Assessing the Validity of Driver Response: Simulator vs. Real Vehicle

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ABSTRACT

Objective: The Federal Law Enforcement Training Centers (FLETC) initiated research to determine if a blended approach of instruction was effective for teaching the driving technique "determining and following an ideal line of travel (LOT)." The LOT is defined as the most efficient path to steer a vehicle when traveling through a turn. It is commonly taught in emergency vehicle operations training. Currently, this concept is taught using a lecture block and a hands-on driving on an outdoor driving range. The problem is students do not get as much driving time due to the limited amount of cars, instructors, and driving ranges available. Research Questions: Can participants who receive training in a blended learning environment perform better on the driving range practical examination? Can participants who receive training with a blended and traditional learning environment transfer that knowledge when presented with a new environment? Can participants who receive training in a blended learning environment (both simulated and live driving) gain a better understanding of the principles of LOT on a cognitive test? Methods: Participants were given a one-hour lecture on the concepts of an ideal LOT. The group was divided into two. The control group went to the driving range to practice LOT techniques. The experimental group was taken to the driving simulators to practice LOT techniques. After practice, the experimental group was then taken to the driving range and allowed to practice with the other group. At the end of practice both groups were giving a driving assessment on the familiar range and a novel range. Then both groups were given a written exam. Results: The differences in driving performance and passing rate between groups were minimal, although a statistical significance was found between groups on the familiar range. Lack of training transfer was found in both groups when taken to the novel range. The blended / simulator group scored higher on the written exam. Conclusion: Use of simulators in a blended approach produced similar results compared to traditional instruction for LOT.

ABOUT THE AUTHORS

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INTRODUCTION

The Federal Law Enforcement Training Centers (FLETC) serves as an interagency law enforcement training organization for more than 95 Federal agencies. The FLETC also provides services to state, local, tribal, and international law enforcement agencies. Traditionally, the Driver and Marine Division (DMD) has utilized various modes of instruction to teach law enforcement driving techniques. Beginning with a traditional andragogic approach, the DMD staff employs a blended learning environment, which includes classroom instruction, hands-on demonstration, and technological resources.

The FLETC's DMD and the Applied Research Branch initiated research to explore a new blended approach to teaching the driving technique of following an ideal "line of travel" (LOT). The LOT is defined as the most efficient path to steer a vehicle when traveling through a turn. It is commonly taught in emergency vehicle operations training (EVOC). The goal is to minimize lateral weight shifts of the vehicle during emergency operation. Currently, this concept is taught using a lecture block and a hands-on application block on an outdoor driving range. One concern with the current approach is that participants may be memorizing ideal vehicle lane positions on the existing driving range, and not transferring the recently obtained knowledge when driving on a new unfamiliar highway. While this might help them pass a specific test on this closed course, it does not necessarily translate to internalizing the concept and principles related to LOT and transferring the skills to unfamiliar roadways.

The FLETC also utilizes three-screen driving simulators as a teaching modality. A driving simulator is the best possible application of a highly structured training program (Kaptein, Theeuwes & Van Der Horst, 1996). One metric that demonstrates driver simulator effectiveness is the increase in actual driving time compared to time in a real vehicle (Roscoe, 1972). The simulated environment offers a unique opportunity to provide a variety of roadway conditions that could address training concerns related to memorization of the range courses. Simulated environments also offer an opportunity to include visual training aids (e.g., roadway arrows) observe multiple views during after-action reviews, a higher percentage of driving range time, and better quantitative and qualitative time on instructor feedback.

To determine a driving simulator's usefulness, there must be a valid measure of driving performance that must concurrently reflect on-the-road driving performance (Matas, Nettelbeck & Burns, 2016). One significant and commonly accepted psychometric property for driving simulators is validity (Bedard et al.2010).

Types of Validity

The idea of validity is of vast importance to the application of driving simulators (Kaptein, Theeuwes, Van Der Horst, 1996). Determining validity depends on the assessment convention (i.e. psychology, engineering) and the type of question being asked (Reimer, et al. 2006 & Wang, et al. 2010). The gold standard for validating driving simulation is by comparing simulation data to data collected from on the road driving (Reimer, et al. 2006; Shechtman, et al. 2009 & Matas, Nettelbeck & Burns, 2016). Several research papers discuss driving simulation validity (Godley, Triggs & Fildes, 2002; Reimer et al., 2006; Shechtman, et al. 2009 & 2010; & Matas, Nettelbeck & Burns, 2016). Two types of validity tested are physical validity and driver response (behavioral) validity. Behavioral validity shows the level of similarity between driving behavior exibited in the simulator and on-road driving (Mullen et al. 2011).

Physical validity demonstrates how the physical components of the driving simulator correspond to the on-road vehicle, to include simulator layout, visual display, and dynamics such as braking, acceleration, and steering. For a driving simulator to be physically valid, and thus a useful tool, it must reproduce driving responses as they would occur in the real-world (Godley, Triggs & Fildes, 2002).

The most objective type of validity measurement is criterion-related validity (Reimer et al. 2006). Criterion-related validity determines the degree to which measures of outcomes in the driving simulator are correlated with measures of outcomes in a road examination (Shechtman, 2010). Shechtman (2010) further states that the true gold standard of a driving simulator and on the road evaluations is when a person drives a car without the presence of an evaluator. He also stated, "…driving simulators must be validated before they are used for driving assessment and/or training," (p. 380).

Transfer of Training

Determining simulator validity is just one goal of this study. Another goal is to determine the transferability of training; can participants transfer what they learned in training to a real-world scenario? The goal of any law enforcement training is the development of skills that transfer into the real world (Staller, Cole, Zaiser, & Körner, 2017). Training transfer is confirmation of the ability to apply trained skills to situations differing from those encountered during original training (Royer, 1978). Training transfer can be divided into two subcategories: (1) *near transfer*, in which the stimulus in the transfer condition closely resembles the original training condition, and (2) *far transfer*, in which the stimulus in the transfer condition is to some measure different from the stimulus in the original training condition (Royer, 1979). This study will only examine near transfer.

Driving is a combination of cognitive and psychomotor skills. Real-world driving is a demanding task requiring the organization of psychological functions to process a multitude of data simultaneously (Casutt et al. 2014). The cognitive portion deals with knowing the functions of a car (e.g. pushing the accelerator makes the car go faster, and rules of the road) the psychomotor portion deals with mechanics of driving a car. This study examined a participant's understanding of the cognitive elements of LOT driving, and the mechanics of actually driving a car using these elements, along with psychomotor skills.

Kaptein, Theeuwes, Van Der Horst, (1996) describe three levels of driving simulators. Low-fidelity simulators consists of a PC, single monitor, and a simple configuration with controls. A mid-fidelity simulator has advanced graphics, large projector screens, a realistic configuation, and a simple motion base. A high-fidelity simulator provides close to a 360-degree view and a extensive moving base. Salas, Bowers, and Rhodenizer (1998) suggest the fidelity level of simulation does not translate to learning. Regardless of the fidelity level provided in a driving simulator, the key issue is that the driving skills learned on a simulator are transferred to the real-world (de Winter et al., 2009).

Research Questions

Based on the training objectives and literature review, three research questions were asked:

Research Question 1: Can participants who receive training in a blended learning environment (both simulated and live driving) perform better on the standard driving range practical examination than those trained with traditional methods?

Research Question 2: Can participants who receive training with a blended and traditional learning environment transfer that knowledge when presented with a new environment?

Research Question 3: Can participants who receive training in a blended learning environment (both simulated and live driving) gain a better understanding of the principles of line of travel on a cognitive test than those trained with traditional methods?

METHODS AND PROCEDURES

Seventy participants volunteered to be part of this study conducted on two consecutive days. Participants under the age of 18 were not allowed to participate. All participants signed an Informed Consent Form before being allowed to participate in this study. In addition, volunteers were excluded from the study if they had previous law enforcement LOT training, did not hold a valid driver's license, had a medical reason that precluded them from driving a standard police vehicle, were on medication that would alter their ability to drive, were pregnant or failed to pass the background checks required for entrance to the training center. To ensure each participant's anonymity, each participant was assigned a unique identification number which was used to label all assessments and performance documents in both electronic and hardcopy form.

Following an introductory lecture, participants were randomly selected to be in either the control group or the experimental group. Those assigned to the control group received the *traditional* instruction module for LOT at FLETC; the experimental group received *blended* instruction. The Traditional Group / TG (control) went to the driving range (Range 6) to practice LOT. The Blended Group / BG (experimental) went to the driving simulators to practice on an exact replica of Range 6.

Driving Environment

Range 6 at FLETC served as the practice and evaluation range for both groups. For this study, L3™ developed a driving simulation package that displayed an exact replica of Range 6 (to include bumps in the road). One instructor was paired with two participants per vehicle for the TG; for BG, two participants were assigned to one pod (there are four driving simulators in each pod), with one instructor assigned to each pod.

The L3 PatrolSim 5 Police Car Driving Simulator™ (see figure 1) was used as part of the blended learning component in this study. Considered a medium fidelity driving simulator, the PatrolSim™ is commonly used for law enforcement training. The simulator driving seat (platform) is considered a low fidelity, due to limited movement. Driving scenarios test trainees under various road, weather, and traffic conditions. The PatrolSim 5™ has three 42" (16x9) plasma screens. The three screens provide a front view and two side views to the driver (the visual field is approximately 180°) and includes rear view and side view mirrors. It runs on a Windows® operating system, and has multiple selectable driver vehicle profiles (police cruiser, sedans, ambulance, fire truck, transit bus and van). For this study the police cruiser was a Ford Crown Victoria.

Figure 1. Type of Simulator Used in Study (L3 PatrolSim 5)

The police vehicles used for both the traditional and blended components were Ford Police Interceptors (see figure 2).

Figure 2. Type of Car Used in Study (Ford Police Interceptor)

Procedure

The study randomly assigned 70 participants into two equal groups: a traditional instruction group (TG) and a blended instruction group (BG). The TG had 21 males and 14 females while the BG had 20 males and 15 females. See table 1 for a breakout of what both groups participated in.

On the first day all participants were welcomed and received a brief introduction. Participants also filled out a demographic sheet, which collected the participants' age, gender, years of driving, and whether they had any specialized driving training. A one-hour lecture on Line of Travel (LOT) components such as vehicle weight distribution when taking curves, extended visual sensitivity, and the dynamics of braking, driving posture, and hand position were then presented. At the end of the lecture, participants were randomly selected to be in either the control group or the experimental group, to go practice on Range 6.

On the second day both groups were placed together to perform some additional driving on Range 6. After the additional practice time, both groups were evaluated using a validated FLETC practical evaluation form that graded the participants on the skills of: braking, acceleration, vehicle position at the entry/apex/exit of a turn, and both the driver's gaze target and hand-position in a turn. This is the same practical evaluation form used on regular FLETC students when they take the LOT training.

Next, the participants were taken to Range 7, a new but similar range. The participants were given one safety practice drive and then given a practical evaluation. After the evaluation on Range 7, participants were taken to a classroom to complete a knowledge test regarding LOT. The 28 question, multiple-choice test consisted of videos showing various roadway curves. Each video was shown for 15 seconds and then the participants were prompted to select the appropriate answer. The roadway knowledge test was developed and validated by the FLETC specifically for this study.

Table 1 - Break Out of Groups

Day	Blended Group (BG)	Traditional Group (TG)
1	1 hr. Lecture on LOT	1 hr. Lecture on LOT
	3 hrs. Practice on Range 6 in the Simulators	3 hrs. Practice on Range 6 in Cars
2	2 hrs. Practice on Range 6 in Cars	2 hrs. Practice on Range 6 in Cars
	Graded Practical Exercise on Range 6	Graded Practical Exercise on Range 6
	1 Safety Lap on Range 7	1 Safety Lap on Range 7
	Graded Practical Exercise on Range 7	Graded Practical Exercise on Range 7
	Graded Cognitive Test on LOT	Graded Cognitive Test on LOT

Day 1

Upon arrival, both the TG and BG were given a one-hour classroom lecture on LOT. During this classroom lecture portion of the study, participants learned about true apex, a late and deep apex, and a late apex as shown in figure 3.

TG: The control group was issued safety equipment and taken to Range 6 to practice using standard police package vehicles. The control group had an instructor verbally coach the participants while they were driving. There was one instructor and two students per vehicle.

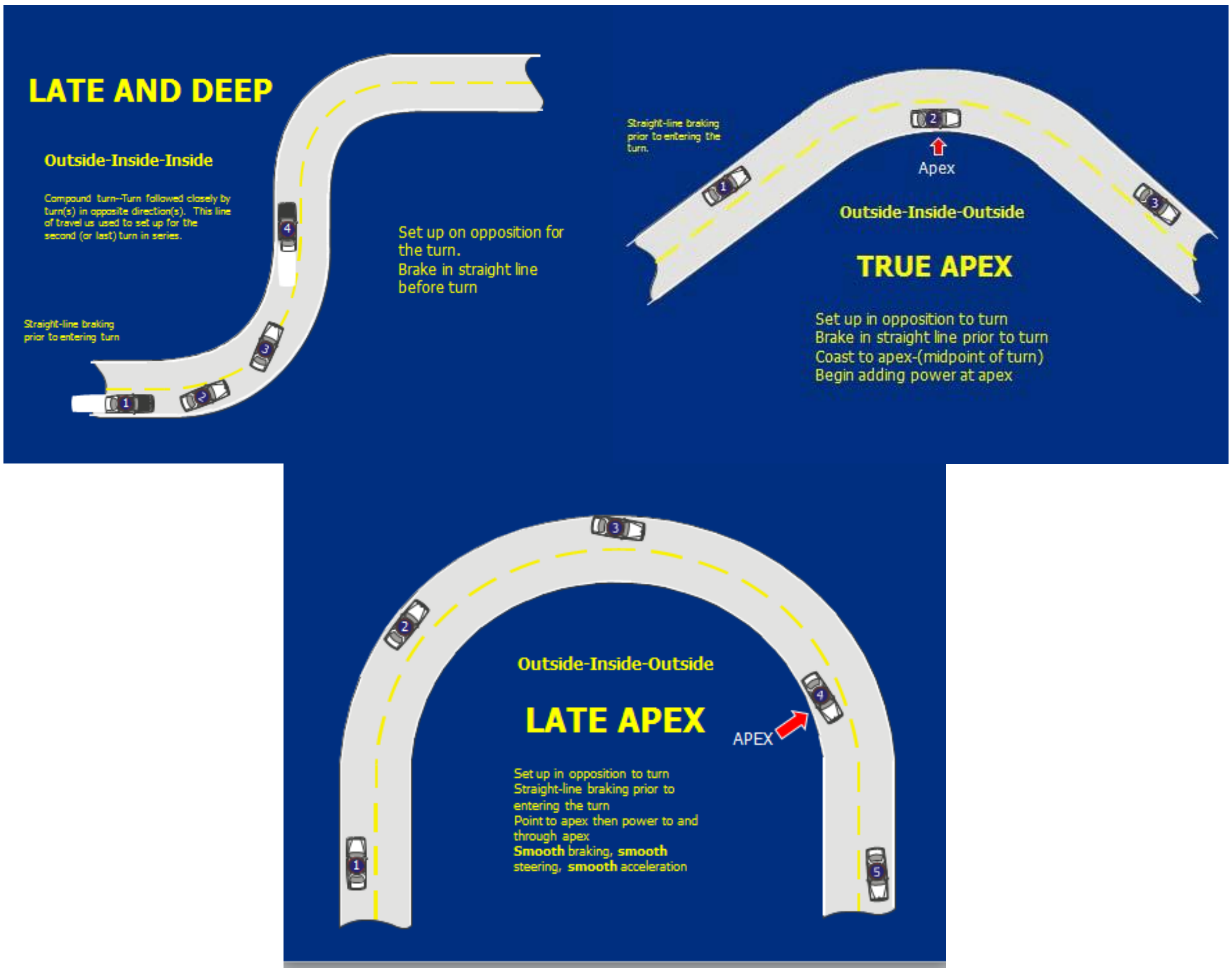

Figure 3. Explanation of the Types of Turns

BG: The overall practice time was approximately 3.0 hours. The BG had the advantage of instructional overlays in the simulators when taking curves. They received red arrow overlay for braking, yellow arrow overlay for coasting, and green arrow overlay for acceleration (see figure 4). As the practice session progressed, the overlays were gradually taken away to facilitate self- reliance. In addition, BG participants received an After Action Review (AAR) where they viewed their performance from seven different angles through video replay and received feedback as the virtual drive progressed.

Figure 4. Color Overlays

Day 2 - Data Collection

Both TG and BG trained together utilizing outdoor Range 6 with law enforcement equipped automobiles to ensure consistency with instructors and instruction. At the end of the practice session, each participant was evaluated on their LOT techniques while driving unsupervised on Range 6.

To assist in evaluating driving skills several Racelogic VBox Pro™ vehicle video systems were installed on the participants' vehicles. The VBox™ has four 580L and 420L bullet cameras, it records acceleration, braking, speed, and RPMs, which logs directly to a secure digital (SD) card. For this study, the cameras were placed on the front windshield, the rear window, and on the driver. Using video and data collected from the VBox, the instructor could view the braking, acceleration, vehicle position at the entry/apex/exit of a turn, and both the driver's gaze target and hand-position in a turn. All of these items were graded elements of the practical evaluations and were recorded while each participant travelled clockwise, and then counter clockwise on the range. (see Figure 5). The practical evaluation was developed by the FLETC and is used on all current and past students when they take the LOT practical evaluation.

Figure 5. VBox™ Evaluator View

After the participants were finished with their Range 6 evaluation, they were taken to Range 7, a new environment. At Range 7 the participants were given a safety lead around the course to orientate themselves to the new course. No instructors were in the participant cars. The orientation consisted of an instructor pointing out the curves of the new course via a radio. After that limited exposure to Range 7, the participants then drove the course for an assessment of their LOT skills, identical to the assessment used for Range 6. After the evaluation on Range 7, participants were taken to a classroom to complete a knowledge test regarding LOT.

Results

This between-groups quasi-experimental study compared the performance of participants trained solely on a traditional, real-world driving course to cohorts trained in a blended (simulator + range driving) environment.

The training design permitted teaching psychomotor, cognitive, and perceptual skills to drivers with no formal experience of LOT training. The design compared the validity of a three-screen fixed-base driving simulator in contrast to real-world driving. There were three independent variables in the experimental design. This study used a *t*-test to examine differences between the driving simulator and on-road driving performance metrics. The near transfer was analyzed using a dependent *t*-test.

Research Question 1

Can participants who receive training in a blended learning environment (both simulated and live driving) perform better on the standard driving range practical examination than those trained with traditional methods?

Range 6 – Practice and Assessment

The mean practical evaluation score on Range 6 for BG was (M = 92.8, SD = 6.98), whereas the mean practical evaluation score for TG was (M= 98.1, SD = 2.6), showing a 5.34-point difference favoring TG (see Table 2). The independent-samples *t*-test found the means differed significantly at the $p < .05$ level. The group variances were not equal for the practical evaluation scores Levene's Test was $F(68) = 41.985$, p = .000 between TG and BG. Therefore, the TG performed better than the BG in regards to the performance on Range 6.

Table 2. Results of Both Groups

Evaluation Session	Traditional/TG		Blended/BG	
	Mean	S.D.	Mean	S.D.
Range 6	98. 1*	2.6	92. 8	6.98
Range 7	71.11	14.16	71.31	11.06
Cognitive Test	67.5	12.05	69.8	9.87

*p < .05

Research Question 2

Can participants who receive training with a blended and traditional learning environment transfer that knowledge when presented with a new environment?

Range 7 – Measuring Transfer

The practical evaluation score for BG on Range 7 was (M = 71.31, SD = 11.06), whereas the mean score for TG was (M = 71.11, SD = 14.16) showing a .2-point difference favoring BG (see Table 2). The independent-samples *t*-test found the mean did not differ significantly at the $p < .05$ level (note: p = .140). What is noticeable is the large standard deviations for both groups in contrast to the noticeably smaller dispersion on the previous Range 6 evaluation.

The mean average for the practical evaluation for TG on Range 6 was 98.11, and the mean average for BG was 92.31. However, when both groups were moved to Range 7 which was a new environment, their scores fell dramatically. The mean average for TG on Range 7 was 71.11, a 27-point drop. For BG the mean average was 71.31, a 21-point drop (See Table 2). This driving assessment took place shortly after all participants had passed the driving assessment on Range 6 with a score of 80 percent or above. This points to an extreme lack of near training transfer. The participants did not fully grasp the concepts of LOT, and were therefore not able to apply those concepts to a novel driving environment, Range 7. Thus, passing a practical exam on Range 6 does not guarantee the participants will be able to transfer their knowledge to the real world driving environment.

To further look at the differences in learning between both groups, TG had an advantage on Range 6 since they had been physically driving on it for five hours. BG did not have the same advantage, which is reflected in their performance on Range 6. However, when driving in a new environment, loss of performance was significantly less in BG. The independent samples *t*-test $t(68) = 2.02$, $p = .047$. This finding suggest BG were more resilient to performance loss due to a new environment. Meaning the BG understood the concepts of LOT better than the TG allowing them adjust to the new environment better than the TG.

Research Question 3

Can participants who receive training in a blended learning environment (both simulated and live driving) gain a better understanding of the principles of line of travel on a cognitive test than those trained with traditional methods?

The BG cognitive test score was ($M = 69.8$, $SD = 9.87$), whereas the TG test score was ($M = 67.5$, $SD = 12.05$) showing a 2.26-point difference favoring the BG (see Table 2). It should be noted at this juncture that the passing cut-score for the DMD practical evaluations and written exams is 80%. The independent-samples *t*-test found the mean did not differ significantly at the $p < .05$ level (note: $p = .162$).

Performance Variance

High standard deviations were found between both groups on Range 7 and on the cognitive test. The mean value is often used as the representative value for a group of scores. The standard deviation (SD) value is used to reflect the amount of variance in that group of values. The standard deviation values for TG and BG on Range 7 look dramatically different when compared to their values on Range 6. The large SDs for both TG and BG on Range 7 suggest limited uniformity and accuracy in the mean value. The results show some participants understood the concepts of LOT, while others did not understand the concepts of LOT. This could be due to multiple variables such as driving history, intelligence, motivation, and other factors as mentioned above. Thus, the mean is a poor representation for the data.

Time on Task

Time on task (TOT) records were kept on all of the participants. This was time actually behind the wheel of the car or a simulator on the first day of practice time. The TOT for the TG was 15:51 minutes of time actually behind the wheel of the car. The TOT for BG was 52:28 minutes of time actually in the simulator driving. This shows the BG had over three times the amount of actual practice time behind the wheel compared to TG. In addition, the ratio of instructors is 4:1 in the simulators versus 1:1 in the cars. There is a considerable amount of downtime in the cars due to the 1:1 ratio.

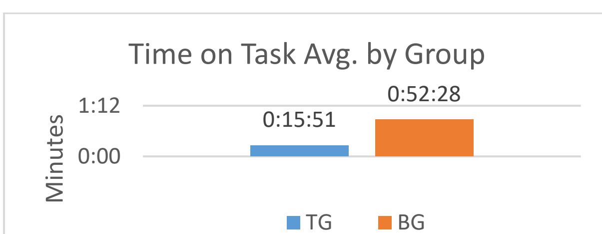

Figure 6. Time on Task by Group

Discussion

It was found by Humphlett (1985) in his study of high speed and low speed student drivers at the FLETC, 236 incidents of improper line of travel in one year. He decided to survey the DMD Branch Chief, and six senior driving instructors regarding this high number of incidents. The responses back are summarized as follows:

> *The results of this survey indicated the professional driver trainers considered the number of incidents of improper line of travel for both the HSG [High Speed Group] and the LSP [Low Speed Group] to be excessive and they concluded the subjects in both groups had not learned to read the road during their respective driver training program.* (p. 70)

The definitive goal of training is to improve the skills and knowledge abilities of the individual, which should lead to increased work performance (Holladay & Quiñones, 2003). These finding show the driving simulators are a valid teaching platform. The lack of training transfer, however, shows an overall problem exists somewhere in the training process (Broad & Newstrom, 1992). Poor instructional design could inhibit individual understanding and subsequent learning of the material. This leads to an inability or failure to transfer learned material and skills, especially if the students do not understand the concepts. The performance on Range 7 and the cognitive test show the participants do not understand the concepts of Line of Travel.

What factors influence the transfer of training? Researchers have generally viewed transfer as being affected by a systems of influences. Much of the literature suggests practice variability as a way to enhance training transfer (Baldwin & Ford, 1988; Holding, 1991; Holladay & Quiñones, 2003). Holladay & Quiñones (2003) found in their study of practice and self-efficacy that practice variability did have an impact on training transfer. In fact, several of the participants in their evaluation of the course suggested using different tracks, so they can better understand the concepts. One particpant wrote: "*Additional time on more than one track, so we can gain more varied experience.*"

Concepts are the key. The participants did not fully understand the concepts of LOT, and therefore, were not able to transfer their knowledge when confronted with a new course. LOT is an advanced racing technique. More time could be spent explaining and showing the participants the concepts in different venues that may enhance their understanding. It is believed realistic training will lead to better transfer of training, due to the similarity to the environment, but familiarity alone many not be enough. Norman, Dore, and Grierson (2012) point to two reasons. First, just knowing how to drive does not ensure you may understand the concepts of LOT. Secondly, cognitive load theory establishes that additions to the learning task may detract from learning due to our limited ability to process incoming information, without varied practice time. The mind seeks the simplest path by memorizing the course, especially if it does not truly understand the concepts.

One possible reason for BG's lower scores on Range 6 could be due to lack of lateral displacement that is not replicated in the simulators. With some certainty the normal cues used in such cases on a real road cannot be used when navigating a curve in a limited motion simulator (Blana & Golias, Summer 2002). However, these finding suggest that BG was more resilient to performance loss due to a new environment. This could be attributed to the After Action Review that BG received in the simulators that TG did not receive.

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