



Training decision making using serious games: Requirements analysis for decision making training

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Contents

1	Executive Summary	1
2	Introduction	3
2.1	Background	3
2.2	Study objective	4
2.3	Study focus.....	4
2.4	Report outline	4
3	Literature Review	6
3.1	Introduction.....	6
3.2	Decision making.....	6
3.2.1	Classical Decision Making approach.....	6
3.2.2	Naturalistic Decision Making approach	8
3.2.3	Training decision making	9
3.3	Games.....	10
3.3.1	Computer games	10
3.3.2	Types of computer games	11
3.3.3	Serious games	12
3.4	Pedagogy	13
3.5	Validation.....	14
3.6	Conclusions.....	14
4	Requirements Analysis.....	16
4.1	Acquisition of domain knowledge, and stakeholder engagement.....	16
4.2	Scenario development	17
4.3	High level software design solutions.....	18
4.4	Instructional design	19
4.4.1	User and user environment	19
4.4.2	Training content and instructional overlay	20
4.5	Scripting and storyboarding	21
4.5.1	Level 1 (Patrol).....	23

4.5.2	Level 2 (Pursuit)	24
4.5.3	Level 3 (Escape)	25
4.6	Design documentation	26
5	Outcome	27
6	Conclusions and Recommendations	28
6.1	Conclusions	28
6.2	Recommendations	29
7	References	30

1 Executive Summary

Dynamic, high stakes decision making is at the centre of all military operations, and as such it is a skill that is vital that all personnel in the armed services acquire, albeit to varying degrees, yet it is difficult to train. Serious games appear to present a viable medium for training decision making, yet despite numerous initiatives having been undertaken to exploit commercial off the shelf games technology for serious training applications, and there being a corpus of decision making theory, few if any inroads have been made to instantiate psychological decision making theory into synthetic environments.

In response to these challenges, the objective of Work Package 4.6 has been to establish the requirements for a desktop synthetic environment (SE) decision making training support tool, and develop a 3D concept demonstrator. The SE concept demonstrator (project name CODE) utilised commercial off the shelf games technology in its development, but was unique in that the content of the SE training package was based upon psychological decision making theory and learning theory rather than being essentially technology driven. CODE has been developed around an urban foot patrol context to help improve the decision making agility of novice decision makers, essentially Private soldiers with little or no operational experience, being deployed to dynamic, complex, high tempo and high stakes operating environments.

Early Work Package 4.6 research activity centred on a comprehensive review of the literature from the military and civilian research domains. It reviewed decision making, improving decision making by means of structuring and training, and the properties of games, computer games and serious games, and different types and structures of computer games, which can be exploited for decision making training purposes, with an emphasis on military gaming applications. A substantial literature review was delivered concluding this early research activity. More recent Work Package 4.6 research activity has centred on establishing the requirements for a decision making SE. This report provides a review of this activity, namely defining the context for the SE, and the approaches undertaken in developing scenarios, establishing the training overlay, scripting and storyboarding the SE, and producing a requirements document. This report also provides a review of engagement with the Operational Law Branch of Army Legal Services (OPLAW) and the Rules of Engagement and Judgemental Training Team from the Operational Training and Advisory Group (OPTAG). A copy of the SE concept demonstrator is being provided under separate cover.

The objective of Work Package 4.6 - to establish the requirements for a desktop synthetic environment decision making training support tool and to develop an SE concept demonstrator, around the context of a contemporary theatre Army urban foot patrol, to support the training of novice decision makers being deployed to dynamic, complex and high stakes environments - has been achieved. The development of the SE has been driven by psychological decision making theory and training theory, and is unique in this approach, demonstrating that it is feasible to develop the requirements for a decision making SE based on psychological decision making theory. Human factors principles have been applied in the development of the requirements including building scenarios

(including their validation), establishing the training overlay, software concept development, scripting and storyboarding the SE, and in preparing requirements documentation.

The SE should help improve the decision making agility of novice decision makers in terms of their ability to identify and assess cues, handle negative information, and make decisions from a number of decision action options. In addition, since the scenarios and the feedback given to trainees are underpinned by Rules of Engagement, the SE should help in training and practicing interpreting Rules of Engagement.

Since the training overlay is embedded in the SE, the ultimate aim is that CODE can act as a stand alone in-barracks (UK and in-theatre) training and revision support tool, potentially alongside the Dismounted Close Combat Trainer (DCCT). The concept demonstrator would be of relevance to the Operational Training and Advisory Group (OPTAG) and the Operational Law branch of Army Legal Services (OPLAW) in delivering pre-deployment training, both of whom have input to the study. The CODE concept demonstrator and the requirements analysis approach would have applications across all three military services for activities where decisions need to be applied in dynamic, high tempo, high stakes environments.

It is recommended that the concept demonstrator be fully evaluated in terms of its utility as a training tool. It is also recommended that the number of decision events should be increased to provide further training and practice opportunities, and an evaluation be made in terms of CODE's ability to support the acquisition of skill and knowledge.

2 Introduction

2.1 Background

'An essential component of expertise in military command and control is the ability to make and implement decisions in a timely, efficient and effective manner, most often with very limited information, in an increasingly fluid and multidimensional battle space' (Serfaty, MacMillan, Entin and Entin, 1997, p.233). Across the armed forces, operational, strategic and tactical decisions are taken on a daily basis, which determine mission success and the safety of personnel and equipment. The change in the nature of warfare from fighting a cold war enemy with a fairly well known military doctrine, to asymmetric warfare incorporating terrorism with no doctrine or history to study, presents new decision making challenges for the highest levels of command and control through to personnel on the ground either engaged in war-fighting, peace-keeping or peace-support activities.

Decision making is at the centre of all military operations and as such the requirement for training military decision making cannot be underestimated. However, decision making is hard to train since there is no evidence to indicate that it is possible to provide generic decision making training (Orasanu, 1993; Means, Salas, Crandall and Jacobs, 1993). However, there are a number of trainable decision making skills which underpin different decision types, and it has been found that training to make more specific types of decision in specific contexts can be successful (Li and Harris, 2006).

It is widely acknowledged that decision making training needs to be taught in an environment in which the decision maker can learn through experience. However, live training is expensive and it is argued that a novice decision maker will not gain as much from live training as a more experienced decision maker, owing to their undeveloped ability to recognise prototypical events from contextual cues. In addition, it may not be appropriate for a novice to be making decisions in certain situations, feedback may be limited, and it may not be practical or safe to witness the outcome of decisions made.

Serious games (alternatively referred to as synthetic environments or SEs), which are developing rapidly for military training by virtue of leveraging commercial off the shelf games technology, present a viable media for training decision making in that well designed games can provide learning environments in which students can develop decision making skills such as cue pattern recognition, situation assessment, handling negative information etc. In addition, SEs provide a low cost benign environment within which students can take risks, explore decision options, and can learn from their actions, with the benefits of immediate feedback from the game and comprehensive after action review. However, despite numerous initiatives having been taken to exploit commercial off the shelf games technology for serious training applications, and there being a corpus of decision making theory, few if any inroads have been taken to instantiate decision making theory into synthetic environments.

2.2 Study objective

The objective of Work Package 4.6 has been to establish the requirements for a desktop synthetic environment (SE) decision making training support tool, and develop an SE concept demonstrator. Commercial off the shelf games technology has been leveraged in the development of the SE concept demonstrator, but the Work Package approach is unique in that the content of the SE training package is based upon psychological decision making theory and learning theory rather than being essentially technology driven.

2.3 Study focus

Since decision making training needs to be targeted to specific types of decisions in specific contexts (Li and Harris, 2006), early Work Package 4.6 activity involved trying to identify potential stakeholders with decision making training needs which would align with the objective of the Work Package to develop a decision making SE based on psychological decision making theory. Exploratory meetings were held with the Submarine School, Devonport (Trafalgar class sonar room training); Flying Training Development Wing, Cranwell (UAV training); and DEC TA (training to support intelligence, surveillance and reconnaissance tasks using Sniper and Litening targeting pods). However, due to issues either of time scale, or required deviation from the Work Package objective, these proposals could not be pursued.

Accordingly, a decision was taken to develop the SE concept demonstrator around a high tempo, Army urban operations decision making context, reflecting current operations in Afghanistan. An appropriate target training audience was considered to be novice decision makers with little or no operational experience, who receive little formal decision making training, yet who are making significant decisions in dynamic high stakes environments. The aim of the SE would be to provide desktop decision making training support to help improve the decision making agility of novice Private soldiers. This concept was further developed having consulted with the Operational Law Branch of Army Legal Services (OPLAW), and the Rules of Engagement and Judgemental Training Team from the Operational Training and Advisory Group (OPTAG). The Army urban operations concept was established as the context for the decision making SE concept demonstrator, which then became known by the project name CODE (Combat Operation Decision Environment).

2.4 Report outline

Early Work Package 4.6 research activity centred on a comprehensive review of the literature from the military and civilian research domains (Caird-Daley and Harris, 2007). The literature review examined in detail the two dominant decision making approaches, Classical Decision Making (CDM) and Naturalistic Decision Making (NDM), before considering common errors in decision making, and means of improving decision making such as through training and structuring. The literature review also examined the properties of games, computer games and serious games, and different types and structures of computer games, which could be leveraged for decision making training

purposes. Attention was paid to military serious games applications, and arguments for robust instructional design and validation were made.

More recent Work Package 4.6 research activity has centred on establishing the requirements for a decision making SE concept demonstrator. This activity has included developing scenarios, building a training overlay, storyboarding and scripting CODE to instantiate the training overlay into the SE, and producing a requirements document. During this process close contact was maintained with an in-house training media development team, who would be responsible for building the SE concept demonstrator based on the storyboards and requirements document. The media development team provided input to the scripting/storyboarding and requirements document activities, established viable options for building the SE concept demonstrator, and built an SE concept demonstrator.

This report provides an updated review of the literature, specifically targeted to the later Work Package 4.6 requirements analysis activities. This is followed by a review of the requirements analysis approaches undertaken including acquiring domain knowledge and stakeholder engagement; scenario development; developing the training overlay; scripting and storyboarding the SE; and preparing requirements documentation.

The SE concept demonstrator is being submitted as a separate deliverable under Work Package 4.6.

3 Literature Review

3.1 Introduction

The study has been informed by literature from military and civilian research domains. This section provides a brief review of decision making, decision making training, gaming and learning theory, which have underpinned the development of the requirements for a decision making SE.

3.2 Decision making

Decision making is a broad topic that has been on the research agenda since the mid eighteenth century (Edwards, 1954). During this time decision making has been investigated using a number of approaches. Two contrasting paradigms, whose work is relevant to military decision making, include the Classical Decision Making (CDM) and Naturalistic Decision Making (NDM) approaches.

3.2.1 Classical Decision Making approach

The classical concept of prescriptive, analytical decision making has its roots in the normative decision making models of economics and statistics, which specify optimal decision solutions (Lehto and Nah, 2006). Classical models are seen as the text book ideal processes to follow when making a decision (Lehto and Nah, 2006) and the decision maker (or 'Economic Man') is seen as being completely informed, infinitely sensitive and rational (Edwards, 1954).

The classical approach assumes that problems are well defined, information is structured in a clear and accessible format, time is adequate, and decision makers have full information on the background, objectives, alternative courses of action, and range of possible consequences. These assumptions are feasible for laboratory based studies; however, a reliance on laboratory experiments has led to the criticism that classical approaches do not take into account the effects of real-world contextual factors and their influences on decision making (Zsombok, 1997). For example, in a dynamic environment, an evaluation of the pros and cons of each option may be impractical due to time constraints, a decision maker may not be aware of all possible alternatives, and the consequences and the quality of outcomes may not be known until after the event (Thunholm, 2004). Kirschenbaum (2001) points out that in the field, information is often ambiguous, unreliable, and difficult or time consuming to obtain, and in a military situation may even be deliberately distorted.

Whilst an optimal solution may be the objective of some decision making events, it may be that all that is sought is a 'good enough' choice (i.e. decision makers are 'satisficers' seeking a satisfactory choice, rather than maximisers, seeking an optimal solution). Indeed, Simon (1955) argues that the information processing requirements of rational decision making exceed limited human cognitive capacities, necessitating the use of heuristics to reduce cognitive load and speed up decision making.

There are a number of heuristics used in making decisions under uncertainty (e.g. Tversky and Kahneman, 1974; Reason, 1990), which are economical and usually highly effective, especially in pressured, uncertain contexts, when more time consuming rational analytical approaches could not be used (Klein, 1997). Three particularly common heuristics which help reduce complex decision making to simple judgemental operations include: representativeness, availability, and adjustment and anchoring heuristics (Tversky and Kahneman, 1974). However, they are associated with systematic biases.

The representativeness heuristic is the tendency to judge someone or something according to how representative it appears to be of a particular category, i.e. *'probabilities are evaluated by the degree to which A is representative of B [...]. When A is highly representative of B, the probability that A originates from B is judged to be high [... and conversely] if A is not similar to B, the probability that A originates from B is judged to be low'* (Tversky and Kahneman, 1974, p. 1124). However, Tversky and Kahneman (1974) identified that this heuristic leads decision makers to ignore relevant information through being insensitive to base-rate frequencies of outcomes; sample size; chance and predictability.

The availability heuristic is the tendency to consider an instance or event as being more probable if it can be easily imagined, as opposed to being difficult to bring to mind, with *'instances of large classes [...] usually recalled better and faster than instances of less frequent classes'* (Tversky and Kahneman, 1974, p. 1127). However, availability is affected by more than just frequency, probability, or recency and as such the heuristic can lead to systematic biases/errors.

There is evidence that when additional information is received, or even when decision makers actively seek further information, that there is a tendency for decision makers to give more weight to evidence that is consistent with their initial hypothesis (or 'anchor') than to contrary information. Anchoring, therefore, seems to represent a sort of 'primacy' in memory, and the biases associated with it include making insufficient adjustment, or making inappropriate calibrations.

Reason (1990) reports two further strong and pervasive biases: overconfidence and confirmatory biases. The overconfidence bias occurs when a decision maker is overconfident in the correctness of his diagnosis, hypothesis formation, and action selection, causing him to prematurely close off a search for information. Confirmatory biases occur when a decision maker seeks information and cues that confirm their tentative hypothesis, yet fail to seek (or discount) information that supports a contrary view (Wickens and Hollands, 2000). Research has shown that when cues are ambiguous and not amenable to diagnosis then decision makers will interpret the data to support their initial hypothesis, and decision makers have been shown to fail to encode or process negative information i.e. information inconsistent with their initial hypothesis. The accidental shooting down of Iran Air flight 655 by the USS Vincennes revealed the operation of the confirmatory bias, and a failure to take into account negative information which had identified the inbound aircraft as neutral.

Heuristics are generally highly effective; however, having an understanding of the different types of systematic decision making biases makes it possible to suggest *'training, procedural, and design remediations, which can lessen their degrading impact*

on diagnosis in the circumstances when those impacts may be severe or safety compromising' (Wickens and Hollands, 2000, p.314).

3.2.2 Naturalistic Decision Making approach

The Naturalistic Decision Making (NDM) framework is the most recent decision making paradigm. It was initiated in 1989 at a conference sponsored by the Army Research Institute for researchers who had stepped away from the classical paradigm and were studying the cognitive processes that underlie *'the way people use their experience to make decisions in [dynamic] field settings'* Zsombok (1997, p.4). From their research a number of coherent themes were identified, which for all intents and purposes define the NDM paradigm and the naturalistic operating environments experienced by military personnel. The themes identified were codified by Orasanu and Connolly (1993) and included: (i) ill structured problems; (ii) uncertain dynamic environments; (iii) shifting, ill-defined, or competing goals; (iv) action/feedback loops; (v) time stress; (vi) high stakes; (vii) multiple players; and (viii) organisational goals and norms.

More recently, the emphasis of the NDM paradigm has shifted from a focus on naturalistic or field settings to a focus on the use of experience by decision makers (Pruitt, Canon-Bowers and Salas, 1997). However, the properties of NDM are particularly useful in defining the requirements for a decision making SE in that they begin to characterise the properties of an operational environment.

Emanating from the NDM perspective are a number of decision making models. Lipshitz (1993) described nine NDM models that either describe the sequences of decision making phases, or that describe the conditions under which different decision processes are used. The number of models that fall within the NDM framework has increased over time, but the most widely recognised model is the recognition-primed decision making (RPD) model (Klein, 1993 and 1997). The RPD model proposed that an assessment of a situation is matched to a prototype based on the similarity of goals, perceptual cues and knowledge of causal factors, which generates a set of options, the first workable option being the one that is implemented. RPD is, therefore, consistent with Simon's (1955) notion of satisficing.

Despite the appeal and broad applicability of the RPD model, experienced decision makers do not appear to use an RPD approach all the time (Orasanu, 1997). Even in naturalistic high pressure environments, experts may use different decision making strategies (e.g. Orasanu, 1993; Flin, Salas, Strub and Martin, 1997; and Flin, O'Connor and Crichton, 2008). Orasanu (1993) identified six different types of decisions which differ according to the structure of the decision task, and surrounding conditions; how well the decision problem is defined; familiarity with the problem; whether a response is prescribed or needs to be generated; how many options are readily available; the clarity of the nature of the problem; and the availability of time (Orasanu and Fischer, 1997). The different decision types identified by Orasanu (1993) include: go, no-go decisions; recognition-primed decisions; option/response selection decisions; resource management decisions; procedural management; and creative problem solving, all of which involve situation assessment, choice among alternatives and assessment of risk. These six different event types would apply broadly across military decision making.

3.2.3 Training decision making

As discussed under Section 3.2.1 the CDM approach has shown that cognitive biases can lead to error prone decision making. However, bearing in mind that biases are systematic and are well understood it is possible to tailor decision making training to target decision making error. This approach is often known as debiasing (Fischhoff, 1982), where the objective is to train decision makers to be more aware of the effects of biases on decision making.

There have been a number of successful debiasing studies including those of Koriat, Lichtenstein, and Fischhoff (1980, cited in Wickens and Hollands, 2000), which addressed overconfidence bias through encouraging forecasters to question why their forecasts may not be correct, and who worked on restoring confidence calibration by providing comprehensive and immediate feedback in predictive and diagnostic tasks, enabling forecasters to focus on the outcome of their rules. Lopes (1982, cited in Wickens and Hollands, 2000) succeeded in training study participants away from non-optimal anchoring biases by making participants aware of their tendency to anchor on initial hypotheses, which may not be informative, and encouraging them to anchor on more informative sources. So in essence, debiasing studies aim to raise awareness of tendencies to bias decision making, train decision makers on the effects of biases and means of overcoming the tendency to bias decision making, and provide feedback on how successful the approaches have been.

Much debiasing research has, as with research into heuristics and biases more generally, been centred on the laboratory and not the dynamic 'real' world. However, SEs present opportunities to develop decision events embedded in larger dynamic tasks to raise awareness of the influence of biases on decision making, whilst exploiting the ability of well designed SEs to provide immediate feedback - in essence synthesising CDM and NDM training approaches.

The proponents of the NDM paradigm have been quick to propose decision making training strategies to accelerate the proficiency of decision makers in the military, emergency services and safety critical industries. However, Means et al (1993) and Orasanu (1993) point out that there is no evidence to indicate that it is possible to provide generic decision making training; rather, specific skills need to be developed. Orasanu (1993) has identified a number of trainable decision making skills which specifically underpin different types of decisions, but in addition has identified a number of trainable skills which cut across decision types. These include situation assessment; risk assessment; planning; resource management; and communication.

Tactical decision games or TDGs (e.g. Crichton and Flin, 2001; Crichton 2009), which are desktop, paper and pencil scenario-based 'what if' facilitated simulations (Flin et al, 2008), have been used successfully to exercise and practice situation awareness skills, recognition-primed, rule-based and knowledge-based decision making, developing shared understandings and recognition of problems, stress management, teamwork and pattern building. To improve decision making agility Fallesen and Pounds (2001) and Cohen, Freeman and Thompson (1997) have focused on metacognitive skills developed around relevancy checking and reflective questioning to improve reasoning skills (Fallesen and Pounds, 2001) and to generate alternative possible assessments (Cohen et al, 1997).

However, all of these approaches build on identifying cues, understanding their salience, and cue pattern recognition, which will be undeveloped in novice decision makers.

According to Flin, O'Connor and Crichton (2008, p. 45) situation assessment is '*the process by which a focused survey and evaluation of the work environment takes place*'. It involves the decision maker in being alert to developing situations, being sensitive to cues and being aware of their implications (Orasanu, 1993), and according to Flin et al (2008) and Orasanu (1993) it is the first stage in the cognitive process to reach a decision, making situation assessment skills paramount.

According to Fallesen and Pounds (2001, p. 63) '*experts seem better able to discriminate relevant cues from irrelevant cues*', and they can recognise cues more quickly, can detect important features of cues, and can recognise patterns of cues better than novices (Canon-Bowers and Bell, 1997). This does suggest that a focus for decision making training for novice decision makers should be on developing cue recognition and developing an understanding of cue significance. Orasanu (1993) and Canon-Bowers and Bell (1997) suggest that situation assessment can be trained through extensive pattern recognition practice and learning to assess the significance of cues. SEs appear to present a viable media for providing training in identifying relevant cues and understanding their salience, due to the ability of instructional designers and developers of SEs to control the characteristics of the decision problem, situational cues and cue patterns, and because decision makers can see and learn from the outcome of decisions made.

3.3 Games

Intuitively the nature of games is well understood since across cultures humans engage in playing games from infancy. However, the broad scope of games makes defining them quite challenging and there is little consensus between game theorists on how games are defined. However, most theorists agree that games proceed according to a set of rules (Salen and Zimmerman, 2004). Games are also engaging (Prensky, 2001) as game rules provide structure, goals provide motivation, and the player is an active rather than passive participant.

3.3.1 Computer games

For all intents and purposes computer games (also known as video games or digital games) are games played on a number of digital platforms, either game consoles, PCs, hand held gaming devices or mobile phones. Zyda (2005, p.25) defines video games as '*a mental contest, played with a computer according to certain rules for amusement, recreating, or winning a stake*'. The rules of video games (or game dynamics) are also primarily the same as the rules for non-digital games i.e. they are '*directly concerned with the actions players take and the outcomes of those actions*' (Salen and Zimmerman, 2004, p.149). However, this does not tell us about the unique properties of video games.

Salen and Zimmerman (2004) suggest that to define digital games you need to understand what digital media can do. They have identified four properties of digital media: immediate but narrow interactivity; information manipulation; automated complex systems; and networked communication. Arguably one of the most compelling qualities

of digital games is that they can offer immediate, interactive feedback. Digital technology, therefore, enables real time (and above real time) game play that '*shifts and reacts dynamically to player decisions*' (Salen and Zimmerman, 2004, p.87). It does have to be borne in mind, however, that interacting with a PC is generally limited to mouse, keyboard and joystick input devices, and screen and sound speaker output devices.

Digital games manipulate vast quantities of information such as text, images, video, audio, animation, 3D content, and every aspect of its program in a way that cannot be achieved in non-digital game formats. They automate complicated procedures such as manipulating game pieces according to explicit instructions, and thereby facilitate the play of games by moving the game forward without direct input from the player. Digital games also facilitate communication between two or more players, either by means of e-mail or text chat, real-time video and audio communication. This means that players do not have to be co-located to engage in joint game play.

3.3.2 Types of computer games

There are a vast number of computer games in existence which can be distinguished from each other according to their genres i.e. according to their style, form and content (Bjork and Holopainen, 2006). Those relevant for leveraging for military serious gaming purposes include: first person shooter (FPS) games through which a player sees their world through the eyes of their on-screen counterpart or avatar, i.e. the game facilitates a first person perspective of the virtual environment; third person games in which the player gets a distanced perspective of the whole scene, including their own character (Thompson, Berbank-Green and Cusworth, 2007); real time strategy (RTS) games which allow players to command some types of operation, typically a military operation; role playing games (RPGs) in which players manage a person or team through typically fantasy or science-fiction settings, building skills and amassing weapons; lastly, simulation games such as *Microsoft Flight Simulator* which simulate tasks, but incorporate features of games such as scoring which are not present in an actual task.

In addition to there being a number of different genres of computer game there are two dominant game structures: linear and sandbox, which represent how a game fits together, i.e. 'how the levels are laid out and how higher objectives are staged' (Thompson et al, 2007, p.32), and which can combine with any one of the game genres above. Linear games provide a single path for the players to follow with explicit goals that must be achieved in a set sequence to progress through the game. Sandbox games allow the player to approach different goals and challenges in almost any order, the name 'sandbox' being derived from the unrestricted games that children play in a sandbox (or sandpit).

These different types and structures of commercial off the shelf games can be leveraged for different types of training. For example the Interactive Trauma Trainer SE (Stone, 2007) developed by the HFI DTC and TruSim (a division of Blitz Games), which trains users in field hospital procedures, takes a first person perspective and a linear structure.

3.3.3 Serious games

The United States Army developed *America's Army*, a PC based game, as a recruiting tool, by leveraging Epic's Unreal game engine. The take up of the game from teenagers, potential recruits, and serving military personnel, was so substantial that there began a revolution in thinking about the potential role of leveraging commercial off the shelf (COTS) gaming tools for non-entertainment domains.

'Serious gaming focuses on the exploitation for real-world applications [. . .] of high-quality computer games and associated software tools, such as those underpinning many of the popular 'first person shooter' or 'role playing' games on the market' (Stone, 2007, p.1). These tools take the form of software development kits (SDKs) and content generation packages released by games developers shortly after the publication of a new game. The availability and affordability of these COTS gaming tools have generated interest from those responsible for researching and designing training systems such as for defence training (Stone, 2007).

Abt (1987, cited in Michael and Chen, 2006, p.21) defines serious games as games with *'an explicit and carefully thought-out educational purpose and are not intended to be played primarily for amusement'*, although Abt does point out that this does not mean that serious games are not, or should not be, entertaining. Serious games, therefore, can be seen as video games that are intended to educate and train, while at the same time engaging and entertaining the user. According to Raybourn, Deagle, Mendini and Heneghan (2005, p.3) well designed *'serious games provide the opportunity for experiential learning [. . . and] they provide an environment for active, critical learning'*. Experiential learning opportunities enable game players to *'learn from contextual information embedded in the dynamics of the game [...], and through the risks, benefits, costs, outcomes and rewards of alternative strategies that result from decision making'* (Raybourn et al, 2005, p.3).

In addition to being able to leverage the properties of games and digital games for learning, serious games also possess many of the properties of simulator based training devices. For example, serious games may provide the opportunity for after action review (AAR), they provide students with a safe, benign learning environment enabling an exploration of decision making under a range of hazards and in dangerous activities and to learn from the outcomes of their actions without risk to life or equipment. They can also enable training to take place 24 hours a day, seven days a week regardless of weather conditions; and without damage to the environment (Rolfe and Staples, 1986).

It is acknowledged that serious games, just as with simulator training devices, have limitations; for example they cannot replicate morale, fear, fatigue or physical adaptations to extremes of climate which are best trained in the live environment. This does not undermine the use of serious games for military training, but acknowledges that serious games are not the media solution for all training needs. However, they certainly appear to be particularly suited to training higher level cognitive skills.

3.4 Pedagogy

It is imperative that researchers, trainers and game developers acknowledge that a serious game or SE requires a training overlay, as a game by itself will not necessarily train. Gagne, Wager, Golas and Keller (2005, p. 213) argue that *'educational media [which includes serious games/synthetic environments] by themselves do not influence the achievement of students; they permit the delivery and storage of instructional messages but do not determine learning'*. Accordingly, SEs designed for training must be integrated with good instructional design.

The design of training, and the theories of instructional design, centre upon the characteristics of the trainees (i.e. who is being trained and their aptitudes and prior knowledge); the training content (i.e. what is being trained); and instructional design methods and strategies (i.e. how the training is structured and how feedback is provided to trainees) (Patrick, 1992). According to Gagne et al (2005) there is no one best way to teach everything, but the training method and media should be aligned with the training objective and the *'cognitive, physical or psychomotor processes that lead to mastery'* (Tannenbaum and Yukl, 1992, p. 404).

Gagne et al (2005) also consider that learner motivation should be taken into consideration when designing instruction. Motivation can be seen as the force that *'causes a learner to engage in study behaviour [and] focus attention on a particular learning goal'* (Gagne et al, 2005, p. 114). Much is written in the serious games literature about the engaging and motivational properties of serious games (e.g. Prensky, 2001). But it must be born in mind that motivation is more than the appeal of participating in gaming as compared with more traditional learning formats. Motivation comes from good instructional design, which includes building credible instructional events that require active participation by trainees, and through providing timely feedback. Indeed, as noted in Section 3.3.1 one of the most compelling qualities of leveraging digital games technology for training is that it can offer immediate interactivity and feedback.

Patrick (1992) argues that *'the most common and powerful method of training is to allow the trainee to perform the task and then to provide some information about the correctness of his/her action'* (Patrick, 1992, p. 325). Discussion under Section 3.2.3 stressed the importance of feedback, In most skills, practice or experience guarantees improved performance. However, according to Wickens and Hollands (2000) general (i.e. day to day) practice in decision making does not necessarily lead to improved performance. Wickens and Hollands (2000) argue that this is due to feedback often being ambiguous, delayed or selectively processed. This lends strong support to Tannenbaum and Yukl (1992, p. 404) who argue that *'all available sources of relevant feedback should be used, and feedback should be accurate, credible, timely and constructive'*. Patrick (1992, p. 330) also adds that *'knowledge of results should be unambiguous, precise and easily interpreted by the trainee in terms of the discrepancy between actual and desired performance'*.

3.5 Validation

Clearly it is not enough that students have fun and play the game. Training objectives need to be achieved and positive training benefit needs to demonstrably transfer to the live environment.

Kirkpatrick (1998) advocates a four level evaluation of training programs starting with a measure of the reaction of the students/learners to the program i.e. assessing their 'customer satisfaction'. Level two involves the measurement of the extent to which students acquire or increase skill, improve knowledge or change their attitudes in response to the training received, i.e. a learning evaluation, with level three measuring the transfer of this learning to the operational environment. The final assessment (level four) then focuses on the training intervention in terms of the results to an organisation, such as through cost savings or reductions in errors/accidents.

A number of military training effectiveness studies exist in the serious games domain (e.g. deFreitas and Jarvis, 2006; Baker, Prince, Shrestha, Oser and Salas, 1993; Green and Bavelier, 2003; and Gopher, Weil and Bareket, 1994). However, Alexander et al (2005) and Hays (2005) highlight the paucity of studies of skill acquisition or transfer of training in the military serious games domain. The challenge to developers of serious games is to move beyond the first stage of Kirkpatrick's (1998) evaluation approach to include robust evaluation of learning and behaviour.

3.6 Conclusions

While there is a corpus of decision making theory, and numerous initiatives have been undertaken to exploit commercial off the shelf games technology for serious training applications, few if any inroads have been taken to instantiate psychological decision making and learning theory into SEs. The challenge, therefore, is to establish the requirements for a decision making SE.

For the purposes of a decision making SE based around an Army urban foot patrol context, the six properties of NDM as codified by Orasanu and Connolly (1993) begin to establish the requirements for the scenario and synthetic operational environment, in that the scenario and environment need to replicate the properties of NDM. SEs appear to present opportunities to develop decision events embedded in larger dynamic tasks to raise awareness of the influence of biases on decision making, whilst exploiting the ability of well designed SEs to provide immediate feedback. They also appear to present viable opportunities for providing training in identifying cues and understanding cue salience, due to the ability of instructional designers to manipulate the characteristics of the environmental cues, and to exploit different feedback mechanisms. However, it is essential that the scenarios and games technology leveraged to build an SE can adequately capture and display cues (visual and auditory) and associated responses. It is also essential that the requirements incorporate a robust training overlay centred on the trainees, training content and instructional methods and strategies (including mechanisms to encourage trainee motivation and provide feedback), and that these are constructively aligned.

Whilst a number of studies have demonstrated the efficacy of serious games for accelerating learning, and developing high level cognitive skills, there is still a paucity of empirically based studies that have moved beyond Kirkpatrick's (1998) first stage to assess the acquisition of skills and knowledge, and to assess the transfer of training to the live operational environment. This would suggest that the evaluation of serious games is an area which needs to be developed.

4 Requirements Analysis

The following section outlines the various approaches undertaken in defining the requirements for an SE concept demonstrator underpinned by psychological decision making theory.

4.1 Acquisition of domain knowledge, and stakeholder engagement

To test the Army urban foot patrol context, and to begin to acquire domain knowledge, opinion and information were sought from an in-house subject matter expert (SME) with operational infantry experience. Various themes were covered including the roles of different members of a four man fire team, how a fire team functions, and which members of a fire team, or which rank levels, may derive most benefit from an SE-based decision making support tool. From this discussion it was considered that Private soldiers with little or no operational experience, who as a result were inexperienced decision makers in terms of their infantry role, yet who face the prospect of having to make high stakes decisions in a complex and dynamic environment, may benefit most from decision making training support.

The focus of the SE was to provide decision making training support, rather than being a rules of engagement (ROE) trainer. However, since decisions taken in theatre involve an interpretation of ROE, and any training scenarios would need to be underpinned by ROE, an understanding of ROE was required. A number of questions were asked in terms of how ROEs are derived, when they are issued to troops, how they are trained, whether there are any issues with training, comprehension or interpretation, who has authority to modify or revise them in theatre, and what challenges are faced when ROEs are modified such as transitioning from a war footing, to peace-keeping, and then peace-support. In response to these questions a tutorial was provided on Rules of Engagement and the Law of Armed Conflict, based on the SME's experience.

The engagement of the Operational Training and Advisory Group (OPTAG) was sought both as SMEs and as potential end users, to inform the development of the decision making SE. A meeting was held with OPTAG's Rules of Engagement and Judgemental Training Team who explained how ROE and decision making skills are trained prior to deployment, and demonstrated the Dismounted Close Combat Trainer (DCCT), and the DCCT debriefing process. The limitations of DCCT were also discussed, namely the inability of DCCT to provide real time visual feedback to students. The concept of developing a decision making SE support tool around an Army urban operations context was also examined, and OPTAG confirmed that they were happy to be contacted at any time in relation to the development of the SE.

It was apparent from this meeting that the ultimate use for a decision making SE could be as a decision making skills work up to DCCT, which could be used as part of formal (i.e. classroom based training) or as an in-barracks (UK and in-theatre) revision tool. The revision tool application being of particular merit due to the time pressures of pre-deployment training referred to by OPTAG. But care would need to be taken to heed the

concerns of OPTAG, that any feedback provided by the decision making SE be validated by appropriate military personnel, and that the SE reflects the seriousness of Army operations, and does not permit students to fire at will, as they may be tempted to do with an off the shelf first person shooter game.

The Rules of Engagement and Judgemental Training Team of OPTAG undertake training on behalf of the Operational Law branch of Army Legal Services (OPLAW). Accordingly the engagement of OPLAW was sought, again as SMEs and as potential end users, to inform the development of the decision making SE. Discussion covered a range of topics and issues, including the law of armed conflict, the development of ROEs, ROE training, the pressure upon training time pre-deployment, the challenges of transitioning from hard operations to soft operations which may benefit from training intervention, and the efficacy of a SE training tool for OPLAW and OPTAG. OPLAW considered that there may be some benefit in a decision making support tool, especially to support individual learning, providing it complements DCCT. OPLAW agreed to support the development of the SE in terms of reviewing and validating scenarios, critically ensuring the accuracy of the SE in terms of interpreting ROE.

4.2 Scenario development

Following the completion of a review of the decision making and gaming literature, the first stage in developing the decision making SE was to build up a number of decision making events in a specific context (Li and Harris, 2006). The properties of NDM as codified by Orasanu and Connolly (1993) define the complex operating environment faced by decision makers, and as such these properties (ill structured problems; uncertain dynamic environments; shifting, ill-defined, or competing goals; action/feedback loops; time stress; high stakes; multiple players; and organisational goals and norms) started to define the requirements of a decision making scenario.

To further develop the scenario requirements it was proposed to capture incident data and elicit information about decision making by means of Klein, Calderwood and MacGregor's (1989) critical decision method interview protocol, interviewing military personnel returning from theatre and training personnel, to capture input from both expert and novice decision makers. However, due to concerns over post traumatic stress it was determined that scenario development should commence drawing on in-house knowledge and experience, namely the in-house SME noted in Section 4.1, then to validate the scenarios with military SMEs to ensure scenario accuracy, relevance and credibility.

Scenario development was an iterative process. An initial scenario was prepared including ambiguous and incomplete information to allow student players to develop alternative interpretations of a situation, in line with Crichton (2009). The scenario was developed based on a routine patrol around the fictitious town of Keelleb in Ghashkin Province in Southern Afghanistan. Feedback was sought from OPLAW, who recommended revisions to the scenario to better represent the challenges and threats of current operations in Afghanistan, and current rules of engagement (ROE).

A modified applied cognitive task analysis approach (Militello & Hutton, 1998) structured the generation of a revised scenario based on critical decision making tasks,

decision making expertise, and underlying cognitive processes. The scenario generation process began with the definition and development of an operational scenario, drawing on in-house subject matter expertise. The scenario centred on a routine patrol undertaken by a multiple of three four-man fire teams in a fictitious southern Afghanistan market town of Markesh, mounted to escort a number of policemen as they interact with the local community during a period of transition to normality, a situation which enemy forces are trying to destabilise. The scenario provided representations of team movements and communications, and included a number of decision points, together with briefings, patrol traces and timelines.

The initial development of the scenario was followed by a knowledge audit interview, which was carried out with the in-house SME to highlight points within the scenario where decision making expertise was required, from which various key decision points were identified. These key decision points were ones deemed likely to be most challenging to novices, all of which involved aspects of uncertainty, time pressure and high stakes.

The knowledge audit interview was finally followed by simulation interviews with the in-house SME and an SME from OPLAW. The simulation interviews were carried out to probe the cognitive processes and behaviours of decision makers during the critical decision points. For each of the critical decision points the SMEs were asked the following questions, derived from Militello & Hutton (1998):

'As a fire team member in this scenario what actions, if any, would you take at this point in time?'

'What do you think is going on here? What is your assessment of the current situation?'

'What information made you select these actions?'

'What errors would an inexperienced person be likely to make in this situation?'

4.3 High level software design solutions

Once the scenario had been developed and the training overlay (see Section 4.4) had been scoped a meeting was held with the training media development team from SEA. This in-house media development team would be responsible for interpreting the storyboards and design document and building the SE concept demonstrator using commercial off the shelf games software. The meeting was held to establish options for embedding the instructional overlay into an SE based on build capability and budget.

Three high level concepts were proposed, the most appropriate of which was a first person 3D interactive multimedia application. The 3D multimedia application would entail constructing the SE concept demonstrator using 3D modelling, animation, video and audio production and multimedia authoring packages. This proposal would allow trainees to effectively view animations from a first person perspective with full audio background and effects. Each animation would form a segment of the overall unravelling of the scenario and would lead up to a decision point. At each decision point a series of options would be overlaid on the screen from which a trainee could select a choice of

action. The chosen action would determine the feedback given to a trainee (text, verbal or visual) or trigger the trainee to replay a scenario.

The concept was expected to be a cost efficient, flexible, yet engaging solution, which would also be easy to update. The 3D multimedia option would be highly portable, potentially enabling trainees to do their training anytime and anywhere provided they have a laptop or PC, and due to interface simplicity trainees would be able to concentrate on learning rather than controlling avatars/game play.

4.4 Instructional design

The instructional overlay was developed around the characteristics of target trainees; the training content; and instructional design methods and strategies drawing on decision making and learning theory. Consideration was given to trainees' operational roles, games playing experience, the training environment for CODE, and preferences for different learning modalities. The training content itself was determined by the nature of the decision events and surrounding circumstances contained within the operational scenario. Lastly, a means of delivering training content and feedback which could be woven into an unfolding scenario was developed.

4.4.1 User and user environment

Target trainees were Private (infantry) soldiers with little, if any, operational experience, working up to being deployed in theatre, where their roles would include undertaking urban foot patrols as members of a fire team.

It was anticipated that the majority of target trainees would be players of a range of commercial off the shelf computer/video games played on games consoles or PC platforms. However, it was also considered that some players would have had no experience of computer games, and would be unfamiliar with the nature of computer/video games and user interfaces and input devices. Accordingly, in specifying the requirements for the SE care was taken to ensure that the SE would be intuitive for all users, irrespective of IT and games playing experience. This was achieved through storyboarding and scripting the SE, and in specifying simple graphical user interfaces (e.g. selection buttons and hot spots).

The training environment was also taken into consideration. Since ultimately the SE was intended to have utility as an in-barracks revision tool, both in the UK and in-theatre, the SE concept demonstrator was specified to be run on desktop or laptop PCs, with a simple mouse input device.

Learner preferences for different learning modalities (visual, auditory, and kinaesthetic) were also taken into consideration. Information provided to learners through the SE was scripted/storyboarded to be delivered by means of on-screen text and/or a voice-over. For ease of comprehension verbal and text based information were also scripted to be short, simple and clear.

4.4.2 Training content and instructional overlay

The types of decision events and surrounding circumstances developed in the operational scenario determined the nature of the decision making skill training content and the instructional approach selected for the decision making SE. The two decision making skills areas which were most appropriate for working into the scenario to support the decision events, i.e. the types of decisions being taken, were debiasing training, to help trainees to handle negative information, and training to identify cues from a dynamic and complex environment and to become aware of their salience. The decision making scenario comprised three decision events each of which became the focus of a different scenario level (Levels 1, 2 and 3) and around which three different training events were structured.

A number of decision points within the SE require trainees to have made an assessment of cues from a dynamic environment in order to make a decision from a number of decision action options. Accordingly, training in situation assessment, in terms of selecting appropriate cues and understanding their salience, was considered to be an appropriate training objective for novice decision makers who would be operating in a complex, dynamic and cue rich environment. Two training events were built into the SE to deliver training on situation assessment. The first training event, built into Level 1 of the SE (see Section 4.5.1), requires trainees to make a decision from a number of decision options, but before making a decision trainees are prompted to select cues which they consider to be salient from a number of hot spots, which have been superimposed on cues making up a complex picture. A number of cues are more salient than others, and they also include red herrings. Once trainees have made their cue selection they receive text based feedback on the salience of each cue they have selected, but also on the cues they have overlooked. Trainees then have time to consider the feedback before selecting a course of action. Again feedback is provided, this time tailored to the decision action option selected, and trainees who have made sub-optimal decisions are directed to review the cues and to repeat their action option selection.

The second situation assessment training event has been built into Level 3 of the SE (see Section 4.5.3). In this level trainees again have to make a decision from a number of decision options, but before they do so a number of hot spots appear on various cues. However, this time the cues have been already labelled as to their salience, but still need to be assessed in order to make a decision from a number of decision options. Having considered the salience of the cues the trainees have to select a course of action from a number of decision action options. However, on this occasion they get to see the outcome of decisions taken, both optimal and sub-optimal decisions. Trainees then receive feedback on the decision action selected, and if they have made a sub-optimal selection they then get the opportunity to see what the outcome would have been like had they have made an optimal selection.

The second decision making training focus was on helping trainees to handle negative information; information which is correct, but which is often overlooked if it does not fit with an initial hypothesis. A decision making training event to help trainees become more aware of negative information was built into Level 2 of the SE (see Section 4.5.2). During Level 2 of the SE there is a fair amount of comms between members of the trainee's fire team, gradually building up a hypothesis of events; however, into this

comms some negative information is introduced. At the end of a period of time trainees once again have to make a decision from a number of decision action options, and they make the decision based on their assessment of the comms they have heard. Trainees then receive feedback on their decision action option, and also receive some generic feedback on negative information having experienced the effects of biases on their decision making.

As can be seen, a number of feedback mechanisms have been made use of, providing feedback on cue selection, decision action option choices, and the effect of biases on decision making. This feedback takes the form of on-screen text, verbal feedback, or seeing the outcome of decision actions taken. The feedback provided was derived from the simulation interviews carried out as part of the development of the scenario. In scripting the feedback for CODE care was taken to ensure that '*results should be unambiguous, precise and easily interpreted by the trainee in terms of the discrepancy between actual and desired performance*' (Patrick, 1992, p. 330). Literacy levels and ease of comprehension of feedback by the training audience were at the fore when scripting feedback, to ensure that feedback was short, simple and clear.

To encourage trainee motivation, trainees were designed to be active participants in the SE in terms of selecting cues and decision action options. Motivation was also taken into account in the development of the scenario and in developing the look and feel of the SE to ensure it had appropriate face validity for the training audience.

Instantiating the decision making and learning theory into the scenario took place during the scripting and storyboarding process.

4.5 Scripting and storyboarding

The operational scenario together with the output of the simulation interviews, the decision making training overlay, and feedback mechanisms were integrated by means of producing a series of scripted storyboards.

According to the scenario and training requirements, the storyboards were developed around a linear game structure, providing a single path for players to follow with explicit goals to achieve in a set sequence to progress through the SE. The storyboards were also developed around student 'players' taking a first person perspective within the SE, in this case taking the role of Pte. Pete Wells, a young grenadier, and member of one of the four-man fire teams mounted to undertake a foot patrol. The first person perspective was selected to facilitate student players' attention to cues in a dynamic and complex synthetic environment.

Reference was made to the games literature for guidance on storyboarding the SE (e.g. Pardew, 2005; Hart, 2008). However, to adequately communicate the decision making training overlay an enhanced storyboard approach was devised in conjunction with the training media development team. This enhanced approach included storyboard layout plans to communicate the structure of the SE, screen shots, and plans showing the relative position of different characters within the SE as the scenario plays out. In addition, it included scripted information on the story and training overlay, and on what a student player could see (from a first person perspective), hear (including comms between

members of the fire team and any verbal briefings and feedback) and touch (including on screen selection buttons, and hotspots) when interacting with the SE, plus any critical information (features which had to be incorporated in the build of the SE).

Storyboard activity started with a scoping exercise during which the operational scenario was broken down into preliminary briefing information, and three linked decision making scenarios (Levels 1, 2 and 3) each of which was matched with an appropriate instructional overlay (see Section 4.4). The output of this scoping exercise was a concise high level set of quickly sketched and scripted storyboards, indicating how the scenario, decision points, training overlay and feedback could be integrated. Great care was taken during this scoping exercise to maintain close links with the training media development team, updating them regularly, to ensure the storyboard proposals could be accommodated.

This initial scoping exercise was followed by detailed elaboration of the storyboards, a fairly lengthy process which involved increasing the number of storyboards and adding information to provide adequate detail of the unfolding story and training overlay. Screen shots were prepared for each storyboard to communicate the story and the perspective taken by the student player. Any text to appear on screen, such as text-based briefings, questions, decision action options, and feedback was scripted; as was comms between characters (primarily members of one of the fire teams), verbal briefings and feedback. In scripting and storyboarding any questions, decision actions and feedback, reference was made to the output of the knowledge audit and simulation interviews. Graphical user interfaces were defined, and a sequence of plans were produced to show the relative positions of characters as the scenario plays out. Layout plans were then prepared to define the sequence of the storyboards for the different levels of the SE.

As was noted, the operational scenario was broken down into preliminary briefing information, and three linked decision making scenarios each of which was supported by an appropriate training overlay. The preliminary briefing information included a number of storyboards providing access to a pre-deployment briefing, a rules of engagement briefing and a patrol preliminaries and patrol orders brief to replicate within the SE reports/briefs that would be provided in the operating environment. The briefing was provided in the SE using a combination of on screen bullet points and a verbal briefing, supported by relevant plans and images.

The urban foot patrol scenario itself, from the point at which the protagonist (Pte. Wells) leaves the forward operating base with his fire team colleagues and heads to Markesh market, was divided into three linked game levels (Level 1: Patrol, Level 2: Pursuit and Level 3: Escape), each with a different decision making training and feedback overlay, as previously noted. A resume of the different levels, including the training objective for each level and the level story interwoven with the training overlay, is included in Sections 4.5.1, 4.5.2 and 4.5.3.

4.5.1 Level 1 (Patrol)

4.5.1.1 Training objective

The objective of the first level was to build a complex dynamic event and then, by means of hot spots overlaid over a frozen image of the complex event (in this case activities in the busy market square), prompt the player to select pertinent cues for assessment. The player receives text-based feedback on his selection, setting him up to make a decision from among three decision action options. He then receives verbal feedback on his action option selection.

4.5.1.2 Story

Members of three fire teams (C/S A, C/S C and C/S D) together with two local police prepare to leave their forward operating base for Markesh Market where they will be providing cover for the two local policemen as they meet with local people. C/S C will be providing an escort for the two local police, with fire teams C/S A and C/S D providing a ring of protection (with C/S A to the north of the square, and C/S D (including the game protagonist) to the south).

The three fire teams assemble at a loading bay at the forward operating base and load weapons and board troop carrying vehicles. They then proceed in convoy to Markesh Market (headed by C/S A, followed by C/S C and C/S D). Our protagonist is with C/S D who head to a drop off point at the south west of the market square. C/S D then proceed in formation through a number of backstreets towards a position of overwatch near the market. Our protagonist goes firm and has a good view of the market and diligently scans the market place activity of local people and traders. As he scans the market square C/S C enter the market square from the north west together with the two policemen. After some time, during which the policemen have been talking to/interacting with locals (with their escort providing cover), our protagonist sees a group of approximately three to four men enter the market square from the east. They are dressed in traditional dress and are carrying AK47 rifles (so could be local tribesmen, militia or Taliban preparing to attack a military or police target). The group of men start to act suspiciously towards C/S C (who are at the north eastern side of the market). The suspicious men then raise their weapons towards the police and C/S C.

At this point the screen freezes and the player is asked *'what cues have you been assessing to help you decide what to do next? Select your cues by clicking on hot spots'*. At this point a number of hot spots appear over different cues, and the player then selects the ones he considers to be most important. The player then receives feedback on his cue selection choice. Having assessed the situation, the player presses a selection button *'next'* taking him to a new screen where he is instructed to decide on a course of action by clicking on one of three selection buttons (*'continue to observe the suspects'*; *'engage the suspects'*; or *'report the situation to your F/T commander'*). The player makes a selection and receives verbal feedback on his selection. If a player has made a poor decision action selection he is instructed to have another look at the cues – he can access the cues using an on-screen selection button *'cues'* which takes the player back to the feedback screen. The player will then have the chance to take the decision again. When

he makes the correct decision he receives verbal feedback (including a sentence or two of generic feedback on cue salience) and congratulations on having successfully completed the first level.

4.5.2 Level 2 (Pursuit)

4.5.2.1 Training objective

The aim of level 2 was to introduce the effect of biases on decision making, in this case confirmatory biases. Adrenaline is high, C/S D (the game protagonist's fire team) are running, and there is a fair amount of comms between the fire team building a picture of events. However, in with the comms is some 'negative' (i.e. correct, but contradictory) information. After listening to the comms the student player protagonist then has to make a decision from three decision options testing the influence of biases on his decision making. He then receives feedback on his chosen action option, is required to replay the scenario if his choice was sub-optimal, and finally receives brief generic feedback on biases and negative information.

4.5.2.2 Story

The screen unfreezes from the end of the first level, and our protagonist reports the presence of the suspicious gunmen to his fire team commander. The Taliban then open fire. One policeman is hit and two bystanders go down. The gunmen run off in a south easterly direction (towards a main road). Our protagonist reports the situation to his fire team commander. The fire team re-group and the fire team commander instructs them to pursue the gunmen. C/S D move off in a direction to attempt to intercept the gunmen. They are moving quickly/running through narrow backstreets off the market square. Tension is building and adrenaline is high. There is a continuous stream of comms between the fire team. Members of the fire team can see (in the distance) the rear of a couple of armed men in traditional clothing moving fast ahead of them (adding weight to the comms suggesting that these men may be the gunmen they are after). However, other comms containing negative information (i.e. correct information, but contrary to the building hypothesis) suggests that it would be too soon to see the gunmen, that the gunmen would be further east of C/S D's position, and that the men ahead could be militia.

These two traditionally dressed men turn left down a narrow side street, and the fire team follow. The fire team round the corner after the two men. Our protagonist is at the head of the fire team as they round the corner. Pte. Wells sees (with his weapon raised) a man in traditional dress (identical to one or two of the armed men from the market), and he has an AK47 slung over his shoulder. The traditionally dressed man has his back to Pte Wells and is talking to other men, with locals around.

The screen freezes and the player hears a question '*ok, so what do you do next?*' The player is simultaneously presented with three decision options on screen ('*ignore the man and continue with the pursuit*', '*engage the suspect*' or '*issue a warning*'). The player makes his decision action selection, and then receives feedback according to the decision action he has selected. If the player has made a sub-optimal call he is directed to replay

the scenario - a selection button takes the player back to the beginning of level 2. Once the optimal decision action is selected (*'issue a warning'*), the screen unfreezes and the protagonist issues a warning. The 'suspicious' man and locals raise their hands in surrender. The 'suspicious' man lowers his weapon to the ground. A gesture of conciliation is offered by the fire team commander to the group of startled men. The fire team commander 'praises' Pte Wells for a good decision call. The fire team re-group. The fire team commander checks his map of Markesh and instructs the fire team to head off further east in pursuit of the gunmen. The screen fades, text (with a voice over) appears on the screen congratulating the player and giving some generic feedback on biases and negative information.

4.5.3 Level 3 (Escape)

4.5.3.1 Training objective

The aim of the final level from a training perspective was to develop situation assessment skills, again making use of hot spots. This level also provides student 'players' with the opportunity to witness the outcome of decision actions selected (both optimal and sub-optimal decisions).

4.5.3.2 Story

The story continues from the end of level 2. Fire team C/S D have set off in a south easterly direction towards a main road leading in/out of Markesh down narrow backstreets off the market square. At a break between two buildings the 'game' protagonist turns between the buildings at the end of which he can see four men in traditional dress (identical to the gunmen from the market square shooting). The suspicious men are agitated, arguing and shouting. Our protagonist and other members of C/S D get closer to the armed men. With his weapon raised our protagonist can see three of the gunmen getting into a taxi and a fourth is arguing with the taxi driver. At this point in time the gunmen have not seen C/S D. The screen then freezes, and a sequence of hot spots with labels (similar to Level 1) appear on the screen with time for the player to read the labels and assess the situation. The player is then instructed to make a decision to either *'issue a warning'* or *'engage the suspect'*. The player makes his selection, and then according to the decision action selected the player sees the outcome of his decision played out. If he chooses to *'engage'* (the sub-optimal choice) he then receives feedback and is advised that the correct course of action would have been to have issued a warning. Together with players who have correctly chosen to issue a warning, he sees the warning being played out. The taxi then takes off at speed, leaving one gunman behind. The gunman raises his weapon at our protagonist. The screen freezes and the player is instructed to make a decision to either *'issue a warning'* or *'engage the suspect'*. Again he makes his selection, and according to the decision action selected the player sees the outcome of his decision played out. If he chooses to issue a warning (the sub-optimal choice) he then receives feedback on his selection and is advised that the correct course of action would have been to engage the enemy. Together with players who have correctly chosen to engage the enemy, he sees the engage the enemy sequence being played out. Pte Wells is then praised by his fire team commander. The fire team then regroup and make their way back to their drop off point (ready to return to the forward

operating base). The player is then congratulated for successfully completing all three levels of the 'game'.

4.6 Design documentation

In addition to communicating the requirements of the SE to the in-house software developers by means of storyboards, a design document was prepared to codify the requirements and game design specification, to enable the software developers to create the SE. Broad headings were defined by the media development team, and then templates for the design document were identified from the games and serious games design literature (Bergeron, 2006; Thompson et al, 2007; Fullerton, Swain and Hoffman, 2004) and adapted for the decision making SE.

The requirements specification included an outline of the purpose and scope of the SE; user profile and user environment; the theoretical decision making underpinnings of the SE; knowledge, skills and attributes (KSAs), technical and conceptual requirements; and game features (including game platform, genre and structure).

The game design specification included an outline of the game concept and setting. It also included a story briefing (taken from the scenario documentation), and details of the game levels including their specific training objectives, story, environment, maps showing the relative positions of characters, and character information. Details were provided on the game protagonist, and other characters including their equipment/clothing, crossed referenced to the storyboards in which each character appeared. Specific sounds required in the SE such as noise from the market, the sound of vehicle engines, and gun shots were specified, and again crossed referenced to the storyboards, and assets to be modelled (including environmental assets, vehicles and weapons) were identified. The game design specification also included the requirements for input controls, and graphical user interfaces.

To supplement the requirements and game design specifications, the design document included an image bank. The image bank provided photographs of local people including men in traditional dress; armed militia; and Afghan National Police. It also comprised photographs of the built environment, and a number of web-links were provided to access military images. The image bank was not intended to be exhaustive, but to help convey the required look and feel of the SE.

A copy of the design document was made available to the software developers before it was finalised, and talked through with them to ensure it was adequate for their needs.

5 Outcome

The objective of Work Package 4.6 was to establish the requirements for a desktop synthetic environment decision making training support tool and to develop an SE concept demonstrator.

This objective has been achieved through the development of a comprehensive review of the decision making and training literature; through the iterative development of an operational scenario using a modified applied cognitive task analysis approach, and its validation with military subject matter experts; and through identifying appropriate decision making training content and using appropriate learning theory to structure the delivery of training which could be woven into the operational scenario. The scenario, the output of the simulation interviews and the training overlay were then integrated by means of a series of scripted storyboards, the format of which was designed to communicate the requirements of a decision making SE being underpinned by decision making theory, and the production of a comprehensive requirements document.

The requirements document and storyboards set the requirements for the build of the first SE concept demonstrator. The first CODE 3D concept demonstrator has been built, and forms a separate deliverable under Work Package 4.6. The concept demonstrator will now undergo user centred evaluation as to its utility.

The design document has recently been talked through with the Rules of Engagement and Judgemental Training Team from OPTAG. They have confirmed that in targeting young Private soldiers with little or no operational experience CODE is targeting an appropriate training audience. OPTAG were also pleased that the training delivered by CODE focused on situation assessment and handling negative information, as these two decision making skills components are seen as crucial to rules of engagement and judgemental pre-deployment training. The idea that CODE could be used both as a cognitive skills work up for existing training such as the Dismounted Close Combat Trainer (DCCT), and as an in-barracks (UK and in-theatre) revision tool was seen as wholly appropriate. OPTAG have also generated recommendations for further scenario development along Counter Improvised Explosive Device (CIED) lines. Following a presentation of the study at the HFI DTC Symposium in March 2009, the Dismounted Counter Mine Capability (DCMC) IPT, and the Training Development Team, Land Warfare Centre, have expressed interest in exploiting the SE decision making training approach, and follow up meetings have been held with both parties.

6 Conclusions and Recommendations

6.1 Conclusions

- The objective of Work Package 4.6 - to establish the requirements for a desktop synthetic environment decision making training support tool and to develop an SE concept demonstrator, around the context of a contemporary theatre Army urban foot patrol, to support the training of novice decision makers being deployed to dynamic, complex and high stakes environments - has been achieved.
- The development of the SE has been driven by psychological decision making theory and training theory, and is unique in this approach, demonstrating that it is feasible to develop the requirements for a decision making SE based on psychological decision making theory.
- Human factors principles have been applied in the development of the requirements including building scenarios (including their validation), establishing the training overlay, software concept development, scripting and storyboarding the SE, and in preparing the requirements documentation.
 - An operational scenario has been developed based on a current theatre of operation. It was developed using a modified applied cognitive task analysis approach, and has been validated ensuring its military relevant and decision making accuracy, in particular in respect of the interpretation of rules of engagement.
 - A decision making training overlay has been developed taking into consideration the characteristics of target trainees and their training environment, the decision events of the scenario and surrounding circumstances, which determined the training content of the SE to be based around identifying cues from the operational environment and assessing their significance, and handling negative information.
 - The training overlay was embedded with the scenario and the output of scenario simulation interviews by means of scripting and storyboarding the SE. An enhanced storyboard approach was developed to communicate the requirements of a decision making SE.
 - The requirements have been codified in a requirements document, and this document, together with the storyboards, formed the requirements for the build of a 3D concept demonstrator.
 - Viable SE build concepts were developed taking into account the target trainees, the scenario, the decision events, the training content and the training overlay. A 3D SE concept demonstrator has been developed.

- The SE should help improve the decision making agility of novice decision makers in terms of their ability to identify and assess cues, handle negative information, and make decisions from a number of decision action options.
- Indirectly, since the scenarios and the feedback given to trainees are underpinned by Rules of Engagement, the SE should help in training and practicing interpreting Rules of Engagement.
- Since the training overlay is embedded in the SE, ultimately CODE can act as a stand alone in-barracks (UK and in-theatre) training and revision support tool, potentially alongside DCCT.
- The concept demonstrator would be of relevance to the Operational Training and Advisory Group (OPTAG) and the Operational Law branch of Army Legal Services (OPLAW) in delivering pre-deployment training, both of whom have input to the study.
- CODE SE and the requirements analysis approach would have applications across all three military services for activities where decisions need to be applied in dynamic, high tempo, high stakes environments, with interest already having been shown by the Dismounted Counter Mine Capability (DCMC) IPT, and the Training Development Team, Land Warfare Centre.

6.2 Recommendations

- The concept demonstrator would benefit from being more fully evaluated in terms of its utility as a training tool.
- The number of decision events should be increased to provide further training and practice opportunities.
- An evaluation should be made in terms of CODE's ability to support the acquisition of skill and knowledge.

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