for profile A between the driving simulator measures suggests that the influence of anxiety on driving could be multifaceted. Indeed, findings indicate that anxious drivers are more likely to drive cautiously and comply with speed limits (Stephens & Groeger, 2009), probably as a result of a lack of confidence about their driving ability. At the same time, due to their poor emotional adjustment, it is plausible that they could be also more exposed to collisions caused by driving errors and/or lapses of attention.

Profile C, which characterized the majority of participants, can be considered at low risk for crashes. Drivers in this subgroup showed altruistic personal values, internality and low scores on sensation seeking and impulsivity. Participant from this subgroup were characterized by safe driving behaviors and the lowest rate of crash involvement on the simulator. As a whole, these findings are congruent with previous studies for what concerns the protective role of both altruistic values and low sensation seeking against youngsters' risk driving behaviors (Machin & Sankey, 2008).

The role of locus of control in our study was less clearly defined: high externality characterized both profile B and A, which in turn reported opposite safety measures on the simulator (but similarly frequent collision rates). Recent findings suggest that the relationship between locus of control and driving behaviors could be mediated by anxiety and driving experience, and to be gender related (Holland et al., 2010). Differences of gender prevalence and overall riding experience between the profiles could partially account for these contrasting results.

Compared to other studies (Brandau et al., 2011; Ulleberg, 2001), we identified a more limited number of clusters; this could be related to the employment of a smaller set of personality measures. Still, this strategy provided an adequate differentiation between profiles. The partial congruence of our findings with previous studies focusing on older and more experienced samples of drivers supports the hypothesis of the presence of stable between drivers' subtypes across adolescence and young adulthood (Lucidi et al., 2010; Ulleberg, 2001). Our findings suggest that such differences could already be present in adolescence at early stages of driving practice, in particular for what concern the presence of a high-risk group characterized by high level of sensation seeking; comparable findings have been recently documented for similarly aged adolescents by Brandau and colleagues (2011).

This study has several strengths. Firstly, a set of personality measures largely shared with the literature on driving behaviors. Secondly, and in contrast with the large majority of studies of this kind, analysis focused on direct measurement of driving behaviors. Lastly, our study focused on a sample of students in transition from early to mid-adolescence, a developmental stage rarely investigated in the study of the antecedents of high-risk driving behaviors.

The chosen approach nonetheless has several limitations. One is related to the sample, which is not representative of the general population. A significant issue regarding the sample is related also to the inclusion of adolescents without prior driving experiences; as previously stated, the study of concordance between simulation data with self-reported driving behaviors was not possible for these individuals. Another limitation is related to the driving related data collected in our study by means of simulation and self-reports, which did not allow us to finely distinguish between different facets of driving failures like violations, errors and lapses, as reported in the Driving Behavior Questionnaire by Reason, Manstead, Stradling, Baxter, and Campbell (1990). Another limitation lies in the choice to use a limited number of relevant personality indicators. This strategy led to shorter administration time, but it negatively affected the possibility to compare our results with other studies.

5. Conclusions

Focusing on a sample of early adolescents, this study identified different subtypes of drivers on the basis of personality and driving related measures. Comparison with studies on older samples suggests these subtypes to be stable in time. In order to shed light on this process, further researches are needed to empirically evaluate the stability of risk subtypes in a longitudinal framework from adolescence to adulthood.

Our study can have relevant implications for the development of prevention programs for risky driving in adolescence. In particular, we propose a way to identify potentially risky drivers on the basis of a limited number of personality measures; the discussed method represents an economical and low time-consuming screening instrument that could be helpful for the development and implementation of risk prevention and safety programs targeted at the individual level.

Findings in our study also support the validity of simulation for the assessment of driving behaviors. Simulation could be especially useful in the context of driving school practice for early identification of trainees with potentially risky driving patterns and collection of relevant information for individual training.

In this light, a more precise operationalization of driving failures in the light of the DBQ model could represent an interesting perspective for the development of new techniques of simulation-based assessment.

Acknowledgements

The data employed in this study has been collected as part of a Research Project supported by Honda Motor Europe. The authors would like to thank Mariana Peruzzo for her help.

References

Allen, J. P., & Brown, B. B. (2008). Adolescents, peers, and motor vehicles: The perfect storm? *American Journal of Preventive Medicine, 35*, 289–293.

Arnett, J. (1990). Drunk driving, sensation seeking, and egocentrism among adolescents. *Personality and Individual Differences, 11*(6), 541–546.

Arnett, J. J., Offer, D., & Fine, M. A. (1997). Reckless driving in adolescence. 'State' and 'trait' factors. *Accident Analysis and Prevention, 29*(1), 57–63.

Arthur, W., Jr., & Doverspike, D. (1992). Locus of control and auditory selective attention as predictors of driving accident involvement: A comparative longitudinal investigation. *Journal of Safety Research, 23*, 73–80.

Assailly, J. -P. (2001).*La mortalité chez les jeunes (Mortality among teenagers) Que sais-je?* P.U.F., Paris.

Bonino, S., Cattelino, E., & Ciairano, S. (2005). *Adolescents and risk, Behaviors, functions and protective factors*. New York: Springer Verlag.

Brandau, H., Daghofer, F., Hofmann, M., & Spitzer, P. (2011). Personality subtypes of young moped drivers, their relationship to risk-taking behavior and involvement in road crashes in an Austrian sample. *Accident Analysis and Prevention, 43*(5), 1713–1719.

Brown, I. D., & Groeger, J. A. (1988). Risk perception and decision taking during the transition between novice and experienced driver status. *Ergonomics, 31*(4), 585–597.

Cestac, J., Paran, F., & Delhomme, P. (2011). Young Drivers' Sensation Seeking, Subjective Norms, and Perceived Behavioral Control and their Roles in Predicting Speeding Intention: How Risk-Taking Motivations Evolve with Gender and Driving Experience. *Safety science, 49*, 424–432.

Dahlen, E. R., Martin, R. C., Ragan, K., & Kuhlman, M. M. (2005). Driving anger, sensation seeking, impulsiveness, and boredom proneness in the prediction of unsafe driving. *Accident Analysis and Prevention, 37*(2), 341–348.

Dahlen, E. R., & White, R. P. (2006). The Big Five factors, sensation seeking, and driving anger in the prediction of unsafe driving. *Personality and Individual Differences, 41*, 903–915.

de Winter, J. C., de Groot, S., Mulder, M., Wieringa, P. A., Dankelman, J., & Mulder, J. A. (2009). Relationships between driving simulator performance and driving test results. *Ergonomics, 52*, 137–153.

Deery, H. A., & Fildes, B. N. (1999). Young novice driver subtypes: Relationship to high risk behavior, traffic accident record, and simulator driving performance. *Human Factors, 41*, 628–643.

Deffenbacher, J. L., Lynch, R. S., Filetti, L. B., Dahlen, E. R., & Oetting, E. R. (2003). Anger, aggression, risky behavior, and crash-related outcomes in three groups of drivers. *Behaviour Research and Therapy, 41*, 333–349.

Donovan, D. M., Umlauf, R. L., & Salzberg, P. M. (1988). Derivation of personality subtypes among high-risk drivers. *Alcohol, Drugs & Driving, 4*(3–4), 233–244.

Dula, C. S., Adams, C. L., Miesner, M. T., & Leonard, R. L. (2010). Examining relationships between anxiety and dangerous driving. *Accident Analysis and Prevention, 42*(6), 2050–2056.

Elder, R. W., Nichols, J. L., Shults, R. A., Sleet, D. A., Barrios, L. C., & Compton, R. (2005). Effectiveness of school-based programs for reducing drinking and driving and riding with drinking drivers: A systematic re-view. *American Journal of Preventive Medicine, 28*(Suppl. 5), 288–304.

Engström, I., Gregersen, N. P., Hernetkoski, K., Keskinen, E., & Nyberg, A. (2003). *Young novice drivers, driver education and training: Literature review*. Linköping: Swedish National Road and Transport Research Institute.

European Road Safety Observatory (ERSO) (2010). *Traffic safety basic facts*. <http://ec.europa.eu/transport/road_safety/pdf/statistics/dacota/bfs2010_dacota-ifsttar-1-3-youngsters.pdf>.

Fondazione ANIA (2011). *L'incidentalità stradale dei giovani*. <http://www.fondazioneania.it/fondazione/fondazione/export/sites/default/documenti/79f0f9d8-e2d2-11e0-8e61-f3c446ddba06___Lxincidentalitx_stradale_dei_giovani.pdf>.

Gardner, M., & Steinberg, L. (2005). Peer influence on risk taking, risk preference, and risky decision making in adolescence and adulthood: An experimental study. *Developmental Psychology, 41*, 625–635.

Gregersen, N. P. (1996). Young drivers' overestimation of their own skill – An experiment on the relation between training strategy and skill. *Accident Analysis and Prevention, 28*(2), 243–250.

Gregersen, N. P., & Nyberg, A. (2003). Phase 2 in the Norwegian driver education: Effect on the accident risk. In M. Hatakka, E. Keskinen, C. Baughan, C. Goldenbeld, N. P. Gregersen, & H. Groot, et al. (Eds.), *Basic driver training: New models* (pp. 73–76). Turku, Finland: University of Turku.

Harré, N., Field, J., & Kirkwood, B. (1996). Gender differences and areas of common concern in the driving behaviours and attitudes of adolescents. *Journal of Safety Research, 27*(3), 163–173.

Holland, C., Geraghty, J., & Shah, K. (2010). Differential moderating effect of locus of control on effect of driving experience in young male and female drivers. *Personality and Individual Differences, 48*, 821–826.

Horswill, M. S., Waylen, A. E., & Tofield, M. I. (2002). Drivers' illusion of superiority for hazard perception and vehicle control skill. In S. Marçal (Ed.), *Behavioural research in road safety: Twelfth seminar*. London: Department for Transport.

Hoyle, R. H., Stephenson, M. T., Palmgreen, P., Lorch, E. P., & Donohew, R. L. (2002). Reliability and validity of a brief measure of sensation seeking. *Personality and Individual Differences, 32*, 401–414.

ISTAT, 2010. National Institute of Statistics (ISTAT) (2009). Statistica *degli incidenti stradali. Anno 2009. Traffic accidents statistics year 2009.* ISTAT, Rome, Italy. <http://www.istat.it/it/files/2011/01/testointegrale20101117.pdf?title=Incidenti+stradali++17%2Fnov%2F2010++testointegrale20101117.pdf>.

Iversen, H., & Rundmo, T. (2002). Personality, risky driving, and accident involvement among Norwegian drivers. *Personality and Individual Differences, 33*, 1251–1263.

Jessor, R., Donovan, J. E., & Costa, F. M. (1991). *Beyond adolescence: Problem behavior and young adult development*. New York: Cambridge University Press.

Jonah, B. A. (1997). Sensation seeking and risky driving: A review and synthesis of the literature. *Accident Analysis and Prevention, 29*(5), 651–665.

Jonah, B. A., Thiessen, R., & Au-Yeung, E. (2001). Sensation seeking, risky driving and behavioral adaptation. *Accident Analysis and Prevention, 33*(5), 679–684.

Jones, B. (1993). *The effectiveness of skid-car training for teenage novice drivers in Oregon*. Salem, Oregon: Driver and Motor Vehicle Services.

Jovanović, D., Lipovac, K., Stanojević, P., & Stanojević, D. (2011). The effects of personality traits on driving-related anger and aggressive behaviour in traffic among Serbian drivers. *Transportation Research Part F, 14*, 43–53.

Katila, A., Keskinen, E., Hatakka, M., & Laapotti, S. (2004). Does increased confidence among novice drivers imply a decrease in safety? The effects of skid training on slippery road accidents. *Accident Analysis and Prevention, 36*(4), 543–550.

Lajunen, T., & Summala, H. (1995). Driving experience, personality, and skill and safety motive dimensions in drivers' self-assessments. *Personality and Individual Differences, 3*, 307–318.

Lee, H. C., & Lee, A. H. (2005). Identifying older drivers at risk of traffic violations by using a driving simulator: A 3-year longitudinal study. *American Journal of Occupational Therapy, 59*, 97–100.

Lew, H. L. et al (2005). Predictive validity of driving simulator assessments following traumatic brain injury: A preliminary study. *Brain Injury, 19*, 177–188.

Linacre, J. M. (1989). *Many-facet Rasch measurement*. Chicago: MESA Press.

Linacre, J. M. (2008). *FACETS version 3.66.2*.

Liu, C. C., Hosking, S. G., & Lenné, M. G. (2009). Hazard perception abilities of experienced and novice motorcyclists: An interactive simulator experiment. *Transportation Research Part F, 12*(4), 325–334.

Lucidi, F., Giannini, A. M., Sgalla, R., Mallia, L., Devoto, A., & Reichmann, S. (2010). Young novice driver subtypes: Relationship to driving violations, errors and lapses. *Accident Analysis and Prevention, 42*(6), 1689–1696.

Machin, M. A., & Sankey, K. S. (2008). Relationships between young drivers' personality characteristics, risk perceptions, and driving behaviour. *Accident Analysis and Prevention, 40*(2), 541–547.

McKenna, C. K., Yost, B., Muzenrider, R. F., & Young, M. L. (2000). *Program evaluation of Pennsylvania's driver education program*. Harrisburg, PA: Pennsylvania Department of Transportation.

Miceli, R., Settanni, M., & Vidotto, G. (2008). Measuring change in training programs: An empirical illustration. *Psychology Science, 50*(3), 433–447.

Milligan, G. W., & Cooper, M. C. (1985). An examination of procedures for determining the number of clusters in a data set. *Psychometrika, 50*, 159–179.

Montag, I., & Comrey, A. L. (1987). Internality and externality as correlates of involvement in fatal driving accidents. *Journal of Applied Psychology, 72*, 339–343.

Oltedal, S., & Rundmo, T. (2006). The effects of personality and gender on risky driving behaviour and accident involvement. *Safety Science, 44*(7), 621–628.

Organisation for Economic Co-operation and Development (OECD) (2006). *Young. Drivers: The road to safety*. Paris, France: OECD Publishing. <http://www.internationaltransportforum.org/Pub/pdf/06YoungDrivers.pdf>.

Özkan, T., & Lajunen, T. (2005). Multidimensional traffic locus of control scale (T-LOC): Factor structure and relationship to risky driving. *Personality and Individual Differences, 38*(3), 533–545.

Reason, J., Manstead, A., Stradling, S., Baxter, J., & Campbell, K. (1990). Errors and violations on the roads: A real distinction? *Ergonomics, 33*, 1315–1332.

Reimer, B., D'Ambrosio, L., Coughlin, J., Kafrissen, M., & Biederman, J. (2006). Using self-reported data to assess the validity of driving simulation data. *Behavior Research Methods, 38*(2), 314–324.

Shahar, A. (2009). Self-reported driving behaviors as a function of trait anxiety. *Accident Analysis and Prevention, 41*(2), 241–245.

Spielberger, C. D., Gorsuch, R. L., Lushene, P. R., Vagg, P. R., & Jacobs, A. G. (1983). *Manual for the state-trait anxiety inventory (Form Y)*. Palo Alto: Consulting Psychologists Press, Inc.

Stanford, M. S., Greve, K. W., Boudreaux, J. K., Mathias, C. W., & Brumbelow, J. L. (1996). Impulsiveness and risk-taking behavior: Comparison of high-school and college students using the Barratt Impulsiveness Scale. *Personality and Individual Differences, 21*(6), 1073–1075.

Stattin, H., & Kerr, M. (2001). Adolescents' values matter. In J. Nurmi (Ed.), *Navigating through adolescence: European perspectives*. London: Routledge Falmer.

Steinberg, L., Albert, D., Cauffman, E., Banich, M., Graham, S., & Woolard, J. L. (2008). Age differences in sensation seeking and impulsivity as indexed by behavior and self-report: Evidence for a dual-systems model. *Developmental Psychology, 44*, 1764–1778.

Stephens, A. N., & Groeger, J. A. (2009). Situational specificity of trait influences on drivers' appraisals and driving behaviour. *Transportation Research Part F, 12*, 29–39.

Sümer, N. (2003). Personality and behavioral predictors of traffic accidents: Testing a contextual mediated model. *Accident Analysis and Prevention, 35*(6), 949–964.

Ulleberg, P. (2001). Personality subtypes of young drivers. Relationship to risk-taking preferences, accident involvement and response to a traffic safety campaign. *Transportation Research Part F, 4*, 279–297.

Ulleberg, P. (2002). Influencing subgroups of young drivers and their passengers. Motivational influences of personality traits on risk-taking attitudes and driving behaviour. Doctor dissertation. Trondheim, Norges teknisk-naturvitenskapelige universitet, 2002.

Ulleberg, P., & Rundmo, T. (2003). Personality, attitudes and risk perception as predictors of risky driving behaviour among young drivers. *Safety Science, 41*(5), 427–443.

Vassallo, S., Smart, D., Sanson, A., Harrison, W., Harris, A., Cockfield, S., et al (2007). Risky driving among young Australian drivers: Trends, precursors and correlates. *Accident Analysis and Prevention, 39*(3), 444–458.

Vernick, J. S., Li, G., Ogaitis, S., MacKenzie, E. J., Baker, S. P., & Gielen, A. C. (1999). Effects of high school driver education on motor vehicle crashes, violations, and licensure. *American Journal of Preventive Medicine, 16*(Suppl. 1), 40–46.

Vidotto, G., Bastianelli, A., Spoto, A., & Sergey, F. (2011). Enhancing hazard avoidance in teen-novice riders. *Accident Analysis and Prevention, 43*(1), 247–252.

Vidotto, G., Sica, C., & Baldo, S. (1995). Vie di sviluppo e nuovi strumenti psicologici per l'individuazione di soggetti a rischio. In: L. Manfredi, L. Salvatico. *Qualità della vita e sviluppo delle risorse umane nelle forze armate* (pp. 53–70), TORINO, UPSEL.

Zuckerman, M. (1979). *Sensation seeking: Beyond the optimal level of arousal*. Hillsdale, NJ: Lawrence Erlbaum.

Zuckerman, M. (2007). *Sensation seeking and risky behavior*. Washington, DC: American Psychology Association.