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The application of the random regret minimization model to drivers' choice of crash avoidance maneuvers

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ABSTRACT

This study explores the plausibility of regret minimization as behavioral paradigm underlying the choice of crash avoidance maneuvers. Alternatively to previous studies that considered utility maximization, this study applies the random regret minimization (RRM) model while assuming that drivers seek to minimize their anticipated regret from their corrective actions. The model accounts for driver attributes and behavior, critical events that made the crash imminent, vehicle and road characteristics, and environmental conditions. Analyzed data are retrieved from the General Estimates System (GES) crash database for the period between 2005 and 2009. The predictive ability of the RRM-based model is slightly superior to its RUM-based counterpart, namely the multinomial logit model (MNL) model. The marginal effects predicted by the RRM-based model are greater than those predicted by the RUM-based model, suggesting that both models should serve as a basis for evaluating crash scenarios and driver warning systems.

1. Introduction

Regret is a comparison-based emotion experienced when the outcome of the non-chosen alternative is perceived to be better than the outcome of the chosen alternative. Since regret is an intense negative feeling, individuals are motivated to minimize it by making prospective assessment about their future post-decisional level of regret as a part of their choice mechanism in economic and health related decisions (Chorus, Arentze, & Timmermans, 2008; Zeelenberg & Pieters, 2007). While regret was proposed as an alternative decision rule to utility maximization in decisions under uncertainty already in the 1980s (see, e.g., Loomes & Sugden, 1982, 1987), the conceptualization of regret theory, the development of regret-based probabilistic choice models and the empirical research regarding regret as a choice motivator are still at their beginning stage (see e.g., Chorus et al., 2008; Zeelenberg & Pieters, 2007).

The role of anticipated regret in decision making related to road safety has been confirmed in a handful of recent studies regarding drivers' intentions to engage in risky road behavior endangering other road users. Newnam, Watson, and Murray (2004) found that higher anticipated regret is positively correlated with lower intentions to exceed the speed limit. Falk and Montgomery (2007) found that remorse is among the anticipated emotions expressed by Swedish young drivers in the context of a hypothetical crash scenario involving another person killed or injured. Elliott and Thomson (2010) showed that anticipated regret was negatively associated with English drivers' intention to speed regardless of past speeding habits, although the effect of anticipated regret was mediated by past speeding habits for actual speeding behavior. Similarly, Chorlton, Conner, and Jamson (2011) uncovered that anticipated regret is negatively correlated with British motorcyclists' intention to ride in an

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extremely high-speed on rural roads, regardless of past speeding habits. Interestingly, research regarding the effect of anticipated regret on one's own risk provides contradicting evidence. While Şimşekoğlu and Lajunen (2008) found that anticipated regret has no significant effect on seat-belt use in Turkey, Haque et al. (2012) uncovered that anticipated regret is significantly and negatively correlated with the intentions of Australian young people to walk while intoxicated.

The current study focuses on exploring the hypothesis that regret minimization is a plausible behavioral paradigm underlying the choice of crash avoidance maneuvers in response to critical traffic events. The investigation of the determinants behind the tendency to perform lateral versus speed control maneuvers is drawing interest because research in active crash avoidance and driver assistance systems is gaining momentum (e.g., Coelingh, Eidehall, & Bengtsson, 2010; Ho, Reed, & Spence, 2006; Jermakian, 2011). Clearly, the preventive success of these systems greatly benefits from the understanding of human behavior in critical traffic events.

In particular, the current study explores the hypothesis that, while taking corrective actions, drivers seek to minimize their anticipated regret from the crash outcomes. The choice of crash avoidance maneuvers is conducted rapidly under time constraints and mental pressure, since the choice of corrective actions is linked to crash severity (Kaplan & Prato, 2012a). Regret minimization is a plausible behavioral mechanism for stressful, time-constrained actions leading to severe life consequences, since regret as a choice-associated feeling develops during early childhood already at 6–7 years of age (O'Connor, McCormack, & Feeney, 2012; Zeelenberg & Pieters, 2007), is experienced in difficult and important decisions with immediate outcomes (Zeelenberg & Pieters, 2007), triggers painful emotions (Kedia & Hilton, 2011), and has a long-lasting effect with little fading for self-caused important life events (Beike & Crone, 2008).

Despite the plausibility of anticipated regret as decision mechanism in crash avoidance maneuvers, previous studies (i.e., Yan, Harb, & Radwan, 2008; Harb, Yan, Radwan, & Su, 2009; Kaplan & Prato, 2012b) employed probabilistic models based on random utility maximization (RUM) to investigate the choice of crash avoidance maneuvers. Yan et al. (2008) linked the propensity to perform an evasive action to driver, road and vehicle characteristics by applying logistic regression. Harb et al. (2009) performed a similar analysis by implementing classification trees and random forests for various accident types including rear-end, head-on and angle collisions. Kaplan and Prato (2012b) analyzed the selection of crash avoidance maneuvers in relationship to driver attributes, critical events, crash characteristics, vehicles involved, road characteristics and environmental conditions, while considering similarity patterns across maneuver types and heteroscedasticity across drivers. The advantage of these models is related to their scientific rigor, the vast experience in their application, their implementation ease and their flexibility in accommodating complex structural assumptions. Nevertheless, the disadvantage of RUM-based models lies in the consideration of utility maximization as the sole cognitive mechanism behind drivers' choices of corrective maneuvers.

The current study explores the plausibility of anticipated regret minimization as an alternative cognitive mechanism to utility maximization for selecting among crash avoidance maneuvers. Specifically, this study applies the newly probabilistic choice model based on random regret minimization (RRM) developed by Chorus et al. (2008) and Chorus (2010, 2012a), which is the first operationalization in the discrete choice context of the notion that anticipated regret influences choice behavior (Hensher, Greene, & Chorus, 2011). The RRM-based model is applied as an alternative approach to the traditional RUM-based models for selecting among five maneuvers involving emergency lateral and speed control actions: "no avoidance maneuvers", "braking", "steering", "braking & steering", and "other maneuvers". The two approaches are then compared in terms of their elasticities and their out-of-sample predictive ability. Data for the analysis are retrieved from the General Estimates System (GES) crash database for the years 2005–2009, which provides information about lateral and speed control maneuvers performed by drivers in critical traffic events. Notably, the newly developed RRM-based model has been applied in several transport-related contexts including travel mode, destination, departure time, vehicle type, road pricing policies, and parking (see, e.g., Chorus, 2012a). While most of these empirical contexts concern either strategic (e.g., car ownership) or tactical (e.g., travel mode) decisions, to the best of the authors' knowledge the current study is the first application of the RRM-based model to operational split-second decisions and to the traffic safety context. Moreover, the current study is among the few studies proposing the comparison of RRM-based and RUM-based models on revealed preferences data, as most studies perform the comparison on stated preferences data with a more limited external validity (see Chorus, 2012a, 2012b).

The remainder of the paper is organized as follows. The next section presents the accident data. The third section describes the RRM-based model applied for analyzing the choice of crash avoidance maneuvers. The fourth section presents model estimates and marginal effects. The fifth section compares the RRM-based to the most prominent RUM-based, namely the multinomial logit (MNL) model. The last section offers conclusions and further research directions.

2. Data

Data for the analysis are retrieved from the General Estimates System (GES) crash database, which is maintained and published by the National Highway Traffic Safety Administration's National Center for Statistic and Analysis (National Highway and Traffic Safety Administration, 2010). In the current study, GES data over a period of 5 years between 2005 and 2009 are analyzed. The GES contains a 1% representative probability sample that is annually drawn from roughly 6 million annual police-reported crashes involving severe property damage, injury or loss of life in 60 geographic areas across the United States. The sampling procedure includes stratification by geographic region, primary sampling unit type, police jurisdiction,