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The on-the-road driving test

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Abstract

The on-the-road driving test examines driving ability on a public highway in normal traffic. Driving performance is objectively measured by on-board computers. The combination of driving in real traffic, which gives the test high ecological validity, and objective measurement of driving performance makes the on-the-road test unique among other driving tests. This chapter discusses the methodology and background of the on-the-road driving test.

Subjects are instructed to drive with a steady lateral position within the right traffic lane while maintaining a constant speed. A camera on the roof of the car records the lateral position of the car. On board computers continuously record the lateral position and speed of the car. The Standard Deviation of Lateral Position (SDLP), i.e. the weaving of the car, is the primary parameter of the driving test. A secondary parameter of vehicle control is the standard deviation of speed.

During the past 25 years the on-the-road driving test has been applied successfully in psychopharmacological research, showing dose-dependent impairment for a variety of drugs including alcohol, antidepressants, hypnotics, anxiolytics, antihistamines and analgesics. Up to now, the on-the-road test has been acknowledged to be the gold standard method to determine drug effects on driving ability.

Introduction

Theoretical accounts making driving behavior understandable can be broadly divided into information processing models and motivational models. Motivational models are primarily concerned with the risks drivers are willing to take during driving, and include risk compensation models [1], risk threshold models [2], and risk-avoidance models [3]. According to motivational models, driving behavior is self-paced and determined by a cost–benefit analysis concerning the motives and

goals of the trip in relation to safety risks [4]. For example, people drive faster in an emergency, or adjust their speed under bad weather conditions. In other words, drivers adapt their driving behavior to their personal or environmental needs. As a result, these models are concerned mainly with risk taking, making them very popular in the field of traffic safety research. However, motivational models give little information about actual driving ability or driving-related skills. In contrast to motivational models of driving behavior, information processing models provide a functional analysis of the driver's task. For example, the model of Rasmussen [5] distinguishes three levels of cognitive control determining complex task performance, including skill-based behavior, rule-based behavior, and knowledge-based behavior. Skill-based behavior is largely automatic and effortless, routine driving (coordination between perception and motor actions), whereas rule-based behavior and knowledge-based behavior are controlled driving actions under new or unexpected circumstances. In rule-based behavior, drivers use prescribed actions (e.g., a passing maneuver) to deal with changed driving circumstances (e.g., a slower vehicle driving in front). If these rules turn out to be effective, behavior soon returns to the skill-based (automatic) level. If rule-based behavior is not sufficient, knowledge-based behavior is necessary, which implies conscious problem solving. Once the driver masters the unexpected or new situation, performance returns to rule-based or skill-based levels. The relationship between Rasmussen's levels of control is shown in Figure 1.

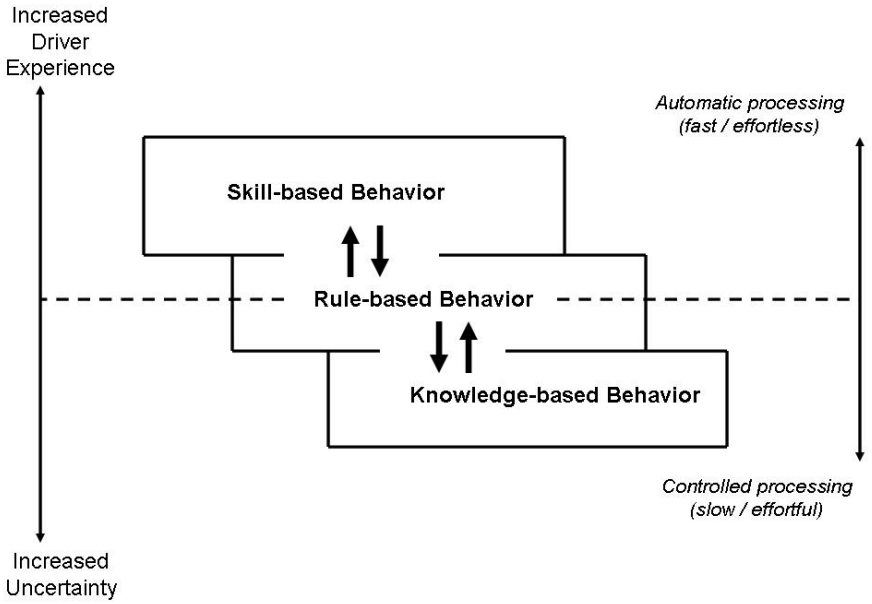

Figure 1 Automatic and controlled processing during driving.

Table 1 Driving behavior according to Michon and Rasmussen.

	Strategic/Navigational level (planning)	**Maneuvering/Tactical level (normal driving actions)**	**Operational/Control level (immediate vehicle control)**
Knowledge based behavior	Navigation in strange town	Controlling a skid on icy roads	Learner on a first lesson
Rule based behavior	Choice between familiar routes	Passing other cars	Driving an unfamiliar car
Skill based behavior	Home/Work travel	Negotiating familiar junctions	Road holding round corners

The distinction between automatic processing (fast and effortless) and controlled processing (slow and effortful) has been thoroughly described by Shiffrin and Schneider [6–7]. As indicated in Figure 1, a shift from automatic to controlled processing is made in case of increased uncertainty. The shift between automatic and controlled processing depends also on the driver's experience with a certain traffic situation. After repeated driving, several initially rule-based behaviors become skill-based behaviors as well. The concept of automatic *versus* controlled processing also applies to the theory posed by Michon [8], who suggested that driving behavior could be explained at a strategic level, a maneuvering level, and an operational level. Performance at the strategic (navigation) level is predominantly memory-driven, controlled processing, and concerns trip-planning, achievement of goals, etc. Performance at the maneuvering (tactical) level is environmental/data-driven, controlled processing, and includes normal driving procedures such as passing other cars, making curves while interacting with other traffic. Finally, the operational level is also data-driven, but automatic processing, and concerns immediate vehicle control, such as changing gears. Decisions made at the strategic level take minutes, those made the maneuvering level are made within seconds and at the operational level decisions are made within one second. The relationship between the models of Rasmussen and Michon is shown in Table 1.

It is evident from the examples in Table 1 that whether driving behavior is automatic or controlled depends on the driver's experience and the familiarity with the driving situation. In general, experienced drivers operate at the gray-scaled diagonal of Table 1, whereas novice drivers operate in the upper right corner of the Table.

Subjective driving assessments

Some research groups use subjective ratings of driving quality such as on-road scoring or using video recordings. The advantage of this method is that no expensive apparatus is needed to measure driving performance. Also, subjects can be tested in

their own cars. Unfortunately, research has shown that subjective ratings – either by experimenters, driving instructors, or the subjects themselves – are unreliable or do not adequately predict objective measures such as speed or SDLP [9]. The scoring methods varied from a simple pass-or-fail judgment to complex scoring of several skills and performances during driving. In has been demonstrated repeatedly that these subjective reports are inaccurate. Young drivers overestimate their driving ability and underestimate the risk of traffic accidents [10–11]. Cross-cultural differences in driver self-assessments have also been reported [12–13], and the accuracy of self-assessments is highly dependent on driving experience [14]. Nevertheless, approximately 80 % of all drivers report their driving abilities to be above average [15–16]. Other researchers concluded that drivers do not exaggerate their own driving skills and safety, but rather consider those of other drivers more negatively [17]. Also, psychoactive drugs may alter the awareness of reduced driving ability. Thus, it seems that subjects are not able to judge their own and others' driving ability accurately. Objective measurements of drowsy driving, such as alerting devices and EEG, are an improvement relative to the subjective measurements and are discussed elsewhere in this volume. Again, these measures – objective or subjective – record correlates to driving but do not predict actual changes in driving performance.

The on-the-road driving test during normal traffic

Up to now, the most accurate and direct way to measure driving ability has been the on-the-road driving test during normal traffic, developed in the nineteen eighties [18–19] and applied in over 50 studies with both healthy volunteers and patients.

In the 100-km driving test, subjects drive an instrumented vehicle over a 100-km highway track. In the right front seat, a licensed driving instructor accompanies the subject. His main job is to ensure safety during the driving test, and he is equipped with a brake and clutch system to intervene in the subject's driving actions, if necessary. If the subject or the driving instructor judges that it is unsafe to continue driving, the test is terminated before completion and the driving instructor transports the subject back to the Institute.

During the driving test, subjects are instructed to operate the instrumented vehicle at a constant speed and steady lateral position within the right (slower) traffic lane. A camera, mounted on the roof of the car, continuously records the actual position of the car within the traffic lane, by tracking the relative distance of the car from a delineated stripe in the middle of the road. Raw data collected during a driving test is shown in Figure 3. From this data the Standard Deviation of Lateral Position (SDLP), i.e. the amount of weaving of the car, is computed. Under placebo conditions, SDLP generally ranges between 10 and 30 cm, with a mean of about 20 cm. However, drug effects can produce an SDLP increment of 35 cm or more. SDLP is an excellent measure of vehicle control: with reduced control, SDLP increases (see Fig. 4). Excessive weaving may result in excursions out-of-lane onto both the road shoulder and the adjacent traffic lane. In this context, SDLP can also be regarded as a measure of traffic safety.

Figure 2 Measurement of lateral position.

Note that the camera for lateral position measurements is equipped with two infrared lights, to enable recording during the night and in dark weather circumstances. All data are continuously recorded on an on-board computer with a sampling rate of 2 Hz and edited off-line to remove data that were disturbed by extraneous events (e.g. passing, traffic jams, road maintenance). The experimenter, seated in the back of the car, monitors the on-board computer (reprinted with permision from reference [21])

A secondary parameter of the driving test giving insight in the amount of vehicle control is the Standard Deviation of Speed (SD Speed). Speed is measured from a pulse generator triggered by magnetic induction at a rate proportional to the revolutions of the drive wheels. Mean lateral position and speed are control parameters used to infer whether the subjects performed the driving test according to the given instructions.

Both SDLP and SD Speed are performance parameters measured at the operational/control level of driving performance. Under normal driving conditions, both lane keeping (expressed in SDLP) and speed control (expressed in SD Speed) are largely automatic processes, and examples of skill-based behavior, acquired through training and depending on the driver's experience. In the standardized driving test, subjects are instructed to drive at a constant speed and steady lateral position. This instruction involves planning at the strategic level, and changes motivational aspects and goals of driving during the test. However, while interacting with other traffic, subjects are sometimes unable to apply the instructions of the driving test.

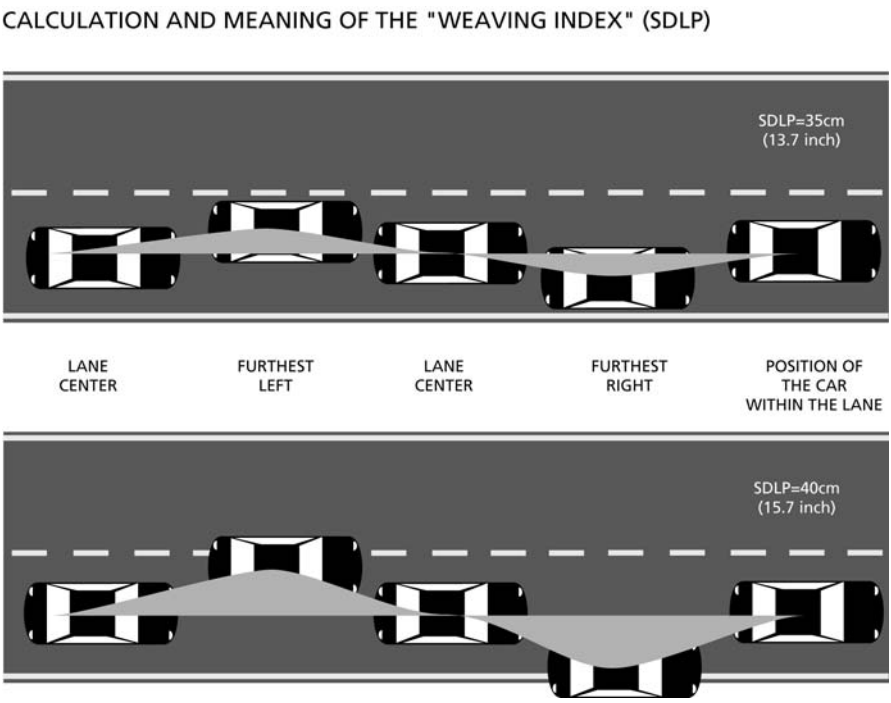

Figure 3 Standard Deviation of Lateral Position (SDLP).

Note that, with increasing SDLP, the weaving of the car becomes more pronounced, which eventually leads to out-of-lane crossings.

For example, sometimes speeding is necessary to pass a slower vehicle, or lateral position has to be changed to avoid an obstacle. These driving actions generally take place at the maneuvering level (but sometimes at the strategic level). The recordings from these driving actions are removed before analyzing the driving test data. It is, however, evident that both performance at the strategic and the maneuvering level will influence driving skills at the operational level (expressed in SDLP). The presence of other traffic and the occurrence of unexpected events, which are sometimes regarded as problematic, in fact are necessary components of the driving test. They are a prerequisite of its ecological validity that is often lacking in simple driving simulators and closed road tests.

Alcohol as historic control

One of the first studies using the on-the-road test examined the effects of different dosages of alcohol on driving performance [20]. Tests were performed on a 25-km

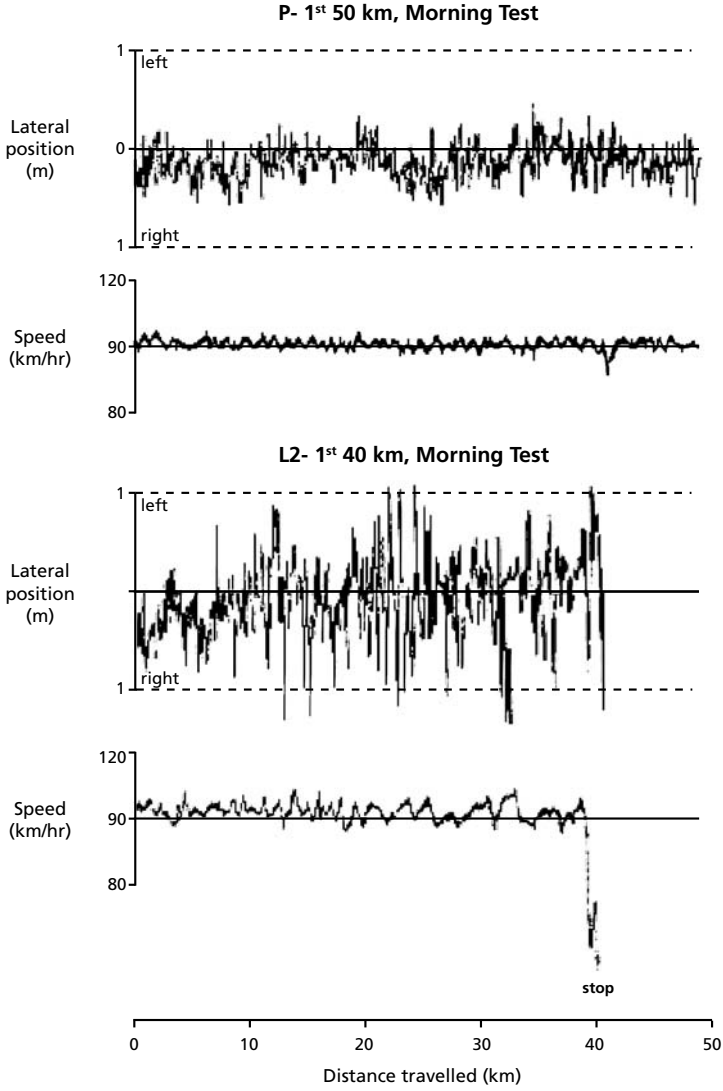

Figure 4 Example of raw data output for speed and lateral position.

Driving performance was measured in the morning following bedtime intake of placebo (P, top) or loprazolam 2 mg (L2, bottom). One meter left indicates crossing the lane boarder into the adjacent traffic lane; one meter into the right direction indicates crossing onto the road shoulder. The driving test in the loprazolam condition was stopped after 40 km due to repeated lane crossing (reprinted with permision from reference [21])

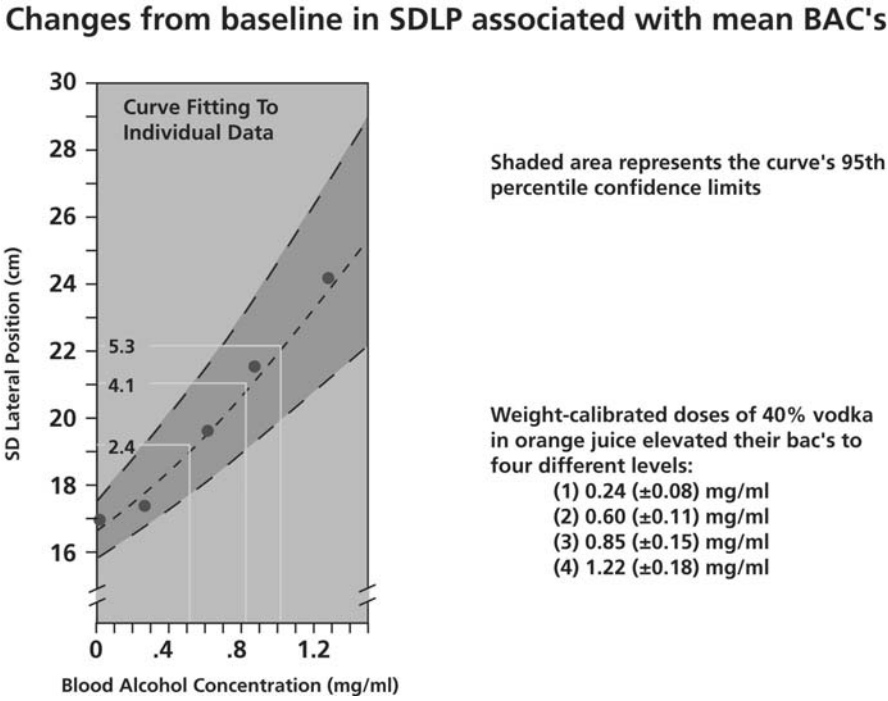

Figure 5 The relationship between blood alcohol concentration (BAC) and Standard Deviation of Lateral Position (SDLP). (Reprinted with permission from reference [22]).

closed road highway track, since Dutch traffic laws do not allow testing alcohol above a blood alcohol concentration (BAC) of 0.05%. SDLP was the primary parameter of the test. Results from different BAC levels are depicted in Figure 5. BAC levels of 0.05%, 0.08% and 0.10% correspond to the most common legal limits for driving a car. Many researchers who apply the on-the-road driving test use these SDLP increments (relative to placebo) to illustrate the magnitude of impairment observed with psychoactive drugs.

References

1 Wilde GJS (1982) The theory of risk homeostasis: implications for safety and health. *Risk analysis* 2: 209–225
2 Näätänen R, Summala H (1976) *Road user behavior and traffic accidents.* Elsevier, Amsterdam, New York
3 Fuller R (1984) A conceptualization of driving behavior as threat avoidance. *Erogonomics* 27: 1139–1155
4 Ranney TA (1994) Models of driving behavior: a review of their evolution. *Accid Anal and Prev* 26: 733–750

5 Rasmussen J (1987) The definition of human error and a taxonomy for technical system design. In: Rasmussen J, Duncan K, Leplat J (eds): *New technology and human error.* Wiley, Chichester, UK
6 Schneider W, Shiffrin RM (1977) Controlled and automatic human information processing: I. Detection search and attention. *Psychological Review* 84: 1–54.
7 Shiffrin RM, Schneider W (1977) Controlled and automatic human information processing: II. Perceptual learning, automatic attending, and a general theory. *Psychological Review* 84: 155–171.
8 Michon JA (1985) A critical view of driver behavior models. What do we know, what should we do? In: Evans L, Schwing RC (eds). *Human behavior and traffic safety.* Plenum Press, New York
9 Verster JC (2002*) Measurement of the effects of psychoactive drugs on driving ability and related psychological processes.* Thesis. Utrecht, The Netherlands
10 Matthews ML, Moran AR (1986) Age differences in male drivers' perception of accident risk: the role of perceived driving ability. *Accid Anal & Prev* 18: 299–313
11 Deery HA (1999) Hazard and risk perception among young novice drivers. *Journal of Safety Research* 30: 225–236
12 Sivak M, Soler J, Tränke U (1989) Cross-cultural differences in driver self-assessment. *Accid Anal & Prev* 21: 371–375
13 Lajunen T, Corry A, Summala H, Hartley L (1989) Cross-cultural differences in drivers' self-assessments of their perceptual-motor and safety skills: Australians and Finns*. Person Individ Diff* 24: 539–550
14 Groeger JA, Brown D (1989) Assessing one's own and others' driving ability: influences of sex, age and experience. *Accid Anal & Prev* 21: 155–168
15 Svenson O (1981) Are we all less risky and more skillful than our fellow drivers? *Acta Psychologica* 47: 143–148
16 McCormick IA, Walkey FH, Green DE (1986) Comparative perceptions of driver ability – a confirmation and expansion. *Accid Anal & Prev* 18: 205–208
17 Walton D, Bathurst J (1998) An exploration of the perceptions of the average driver's speed compared to perceived driving safety and driving skill. *Accid Anal & Prev* 30: 821–830
18 O' Hanlon JF, Haak TW, Blaauw GJ, Riemersma JBJ (1982) Diazepam impairs lateral position control in highway driving. *Science* 217: 79–81
19 O' Hanlon JF (1984) Driving performance under the influence of drugs: rationale for, and application of, a new test. *Br J Clin Pharmacol* 18: 121S–129S
20 Louwerens JW, Gloerich ABM, De Vries G, Brookhuis KA, O'Hanlon JF (1986) The relationship between drivers' blood alcohol concentration (BAC) and actual driving performance during high speed travel. *Proceedings of the 10th International Conference on Alcohol, Drugs and Traffic Safety*, Amsterdam
21 Verster JC, Verbaten MN, Volkerts ER (2006) Next-day residual effects of sleeping medicine on driving ability: a review of the literature. In: Lader, Cardinali, Pandi-Perumal (eds.). *Sleep and sleep disorders: a neuropsychopharmacological approach*. Landes Bioscience, 188–200
22 Verster JC, Veldhuijzen DS, Volkerts ER (2005) Is it safe to drive a car when treated with anxiolytics? Evidence from on-the-road driving studies during normal traffic. *Current Psychiatry Reviews* 1:215–225