A LONGITUDINAL STUDY TO EVALUATE RIDING TRAINER EFFECTIVENESS IN TEENAGERS

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ABSTRACT

This work is part of a study aimed to test the effectiveness of a virtual riding trainer (Honda Riding Trainer, HRT) as a tool to improve hazard perception in riding. The HRT offers a wide range of scenarios within urban, seaside, mountain, and countryside areas. During the simulation, the rider can interact with more than 350 other vehicles, bicycles, and pedestrians, experiencing the most common potential accident configurations. In each course, seven or eight hazard scenes are present. The scenes are set to allow the rider to avoid the danger associated with reducing the speed of the motorcycle or changing lanes when anticipating the hazard.

Previous studies proved that participants participating in a riding training program showed improvement in hazard avoidance.

Twenty-four participants, who were supposed to ride a moped in the following 12 months, were involved in this research. We studied their behavior on 12 different riding courses on the HRT; one year later they attended the same program. The aim was to compare their performance at the follow up with that achieved one year prior during the training phase.

Results confirmed expectations with a high level of avoided-accidents and consistent maintenance of the same level of skills in recognizing hazards and in riding safety.

KEYWORDS: hazard perception, riding trainer, longitudinal study

INTRODUCTION

Motorcyclists are one of the most vulnerable road users. Crashes involving a motorcycle and at least one other vehicle account for over half of all motorcyclist deaths in the United States (National Highway Traffic Safety Administration, 2008). Motorcycle accident statistics show that in Europe and Australia, motorcyclists are more likely than any other vehicle users to be involved in collisions with a fixed object (Australian Transport Safety Bureau, 2008; European Transport Safety Council, 2007). In recent years, the high number of motorcycle crashes sparked scientists' interest in the role that a riding trainer could play in reducing crashes rates.

Although several studies showed that hazard perception training in novice drivers lead to improved performance on hazard perception tests, it is still controversial whether such training will, in the long run, actually result in safer driving behavior and in fewer crashes. Research examining the effectiveness of rider-training programs has generally yielded controversial results (Savolainen and Mannering, 2007). This is probably because, traditionally, rider-training programs have been based on teaching vehicle control skills (Chesham et al., 1993) rather than on the improvement of hazard perception skills, and no standard methods for evaluation exist (Daniello et al., 2009).

In a recent review, Savolainen and Mannering (2007) found an increase in fatalities among those who attended motorcycle safety classes. The authors hypothesized several explanations for this result: from the use of ineffective course material to a worsening in risk perception as a consequence of following the course or, furthermore, to the fact that riders attending the training were inherently less skilled than those who did not. Thus, it remains unclear whether riding-skills training reduces incidence of motorcycle crashes.

However, some studies support the evidence that trained riders tend to have fewer or less severe motorcycle accidents. Although these differences are not clearly defined, they suggest that when trained and untrained riders' performances are compared, training is associated with a reduction in accidents (Fisher et al., 2006; McDavid et al., 1989; Pradhan et al., 2006).

Research in hazard perception is largely focused on young, novice, and inexperienced drivers; it was established that their hazard perception was poorer than their experienced counterparts. Chapman and Underwood (1998) found differences between experienced and novice drivers on hazard perception. On the basis of these differences, experienced and novice riders should also differ on riding behavior in response to hazards. Recently, Liu et al. (2009) confirmed this prediction using an interactive motorcycle simulator. The authors found that experienced riders (relative to inexperienced or novice riders) crashed less often, were given better evaluations, and approached hazards at more appropriate speeds.

On the basis of these considerations, Vidotto et al. (2008; 2011) carried out a study to investigate the effect of a riding simulator on teenagers, that is to say, novice riders, before they took the riding license exam. They demonstrated the effectiveness of this tool in enhancing hazard avoidance due to improvement in the ability to identify potentially dangerous situations in a virtual environment. The long-term persistence of the added progress was not proved in Vidotto et al.'s study.

A few recent studies explored the effectiveness of simulation-based training interventions on novice drivers using driver simulators (Morgan et al., 2011; Pradhan et al., 2006; Wang et al., 2010).

The aim of the present research was to address this question by retesting, one year later, a subgroup of participants of the original research. Our hypothesis was that, whether or not the training effect is long lasting, participants should show, in the very first phase of the follow up, an equivalent or better performance than that of at the end of the first phase (Figure 1a); this improvement should indicate that the previous learning consolidates over time. Conversely, in the case of an overall decay of learning effects, in the follow up, we expected a learning curve resembling what was recorded one year prior (Figure 1b). Finally, in the presence of implicit or explicit task memory, we expected a worsening in performance at the beginning of the follow up, followed by a re-learning with a slighter slope with a higher starting point than that observed during the training phase (Figure 1c).

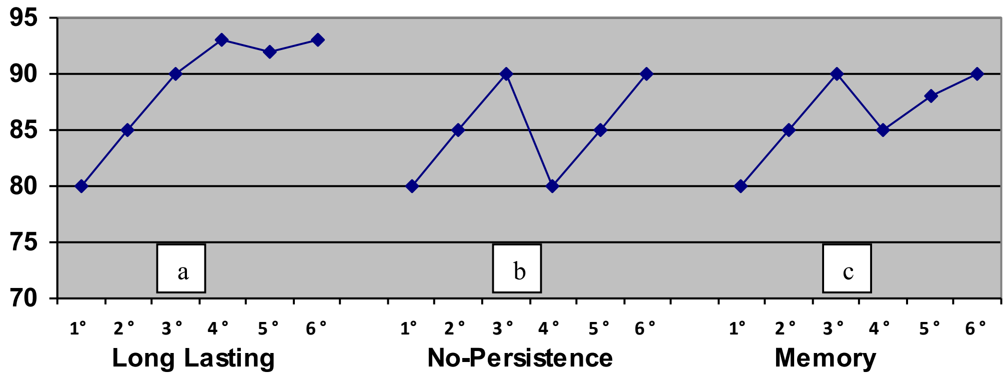

Figure 1. Theoretical representation of the hypotheses of the present study. Proportion of avoided hazards (y-axis) on the six sessions (x-axis) for the three different hypotheses; where sessions 1 to 3 refer to the training phase and 4 to 6 to the follow up.

METHODS

Riding Simulator

The Honda Riding Trainer (HRT) is a motorcycle simulator powered by PC Pentium 4-based computer equipment connected to a 19 inch LCD monitor at 1024 x 768 resolution and motorcycle controls (handlebar and foot pedals). The screen was located in front of the rider at a distance of approximately 80 cm; the horizontal angle of the visual field was 27.2 degrees, and the vertical angle was 21.7 degrees (Figure 2).
The simulator technology was created as part of an integrated motorcycle safety concept focused on addressing the human factor element. The HRT was developed to provide the rider with better awareness of traffic situations and to build up skills in defensive riding, a riding style based on the anticipation of other road users' behavior.
The HRT offers a wide range of scenarios within urban, seaside, mountain, and countryside areas in 16 different courses: 2 training courses (used to become accustomed to the HRT; in these courses no other vehicles are present on the road), 6 courses on main streets, 5 courses on secondary streets, and 5 courses for "touring" (city, highway, seaside, mountain, and neighborhood). Before each ride, several characteristics are set: engine size (small, medium, and large), transmission type (manual, automatic), setting (main street, secondary street, and extra urban environment) and light conditions (day, night, or fog).

Figure 2. Honda's Riding Trainer is a computerized traffic simulator for beginning riders

There are eight hazard scenes in each course, except for one that has only seven scenes. They reproduce the traffic configurations of a study analyzing 921 motorcycle accidents that, over the course of three years, identified the most common motorcycle accidents scenes (MAIDS, 2004). The HRT software has an algorithm that can refer to the motorcycle operating speed. In this way, the generation of dangerous scenes is timely, even if each rider's speed is different. Hazards are set along the course at specific moments, and the participant is guided on the predetermined course via voice announcements. There can be deviations and/or accidents, but the rider always arrives at the end of the predetermined course. Whenever an accident occurs, the software automatically replays the events that led up to the crash. Each course ends with a replay of the entire course integrated with comments and advice on riding behavior and a final spreadsheet summarizing what has already been explained during the replay.

Participants

Twenty-four participants (15-16 years old) took part in this study. We randomly selected them among the students of two schools that agreed to participate in the follow up of a simulator riding training program previously completed (Vidotto et al., 2011). In order to plan the follow up exactly one year after the end of the training phase, we contacted the schools' staff eleven months after the first study. Participants had normal or corrected to normal vision and were naïve about the aim of our research. Motivation to take part in the project was supported by a reward, which was the opportunity to earn school credits that could be used by the participants in their final examination. Moreover, all of them rode a moped in the 12 months after the training phase. Formal consent to take part in the study was obtained from participants and their parents. There were no other inclusion criteria.

Procedure

In order to compare the performance in the training phase on HRT with that observed one-year later, participants completed three sessions of four courses in three different weeks using the same procedure as in the training phase. Each session included four courses, (for a total of twelve: six courses on main streets, five on secondary streets, and one course on neighborhoods).

It took one week between the first session and the second one, and one week between the second session and the third one. The courses' presentation order was randomized using a Latin-square-like design, so that each course was included in each order position the same number of times (i.e., each course was presented with the same frequency in all of the order positions). This method ensured both the estimation of practice effect and the control of stimuli sequence effect (Miceli et al., 2008). All participants had a setup with small engine size, automatic transmission, and daylight conditions, and they always began the first session with the 2 training courses in which no other vehicles were present on the road (preliminary training). The completion of all twelve courses took approximately one hour, and each participant was tested individually. An instructor, who was always present during the training, supervised all participants. Although he was allowed to speak to the participants during the training, the interaction was kept neutral and as limited as possible. At the beginning of the first session, the instructor provided technical information. During the courses, he could answer questions, but not remind the participants about the content of the voice announcement. The instructor was allowed to intervene whenever a participant demonstrated a reckless attitude, and he was asked to take notes on riding behavior.

RESULTS

Statistical analyses were conducted using R (R Development Core Team, 2011) to test hazard avoidance changes over time at the follow up. The number of avoided hazards was considered a dependent variable, whereas the phases or sessions over time were the within-subject factors for the analyses. An index related to the difficulties of the courses was also introduced as a covariate. It was based upon the average proportion of accidents for each scene on a large sample of more than 400 individuals.

Generalized linear models (GLMs) represent a class of fixed effects regression models for several types of dependent variables, which include logistic regression. Developments include generalized linear mixed models (Bates et al., 2011; GLMMs; Pinheiro and Bates, 1989), which extend GLMs by including random effects in the predictor. Logistic GLMMs were chosen for the analyses since they deal with non-normal responses (e.g., binomial) and repeated measures (e.g., phases/sessions over time).

Figure 3 shows the proportions of avoided hazards inherent in the six sessions (1 to 3 at the training phase, 4 to 6 at the follow up) for each of the 24 participants with their general linear trend. It has to be stressed that trend variability is not only due to individual differences but also to the randomization of the courses. Indeed, it is worth noting that courses had different difficulties and were in a different order for each of the participants. This evidence makes clear the opportunity of using the difficulty index as a covariate in the following analysis.

Figure 4 displays, on the left side (a), the mean proportion of avoided hazards for the three sessions during the training phase (.87, .88, .89) and the follow up (.96, .95, .92). The greatest amount of improvement occurred between the last session of the training phase and the first session at follow up (.07). On the right side, the mean proportion of avoided hazards related to the difficulty of the courses is reported. The results of the logistic GLMM analysis showed how the means increased from the first session to the last one (χ^2 (5) = 67.80; $p < 10^{-13}$) following a trend with strong linear ($z = 6.54$; $p < 10^{-11}$), quadratic ($z = -3,85$; $p \sim 10^{-5}$), and cubic ($z = -4.62$; $p < 10^{-6}$) components. Results also showed the significant effect of the covariate (χ^2 (1) = 25.28; $p < 10^{-7}$), denoting that the difficulty level of the completed course affects the observed performance.

It is worth noting that the mean proportion of avoided hazards in the follow up was considerably larger than during the training phase (.88 vs. .94; χ^2 (1) = 7.64; $p < 10^{-14}$) with a difference of .06. No other statistically significant effects were observed.

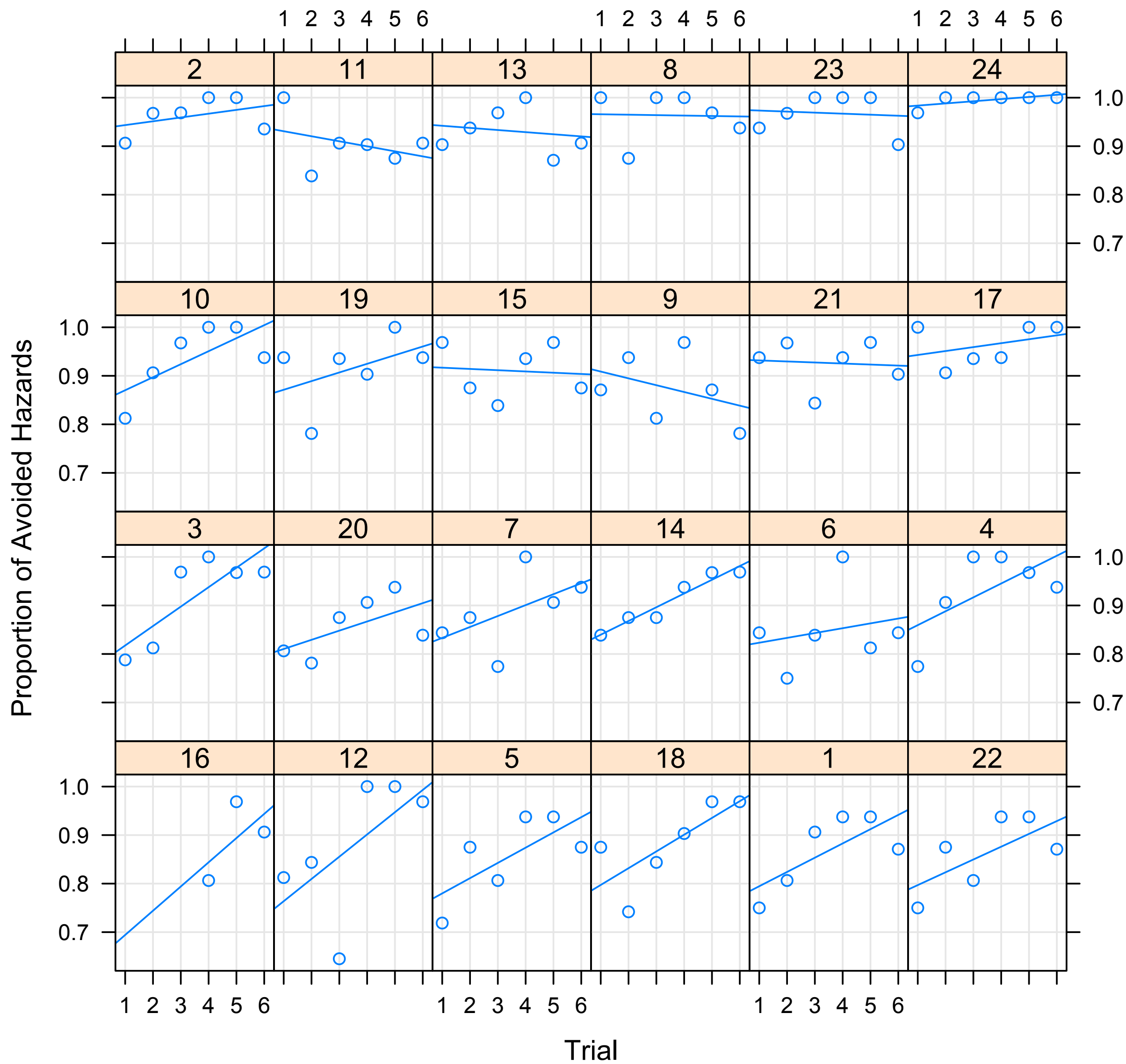

Figure 3. Proportion of avoided hazards (y-axis) during the six sessions (x-axis) with the linear trend for each participant (numbers from 1 to 24 identify participant's plots). Sessions 1 to 3 refer to the training phase and 4 to 6 to the follow up.

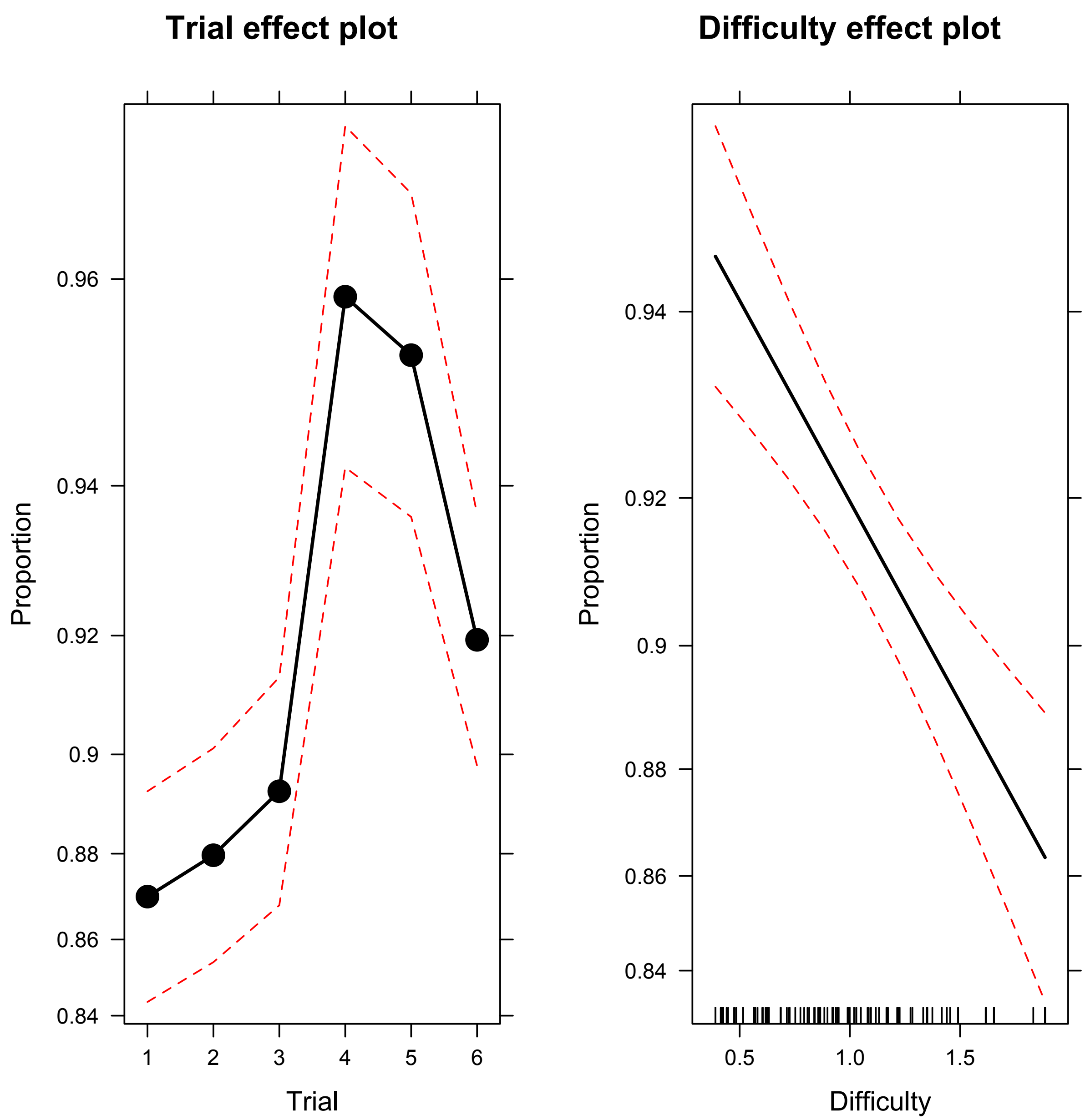

Figure 4. Plot on the left side: Proportion of avoided hazards (y-axis) during the six sessions (x-axis); sessions 1 to 3 refer to the training phase and 4 to 6 to the follow up. Plot on the right side: Predicted proportion of avoided hazards (y-axis) against the index of difficulty of the courses (x-axis). 95% pointwise confidence bands are shown as broken red lines.

CONCLUSIONS

High mortality and, in general, high accident rates in riding powered two-wheel vehicles have a significant impact all over the world. The consequences of riding crashes are very often more serious than those following driving accidents because of the greater vulnerability of motorcyclists. This is why studies on riding abilities have attracted attention of different types of specialists, from those who design safety devices for vehicles, to cognitive psychologists, who

devote much energy to investigate all of the cognitive abilities implied in riding, aiming at planning training programs to maximize riding efficacy to prevent accidents.
The entire project moved on from this aim and, in the previous phase, showed that simulator training provides the opportunity to cope with unforeseen and dangerous road events that would be unsafe to experience in a real environment, which improves the ability of the novice rider to recognize hazard situations and to react in such a way as to avoid risks (Vidotto et al., 2008; 2011). However, besides demonstrating that virtual training is highly efficacious, it is crucial to prove that learned abilities acquired in such a way are retained longer.
Thus, one year later, we retested part of the original sample of teenagers, hypothesizing that long lasting effects should have been evident from the first sessions of the follow up, whereas other trends in the learning curve would have indicated implicit or explicit memory of training or no persistence of the learning effects at all.
In other words, despite the lack of a control group in the present follow-up study, we hypothesized that, in the case of non-specific contextual effects of familiarization to the device, the improvement noted at the beginning of the follow up would not be higher than the improvement recorded at the end of the training phase one year prior. On the contrary, results showed that the greater amount of improvement in the riding performance occurs between the last session of the training phase and the first session of the follow up. No doubt, that means not only that whatever was learned is still active one year later, but also that the effect of learning was enhanced over time. The only way to explain such a result is by means of the concept of consolidation (i.e., a process during which new knowledge is gradually incorporated into internal representations), which allows them to be reactivated when some elements of specific experiences appear anew and is used to govern related behaviors (McClelland et al., 1995).
It can be pointed out that participants continued to train themselves in their daily life after the end of the training phase with the simulator (in effect, all the participants rode a moped after the training phase), and this might be the cause of the consolidation of the learning effect recorded. In this circumstance, it would be as if participants had made a "rehearsal" of the simulator experience while riding with their real motorcycle during the year so as to show additional improvement in performance once the simulator sessions were re-administered. If this were the case, it would indicate a generalization process backward from real life to the simulator performance, which is impossible if a previous generalization from virtual experience to real life did not occur.
In sum, results show that the virtual riding training program provides a long lasting learning effect, as demonstrated by the fact that, despite the subjective variability, the overall participants' performance was better in all steps of the follow up with the greatest amount of improvement occurring between the last session of the training phase and the first one of the follow up.
This strengthening or consolidation effect over time has been shown in several studies focused on learning effects, no matter the cognitive process implied. For instance, Tagliabue et al. (2000) demonstrated the existence of consolidation in the effects of learning with spatial compatibility tasks (in which the spatial position is the relevant dimension for response selection) on a Simon task in which spatial position interferes despite its irrelevance for the task. The result of the consolidation of learning is interpreted as an index of cognitive plasticity. It is worth noting that plasticity shown in the just mentioned study referred to spatial information; indeed, it is evident that spatial learning plays a crucial role in riding training as well. This could be an additional important contribution, which deserves further investigations, of the present study in riding safety, since only follow-up research can provide information about the potential long-term efficacy of learning programs.

Caution is required in generalizing these findings since our results refer to a virtual environment; we are mainly interested in understanding how much of this progress is compatible with an enhancement in safety on the road. It has to be mentioned that some evidence has already been provided about the transfer of learning acquired in virtual environments to real world performance, even if not for motorcycle simulators (Fildes et al., 1997).
Finally, the main result of the present study is the enhancement of learning effects as measured by means of the simulator during the year between the training and follow up phases. The consolidated effect recorded at the follow up, especially in the hypothesis, which states it was due to practice with a moped, constitutes additional evidence of the generalization of learning among the virtual and real experiences.
In conclusion, the present research provides evidence that the HRT program could be considered a useful tool for riding training in that it should allow novice riders to cope with potentially dangerous road situations, inducing long-lasting improvement of the ability to recognize advance hazards so as to avoid risky behaviors.

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