THE VAIST CONCEPT TO TRAIN NOVICE DRIVER

AN APPROACH TAKING ADVANTAGE OF TEMPORAL SEQUENCE LEARNING WITH A CLOSED LOOP CHECK PROCEDURE TO MENTALLY PROGRAM A DRIVER

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ABSTRACT

This paper presents experimental novis driver training carried out in Sweden in an effort to show and explain how a human being can be mentally programmed to gain increased "crashavoidiness". The working name of the concept is VAIST - **V**ehicle **A**dapted for an **In**creased **S**kill of a **T**rainee) - a novis driver training concept based on driving exercises where the trainee will experience vehicle behaviour near the limits for the road grip. It is a multidisciplinary practical concept where a special vehicle is used capable to adapt to the actual skill of the trainee.

An increased crashavoidiness for a human means that

a) the human will have an increased skill in handling a vehicle,

b)in a near accident situation the human will more likely behave constructively, and

c) panic reactions are eliminated to a great extend

KEYWORDS SKILL BY EXPERIENCE,HUMAN CRASHWORTHINESS, AVOIDING PANIC BEHAVIOUR, COMPUTING SUPPORT, DRIVER SKILL, QUALITY ENSURED, SLIPPERY ROADS, NOVIS DRIVER TRAINING, SYNAPTIC DENSITY PROGRAMMING

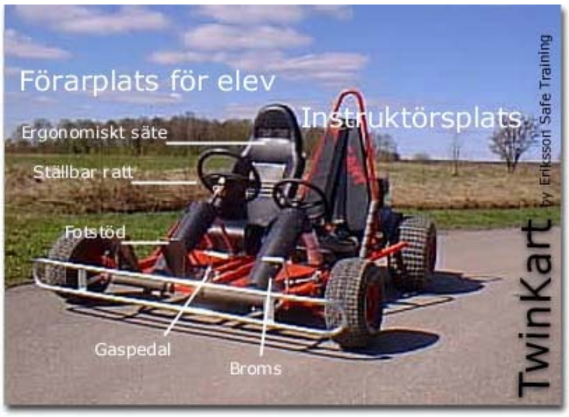
BACKGROUND

To safely drive a car the driver must perform a complex interaction with the road and the vehicle. Continuously there is big flow of dynamically variable information and all the time decisions of decisive importance have to be made. All the things happening during driving cannot be considered and dealt with logically and consciously in a mental activity, but must take place automatically. The driver has to trust not just his reflexes and intuition. He or she must also be capable of predictive performances. This can also be expressed as the driver performs will-powered (pyramidalic) commands, which are embedded in unconscious (extra-pyramidalic) minor position commands to safely manoeuvre the vehicle.

LEARNING AND PRACTICING SKILLED PERFORMANCE by Francis Mechner is about training to learn to play an instrument. Much of what is stated in his works also goes for learning to drive a car successfully.

OBJECTIVES

Crashworthiness of vehicles should be complemented by crashavoidiness of the drivers. First when this is achieved driver supporting technique may have a major impact on road safety. To obtain crashavoidiness of the drivers it is necessary to train or mentally program them to assure a safe and confident acting behind the steering wheel. It goes without saying that this confidence must be based on a genuine ability to handle the vehicle in situations of near accidents or close escapes, also on slippery roads.



The experiences in using this human instructor controlled vehicle made us convinced to use a computerized iterative instructing technique using the VAIST vehicle (Vehicle Adapted to an Increased Skill of the Trainee)

METHODS

It is very difficult to see what is actually going on in a human brain while practising for new skills, but the result of the training can be seen when observing carried out practising exercises.

An increased crashavoidiness means that the drivers will have an increased skill in handling the vehicle. In a near accident situation the driver will more likely behave correctly, and panic reactions can to a great extend be eliminated.

The VAIST training on slippery winding tracks at low speeds increases dramatically the possibilities to integrate the vehicle performance in the sensomotoric system of the driver. A comparison can be made with how to learn to ski, i.e. you must be able to control the slipperiness without being afraid. In real life fear can easily result in panic behaviours and wrong reactions.

When a trainee enters the training vehicle a computing system will control the practice to come. Initially the maximum speed is low. The trainee will be given information from the computing system and starts with simple exercises. The purpose is to program/train in control/managing the vehicle and to develop an active and necessary “flow” in the information exchange, i.e. feed back and feed forward inputs and outputs from driver, vehicle and road. To obtain awareness of existing limits ruled by the law of nature, slippery tracks are used at an early stage of the training. The computing system will record the movements and the inertia forces of the vehicle. The driver must perform a certain combination of parameter values to pass the exercises. When there is an acceptance the system estimates the obtained level of motoric skills. A flow of “correct” behaviours will be recorded and more power in the vehicle will be available. The purpose is to mentally program the brain of the trainee to gain a higher synaptic density in the nervous network involved in the activity and establishing the skill of handling the vehicle. The panic threshold will probably be higher, i.e. the probability for

The speed is just about 30 km/h but the track is slippery and the trainee has full control

panic behaviours will be decreased. A higher synaptic density programming of the brain is important, i.e. to involve several senses in the experiences. The vehicle itself is simple. It is very important to have a feeling about the vehicle's grip on the road and to experience the vehicle performance when the grip is lost,or almost lost on slippery roads. It is critical to the trainee to feel safe and comfortable behind the steering wheel to be able to try and learn what is actually working in a constructive way.

TEMPORAL SEQUENCE LEARNING IN A CLOSED FEED BACK LOOP PROCESS

Feedback loops try to maintain a desired state by comparing the actual input-value(s) with a predefined state and adjusting the output so that the desired state is optimally maintained. There is always a risk that a feedback loop is too late and that it is therefore not able to maintain a desired state of control continuously. By training on slippery tracks the driver will experience when futile and not controllable performances of the vehicle occurs and also to predict the unwanted reflex-reactions and avoid them by learning how to react to keep the vehicle in a controlled state.

CONTROL THEORY

The VAIST Concept from a control theory view.
A reflex loop is represented by a fixed feedback loop (Ashby, 1956; McGillem and Cooper, 1984; D'Azzo, 1988; Nise, 1992; Palm, 2000).
In control theory noise only plays an implicit role in the sense that it disturbs the control loops. It is the power of classical feedback-control (like PID-controllers) that it works without knowing the explicit origins of the disturbances (Phillips, 2000). However, in this context the noise is all inputs to the human senses and from which only a few or a combination of few does really matter for a safe performance behind the steering wheel. These inputs to the senses are seen as unexpected from the driver's point of view as unexpected events and can therefore be regarded as disturbances. There are an infinite number of disturbances in the ac-

tivity driving a car, only those disturbances can be of any interest to the driver which actually disturb the feedback loop(s). Since the feedback loop(s) is(are) described in terms of neuronal signals the disturbance can also be described by the driver's internal neuronal signals.
As pointed out above, the feedback loop has the inherent disadvantage that it is always too late. Including a disturbance this can be formulated more precisely:
Any feedback loop (or reflex) has the inherent disadvantage that the organism can not predict when a disturbance D will actually happen. The inherent delay of any reflex behaviour poses an objective problem which has to be solved. This can be achieved if the driver can turn the contingency of D into certainty. This is the case if the driver is able to predict the disturbance D and generate an appropriate motor reaction before the disturbance reaches the driver.
In other words, any organism which relies only on feedback-mechanisms has to cope with unpredictable events from the environment and has to live with the disadvantage that its desired state(s) can not be maintained all the time. Of course, this also goes for driver training their skills.

THE VAIST CONCEPT

LEARNING TO DRIVE A CAR BY INPUTS TO THE STEERING WHEEL AND FEED BACK TO THE SEAT

The torque acting on the steering wheel is a representation of the driver's influence on the vehicle by the steering wheel. This torque signal is more important than the angle deflection of the steering wheel because it exists in chronological order ahead of the deflection and a change of the torque must not necessarily result in a change of angle deflection of the steering wheel. Compared with the reasoning about exertion-relaxation it seems plausibly that most of the manoeuvres are not perceptible as angle deflections at all, but just as a "counteraction". It is possible to see the micro control as an inquiry, a reply and compensation. The driver seeks information, deciphers said information instinctively and reacts and the car responds. The response from the car is at the same time a question back to the driver and the drivers response is again a new question to the car, i.e. a continuous dynamic interaction is in progress. The commands from the driver have to be distinct as well as the responding of the vehicle to these commands must be consistent, clear and logical. The tires, the wheel suspension and the steering must bring about information from the road and give signals about the behaviour of the vehicle; i.e. as a response to executed influence on the steering wheel. It may also be expressed such that the vehicle ought to supply the driver with small but clear signals confirming and supporting the driver in his or her further control of the vehicle. This clear signalling is achieved first after filtering and removal of noise and unnecessary disturbances. Different signals initiated from the vehicle may be of different strength at different speeds and at different states of the road.

The VAIST concept involves a continuous supervision of the interaction between driver/vehicle/road over the interface driver/vehicle. By a very early establishment of the conditions for the driver to really be able to drive his vehicle in a safe way, or establishment of the capability of the vehicle to react on the actions from the driver, the incompatibility between the driver and the vehicle, and to some extend also between the driver and road by way of the vehicle in the interface driver/vehicle is disclosed. In this lies also to identify such shortages in the communication (interaction) which are considered to increase the risks for misjudgement and near-accidents/accidents. It is here also possible to get an understanding about how the driver's prospective memory, working storage and semantic memory, respectively are active and involved during different cognitive stress. To some extend it is also possible to perceive the legibility and the reaction time for separate perceptions, e.g. the interaction of the sight in a driving sequence.

The VAIST concept is about how to train and confirm the ability of the driver to both register and "understand" the behaviour of the vehicle caused by the manoeuvring and by outer influences. What is important in this respect is not to understand in a conscious way, but to make it easy and possible to train a sensation of where the limits are both considering the road grip and the behaviour of the vehicle, i.e. also over the interface vehicle/road. This sensation is necessary in the achievement of a healthy confidence in the role as a driver.

Most of the human activities are working as feed back systems, where impressions from our senses are processed in the brain and result in a certain wanted movement of the body, which in turn has an influence on the activity and this is again fed back by our senses in sensoric activity to the brain. We strive to obtain a balance and a correspondence between a wanted condition and the actual condition. Generally speaking the communication hereby obtained can be said to take place in the one hand of our free will to control or direct the activity (macro) and on the other hand in a more intuitively (micro) way where the balance is achieved. To decide about a specific situation the brain has often to create a small movement, i.e. ask a control inquire to the body and to the surroundings to form a true picture of the situation. Learning and experience is a matter of decisive importance. Often the driver follows the road and places the vehicle on the road within the zone he thinks to be safe. With reference to neurology and research about how the brain, and especially the cerebellum in an intuitive way controls the body/vehicle, it is stated that the muscle system is active as long as the person is awake and it is about a continuous dynamic interplay to obtain a balance between muscles and groups of muscles and that this is dependent upon a continuous feed back. To obtain a controlled movement or to just keep the body/vehicle in a certain position a very complicated interaction between tension and relaxation is necessary. When holding the hand immovably in front of oneself the hand seems to be inactive. The underlying interaction is not visible. This can be called microcontroll and it is most likely that this also goes for the driver's way of controlling the vehicle as an extension of his own body. The underlying interaction is mostly not visible to the naked eye.

The VAIST concept also includes the detection of an existing incompatibility between driver and vehicle, i.e. when the driver and the vehicle do not "speak the same language". Hereby increased risks for defective behaviours from the driver are quickly detected, i.e. already prior to them necessarily have come into existence.

THE COMPUTING SYSTEM

In fig. 1 a flow scheme of the signal reading is shown and how parameters are extracted from the signals from the sensor for the force acting on the steering device 1 and the sensor for the lateral acceleration 2. The signal from each sensor will pass a phase corrected band pass filter 3 with break frequencies in the magnitude of 0,3 to 5 Hz where also the amplitude is normalised to make the signals comparable. The signal for the lateral acceleration 2 will be delayed in a delay link 6 either with a fixed time corresponding to the median value of the reaction time of the driver, see fig. 4 (17), or with the instantaneous reaction time of the driver. The coupling grade 9 of the reactions of the driver on the movements of the vehicle is calculated 5 as the absolute value of the difference between the absolute values of the integrated signals over a certain time, see fig. 4 – the shady area 16. In the same way the coupling grade 9 for the respond of the vehicle is calculated if now the signal 1 is delayed 4. The variation of the amplitude 10 is calculated 5 as the difference between the top value and the bottom value of a running average value of the absolute amount of the signal amplitude during a certain time, e.g. 10-sec. To be able to make calculations of the reaction times 11, 12, 13 of the driver and of the vehicle said signals flanks 7 are detected by derivate each signal and look for sign changes: zero, plus, zero for a positive flank, fig. 3 (14b) and zero, minus, zero for a negative flank, see fig. 2 (14a) The reaction times 11 are calculated 5 as the time – fig. 2 (15a) and fig. 3 (15b) respectively – between a flank on one of the signals and the next flank on the other signal fig. 2 (14a) and fig. 3 (14b) respectively. The reaction times are divided 8 in at least two categories (12a, 12b, 12c, 12d) where the number of different reaction times is summed up during a certain time. These are brought together to reaction spectra – fig. 5. The inquire frequency 13a is calculated 5 as the accumulated number of flanks on each signal during a certain time. The fault frequency 13b is calculated 5 as the difference between the accumulated number of positive and negative flanks of the signals.

The diagrams according to fig. 2a and 2b show the force exerted on the steering device 1 in relation to the lateral acceleration 2. The X-axis represents time and the diagrams cover 18 sec. The Y-axis represents normalised amplitude. It is clear how the driver's manoeuvring of the steering device is directly connected to the lateral acceleration of the vehicle. Further to a timely displacement 15a, which can be seen as the time between two on each other following flanks 14a, the deviation can also be seen in the shape of the curve. These deviations appear because of the condition of the road and the environment and are dependent of the driver's ability to understand and perceive the movements of the vehicle.

Thus the diagram according to fig. 3 shows the applied force on the steering device 1 in relationship to the lateral acceleration 2. The X-axis represents time and the shown diagrams cover 18 sec. The Y-axis represents normalised amplitude. The micro communication takes place in two directions, thus the same signal contains both inquires and responses. To illustrate the driver's response on the movements of the vehicle signal 1 is in this case inverted in relationship to fig. 2. This is possible thanks to that the direction of that on the steering wheel applied force will go to the opposite direction when the driver initiates a wanted movement and when compensating for a not wanted movement. The reaction time 15a of the driver can be seen in the same way as in fig. 2 – with the difference that the flank on the lateral acceleration 14b is initiating.

The inherent delay of any reflex behaviour poses an objective problem which has to be solved. This can be achieved if the driver can turn the contingency of D into certainty. This is the case if the driver is able to predict the disturbance D and generate an appropriate motor reaction before the disturbance reaches the driver.

CONCLUSIONS

We belive that the possibility to train safe and careful drivers to a high level of motoric skills may result in a higher safety out on the open roads. The experiences in passing limits – both limits set by the nature and physics and own limits in skill - will deeply influence the driver to act safely and drive slow when the exposures to increased real risks is recognized in real traffic.

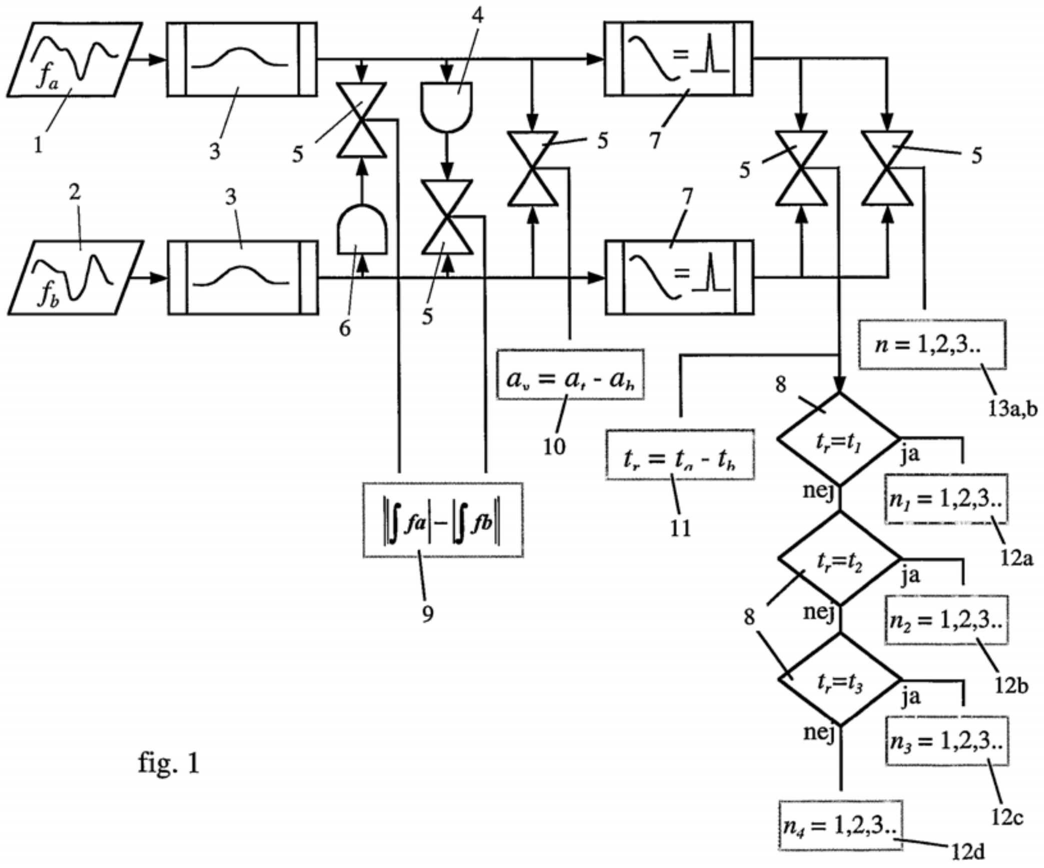


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fig. 1

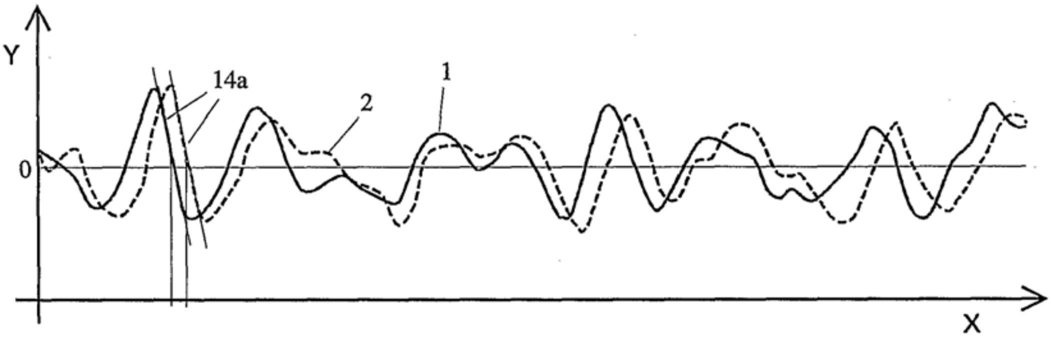

Fig. 2a

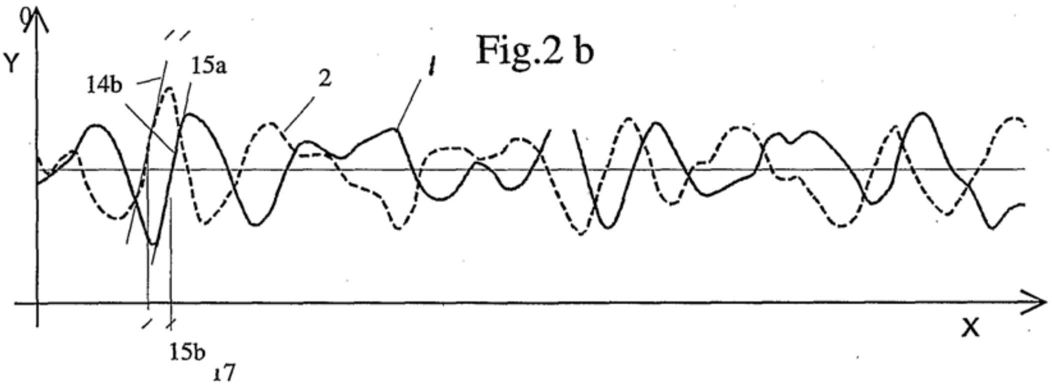

Fig.2 b

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Fig.3