DRILL ACQUISITION IN WEAPON HANDLING: EVALUATING THE EFFECTIVENESS OF AN EXPERIMENTAL MULTIMEDIA REVISION TOOL

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Abstract

Multi-media is widely regarded as useful in discrete psychomotor skills training and re-familiarisation. However, the effective exploitation of multi-media in Defence requires an empirical evaluation of its effectiveness compared to traditional training methods. Sixty-four participants undertaking weapon handling drills training were assigned to one of two groups: an experimental multimedia revision tool group and a standard training only control group. No difference in weapon handling test performance was observed between the groups, demonstrating there was no negative effect on learning. The real utility of multi-media may be in *retention* of discrete psychomotor skills rather than their acquisition when physical hands-on practice is not possible.

Introduction

Procedures (sequences, procedures, drills, and algorithms) underpin many core military activities and will continue to do so in the foreseeable future. Weapon handling drills cover all aspects of handling the weapon, except firing and are assessed by a Weapon Handling Test (WHT). They represent the application of a discrete psychomotor skill that has a strong procedural element. The approach adopted in training a skill is a key factor that moderates the extent to which a skill is retained over time (Angel et al., 2012). Military training and education aim to improve skills acquisition in order to produce qualified and competent individuals through knowledge and skill retention. Virtual Part Task Trainers (VPTTs) with Computer Generated Imagery (CGI) are an example of a new technology that could, if designed and employed appropriately, be exploited to deliver supplementary revision material to support skill acquisition and maintenance (Gonos, 2006). However, the effectiveness of such technology, in terms of its ability to support skill acquisition and maintenance requires an empirical evaluation.

Part-task training, adopted in the design of VPTTs, involves breaking down tasks and training their subcomponents. Once mastered, the whole task can be then practiced. This method is particularly beneficial for procedural tasks. Whole task training focuses on training the whole task and is better for learning simple skills (Angel at al., 2012). This implies that for time and safety critical tasks, such as weapon handling, supplementing conventional training of the whole task with the use of a VPTT for part-task revision, may be beneficial for the acquisition of the procedural component of weapon handling drills.

The scientific literature suggests that for discrete psychomotor skills acquisition the most effective solution is physical hands-on practice. However, in situations where access to real equipment is not possible, supplementing access to real equipment with revision using a VPTT may assist in the acquisition of discrete psychomotor skills. Physical hands-on practice of discrete psychomotor skills during training acts to support their proceduralisation in memory (Driskell, Copper, & Moran, 1994), whilst the cognitive processes underpinning the compilation of domain knowledge may be further supported using VPTTs with multi-media content.

In the context of discrete psychomotor skill acquisition, cognitive rehearsal can be defined as the cognitive rehearsal (e.g., visualisation) of the procedural component of a task in the absence of overt physical movements being conducted (Driskell et al., 1994). In order for cognitive rehearsal to be effective, it must take place when the learner is already familiar with a task and its components and has thus received hands-on practice during training (Rogers, 2006). An example of the cognitive rehearsal of a discrete psychomotor task is a soldier thinking a drill through and visualising the steps in the sequence required to perform the drill successfully. According to Driskell et al., cognitive rehearsal has been found to have a moderate and significant effect on performance. Further, the more cognitive elements in a task, the more of an influence cognitive rehearsal has on performance for that task.

An opportunity for maintaining discrete psychomotor skills such as weapon handling may be provided by supplementing physical practice with cognitive rehearsal. Cognitive rehearsal acts to strengthen discrete psychomotor skills that involve cognitive control of physical movements and manipulations. Cognitive rehearsal of these physical movements and manipulations generates cognitive representations of these sequences and rehearsal of these cognitive representations enables the movements to become familiar and automatic (Vealy & Walter, 1993). This theory is supported by research evidence demonstrating a greater effect of cognitive rehearsal on the performance of these skills.

Research in human memory has shown that chunking or grouping elements of a sequence improves the later serial recall of that information (e.g., Miller, 1956; Baddeley, 2000). Chunks in motor learning reflect pauses between successive actions. Experienced individuals have a cognitive (motor schema) memory of the physical manipulations involved in a task (Schmidt, 1975). Those with more experience of a task have a stronger cognitive representation of that task and are thus better able to *chunk* new task-related components (c.f., Posner, 1989). It follows that cognitive rehearsal may be more beneficial for individuals with more experience of a particular discrete psychomotor skill. Such individuals are equipped with the requisite cognitive representation of the task to imagine the accurate and specific outcomes associated with the imagined procedure. Research in cognitive psychology (Godden & Baddeley, 1975; Raaijmalus & Shriffrin, 1981) has demonstrated the context-dependent nature of memory, which refers to the observation that people are better at recalling information if they either return to the environment in which it was learned or imagine the environment in which they acquired the information. This is a powerful and often unexploited feature of human cognition in the design of human-computer interfaces (Stefanucci, O'Hargan, & Proffitt, 2007). Use of video demonstrations, for example, capitalises on the finding that, when people who are associated with the context are the same at encoding and retrieval, the recall of information for trainees is better. Distinctive faces and voices associated with the environment during memory encoding serve as cues for successful memory retrieval (Smith & Vela, 2001). When sounds are paired with congruent images (e.g., the instructor and the commanding voice) as contexts for encoding, an improvement in memory is observed in comparison to when images are presented without complementing sounds (Stefanucci & Proffitt, 2002). Thus multiple contextual cues may improve memory recall.

Research has shown (Craik & Lockhart, 1972; Lockhart, Craik, & Jacoby, 1975) that memory recall of discrete psychomotor skills can also be improved by developing a conceptual understanding alongside the execution of motor actions. Improved conceptual understanding of the reasons and actions involved in performing the discrete psychomotor skills would enable them to be encoded to a deeper level resulting in improved memory retrieval.

Learning design principles that harness the cognitive processes involved when learning from a dual channel environment are highly relevant to the design of e-learning content. When a principle-based approach that addresses technology-enabled human cognition is applied, the intended learning outcomes are more likely to be met. MacLean and Cahillane (in preparation) emphasise the importance of applying these principles in the design of learning technologies. It is important to focus on learners and their cognitive processes and not solely on the technology and materials or animations (Clark & Mayer, 2011; Dror, 2008; Stone, 2008, 2011).

The aim of this trial was to conduct an empirical evaluation of a PC-based multi-media tool, which uses video and still images to augment the acquisition and maintenance of weapon handling drills. The use of video in addition to static images has been shown to improve the acquisition of procedural content (Arguel & Jamet, 2009). We hypothesised that participants in the multi-media tool group would perform significantly better on the WHT than those in the control group.

Method

The Ministry of Defence Research Ethics Committee (MoDREC) approved the methodology that was adopted.

Participants
Sixty-four volunteer military recruits from two platoons not currently involved in operations took part in the study.

Materials and Equipment
An information technology (IT) room equipped with headphones was used. A prototype PC-based multi-media sequence revision tool was developed using web-based technologies (HTML and JavaScript). It reflected the contents of six out of a total of eleven weapon handling drills. The tool was developed in line with learning design principles, founded in principles of cognitive psychology, for learning sequences in order to engage the cognitive processes involved in skill acquisition and retrieval. It was designed to elicit visualisation and cognitive rehearsal, so that the learner associates an image and movement with the sound of the voice command. It comprised multi-media material (video, images and audio) and interactive revision exercises to assist in revising and recalling the drill sequences. The design for the tool drew upon Gagné, Wager, Golas, and Keller's (2005) definition of instruction "as a set of events external to the learner designed to support the internal processes of learning" (p.194).

The introduction section of the VPTT provided text and audiovisual guidance on how to optimise the revision and application of the drills. Learners were also given the opportunity to practise the types of activity they would use for revising elements of the drills. Multimodal cues were presented that encouraged the learner to visualise and cognitively rehearse the required actions, supporting the retrieval of the weapon handling drills. For each drill, a video of a Quartermaster Sergeant Instructor (QMSI) explaining how various parts of the drill are conducted was presented, emphasising and reinforcing the importance of particular drill elements. This acted to assist learners in developing a deeper understanding of the reasons behind the execution of the drills, thus improving their conceptual understanding of their actions. After the video demonstration for each drill, learners were presented with chunked still video images and audio in order to reinforce the sequence.

Participants were presented with a series of interactive revision exercises, the completion of which required the accurate retrieval of the drill sequences. There were three types of revision exercise: a gap filling exercise, a drag and drop exercise, and a mixed-up sentence exercise. Owing to the variation in the cognitive ability of recruits and in the time taken by recruits to acquire the drills, the tool provided 17 supplementary exercises offering learners an opportunity to practise drill retrieval having completed the revision sections. These supplementary exercises were timed and therefore simulated the stress experienced in the classroom environment when the WHT takes place. Learning guidance was provided to help learners establish connections between what they knew and what was being revised before they were asked to demonstrate, albeit to themselves, that they had learned the sequence. Pre-programmed text-based feedback was used to recognise and confirm successful performance or to correct less successful attempts. Other than interactive quizzes, there were no other events assessing performance in the revision tool.

Study Design

This between independent-groups trial compared WHT performance in a multi-media PC-based revision group with performance in a standard training only (baseline) control group. Thus, two groups were compared (see Table 1). Trainees are organised into platoons at the beginning of their Phase 1 training. An opportunistic sample of 64 Phase 1 recruit volunteers from two platoons, participated in the research. The two platoons were randomly assigned to one of the two revision conditions.

Table 1

Trial Design

Control	Multi-media PC tool	Total
32	32	64

Outcome Measures

The main measure of participant performance (the Dependent Variable (DV)) was the First Time Pass Rate (FTPR) on the WHT. Military personnel pass their WHT if they perform all the drills required, such that they do not fail any element of the drills that breach safety or are deemed critical. The WHT comprises 11 test items (drills). An additional measure of performance was planned as part of this study. The number of errors made by participants whilst conducting their WHT was recorded for each group. These data provide a performance measure of finer granularity than pass or fail data alone.

Procedure

Before the trial began, participants were briefed on the nature of the trial and received a trial information sheet. An informed consent form was read out to participants and subsequently completed and signed by participants before allowing them to take part in the trial. The informed consent form was collected before the commencement of the trial and kept separately from the data to ensure participant anonymity. The service numbers of participants who had given their consent to take part were recorded and given to the weapon handling instructors involved in running the trial.

In the control condition, volunteer recruits received their standard training only and did not have access to the multi-media PC tool. The trial ran for two weeks, in alignment with the Army's core Phase 1 weapon handling training. During this period, participants using the multi-media tool received 30 minutes of revision every evening for a total of 10 revision sessions over the two weeks. The revision sessions were conducted outside of normal working hours and took place using a classroom that was close to participants' living quarters. During the revision sessions, participants had use of dummy wooden rifles, as did those in the control group. These are available to personnel ordinarily during "down time" in the evenings. Participants in both groups recorded their use of the dummy rifles. This information was required to ascertain whether or not the multimedia group had used their dummy rifles in conjunction with the multimedia tool.

At the beginning of each revision session, instructors kept a record of all participants in attendance, as it was important for experimental control purposes to keep note of all participants who had completed the allocated revision time. During the first revision session, the instructors made a note of any participant who had previous weapon handling experience and, if so, the type of weapon handling experience.

In the multi-media group, participants were instructed to select the Introduction and then the learning tips. Participants were asked to read the tips and watch the complementary video, which reinforced the tips and allowed for differences in reading ability. Participants in the multi-media group were instructed to spend approximately 10 minutes on the introduction material as the objective here was to familiarise them with the interface of the revision tool, leaving at least 20 minutes to go through the relevant drills for the revision session. The following six (out of 11) weapon handling drills were revised: Normal Safety Precautions, Ease Springs, the Functions Test, and the Load, Ready and Unload. During each revision session, participants revised each drill at least once individually, with an instructor supervising the revision session. Thereafter, participants could choose what drill(s) to revise in the remaining time. Instructions on how to run the program were given to the instructors, and they were briefed before the start of the trial on how to use the multi-media tool.

Following the introduction, three practice exercises were presented that allowed the participants to practise the type of activities they would be asked to do as they used the revision materials for each drill. Instructors briefly summarised the learning tips and ensured all participants had successfully gone through the introduction. The revision exercises completed were the same as the practice exercises. Each drill had from one to three versions of each exercise, depending on its complexity (number of steps to be performed). Points were awarded after the completion of the exercise with the participant's score being reduced if they asked for clues. The scores were not tracked, as the aim of the scoring function was to help participants monitor their performance. In addition to using the hints/clues, if participants made more than one attempt before getting all the drills correct during the drag and drop exercise, their scores were also reduced.

At the end of the two-week period of training, participants received their end of training WHT. A qualified, competent instructor conducted the WHT as required by the Ministry of Defence (MOD), with one instructor per trainee. A member of the research team was present to observe. The training instructors conducting the WHT assessments were blind to each participants training group. The WHT comprises 11 sub-tests, each corresponding to an individual drill. A check sheet, designed for the purposes of the trial, was used to assess performance for each drill. The revised check sheet did not change pass criteria for the WHT. There was a ratio of one instructor per participant during the WHT. Instructors assessing performance recorded pass and fail classifications including any errors made by each participant. For each drill (test item), the instructors were asked to tick one of two error boxes presented for each step. The two types of error participants could make were as follows*: Replaced with another incorrect action (tick Done but incorrect)* and *Skipped completely and not replaced by another action (tick Forgotten).*

Results

None of the participants in the multimedia group used the revision aid allocated outside of the trial revision time. Also, both groups had similar past experience. Eight participants in the multi-media tool condition reported having previous weapon handling experience compared to six participants in the control condition. All participants spent the allocated 30 minutes each evening revising their drills with the allocated revision tool.

Table 2

Contingency Table for Chi-Square Test (Expected Frequencies for Each Cell Are in Brackets)

	Multi-media tool	Control	Total
Pass	a. 26 (24)	b. 22 (24)	48
Fail	c. 6 (8)	d. 10 (8)	16
Total	32	32	64

Examination of the contingency table (Table 2) revealed a trend toward higher FTPR achieved by participants in the multi-media PC-based tool group in comparison to those in the control group, who received standard training only. This difference was not statistically significant ([X^2 (1, $N = 64$) = 1.3, $p > 0.05$]) Twenty-six out of 32 participants (81%) passed first time in the multi-media PC-based tool group compared to twenty-two out of 32 participants in the baseline control group. A Chi-square test was carried out to examine whether there was a difference between groups (conditions) in the proportion of participants classified as having passed their WHT. Passing or failing the WHT can only be measured on a nominal scale, with each participant being allocated to one of two categories that of pass or fail. The Chi-square test compared the observed frequencies (actual number of participants) in each of the cells of the contingency table (Table 2) with the expected frequencies for each cell (the number of participants we would expect to fall into each cell if there were in fact only random differences between the groups in their WHT performance).

No statistical differences in FTPRs were observed between the two groups, confirming what can be ascertained by a visual inspection of the descriptive statistics in Table 2 [X^2 (1, N = 64) = 1.3, $p > 0.05$]. An independent T-Test was performed on the number of errors for each condition collapsed across the drills. No statistical difference was found between the two groups: t (62) = 0.16, p > 0.05 (see Figure 1).

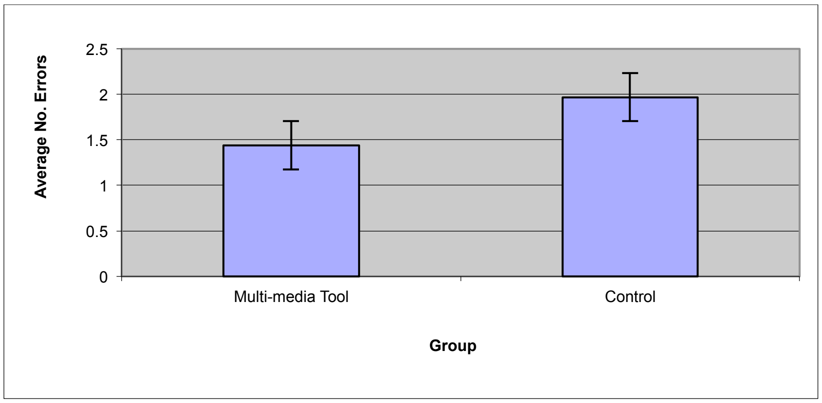

Figure 1. Average number of errors collapsed across WHT items (drills) per experimental cognitive condition. Error bars represent standard error above and below the mean.

Discussion

The results suggest that the use of the multi-media revision tool for the revision of weapon handling drills has no significant effect on Phase 1 WHT performance. The observed equivalence in the WHT performance of both groups is in agreement with the literature showing that physical hands-on practice is the most effective for discrete psychomotor skills acquisition (Driskell et al., 1994). Both groups had received physical hands-on practice during their standard training. That no statistical difference in WHT performance was observed between the groups also demonstrates that the use of the multi-media tool had no negative effect on learning.

FTPRs were at 69% for those who received standard training only, which, in comparison to 81% for those in the multi-media tool group, indicates baseline performance was already at a high level at the acquisition point. This could imply that the multi-media revision tool may have greater utility in supporting the retention of weapon handling drills rather than their initial acquisition, assuming those drills have been fully proceduralised during initial training. A multi-media revision tool may therefore be of more use to military personnel who have already acquired the weapon handling drills but who need to re-familiarise themselves in preparation for their weapon handling Military Annual Training Test (MATTs). Research in cognitive science indicates that experienced individuals can benefit from the cognitive rehearsal of the procedural component of physical tasks more than inexperienced individuals, since they have fully proceduralised the discrete psychomotor actions and have established cognitive representations for these action sequences (Driskell et al., 1994; Kim et al., 2013).

The finding of no significant difference in overall errors between the multi-media and control group may be due to problematic drills not being included in the multi-media revision tool developed for the trial. Only six out of the 11 weapon handling drills were included in the tool. Consultations with the participants revealed that the multi-media tool could be improved by incorporating the entire weapon handling drills. However, the constraints surrounding the experimental design were recognised by the participants. Instructors may have focused the attention of recruits on the most critical information required to pass the WHT during the standard training sessions, given that participants will pass unless they make more than two mistakes on each drill or safety is breached. However, although it was not possible to control for the delivery of rifle lesson material during the standard training received by both groups, all instructors delivered this material to the same standard as outlined in military training doctrine.

Although no statistical difference in FTPRs was observed between both groups, the data demonstrate a trend for participants using the multi-media tool to perform better on their WHT than those in the control condition. This finding suggests that the design of the multi-media tool, which incorporated the human component and cognitively challenging formative assessment, adequately addressed learning design principles. These principles support the cognitive processes underlying the acquisition and reinforcement of discrete psychomotor skills. Any developments in new learning technologies for discrete psychomotor skill maintenance should consider incorporating the human component and addressing the learning design considerations outlined here. Incorporation of the human component can be achieved using virtual hands or video based demonstrations for the more difficult weapon handling manipulations or where audio only instruction can be interpreted not as intended. The use of video clips would also help demonstrate the required position of the weapon in relation to the body. The implementation of video in learning environments such as VPPTs is a step forward. The use of interactive videos, where learners take an active role, that is, they are required to respond and be actively involved have been found to enhance the learning experience (Cherrett, Wills, Price, Maynard, & Dror, 2009).

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