Can Novice Drivers Be Trained Where to Look for Potential Hazards?

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ABSTRACT

Sixteen-year-old drivers are involved in 10.3 fatal crashes per 100 million vehicle miles, a rate almost double that of 18-year-olds and almost eight times that of 45-64-year-olds, who are the safest group of drivers. Crash rates are particularly elevated during the first month of licensure and decline rapidly for about six months and 1000 miles and then much more slowly for at least two years, consistent with a typical learning curve. Research indicates that newly licensed drivers have particular difficulties identifying areas of a scenario from which hidden risks could emerge. Standard driver education programs do not appear to address these difficulties adequately. This suggests that some alternative form of driver training could reduce the crashes, either in the classroom or on the road. A PC-based program designed to teach novice drivers to recognize risks is shown to improve their awareness of hazards, both on an advanced driving simulator and on the road.

AUTHOR BOX

Donald Fisher is a professor in the Department of Mechanical and Industrial Engineering at the University of Massachusetts-Amherst. He is the director of the Human Performance Laboratory, where ongoing research includes Project MIDAS (Massachusetts Interactive Driving and Acoustic Simulator), the goal of which is to test the safety and usability of many of the new technologies that will form the backbone of Intelligent Transportation Systems, and Project PROTO, whose purpose is to develop the tools for rapidly prototyping the visual and auditory interface between users and new and evolving products such as audio remote controls, cellular phones, voice mail, ATM, etc. Dr. Fisher received a Masters of Education from Harvard University and a Ph.D. in Psychology from the University of Michigan.

1. INTRODUCTION

Sixteen-year-old drivers are involved in 10.3 fatal crashes per 100 million vehicle miles, a rate almost double that of 18-year-olds and almost eight times that of 45-64-year-olds, who are the safest group of drivers.[1] Crash rates are particularly elevated during the first month of licensure. They decline rapidly for about six months and 1000 miles and then much more slowly for at least two years (consistent with a typical learning curve). This raises the question of whether some form of driver education – either in the classroom or on the road – could reduce the crashes among *newly licensed* drivers (novice drivers with their license six months or less).

Unfortunately, standard driver education programs in the United States (30 classroom hours, six hours behind the wheel and six as observer) and more advanced vehicle handling courses have failed to decrease newly licensed drivers' fatalities demonstrably. This is as true today [2] as it was almost thirty years ago when the landmark DeKalb County study was undertaken.[3] More recent studies have shown that there is actually a slightly greater crash risk for graduates of standard training programs,[4][5][6] perhaps because driver education graduates are licensed earlier than their counterparts.[7][3][8]

The situation is changing somewhat with the widespread introduction of graduated driver licensing (GDL) programs in the United States, in which there are a minimum of three stages in the licensing process (learner's permit, restricted licensure and full licensure). Graduated licensing programs in this country typically require that novice drivers spend upwards of 30 hours driving with an adult in a car during the learner's permit phase, thus increasing the novice driver's supervised experience on the road. (The label "novice drivers" will be used to refer to any subset of drivers who have had their license six months or less. It will be clear from the context to which subset reference is being made.) However, it is disturbing that, at least in the United States, there is no clear relation between the number of hours that a novice driver spends in supervised driving with their parents and the crash rate of the novice driver once he or she is out on the road unsupervised.[9] Thus, the value of training is again brought into question, this time training behind the wheel with the parent as supervisor.

It has been demonstrated that a major cause of newly licensed driver crashes is the failure to scan effectively for potential risks.[10][11][12][13][15] This demonstration comes both from field studies and studies undertaken on a driving simulator. A recent field analysis of 2000 police crash reports (1000 from drivers 16-17 years old and 1000 from drivers 18-19 years old) found that the largest fraction were due to failures of attention and visual search.[10] Differences in the distributions of error types for the two cohorts were negligible. More importantly, high absolute speeds and patently risky behavior accounted for a very small percentage of the errors. The authors concluded that the younger drivers are clueless, not careless, for the most part. Similar results were reported some 25 years ago, with visual search and attention predominating as causes of newly licensed driver crashes. [11]

Recent studies on a driving simulator confirm that novice drivers fail to look at the regions where hidden risks may emerge or may fail to look at the critical elements of a scenario which create a potential risk when those elements are not obviously themselves risky. So, for example, in the *Truck Crosswalk* scenario (Figure 1) used in one simulator study, a truck is stopped on the side of the road in front of a marked midblock crosswalk in a suburban development. The participant driver is in the two-toned car in the right lane in the figure and so cannot see potential pedestrians crossing in front of the truck. Thus, the driver should look to the right for a pedestrian and also steer further to the left as he or she passes in front of the truck. It was found that only 10% of the novice drivers in the learner's permit phase looked to the right whereas 58% of the drivers between the ages of 60 and 75 did so. [13] These results persisted in nighttime conditions in the simulator: novice drivers were less likely to look for a potentially encroaching pedestrian than more experienced drivers. [14] Perhaps more surprisingly, this was true even for novice drivers who had fixated on a pedestrian emerging from behind the truck as they approached it at a distance; they were still less likely than more experienced drivers to look to the right for a second pedestrian as they passed in front of the truck. [15]

Figure 1: Plan View -- Truck Crosswalk Scenario

In summary, there is considerable evidence that novice drivers, both those newly licensed and those still in the learner's permit phase, are not aware of hidden hazards. Recently, PC based training programs have been devised that target this problem. However, only a handful of these programs have actually been evaluated, including the programs developed by the AAA Foundation for Traffic Safety,[16][17] the University of Monash Accident Research Center,[18] and Systems Technology, Inc.[19] The evaluations have shown that PC-based training helps both learner's permit and newly licensed drivers perform better on a driving simulator.

There is still much to be done, however. First, all the above evaluations were completed using vehicle behaviors as the dependent variables, but as noted above, a major difficulty the newly licensed driver has is scanning the roadway,[10] and this is not easily measured with vehicle behaviors. Second, in the above studies, the effects of training in a simulated driving environment were evaluated immediately after the PC-based training and not at some longer lag which might be more representative of the time between PC-based training and actual driving. Third, there were no attempts to determine whether the effects of PC-based training transfer not only to a driving simulator, but also to the open road. Three studies are described below which address these related issues. These studies are an evaluation of a PC-based risk awareness and perception training program (RAPT). Two of the studies assessed the training of risk awareness on a driving simulator (using versions 1 and 2 of RAPT, RAPT-1 and RAPT-2, respectively), and one assessed it in the field (RAPT-3).

2. NOVICE DRIVER RISK AWARENESS TRAINING PROGRAMS

The RAPT program has been designed with certain general principles in mind. First, we want the learner's permit or newly licensed driver to have the information learned on the PC available at the time they need to retrieve it on the open road. Towards this end, RAPT is consistent with the theoretical research which indicates that the deeper the level of processing of an event, the more likely the event is to be stored in long term memory.[20][21] RAPT encourages deep processing by asking trainees to visualize where the hidden risks are located rather than simply presenting those risks. Second, we want trainees to recognize risky scenarios on the road that resemble, but can never be identical to, the ones they saw in training. In this respect, RAPT is consistent with the literature that indicates that near transfer is maximized when the cues needed to retrieve the knowledge in the situation for which transfer is needed are directly present in the training situation.[22][23][24] RAPT uses a technique referred to as hugging,[24] or targeted training, to maximize this type of learning, giving trainees explicit but schematic plan (top down) views (see Figure 1) of the scenarios that are risky, and trains them to identify regions where hidden risks may be in those scenarios. Finally, we want the trainees not only to recognize risks in scenarios that are similar to the ones that they encounter in RAPT, but also to recognize risks in the broad range of scenarios that they might encounter on the open road. RAPT is consistent with the research that indicates that learning transfers best when the principles needed to generalize what one has learned are explicitly abstracted for the learner.[25][26] Toward this end, RAPT not only presents a scenario which is risky, but also explains to the trainee why it is risky and actually displays to the driver what areas of the visual field are obstructed in a particular scenario. In our assessment of RAPT, we have tested for the effects of training both in situations that resemble the scenarios in training (*near transfer*) and those that embody only certain general principles taught in the training (*far transfer*).

2.1. Simulator Tests: RAPT-1

In the first reported study of RAPT, 48 novice drivers were run in a simulated driving environment to evaluate whether hazard detection training on a PC could be effective.[27][28][29] All were high school students who had had their learner's permit for one to five months. Twenty four were randomly assigned to the trained group (RAPT-1) and the other 24 to the untrained group. Each PC training session consisted of three sections: a pre-test, training and post-test section. Here we describe just the pre-test and post-test sections (which were identical). The details of training are described fully in other publications, but basically, they involved instruction using the same plan views as the pre- and post-test.[27][28][29]

In the pretest, each participant saw a plan view of a scene with vehicles and pedestrians (in some cases), along with the three red circles and the three yellow ovals on the side. The participants were told to imagine that they were driving the two-toned car in the plan view (color was used in the actual training scenarios; the figures are in grayscale) and that they had two tasks. The first was for participants to drag a *red circle* to any area of the scene which *they should monitor more or less continuously*. For example, consider again the *Truck Crosswalk* scenario (Figure 1). In this case, the participants should have dragged a red circle to an area ahead of them beside the front left edge of the truck. The second task was for participants to drag a *yellow oval* to any area of the scene which could potentially contain *a vehicle or pedestrian that they could not see* from their current position but with which they *could be in conflict as they traveled forward*. In this case, the participant should have dragged a yellow oval to an area in front of the truck which obscured a potential pedestrian. The positions of the ovals and circles were scored in the pre-test and post-test as correct or incorrect.

The pre-test data indicated that the untrained participants were not good at either the yellow oval or red circle tasks. Additionally, and importantly, the post-test data indicated that the training was successful in getting the participants to perform the two required tasks well. Participants were almost twice as good at placing the red circles correctly after training, scoring 50% on average in the pretest and 91% on the posttest, a difference which was significant.[29] They were about three times as good at placing the yellow ovals after training, scoring 32% on the pre-test and 90% on the post-test, again a significant difference.

Immediately after being trained on the PC, the 24 novice drivers were asked to negotiate a drive containing 16 different scenarios on the University of Massachusetts driving simulator (Figure 2). Ten of the scenarios were similar to scenarios that the novice drivers had seen in the PC-based training (the near transfer scenarios); six were quite different (the far transfer scenarios). The novice drivers operated the controls of the vehicle in which they sat just as they would at the controls of any normal vehicle, moving through the virtual world accordingly. A head-mounted eye tracker was used to record their gaze. An additional set of 24 untrained novice drivers was also evaluated on the driving simulator. Most of the simulated drive consisted of fairly neutral portions that did not contain any potential risks. The participants were instructed that they were to follow a *lead vehicle* (that was controlled by computer), but that they could lag behind it a reasonable distance (the lead vehicle indicated to the participant driver when to turn and in which direction).

Figure 2: University of Massachusetts Driving Simulator

A snapshot from the actual simulation for the truck crosswalk scenario whose plan view was diagrammed earlier is displayed in Figure 3. In this case, the truck obscures pedestrians in the crosswalk from the participant driver's view, and although no pedestrian ever appeared from behind the truck on the right, it would clearly pose a threat if one did. The eye tracker was used to determine whether the driver looked to the right as he or she passed the truck, presumably checking for a pedestrian who might be emerging. A detailed procedure was set forth for scoring each scenario. The scorer did not know whether the driver was trained or untrained (this is true in all the studies discussed here).

Figure 3: Simulator View – Truck Crosswalk Scenario

The overall effect of training over the near and far transfer scenarios was highly significant ($p < .001$), with trained drivers fixating areas of the roadway which could reduce their likelihood of a crash 57.7% of the time and untrained drivers making such fixations only 35.4% of the time (a difference of 22.3%). Moreover, the training effect was about as large for far transfer as it was for near transfer; the difference between the trained and untrained drivers was 24.6% for the near transfer and 20.0% for near transfer (the interaction between far vs. near transfer and training had an $F < 1$).

2.2. Simulator Tests: RAPT-2.

One of the potential weaknesses of the above study is that the trained novice drivers were evaluated on the driving simulator immediately after they had completed the PC-based training. In order to remedy this shortcoming, the above study was replicated, only this time 12 novice drivers were evaluated on the simulator three to five days after training.[30] As before, all novice drivers had their learner's permit. The delay represents a period of time which might elapse between PC-based training in driver education classes and when the novice driver would apply that training on the road as part of the learner's permit phase. Another set of 12 participants were evaluated on the simulator as the control group without having prior training. The PC-based training program used in the second study (RAPT-2) was modified slightly from RAPT-1, as it now included in the training section perspective open road views of the three scenarios on which participants in the first study performed most poorly in the driving simulator. The trained novice drivers again performed much better on the PC post-test than on the PC pre-test. The crucial question, however, was whether the training on the PC program would lead to improvements on the driving simulator after several days had elapsed since the novice drivers had been trained on the PC. As in the above study, the eye-gaze data were analyzed for fixations on risky areas of the scene. The novice drivers who had the advantage of the PC-based training performed better than the untrained group, fixating on the risky areas 52.1% of the time, compared to 28.1% for the untrained drivers, a 24.0% difference which was significant ($p < .05$) and about the same size as in the above study where the test was immediate. As in the first study, the effect of training for near-transfer and far-transfer scenarios was about the same ($F < 1$): 23.0% for the near transfer scenarios and 26.0% for the far transfer scenarios.

2.3. FIELD TEST: RAPT-3

Finally, it is crucially important to know whether training generalizes to the open road. As a preliminary indication of this capability, we have just completed a study of 24 drivers 18-21 years old. The *recently licensed* drivers have been driving by themselves one to four years. This evaluation is being carried out with a newer version of the training program, RAPT-3. The modifications were introduced to RAPT-2 because even though the risk recognition of the trained novice drivers using RAPT-2 was equivalent to that of experienced drivers, both groups were still far from perfect. Among other things, in RAPT-3 the pre-test and post-test sections contain perspective views only (recall that RAPT-1 and RAPT-2 contained only plan views in these sections). More specifically, the user is presented with a set of progressively advancing perspective snapshots of a scenario, as seen from the driver's point of view (Figure 4). The user is asked to imagine himself/herself as the driver of the vehicle, and is instructed to use the mouse to click on areas in the view where he/she would look if he/she were actually driving the scenario. Each snapshot is displayed for only three seconds. A particular scenario consists of 5-12 snapshots, depending on the length and complexity of the scenario. A total of nine scenarios are presented in the pre- and posttest. A driver's score is based on the location of the mouse clicks.

Figure 4 - Sequence of (five) perspective snapshots for Abrupt Lane Change Scenario

We have now completed the evaluation in the field of 24 drivers, 12 trained on RAPT-3 and 12 untrained drivers. Each of the drivers wore a head-mounted portable eye tracker (ASL Mobile Eye) that overlays a cursor representing the driver's eye fixations on top of a video recording of the driver's point of view, *i.e.*, the roadway through which the driver is traveling. A 16-mile course in the Amherst and Hadley (Massachusetts) area was mapped out which included major arterials and a variety of intersections. Ten different situations/scenarios were chosen along this route. Five of them were similar to some of the scenarios that were used in the PC-based training – the near transfer scenarios (*e.g*., in Amherst a tall hedge obstructs the view of a pedestrian sidewalk from the driver while he/she is approaching an intersection, behind which bicyclists or pedestrians could potentially emerge; this field situation is similar to the Hidden Sidewalk scenario used in RAPT-3) -- and the remaining five were different from those used in training – the far transfer scenarios. The data collected from these 10 locations in the field were used to analyze the eye-glance behavior of the drivers. We found that significantly more trained drivers (70%) in the near transfer scenarios fixated areas of the roadway scenarios which contained information which could reduce in their likelihood of a crash than do untrained drivers (33%, $p < .001$), a difference almost identical to what was observed on the driving simulator. Furthermore, although the differences between the trained (59%) and untrained (39%) drivers on the far transfer scenarios were smaller, they were still significant ($p < .01$).

3. DISCUSSION AND SUMMARY

We have found a substantial effect of a PC based training program on learner's permit and recently licensed drivers' awareness of risks -- on the PC, on a driving simulator and on the road. These are the first studies to report gains in all three situations. In contrast to the above, a more recent video-based study of the hazard detection skills of newly licensed drivers conducted by Sagberg and Bjørnskau concluded that hazard detection skills do not account for most of the decrease in risk seen in newly licensed drivers over the first six months of driving.[31] However, there is a critical difference between this study and the Pradhan *et al*. study reported above.[13] In particular, the hazards were visible in a large majority of scenarios that Sagberg and Bjørnskau used.[31] This may have made the task too easy and thus produced a ceiling effect. Consistent with this hypothesis, the only three scenarios in the Sagberg and Bjørnskau study in which the newly licensed drivers were less likely to perceive the hazard than the more experienced drivers appeared to involve hidden risks emerging suddenly. In summary, the Sagberg and Bjørnskau study indicates that there may be many situations in which even newly licensed drivers perform reasonably well without training, as long as the risk is visible. However, our studies indicate that there are many situations involving hidden risks that present very real problems for learner's permit and recently licensed drivers and that training can help to reduce these problems. [32] In fact, most of our training studies have succeeded in raising learner's permit and recently licensed drivers' performance to a level comparable to that of the safest drivers [13][29].

Based on the above results, we believe that future studies should include learner's permit and newly licensed drivers in field tests of the effectiveness of a PC-based training program such as RAPT-3. And we believe that parents should be included in a training program as well, given that our results suggest even experienced drivers did not often recognize the risks.[13] Such a program could be incorporated into current attempts to involve parents as participants in the restricted licensure phase of the GDL.[33]

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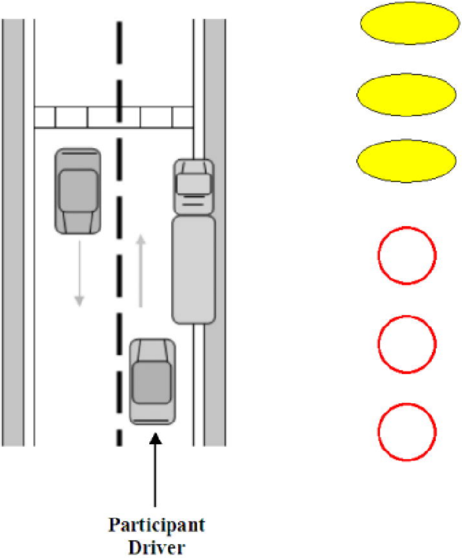

Figure 3: Plan View - Truck Crosswalk Scenario

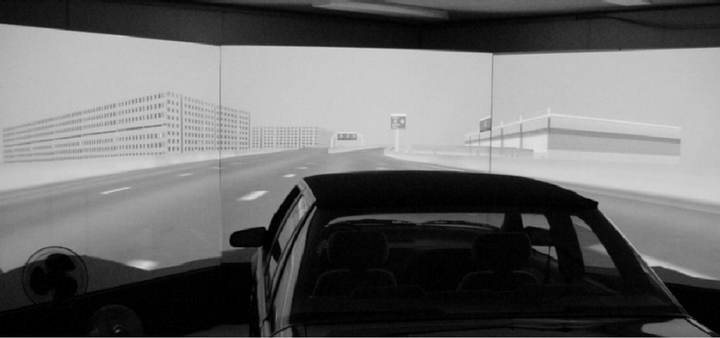

Figure 2: University of Massachusetts Driving Simulator

Figure 3: Simulator View - Truck Crosswalk Scenario

Figure 4: Sequence of (five) perspective snapshots for Abrupt Lane Change Scenario