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A perceptual training module for pilot instrument scans

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The current generation of young people have grown up with digital technologies and this has led to widespread consideration of how to use these technologies for education and training. We are interested in the potential for developing game-like training modules for deployment on personal digital devices to allow trainee pilots to practise information extraction skills for a variety of different contexts. The current study is based on an instrument scanning perceptual training module reported by Kellman and Kaiser (1994). While we expect that novices will be able to easily learn the instrument scanning tasks, it is important to ascertain whether their performance reflects an increased understanding of the flying situation, or just a correct choice learned implicitly within the context of the specific experimental tasks. If the latter, the possibility of negative transfer of gaming strategies to real world performance requires further examination.

Key words: cognitive skills, instrument scanning, aviation, perceptual training

Introduction

Growing up digital

Growing up digital means that many children will have spent as much time interacting with digital technologies and virtual worlds as with the real world (Gee, 2007). Because of this, it has been argued that their skills and knowledge may be different through greater exposure to virtual, rather than real, experiences. The nature of experiential learning, and the patterns of sensory and motor information accumulated over a lifetime of experience may be subtly skewed by vast amounts of visual data impinging on cognition from screen-based activities. Growing up digital may result in automated responses learned through video games and virtual worlds becoming more deeply embedded than responses to real-world stimuli (Gee, 2007). The fact that the current generation of young people have grown up with digital technologies has led to widespread consideration of how to leverage these technologies for education and training. Given the degree of engagement engendered by video games and interactive multimedia, there has also been much interest in using a gaming metaphor in training and education (Gee, 2007). The current study is based on an instrument scanning perceptual training module reported by Kellman and Kaiser (1994). We are interested in assessing the potential for developing game-like training modules for deployment on personal digital devices to allow trainee pilots to practise information extraction skills for a variety of different contexts.

Information management skills for flying training

New generation aircraft have more advanced avionics and customisable multi-function displays, requiring pilots to have better information integration and information management skills. New perceptual training paradigms are being investigated to develop rapid information extraction and the ability to scan instruments and sensors for contextually relevant information at an automatic level. It is important that flying training methods support the development of appropriate cognitive skills to interpret instrument readings in context and avoid the danger of negative transfer that interferes with future performance when reading instruments in the actual aircraft. To this end, the ability to extract information from instrument displays must be achieved through tasks that facilitate the development of appropriate mental models of the flying domain.

Kellman and Kaiser (1994) reported on a prototype perceptual training module using an instrument scanning task, aimed at promoting more efficient information extraction, higher order pattern processing, and automaticity. The task required the participant to identify the situation depicted by a standard 6-instrument display under speeded forced choice conditions. Flying an aircraft is an inherently dynamic activity and the instrument readings during flight are constantly changing. In order to create a snapshot of a dynamic display that represents a range of specific flying situations, movement of instruments was represented symbolically by arrows rather than displaying actual movements. The use of symbolic representation of movement within a perceptual training module is problematic however if moving stimuli were used, there would be a more serious problem. Many depicted situations can only be maintained for a limited timeframe, e.g., in the extreme situation, a descending turn will eventually become a crash landing.

Kellman and Kaiser (1994) showed that reasonably brief periods of perceptual training (between 1 to 2 hours) produced dramatic improvements in speed and accuracy for determining the aircraft situation, both in experienced civil aviation pilots and in non-pilots. Although, as would be expected, experienced pilots were initially faster than non-pilots, by the end of the training period, novices were extremely accurate (performing at ceiling) and faster than the initial performance of experienced pilots on the task. Kellman and Kaiser (1994) tested novice and experienced pilots but even for experienced pilots, the initial response times were around 7 secs. With practice, response times for novices and experienced pilots fell to around 5 and 3 seconds respectively. These data suggest that participants learned to recognise the tested situations rapidly, but then needed to check each instrument sequentially to confirm that it was congruent with the depicted situation.

The current study uses a similar paradigm to Kellman and Kaiser, but also includes some extra speeded training to emphasise information extraction and to consider differences between novices and experts. In particular, the expertise reversal effect (Kalyuga, 2007) describes the fact that the same task will be perceived differently by novices versus experts, and that the cues and aids provided to help novices may interfere with performance of experts (and vice versa). In order to complete the task, particularly given that arrows indicate direction of motion rather than subtle movement of the instrument, a novice can get most information from the attitude indicator without reference to other instruments. In contrast, an experienced pilot will recognise the need to check other instruments depending on the flying situation indicated. A novice will be able to complete the experimental task without needing to form a more complete mental model that incorporates complexities of the flying domain not represented in the specific training task.

In order to investigate what information is being used by novices who can complete the experimental task as quickly as experienced pilots, our study includes some additional conditions. The attitude indicator will be displayed for differing amounts of time (between 250 ms and 600 ms) and then one of the five other instruments will be displayed. The participant will be asked to identify whether the second instrument is consistent with the attitude indicator (i.e., have novices learned the relationship between the attitude indicator and other readings, or have they just learned to complete the task using the least amount of information required).

Given our interest in the development of mental models, it is also important to ensure that novices are not just relying on a single display (the attitude indicator) to determine the aircraft situation, and then checking by whatever means available that other instruments are compatible with this reading. A second speeded task will be included whereby five instruments other than the attitude indicator are displayed, then those instruments disappear and the attitude indicator is shown. The participant needs to decide whether the attitude indicator is congruent with the instruments, a task that will be difficult if they have previously only focused on interpreting the attitude indicator and then checking the consistency of other instruments with this.

Method:

Participants

Preliminary data have been recorded from two of the authors of the paper in order to set parameters for the actual data collection. Participants for the data to be reported at the conference will be university students enrolled in a first year psychology program who be invited to participate as part of their research experience.

Materials

The main stimuli used in the study comprised a prototype of a standard 6 instrument panel (Figure 1). Participants will also be asked to complete a questionnaire which provides brief demographic information and information on previous flying experience and gaming experience. The study will be delivered via the web using Inquisit v3 (Millisecond Software, http://www.millisecond.com). Participants will be requested to devote their full attention to the task, and work in a quiet environment free from distractions, but it should be noted that the use of web-based delivery in relatively uncontrolled circumstances mimics the conditions under which web-based and mobile training operates. It is left to the participant to set the parameters of their working environment. We predict that, while data may well be more variable, the findings will not be compromised by web-delivery, and indeed, any findings that are not sufficiently robust to be demonstrated in these conditions will not be sufficiently robust to provide opportunities for future mobile training.

Figure 1. Six main instruments of the Cessna-based instrument panel used for stimuli in this study.

Procedure

Participants who consent to participate in the study will be presented with a brief description of the study, and then a sequence of training pages describing each instrument of the instrument panel (see Figure 1) and what information it displays. They will then be given a series of instrument clusters depicting specific aircraft situations. Two such situations are shown in Figure 2. In the left hand panel, the artificial horizon shows the aircraft pointing to the blue and banked left with respect to the horizon. The turn indicator and heading indicator show a left turn and the altitude indicator and vertical speed indicator are both consistent with an aircraft climbing in altitude. The airspeed indicator shows an appropriate speed. Thus all the information is consistent with an aircraft in a climbing left turn. In the right hand panel, the artificial horizon shows the nose pointing down and the aircraft banking right with respect to the horizon. The turn coordinator and heading indicator also indicate a right turn, and the altitude indicator and vertical speed indicator are consistent with an aircraft descending in altitude. Thus all the information is consistent with a descending right turn. The nine aircraft situations depicted in the experiment are Straight and Level, Level Climb, Level Descent, Climbing Left Turn, Climbing Right Turn, Descending Left Turn, Descending Right Turn, Level Left Turn and Level Right Turn. An additional Incongruent condition is also included, where one of the instruments is not congruent with each of the other instruments. For example, the turn coordinator displayed in the left image of Figure 2 may be changed to indicate a right turn such that it would be incongruent with each of the other instruments indicating a climbing left turn.

Figure 2. Left panel shows a climbing left turn whereas the right panel shows a descending right turn

Having completed the training section, participants will be presented with a sequence of 30 instruments clusters (*Standard Block*) and will be asked to identify the aircraft situation as rapidly as possible. Although there will be 30% of trials that are incongruent, theoretically requiring participants to check at all the instruments, it may be that they tend to focus on the artificial horizon to identify the aircraft situation and do not check all other instruments systematically. In order to promote more rapid effective information extraction using all the instruments, participants will be asked to practice with a sequence of trials in which the artificial horizon is presented briefly with all other instruments masked, then it is masked, while one other instrument is revealed (*Speeded Single Instrument Block*). The participant's task will be to identify whether the instrument is congruent with the artificial horizon. We will attempt to use this task for establishing a threshold for information extraction from the artificial horizon. In order to test whether participants are focusing primarily on the artificial horizon to interpret the aircraft situation, then checking via possibly idiosyncratic perceptual cues whether the other instruments match the artificial horizon, a further training condition will be used. In this condition (*Reverse Instrument Block*), all instruments except the artificial horizon will be shown, and then they will be masked and the artificial horizon revealed. The participants will be asked to identify whether the artificial horizon is congruent with the other instruments. In between each sequence, the participant will complete a Standard Block of trials to track performance at identifying the aircraft situation. In order to test the perceptual versus cognitive nature of the learning achieved, participants will finally be tested on a set of instrument panel stimuli in which the nature of the instruments and their interaction will remain consistent with previous training; however the overall position and look of the instrument panel will have changed substantially.

Results and Discussion

Data from our participants will be collected and analysed in August/September to be presented at the conference. The first pass of analysis will be to confirm that novices can learn the task of identifying the aircraft situation from instruments. Preliminary data have already been collected from two of the authors, neither of whom are pilots, and these data suggest that the tasks are all manageable within the allocated timeframes. There is an obvious caveat is that each author has gained incidental experience with the tasks while constructing the experimental stimuli, and has at least some familiarity with the flying domain. The preliminary data from two of the authors demonstrated two quite different strategies for completing the tasks that bear on the suitability of games-based training modules for high risk real world tasks. One of the authors, who has not played any videogames, focused on establishing the aircraft situation and then establishing the correct response in the given task, either selecting the aircraft situation, or stating whether the instruments were congruent. The other author, who played videogames regularly as a young person, was strongly motivated to establish the fastest performance with greatest accuracy, thereby looking for any perceptual cues that allowed the task to be performed rapidly, whether or not the aircraft situation was consciously identified. These different strategies prompted us to implement the extra condition to test transfer to slightly different instrument layout to see whether automatic processing as a result of repeated speeded practice results in transfer to a new layout without conscious awareness of the aircraft situation, or whether this strategy promotes negative transfer by fixating on very specific perceptual cues available in a given context rather than on developing a cognitive model of the flying task from which the instrument scanning task has been extracted. If the training task implicitly activates performance strategies based on a gaming metaphor, there is an urgent need for careful research on what exactly is being learned from virtual training environments and what are the implications of using virtual environments for training novices. While we expect from previous research (Kellman & Kaiser, 1994) and from our own experience that novices will be able to easily learn experimental tasks that mimic information integration of a complex form (instrument scans), it is important to ascertain whether their performance reflects an increased understanding of the flying situation, or just a correct choice learned implicitly in terms of the responses required of them (congruent versus incongruent). The latter situation gives rise to the very real possibility of negative transfer in future training tasks and real world flying situations.

Conclusions

Automated responses are based on trust in the anticipatory cues embedded in information being processed, and we extract anticipatory cues implicitly and without conscious awareness (e.g., Starkes & Ericsson, 2003). This study investigates the type of learning taking place in a game-like perceptual training module based on an instrument scanning task. If growing up digital results in automated responses learned through video games and virtual worlds becoming more deeply embedded than responses to real-world stimuli and we have only limited control over how automatic behaviours are selected and activated, it may be difficult to remediate automatic trained responses that are dangerous when real-world risks are involved.

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