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## ► To cite this version:

Martin Nicolleau, Nicolas Mascret, Cécile Martha, Claire Naude, Thierry Serre, et al.. Implicit theories in driving: Scale development, validation, and predictive role on violations and driving self-efficacy. *Transportation Research Part F: Traffic Psychology and Behaviour*, 2022, 86, pp.333-344. 10.1016/j.trf.2022.03.003 . hal-03644434

**HAL Id: hal-03644434**

**<https://hal.science/hal-03644434v1>**

Submitted on 19 Apr 2022

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1       Nicolleau, M., Mascret, N., Martha, C., Naude, C., Serre, T., & Ragot-Court, I. (2022).  
2       Implicit theories in driving: Scale development, validation, and predictive role on violations  
3       and driving self-efficacy. *Transportation Research Part F: Traffic Psychology and*  
4       *Behaviour*, 86, 333-344.  
5       <https://doi.org/10.1016/j.trf.2022.03.003>

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7       **Implicit theories in driving: Scale development, validation, and predictive**  
8       **role on violations and driving self-efficacy**

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### **Abstract**

Implicit theories focus on how ability may be perceived by individuals. There are two main beliefs: entity beliefs (i.e., driving ability is a gift) and incremental beliefs (i.e., driving ability is improvable through effort). Implicit theories have been studied in various domains (e.g., education, sport), but never in driving, even though they could improve the knowledge of drivers' psychological characteristics. The first objective of the present study was to develop and validate a questionnaire measuring implicit theories in driving. The second objective was to assess the predictive role of implicit theories on violations and driving self-efficacy, and the moderating role of gender. In study 1, confirmatory factor analysis, analyses of gender invariance, and concurrent validity were assessed to validate the questionnaire named Implicit Theories in Driving Questionnaire (ITDQ). In study 2, the predictive role of implicit theories on violations and driving self-efficacy was evaluated using multiple regression analyses. Moderation analyses evaluated the moderating role of gender on the relationships between implicit theories and violations, along with driving self-efficacy. The ITDQ showed acceptable psychometric properties. The results highlighted that entity beliefs positively predicted aggressive violations and negatively predicted driving self-efficacy. Conversely, incremental beliefs negatively predicted ordinary violations and positively predicted driving self-efficacy. The ITDQ is a valid scale now available for assessing implicit theories in driving, that have been shown to influence self-reported driving behavior. Future research on implicit theories in driving may help to better understand the psychological characteristics of at-risk drivers and improve driver's training, to reduce the number of road accidents.

**Keywords:** Entity beliefs; incremental beliefs; accidents; risky driving; driving behavior

42 **1. Introduction**

43           Worldwide, the number of car user fatalities is estimated at 392,904 people in 2016  
 44 and this number is increasing each year (World Health Organization, 2018). Consequently,  
 45 road safety may be considered a major global issue. In France, 3,239 people died on the road  
 46 in 2019, including 1,621 car drivers (ONISR, 2020), which is the leading cause of death  
 47 among 18-24-year-olds. In 90% of cases, human error is involved (Van Eslande, 2000) as  
 48 well as risky behaviors (Reason et al., 1990). To better understand what may influence and  
 49 motivate drivers to adopt risky behaviors, a large body of research has studied their self-  
 50 reported psychological characteristics, such as sensation seeking (Jonah, 1997), self-efficacy  
 51 (Boccaro et al., 2011), or anger (Delhomme et al., 2012). But some theoretical frameworks  
 52 have not yet penetrated the driving domain. For instance, it has been shown that beliefs about  
 53 human abilities, called *implicit theories*, have an influence on cognition, affect, and behavior  
 54 (Dweck, 1999). This theoretical framework has been widely developed in the last 30 years in  
 55 many areas such as education and sport, but not so far in the driving domain.

56           Magill (2001) defines ability as “a general trait or capacity of an individual that is a  
 57 determinant of a person’s achievement potential for the performance of specific skill” (p.17).  
 58 Lohman (1997) argues that ability depends on both innate traits and genetics, but also on  
 59 learning and practice. The purpose of studying implicit theories is not to determine whether an  
 60 ability is objectively innate or acquired, but rather to focus on what individuals think about  
 61 the nature of this ability. The review of Dweck (2002) showed that many theorists believe that  
 62 ability is a personal and social construct, and this construct can change from person to person  
 63 and from culture to culture. These interindividual differences are central to the definition of  
 64 implicit theories. Implicit theories can be defined as the beliefs that individuals have about the  
 65 changing or fixed nature of human traits and abilities (Biddle et al., 2003; Dweck & Molden,  
 66 2005). Implicit theories are conscious and unconscious representations of the nature of human

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67 abilities. They are personal theories based on naive theories (Heider, 1958; Kelly, 1955),  
68 which allow people to interpret events in their social life according to their own theories and  
69 interpretations. Dweck et al. (1995) characterized implicit theories as assumptions that define  
70 an individual's reality and give sense to events. They exert a strong influence on motivation,  
71 as they provide a response pattern in achievement situations (Dweck & Leggett, 1988). There  
72 are two main beliefs. An individual pursues *entity beliefs* when he/she considers ability stable,  
73 fixed, and not improvable. An individual pursues *incremental beliefs* when he/she considers  
74 ability to be malleable and improvable through work and effort. There is no right or wrong  
75 theory, as these beliefs are alternative ways for individuals to perceive reality. The study of  
76 implicit theories is not interested in reality, but in the perception of reality by individuals. An  
77 individual will not pursue a unique pattern of belief in all domains, as it is possible to  
78 predominantly pursue entity beliefs in one domain, and incremental beliefs in another domain.  
79 Sarrazin et al. (1996) have shown that individuals pursue both types of beliefs at the same  
80 time, and therefore that they should not be seen as two extremities of a continuum. The model  
81 of implicit theories developed by Dweck (1986), and by Dweck and Leggett (1988), is not  
82 intended for the study of general and observable abilities. Various studies have shown that it  
83 is possible to evaluate implicit theories at a general level (i.e., people's personality) and at  
84 more specific levels (e.g., intelligence, sport ability, use of technologies, work). Dweck and  
85 colleagues (1986, 1988) were the first to study the beliefs of individuals about the nature of  
86 intelligence. People pursuing entity beliefs consider intelligence or a gift, a fixed and innate  
87 attribute that cannot be improved, while those pursuing incremental beliefs consider  
88 intelligence or athletic, malleable, and improvable. Beliefs about the nature of athletic ability  
89 were then investigated (Biddle et al., 2003; Sarrazin et al., 1996), and more specifically  
90 beliefs about swimming and basketball abilities (Mascret et al., 2016). In other contexts, very  
91 specific skills such as intention to use a new technology (Solberg et al., 2020) , passion for

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92 work (Chen et al., 2015), and also beliefs about body weight (Burnette, 2010) have been  
93 studied.

94           Investigating implicit theories in driving would examine whether a driver considers  
95 driving skills to be stable, to be a gift (entity beliefs) or improvable with practice and  
96 experience (incremental beliefs). The question: Are you born a good driver or are you in the  
97 process of becoming one? In other words, are there innate driving skills or can they be  
98 improved by experience? Is reversing into a parking space a gift or a skill that can be  
99 acquired? Is it innate to be able to take curves properly in the mountains innate or is it  
100 developed through experience? Examination of drivers' implicit theories could explain certain  
101 behaviors, affects, and cognition in different situations, e.g. when people give up the idea of  
102 parking in a small area, or when people approach curves too slowly. It is important to  
103 remember that implicit theories of driving are concerned with what people think about  
104 driving, not with reality.

105           Due to the lack of studies on implicit theories in driving, no specific questionnaire was  
106 available. However, questionnaires have been developed in other domains such as education  
107 and sport. Dweck, Chiu, and Hong (1995) developed a three-item scale to assess beliefs about  
108 the nature of intelligence. This scale has been frequently used in various studies (Aditomo,  
109 2015; Yeager et al., 2019), but it has been called in to question because it considers entity and  
110 incremental beliefs as the opposite of a continuum (Biddle et al., 2003). Consequently, Dweck  
111 (1999) developed a new eight-item scale that separately assesses entity beliefs (four items)  
112 and incremental beliefs (four items) of intelligence. Then, Sarrazin et al. (1996) validated the  
113 first scale in the field of sport, followed by Biddle et al. (2003) who proposed a modified  
114 version of this scale called the "CNAAQ-2" (Conception of the Nature of Athletic Ability  
115 Questionnaire-2). This scale is the most used in studies assessing implicit theories in the fields  
116 of sport, physical exercise, and physical education (for a review, see Vella et al., 2016).

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117 Hence, the first objective of the present study was to validate a scale specifically assessing  
118 implicit theories in driving, in order to improve knowledge of drivers' psychological  
119 characteristics through a theoretical framework never used before but seemingly worthwhile  
120 in this area, as seen previously.

121         After this first step, it would be relevant to evaluate the relationships between implicit  
122 theories and usual variables of interest in the field of driving. In sport and education, research  
123 has shown that incremental and entity beliefs are correlated with different outcomes. In the  
124 education domain, Dweck et Molden (2005) observed that incremental beliefs were more  
125 often linked to positive consequences (e.g., pleasure, persistence, performance) than entity  
126 beliefs which were rather linked to negative outcomes such as abandonment, high level of  
127 anxiety, and lower performance. In the domains of sport, physical exercise, and physical  
128 education, incremental beliefs were also linked to positive and adaptative consequences, such  
129 as lower levels of anxiety, better satisfaction, and higher enjoyment (Biddle et al., 2003;  
130 Warburton & Spray, 2017). On the contrary, entity beliefs were associated with negative  
131 outcomes, such as amotivation, anxiety, and lower levels of satisfaction (Biddle et al., 2003;  
132 Ommundsen, 2001). In summary, the adoption of incremental beliefs appears to be more  
133 beneficial than the adoption of entity beliefs. Based on the previous tendencies, we  
134 hypothesized that, in driving, incremental beliefs might be linked to more positive  
135 consequences. Conversely, entity beliefs could be linked to more negative outcomes. In order  
136 to test these general hypotheses more specifically, we selected variables frequently used in the  
137 driving literature: driving self-efficacy, violations, accidents, and emergency maneuvers.  
138 Indeed, self-efficacy is a variable often used to study psychological profiles in driving (Miele  
139 et al., 2021; Zhang et al., 2020). Violations are measured with the Driving Behaviour  
140 Questionnaire (DBQ), which has been used extensively in the field of driving (de Winter and  
141 Dodou (2010) reported 174 studies using this questionnaire). DBQ's scores are frequently

142 related to self-reported accidents. Emergency maneuvers, are often measured in Naturalistic  
143 Driving Studies (NDS) under the name of "driving events" or "near-crashes" (Dingus et al.,  
144 2016; Wu et al., 2014); in this study, the term "emergency maneuvers" was preferred, as it  
145 was more meaningful to individuals. Furthermore, these variables have already been used in  
146 studies focusing on the development of psychometric scales in the driving domain, such as  
147 achievement goals in driving (Mascret et al., 2020). First, self-efficacy is generally defined as  
148 "beliefs in one's capabilities to mobilize the motivation, cognitive resources, and courses of  
149 action needed to meet given situational demands" (Wood & Bandura, 1989, p.408). Driving  
150 self-efficacy represents the driver's self-assessment of his/her capacities to meet the  
151 requirements of the driving situation. In sport, incremental beliefs positively predict self-  
152 efficacy (Kasimatis et al., 1996; Lirgg et al., 1996; Wood & Bandura, 1989). In education,  
153 self-efficacy is positively correlated with incremental beliefs, while self-efficacy is negatively  
154 correlated with entity beliefs (Diseth et al., 2014; Komarraju & Nadler, 2013). Based on the  
155 literature, one would expect incremental beliefs in driving to positively predict driving self-  
156 efficacy (H1), while entity beliefs should negatively predict driving self-efficacy (H2).

157         Secondly, this study investigated violations so as to examine risky driving behaviors.  
158 Violations represent transgressions of official traffic rules and social codes between drivers  
159 (Reason et al., 1990). Ordinary violations are defined as deliberate traffic violations, without  
160 aggression towards other drivers (e.g., exceeding speed limit, failing to stop at a red light).  
161 Aggressive violations refer to behavior that is violent towards others, putting other drivers at  
162 risk (e.g., deliberately refusing to yield at an intersection). Both ordinary and aggressive  
163 violations refer to intentional risky driving behavior. These violations while driving may refer  
164 to cheating and aggression in other areas. In education, Yeager et al. (2011) observed that  
165 entity beliefs are related to a desire for revenge after a conflict with peers: while driving, this  
166 reaction could produce aggressive behavior (e.g., cutting the road, honking the horn etc.). In



167 contrast, Yeager et al. (2013a) found that incremental beliefs could improve and reduce the  
 168 desire for revenge. In physical education, entity beliefs positively influenced the judgement of  
 169 cheating acceptability, highlighting that students with high entity beliefs are more likely to  
 170 accept cheating in physical education (Corrion et al., 2010), while incremental beliefs were  
 171 related to positive reactions after failure (Potgieter & Steyn, 2010). Based on these previous  
 172 results, we hypothesized that entity beliefs would be positive predictors of ordinary and  
 173 aggressive violations (H3) and that incremental beliefs would be negative predictors of these  
 174 violations (H4).

175 Thirdly, implicit theories may be studied in relation to other self-reported variables  
 176 relevant in the driving literature: past accidents and emergency maneuvers. Accidents are  
 177 strongly related to the adoption of risky driving (de Winter & Dodou, 2010). In our study,  
 178 road accidents are a collision on a public or private road between at least one moving vehicle  
 179 and another vehicle, a pedestrian, an animal, or a fixed obstacle. Since the frequency of  
 180 accidents has decreased in recent years, it may also be relevant to study emergency maneuvers  
 181 or hazardous driving situations (Serre et al., 2014). (Wu et al., 2014) reported a significant  
 182 positive correlation between accidents, near crashes, and crash-relevant accidents. Emergency  
 183 maneuvers are part of near crashes. In other domains, such as education or sport, the notion of  
 184 performance is often related to implicit theories, but it is difficult to give a precise definition  
 185 of “performance” in the driving domain. In the study by, driving performance was assessed by  
 186 accident history and by driving errors made during a test drive. Compared to sport or  
 187 education, fewer accidents and emergency maneuvers could represent a kind of positive  
 188 performance. In education, entity beliefs are mostly negatively related to academic  
 189 performance (Cury et al., 2008; Thompson & Musket, 2005), while incremental beliefs are  
 190 strongly positively related to performance (Cury et al., 2008; Dupeyrat & Mariné, 2005). In  
 191 sport, incremental beliefs are positively related to effort and persistence, which are essential

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192 components of sport performance. Consequently, we hypothesized that incremental beliefs  
193 would be negative predictors of accidents and emergency maneuvers (H5), and that entity  
194 beliefs would be positive predictors of these variables (H6).

195         Finally, our study evaluated the influence of gender on the different variables selected  
196 (i.e., implicit beliefs, driving self-efficacy, violations). Many studies in driving have observed  
197 gender differences, for instance anger in driving (González-Iglesias et al., 2012) : men have  
198 higher driving anger than women. Gender differences in driving self-efficacy have been  
199 identified in previous studies (e.g., Delhomme, 1991; Sundström, 2008), showing that men  
200 tend to overestimate their driving abilities. We supposed that men have a higher level of  
201 driving self-efficacy than women (H7). Concerning driving violations (ordinary and  
202 aggressive), men reported more ordinary violations (traffic violation) than women (Guého et  
203 al., 2014; Özkan & Lajunen, 2005). No gender difference in aggressive violations was shown  
204 by Guého et al. (2014), while previous studies revealed that men declared more aggressive  
205 violations than women (Lawton et al., 1997; Özkan & Lajunen, 2005). Santamariña-Rubio et  
206 al. (2014) found that men have significantly more road accidents than women. Concerning  
207 implicit theories, Spinath et al. (2003) observed that women report less stable intelligence  
208 than men do. In sport, Li et al. (2006) reported that incremental beliefs do not differ by  
209 gender, but that men score higher than women do on entity beliefs. Based on previous studies,  
210 we hypothesized that while driving, men pursue entity beliefs to a greater extent than women  
211 do (H8). Based on all these results, gender appears to be a relevant variable to consider when  
212 studying implicit theories, driving self-efficacy, violations, accidents, and emergency  
213 maneuvers. Therefore, we investigated the potential moderating role of gender between

214 implicit theories and variables of interest in the driving domain (driving self-efficacy,  
215 ordinary violations, aggressive violations, accidents, and emergency maneuvers).

216 This research consisted of two studies. The objectives of the first study were (a) to  
217 develop a questionnaire assessing implicit theories in driving, (b) to test the factorial structure  
218 of this scale, and (c) to examine the concurrent validity with self-reported variables of interest  
219 in the driving domain (i.e., accidents, responsible accidents, emergency maneuvers). The  
220 objectives of the second study were (a) to evaluate the predictive role of implicit theories in  
221 driving on self-reported drivers' aggressive violations, ordinary violations, and driving self-  
222 efficacy and (b) to investigate the moderating role of gender among the preceding variables.

223

## 224 **2. Study 1**

### 225 **2.1. Method**

#### 226 **2.1.1. Participants**

227 A total of 318 French car drivers (180 women, 138 men,  $M_{age} = 30.68$  years,  $SD =$   
228  $12.78$ , range = 18-70 years) participated in the study. Only drivers with a category B license  
229 were included ( $M_{years\ of\ driving\ license} = 11.41$ ,  $SD = 12.54$ ), with an annual mileage of  
230 approximately 11 377 kilometers ( $SD = 10\ 445$ ). In terms of driving frequency, 45.60% of the  
231 sample reported driving every day, 20.75% about three times a week, and 33.65% less than  
232 three times a week. 50% of the participants reported having had more than one accident since  
233 the obtention of their driving license. Then, regarding at-fault accidents, 29.79% of the sample  
234 reported being at fault for at least of one accident. The number of emergency maneuvers  
235 reported by participants in the previous week ranged from 0 (64.15%) to more than 2 (9.75%).

236 **2.1.2. Procedure**

237 The development of a scale measuring implicit theories in driving was based on the  
 238 scale developed by Dweck (1999), which measures implicit theories of intelligence. Dweck’s  
 239 scale has been modified to apply to the field of driving. Terms related to intelligence such as  
 240 “amount of intelligence” have been modified to “driving level” and the initial items have been  
 241 adjusted to be transposed to the driving domain. Some additional items were proposed,  
 242 respecting the theoretical framework of Dweck’s scale (2000).

243 The participants completed either a web-based or paper questionnaire. The use of these  
 244 two collection methods resulted in the most representative sample, with similar results being  
 245 obtained with both methods (Birnbaum, 2000; Buchanan & Smith, 1999). For the paper  
 246 session, participants volunteered to answer on their own, without interaction with the  
 247 researcher and other participants. For the web version, 100 participants were recruited through  
 248 social networks (e.g., Facebook, LinkedIn). A brief description of the study, the time required  
 249 to complete the questionnaire (approximately 10min) and the link to access it were  
 250 provided. Participants were then invited to share the questionnaire with three people close to  
 251 them. The only inclusion criterion was a category B driving license. The study met the  
 252 requirements of the institutional boards of XXX, XXX, and the XXX (n°2004-801). It was  
 253 conducted in accordance with the Declaration of Helsinki. Consent was requested beforehand,  
 254 and participants’ responses were completely anonymous.

255 **2.1.3. Measures**

256 **Implicit theories in driving.** Incremental and entity beliefs were measured with the  
 257 scale developed for this study, called ITDQ (Implicit Theories in Driving Questionnaire).  
 258 Participants responded to items using a Likert scale ranging from 1 (strongly disagree) to 5  
 259 (strongly agree). The description of the scale, its factorial structure, and its internal  
 260 consistency are presented in the Results section.

261           **Demographic information.** Information usually collected in traffic psychology  
 262 studies, such as age, gender, years of driving experience, and annual mileage, was obtained  
 263 from the participants. In addition, self-reported information on driving was requested: number  
 264 of accidents since licensing, number of at-fault accidents, and number of emergency  
 265 maneuvers performed in the previous week. So as to get more representative indicators, the  
 266 numbers of accidents and at-fault accidents were divided by the number of years of driving.

267           2.1.4. *Data analyses*

268           Preliminary analyses were performed to detect missing values and to detect outliers  
 269 using the Mahalanobis distance (In'nami & Koizumi, 2013). Skewness (values  $\leq |2|$ ) and  
 270 kurtosis (values  $\leq |7|$ ) were used to test the univariate normality of the main variables,  
 271 following the recommendations of Curran et al. (1996). Then, descriptive statistics and  
 272 correlations between variables were calculated (see Table 1).

273           Main analyses were then conducted. First, a Confirmatory Factor Analysis (CFA) was  
 274 carried out with the JASP software (version 13.1.0) to test the internal validity of the ITDQ.  
 275 The adjustment indices used in the study were the Comparative Fit Index (CFI), the Tucker-  
 276 Lewis Index (TLI), the Standardized Root Mean Square Residual (SRMR), and the Root  
 277 Mean Square Error of Approximation (RMSEA). The criteria for a good fitting model were  
 278  $CFI \geq .95$ ,  $TLI \geq .95$ ,  $SRMR \leq .08$  and  $RMSEA \leq .05$ , and the criteria for an acceptable fitting  
 279 model were  $CFI \geq .90$ ,  $TLI \geq .90$ ,  $SRMR \leq .08$  and  $RMSEA \leq .08$  (Byrne, 2010). A value of  $\leq$   
 280  $.10$  is also considered acceptable for RMSEA (Blunch, 2008). Secondly, we tested the  
 281 convergent validity, using item reliability (each factor loading  $> .50$ ), composite reliability  
 282 (each factor  $> .70$ ), and the average variance extracted ( $AVE > .70$  for each factor), following  
 283 the recommendations of Hair et al. (2006). Thirdly, we assessed discriminant validity: an item  
 284 is considered as independent of another if the  $\sqrt{AVE}$  is higher than the correlation between the  
 285 factor and other factors of the model. We calculated McDonald's omegas to assess the

286 internal consistency. They must be superior to .70 (Dunn et al., 2014) to be considered  
287 acceptable.

288 Finally, we performed correlation analyses and multiple regression analyses to  
289 estimate whether the two implicit beliefs predicted accidents, at-fault accidents and  
290 emergency maneuvers, controlling for gender, age, annual mileage, and years of driving  
291 license, in order to evaluate the concurrent validity of the ITDQ.

## 292 **2.2. Results**

### 293 **2.2.1. Preliminary results**

294 First, 0.64% of the initial data was missing and was replaced by the participants' mean  
295 of the item sub-scale (Roth et al., 1999). Eight participants were excluded from the study  
296 because they were detected as outliers based on a Mahalanobis distance at the multivariate  
297 level greater than the critical value of  $\chi^2(9) = 27.88, p < .001$ . The distribution of the variables  
298 of interest was approximately normal, consistent with measures of skewness (maximum =  
299 0.664) and kurtosis (maximum = 2.102).

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300 Table 1. *Descriptive statistics of the final sample, correlations, internal consistency,*  
 301 *Skewness, Kurtosis, and discriminant validity.*  
 302

Variable	M	SD	1	2	3	4	5	6
1. Entity beliefs	1.86	0.72	<b>(.80)</b>					
2. Incremental beliefs	4.30	0.64	-.46***	<b>(.75)</b>				
3. Gender	0.43	0.50	0.13*	.00	-			
4. Age	30.68	12.78	.04	.02	.03	-		
5. Years of driving License	11.41	12.54	.03	.02	.03	.99***	-	
6. Annual mileage	11377	10445	.03	.01	.16**	.21***	0.22***	-
McDonald's omega	-	-	.79	.84	-	-	-	-
Skewness	-	-	0.664	-1.085	-	-	-	-
Kurtosis	-	-	-0.138	2.102	-	-	-	-

303 *Notes.* \* $p < .05$ , \*\* $p < .01$ , \*\*\* $p < .001$ , M = Mean, SD = Standard Deviation, Gender (boys = 1, girls  
 304 = 0), the diagonal elements in bold represent  $\sqrt{AVE}$  for the two implicit theories, AVE = Average  
 305 Variance Extracted.  
 306  
 307

### 308 2.2.2. Factorial structure

309 The CFA conducted on the covariance matrix of the 8-items (ITDQ) supported an  
 310 acceptable fitting model:  $\chi^2 (19, N = 318) = 38.75, p < .005$ , CFI = .979, TLI = .969, SRMR =  
 311 .036, RMSEA = .057. The standardized factor loadings ranged from .58 to .85, composite  
 312 reliability from .84 to .88, and AVE from .57 to .64 (see Table 2). Consequently, convergent  
 313 validity was supported. Finally, discriminant validity was evaluated to show whether each  
 314 implicit theory shares more variance with its items than the other implicit theory. The  
 315 discriminant validity was considered satisfactory (see Table 1) according to the  
 316 recommendations of Teo et al. (2009).

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317 Table 2. *French version of the ITDQ (English translation), construct reliability, and average variance*  
 318 *extracted.*

<b>Factors/Items:</b>			
<b>En conduite automobile,... (In driving,...)</b>	<b>SFL</b>	<b>CR</b>	<b>AVE</b>
<b>Factor 1: Entity beliefs</b>			
1. Même si on conduit beaucoup, on changera très peu son niveau <i>Even if you drive a lot, your driving skill level will barely change</i>	.58	.88	.64
3. Il est difficile de modifier son niveau <i>It is difficult to change your skill level</i>	.62		
5. Il est difficile de progresser <i>It is difficult to improve</i>	.71		
7. Même en pratiquant beaucoup, il est difficile d'améliorer sa conduite <i>Even if you practice a lot, it is difficult to improve your driving</i>	.85		
<b>Factor 2: Incremental beliefs</b>			
2. On peut toujours s'améliorer <i>You can always improve</i>	.75	.84	.57
4. La progression est toujours possible <i>Improvement is always possible</i>	.77		
6. Si on s'en donne les moyens, on s'améliore toujours <i>If you provide yourself with the means, you always improve</i>	.73		
8. Le niveau s'améliorera toujours si on fait ce qu'il faut pour ça <i>Your skill level will always improve if you do what it takes</i>	.78		

319 *Notes.* SFL = Standardized Factor Loading, CR = Composite Reliability, AVE = Average Variance  
 320 *Extracted*

321

### 322 **2.2.3. Concurrent validity**

323 Correlation analyses showed (Table 3) a positive relation between entity beliefs and  
 324 emergency maneuvers ( $r = -.12; p = .030$ ). The results of the multiple regression analyses  
 325 showed that incremental beliefs negatively predicted at-fault accidents ( $\beta = -.13; p = .049$ ), and  
 326 entity beliefs positively predicted emergency maneuvers ( $\beta = .16; p = .011$ ), controlling for  
 327 gender, age, years of driving license, and annual mileage. No significant relationship was  
 328 found between incremental beliefs ( $p = .604$ ) and accident, and also between entity beliefs ( $p =$   
 329  $.091$ ) and accidents. The detailed results of the multiple regression analyses are presented in  
 330 Table 4.



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Table 3 Correlations between accidents, responsible accidents, emergency maneuvers, and other variables.

	Accidents	Responsible accidents	Emergency maneuvers
Gender	.028	.015	-.052
Age	-.126*	-.058	-.008
Years of driving license	-.127*	-.059	-.010
Annual mileage	.055	.037	.222***
Entity beliefs	-.090	.017	.121*
Incremental beliefs	.014	-.107	-.008

336 *Note.* \* $p < .05$ , \*\* $p < .01$ , \*\*\* $p < .001$

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Table 4. Summary of multiple regression analyses predicting accidents, responsible accidents, and emergency maneuvers.

	Accidents		Responsible accidents		Emergency maneuvers	
	$R^2$	$\beta$	$R^2$	$\beta$	$R^2$	$\beta$
	.033		.019		.081***	
Gender		.03		.01		-.11*
Age		.03		.02		.12
Years of driving license		-.17		-.09		-.19
Annual mileage		.09		.05		.25***
Entity beliefs		-.11		-.04		.16*
Incremental beliefs		-.03		-.13*		.00

342 *Note.* \* $p < .05$ , \*\* $p < .01$ , \*\*\* $p < .001$

343

### 2.3. Discussion

344  
345 This study is the first to develop and validate a questionnaire measuring implicit  
346 theories in driving. The structure of the ITDQ (Implicit Theories in Driving Questionnaire)  
347 showed acceptable psychometric properties and the concurrent validity was assessed using  
348 main variables in driving (accidents, responsible accidents, and emergency maneuvers). Using  
349 the ITDQ, it is now possible to study the relationship between implicit theories and usual  
350 variables of interest in the driving domain (e.g., aggressive and ordinary violations, driving  
351 self-efficacy). Furthermore, the regression analyses highlighted that entity beliefs positively  
352 predicted emergency maneuvers and incremental beliefs negatively predicted responsible  
353 accidents. Entity beliefs in driving were linked with more negative outcomes than incremental

354 beliefs. This finding supports our general hypotheses and are consistent with the literature in  
 355 education and sport (Dweck & Molden, 2005; Warburton & Spray, 2017), which attest to the  
 356 concurrent validity of the ITDQ.

357

### 358 **3. Study 2**

#### 359 **3.1. Method**

##### 360 **3.1.1. Participants**

361 A total of 309 volunteers (131 women, 178 men,  $M_{age} = 36.95$ ,  $SD = 13.90$ , range =  
 362 20-78 years) participated in the study. All participants had a French category B driving license  
 363 ( $M_{years\ of\ driving\ license} = 18.23$  years,  $SD = 13.56$ , range = 0-59 years), with an annual  
 364 mileage of approximately 16 416 kilometers ( $SD = 13\ 354$ ).

##### 365 **3.1.2. Procedure**

366 Participants completed the questionnaire in online sessions only. As in Study 1, it was  
 367 distributed through social networks (e.g., LinkedIn) and an email list. Participants completed  
 368 the questionnaire individually and anonymously; consent was obtained before completion.  
 369 The study followed the same ethical requirements as Study 1.

##### 370 **3.1.3. Measures**

371 **Implicit theories in driving.** The two implicit beliefs in driving were measured using  
 372 the ITDQ scale that has been developed in study 1. Entity beliefs (e.g., “*In driving, It is*  
 373 *difficult to change your skill level*”) and incremental beliefs (e.g., “*In driving, improvement is*  
 374 *always possible*”) were assessed with a five level Likert scale ranging from 1 (strongly  
 375 disagree) to 5 (strongly agree). According to the recommendations of Blunch (2008), Byrne  
 376 (2010), and Hu and Bentler (1999), the first results of the CFA were not acceptable:  $\chi^2 (19, N$   
 377  $= 309) = 108.03, p < .001, CFI = .900, TLI = .853, SRMR = .059, RMSEA = .123$ . The JASP  
 378 software suggested modification indices, consisting in adding covariance errors between item

379 3 and 4 of incremental subscale, and between item 1 and 3 of entity subscale. After this step,  
 380 the results showed an acceptable fitting model:  $\chi^2 (17, N = 309) = 62.57, p < .001, CFI = .949,$   
 381  $TLI = .916, SRMR = .048, RMSEA = .093$ . Internal consistency was satisfactory for the  
 382 entity ( $\omega = .76$ ) and for the incremental ( $\omega = .82$ ) subscales.

383 **Driving self-efficacy.** The scale developed by Boccara et al. (2011) was used to assess  
 384 driving self-efficacy. The two items focusing on driving license test and driving lessons were  
 385 removed, so that participants responded to 10 items (e.g., “*I make driving mistakes*”). A  
 386 seven-level Likert scale ranging from 1 (strongly disagree) to 7 (strongly agree) was used to  
 387 answer the questions. The first results of the CFA were unsatisfactory:  $\chi^2 (35, N = 309) =$   
 388  $172.98, p < .001, CFI = .823, TLI = .773, SRMR = .071, RMSEA = 0.113$ . Modification  
 389 indices suggested adding covariance errors between items 7 and 8, between items 4 and 5, and  
 390 between items 9 and 10 to improve model fit:  $\chi^2 (32, N = 309) = 75.29, p < .001, CFI = .944,$   
 391  $TLI = .922, SRMR = .051, RMSEA = .066$ . Internal consistency was satisfactory ( $\omega = .73$ ).

392 **Violations.** Ordinary and aggressive violations were assessed using two subscales of  
 393 the French version of the Driver Behavior Questionnaire (Guého et al., 2014). Ordinary  
 394 violations were measured by six items (e.g., “*You ignore the speed limit in a residential*  
 395 *area*”), and aggressive violations were measured by six items (e.g., “*You get angry at another*  
 396 *driver and you chase him to let him know how you feel about him*”). Participants responded  
 397 on a scale from 1 (never) to 6 (almost all the time). The results of the first CFA were not  
 398 acceptable for CFI and TLI:  $\chi^2 (53, N = 309) = 155.84, p < .001, CFI = .825, TLI = .783,$   
 399  $SRMR = .070, RMSEA = 0.079$ . Following the modification indices suggested by JASP  
 400 software, covariance errors were added between items 5 and 6, between items 3 and 5 of  
 401 ordinary violations subscale, between items 5 and 6, between items 2 and 5, between items 2  
 402 and 6 of aggressive violations subscale, to improve model fit:  $\chi^2 (53, N = 309) = 85.54, p <$   
 403  $0.001, CFI = .936, TLI = .912, SRMR = .048, RMSEA = .050$ . Internal consistency for

404 aggressive violations ( $\omega = .66$ ) and ordinary violations ( $\omega = .67$ ) was somewhat low.  
405 However, these results are consistent with those obtained in the validation study of the French  
406 version of the Driver Behavior Questionnaire (Guého et al., 2014), in which Cronbach's  
407 alphas were acceptable for aggressive violations ( $\alpha = .72$ ) and low for ordinary violations ( $\alpha =$   
408  $.64$ ).

### 409 **3.1.4. Data analyses**

410 In a first step, preliminary analyses were conducted to detect outliers using the  
411 Mahalanobis distance (In'nami & Koizumi, 2013) and to test the normality of the main  
412 variables (Curran et al., 1996) using skewness (values  $\leq |2|$ ) and kurtosis (values  $\leq |7|$ ). In a  
413 second step, correlation analyses and multiple regression analyses were conducted to assess  
414 whether gender, age, years of driving license, annual mileage, and implicit theories were  
415 predictors of violations and self-efficacy. Finally, we conducted moderation analyses to  
416 evaluate the moderating role of gender on the relationship between the two implicit theories  
417 and violations, along with driving self-efficacy.

## 418 **3.2. Results**

### 419 **3.2.1. Preliminary results**

420 Five participants were excluded from the study because they were detected as outliers  
421 based on a Mahalanobis distance at the multivariate level greater than the critical value of  
422  $\chi^2(9) = 27.88, p < .001$ . The distribution of the variables of interest was approximately  
423 normal, consistent with measures of skewness (maximum = 0.989) and kurtosis (maximum =  
424 1.288). The results are presented in Table 5.

425

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428

429 Table 5. *Descriptive statistics of the final sample (without outliers), internal consistency,*  
 430 *Skewness, and Kurtosis.*

	Entity beliefs	Incremental beliefs	Driving self-efficacy	Aggressive violations	Ordinary violations
Mean	2.12	4.42	5.65	1.99	2.02
Standard deviation	0.85	0.64	0.67	0.71	0.75
McDonald's omega	.76	.82	.73	.66	.67
Skewness	0.639	-1.168	-0.296	0.989	0.827
Kurtosis	-0.252	1.288	-0.225	1.099	0.486

431

432 **3.2.2. Correlation analyses and regression analyses**

433 Correlational analyses (Table 6) showed that incremental beliefs were positively  
 434 related to driving self-efficacy ( $r = .14; p = .011$ ) and entity beliefs were negatively related to  
 435 driving self-efficacy ( $r = -.19; p < .001$ ).

436

437 Table 6. Correlation analyses between aggressive violations, ordinary violations, driving self-  
 438 efficacy and other variables.

439

	Aggressive violations	Ordinary violations	Driving self-efficacy
Gender	.161**	.177**	.097
Age	-.269***	-.281***	.005
Years of driving license	-.252***	-.267***	.015
Annual mileage	.058	.188***	.082
Entity beliefs	.076	.016	-.194***
Incremental beliefs	-.004	-.013	.137*

440 *Note.* \* $p < .05$ , \*\* $p < .01$ , \*\*\* $p < .001$

441

442 The results of the multiple regression analyses showed that entity beliefs positively  
 443 predicted aggressive violations ( $\beta = .18; p = .049$ ), and negatively predicted self-efficacy ( $\beta = -$   
 444  $.23; p = .015$ ), controlling for gender, age, years of driving license, and annual mileage. No  
 445 significant relationship was found between entity beliefs and ordinary violations ( $\beta = -.07; p =$   
 446  $.434$ ). Incremental beliefs were negative predictors of both ordinary violations ( $\beta = -.20; p =$   
 447  $.035$ ) and driving self-efficacy ( $\beta = .20; p = .032$ ), controlling for the same variables. There  
 448 was no relationship between incremental beliefs and aggressive violations ( $\beta = .08; p = .411$ ).

449 The detailed results of the regression analyses are presented in Table 7.

450 **3.2.3. Moderation analysis**

451 Only one interaction effect between incremental beliefs and gender was found for  
 452 ordinary violations ( $\beta = .22$ ;  $p = .020$ ).

453 Table 7. Summary of multiple regression analyses predicting aggressive violations, ordinary  
 454 violations, and self-efficacy in driving.

	Aggressive violations		Ordinary violations		Driving self-efficacy	
	$R^2$	$\beta$	$R^2$	$\beta$	$R^2$	$\beta$
	.105***		.133***		.076	
Gender		.12*		.13*		.07
Age		-.67*		-.74*		-.03
Years of driving license		.42		.48		.05
Annual mileage		-.04		.07		.07
Entity beliefs		.18*		-.07		-.23*
Incremental beliefs		.08		-.20*		.20*
Entity X Gender		-.12		.11		.09
Incremental X Gender		-.05		.22*		-.18

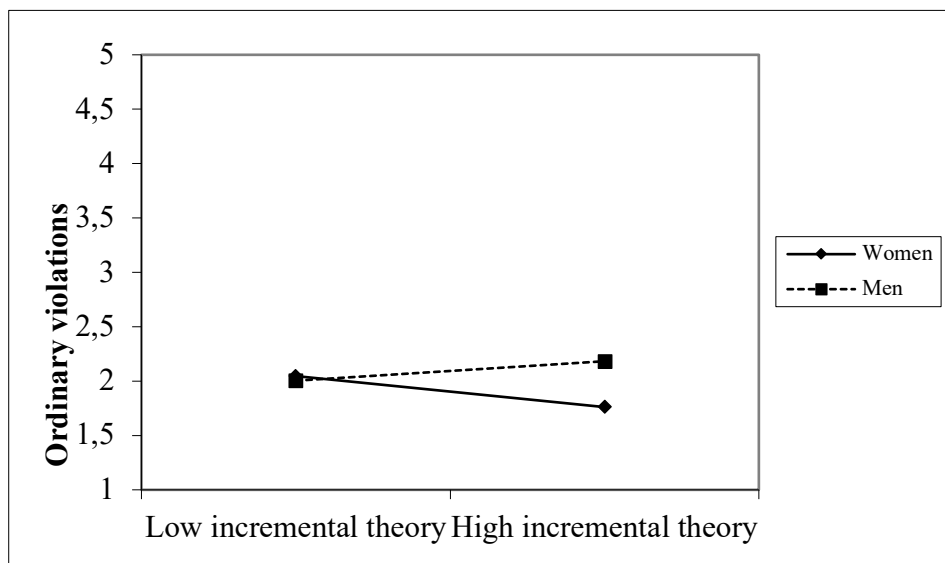
456 Note. \* $p < .05$ , \*\* $p < .01$ , \*\*\* $p < .001$

457

458 Simple slopes analyses showed that women with high incremental beliefs commit  
 459 fewer violations than women with low incremental beliefs ( $p < .001$ ). The results are not  
 460 significant for men ( $p = .312$ ). The results are graphed in Figure 1.

461 Figure 1. The interaction between incremental beliefs and gender in predicting ordinary  
 462 violations.

463



464

465        **3.3. Discussion**

466            Study 2 showed the predictive role of implicit theories on aggressive and ordinary  
 467 violations, on driving self-efficacy, and the moderating role of gender. Entity beliefs were  
 468 found to be positive predictors of aggressive violations. It is difficult to compare these results  
 469 directly with other findings in driving, since to our knowledge there are no other studies than  
 470 the previous two. However, aggressive or ordinary violations in driving can be compared with  
 471 cheating in sport, or aggressive behavior in other domains. Hence, our results are in line with  
 472 those observed in the domains of sport and intelligence, in which entity beliefs are positive  
 473 predictors of cheating acceptability and the desire for revenge after failure (Corrion et al.,  
 474 2010; Yeager et al., 2011). Moreover, the present study found that entity beliefs negatively  
 475 predicted self-efficacy in driving, indicating that individuals who believe that driving abilities  
 476 are stable and not improvable tend to be less confident in their driving. This finding  
 477 confirmed our hypothesis 2 and previous results found in the field of education (Diseth et al.,  
 478 2014; Komarraju & Nadler, 2013). The results also showed that incremental beliefs  
 479 negatively predicted ordinary violations, which is in accordance with our hypothesis 4. This  
 480 result corroborates the findings of Yeager et al. (2011) who found that people who pursue an  
 481 incremental belief have less desire for revenge than those who pursue entity beliefs. People  
 482 who think that ability is malleable are less prone to aggressive behavior. As expected  
 483 (Hypothesis 1), incremental beliefs were positive predictors of driving self-efficacy. This is  
 484 consistent with the results observed in sport (Kasimatis et al., 1996) and education (Diseth et  
 485 al., 2014).

486            Finally, gender moderates the relationship between incremental beliefs and ordinary  
 487 violations, indicating that women with high incremental beliefs committed fewer ordinary  
 488 violations than women with a low level of incremental beliefs. This finding was predictable  
 489 because a higher level of incremental beliefs was related to more positive outcomes, such as  
 490 fewer ordinary violations in the present study. But this result was significant for women only,

491 maybe because men have in general a higher level of incremental beliefs than women in other  
492 domains than driving (Li et al., 2006).

493

### 494 **4. General discussion**

495         The present research is the first to develop and validate a scale (ITDQ) measuring  
496 implicit theories in the driving domain and to evaluate the predictive role of implicit theories  
497 in driving. The development and the validation of the ITDQ were successful. The factorial  
498 structure (i.e., internal validity, convergent validity, discriminant validity, and internal  
499 consistency) was found satisfactory. Secondly, the concurrent validity was tested, and it was  
500 found that entity beliefs were positive predictors of a negative outcome (i.e., emergency  
501 maneuvers) and that incremental beliefs were negative predictors of a negative outcome (i.e.,  
502 responsible accidents). These results are consistent with the literature in education (Costa &  
503 Faria, 2018) and sport (Biddle et al., 2003). Indeed, in many studies in these domains,  
504 incremental beliefs were linked with adaptative outcomes (e.g., intrinsic motivation,  
505 performance, enjoyment, effort, perceived competence, lower level of anxiety and cheating  
506 acceptability). Conversely, entity beliefs were associated with non-adaptive and negative  
507 outcomes (e.g., cheating acceptability, high level of anxiety, hostile intent). Based on these  
508 results, we can recommend using the ITDQ to assess implicit theories in the driving domain.  
509 The future use of the IDTQ will improve the knowledge of implicit theories in driving, in  
510 order to adapt the training of drivers to their psychological profile.

511         Study 2 confirmed the results observed in study 1 and showed that entity beliefs were  
512 positively related to negative outcomes (i.e., aggressive violations) and negatively related to  
513 positive outcomes (i.e., self-efficacy). Secondly, Study 2 showed that incremental beliefs  
514 positively predicted driving self-efficacy and negatively predicted ordinary violations.  
515 Moreover, a moderating role of gender was found between incremental beliefs and ordinary



516 violations, indicating that women who are more inclined to believe that driving is a malleable  
517 ability committed more ordinary violations than women with lower incremental beliefs.

518 All these results cannot be directly compared to other studies in driving, but they are in  
519 accordance with our hypotheses, and also consistent with findings observed in various  
520 education and sport studies (Guého et al., 2014; Vella et al., 2016; Warburton & Spray, 2017).  
521 Indeed, the positive relationship between entity beliefs and aggressive violations in driving is  
522 in accordance with our hypothesis 5 and the findings observed in education by Yeager et al.  
523 (2011). The authors found that entity beliefs were positively related to a desire for revenge  
524 after conflict with peers, and this desire for revenge in education appeared to correspond to  
525 aggressive driving behavior. This relationship demonstrates that individuals who pursue entity  
526 beliefs are more likely to adopt aggressive and risky driving behavior. Conversely, the  
527 negative relationship between incremental beliefs and ordinary violations is consistent with  
528 our hypothesis 4, and the results observed in education by Yeager et al. (2013a). They found  
529 that incremental beliefs could reduce the desire for revenge after failure. According to these  
530 results, a driver who believes that driving ability is malleable seems to pursue a safer driving  
531 behavior than entity theorists do.

532 Concerning driving self-efficacy, the positive relationship with incremental beliefs and  
533 the negative relationship with entity beliefs support our hypotheses 1 and 2, as well as the  
534 findings obtained in education and sport (Komarraju & Nadler, 2013; Moritz et al., 2000). In  
535 education and sport, self-efficacy is positively linked with performance and motivation  
536 (Bandura & Locke, 2003; Feltz et al., 2008). In driving, it has been observed that an  
537 overestimation of driving self-efficacy in young drivers is linked to risky driving behavior  
538 (Delhomme, 1991, 1994). The adoption of incremental beliefs can result in more adaptive  
539 driving outcomes, if they do not overestimate driving self-efficacy in young drivers. The

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540 pursuit of incremental beliefs seems to be the most beneficial for driving, contrary to entity  
541 beliefs.

542         The present research is not without limitations. First, both studies took place in one  
543 country (France). Since driving style differs from country to country (Özkan et al., 2006),  
544 cross-cultural studies are needed to examine whether the same pattern of results may be found  
545 in other countries. Secondly, the sample size could be larger to increase the proportion of  
546 under-represented people (> 65 years old), in order to generalize the results, and also because  
547 driving behaviors are different across age groups (Jonah, 1990). Finally, the driving variables  
548 used in the present research are self-reported measures. It could be relevant to use objective  
549 criteria developed by Naturalistic Driving Studies (Jamson et al., 2008; Naude et al., 2017),  
550 and to cross with implicit theories in order to assess whether the adoption of incremental or  
551 entity beliefs predicts objective driving behaviors (e.g., number of road incidents).

552         Complementarily, in sport, education and personality, a few studies tried to manipulate  
553 the beliefs in order to positively influence behavior. In education, Yeager et al. (2019)  
554 implemented a light protocol (less than an hour) of teaching incremental beliefs to 12 490  
555 students and observed a positive effect on grades. Orvidas et al. (2018) fostered incremental  
556 fitness beliefs, with a basic manipulation (i.e., reading a text reinforcing the malleability of  
557 fitness), and highlighted a significant increase in intention to exercise. Yeager et al. (2013b)  
558 manipulated incremental personality beliefs and showed a significant decrease in aggressivity  
559 after a victimization experience. According to these studies, it might be relevant to manipulate  
560 drivers' implicit theories to induce safer driving behavior. We could also adapt the training  
561 course of drivers, presenting both types of beliefs so that learner drivers are informed about  
562 them, and then encouraging the adoption of incremental beliefs. The promotion of incremental  
563 driving beliefs could follow the recommendations proposed by Vella et al. (2014): focusing  
564 on effort and persistence (e.g., emphasize the importance of driving a lot and continue even if

565 you make mistakes); facilitating challenge (e.g., encourage them to carry out difficult  
566 maneuvers or driving in difficult situations); defining success as effort (e.g., it is through  
567 effort that we can become a good driver); promoting learning (e.g., show that learning is  
568 essential to becoming a good driver); providing high expectations (e.g., expecting the success  
569 of all the maneuvers performed). The recommendation "promoting the value of failure" proposed  
570 by Vella et al. (2014) cannot be implemented in the driving domain, because it may be related to  
571 driving events or even to accidents. This manipulation of incremental beliefs could take place  
572 during point recovery courses, during driver training, and during prevention messages.

573

### 574 **5. Conclusions**

575         Prior to this present research, implicit theories had been widely developed in different  
576 domains (e.g., education, sport), but never in the driving domain. This research filled this  
577 lack. A questionnaire, called Implicit Theories in Driving Questionnaire (ITDQ), was  
578 developed and validated to measure implicit theories in driving. The scale was validated using  
579 a confirmatory factor analysis, and regression analyses were performed between the two  
580 implicit beliefs and accidents, at-fault accidents, and emergency maneuvers to test the  
581 concurrent validity of the scale. The second study showed that entity beliefs are linked with  
582 maladaptive outcomes (i.e., aggressive violations, low level of driving self-efficacy), while  
583 incremental beliefs are linked with positive outcomes (i.e., low level of ordinary violations,  
584 high level of driving self-efficacy). A moderating role of gender between incremental beliefs  
585 and ordinary violations was found. All these results are in line with findings in other domains.  
586 From now on, the IDTQ is available to assess drivers' implicit theories, thus improving  
587 knowledge of drivers' psychological characteristics. Furthermore, it will be possible to adapt  
588 drivers' learning to their implicit beliefs, so they can adopt the safest behaviors. Future

589 research can also attempt to modify the implicit theories of at-risk drivers in order to change  
590 their behavior, in order to reduce the number of crashes and improve road safety.

591

592 **Acknowledgments**

593 The authors would like to acknowledge Valentine Naude for her proofreading of the English  
594 version of the article.

595

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