Design of a Cognitive Skills Trainer for Novice Car Drivers
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ABSTRACT: A simulator-based driver training research program at Monash University Accident Research Centre has culminated in the design of a CD-ROM based cognitive skills training product for young novice car drivers. The early research and analysis effort associated with this project was reported in a paper at SimTecT98. The present paper follows on from this earlier paper to describe the process of product development through contracted production of digitised video and construction of a CD-ROM interactive training program.

1. Introduction

1.1 Background

Novice drivers in their first year of driving are about three times more likely than experienced drivers to be involved in a casualty road crash. This is due largely to inexperience: novice drivers do not possess the highly developed perceptual and cognitive driving skills that make more experienced drivers safer on the roads.

Regan, Triggs and Deery [1] have defined four such skills that are critical in moderating the crash risk of novice drivers: risk perception, attentional control, time-sharing and calibration. Historically, driver training programs have been unsuccessful because the focus of training has generally been on vehicle handling skills rather than on these higher level perceptual and cognitive skills. This is not surprising, given that the importance of these skills in moderating the accident involvement of novice drivers has only recently been established.

In 1995, the Monash University Accident Research Centre (MUARC) was contracted by the Victorian Transport Accident Commission (TAC) to carry out research using a mid-range driving simulator to better understand these skills and to develop a CD-ROM product for training these skills in young novice drivers. The outcomes of the simulator research are described in detail in Triggs and Regan [2]. The process of translating these findings into a design specification for a driving skills training product was described in a previous paper presented at SimTecT98 [3]. The present paper describes the design specification deriving from these efforts and the process of product development.

1.2 The Design Specification

The design specification was based on content, context, instructional strategy and technical performance requirements.

The content to be addressed through the novice driver cognitive skills trainer was drawn from reputable literature in the field and the findings of a lengthy research program at MUARC [2]. The literature provided keypoints, such as ‘insight training’, that had been shown to be effective. Research in Sweden [4], for example, has shown that novice drivers can derive greater benefit from understanding dangers in the driving environment and their inability to safely cope with these than through skills training which attempts to teach advanced driving techniques to handle road hazards. The series of simulator-based experiments conducted at MUARC provided content such as ‘variable priority training’; novice drivers were found to exhibit improved attentional control skills following exercises which required subjects to cope with competing tasks while applying varying priorities to each task [4].

Fourteen content areas were developed from research conducted at MUARC and literature in the field. Contexts then needed to be selected through which the content could be treated. A review of recent driving educational programs resulted in the major context divisions of urban, freeway and country. The freeway context was subsequently subsumed into both urban and country and a range of specific contexts selected on the basis that they were relevant to the types of accidents novice drivers are known to be over-represented in; for example, a collision with an oncoming right-turn vehicle at a cross-intersection.

With content and context decided, the next step was to apply an instructional strategy. The approach of Incremental Transfer Learning (ITL) [3] had been selected at an early stage as the general instructional strategy to be applied. This approach views skill learning as occurring through task performance in a progression of contived environments, such that each is more complex and demanding than the previous. In this sense, learners are considered to be incrementally
transfering their past learning to contexts more and more similar to those which will eventually be encountered in real life. Moreover, ITL places considerable importanace on the need to plan for both near-transfer and far-transfer of skills. Near-transfer refers to real life skill applications where the context is similar (or near) to those experienced in training. Far transfer refers to real life skill applications where the context is novel and has not been addressed in training. Clearly, near and far transfer require different instructional methods and these are available through the ITL approach.

The combination of content, context and instructional strategy resulted in the progression of training modules shown in Table 1. A cognitive skills trainer consistent with Table 1 would introduce learners to key terminology and concepts, provide focussed part-task practise, to establish required mental models, and then provide both near and far transfer practise.

In order to implement the concept illustrated in Table 1, two learning environments are required. First, the series of modules in the middle column of Table 1 require the presentation of real-world driving scenes (as seen through the windscreen of a car) in which hazardous traffic scenarios unfold. In this environment, novice drivers are given practice in exercising risk perception skills: in effectively scanning the driving environment for emerging traffic hazards; in predicting the actions of other road users; and in making safe driving decisions. For this, a video-based approach was adopted. Second, the series of modules in the right-hand column of Table 1 require learners to give varying attentional priority to simultaneous tasks in a driving environment – in order to enhance their attentional control skills; for this, a three-dimensional synthetic driving environment was employed.

<table>
<thead>
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<th>Transfer Stage</th>
<th>Digitized Video Simulation</th>
<th>3D Virtual World Sim</th>
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<tbody>
<tr>
<td>Knowledgeable</td>
<td>Introduction</td>
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<tr>
<td>Far Transfer Practise</td>
<td>Advanced Decision-Making</td>
<td>Advanced Concentration Practise</td>
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</table>

Table 1. Organisation of Modules by Transfer of Learning Stage.

The requirements described to this point provided a basis for specifying certain technical specifications, such as the type of PC platform to be used. In addition to the technical requirement flowing from content, context and instructional method, the TAC who sponsored the project wanted the eventual training product to be widely accessible to novice Victorian drivers and this placed certain bounds on the types of technology which could be employed. In particular, a typical home PC was considered to be the base platform for use of the final training product.

1.3 The Cognitive Skills Trainer Production Process

An early decision was taken to separately contract the production of video clips which would then be incorporated into the production of a CD-ROM based training product. A total of 67 video clips were shot over a period of approximately six weeks. These clips were then provided to the CD-ROM contractor (Adacel Multimedia P/L) for incorporation into the emerging product.

The video clips were scripted to ensure that the type of driving hazard portrayed was the one desired. Scripts for video clips included diagrams of what action was expected to occur, key points to be made and resources required. Once on location scripts invariably underwent modification to cater for local conditions, however this was done by instructional design staff thereby ensuring that the instructional purpose was still achieved.

Scripts for how video clips were to be incorporated into the CD-ROM training product were developed following video production. These scripts included voice-overs and learner interactions. Development of these scripts was a lengthy process as variations were adopted and then reviewed by academic researchers, instructional design staff, TAC representatives and CD-ROM production staff.

While video clips support a major component of the training product, an equally important component comprises a virtual road environment which users drive through. This synthetic environment module is designed to provide attentional control training.

Within the synthetic environment, users are presented with two competing tasks. One task involves maintaining a steady gap between the user’s car and a car immediately ahead. The other task requires the user to monitor a sequence of numerals, which appear randomly in the driving scene, and perform calculations with these; this is a continuous cognitive task which may be compared with conducting a conversation with a passenger while driving.

Users are required to prioritize their attention to each of the two tasks in ratios which vary between exercises. Feedback on relative performance on the two tasks is provided graphically.

The software application providing the synthetic environment, for attentional control training, was written in Borland Delphi, an object oriented programming tool. The 3D environment utilises a parallel projection model. The vehicle dynamics utilise a basic linear interpretation of an acceleration and deceleration model.

The synthetic environment application resides as a Windows .dll (dynamic linked library) file which is called from the computer-based instruction application. The .dll passes parameters back and forth, such as user’s progress and baseline performance measurement. This enables the computer-based instruction application to store and pass back information required by the
consisted of having the fourth camera view slide in and the fourth camera driver's view. This transition was used to transition between the normal driver's view with the other three views, but rather a special effect important.

a few drives where an extreme view to the right was window. This fourth camera position was only used in to view directly to the right out of the driver's side-perspective. The fourth camera was then re-positioned was sufficient to capture the forward-looking driver’s perspective. The fourth camera was then re-positioned to view directly to the right out of the driver's side-window. This fourth camera position was only used in a few drives where an extreme view to the right was important.

The scene from the fourth camera was not combined with the other three views, but rather a special effect was used to transition between the normal driver’s view and the fourth camera driver’s view. This transition consisted of having the fourth camera view slide in from the right, suggesting the driver’s view was moving from directly ahead to out the right window, and then slide out to the right, suggesting reversion of the driver’s view to straight ahead.

2.2 Digitizing Format

The product is intended to be capable of running on a wide range of home PCs. Initially, this requirement appeared to limit video encoding to formats such as Indeo (Video for Windows) and Quicktime. However, the introduction of ActiveX controls by Microsoft has allowed MPEG to be software decoded on reasonably low-end PCs. Microsoft claims that full-motion, full screen MPEG1 can be achieved on a minimum 90MHz Pentium PC platform. Consequently, a decision was taken to use MPEG1.

MPEG1 can be compressed from its standard bit-rate of about 1.1 Mb/s data rate to rates as low as 150 kb/s, albeit with some degradation in quality dependent upon the capability of the system used for playback. In a compromise between PC platform capability, the need to be able to play video from a CD drive and available space on the product CD-ROM, a decision was taken to compress the MPEG1 clips to between 150 kb/s and 250 kb/s. While a final decision regarding the minimum PC configuration recommended for running the product had not been taken at the time this paper was prepared, MPEG1 at 150kb/s has been demonstrated to run satisfactorily on a Pentium 133MHz PC.

2.3 Clip Structure and Length

Each video clip must provide some lead-in to a risky situation so that learners have time to understand the context of the particular scenario. Accordingly, video clips were planned to be no less than 20s in duration, with a preference for no more than 30s in order to minimise required space on the CD-ROM.

Clips commence with an orienting approach to the location where a potential hazard will appear, followed by presentation of the hazard, and a few seconds to reveal the outcome and close the scenario.

It is important to understand that the video clips are not intended to provide instruction by themselves. The clips merely provide a context for instructional activities. These instructional activities are mediated through functions provided by the software. For example, a subjective view of approaching an intersection may be followed by a direction for the learner to locate potential hazards, visual advice of actual potential hazards and verbal reinforcement.

3. CD-ROM Production Issues

The CD-ROM is under production as this paper is being prepared. Issues related to production will be addressed during the presentation of the paper.

4. Conclusions

The specification for design of a cognitive skills trainer for novice car drivers, as reported at SimTecT98, has now been translated into a CD-ROM based training product. A detailed evaluation of the product will be completed prior to decisions on its implementation.

The extensive research and instructional analysis work that went into defining the required training product necessarily resulted in a complex design specification. Consequently, several important issues arose during production and these required careful management.

Issues which proved to be critical included retaining the quality and intent of content and instructional approaches throughout lengthy re-scripting, working closely with CD-ROM production staff to achieve optimum technical solutions to product development problems, adjustment of video camera angles and configurations to achieve best results on location, and selection of a video digitising format best suited to the desired quality and learner computing resources

5. References


6. Acknowledgements

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7. Author Biographies

Dr Mike Regan is a human factors psychologist with specialist expertise in aviation human factors, road user behaviour and ergonomics. He has BSc(Hons) and PhD degrees in psychology and human biology from the Australian National University. Mike is a respected member of the Australian ergonomics and psychological communities and has designed, delivered and assessed a wide range of courses in human factors psychology, ergonomics, and safety psychology in Australia and overseas. He has published locally and internationally on a range of human factors and safety-related topics. He is a Member of the Ergonomics Society of Australia, US Human Factors and Ergonomics Society and Australian Aviation Psychology Association. Mike is employed as a Senior Research Fellow at the Monash University Accident Research Centre, where he has been Project Manager for a simulator research program aimed at developing a cognitive skills training product for young novice Victorian drivers.

Professor Tom Triggs is Professor of Psychology at Monash University in Melbourne, Australia. From January 1993 until June 1995, he was the Head (Chair) of the new, reconstructed Department of Psychology with 45 academic staff members. He also serves as Deputy Director of the Monash University Accident Research Centre, where he is Project Director for the advanced driving simulation and young driver research program. From 1989 to 1991, he was the Director of the Battelle Human Factors and Organisational Effectiveness Research Center in Seattle, U.S.A. His human factors research interests are in human performance and decision making in complex systems, including surface transportation, aviation and nuclear power. He has a strong current interest in human-in-the-loop simulation. His major basic research area is in attentional performance. He is a Fellow of the Human Factors Society and a Fellow of the Ergonomics Society of Australia.

Phil Wallace is the principal consultant for Learning Systems Analysis P/L. He left the RAAF in 1997 after 21 years service with most of his work being in the analysis and design of aircrew and technical training. Phil’s special area of expertise is instructional technologies and in 1991 he held a Defence Force Fellowship to investigate instructional design issues for simulation systems. Over the past two years, Phil has undertaken training task analysis studies for several major defence projects and provided instructional analysis and design services to civilian organisations such as Monash University.
Figure 1. Car Scene.

Figure 2. Initial Camera Positions.