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THE LIMITED POTENTIAL OF TRAINING FOR LEARNER DRIVERS: A VIEW FROM THE PSYCHOLOGISTS' LAB

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INTRODUCTION

Novice Driver Crash Problems

There is substantial evidence and wide acceptance that young or, more accurately, inexperienced drivers represent a significant crash risk compared to older or more experienced drivers. Certainly in Victoria, results published by the Accident Research Centre using crash data, exposure data based on road-side surveys, and age as a surrogate for experience underscore the high risk of crash involvement for inexperienced drivers (Diamantopoulou, Skalova, Dyte, & Cameron, 1996). Similar findings have been reported for Victorian drivers by Procko (1996) at the Transport Research Centre.

In 1996 and the early part of 1997, the Accident Research Centre assisted VicRoads in the development of guidelines for learner drivers. The guidelines were based on a fundamental position that emphasises the importance of driving experience in the development of safe driving skills. While the mechanisms underlying the effect of experience may be uncertain, the association between experience and safety is well-accepted.

It is my intention in this paper to examine the potential for driver training in light of the evidence and theory bearing on the importance of driving experience and the function that driving experience seems to fulfil in the development of higher-order driving skills. One characteristic of the present paper is its emphasis on higher-order skills in driving. While vehicle-control skills and knowledge of traffic law are likely to relate to driver safety, the higher order skills that develop after initial contact with driving (such as risk and hazard perception, attentional control, attentional or task timesharing, and situational awareness) are of increasing interest in debate about the likely potential of driver training.

Training as a Potential Solution

The accrual of driving experience takes place over a substantial period of time, during which the lack of experience increases the crash risk of the new driver in the short term.

The argument supporting the potential for training can take a number of forms, but the most relevant in the context of the present paper is that driver training can reduce the need for experience by facilitating the effect of smaller amounts of driving experience or by replacing the need for some driving experience with the product or outcome of the driver-training process. According to this argument, driver training of some sort would assist the development of safe road use skills in the context of reduced or limited driving experience.

Training, under this viewpoint, is not seen as a complete replacement for driving experience but rather as a means of reducing the amount of driving experience needed to reduce crash risk to the levels of more experienced drivers. This is a relatively conservative viewpoint as it does not view driver training as a panacea or as a replacement for driving experience. It is clear, however, that the potential success of driver training in general rests on a number of assumptions and that these assumptions must hold whether an extreme or conservative attitude is held towards the potential for driver training.

ASSESSING THE ASSUMPTIONS UNDERLYING THE USE OF TRAINING

Arguments concerning the potential for driver training to substitute for or facilitate driver experience make a number of assumptions. These assumptions are usually implicit in any discussion in favour of training and include assumptions:

- that there are some characteristics of novice drivers which lead to increased crash risks;
- that these characteristics differentiate them from more-experienced drivers, and
- that these characteristics are able to be influenced by some form of driver training with the same cognitive and behavioural outcome which results from the usual accrual of driving experience.

These assumptions are keys to any argument in favour of driver training and are addressed below.

Novice Driver Characteristics and Crash Risk

Driver training arguments assume that the increased crash risk of novice drivers relates to some characteristics (either of individuals or of behaviour) that are prevalent in this group. Training for increased driving skill must have training goals or targets that would lead to increased skill and safety, underscoring the assumption that there are personal or behavioural characteristics that lead to increased crash risk. If there are no characteristics of either the drivers or their behaviour that relate to crash risk in novice drivers it is difficult to envision a training program that could impact on their safety.

The evidence relating to this assumption is consistently supportive. There are indeed a number of characteristics of novice drivers and their driving behaviour that would be expected to increase their risk of crashing, and a number of such characteristics which have been shown to do so.

A number of reviews of the road safety and novice-driver literature (e.g. Mayhew and Simpson, 1995) detail the consistency of results in this area. Some of the characteristics of novice drivers that are thought likely to increase crash risk include peculiarities in the weighting given to various potential hazards in the road environment, the foci of visual scanning, and poor levels of attentional control and situational awareness. These could all conceivably be the appropriate targets for training efforts for novice drivers.

Crash-Related Novice Driver Characteristics and Experienced Drivers

Arguments in favour of using training as either a substitute for experience or a facilitator of experience assume that the characteristics outlined above and targeted for training differentiate novice and experienced drivers.

If it were the case that some characteristic of novice drivers which was associated with crash risk was found to be as prevalent in the experienced driver population as it is in the novice driver population, then it would be inappropriate to target this characteristic in a training program seeking to use training in place of experience as it is clear that experience does not reduce its prevalence. It is possible that crash-related characteristics common to experienced and inexperienced drivers may serve as potential targets for training

programs, but the specific focus of this paper is on the possibility of reducing the need for experience through the use of training programs for novice drivers.

Using training to substitute for experience or as a facilitator would aim to reproduce the safe driving outcomes associated with experience and so assumes that inexperienced drivers differ from experienced drivers in the targeted characteristics.

Again, empirical evidence reviewed in a number of papers (such as Mayhew and Simpson, 1995) is consistent in its support for this assumption. The characteristics outlined above that are associated with crash risk in inexperienced drivers are for the most part characteristics that are more prevalent or more characteristic of less-experienced drivers.

Crash-Related Novice Driver Characteristics and Training

The final assumption implicit in arguments supporting the use of training for learner drivers relates to the trainability of the characteristics associated with safe road use. Training is unlikely to be helpful to learner drivers if the characteristics or behaviours of learner drivers identified above are not amenable to training. At a more complex level, it is also implicitly assumed that training a characteristic that would more-usually develop with experience has the same cognitive or behavioural outcomes as experience itself.

The second assumption is important. While a training program in a skill such as hazard perception at intersections may increase the perception of hazardous situations in this context, it may be the case that the training creates cognitive strategies for hazard perception that are dissimilar to the strategies that result from experience. This dissimilarity may become a problem if there is competition between the trained process and the process that continues to develop with experience. It is important, then, that the outcome of the training match the outcome of experience at the level of the processes involved in the generation of the safety-related skill or behaviour.

These two assumptions provide the most difficult hurdle for training adherents. There are some reasons to believe that the higher-order processes needed for safe driving may derive almost entirely from experience in the driving context. If this is the case, the upper limit to what may be achieved through training may be quite low and focused specifically on lower-order skills such as vehicle handling, and the addition of training-based changes in driver skill may act to slow the development of experience-based skills which ultimately will reduce the crash risk of the driver.

Are Characteristics Affected by Training?

The assumption that the high-crash-risk characteristics that differentiate novice drivers from experienced drivers may be influenced by training is less clearly supported in the empirical literature than the other assumptions. It is widely known that driver-training programs routinely fail to have a demonstrable positive impact on either driver behaviour or driver crash risk when evaluated in properly-controlled studies. This outcome is often difficult to accept in the context of a widespread attitude discussed briefly by Mayhew and Simpson (1995) who note the assumption that any lack of skill can be remedied by training, but it is becoming increasingly clear that education and training programs are not generally supported by the empirical data.

At a more-specific level however, there is some evidence that some particular characteristics of the driving and cognitive skills of novice drivers may be influenced with appropriately developed and targeted training.

At a relatively low level, conditioning approaches have been shown to impact consistently on the activation of internal representations of events and the generation of behavioural responses. While it may be technically possible to use conditioning approaches to modify some aspects of the driver's behaviour and attention, it is unlikely to be practically feasible to construct a training program around this type of approach. It is also unlikely, in the context of the relative impact of a training program and vastly more time spent driving in the real world (with all the conditioning that occurs in this context), that a training program based on conditioning or similar low-level processes would have a significant long-term impact.

There is some evidence that it may be possible to train some skills that are relevant to safe driving. Training effects have been reported in relation to judgement or decision making amongst pilots (Buch and Diehl,

1984), self calibration (Gregersen, 1996), and attentional control in complex tasks (Gopher, 1992). It is clear, however, that the data weigh strongly against the trainability of safe driving skills in general, and while it may be the case that there is some potential for training programs to be developed that target higher-order driving skills in particular it is incumbent on protagonists in this area to provide clear evidence that training programs are likely to be successful before they are used as part of driver training as a way of reducing the need for driving experience.

Does Training Result in the Same Changes as Experience?

Assuming that evidence accumulates that it is possible to change some of the crash-associated characteristics of novice drivers using a training program or module, there is still a need to address the assumption that the outcome of the training program is the same as the behavioural and cognitive outcome of experience as a driver.

This assumption is the most problematic of all for driver training protagonists. Drivers continue to accrue experience regardless of the use of training opportunities, and this experience is likely to impact on the development of specific cognitive and behavioural skills critical to safe driving. Training programs that affect these cognitive and behavioural processes may be counterproductive if their effect is inconsistent with the experience-based changes which will occur over time, regardless of training experiences.

Understanding the potentially limited effect of training requires a fuller understanding of the way in which experience may impact on driving skill.

How Might Experience Improve Safety?

Experience with the road system and the behaviour of other drivers is likely to impact on the safety of novice drivers in a number of ways.

Driving is a task that requires a substantial degree of cognitive skill. The road environment is perceptually complex and changing rapidly. The information-processing system must meet a constantly high level of demand, and while it may rarely exceed the information processing capacity of experienced drivers, this is most likely due to the development of strategies for processing information and making decisions based on a substantial amount of experience in the driving environment. These strategies act to ensure that the driver can attend to (and respond to) stimuli in the driving environment that are important in terms of trip completion and safety.

Models of information processing are relatively commonplace in psychology. For the purpose of examining the importance of experience in the development of safe driving skills, the model discussed in detail by Cowan (1995) is used here. Cowan (1995) proposed a model of information processing that combines perceptual, attentional, memorial, and behavioural components. In the context of the development of cognitive skills in novice drivers, his model provides a foundation for understanding the role of experience.

Cowan argues that the amount of attention given to a stimulus depends on a number of things, including its novelty, its importance to the survival of the person, and the extent to which the stimulus is of current interest to the person. He also argues that the link between stimuli and behavioural responses is mediated by the activation of internal representations of the stimuli which may be attended or not, but that the activation of these representations also depends on the novelty, importance, and interest of the person. Thus, stimulus events that are not novel, perceived to be important, or of direct interest to the person are unlikely either to be attended to or to generate behavioural responses that might be appropriate. The implications of this for driver safety are obvious, and under Cowan's model, experience with stimulus events largely determines the novelty and perceived importance of those events.

Experience may lead to two processes that reduce the information processing workload. In the first instance, experience in the driving environment would be expected to allow the driver to focus less attention on less important cues and more attention on cues that are important to the driving task. The shift in attentional focus from novice to experienced drivers has been demonstrated empirically and most likely represents an extinction or habituation process.

The novice driver enters the driving environment where all events and relationships, in the short term, are novel. Cowan argues that the novelty of an event is a key determinant of the amount of attention the event

controls, so the novice driver is likely to direct attention to a wide range of events or stimuli, many of which are irrelevant to the safe-driving task. Cowan further argues that as stimuli in the environment lose their novelty and their importance (in survival terms), they also lose their ability to draw attentional focus, except where there are other reasons for attending to them. For the novice driver this means that experience in the road system where some events are not predictive of danger or directly relevant to the driving task will lead to a reduction in the attention given to them and an increased ability to focus attention on other events which are likely to be more important. Thus the increase in appropriate attentional allocation that occurs with experience may actually be the result of an habituation of the attentional response to less important stimuli.

This strategy for coping with the potential for information overload (reducing the likelihood of responding to events that have been experienced without risky consequences) would be successful if the driving context were firmly rule-based or deterministic in nature. This is not the case, however. The driving environment is probabilistic in nature rather than deterministic, and events which have not predicted negative consequences in limited driving experience may, in time, precede risky situations and may, therefore, be worthy of some level of attention by the driver. An example here might be another vehicle waiting at a stop sign on a side street. The new learner driver is likely to notice and attend to this fairly closely while it is novel, but under Cowan's model the level of attention given to this stimulus will decline quickly if the event is not predictive of something important to the driver such as a hazardous situation. In a deterministic world, this strategy would work. In a probabilistic world where another vehicle at a stop sign will sometimes predict a hazardous situation, failing to attend to the vehicle is not helpful.

The second process that occurs with experience is the development of a complete internal model or representation of the driving environment and the behaviour of other vehicles in that environment. The habituation process outlined above most likely aids in the development of a deterministic or rule-based internal model of the driving environment where there are clear relationships between events and consequences. Increasing experience in the driving environment and, in particular, experiences that are inconsistent with the earlier model of that environment most likely results in the development of a probabilistic model of the environment and the behaviour of other drivers where the relationship between events and consequences is more flexible.

The change from a deterministic to a probabilistic model of the driving context is important from the point of view of driver safety as driving guided by a probabilistic model is more likely to take into account the possibility that some generally-safe situations may from time to time be unsafe. Under Cowan's model and this point of view, the ability of drivers to perceive and avoid risky situations is likely to decline initially (in the presence of a developing deterministic model) and then improve as the driver's representation of the driving environment becomes more probabilistic.

Thus, the habituation process that leads to an initially-deterministic model of the driving environment will have the effect of reducing the hazard-detection skill of the novice driver as many potentially-important stimuli will be unprocessed due to their lack of novelty and perceived importance. Increasing experience undoes part of this process. The increasingly probabilistic internal model of the driving environment allows a larger range of stimulus events to take on a level of importance that ensures the activation of appropriate internal representations and consequent behavioural responses because the events may precede a risk or hazard to the driver.

The developing probabilistic model or representation of the driving environment discussed here is consistent with recent consideration given to the application of the concept of situational-awareness to driver safety, and represents a higher-order consequence of experience for the novice driver.

The developing accuracy of the driver's internal model of the driving environment and the behaviour of other drivers is also likely to facilitate the development of some of the other characteristics of experienced drivers that seem to be implicated in safer driving, such as appropriate visual scanning and attentional control.

The automation of driving behaviour is also a product of driving experience and also fits comfortably into the outline provided by Cowan's model of information processing. Under Cowan's model, repeated instances of stimulus events and behavioural responses result in a declining need for attentional processing of the stimulus and response and an increasing automaticity of the generation of the response. Thus,

experience in the driving environment will allow the development of automatic responses to stimuli. These in turn will be influenced by the deterministic/probabilistic dimension of the drivers model – with the generated behavioural response likely to be more flexible (but still automated) under the probabilistic internal model as it develops with experience.

OUTCOMES OF TRAINING

It is clear from the discussion above that there is little evidence bearing on the mechanisms by which training in higher order driving skills might influence the development of these skills in place of driving experience. There are, however, two aspects of the experiential changes in higher order processes that may set an upper limit on the potential of driver training to replace or facilitate experience.

Automation of Behavioural Responses

Experience has the effect of automating the mechanism by which behavioural responses are consequent on (and appropriate to) events in the driving environment. Under Cowan's model, events in the environment that are novel or important activate an internal representation of the event which in turn activates any behavioural response associated with the stimulus. The association between the event's representation and the behaviour, and the automation of the process without attentional involvement both depend on experience with the event and the behaviour.

Cowan's model allows for the involvement of a "central executive" process which might be likened to conscious control of the attentional process and behaviour. It would clearly be influenced by training, but the involvement of this process precludes automatic processing. So while the model allows for a direct training effect through the input of the central executive, the input of this process requires attentional awareness and so cannot occur outside attention or as an automatic process.

It is difficult to envisage a means of encouraging automaticity of driving behaviours through training. Cowan's model, and views of driver skill development such as those proposed by Lewin (1982) and Logan (1985, 1988), are consistent in their emphasis on the need for experience before aspects of driver behaviour become automated. Evidence from non-driver areas (see Logan, 1985) supports this point of view, and this author is unaware of any substantial body of evidence that the development of automaticity in skilled behaviour can be made to occur more quickly through training except where the training involves the provision of experience in the task concerned. For these reasons it seems likely that the development of automaticity in driving behaviour is beyond the effect of training. If this is the case, then automaticity is a characteristic of driving behaviour which sets an upper limit on the potential for driver training.

This has profound consequences for arguments about the potential for driver training. Automaticity is a fundamental component of safe driving behaviour – partly as it helps drivers to respond more quickly to potential hazards and partly because it frees attentional capacity for other tasks. While Lewin and Logan note that the development of automaticity is the final stage of learning to drive, Cowan's model would have automaticity developing from the earliest stages of learning to drive and strengthening throughout the learning process. If automaticity develops gradually throughout the learning time period and is based on experience as a driver, then driver training is unlikely to have significant potential beyond the early stages of learning to drive when the novice driver is learning vehicle control and other low-level driving skills.

This is reinforced by consideration of the importance of attentional processes in the developing automaticity of driving behaviour. Automaticity is based on a declining involvement of attentional processes in the behaviour. Training processes that activate increased attention on the behaviour are likely to reduce the effectiveness of the automatization processes rather than increase it.

Internal Models of the Driving Environment

It was noted above that a substantial effect of experience in the driving environment is the development of an internal model of the driving environment that more and more closely represents the environment as experience is accrued. The initial stages of development of this model are based on limited experience and are likely to be deterministic in nature, reflecting the apparent determinism of the driving environment. With increased experience of the probabilistic nature of the environment and the behaviour of other drivers, the model is thought to develop a more probabilistic nature.

The effect of this model development is that drivers are likely to become less safe in the early stages of the development of the model when the determinism of the model and the rule-based nature of their behaviour does not adequately reflect the reality of their driving environment, and then increasingly safe as their internal model catches up with the probabilistic nature of reality.

It is conceivable that a rule-based model of the driving environment could be taught through training techniques. Using these techniques to teach a more-probabilistic model of the driving environment is less easily conceived, however. Internal models develop through experience with the real world, so aiding in the development of a model would require experience-based training focused on the particular aspects of the model that are relevant to safe driving. This might be possible if driving experience could be arranged in a controlled environment.

It might be possible to use a simulation approach to assist in the development of an internal representation of the driving environment that includes some probabilistic components in addition to the more predictable aspects of the environment, but there are a number of problems here that would need to be addressed:

- A simulation approach would need to be based on a high-level simulation which closely resembled the real world. Without this, any internal model developed would be an inadequate reflection of the driving environment and may, therefore, place the novice driver at greater risk of crashing.
- An additional problem with a low-fidelity simulation relates to the novelty of the driving environment compared to the experiences in the simulation. It will be recalled that novel stimuli activate attentional involvement in information processing under Cowan's model. It is not inconceivable that the perception that the simulated environment and the real driving environment are different would lead to the formation of two internal models – one for the simulation and one for the real world. This is likely to be a problem in all but the highest-level simulation systems. There may, therefore, be only minimal transfer from the simulated environment to the driving environment.

There is still a strong need to investigate the usefulness of simulation systems in the training of higher-level driving skills. In the absence of empirical data demonstrating the transfer of this type of training to the real world it is difficult to recommend such an approach.

A controlled environment for experience-based training focused on the particular aspects of the driver's internal model that relate to the probabilistic characteristics of the driving environment may be provided in the context of real-world driver training. It is conceivable, for example, that driving instruction could take place in a real driving context but with events in that context under control of the instructor. Unusual but hazardous events could be programmed to occur early in the driver training process rather than later in the novice driver's experience, potentially leading to the development of a less-deterministic model of the environment.

Apart from the obvious problems relating to the intensiveness of this approach to training and the likely costs involved for each driver, there are some problems relating to the development of the internal model of the driving environment. It is possible that the development of a probabilistic model of the driving environment depends on the existence of a well developed deterministic model. The rule-based model of the driving environment that develops with early driving experience may be the foundation for a more sophisticated model. Certainly Endsley's (1995) discussion of the relationship between situational awareness and human information processing emphasises the layered development of situational awareness, with higher-order skills and internal representations building on the foundation of lower order skills and representations.

If it is the case that the ultimate probabilistic internal model of the driving environment requires the pre-existence of the earlier deterministic model for its development, then it is again unlikely that driver training techniques will be able to improve the rate at which the safer internal representation develops.

CONCLUSIONS

The potential for the use of driver training as an aid to the development of safer higher-order driving skills is a contentious one. The weight of evidence does not provide much support for protagonists of training

approaches, and the theoretical considerations raised here argue against an optimistic viewpoint for future work in this area.

The development of automaticity and a probabilistic internal model of the driving environment are necessarily experience-based, and in both cases it is difficult for both practical and theoretical reasons to envisage a training method that could be used to replace the need for driving experience.

This will not, of course, discourage the optimism of those who argue for the use of driver training. Indeed, training is likely to be highly effective in the development of lower-level skills such as vehicle control which in turn are likely to impact on driver safety. As far as higher-order skills in the cognitive domain are concerned however, there is a strong need for empirical support for training before it is seen as an effective addition (or replacement) for driving experience for novice drivers.

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