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Transport Research Arena (TRA) Conference

# Predictive role of achievement goals on objective driving behavior

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## Abstract

Investigating psychological characteristics and dynamic behaviors can provide insight in the behavior of at-risk drivers. Achievement goals in driving have recently been studied to assess driver motivation. The four achievement goals in driving are mastery-approach, performance-approach, mastery-avoidance, and performance-avoidance. Naturalistic Driving Studies provide access to objective measurements of driving (i.e., speed, acceleration). Three dynamic criteria have been developed to objectively characterize driver behavior. The aim of this study was to examine the predictive role of achievement goals on objective driving behaviors. During 8 months, 4,626,379 km of 299 drivers was recorded, and simultaneously, the Achievement Goals in Driving Questionnaire was completed. Mastery-approach goals seem to be the most protective goals in driving, as opposed to performance-approach goals.

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*Keywords:* achievement goals; data recorder; objective measures; driving behavior; self-reported measures; motivation in driving

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## 1. Introduction

In Europe, 80,559 people died in road accidents in 2016 (WHO Regional Office for Europe, 2020), and approximately 3 million people were injured. In France, in 2019, 3,239 people died on the road, which involved 1,621 motorists (ONISR, 2020). Road accidents represent the major cause of death among young people aged 15 to 24. Road safety remains a major societal issue. Based on the studies of Blanco (2013) and Van Eslande (2000), human error is involved in 70 to 90% of cases. For this purpose, driving behavior can be investigated through self-reported

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studies of psychological characteristics (e.g., anger, sensation seeking, self-efficacy), or also by dynamic behavior studies with objective measures (e.g., speed, acceleration, driving events). In this study we were interested in the crossing of these two types of studies. Indeed, we investigated achievement goals in driving with dynamic behaviors. The study of achievement goals allows to better understand the motivation of individuals who are engaged in driving. This theoretical framework in driving is very recent (Mascret et al., 2020, 2021). A new kind of research has been developed called Naturalistic Driving Studies (NDS), to investigate driving behavior under usual conditions. It provides access to objective data such as longitudinal and lateral acceleration, GPS speed and position, measured using on-board recorders or smartphones installed in cars.

### *1.1. Achievement goals*

Achievement goals have been extensively studied in the literature in sport, education, and work, to assess the motivation of individuals engaged in an achievement context. In driving, this theoretical framework has been studied very recently (Mascret et al., 2020,2021) It can be described as the way in which the individual values the demonstration of his/her competence or avoids the demonstration of his/her incompetence in relation to him/herself or to others.

The studies that led to the conceptualization of achievement goals were conducted by Dweck and Elliot (1983), Maehr and Nicholls (1980) and Nicholls (1984). Then it was Elliot (1999) and Pintrich (2000) who developed the 2x2 model, which is currently the most widely used in the literature on achievement goals. Mascret et al (2020) were the first to introduce this theoretical framework in driving in order to study drivers' achievement motivation. In driving, the four goals which constitute this model represent: a driver who seeks to improve his or her driving skills and master the driving task (mastery-approach goal), a driver who wants to be better than other drivers (performance-approach goal), a driver who wants to avoid driving badly and making driving errors (mastery-avoidance goal), and a driver who wants to avoid being the worst driver (performance-avoidance). Mastery approach goals have been found to positively predict only interest in driving (Mascret et al., 2020), whereas in the literature these goals are most related to positive consequences (Van Yperen et al., 2014). In driving, mastery-avoidance goals were found to be negatively related to self-reported accidents, self-reported at-fault accidents, and violations (Mascret et al., 2020, 2021). Surprisingly, mastery-avoidance goals seem to have a protective role in the driving context. Indeed, in other domains, this goal is contrastingly linked to positive consequences (Baranik et al., 2010). Conversely, performance-approach goals were found to be related to the most negative effects on driving such as violations and sensation seeking (Mascret et al. 2021), which contrasts with findings in the literature in others domains where performance-approach goals are sometimes linked to positive outcomes (Baranik et al., 2007). Concerning performance-avoidance goals, they are positively related to aggressive violations in driving (Mascret et al., 2021), which consistent with findings in others domains (Lochbaum & Gottardy, 2015).

Self-reported driving behavior variables (e.g., accidents, violations etc.), which have been related to achievement goals in studies conducted by Mascret et al. (2020,2021), have the benefit to be low-cost and easy to collect from a large sample. However, this kind of measures can be affected by recall bias (Blanchard & Myers, 2010), social desirability (af Wåhlberg, 2010) and participant rough estimates (Grengs et al., 2008). NDSs provide access to objective driving behaviors obtained under ordinary driving conditions, as well as data unavailable through self-reported measures such as speed, accelerations, GPS positions etc.

### *1.2. Naturalistic Driving Studies*

These studies consist in equipping volunteer cars with an Event Data Recorder (EDR) or a smartphone application, to continuously record their driving, for a few months to several years (Dingus et al., 2006). These studies provide access to real driver behavior, to study crashes, near-crashes, and incidents. The first NDS was conducted by Dingus et al. (2006), named U.S 100 car driving study. Afterwards, many NDSs were conducted: in 2020 Singh and Kathuria (2021) identified a total of 135 NDS in the literature. Variables have been conceptualized, such as driving incidents,

extent of dynamic demands, and percentages of time spent above acceleration thresholds, to characterize driving behavior.

Near-crashes, incidents or so-called “events” are often studied in NDS instead of crashes (Dingus et al., 2006). Indeed, the low occurrence of crashes does not allow a sufficient comprehension of the behavior during these events. Moreover, Wu et al (2014) observed a positive relationship between crashes, near-crashes and crash-relevant accidents. During a one-year recording period, (Naude et al., 2017) observed 338 incidents on 51 drivers and estimate a ratio of one crash every 20,000 incidents. To determine the incidents, they used longitudinal and lateral acceleration, speed and jerk (i.e., derivative of acceleration). A ratio of the number of kilometers between each incident is then calculated. The lower the ratio, the more risky driving situations the driver is exposed to.

To evaluate drivers’ dynamic demands (i.e., acceleration/braking, right/left turn), (Lechner & Naude, 2011) have developed a “Travel synthesis”. They crossed longitudinal and transversal accelerations for every instant of a trip, to represent an extent of dynamic demands in a 2d matrix with  $1\text{m/s}^2$  intervals. The area of the 2d graph obtained represents the level of dynamic loads, and in particular the range of extreme values reached at least once. A large extent means that the driver loads the car considerably.

Lechner and Perrin (1993) and Naude et al. (2017) used percentages of time spent above longitudinal or transversal acceleration thresholds, to assess high acceleration, braking and cornering demands. According to these authors exceeding  $3\text{ m/s}^2$  in transversal acceleration is an unusual behavior (occurring only 2% of the time) and even more infrequently in longitudinal acceleration (0.4%-0.5% of the time). Individuals who regularly exceed these percentages of the time would adopt a sportier driving, which may be risky driving depending on the driving situation.

Recently, NDSs have been cross-referenced with self-reported measures of personality traits or characteristics, such as anger (Precht et al., 2017), openness to experience, conscientiousness, extraversion, agreeableness, and neuroticism (Guo & Fang, 2013; Guo et al., 2016). To date achievement goals have not been related to objective driving behaviors measured by the NDSs.

### *1.3. Achievement goals and objective measures*

In the literature, achievement goals have often been related to objective measures and in particular to performance, Van Yperen et al. (2014) conducted a meta-analysis on the relationships between achievement goals and objective performance at work, sport and school. They identified that mastery-approach and performance-approach goals were positively associated with performance, in contrast to performance-avoidance and mastery-avoidance goals which were negatively related to performance. Van Yperen et al. (2014), also found a moderating role of the domain between achievement goals and performance. Indeed, mastery-avoidance goals were found to be negatively related to performance in education, but this relationship is not observed in the sport domain. It would be interesting to study whether this relationship is found in the driving domain.

Performance in the meta-analysis of Van Yperen et al. (2014), is defined from a global aspect: it can be identified as the result of tests, results of competitions, evaluation of coaches, teachers. In driving, it is difficult to define performance, however, it can be considered as the safest driving. This driving performance can be characterized by incidents, percentage of time spent above an acceleration threshold, or the extent of dynamic demands. However, there are no studies that examine the relationship between achievement goals and objective driving behaviors (i.e., incidents, percentage of time spent above an acceleration threshold, etc.), which is the aim of the present study.

### *1.4. Hypotheses*

In the literature, mastery-approach goals have been found to be the most adaptive goals across all domains (Van Yperen et al., 2014), and are positive predictors of interest in driving (Mascret et al., 2020). Therefore, we can expect that mastery-approach goals to be negatively related to incidents, extent of dynamic demands, and percentage of time spent over an acceleration threshold. Concerning performance-approach goal, the relationships are more contrasted, but it is sometimes linked to positive consequences such as performance (Van Yperen et al., 2014), whereas in driving these goals were found to be negatively related to self-reported driving behaviors (Mascret et al., 2021). We can expect performance-approach goals to be positive predictors of incidents, extent of dynamic demands, and percentage of time spent over an acceleration threshold. Mastery-avoidance goals are more contrastingly linked to performance (Van

Yperen et al., 2014), in driving: it has been observed that these goals may have a protective role, because they are positively related to self-reported driving variables (Mascret et al., 2020, 2021). Thus, these goals can be expected to be positively related to objective driving behavior. Performance-avoidance goals are negatively related to performance (Van Yperen et al., 2014), and they are positively related to aggressive violations in driving. Based on these findings, we can expect that these goals may be negatively related to incidents, extent of dynamic demands, and percentage of time spent over an acceleration threshold.

## 2. Method

### 2.1. Participants

A total of 299 French car drivers (114 women, 185 men,  $M_{age} = 42.27$  years,  $SD = 11.25$ ) took part in the study. All participants had a French category B driving license ( $M_{years\ of\ driving\ license} = 22.08$  years,  $SD = 12.07$ ). The total mileage of 4,623,379 kilometers ( $M_{mileage\ of\ drivers} = 15,472$  km,  $SD = 8,925$ ).

### 2.2. Procedure

Participants completed individually and anonymously a questionnaire assessing achievement goals in driving. Consent was obtained before the completion. Simultaneously, all cars were equipped with a data recorder called “Dwilen” (developed by DDI an initiative of the Michelin Company), to assess the driver’s behavior. This data recorder is equipped with a GPS with an acquisition frequency of 1 Hz, and a three-dimension accelerometer (i.e., x: transversal acceleration, y: longitudinal acceleration, and z: vertical acceleration) with an acquisition frequency of 5 Hz. During 8 months, a total of 35,801 hours of driving were recorded. The study met the requirements of the institutional board of Aix-Marseille University and the Commission Nationale de l’Informatique et des Libertés (n°2004–801).

### 2.3. Measures

**Achievement Goals in driving.** The four achievement goals were measured using the Achievement Goal Questionnaire in Driving (AGQ-D, Mascret et al., 2020). To assess mastery-approach goals (e.g., “*My goal is to progress as much as possible*”), mastery-avoidance goals (e.g., “*My goal is to avoid making mistakes*”), performance-approach goals (e.g., “*I am striving to be superior to others*”), and performance-avoidance goals (e.g., “*My goal is to avoid driving less well than others*”) a Likert scale ranging from 1 (completely agree) to 5 (completely disagree) was used. The results of the confirmatory factor analysis (CFA) showed an acceptable fitting model (Byrne, 2010; Hu & Bentler, 1999):  $\chi^2(48, N = 299) = 124.43, p < .001, CFI = .936, TLI = .912, SRMR = .053, RMSEA = .073$ . Through McDonald’s omega, internal consistency was considered acceptable for each subscale above 0.70 threshold (Dunn et al., 2014).

**Longitudinal Accelerations.** A distribution of longitudinal acceleration every 1 m/s<sup>2</sup> was performed. A percentage of time spent by drivers above 3 m/s<sup>2</sup> was calculated. A high percentage means that the driver performs significant accelerations. A percentage of time below -3 m/s<sup>2</sup> was also measured. The higher the percentage, the more braking the person achieves. These thresholds were used by Klauer et al. (2009) and also by Lechner and Perrin (1993) to study strong braking and acceleration.

**Lateral Accelerations.** As for the longitudinal acceleration, a distribution every 1 m/s<sup>2</sup> was performed and then the percentage of time spent above 3 m/s<sup>2</sup> was calculated. This threshold was used by Klauer et al. (2009) and also by Lechner and Perrin (1993) to assess high cornering demands. A high percentage means that the driver stresses the vehicle heavily during cornering. Right and left turns were also separated to see if there is an influence of the type of turn.

**Incidents.** An incident can be considered as a critical situation, in which the driver stresses his vehicle heavily in the longitudinal, lateral or combined directions. Incident identification was based on the work of Naude et al. (2017).

It is necessary to measure the longitudinal, lateral acceleration and Jerk (derived from acceleration). Naude et al. (2017) developed these criteria with an acquisition frequency of 100 Hz. It was necessary to adapt these criteria to the acquisition frequency of 5 Hz (acquisition frequency of the data recorder used).

The thresholds used in the study are:

- Acceleration norm (x and y) > 6 m/s<sup>2</sup> & Jerk norm (x and y) > 3 m/s<sup>3</sup>

A ratio of the driving time (in minutes) between two incidents was calculated. The higher the ratio, the smoother the driver's driving style, the lower the ratio and the more risky driving situations the driver is exposed to.

**The extent of dynamic loading.** This criterion consists of the combination of longitudinal and lateral acceleration, to form a 2d matrix. We are interested here in the percentage of filling of the matrix, which will allow us to characterize how an individual dynamically loads his vehicle. The higher the percentage, the more dynamically the driver stresses his vehicle, by strong acceleration, strong braking, or by strong lateral acceleration.

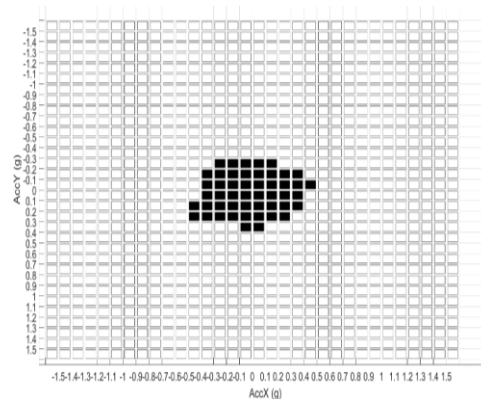


Fig.1. Example of extent of dynamic load 1

#### 2.4. Data analyses

In first, the Mahalanobis distance was used to detect outliers (In'nami & Koizumi, 2013). Based on the recommendations of Curran et al. (1996), Skewness (values  $\leq |2|$ ) and Kurtosis (values  $\leq |7|$ ) were also used to test the univariate normality of key variables. Secondly, descriptive statistics were performed. Then, multiple regression analyses were conducted to examine how the four achievement goals in driving were predictors of longitudinal acceleration (i.e., acceleration and braking), lateral accelerations (i.e., right and left turns), incidents, and the extent of dynamic demands, controlling for gender, age, years of driving license, and driving time.

### 3. Results

84 participants were detected as outliers, because their Mahalanobis distance was higher than the cut-off criteria of  $\chi^2(9) = 27.88$ ,  $p < .001$  (In'nami & Koizumi, 2013). The univariate normality of the mains variables was validated, according to the measures of skewness (max = .787) and kurtosis (max = .609).

Multiple regression analyses showed that mastery-approach goals positively predicted longitudinal acceleration higher than 3 m/s<sup>2</sup>, negatively predicted braking lower than -3 m/s<sup>2</sup> and global extent. These results mean that a person who seeks to drive better and better (i.e., mastery-approach goals), will accelerate more vigorously, brake less hard, and will stress more his vehicle. Performance-approach goals positively predicted acceleration above 3 m/s<sup>2</sup>; conversely performance-avoidance goals negatively predicted acceleration above 3 m/s<sup>2</sup>. These results mean that a driver who seeks to be better than the other will accelerate more. In contrast, the driver who wants to avoid being the

worst driver will accelerate less. There are no achievement goals that predict incidents and important lateral acceleration. The results of the multiple regression are presented in Table 1.

Table 1. Results of the regression analyses.

	Accelerations > 3 m/s <sup>2</sup>		Braking < -3 m/s <sup>2</sup>		Global extent		Incidents		Right turn > 3 m/s <sup>2</sup>		Left turn > 3 m/s <sup>2</sup>	
	R <sup>2</sup>	$\beta$	R <sup>2</sup>	$\beta$	R <sup>2</sup>	$\beta$	R <sup>2</sup>	$\beta$	R <sup>2</sup>	$\beta$	R <sup>2</sup>	$\beta$
<b>Model: Achievement goals</b>	.101		.060		.537		.129		.094		.053	
Gender		-.019		-.053		.026		-.038		-.134*		-.061
Age		-.111		-.150		.107		.225		-.412**		-.033
Years of driving license		.007		.053		-.066		-.255		.222		-.175
Driving time		-.181**		.109		.729***		.311***		-.096		-.019
Mastery-approach goals		.141*		-.189**		-.108*		-.118		-.103		-.005
Performance-approach goals		.255***		-.042		-.041		.026		.148		.110
Mastery-avoidance goals		-.035		.052		.091		-.029		-.022		.018
Performance-avoidance goals		-.153*		.060		.095		.047		.005		-.052

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

#### 4. Discussion

This is a pioneer study, because this is the first to investigate the predictive role of achievement goals on objective driving behaviors. Consequently, the results are difficult to related to others findings in driving, but it is possible to compare them with studies conducted in other domains (e.g., work, sport, education). Mastery-approach goals are positive predictors of high accelerations, which was not expected because it may be associated with a negative driving consequence, yet these goals in the literature are the most adaptive (Van Yperen et al., 2014). This result can be interpreted as follows: an individual who seeks to drive as well as possible will achieve heavy accelerations (i.e., > 3 m/s<sup>2</sup>), in order to feel a sense of control and mastery of the task which is an essential component of these goals (Mascret et al., 2020,2021). Consistent with our hypotheses and the literature in other domains (Payne et al., 2007), these goals were found to be negative predictors of hard braking (< -3 m/s<sup>2</sup>) and the extent of dynamic demands. Mastery-approach goals appear to be related to positive driving behaviors.

In this study, it was found that performance-approach goals were predictors of high acceleration. For these drivers, making heavy accelerations to overtake, or to restart after a stop, is a way to show their superiority to other drivers. This result is consistent with our hypotheses and with findings from the literature with self-reported variables (Mascret et al., 2021), where these individuals positively predict violations (aggressive and ordinary), and sensations seeking in driving. Further studies are needed to confirm whether these individuals are more likely to engage in risky driving.

Concerning performance-avoidance goals, it was observed that they negatively predict heavy accelerations. This is not consistent with our hypotheses and the results obtained in the literature. Indeed, at work or school these goals are more often linked to negative outcomes such as anxiety or negative affect (Elliot, 2005), and in driving they are negatively related to self-reported aggressive violations (Mascret et al., 2021). However, Van Yperen et al (2014), observed in sport that these goals were not always negatively related to objective performance, so the relationship observed in this study supports this result. This can be explained by the fact that the performance-avoidance goals are

strongly associated with fear of failure (Elliot, 1997). In driving, failure can be manifested by a crash, with consequences that can be severe. Therefore, individuals who want to avoid being the worst drivers, will accelerate less than others to avoid being failure.

Surprisingly, the protective role of mastery-approach goals in driving was not found in this study (Mascret et al., 2020, 2021). This absence of a relationship may be explained by the type of driving behavior measure, in this study we measured behavior objectively, whereas previous studies have measured self-reported behavior (Mascret et al., 2020,2021). In sport, Lochbaum and Gottardy (2015) observed a moderating role of the type of performance measure between achievement goals and sport performance. However, additional studies are needed to affirm that there is no positive relationship between mastery-avoidance goal and objective driving behaviors.

We can identify several limitations in this study that may open up future perspectives. First, this study took place in a single country and it would be interesting to see if the culture or the country could influence the relationships observed. Indeed, Hulleman et al. (2010), have shown that achievement goals can be affected by culture, and Özkan et al. (2006) observed that driving style can also vary by country. Secondly, our study was conducted on a sample of 299 individuals for 4,626,379 km recorded. Conducting a study on an even larger sample would provide a more representative driving data, including road type (i.e., highways, arterials, local streets etc.), relief (i.e., mountainous, hilly, plain). NDS such as the SHRP-2 conducted by Antin et al. (2011) were conducted on over 3,400 drivers, a sample size 11 times larger than our study. Thirdly, Van Yperen et al. (2015) have shown that it is possible to manipulate achievement goals in order to influence the behavior of individuals. Therefore, it would be interesting to promote the adoption of mastery goals in an attempt to modify the behaviors of the most at-risk drivers. This intervention could take place during driver training, during point recovery courses, or during road safety campaigns. Finally, in this study we were only interested in car drivers, who constitute 49 % of road deaths, but the second most affected population is the two-wheelers since in France they are involved in 22.8% of the accidents (ONISR, 2021), while they represent 1.9 % of the road users. It would be interesting to investigate the achievement goals and objective behaviors of two-wheelers, in order to improve our understanding of the risky behaviors of two-wheelers, and also improve their behavior and safety.

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