Measuring Individual Differences in Driver Inattention: Further Validation of the Attention-Related Driving Errors Scale

Rubén Daniel Ledesma, **Silvana Andrea Montes**, and **Fernando Martín Poó**, Consejo Nacional de Investigaciones Científicas y Técnicas (CONICET)–Universidad Nacional de Mar del Plata, Buenos Aires, Argentina, and **María Fernanda López-Ramón**, Universidad de Zaragoza, Zaragoza, Spain

Objective: The aim of this research was (a) to study driver inattention as a trait-like variable and (b) to provide new evidence of validity for the Attention-Related Driving Errors Scale (ARDES).

Background: Driving inattention is approached from an individual differences perspective. We are interested in how drivers vary in their propensity to experience failures of attention and in the methods to measure these differences.

Method: In a first sample (n = 301), we tested, via confirmatory factor analysis, a new theoretical model for the ARDES. In a second sample (n = 201), we evaluated the relationship between inattention and internal and external sources of distraction and social desirability bias in ARDES responses. A subsample (n = 65) was reevaluated to study temporal stability of the ARDES scores.

Results: Errors measured by the ARDES can be classified according to the driving task level at which they occur (navigation, maneuvering, or control). Differences in ARDES scores based on collision history were observed. ARDES was related to internal sources of distraction and was independent of the level of exposure to distracting activities. Test-retest showed a high degree of stability in ARDES scores. Low correlations were found with a social desirability measure.

Conclusion: ARDES appears to measure a personal trait that remains relatively stable over time and is relatively independent of distracting activities. New evidence of validity emerged for this self-report.

Application: ARDES can be used to measure individual differences in driving inattention and to help tailor preventive interventions for inattentive drivers. It can serve as an instrument of driver self-assessment in educational and training contexts.

Keywords: road safety, driving, driver inattention, measurement, social desirability, temporal stability, personality traits

Address correspondence to Rubén Daniel Ledesma, CONICET–Universidad Nacional de Mar del Plata, Río Negro 3922, Mar del Plata (7600), Argentina; e-mail: rdledesma@conicet.gov.ar.

HUMAN FACTORS
Vol. 57, No. 2, March 2015, pp. 193–207
DOI: 10.1177/0018720814546530

INTRODUCTION

Driver inattention and distraction are the primary causes of motor vehicle collisions and incidents (Dingus et al., 2006; Klauer, Dingus, Neale, Sudweeks, & Ramsey, 2006); consequently, these phenomena have received much attention in the specialized literature, although in a fragmented manner and in the absence of a unifying theoretical focus and definitions. Regan, Hallet, and Gordon (2011), following a detailed analysis of definitions and taxonomies, concluded that driving inattention means "insufficient, or no attention, to activities critical for safe driving" (p. 1780). The authors also propose driving inattention subtypes; one such subtype is "distractions" (driver diverted attention, according to their taxonomy), in which inattention is due to the presence of another activity that competes for the driver's attention (e.g., speaking on a cell phone).

Generally, research on driving inattention has focused mainly on distractions and, in particular, on the effect of certain activities or sources of distraction, such as communication and driver-assistance technologies (Martens & Brouwer, 2013). Other aspects of the problem have received less attention. For example, the personal factors that may moderate driving inattention or predispose one to it have gone relatively unstudied. These factors include personality and cognitive variables that may be associated with greater inattention (e.g., boredom proneness), "internal" sources of distraction (e.g., daydreaming), and the individual's manner of managing distractions (e.g., choosing when to engage in distracting tasks and implementing mechanisms to compensate for the effect of distractions). Ledesma, Montes, Poó, and López-Ramón (2010) emphasized the need to study some of the factors related to these phenomena and developed the Attention-Related Driving Errors Scale (ARDES), a self-reporting instrument that evaluates individual differences in the frequency with which errors related to a lack of attention while driving are experienced. It is believed that a measure of this kind could help further research on the personal factors linked to driving inattention as well as the interaction of those factors with other factors (environmental, situational, etc.). It could also serve as an interesting complement in experimental studies on distraction (e.g., research on the distraction potential of in-vehicle devices). In such instances, the ARDES could be included as a covariate to control for individual differences and to increase the statistical power of the study's design.

Individual Differences in Driving Inattention: Theoretical Basis of the ARDES

In a previous work (Ledesma et al., 2010), we focused on driver inattention from the perspective of individual differences, as a trait-like variable (alluding to the concept of *personality trait*). We were interested, therefore, in driving inattention as a tendency or personal propensity of drivers to experience attentional lapses. It is assumed that this tendency can vary from driver to driver, is relatively stable in any one driver, and operates with relative independence from environmental and situational factors. Below, we define in greater detail how driving inattention is understood from this perspective.

As authors of the ARDES, we started with the assumption that attentional errors while driving are present in all human operators due to a variety of personal and environmental factors or a combination of them. However, we suggested that there exist *interindividual differences* in terms of the frequency with which these failures are experienced. In other words, although all drivers have attention-related errors at some point, some are more inclined to experience them than others. As a trait-like variable, we assume that this disposition tends to be consistent and stable for any single individual. In the case of the ARDES, although its items evaluate the presence of errors in very diverse situations, the evidence suggests there is a common underlying factor in all items (indicators) and a high degree of internal consistency in the scores (Ledesma et al., 2010; Roca, Padilla, López-Ramón, & Castro, 2013). This evidence allows us to suppose that the ARDES does in fact evaluate an individual characteristic of a driver that is consistent across situations and contexts.

Obviously, the frequency with which attentional errors while driving are experienced could be explained by the level of personal exposure to activities or potentially distracting sources, whether external or internal. We are inclined to believe that ARDES scores are mainly related to a driver's personal and internal factors, which configure a more or less "inattentive" style of driving. Additionally, we believe that greater or lesser exposure to potentially distracting "external" activities (e.g., frequency of cell phone use) is not necessarily associated with ARDES scores. Prior results indicated that the ARDES is strongly associated with measures of attentional functioning, including measures of attention-related errors in everyday life (Cheyne, Carriere, & Smilek, 2006), present event awareness and attention (Brown & Ryan, 2003), and dissociative personality traits (Bernstein & Putnam, 1986). Further, in a study that combined the evaluation of performance using the Attention Network Test for Interactions experimental paradigm and the ARDES, it was found that drivers with higher ARDES scores had less processing speed and less preparation to attend to high-priority signals (López-Ramón, Castro, Roca, Ledesma, & Lupiañez, 2011). To sum up, it seems evident that there exist individual variables of personality and cognitive functioning that play an important role in driving inattention, at least as evaluated by the ARDES.

Another underlying assumption of the ARDES is that the personal tendency to experience attentional errors can manifest itself at all levels of the driving task, from the most automatized to those that require greater attentional control. One type of error is found at the *operational or control* level (Michon, 1985), the lowest-level driving task, which involves the execution of basic actions, such as steering, braking, and handling other automobile controls. Examples of ARDES items in this group include "I signal a move but unintentionally make another" and "I unintentionally shift gears incorrectly or shift to the wrong gear." They basically imply coordination between perception and motor actions and show basic errors in skill-based behavior (Rasmussen, 1986) that form part of the automatic and effortless routine of operating a vehicle.

Additionally, a propensity toward driving inattention can manifest itself in performance errors at the *tactical or maneuvering level* (Michon, 1985). Examples of ARDES items at this level include "At a street corner, I fail to realize that a pedestrian is crossing the street" and "I fail to realize that the vehicle right in front of me has slowed down, and I have to brake abruptly to avoid a crash." This level is more environmental/data driven, implies controlled processing, and includes driving behaviors such as changing lanes and crossing an intersection. They generally involve rule-based behaviors (Rasmussen, 1986), which imply the automatic activation of rules or response patterns in traffic situations. Obviously, errors at this level can have more drastic consequences on safe driving performance and increase the probability of motor vehicle collisions.

Last, a tendency toward driving inattention may be manifested by errors at the strategic or *navigation level*, which is the top-level driving task and deals with processes such as route planning and maintenance (Michon, 1985). An example of an ARDES item at this level is "When driving somewhere, I make more turns that I have to." Except when driving along a routine trajectory, these tasks imply problem solving (e.g., trip planning and achievement of goals), controlled processing, and knowledge-based behaviors (Rasmussen, 1986).

Another important assumption in the construction of ARDES is that individual differences in driving inattention can be measured reliably with a self-reporting instrument. This is an important methodological assumption that is, to some extent, open to debate. On the one hand, various authors point to the advantages of self-reporting methods in traffic research, including their low cost and ability to evaluate driving behaviors, that are difficult to study with other methods (e.g., Lajunen & Summala, 2003). Others, conversely, warn about the limitations and possible validity issues of self-reporting instruments (e.g., af Wahlberg, 2010). One arguable factor is the degree of convergence between self-reporting and other "objective" sources of information, such as motor vehicle collision data (Arthur et al., 2001; Boufous et al., 2010; Marottoli, Cooney, & Tinetti, 1997; McGwin, Owsley, & Ball, 1998). Given that the validity of self-reporting is a controversial issue, it is important to carefully study its properties and compile evidence of validity through various means. In terms of the ARDES, some evidence is available of its convergent validity with objective methods of attentional performance (López-Ramón et al., 2011), and there are also studies that replicate the questionnaire's psychometric properties in other cultures (Roca et al., 2013).

Justification, Objectives, and Hypothesis

Although evidence of validity for ARDES has been reported, it remains a novel instrument and further research to assess its psychometric qualities is needed. One area for further study is its internal structure. ARDES measures driver inattention as a one-dimensional construct by assuming that all items are indicators of a single factor. This one-dimensional assumption was supported by an exploratory factor analysis (EFA) that revealed a factor structure consisting of a single dimension. Measurement models derived from an EFA, however, are descriptive in nature. Therefore, alternative statistical analyses are needed to confirm these results. The first objective of this study was to compare the original one-dimensional model with an alternative measurement model. In the new alternative model, ARDES items are grouped in three dimensions according to the level of the driving task in which they occur: *navigation, maneuvering,* and *control* (Michon, 1985). Thus, the new measurement model supposes three latent and interrelated variables that explain responses to ARDES items. As part of this first aim, we also analyze the relationship between the three factors and the drivers' self-reporting of motor vehicle collisions and traffic tickets for traffic violations. We hypothesized that subjects who report traffic collisions and tickets will score higher on the three ARDES factors. We also predict higher effect sizes for the maneuvering factor because it involves errors with more catastrophic immediate consequences (e.g., failure to see a pedestrian or to notice a vehicle braking ahead).

Another important aspect that was not analyzed in the original ARDES validation study is ARDES's degree of independence from external sources of inattention. No ARDES study conducted thus far has tracked an important variable: the subjects' varying levels of exposure to distracting activities while driving. Clearly, a high score could be the result of a driver's engagement in or exposure to a number of distractor activities rather than a personal proneness to commit errors. Therefore, a second objective of this study was to determine if the errors assessed by ARDES could be the result of exposure to distracting activities rather than a personal disposition, as originally hypothesized. To determine this, we administered the Dissociative Experiences Scale–Modified Version (DES-M; Montes, Ledesma, & Poó, 2011) to measure internal sources of inattention (e.g., psychological abstraction) and an ad hoc index of distracting activities (IDA) to measure external sources of distractions (e.g., speaking on a cell phone or eating while driving). The phenomena evaluated with the DES-M indicated a personal disposition to experience internally motivated distracting psychological processes. This is a widely used measure with significant evidence of validity (see, for example, Carlson & Putnam, 1993). We expected that ARDES scores would be better predicted by DES-M scores rather than IDA scores.

Another unknown aspect of ARDES that is fundamental to its validity is its temporal stability. Assuming that ARDES provides a relatively consistent measure of personal propensity, it is reasonable to expect scores to remain stable over time. Thus, the third objective of this study was to analyze the test-retest correlation following a 6-month period. Our hypothesis was that there would be a strong positive correlation and an absence of significant differences between mean scores across time.

Last, as a self-reporting instrument, the ARDES is vulnerable to different response styles and biases, such as social desirability. Previous studies do not address this possibility. Thus, the fourth objective of this study was to assess ARDES responses for the possible effects of social desirability bias. Following the example of Lajunen, Corry, Summala, and Hartley (1997), we evaluated the two basic dimensions of social desirability in drivers: impression management (IM) and self-deception (SD). According to Lajunen and Summala (2003), "Impression Management refers to the deliberate tendency to give favourable self-descriptions to others and therefore comes close to lying and falsification. Self-deception can be defined as a positively biased but subjectively honest self-description" (p. 98). In psychometric terms, the key is to check for IM, which constitutes deliberate bias (Lajunen & Summala, 2003). On the basis of previous research (Poó, Ledesma, & Montes, 2010), we expected a low to moderate correlation with SD and a low to no correlation with IM.

METHOD

Participants

Sample 1. First, we reanalyzed data from the original ARDES validation study (Ledesma et al., 2010). The sample consists of 301 drivers drawn from the general population of the city of Mar del Plata, Argentina. Participants completed the survey using paper and pencil. The following inclusion criteria were used: (a) must be at least 18 years of age, (b) must have a valid driver's license, and (c) must have reported driving at least once a week during the past 3 months. The age of the subjects ranged from 18 to 79 (M = 38, SD = 13.6); 39% were in the 18-to-30 age group, 46% were in the 31-to-55 age group, and 15% were above 55 years of age. Women accounted for 48.8% of the sample. Most participants drove regularly (70.6% almost every day; 20.4% some days of the week). On average, prior driving experience amounted to 18 years (SD = 13.5). Most participants (86%) had at least completed high school. No financial compensation was offered for taking part in the study. This sample was used to specify and test the new measurement model and to analyze the relationships with self-reported car crashes (first research objective).

Sample 2. In a second moment, we validated the three-factor model with an independent replication sample that consists of 201 drivers, all residents of the city of Mar del Plata, Argentina. This new sample also provided the data for the remaining research objectives. Participants were recruited to participate via e-mail. A series of personal invitations were sent, followed by a snowball sampling strategy whereby e-mail recipients suggested other potential participants. Participants were invited to complete the ARDES instrument through a website in which they were briefly informed of the type of research that was being conducted and the specific purpose of the collected data. The response format was the same as that of the paper-and-pencil version of the instrument. The age of the drivers ranged from 19 to 64 ($M = 38$, $SD = 12$). Women accounted for 52.8% of the sample. Most participants drove regularly (68.8% almost everyday), and prior driving experience amounted to 14 years ($SD = 11$). Most participants (91%) had at least completed high school. No financial compensation was offered for taking part in the study.

A subsample of $n = 65$ extracted from the replication sample was used to analyze the stability of the scores across time. Age range was 20 to 62 years of age ($M = 34.12$, $SD = 10.57$). The sample had slightly more females (55%) than males. Most participants drove almost daily (72%). Most participants (97%) had an education level of at least high school.

Measures

ARDES. This self-reporting instrument is composed of 19 items that relate to driving errors caused entirely or in part by attentional failures (see Table 1). Drivers are asked to read each item and indicate the frequency with which they experience the described situation by using a 5-point scale, ranging from 1 (*never or almost never*) to 5 (*always or almost always*). Subscale scores were calculated by adding up the responses and dividing by the number of items. The ARDES has both similarities and difference with other existing measures, such as the Lapses scale of the Driving Behaviour Questionnaire (Reason, Manstead, Stradling, Baxter, & Campbell, 1990) and the Dissociative Driving Style scale of the Multidimensional Driving Style Inventory (Taubman–Ben-Ari, Mikulincer, & Gillath, 2004). The ARDES shares the content of some items with these instruments but differentiates itself by emphasizing the nonintentional character of the errors and their attentional nature. For a more exhaustive comparison, see Ledesma et al. (2010). The original study provided evidence of reliability and validity for ARDES scores. Results from the validation study indicated high internal consistency (Cronbach's alpha = .88), high item-discrimination measures (between .33 and .62), and strong correlation with validation scales (e.g., $r = .73$ with a measure of attentional failures in daily life; Cheyne et al., 2006). ARDES was also capable of discriminating between drivers who reported having been involved in motor vehicle collisions and participants who reported not having ever been in one. In like manner, it can also identify drivers who received a traffic ticket for the specific traffic violations that were analyzed.

DES-M. This scale is a brief version of the original DES (Bernstein & Putnam, 1986), composed of 18 items (Montes et al., 2011). DES measures dissociation as a dimensional construct that involves experiences ranging from nonpathological manifestations, such as absorption and daydreaming, to more pathological ones, such as identity disorder symptoms. Items are answered on a 5-point scale, from *never or almost never* (1) to *always or almost always* (5). The scale is composed of three dimensions: (a) absorption and imaginative involvement (Cronbach's alpha in this sample = .71), (b) dissociative amnesia and fugues (Cronbach's alpha = .72), and (c) depersonalization and derealization experiences (Cronbach's alpha = .62).

IDA. Exposure to distractors was measured by a self-reporting of the distracting activities drivers engaged in over the previous 2 weeks. The IDA was specifically developed for this study because, as far as we were aware, a similar measure did not exist. Fourteen distracting activities were assessed (e.g., speaking on a cell phone while driving, reading or texting messages, eating, chatting with a passenger, etc.). To simplify analysis, our IDA consisted of the tally of activities reported (Cronbach's alpha = .76).

Driver Social Desirability Scale (DSDS). The DSDS includes 12 items that evaluate a driver's tendency to provide positively biased descriptions of one's own conduct (Lajunen et al., 1997;

TABLE 1: List of Items Forming the Attention-Related Driving Errors Scale

1. When heading to a known destination, I become distracted and drive a few blocks past it.
2. I signal a move but unintentionally make another (e.g., I turn on the right-turn blinker but turn left instead).
3. At an intersection, I fail to pay attention and don't see a car coming the other way.
4. Suddenly, I realize I've made a mistake or lost my way to a known destination.
5. At an intersection, instead of looking in the direction of oncoming traffic, I look in the opposite direction.
6. At a street corner, I fail to realize that a pedestrian is crossing the street.
7. I don't notice an object or a car behind me, and I unintentionally crash into it.
8. I fail to realize that the vehicle right in front of me has slowed down, and I have to brake abruptly to avoid a crash.
9. Another driver honks at me because I failed to realize that the traffic light has turned green.
10. I forget that my headlights are on high bean until another motorist flashes his lights at me.
11. For a brief instant, I forget where I'm driving to.
12. When driving somewhere, I make more turns that I have to.
13. Following the car in front of me, I drive through a traffic light that has just turned red.
14. I try to move forward, but then realize I haven't put the car in gear.
15. I attempt to turn on one of the automobile's devices, but turn on another instead (for example, attempting to turn on the windshield wipers, I turn on the lights instead).
16. I head out to a destination and suddenly realize I'm going the wrong way.
17. I realize that I failed to see a traffic light simply because I was not paying attention.
18. I unintentionally make a wrong turn or drive the wrong way down a one-way street.
19. I unintentionally shift gears incorrectly or shift to the wrong gear.

Argentine version, Poó et al., 2010). The DSDS is composed of two subscales: Driving Impression Management (Cronbach's alpha in this study = .80) and Driver Self-Deception (Cronbach's alpha in this study = .78). Responses are given on a 7-point scale ranging from 1 (*not at all true*) to 7 (*completely true*).

Driving variables. A structured questionnaire was used to measure driving variables, including number of years driving, driving frequency, and motor vehicle collisions and traffic tickets for traffic violations over the past 2 years.

Procedure

A series of confirmatory factor analysis (CFA) models were tested using AMOS 16. Given the ordinal nature of the data, the asymptotically distribution-free estimation procedure (Browne, 1984) was selected as our first choice. However, frequent estimation problems were encountered, which led us to switch to the maximum likelihood procedure. As is usual in CFA, we evaluated parameter estimates in relation to model predictions and assessed the goodness of fit for each model. The following fit indices were reported: (a) for absolute fit, root mean square error of approximation (RMSEA), goodness-of-fit index (GFI), adjusted GFI (AGFI), Tucker-Lewis index (TLI), the comparative fit index (CFI), and the chi-square test statistic; (b) for comparative fit, incremental fit index (IFI), TLI, and CFI; and (c) for parsimonious fit, parsimony normed fit index (PNFI) and parsimony normed CFI (PCFI). We also used modification indices to guide model revision.

Using Sample 1, we specified and tested the following models. Model 1 is the one-factor, one-dimensional model. Model 2 is a first-order oblique model in which three factors (i.e., maneuvering, navigation, and control) are specified as intercorrelated. Strictly for comparison's sake, we also specified and evaluated several bidimensional models. Models 3, 4, and 5 are two-factor, first-order oblique models. Each one of these models represents a different combination of the three primary factors: Model 3 combines navigation and control in the same factor, Model 4 combines the maneuvering and navigation factors, and Model 5 unites maneuvering and control. Last, based on Model 2, we estimated Model 6, a second-order model with three lower-order factors (maneuvering, navigation, and control) and one higher-order factor (driver inattention).

Additionally, the following analyses were undertaken: multiple logistic regression to analyze the relationship between ARDES factors and the presence/absence of traffic collisions and tickets (Sample 1), multiple regression analysis to estimate the effects of the DES and IDA (predictor variables) on ARDES scores (Sample 2), correlation analysis and difference-of-means testing to evaluate ARDES stability over time (Subsample 2), and correlation analysis between the ARDES and DSDS to detect the possible effects of social desirability (Sample 2).

RESULTS

CFA

A first CFA suggested the elimination of Item Number 18 due to a low factor loading (i.e., < .20) in all the tested models. Also, the modification indices suggested adding error covariance between Items 1 and 4 as well as between Items 3 and 5. This can be attributed to the similarity in wording and content of the items. After introducing these minor changes, all models tended to show better fit indices.

Table 2 shows the fit indices for the one-, two-, and three-factor models. As can be seen, the three-factor models have the best GFIs when compared to the other models, particularly to the original one-factor model. In addition, the three-factor model also revealed good item factor loadings (standard regression weights) that were all significant ($p < .001$). As can be seen in Figure 1, the three factors are strongly interrelated, which leads to the assumption that a second-order underlying factor exists. We call this second-order factor "driver inattention" (see Figure 2).

The results from Models 1 and 2, which are those that have theoretical interest in this study, were validated with the second sample. Again, the three-factor solution showed good model fit in this replication sample (see Table 3).

Given the good fit of Models 2 and 6, we computed composite scores for each one of the three factors. The Cronbach's alpha for the resulting subscales were as follows: (a) Navigation = .74, (b) Maneuvering = .75, and (c) Control = .68. All of these values are above or close to the acceptable values for research purposes.

ARDES and Self-Reported Motor Vehicle Collisions and Tickets

Table 4 presents results from the multiple logistic regression models, assessing the association between the ARDES scores and different types of self-reported motor vehicle collisions and traffic tickets. Overall, attention-related errors at the maneuvering level tend to be associated with motor vehicle collisions and traffic tickets, whereas no significant associations were observed with the other two factors (navigation and control).

ARDES, Dissociative Experiences, and Distracting Activities

As shown in Table 5, ARDES total correlated positively and moderately with the DES-M total ($r = .50$, $p < .01$) and weakly with the IDA ($r = .16$, $p < .05$). The correlation between DES-M and IDA was also weak ($r = .18$, $p < .01$). A multiple regression analysis suggested that ARDES scores are significantly associated with DES-M (standardized beta = .49, $t = 7.899$, $p < .01$) but not with IDA (standardized beta = –.07, $t = –1.198$, $p > .05$).

ARDES subscales moderately correlated with the DES-M (Navigation, $r = .38$, $p < .01$; Maneuvering, $r = .47$, $p < .01$; Control, $r = .35$, $p < .01$) and weakly with the IDA (Navigation, $r = .18$, $p < .05$; Maneuvering, $r = .20$, $p < .01$; Control, $r = –.09$, $p > .05$). Correlations between the ARDES and the DES-M subscales were similar to those of the DES-M overall.

Temporal Stability of ARDES Scores

Table 6 shows the test-retest means for the ARDES scores. There was a significant but small observable difference in the overall means, $t(64) = –2,946$, $p = .004$, $d = –0.24$. At the subscale level, there was a significant difference in means

TABLE 2: Fit Indices for the Tested Measurement Models

						Absolute Fit			Comparative Fit			Parsimonious Fit	
Model	χ^2	*df*	*p*	CMIN/ DF	AIC	RMSEA	GFI	AGFI	IFI	TLI	CFI	PNFI	PCFI
1. One factor	402.55	133	>.01	3.03	478.6	.08	.86	.82	.80	.77	.80	.68	.70
2. Three-factor oblique: (a) navigation, (b) maneuvering, (c) control	277.94	130	>.01	**2.14**	**359.9**	**.06**	**.90**	**.87**	**.89**	**.87**	**.89**	**.69**	**.76**
3. Two-factor oblique: (a) navigation and control, (b) maneuvering	381.94	132	>.01	2.89	459.94	.08	.86	.82	.82	.79	.82	.64	.70
4. Two-factor oblique: (a) navigation and maneuvering, (b) control	394.33	132	>.01	2.99	472.33	.08	.86	.82	.81	.78	.81	.64	.70
5. Two-factor oblique: (a) navigation, (b) maneuvering, (c) control	317.62	132	>.01	2.40	395.6	.07	.89	.85	.74	.69	.73	.54	.63
6. Second-order, three first-order factors: (navigation, maneuvering, control) and one second-order factor (driver inattention)	277.94	130	>.01	**2.14**	**359.9**	**.06**	**.90**	**.87**	**.89**	**.87**	**.89**	**.69**	**.76**

Note. CMIN/DF = chi-square divided by its degrees of freedom; AIC = Akaike information criterion; RMSEA = root mean square error of approximation; GFI = goodness-of-fit index; AGFI = adjusted GFI; IFI = incremental fit index; TLI = Tucker-Lewis index; CFI = comparative fit index; PNFI = parsimony-adjustment normed fit index; PCFI = parsimony-adjustment CFI. The best-fitting model is indicated by bold type.

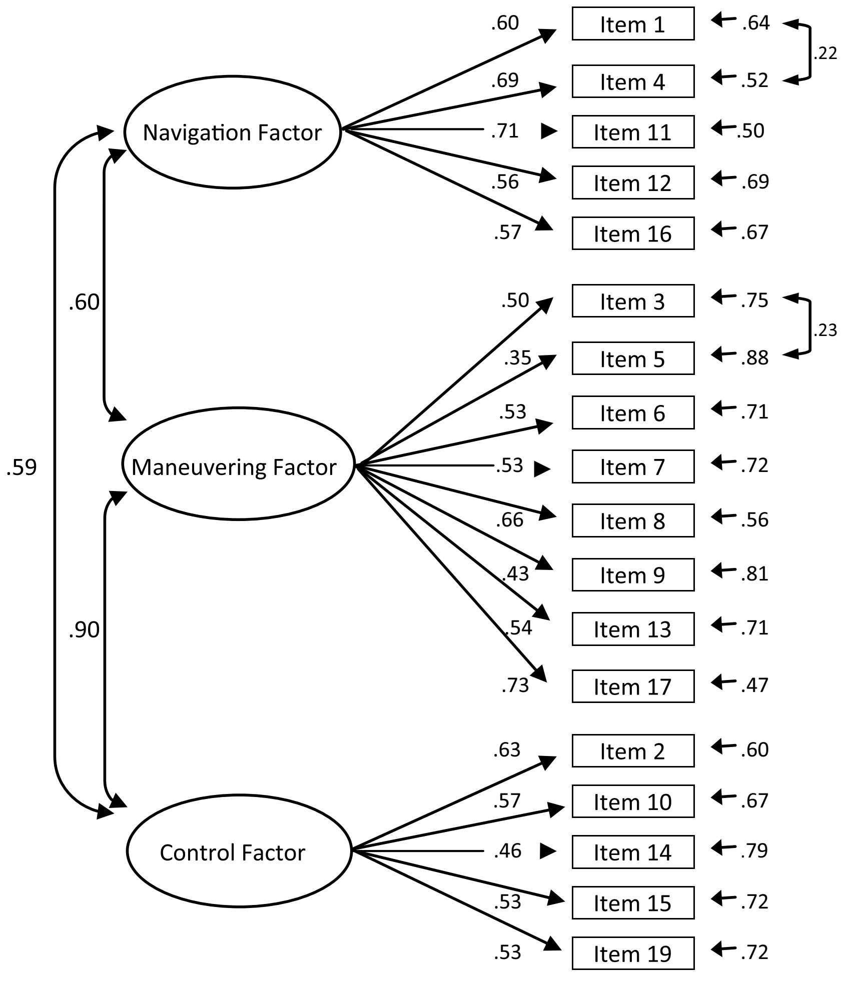

Figure 1. Standardized solution for the first-order confirmatory factor model. Correlation among factors and standard regression weights were all statistically significant, $p < .001$.

for Maneuvering, $t(64) = –2,419$, $p = .018$, but not for Navigation, $t(64) = –1,952$, $p = .055$, and Control, $t(64) = –1,665$, $p = .101$. Further, a positive significant correlation was found between the scores generated by the first and second administration of the ARDES ($r = .79$, $p < .01$). Correlations were also positive and high for the subscale scores generated at the different moments in time (Navigation, $r = .74$, $p < .01$; Maneuvering, $r = .73$, $p < .01$; Control, $r = .71$, $p < .01$).

ARDES and Social Desirability

The ARDES and its subscales had a low negative correlation with the IM subscale and a moderate negative correlation with the SD subscale (see Table 7). These results suggest a low IM effect, which is the dimension that can most affect self-reported results (Lajunen & Summala, 2003).

DISCUSSION

The results suggest that driver inattention as measured by the ARDES reflects a personal variable that tends to be relatively consistent and stable over time. This consistency is reflected in stable scores for the same individual over time (test-retest at a 6-month interval). This finding is in line with the idea that ARDES is measuring individual differences in a trait-like variable, which manifests itself as a greater or lesser

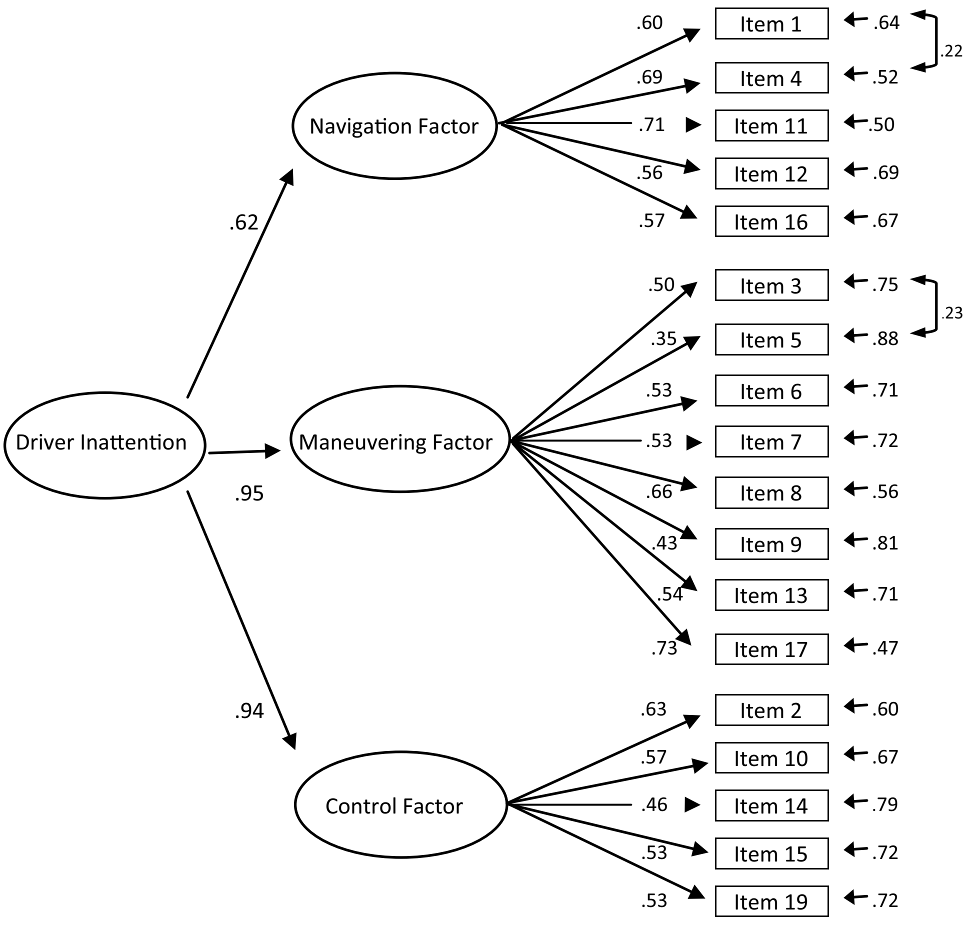

Figure 2. Standardized solution for the second-order confirmatory factor model. Estimated coefficients were all significant, ($p < .001$).

TABLE 3: Fit Indices for the Original One-Dimensional Model and the Novel Three-Factor Model in the Replication Sample

					Absolute Fit			Comparative Fit			Parsimonious Fit	
Model	χ^2	*df*	*p*	CMIN/ DF	RMSEA	GFI	AGFI	IFI	TLI	CFI	PNFI	PCFI
1. One-factor model	290.40	133	>.01	2.18	.08	.86	.82	.78	.73	.77	.57	.67
2. Three-factor oblique: (a) navigation, (b) maneuvering, (c) control	231.22	130	>.01	1.78	.06	.88	.85	.86	.83	.85	.61	.72

Note. RMSEA = root mean square error of approximation; GFI = goodness-of-fit index; AGFI = adjusted GFI; IFI = incremental fit index; TLI = Tucker-Lewis index; CFI = comparative fit index; PNFI = parsimony-adjustment normed fit index; PCFI = parsimony-adjustment CFI.

TABLE 4: ARDES Scores and Self-Reported Traffic Collisions and Tickets

	Independent Variables Exp(*B*) [95% CI], *p*		
Dependent Variable	ARDES Control	ARDES Maneuvering	ARDES Navigation
Traffic collision: Involvement in any type of traffic collision	0.62 [0.32, 1.19], $p = .15$	**2.65** [1.19, 5.94], $p = .02$	1.51 [0.93, 2.44], $p = .09$
Minor material damages: Involvement in traffic collision with only minor material damages	0.66 [0.33, 1.28], $p = .22$	**2.35** [1.04, 5.34], $p = .04$	1.54 [0.95, 2.5], $p = .08$
Major material damages: Involvement in traffic collision with total or partial vehicle destruction	1.97 [0.42, 9.33], $p = .39$	0.84 [0.10, 7.0], $p = .87$	1.23 [0.36, 4.25], $p = .74$
Traffic injuries: Involvement in traffic collision resulting in injuries	0.70 [0.23, 2.12], $p = .52$	3.40 [0.90, 12.95], $p = .07$	1.18 [0.56, 2.51], $p = .66$
Traffic ticket: Traffic tickets for traffic violations	0.85 [0.37, 1.92], $p = .69$	**5.56** [2.04, 15.21], $p < .001$	0.58 [0.30, 1.14], $p = .12$

Note. Significant effects shown in bold. ARDES = Attention-Related Driving Errors Scale; CI = confidence interval.

tendency to experience attentional failures while driving (Ledesma et al., 2010). As indicated by Lee (2009), attention-related failures do not appear to occur randomly but, rather, reflect "enduring behavior patterns." What is even more interesting is that this tendency is related to personal characteristics and internal sources of distraction and not as much to involvement in secondary activities (e.g., level of engagement in activities like speaking on the telephone). In fact, our results indicate a weak relationship between the frequency of attentional errors and involvement in distracting activities.

A possible explanation for the findings is that drivers with greater "inattention" proneness may be aware to some extent of their attentional limitations and consequently control the degree to which they expose themselves to distractors as a means of mitigating the effects of inattention. On the other hand, they seem incapable of adequately "managing" the internal sources of distraction (e.g., intrusive or task unrelated thoughts), possibly because they are associated with psychological characteristics that are more stable and difficult to control (Smallwood, Baracaia, Lowe, & Obonsawin, 2003; McVay, Kane, & Kwapil, 2009). Another contributing factor is the fact that "internal" distractions are beyond the reach of enforcement actions and that, unlike with other sources of distraction, such as cell phone use, there is not much public awareness as to their effects (National Highway Traffic Safety Administration, 2010; Vermette, 2010).

With respect to the internal structure of the ARDES, the CFA suggests that items can be empirically grouped according to the task level

TABLE 5: Correlations Between ARDES Scores, DES-M, and IDA

	ARDES	ARDES Navigation	ARDES Maneuvering	ARDES Control	DES-M	DES-M Absorption	DES-M Amnesia	DES-M Depersonalization
ARDES Navigation	.79**							
ARDES Maneuvering	.87**	.49**						
ARDES Control	.74**	.41**	.54**					
DES-M	.50**	.38**	.47**	.35**				
DES-M Absorption	.44**	.32**	.39**	.33**	.84**			
DES-M Amnesia	.48**	.38**	.43**	.31**	.87**	.55**		
DES-M Depersonalization	.31**	.22**	.25**	.24**	.75**	.52**	.53**	
IDA	.16*	.18*	.20**	-.09	.17*	.11*	.24**	.03

Note. ARDES = Attention-Related Driving Errors Scale; DES-M = Dissociative Experiences Scale–Modified Version (total score); IDA = Index of Distracting Activities.
**p* < .05 (unilateral). ***p* < .01 (unilateral).

TABLE 6: Test-Retest Means for the ARDES Scores

	ARDES Total		Navigation		Maneuvering		Control	
	M	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
Test	1.49	.32	1.60	.51	1.52	.36	1.34	.35
Retest	1.60	.31	1.72	.56	1.65	.35	1.40	.35

Note. ARDES = Attention-Related Driving Errors Scale.

TABLE 7: Correlations Between ARDES Scores and the DSDS

Scale	ARDES Total Score	ARDES Navigation	ARDES Maneuvering	ARDES Control
DSDS Impression Management	–.19**	–.15*	–.28**	.02
DSDS Driver Self-Deception	–.40**	–.29**	–.38**	–.33**

Note. ARDES = Attention-Related Driving Errors Scale; DSDS = Driver Social Desirability Scale.

at which the errors occur (i.e., maneuvering, navigation, and control; Michon, 1985). This differentiation is useful in that each factor seems to relate differently to driver safety. In fact, only the Maneuvering subscale is consistently associated with involvement in traffic collisions and the incurring of traffic tickets. Nonetheless, it is also true that these three factors share a strong common basis, having already been found to be strongly related among each other and having similar correlation profiles with respect to other variables that have been studied. This finding suggests the plausibility of a second-order factor that measures overall inattention while driving.

In short, the three-factor structure seems adequate and contributes relevant information in terms of road safety. However, in light of the results, a single total score could also be valid and, in some cases, more convenient. For example, in studies on the distraction potential of in-vehicle devices, ARDES could be included as a simple measure to control individual differences and increase the statistical power of research. In this case, a global score would be sufficient and would also offer a more reliable measure than the subscales would (the reliability of the subscales tends to be less than the reliability of the total score due to the smaller number of items).

With respect to reliability, another important factor is that the ARDES is a self-reporting instrument and could therefore be sensitive to social desirability bias. For this reason, it is important to control this possibility. In this regard, our results are in line with the findings of previous studies. Poó et al. (2010) found the same correlation patterns between the DSDS and The Dissociative Driving Style subscale of the Multidimensional Driving Style Inventory (that is, a low correlation with the IM scale and a moderate correlation with the SD scale). We believe it is best to be cautious and check for such bias when possible. We recommend including desirability measures to screen subjects with high scores and providing response conditions that reduce bias (responder anonymity, confidentiality, etc.).

We believe this study gives a useful research tool and opens interesting lines of future work into individual differences in driving inattention. First, it would be interesting to deepen our understanding of the psychological correlations of driving inattention through correlational studies on personality and cognitive variables. It would be worthwhile to work with comprehensive personality models, such as the Big Five (McCrae & Costa, 2003) or the Alternative Five (Zuckerman, 2005) to obtain a fuller understanding of the relationship between personality and driver inattention. Experimental cognitive psychology research, such as Lopez-Ramón et al. (2011), would also be essential. These studies are vital to understanding the individual differences in driving inattention and also to providing evidence of validity for self-reporting instruments.

In addition to deepening our understanding of the psychological correlations of inattention, it would also be important to study the manner in which this variable interacts with other factors. As Reason (1990) and Stanton and Salmon (2009) state, a complete analysis of human error requires a systematic perspective that includes driver, vehicle, and road environment factors. Besides theoretical questions on the nature of individual differences in driving inattention, we believe our research also leads to practical questions. For instance, to what degree is the effectiveness of interventions to address or reduce driving distractions moderated by individual differences in driver inattention? Might subjects with a high propensity toward inattention be more resistant to certain preventive actions? If so, what kind of actions might be more appropriate for this type of driver? We believe the ARDES is a useful tool for future research into questions such as these.

In summary, this study clarifies and improves the psychometric basis of ARDES and provides new evidence supporting its potential use in research. It should be made clear that we are not inclined to believe that this type of instrument should be used for driver licensing testing, since the responses can be manipulated by the subjects being evaluated. We do believe that the ARDES can serve as an instrument of driver self-assessment in educational and training contexts, in other words, as a tool to help drivers become aware of their personal tendency toward driver inattention. An example of this type of use is the "Drivers 65 Plus" of the AAA Foundation for Traffic Safety (2010). This is a self-rating instrument designed to help adult drivers become aware of some age-related changes that can affect safe driving. Of course, in order to be used for this purpose, additional validation studies and normative data on target populations are required.

ACKNOWLEDGMENTS

This study was supported by a contribution from the World Bank's Global Road Safety Facility and the Global Forum for Health Research through their grant facility to the Road Traffic Injuries Research Network (Agreements No. RTIRNWB-004d and No. RTIRNWB-005d). It also received support from the Universidad Nacional de Mar del Plata and CONICET (Consejo Nacional de Investigaciones Científicas y Técnicas, Argentina). We express our gratitude to these institutions for their support. The authors also wish to thank Darío Bard for his translation services.

KEY POINTS

- Results reflect a personal tendency toward inattention that appears to be relatively consistent and stable for each individual driver.

- Individual differences in driver inattention are associated with road traffic collisions.
- Driver inattention can be easily assessed by the Attention-Related Driving Errors Scale.

REFERENCES

AAA Foundation for Traffic Safety. (2010). *Drivers 65 plus: Check your own performance. A self-rating form of questions, facts and suggestions for safe driving*. Washington, DC: Author.

af Wahlberg, A. (2010). Social desirability effects in driver behaviour inventories. *Safety Science*, *41*, 99–106.

Arthur, W., Tubre, T., Day, E. A., Sheehan, M. K., Sanchez-Ku, M. L., Paul, D., & Archuleta, K. (2001). Motor vehicle crash involvement and moving violations: Convergence of self-report and archival data. *Human Factors*, *43*, 1–11.

Bernstein, E. M., & Putnam, F. W. (1986). Development, reliability, and validity of a dissociation scale. *Journal of Nervous and Mental Disease*, *174*, 727–735.

Boufous, S., Ivers, R., Senserrick, T., Stevenson, M., Norton, R., & Williamson, A. (2010). Accuracy of self-report of on road crashes and traffic offences in a cohort of young drivers: The DRIVE study. *Injury Prevention*, *16*, 275–277.

Brown, K. W., & Ryan, R. M. (2003). The benefits of being present: Mindfulness and its role in psychological well-being. *Journal of Personality and Social Psychology*, *84*, 822–848.

Browne, M. W. (1984). Asymptotically distribution-free methods for the analysis of covariance structures. *British Journal of Mathematical and Statistical Psychology*, *37*, 62–83.

Carlson, E., & Putnam, F. (1993). An update on the Dissociative Experience Scale. *Dissociation*, *6*, 16–27.

Cheyne, J. A., Carriere, J., & Smilek, D. (2006). Absent-mindedness: Lapses of conscious awareness and everyday cognitive failures. *Consciousness and Cognition*, *15*, 578–592.

Dingus, T. A., Klauer, S. G., Neale, V. L., Petersen, A., Lee, S. E., Sudweeks, J., Perez, M. A., Hankey, J., Ramsey, D., Gupta, S., Bucher, C., Doerzaph, Z. R., Jermeland, J., & Knipling, R. R. (2006). *The 100-Car Naturalistic Driving Study, Phase II: Results of the 100-car field experiment* (Tech. Rep. No. DOT HS 810 593). Washington, DC: National Highway Traffic Safety Administration.

Klauer, S. G., Dingus, T. A., Neale, V. L., Sudweeks, J. D., & Ramsey, D. J. (2006). *The impact of driver inattention on near-crash/crash risk: An analysis using the 100-Car Naturalistic Driving Study data* (DOT HS 810 594). Washington, DC: National Highway Traffic Safety Administration. Retrieved from http://www.nsc.org/safety_road/Distracted_Driving/Documents/The%20Impact%20of%20Driver%20Inattention%20on%20Near-Crash.pdf

Lajunen, T., Corry, C., Summala, H., & Hartley, H. (1997). Impression management and self-deception in traffic behavior inventories. *Personality and Individual Differences*, *22*, 341–353.

Lajunen, T., & Summala, H. (2003). Can we trust self-reports of driving? Effects of impression management on driver behavior questionnaire responses. *Transportation Research Part F: Traffic Psychology and Behaviour*, *6*, 97–107.

Ledesma, R., Montes, S., Poó, F., & López-Ramón, M.F (2010). Individual differences in driver inattention: The Attention-Related Driving Errors Scale. *Traffic Injury Prevention*, *11*, 142–150.

Lee, J. D. (2009). Engineering. Can technology get your eyes back on the road? *Science*, *324*, 344–346.

López-Ramón, M. F., Castro, C., Roca, J., Ledesma, R., & Lupiañez, J. (2011). Attentional networks functioning, age, and attentional lapses while driving. *Traffic Injury Prevention*, *12*, 518–528.

Marottoli, R. A., Cooney, L. M., & Tinetti, M. E. (1997). Self-report versus state records for identifying crashes among older drivers. *Journal of Gerontology*, *52*, 184–187.

Martens, M. H., & Brouwer, R. F. (2013). Measuring being lost in thought: An exploratory driving simulator study. *Transportation Research Part F: Traffic Psychology and Behaviour*, *20*, 17–28.

McCrae, R. R., & Costa, P. T., Jr. (2003). *Personality in adulthood: A five-factor theory perspective* (2nd ed.). New York, NY: Guilford Press.

McGwin, G., Owsley, C., & Ball, K. (1998). Identifying crash involvement among older drivers: Agreement between self-report and state records. *Accident Analysis & Prevention*, *30*, 781–791.

McVay, J. C., Kane, M. J., & Kwapil, T. R. (2009). Tracking the train of thought from the laboratory into everyday life: An experience-sampling study of mind-wandering across controlled and ecological contexts. *Psychonomic Bulletin & Review*, *16*, 857–863.

Michon, J A. (1985). A critical review of driver behaviour models: What do we know, what should we do? In L. Evans & R. C. Schwing (Eds.), *Human behaviour and traffic safety* (pp. 487–525). New York, NY: Plenum Press.

Montes, S., Ledesma, R., & Poó, F. (2011). Evaluación psicométrica de una versión modificada de la Escala de Experiencias Disociativas (DES-M) [Psychometric properties of the dissociative experience scale (modified version)]. *Revista Argentina de Clínica Psicológica*, *20*, 67–77.

National Highway Traffic Safety Administration. (2010). *Overview of the National Highway Traffic Safety Administration's Driver Distraction Program* (DOT HS 811 299). Washington, DC: Author. Retrieved from http://www.nhtsa.gov/staticfiles/nti/distracted_driving/pdf/811299.pdf

Poó, F., Ledesma, R., & Montes, S. (2010). Propiedades Psicométricas de la Escala de Deseabilidad Social del Conductor (Versión en Español) [Psychometric properties of the driver social desirability scale driver (Spanish version)]. *Avaliação Psicológica*, *9*, 299–310.

Rasmussen, J. (1986). *Information processing and human machine interaction: An approach to cognitive engineering*. New York, NY: Elsevier.

Reason, J. (1990). *Human error*. New York, NY: Cambridge University Press.

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

Regan, M., Hallett, C., & Gordon, C. (2011). Driver distraction and driver inattention: Definition, relationship and taxonomy. *Accident Analysis & Prevention*, *43*, 1771–1781.

Roca, J., Padilla, J. L., López-Ramón, F. M., & Castro, C. (2013). Assessing individual differences in driving inattention: Adaptation and validation of the Attention-Related Driving Errors Scale to Spain. *Transportation Research Part F: Traffic Psychology and Behaviour*, *21*, 43–51.

Smallwood, J. M., Baracaia, S. F., Lowe, M., & Obonsawin, M. (2003). Task unrelated thought whilst encoding information. *Consciousness & Cognition*, *12*, 452–484.

Stanton, N., & Salmon, P. (2009). Human error taxonomies applied to driving: A generic driver error taxonomy and its implications for intelligent transport systems. *Safety Science*, *47*, 227–237.

Taubman–Ben-Ari, O., Mikulincer, M., & Gillath, O. (2004). The multidimensional driving style inventory-scale construct and validation. *Accident Analysis & Prevention*, *36*, 323–332.

Vermette, E. (2010). *Curbing distracted driving: 2010 survey of state safety programs*. Washington, DC: Governor's Highway Safety Association.

Zuckerman, M. (2005). *Psychobiology of personality*. Cambridge, UK: Cambridge University Press.

Rubén Daniel Ledesma, PhD Psychologist (Valencia, Spain, 2001), is a researcher at CONICET (Consejo Nacional de Investigaciones Científicas y Técnicas) and Universidad Nacional de Mar del Plata, Argentina.

Silvana Andrea Montes, PhD Psychologist (Mar del Plata, Argentina, 2013), is a postdoctoral scholar at CONICET (Consejo Nacional de Investigaciones Científicas y Técnicas) and Universidad Nacional de Mar del Plata, Argentina.

Fernando Martín Poó, PhD Psychologist (Mar del Plata, Argentina, 2011), is a researcher at CONICET (Consejo Nacional de Investigaciones Científicas y Técnicas) and Universidad Nacional de Mar del Plata, Argentina.

María Fernanda López-Ramón, PhD Psychologist (San Luis, Argentina, 2006), is an assistant professor in the Department of Didactic and Education, Faculty of Humanities and Social Sciences, Universidad de Zaragoza, Spain.

Date received: April 13, 2013
Date accepted: July 14, 2014