

VALIDATION OF SIMULATED ASSESSMENT OF TEEN DRIVER SPEED MANAGEMENT ON RURAL ROADS

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ABSTRACT

More US teens die from traffic crashes than from any other cause, with speed and rural roads major contributing factors. This study aimed to validate a high-fidelity simulator to explore these risks in an injury-free environment. Twenty-one newly-licensed 16-year-old males completed simulated and on-the-road drives of the same rural roads. Average free speeds on three road segments showed no systematic differences across segments. The majority of teens exhibited speeds in the simulator within 10% of those on-the-road. These findings validate the simulator for further research on teen driver free speeds on rural roads. Further analyses are needed to validate other performance measures.

As found in developed countries worldwide, US teenagers are overrepresented in motor vehicle crashes [IIHS, 2006]. In 2005, 3,467 15-20 year-old drivers were killed. Between 1995 and 2005, fatalities of drivers of this age group increased by 4% [NHTSA, 2006]. A major contributing factor was inappropriate speed, with the majority of fatalities occurring on rural roads.

Inappropriate speed includes speeds within posted limits but too fast relative to driving conditions, speeding over the posted limit but in keeping with the traffic and, less often, intentional aggressive or reckless speeding [Lam, 2003; McKnight & McKnight, 2003]. Of young drivers in US fatal crashes in 2005, 38% of males and 25% females were travelling over the posted limit at the time of the crash [NHTSA, 2006]. Young males have been found to drive more quickly, more aggressively, have a greater propensity to violate rules and react more quickly in traffic; thereby leaving smaller margins of error [Maycock, 2002]. Therefore, when investigating speed control among teen drivers, young males should be a particular focus.

The risk of a fatality crash is higher on rural roads than urban roads for all drivers, including teen drivers [Donaldson, 2006; Marmor & Marmor, 2006; Zwerling et al, 2005]. There are approximately 35% more crashes and deaths in rural areas than in urban areas, despite fewer vehicle miles traveled [Burgess, 2005]. A study of young driver single-vehicle crashes in Florida found rural locations and increased speeds were among factors that significantly increased the probability of having a more severe crash [Dissanayake & Lu, 2002]. Therefore, both speed and rural roads are among the most important factors to examine in teen driving research.

A safe way to explore risky teen driving is in a simulated environment. A high-fidelity simulator in East Iowa, the National Advanced Driving Simulator (NADS), offered this possibility in a rural setting, but had not yet been validated for research with teen drivers. Therefore, the objective of the current study was to validate the NADS for teen driver research, by comparing simulated driving with actual on-the-road driving for the same rural road segments. The focus of this paper is on validation of free speeds, that is, speeds on open road segments that are not limited by other traffic or road features. As resources precluded a large sample, and as teen males are at greatest risk for crashes, including speed-related crashes, only males participated in the evaluation.

METHODS

EQUIPMENT AND MATERIALS -

Survey – The survey was programmed and published on the NADS & Simulation Center website using SurveyPro Netcollect 3.1 software (Apian Software, Inc., 2005). Access to the surveys was restricted by sign-on requirements with user names and passwords. Relevant survey items included standard demographics: “What is your birth date? (Month/Day/Year)”; “What is your gender? (Male/Female)”; “Are you yourself of Hispanic origin or descent, such as Mexican, Puerto Rican, Cuban or some other Spanish background? (Yes/No/Don’t know)”; and “What do you consider your race to be? (American Indian/Alaska Native, Asian, Black/African American, Native Hawaiian/Other Pacific Islander, White/Caucasian, Other”.

Additional items were included to assess licensure and driving experience: “When did you get the following driving permit or license? Instructional Permit [learner’s permit], Minor School License [allows unsupervised driving to/from school only] (Month/Year, Do not have)”; “When do you plan to get your Intermediate license? (Within the next week/Within the next 2-3 weeks/Within the next month/During July/During August/During September); and “Have you ever driven in the following vehicles and situations? Thinking of the last 30 days, on how many days did you drive the following? Car, Other passenger vehicle, Motorcycle, Moped or ATV, Farm vehicle, Other (Supervised/Unsupervised)”.

A sensation seeking measure was included as a proxy for likely intentional driving risk-taking after licensure [see e.g., Arnett, 1996]. The brief, valid and reliable scale, the Brief Sensation Seeking Scale (BSS) [Hoyle et al, 2002], comprises 8 items: “I would like to explore strange places”, “I would like to take off on a trip with no pre-planned routes or timetables”, “I get restless when I spend too much time at home”, “I prefer friends who are exciting and unpredictable”, “I like to do frightening things”, “I would like to try bungee jumping”, “I like wild parties” and “I like new and exciting experiences, even if I have to break the rules” (1=Strongly disagree, 2=Disagree, 3=Neither disagree or agree, 4=Agree, 5=Strongly Agree).

Simulator and On-the-Road Drives – The National Advanced Driving Simulator is an advanced high-fidelity ground simulator with a 13-degrees-of-freedom motion system.

Velocity data for the simulator and on-the-road trials were analysed to determine any effects associated with the location of the evaluation (i.e., simulator or on-the-road). This data were examined for three rural driving segments of approximately $\frac{3}{4}$ of a mile each. The posted speed limit on each segment was 55 mph. The simulated environment contained no traffic impeding the driver; however, traffic was present and uncontrolled for the on-the-road drives. Several different aspects of speed were examined for each segment: 1st quartile speed, median speed, 3rd quartile speed, mean speed, maximum speed and standard deviation of speed.

On-the-road driving data were collected by means of a simple data logger, which was installed in participants' own vehicles. The device was unobtrusive and connected to the On-Board Diagnostic (OBD) port under the dashboard of the vehicle. This is the same port mechanics use to perform diagnostic checks on vehicles and commercial devices (e.g., CarChipE/X, Davis Instruments, San Diego), and posed no additional risk to participants or their vehicles. Due to limitations in the reliability and sampling frequency of the commercially available devices at the time of this study, the logging device was constructed by NADS engineering personnel and was comprised of a micro-processor, an accelerometer and a global positioning system (GPS).

PARTICIPANTS AND PROCEDURE – The current study was part of a larger project that targeted teens and their parents. Recruitment drives were conducted via flyer distribution at high schools in 12 school districts local to the NADS, newspaper advertisements and an information booth at a local mall. Additionally, several driving safety presentations were given at area high schools and driver education programs, reaching approximately 1,000 teens. Potential participants were directed to a web page at the NADS website. The web page described the requirements for participation, allowed potential participants to download Informed Consent forms or request preprinted versions, and provided contact information so they could obtain more information and ask questions. To qualify for the study, teen participants were required to be 15 to 16 years of age, possess a valid Iowa Instructional Permit, and intend to possess a valid Iowa Intermediate License before August 31, 2006. These inclusion criteria controlled for effects of age and independent licensed driving experience.

Only male teens in the larger project who were not engaged in full-time employment that required driving were invited to

participate in the simulation validation study to further control for driving experience and for gender. They were also required to pass a battery of health- and medication-related screening criteria required by the NADS facility. An additional Informed Consent document describing the simulated drive and on-the-road portion of the study was required.

Of the 73 teens who qualified and enrolled in the project, 45 (61.6%) were male. Of these, 21 (46.7%) participated in the simulator validation study. The mean age was 16 years 2 months (range 16 years 0 months to 16 years 7 months). Only 1 (4.8%) participant identified as Hispanic. The majority (18 or 85.7%) was White/Caucasian, with 1 (4.8%) Black/African American, and 2 (9.5%) of mixed race.

Participants completed a web-based survey at the time of licensure and participated in two simulator drives and one on-the-road drive on a single visit to the NADS during their second month of licensure. Half the participants completed the on-the-road drive first and half completed the simulator drives first. A data logger was installed in the participants' own vehicles prior to their on-the-road drive and was removed after that portion of their visit was completed. Participants were requested to drive normally and safely on both the public roads and in the NADS. In total, they drove for one hour on the NADS and for 40 minutes on public roads.

Prior to the 40-minute on-the-road drive, participants were shown a map of the route and allowed to ask questions. An experimenter rode in the back seat of the participant's vehicle to give route instructions and make note of unusual occurrences during the drive. The first portion of the on-the-road drive took the participants north of the NADS facility. At the end of the north-bound drive, participants stopped and were given the opportunity to ask questions. Participants then followed a different route south to return to the NADS facility.

Participants were given a 15-minute break between the on-the-road and simulator drives. The simulator trials consisted of two drives, programmed to represent the same roads and driving situations as encountered during the two halves of the on-the-road drive. An experimenter rode in the backseat to give route instructions. Immediately following the simulator drives, participants answered questions regarding symptoms related to simulator disorientation to ensure they were not experiencing any such disorientation.

Monetary incentives were offered for participation. In addition, participants were given the opportunity to drive a sports car simulator at the NADS facility at the end of the broader project (several months later). The full project and simulator validation protocol was approved on full review by the Institutional Review Board at the University of Iowa, and administrative review at The Children’s Hospital of Philadelphia.

RESULTS

Four (19.0%) of the 21 participants held a Minor School License and had been driving unsupervised for an average of 7.04 months (range 1.57 to 11.04 months). Nonetheless, all remaining participants also reported unsupervised driving prior to their independent license, with 5 (41.7%) reporting driving unsupervised during the past 30 days. This suggested all participants had some baseline unsupervised driving experience prior to the independent licensure.

Sensation seeking scores for all participants are displayed in Figure 1. As shown there was a spread of scores from lower to higher sensation seeking, suggesting heterogeneity among participants.

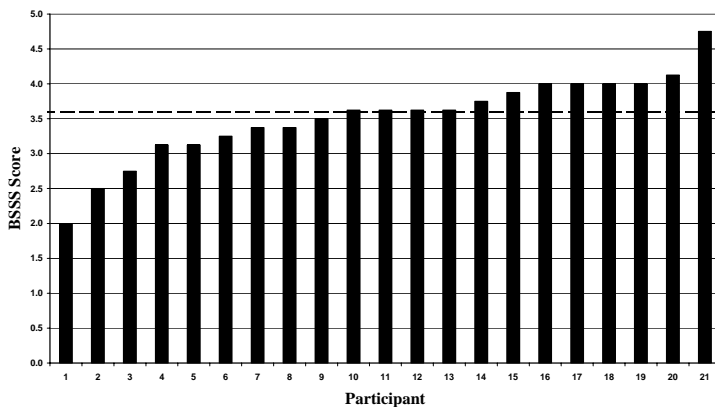


Figure 1 – Sensation Seeking Scores for all participants (score range 1 to 5) with median split

The SAS General Linear Models (GLM) procedure was used to analyze the impact of location of the drive and segment of the drive. A summary table of averaged speeds in miles per hour (mph) is presented in Table 1, and significance test values in Table 2. Location data are based on total n=21, however, due to missing data, segment and interaction results are based on n=17.

Table 1 – Averaged Speeds (mph) by Segment, Simulator Location and On-the-Road Location

	Mean	SD	1 st Quartile	Median	3rd Quartile	Maximum
Segment 9	54.93	1.59	53.61	54.82	56.22	57.60
Segment 10	54.97	1.07	54.02	54.92	55.79	56.87
Segment 11	55.59	1.79	54.19	55.66	56.98	58.52
Simulator	56.29	1.69	55.21	56.19	57.34	58.55
On-the-Road	54.04	1.27	52.71	54.07	55.32	56.78

Table 2 – Significance of Averaged Speed (mph) by Segment, Location, and the Interaction of Segment by Location

		F value	DF	P value
Segment	Mean	0.44	2	0.6484
	SD	4.23	2	0.0191 ¹
	1st Quartile	0.32	2	0.7274
	Median	0.65	2	0.5238
	3rd Quartile	0.99	2	0.3776
	Maximum	1.73	2	0.1853
Location	Mean	13.53	1	0.0006 ^{1,2}
	SD	4.06	1	0.0496 ¹
	1st Quartile	15.23	1	0.0003 ^{1,2}
	Median	10.13	1	0.0026 ^{1,2}
	3rd Quartile	8.04	1	0.0067 ^{1,2}
	Maximum	3.33	1	0.0742
Segment by Location	Mean	0.93	2	0.4009
	SD	0.08	2	0.9247
	1st Quartile	0.55	2	0.5815
	Median	0.54	2	0.5877
	3rd Quartile	1.08	2	0.3479
	Maximum	0.82	2	0.4470

¹ Significant at $\alpha=0.05$; ² Significant after Bonferroni correction ($0.05/6=0.008$)

Although location (simulator vs. on-the-road) was the primary comparison of interest, segment was included to ensure that there was no systematic difference between the segments that was impacting the data. As such the impact of segment will be discussed prior to location comparisons.

When examining the impact of the segments, it was found that there were no interactive effects with location for any of the dependent measures. For all of the dependent measures except standard deviation of speed, there was no measurable difference among mean speeds across the three segments of 55.2 mph. For standard deviation of speed, two of the segments differed from each other but not from the third. As there was no interactive effect of segment with location, it was valid to consider the impact of location without consideration of the segment.

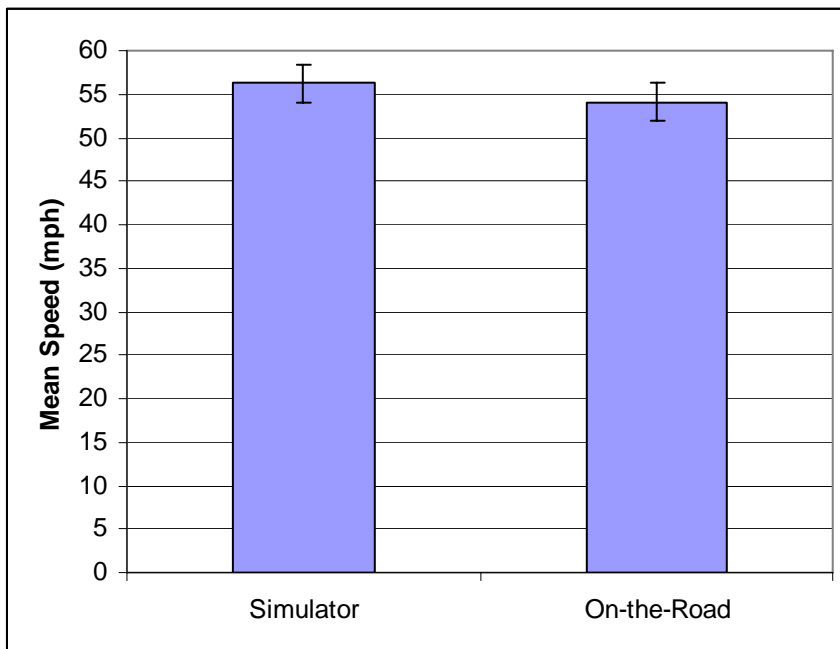


Figure 2 – Average Speed in Simulator and On-the-Road

When examining location of the test, there were statistically significant differences in speed after Bonferroni correction for the following measures of speed: mean, 1st quartile, median and 3rd quartile. In the simulator, teens drove at an average 2.26 mph faster than on-the-road (see Figure 2), with simulated drives averaging 1.1 mph over the speed limit and on-the-road drives 1.16 mph under the

speed limit. First quartile, median, and 3rd quartile speeds also showed similar differences (see Figure 3).

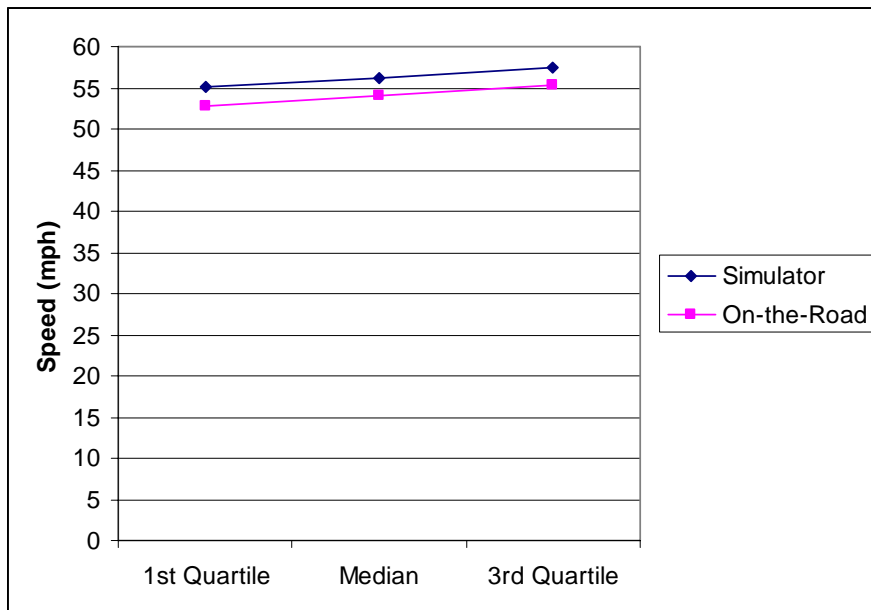


Figure 3 – Average 1st Quartile, Median and 2nd Quartile Speed in Simulator and On-the-Road

When examining the variability of the drivers' speed across the three segments, it was found that drivers on the road had significantly more variability than they did in the simulator (see Figure 4). This would be consistent with the need to vary speed in response to other traffic on the road.

As can be seen in Figure 5, little variation was seen for speeds among the drivers. By looking at the average speeds for each driver, it was determined that 15 out of the 17 (88.2%) drivers that completed both drives had simulator speeds that were within 10% of their on-the-road speed and that 10 (58.8%) were within 5%.

Additionally, all 17 participants were within 10% of the posted speed limited (i.e., between 49.5 mph and 60.5 mph) for both the simulator and the on-the-road drives. From a comparison standpoint, in the simulator 11 of the 17 drivers (64.7%) had speeds within 5% of the posted speed limit (i.e., between 52.25 and 57.75 mph); whereas on-the-road there were also 11 of 17 participants (64.7%) that were within the same speed range.

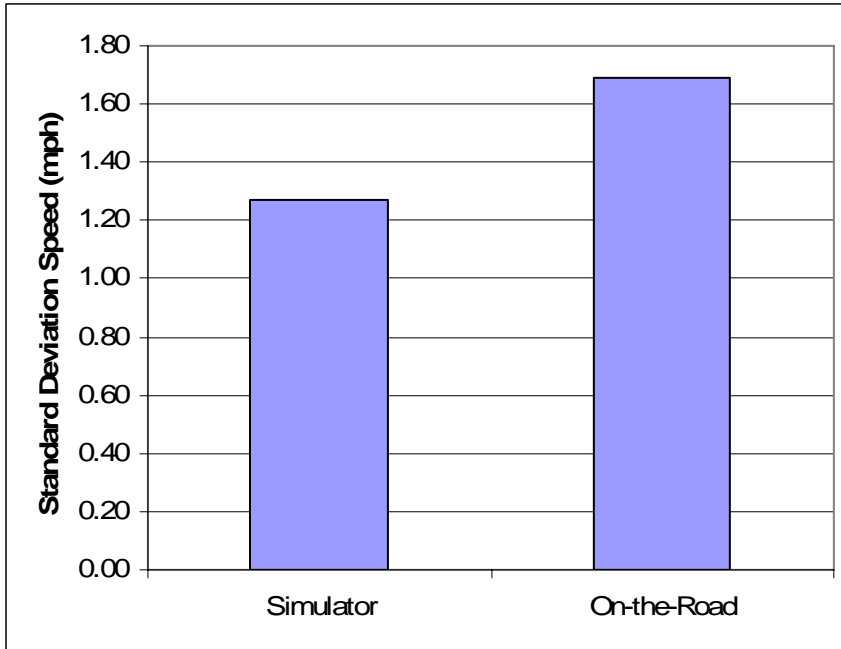


Figure 4 – Standard Deviation of Speed Across Segment

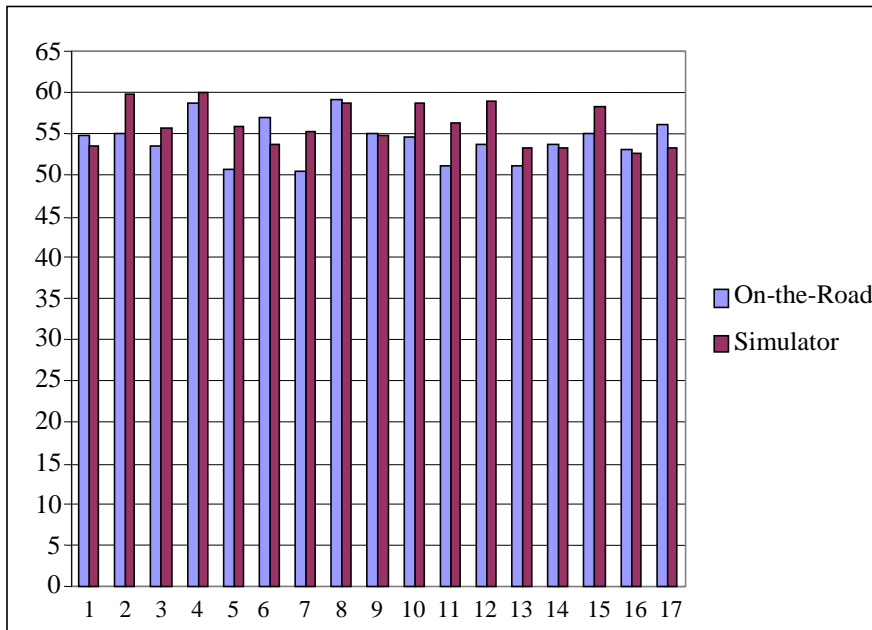


Figure 5 – Average Speed in Simulator and On-the-Road by Driver

CONCLUSIONS

Our results showed no systematic bias in speed by rural road segment, or by simulator versus on-the-road location, with the vast majority of participants exhibiting speeds in the simulator within 10% of speeds on-the-road, and more than half exhibiting speeds within 5% difference. Therefore, the NADS was found to be a valid instrument to explore teens' free speeds on rural roads in our sample of rural male teens.

Limitations of this study include low response rate and comparable on-the-road data to simulator data, although the within subjects design overcomes some of these limitations for the purpose of validation. Further, the spread in sensation seeking scores suggested heterogeneity among participants. The speeds recorded are not generalizable to other rural male teens or other teens rather, the most important finding, regardless of the actual speeds recorded, is that participants drove at speeds in the simulator that were very similar to their speeds on-the-road for the same road type and conditions.

This paper examines only one of many aspects of teen driving performance that also need to be validated in the NADS using the data from this study and are planned for future reports. These include acceleration and braking patterns (smooth, erratic), lane position deviations, and vehicle following distances.

Validation of the NADS for teen driver research is an important task. Teen drivers have been included in driving simulator studies less frequently than other segments of the population, yet teens, particularly rural teens, are among the highest risk drivers of the roads. Better understanding of teen driver performance and causal pathways to risk is essential for improved intervention. The NADS allows us to examine risky behavior and high risk situations in a safe, injury-free environment. This study suggests the NADS offers a valid tool for such research in relation to free speeds on rural road segments.

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