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## **VALIDITY OF AN ON-ROAD DRIVER PERFORMANCE ASSESSMENT WITHIN AN INITIAL DRIVER TRAINING CONTEXT**

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**Summary:** Based on a competence-oriented view of driving a driver performance assessment (DPA) has been developed to inform learner drivers about their progress in acquiring driving proficiency. An initial validation study was carried out to evaluate the adequacy of inferences based on DPA-scores assigned by driving instructors. The results of two pilots are presented. Implications for driving performance assessment within driver training programs are discussed.

### **INTRODUCTION**

All over the world novice drivers are heavily over-represented in traffic accidents and fatalities, and male novice drivers even more so. Most studies (among others Maycock, Lockwood & Lester, 1991; Gregersen & Bjurulf, 1996; Sagberg, 1998) have shown that in addition to age related factors a lack of driving skills is an important factor in explaining the involvement in accidents. More specifically, novice drivers appear to lack higher order skills: being able to observe relevant information within the traffic situation; to concentrate on aspects of the traffic environment that are potentially dangerous and to tailor their actions to their level of proficiency (self-calibration).

With these findings in mind scholars have argued for a different view of driving and driver training. Until recently the drivers' task was perceived as a set of elementary driving tasks pertaining to vehicle control and applying traffic rules. More recently, driving has been considered as a broader domain of competence. A stepping stone in this respect was the taxonomy of driving competence known as the GDE matrix (Goals for Driver Education). It is now being used for developing curricula for driver training at both pre- and post-license stages. The matrix stresses the overriding significance of the higher levels of driver behavior with regard to accidents, and the need for drivers to possess not only knowledge and skills, but also risk awareness and self-evaluation skills at multiple levels (Hatakka, Keskinen, Gregersen, Glad, & Hernetkoski, 2002).

In various European countries a two-phased driver training program, including a pre-license and post-license phase, is now under consideration. In addition, initial driver training programs have been further improved by using lesson designs led by professional driving instructors aimed at systematic teaching of meaningful driving tasks. In addition, initiatives for permanent (ongoing) road safety education have emerged. Driver education is considered to be a long-lasting or even a life-long process (Vissers, Van Betuw, Nägele, Kooistra & Hartevelde, 2007).

This shift towards competence-oriented driver training requires new forms of driving assessment which inform and support the learner driver and the instructor about the acquisition of driving competence (Dierick, & Dochy, 2001). Until recently, and in line with traditional views on driver training, assessment instruments took the form of rather isolated testing of knowledge about traffic rules in theory tests and technical driving skills in predominantly examiner-led road tests. Internationally it is increasingly advocated to also assess higher order aspects of driving as represented in the GDE-matrix: risk tolerance, reflection on one's own driving behavior and hazard perception (Vissers, 2004).

In 2007, the Dutch national institute for educational measurement (Cito) formed a consortium with organizations active within the field of driver training. The aim of this consortium is to develop assessment instruments which monitor driving competence for educational purposes throughout peoples' traffic career. This paper describes the development and application of an on-road driver performance assessment (DPA), reflecting the innovative view on driving competence. The focus is on a domain of driving competence building on the GDE-matrix, including performance criteria and an assessment and scoring procedure for driving instructors and driver examiners. The assessment procedure was tested within the context of initial driver training. Because it is meant to inform the driver about his progress towards initial driver proficiency, the DPA is regarded as a monitoring instrument, to be used on multiple occasions throughout the training period. To evaluate the adequacy and appropriateness of inferences based on DPA-scores, an initial validation study was set up.

Although the entire validation study addressed a wider range of aspects of validity (Kane, 2006) this paper is restricted to the following research questions:

1. How reliable are the instructors' assessments of their learner drivers' driving performance?
2. To what extent do DPA-scores yield correct predictions about the final driving exam result?

## **METHOD**

### **The driver performance assessment framework**

Based on a framework for competent driving a scoring procedure was developed, in which driving tasks are judged against strict criteria (Cito, 2008). Five performance criteria were used:

*Safe driving* refers to one's ability to drive in such a way that the risk of injury or damage to the driver himself or other road users is kept to a bare minimum. The driver is expected to constantly drive at an appropriate speed: adapted to the circumstances and to the tasks at hand, and to his own ability. He maintains sufficient safety margins in relation to other road users, correctly assesses risk, recognizes danger in time and then chooses to act accordingly.

*Consideration for other road users* means that the driver pays attention to the safety and progress of other road users as well as himself. This means that he does not stick dogmatically to his own rights and he shrugs off other people's mistakes. He avoids surprising others with his actions by making his intentions clear well in advance. He gives others space to correct their mistakes. He

puts himself in the position of other road users and can judge if his own behavior causes others irritation or nervousness.

*Facilitating traffic flow* implies the ability to drive in traffic without impeding the progress of other road users. The driver's actions are not only safe but also vigorous and smooth. A driver chooses where to stop or where to turn in a way that causes the least inconvenience to other traffic. The same applies to performing maneuvers, such as reversing and parking. These tasks are carried out in such a way that they do not hinder other road users.

*Environmentally responsible driving* involves driving in such a way that emissions of harmful gases and noise levels are kept to a minimum and that optimal use of fuel is achieved. Such driving involves avoiding large changes in speed: calm accelerating and decelerating, changing up to a higher gear in good time and making use of the car's rolling momentum, gentle use of the accelerator and clutch when carrying out maneuvers. The engine should be switched off during long stops.

*Controlled driving* means smooth technical vehicle handling and control. This means operating navigational systems skillfully, carrying out actions smoothly: is the car being steered and controlled smoothly, is the driver turning, stopping and driving off without stutters and jerks? On an operational level this means supple and skilful execution of maneuvers: steering, accelerating, using the clutch and braking are all done automatically and without fault.

### **The scoring procedure**

Experienced driving instructors are responsible for the performance assessment. As part of a practical training session, the learner driver drives along a route on public roads to enable a judgment of his/her driving performance. Part of the session consists of driving without intervention from the driver instructor, whose task is to observe the learner driver's driving skills. To collect evidence of driving competence the driving instructor instructs the participant to drive along a representative route through five different areas, requiring a full range of typical driving actions: residential access roads 1) inside and 2) outside built-up areas, roads connecting towns 3) inside and 4) outside built-up areas, and 5) highways.

In order to make a systematic and comparable judgment of driving proficiency, scoring forms were developed in which the various driving tasks were judged against the five criteria described above. Two versions were elaborated. Firstly, a fine grained version in which each performance criterion is elaborated further into specific performance indicators and in which 13 different specific driving tasks are discerned. These tasks can be categorized under five main tasks: preparing for driving (e.g. prepare vehicle and driver), making progress (e.g. driving off and stopping), crossing intersections, moving laterally (e.g. changing lanes), carrying out special maneuvers (e.g. turning). The resulting scoring form consisted of 126 cells to be scored, after combination of 13 driving tasks and 12 performance criteria, and excluding 30 cells which do not yield unique information about environmentally responsible driving. The assessor is expected to score each cell on a rating scale ranging from 1 (very unsatisfactory) to 4 (optimal).

The second version, the 'global task area version', was more general in nature. In this version, driving through a specific type of area is considered as a task. The task performances were

scored directly according to the five performance criteria. The resulting scoring form consisted of 30 cells to be scored, after combination of six driving tasks (five areas plus 'carrying out special maneuvers') and five performance criteria. The assessor assigned scores for each cell on a five point rating scale ranging from 4 (unsatisfactory) up to 8 (optimal). The reason for using this scoring range is that the assessors' work within an educational context, described below, where scoring levels 1 up to 3 refer to preliminary driving proficiency levels. The lowest scoring level was set at level 4, which is fully equivalent with score level 1, as used in the fine grained version.

The driving instructors acting in the role of assessors were trained to carry out the performance assessments in a series of three 3-hour workshops. A detailed scoring manual was developed to support the scoring procedure. Inter rater reliability was tested by using a set of 12 video-clips showing critical parts of the task performance of four drivers, to be scored individually by each of the assessors. Inter rater reliability coefficients were calculated to indicate assessors' mastery of the assessment procedure. For both versions of the form the inter rater reliability reached an acceptable level (mean Gower coefficients for similarity above .70).

## **Subjects**

The performance assessment procedure was carried out within two separate pilot studies. The first pilot took place within a Dutch driving school, delivering short and condensed training programs which culminated, approximately 15 days after the start, with a final exam consisting of a 55 minute practical driving test. A total of 11 driving instructors participated. Their instructional experience was on average 15 years (SD=7.5). Their mean age was 43.2 (SD=8.1). The instructors used the DPA within a two month period during their regular training program and was administered to each learner driver on two occasions. The first occasion was a driving assessment administered during the training program, which yielded a partial dispensation on the final exam (the so called 'learner interim test'). On this occasion a professional driver examiner from the Dutch National Driving Examination Institute (CBR) administered an official driving assessment lasting approximately 55 minutes. In the meantime the driver instructor independently judged the performance of the learner driver using the DPA. The second occasion on which the DPA was used by the driver instructor was during the final exam, again administered by a CBR examiner. In sum, 41 female (mean age 20.6 years) and 50 male learner drivers (mean age 19.8 years) participated in the first study. The sample was representative in terms of their prior school education.

The second pilot involved 26 Dutch driving instructors who work according to the method of 'Driver Training Stepwise' (DTS; Nägele & Vissers, 2003). DTS is a modular driver training program which differs from the traditional (driving school-based) training in two fundamental respects: 1) the pupil learns how to drive in a series of highly-structured steps (driving scripts) and 2) the pupil is only allowed to enter the next stage of learning if he shows complete mastery of the previous stage. At the end of each learning stage there is a test to assess whether the pupil has obtained the required level. In DTS-programs learner drivers are taught an average of 38 practical driving lessons of 60 minutes.

The driving instructors administered the DPA to each learner driver after the first two learning stages or modules of DTS had been completed (score 1). In addition to this the DPA was also

used by the driver examiner at the learner interim test (score 2) and at the official driving test (score 3). In the second pilot 35 female learner drivers (mean age 20.3) and 26 male learner drivers (mean age 19.6) participated. The sample was representative in terms of their prior school education.

## Analysis

Overall scores on the DPA formed the basis for further analyses. To arrive at an overall score for driving performance on the fine grained version the individual cell scores were aggregated across the tasks towards indicator scores. Five criteria scores and an overall score were then calculated. For the global task area version, the first step in the aggregation procedure was the aggregation towards criteria scores, which in turn were aggregated towards overall scores.

In order to estimate a pass/fail prediction boundary for the DPA score, logistic analyses were carried out. In this analysis the logit of the odds ratio between passing and failing on the final examinations is predicted by the DPA-score.

$$\ln \frac{p_{pass}}{p_{fail}} = a + b x \quad (1)$$

where:  $p_{pass}$  = the chance to pass and  $p_{fail}$  the chance to fail,  $a$  is a constant,  $b$  a regression coefficient belonging to  $x$ , referring to the DPA score.

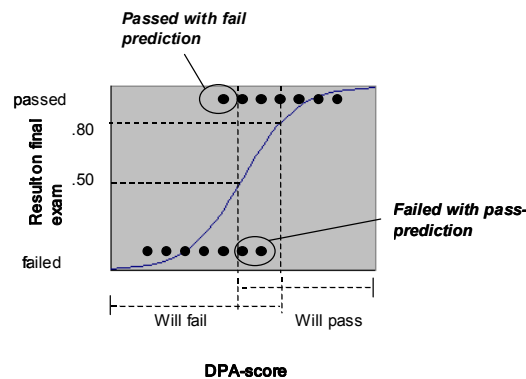


Figure 1. misclassifications using DPA cut-off scores at  $p=.50$  and  $p=.80$

The cut-off score for the DPA is determined by choosing a cut-off point where the probability to pass rises rapidly. In the present analyses the cut-off was set at  $p=.50$ . The cut-off score for the DPA can be determined in such a way that the number of misclassifications is minimized. Misclassified learner drivers can either be those who fail the exam with a ‘pass’ prediction, or those who pass the exam with a ‘fail’ prediction. Using a relatively high cut-off score for the prediction based on the DPA, such as one corresponding to an 80 percent pass probability, leaves less failed candidates with a pass prediction. However, more learner drivers will find themselves passed with a fail prediction (see figure 1).

## RESULTS

### Reliability and discriminative power

To estimate the test-retest reliability of the DPA-measurements the scores on the two last measurement moments were correlated. In pilot 1 the correlation between the first and last moment was .80. In the second pilot the correlation between the second and the third measurement score was .70. Note that due to differential growth of driving proficiency during the training period, this correlation is an underestimation of the test-retest reliability.

Comparisons of mean DPA-scores for learner drivers who passed and failed on the final exam show large and significant differences to the advantage of those who passed. Most of the effect sizes (Cohen's *d*) are above 1, depicting large effects (see table 1). In pilot 2 the differences between failing and passing learners drivers amount to 1.5 standard deviation on the third DPA assessment, which is closest to the exam. In the first pilot, DPA score 1 is assigned a few days before the final exam. Its discriminative power is also big ( $ES=-1.07$ ).

**Table 1. Means and standard deviations on the consecutive assessments for learner drivers who failed and passed the final exam**

	Failed			Passed			<i>t</i>	<i>df</i>	<i>ES</i>
	<i>N</i>	<i>Mean</i>	<i>SD</i>	<i>N</i>	<i>Mean</i>	<i>SD</i>			
<b>Pilot 1</b>									
DPA score 1	23	2.45	0.42	23	2.85	0.53	-2.85*	44	-1.07
DPA score during final exam	45	2.56	0.50	47	3.13	0.56	-5.05**	90	-0.84
<b>Pilot 2</b>									
DPA score 1	6	5.49	0.42	50	6.13	0.48	-3.13**	54	-1.20
DPA score 2	7	5.63	0.34	52	6.15	0.47	-2.83*	57	-0.98
DPA score 3	7	5.82	0.28	52	6.57	0.45	-6.12**	57	-1.55

Note \*  $p < .05$ ; \*\*  $p < .01$

### Predictions of results on the final exams

Table 2 up to 5 show cross tabs in which the actual result on the final examination is tabulated against the predicted results, based on the dichotomized DPA score. Using the results of logistic regression analyses, the cut-off scores corresponding a probability  $p = .50$  were calculated as a basis for dichotomization. Misclassifications are the observations that fall in the off-diagonal cells.

**Table 2. Classification table for DPA predictions (Pilot 1, at moment 1) against the result of the final exam**

		Predicted result		
		Failed	Passed	
Actual result of final exam	Failed	14	9	65
	Passed	7	16	
Percentage correct		67	64	

Note: Calculated cut-off score on the DPA: 2.65 using a cut-off probability  $p = .50$ .

**Table 3. Classification table for DPA predictions (Pilot 2, at moment 1) against the result of the final exam**

		Predicted result		
		Failed	Passed	
Actual result of final exam	Failed	2	4	91.2
	Passed	1	50	
Percentage correct		67	93	

Note: Calculated cut-off score on the DPA: 4.92 using a cut-off probability  $p = .50$ .

**Table 4. Classification table for DPA predictions (Pilot 2, at moment 2) against the result of the final exam**

		Predicted result		
		Failed	Passed	
Actual result of final exam	Failed	1	6	89.8
	Passed	0	52	
Percentage correct		100	90	

Note: Calculated cut-off score on the DPA: 4.73 using a cut-off probability  $p = .50$ .

**Table 5. Classification table for DPA predictions (Pilot 2, at moment 3) against the result of the final exam**

		Predicted result		
		Failed	Passed	
Actual result of final exam	Failed	3	4	88.3
	Passed	3	50	
Percentage correct		50	93	

Note: Calculated cut-off score on the DPA: 5.63 using a cut-off probability  $p = .50$ .

In the first pilot 65 percent of all predictions based on the DPA-scores turn out to be correct. There is no meaningful difference in the correctness of pass and fail predictions. Looking at the results of pilot 2 it can be observed that the percentage of correct predictions is higher than was the case for pilot 1. Most of this is attributable to the large number of (correct) pass predictions. There are only a few learner drivers who failed on the final exam (7 out of 60). The correctness of their ‘fail’ prediction varies across the three measurement moments. If the DPA cut-off score is set at a pass probability level of  $p = .80$ , with a corresponding a DPA-score of 5.89, this has a positive but small influence on the correctness of both ‘fail’ and ‘pass’ predictions.

## DISCUSSION

For educational purposes a formative driver performance assessment (DPA) was developed to support training decisions and to enable predictions about pass probabilities on the final driving exam. To evaluate the adequacy and appropriateness of inferences based on DPA-scores, a first validation study was set up. In the present study only part of a full validity argument could be evaluated. Building on Kane (2006) a validity argument can be set up in which the chain of inferences when interpreting the outcomes of a performance assessment is evaluated. More specifically, three inferences form the core of the validity argument: (1) reliable scoring of performance by assessors, (2) generalization from the observed score on a specific assessment task to a full range of assessment tasks, (3) extrapolation of assessment results to practice. In the subsequent discussion these inferences will be addressed.

A first condition for performance assessments to yield valid score interpretations is score reliability (research question 1). Results of inter rater reliability analyses during assessor training indicated satisfying levels of rater agreement. In addition intercorrelations among successive DPA measurements show that instructors’ judgments get stable towards the end of the training period, i.e. later measurements are more highly intercorrelated than early measurements. It was suggested that PDA-scores assigned early in the training program can vary more within learner drivers because they may show differential growth patterns. This may have inhibited the size of the test-retest correlation.

A limitation is that no direct inter rater reliability data could be collected for a large number of assessors doing their job within a real driving situation. Some instructors in the assessor role indicated that using video episodes of driving limited their ability to observe all aspects of driving, for instance in determining the adequacy of speed choice, and vehicle control.



Another issue pertains to the nature of the performance scoring. Different versions of the DPA were employed, involving rating scales of different lengths and a different degree of decomposition into subtasks. The fine grained version involves a highly analytical judgment, whereas the global task area form requires a more holistic judgment (Clouser, 2000). The question can be raised whether both versions are equally decisive and informative about the state of the drivers' driving proficiency.

The second inference in the validity argument was an unaddressed issue, the generalizability of performance scores. We did not estimate the effects of differences between the assessors, as a potential source of measurement error, nor did we estimate the effects of differences in the driving tasks that learner drivers were exposed to. The question is whether the tasks which learner drivers carried out were representative for the full range of possible tasks. It is a well-known finding that task variation accounts for much of the variance in performance (Brennan, 2000)

The third inference, extrapolation, addressed the question whether the assigned DPA-scores are predictive of success on the final driving exam (research question 2). The results show meaningful differences in DPA scores between passed and failed learner drivers. High effect sizes were found, indicating high differential capacity. This relation is probably even underestimated, taking into account that the examiners' judgments on the final exam will not be perfectly reliable.

Another way to look at the predictive validity of the DPA is to consider misclassifications regarding the 'fail' and 'pass' predictions on the (future) final exam, based on the DPA-scores. The results show different pictures for the two applications of the DPA. In the first pilot a fine grained version of the DPA was used in the context of condensed driver training. Results show that 65 percent of the learner drivers were correctly classified. In the second pilot, the context of Driver Training Stepwise (DTS) a more holistic version of the DPA was employed. Using DPA-scores 90 percent of the learner drivers could be classified correctly in terms of the predicted outcome of the final exam. The higher percentage of correct decisions compared to the first DPA pilot is mainly attributable to the correctness of pass predictions. This finding could be explained by the nature of the DTS training program. Within this program the driver instructor collects a lot of information about the learner driver regarding the progress on script mastery, by means of specially designed progress cards. He does so over a relatively long period which lasts nearly five months on average. The instructor will only send his learner driver to the final exam once he has mastered all driving scripts and has passed the formative assessments. These drivers will receive DPA-scores above the cut-off which instructors (implicitly) use in their judgments.

Looking back at the extrapolation inference, the quality of the external validation criterion used can be questioned. For purposes of initial driver training the pass/fail prediction is a sufficient criterion. For the instructor and the learner the growth towards exam preparedness is an important issue. However, DPA was also meant to inform drivers about their driving proficiency beyond the final exam, in the context of life-long learning. This would require an external criterion that relates to actual driving outcomes during the subsequent driving career, such as involvement in collisions and damage claims for one's own and other vehicles. For now, it seems

at least that the DPA is an appropriate tool to inform learner drivers about their progress towards their obtaining their driving license.

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