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EFFECTS OF 3D STEREOSCOPY, VISUO-SPATIAL WORKING MEMORY, AND
PERCEPTIONS OF SIMULATION EXPERIENCE ON THE MEMORIZATION OF
CONFUSABLE OBJECTS

by

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A dissertation submitted in partial fulfillment of the requirements
for the degree of Doctor of Philosophy
in the Department of Psychology
in the College of Sciences
at the University of Central Florida
Orlando, Florida

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2011

Major Advisor: Florian G. Jentsch

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ABSTRACT

This dissertation investigated the impact of active stereoscopic 3-dimensional (3D) imagery equipment and individual differences in visuo-spatial working memory (VSWM) capacity on retention of a set of similar, novel objects (i.e., armored military vehicles). Seventy-one participants were assessed on their visuo-spatial working memory using the Visual Patterns Test (Della Sala, Gray, Baddeley, & Wilson, 1997). They were then assigned to one of four different conditions (3D high VSWM, 3D low VSWM, 2D high VSWM, 2D low VSWM) based upon their visuo-spatial working memory. Participants were then trained to identify military vehicles using a simulation that presented the training stimuli in one of two dimensionalities, i.e. two dimensional (2D) or active stereoscopic three-dimensional (3D).

Testing consisted of a vehicle memory training assessment, which challenged participants to choose the correct components of each vehicle immediately after studying; a measure of retention for military vehicles which asked participants to categorize the alliance and identify previously studied vehicles; and a transfer measure using video footage of actual military vehicles. The latter measures depicted military vehicles in an array of combat situations, and participants were asked to decide on whether or not to shoot each vehicle, as well as identify the vehicles. Testing occurred immediately after training. The moderating, as well as main effects, of VSWM were assessed. The mediating/moderating effects of several experiential factors were measured as well, including: immersion, presence, engagement, flow state, and technology acceptance.

Findings indicate that perceptions of the simulation experience and VSWM are strong positive predictors of performance, while 3D was not predictive, and in some instances, significantly worse than the 2D condition. These findings indicate that individual differences in visual memory and user experiences during the SBT both are predictive factors in memory tasks

for confusable objects. The SBT designed in this study also led to robust prediction of training outcomes on the final transfer task.

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CHAPTER 1: INTRODUCTION

Statement of the Problem

Identifying objects is a critical component of human perception; that is, people must identify and perceive a multitude of objects (e.g., faces, cars, tools) every day. Since identifying and perceiving objects is so fundamental to daily functioning, humans have become experts at recognizing specific visual patterns (e.g., faces; Bukach, Gauthier, & Tarr, 2006). In addition to our daily lives, some professional fields require the memorization of a vast number of different objects, since it is vital for decision making (Wickens, 1992). Further, other domains necessitate the memorization of a large number of objects as well as the specific properties of each object (e.g. anatomical science). Because accurate memorization and identification of objects is paramount to the decision making process for some professional domains (e.g., military vehicle identification, anatomical learning), it is essential that training accelerate the development of acquiring object identification skills, and that it does so effectively.

Dimensionality of training (i.e., 3D and 2D) may be one potential mechanism for improving object identification. Although investigations concerned with the study of dimensionality are prevalent in both the scientific and lay community, there is still some confusion. To clarify the use of 3D within the context of this dissertation, a table has been created (Table 1). This was intended to aid the reader in differentiating between the multiple types of 2D/3D stimuli in context of this study. Research regarding the effectiveness of the dimensionality of training is inconsistent.

There is evidence across multiple domains that 3D training, specifically through the use of stereoscopic stimuli, can substantially strengthen performance outcomes (Chen, Oden, Kenny, & Meritt, 2010; Keebler, Harper-Sciarini, Curtis, Schuster, Carroll, & Jentsch, 2007; Kim, 2006). Some have found that spatial ability can be improved through the use of 3D training (Duesbury &

O’Neil, 1996). As an example, Hu (2005) found that surgeons using 3D visualization during lung surgery planning experienced a significant decrease in both workload and planning times.

Furthermore, researchers found utility in incorporating 3D stereoscopic training aids into simulation-based training (SBT) to increase initial acquisition and retention for objects (Garg et al., 2002; Keebler, Curtis, Sciarini, & Jentsch, 2010; Kim, 2006; Nicholson et al., 2006).

For example, Garg and colleagues (2002) found that utilizing multiple orientations through a realistic 3D training did not benefit learning in an anatomical task compared to performance of a control group that was instead provided key-viewpoint imagery.

Table 1

Differences between levels of 2D and 3D

Dimensionality of Stimulus	Explanation	Example
2D	A flat, non perspective image of an object	Shapes on a playing card
2D perspective	A flat image that includes perspective to give depth information, but does not contain multiple views	An architectural sketch
Pseudo-3D/2.5D	A flat image that gives perspective and contains multiple view information, but provides the same image to both eyes	Vehicles in the game “Command and Conquer”
Stereoscopic 3D	Flat image that gives perspective, contains multiple views, and provides different images to each eye, inducing the illusion of depth	The Na’Vi people in the movie “Avatar”
Passive Stereoscopic 3D	Stereoscopy induced through using two overlaid images that are seen through polarized glasses, allowing each eye to only see the appropriate side of the image	Red/Blue glasses commonly seen in magazines and children’s books
Active Stereoscopic 3D	Stereoscopy induced by	NVIDIA 3D System

Dimensionality of Stimulus	Explanation	Example
Real 3D	flashing shutter glasses synchronized with flashing onscreen images allowing each eye to only to see the appropriate side of the image Actual real world objects, containing true multiple views and true depth information.	A basketball

However, Garg et al.'s study had two limitations that may have impacted the implications of their results. First, the study stimulus was a two plane structure (i.e., the wrist); therefore, the extra depth information provided by multiple view condition was not necessary. Second, individual differences in spatial ability were a significant covariate, but the authors did not investigate the interaction between spatial ability and training condition, which could have had implications for designing effective training.

Integrating 3D imagery into SBT could provide multiple advantages. For example, 3D Simulation Based Training (SBT) technology enriches training by providing additional visual information above 2D imagery as well as eliciting more positive reactions from the learner (Hu, 2005; Keebler, 2010; Kim, 2006). Three dimensional training may also create interest, immersion, motivation and engagement above that of a comparable 2D training, and therefore, be a better training medium (Malone, 1981).

Therefore, to better understand the differences between 2D and 3D training, this dissertation investigated the effectiveness of 3D stereoscopic imagery training on long term retention for a set of objects (i.e., armored military vehicles) by manipulating the stereoscopic properties of a visual training system that can create 2D or 3D imagery. Through producing both 2D and 3D imagery, it was possible to provide quantifying evidence of the differences between training on 3D stereoscopic imagery.

Expected Relationships among Study Constructs

As previously mentioned, the primary focus of this dissertation was to investigate the impact of differences between 3D and 2D training for object learning and retention. Therefore, the dimensionality of training (i.e., stereoscopic 3D imagery vs. 2D imagery) was manipulated. To assess the relationship between dimensionality of training and retention, this research utilized the domain of military vehicles for identification. Participants were trained on a set of military vehicle images in a simulation that was rendered using either 2D imagery or 3D stereoscopic imagery, as displayed in Table 1.

Although dimensionality may be a major component of object identification training, as described above, other factors can play an important role in increasing the effectiveness of training outcomes (Salas & Cannon-Bowers, 2001). Specifically, the effectiveness of training is related to variables that engage the trainee to learn and participate in developmental activities. Also, individual differences in acceptance of the technology through which the training is presented can affect learning. Thus, major contributing factors also investigated include: measuring enjoyment and fascination during the training state, acceptance of the training technology in the SBT, and motivation during training to learn the necessary material.

Because a major focus of this dissertation was the effect of dimensionality on learning, this dissertation also assessed visuo-spatial working memory (VSWM), the conduit through which long term visual memory is thought to form (Logie, 1995; Salvendy, 2006; Sanders & McCormick, 1993). It was expected that the effect of training dimensionality would be moderated by VSWM as well, such that high-VSWM individuals trained with 3D technology would elicit the highest performance outcomes (Keebler, Sciarini, Fincannon, Jentsch, & Nicholson, 2009). VSWM may have a direct positive relationship with longer term memory stores as described in the Model of Information Processing (Wickens, 1992). Individual levels of VSWM could have a

substantial impact on individual performance, acting through a direct relationship to long term memory, and through a moderating relationship with the SBT. Thus, the outcome variables were multiple measures assessing memory and retention of the trained objects.

Although 3D stimuli and VSWM were the main constructs of interest for this research initiative, it was also vital to examine how effective the training was in creating interest, fascination, and desire to interact with the training system. The level of interactivity that is produced by different training dimensionalities could help foster individuals to learn a set of objects more readily. It could be argued that the training was less effective, regardless of its perceived dimensionality, if it did not induce fascination or affect in the individuals being trained (Malone, 1981). Thus, optimal experience was measured by the flow state scale (FSS-2 short form; Jackson, Martin, & Eklund, 2008). Flow's mediating effects on the relationship between training modality and retention were also assessed. 3D imagery should inherently induce curiosity; hence, it was expected that training should create a more engaging and interesting experience for the trainee (Kim, 2006). According to the proposed model, individuals who trained on 3D stereoscopic images and who have higher levels of VSWM should have retained the most information from the training. If these individuals achieved a state of optimal experience during training, their performance outcomes should be even stronger (Csikszentmihalyi, 1990). Figure 1 demonstrates a graphical representation of the proposed model depicting the relationships between the constructs:

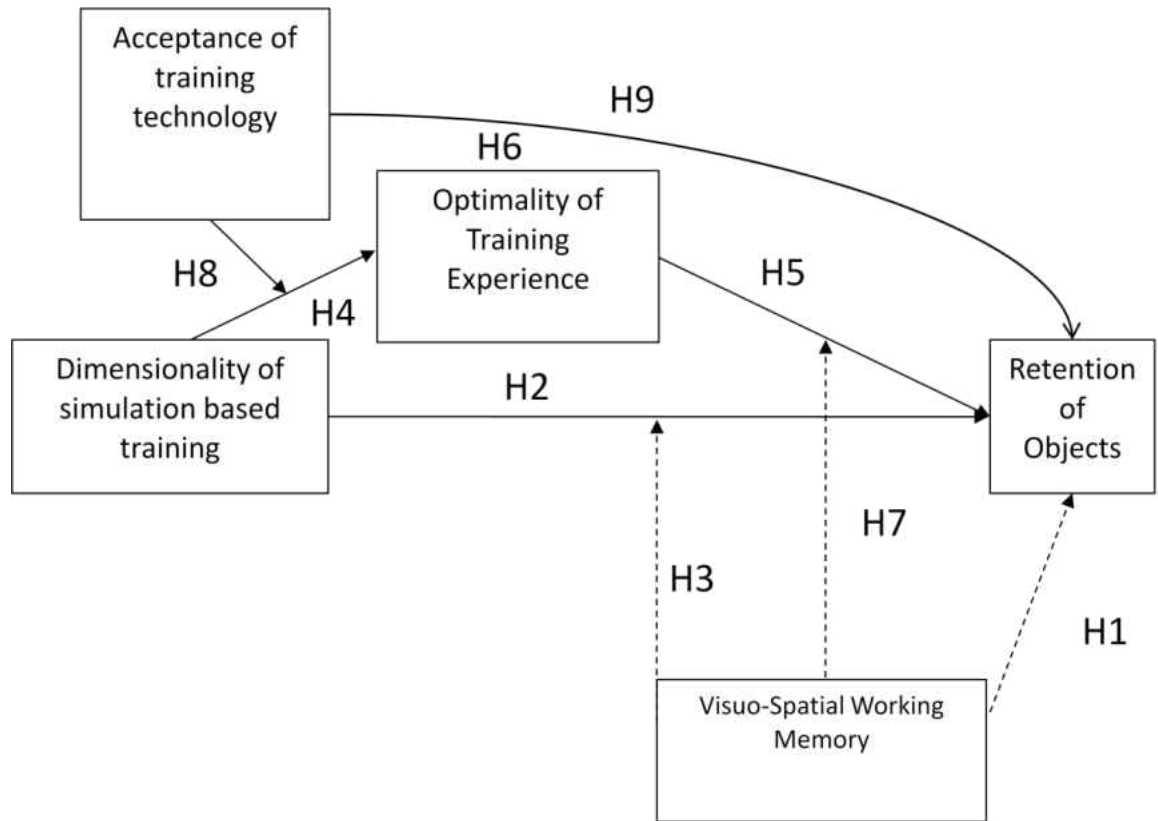


Figure 1. Model for construct relationships

To evaluate the proposed model and relationships, a review of the individual constructs was undertaken. The next section describes the literature in support of this model as well as discusses the rationale for each of the proposed hypotheses. **H1**: VSWM to Retention of objects; **H2**: Dimensionality (2D/3D) to Retention of Objects; **H3**: VSWM moderating Dimensionality to Retention of Objects; **H4**: Dimensionality predicting Optimality of Experience; **H5**: Optimality predicting retention; **H6**: Optimality mediating the relationship between Dimensionality and retention; **H7**: VSWM moderating the relationship between Optimality and Retention; **H8**: Technology Acceptance moderating the relationship between dimensionality and Optimal experience; **H9**: Technology acceptance predicting retention

CHAPTER 2: LITERATURE REVIEW- BUILDING A FRAMEWORK FOR 3D STEREOSCOPIC SBT

The literature on human sensation, perception, and cognition is integral to understanding how individuals store and retrieve memories of objects. Due to sensation, perception and cognition being subsystems of human mental functioning, it is vital to discuss the model of Information Processing (Wickens, 1992). The theory of Information Processing integrates sensation, perception, and cognition into a model that can aid in understanding the way objects are mentally stored, categorized, and later retrieved. Additionally, understanding the literature on human expertise for objects is fundamental to identifying the elements necessary to create training aimed for expert memory systems. The methods of the cognitive neuroscience of memory systems can also aid as guidelines for developing training in the domain of object identification. However, to develop effective memories in those individuals receiving training, it is crucial to conceptualize individual characteristics (cognitive and motivational), and conditions before, during and after training (Salas & Cannon-Bowers, 2001).

Understanding how effective a given training intervention is at motivating individuals is important for learning outcomes. One means to create motivation during training is through creation of an interesting training technology. This makes it vital to review individual differences in relation to training technology, specifically the constructs of simulation enjoyment. Through measuring the construct of flow state (Csikszentmihalyi, 1990; Jackson & Marsh, 1997) and technology acceptance (Szajna, 1996), a clearer understanding can be made of how human beings process and store novel objects in memory as well as whether such a training process is interesting, fascinating, and motivating.

The Role of Information Processing

This section describes the model of information processing (Figure 2) and its role in this dissertation. The model of information processing proposes a multi-mechanistic view of the way that information enters and is processed in the brain through sensory input, perception, memory and attention. Often this model likens the human brain to a computer. Information processing includes multiple cognitive sub constructs: sensory input, perception, attention, working memory, long term memory, and decision making (Wickens, 1992). Working memory (Baddeley & Hitch, 1974) is of key importance in this proposed research. Working memory incorporates three subcomponents: a temporary store and work-space for visual information; a store for phonological information; and an executive component. The subsystems communicate to an executive component to integrate visual and audio information (Baddeley & Hitch). The executive component is associate with higher-order functioning and synthesis of information (Baddeley & Hitch). Some argue that to learn novel information, perceptual data must always be processed through this limited channel of WM (Simon, 1974)

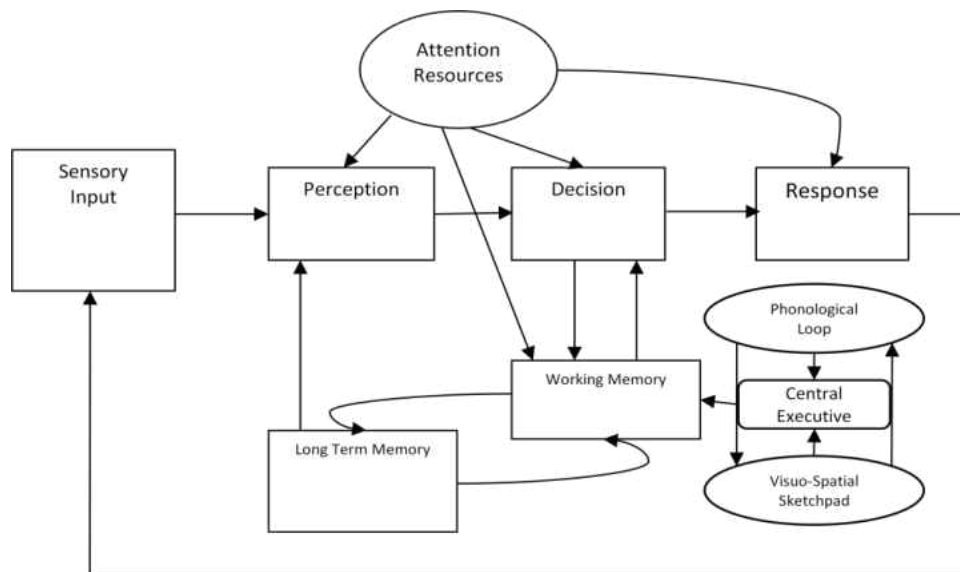


Figure 2. The model of information processing (adapted from Wickens, 1992) including Baddeley's Working Memory Model.

Visuo-Spatial Working Memory (VSWM) in Object Identification

Baddeley's working memory model suggests that WM is divided into three major components: a visuo-spatial component, a phonological component, and a central processing component that interprets and analyzes information from the other two sub-components (Baddeley & Hitch, 1974). Research has shown support for this view of WM (Broadbent, 1982). Importantly, many research findings have demonstrated that the visual and phonological sub-components may interfere with one another through inattention blindness (Briand & Klein, 1987; Treisman & Gelade, 1980). Information entering both the visual and phonological pathways simultaneously can lead to a disruption in both channels. For this dissertation, the construct of VSWM was of major importance due to the inherent visual nature of the task being trained.

It has been found that measuring spatial abilities is most effective in relation to abstract geometrical shapes (Burton, 2003). Also, expertise for a given object class has been shown to increase visual working memory capacity (Curby, Glazek, & Gauthier, 2009). Therefore, VSWM is a useful construct because memorizing a discrete set of pseudo-abstract-objects within the same class (e.g., military vehicles) is a major component of the task in this dissertation, and telling objects apart that share the same class is difficult without detailed-referent memories. Measuring VSWM allows for a deeper understanding of the impact of 3D training. Through the interaction of the three systems defined by Baddeley, information in the world can be interpreted and stored into long term memory. It has been argued that working memory is the major conduit to long term memory (Sanders & McCormick, 1993). Therefore, differences in VSWM should be highly related to memory formation and recall of information from long term memory. This led to H1:

Hypothesis 1- VSWM and quantity of objects retained

It was expected that VSWM would be positively and significantly related to the quantity of objects retained.

Human Expertise for Objects

Two opposing views of human object expertise have been heavily debated: Whether individuals store object memories as separate views of imagery or that individuals store entire objects in their memory. In this section, the extant literature describing these two viewpoints is reviewed.

Human Cognition for Objects

Two theories have dominated the area of visual cognition as it relates to memory for objects: Irving Biederman's structural theory, which uses a set of approximately 36 volumetric primitives called geons to describe all the shapes in the world (Figure 3; Biederman, 1987), and Heinrich Bulthoff's imagery-based theory, which instead describes shapes as a store of images consisting of the most familiar viewpoints of objects (Tarr & Bulthoff, 1995). These theories disagree on whether vision is view-dependent or view-independent. View-dependent mechanisms constitute the majority of Bulthoff's argument and state that visual memory and cognition are based around the use of imagery to store objects. The term viewpoint-dependent refers to the fact that human beings can only identify objects under certain viewing angles and that they store objects as multiple images. Under other viewpoints that are unfamiliar according to this theory, the same objects are rendered effectively unrecognizable. Bulthoff's research demonstrates support for the storage of objects in memory as a set of specific *canonical* images. Canonical, in this case, refers to the viewpoints of the most well known orientations of objects. As an example, the front or side of a car would be its canonical viewpoints, whereas a bird's eye view of a car would be a non-canonical viewpoint. This type of view could possibly render an individual's own vehicle as unfamiliar.

Conversely, in Biederman's argument (Recognition by Components theory), the proposition is that the memory of an object is actually a structured volumetric representation of the object (Biederman, 1987). According to this theory, these stored memory objects are based upon invariant features learned from the actual object in the world (Figure 4). The invariant features consist of those features of an object that create a retinal image that can only represent a specific structure in the real world. Upon interpretation of the image that an object leaves on the retina, the invariant properties demonstrate with a high probability the actual features of the object.

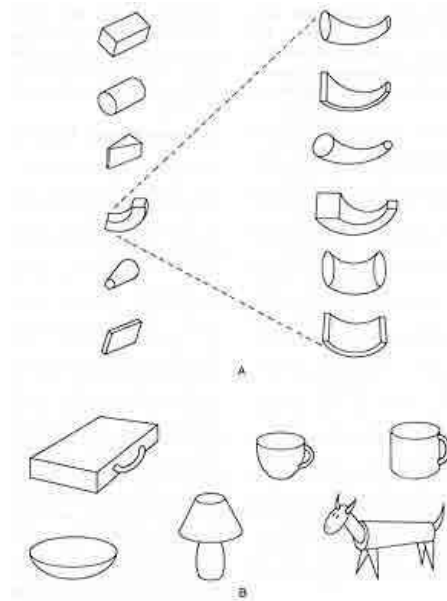
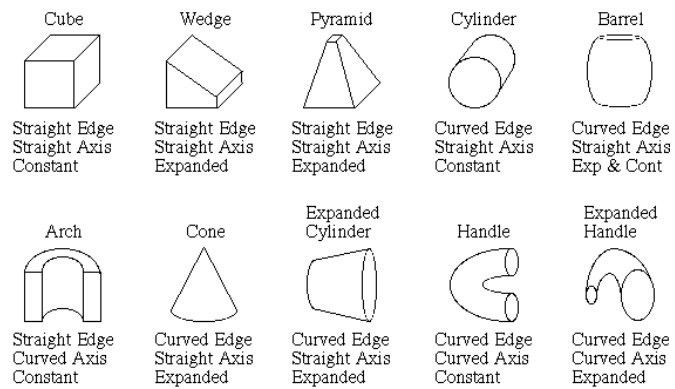


Figure 3. A set of Biederman's geons demonstrating alterations (A) and proposed object representations (B)

Due to the nature of this type of perception, Biederman deemed these properties to be called *non-accidental*, referring to the inability for a perceptual accident (mistaking the feature for some other structure/feature of the object or a different object) to occur when viewing the feature (Figure 4). *Non-Accidental* properties are important properties of an object when used to identify that object. Because these properties are unchanged across multiple viewing angles, they can be reliably used to identify an object. In contrast, *accidental properties*, or variant features, are those properties that change when viewed from different angles. A property such as length, for example, would be considered accidental if it could not be perceived from certain viewing angles. *Accidental properties* are dangerous to use for identification purposes in high-risk tasks because they are unreliable indicators of object identity. The orientation of objects is going to vastly affect performance outcomes if an accidental property is used as a critical identification feature (Demeyer, Zaenen, & Wagemans, 2007). Therefore, it is dangerous to use *accidental* properties as criteria for training the ability to differentiate and identify objects. Instead, *non-accidental* properties must be used as reliable and consistent cues (Biederman, 1987). Detection and relation of these features to stored object representations for identification is demonstrated in Figure 5.

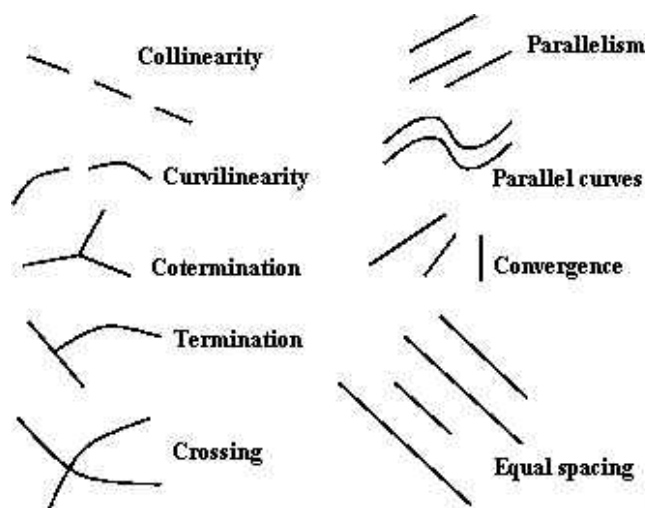


Figure 4. An example of non-accidental properties from Biederman, 1987.

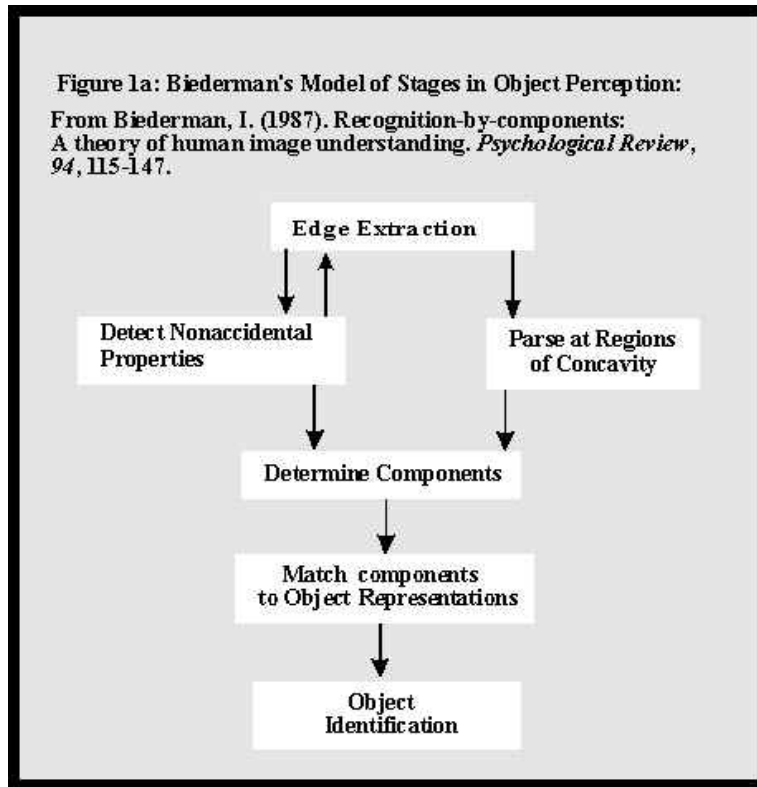


Figure 5. A model demonstrating Biederman's object identification theory.

Until the previous decade, it seemed as if the differences between these theoretical perspectives would remain unresolved. More recent research has demonstrated reconciliation for both theories (Foster & Gilson, 2002; Wallraven & Bulthoff, 2009), concluding that the type of processing used is associated with the demand and the amount of visual experience the individual has with the current task. The more demand that is associated with a given visual task, the more likely it is that mental images are used. As an individual gains expertise concerning a particular object, the mental representation of that object becomes closer to an actual object representation (Foster & Gilson, 2002). Expertise is a predictive factor in whether viewpoint-invariant or viewpoint-dependent cortical mechanisms are used to mentally represent objects. Therefore, training systems aimed at improving object identification processes through creating viewpoint-invariant mental representations must strive for expert-like learning.

Classification of Objects and Expertise

Having examined the way in which objects are processed and how the human memory system integrates new information into long term memories, it is necessary to also look at the research that has been conducted on the long term memorization of objects. Research investigating visual expertise training has found that expertise is directly related to the granularity of an individual's ability to label differences between highly similar objects (Tanaka & Taylor, 1991). In other words, the more expert-like an individual is with a certain set of objects, the better one is at identifying that object from other highly similar objects. Through understanding how humans classify objects and how this is moderated by expertise, insight can be gained into the process of becoming an expert identifier, which is a fundamental goal of training (Ericsson et al. 2006). The relationship between expertise and retention of objects can be better understood through expert classification.

The work of Tanaka and Taylor (1991) described the levels of organization used to classify objects into categories. According to this research (e.g. Rosch, 2002; Tanaka & Taylor), there are three levels of categorization: the basic level, the super-ordinate level, and the sub-ordinate level. Understanding the differences between these levels is fundamental to understanding object confusion and expertise. The *basic level* is the label for an object that defines its class (e.g., table and bird) (Tanaka & Taylor). Using the same examples, the *super-ordinate* level for table and bird would instead be furniture and animal, while the *sub-ordinate* level would be reclassifying the objects at the *basic level* into more specific instances of that object (i.e., coffee table or robin; Tanaka & Taylor). Research has demonstrated that novices are faster to classify objects within the basic and super-ordinate levels, compared to the sub-ordinate levels, and that this effect is moderated by expertise (Tanaka & Taylor), such that experts identify objects just as well at the sub-ordinate level as they do at the basic level. This demonstrates that visual categorization and

identification tasks require expertise training for effective performance outcomes (Gauthier, Williams, Tarr, & Tanaka, 1998; Tanaka & Taylor, 1991). However, some research demonstrates that expertise can be acquired quickly in visuo-spatial tasks (Biederman & Shiffrar, 1987), making the development of training that leads to effective acquisition of expert skill sets a possibility. Therefore, the SBT system developed for this dissertation focused on quick and effective training methods for visual categorization of novel objects.

Long Term Memory and Expertise for Objects

The most fundamental work in the area of memory for novel object identification has been created by Isabel Gauthier. Using a set of fictional objects called Greebles (Figure 6), Gauthier (1999) investigated the relationship between training and memorization for a novel set of objects. Gauthier developed an extensive training protocol for these novel objects, and found that individuals trained with this protocol could become experts in a relatively short amount of time. This research demonstrated that individuals could memorize a large set of objects (i.e., 30 individual objects) in approximately nine hours. Longitudinal measures demonstrated that Gauthier's expertise training led to long term memory benefits, with experts achieving high performance levels up to eight weeks post training. When compared to novices, the experts were significantly better at their ability to learn a new set of greebles as well (Gauthier, Williams, Tarr, & Tanaka, 1998). Therefore, to best train for object identification, effective training must strive to bring novices to expert-like levels.

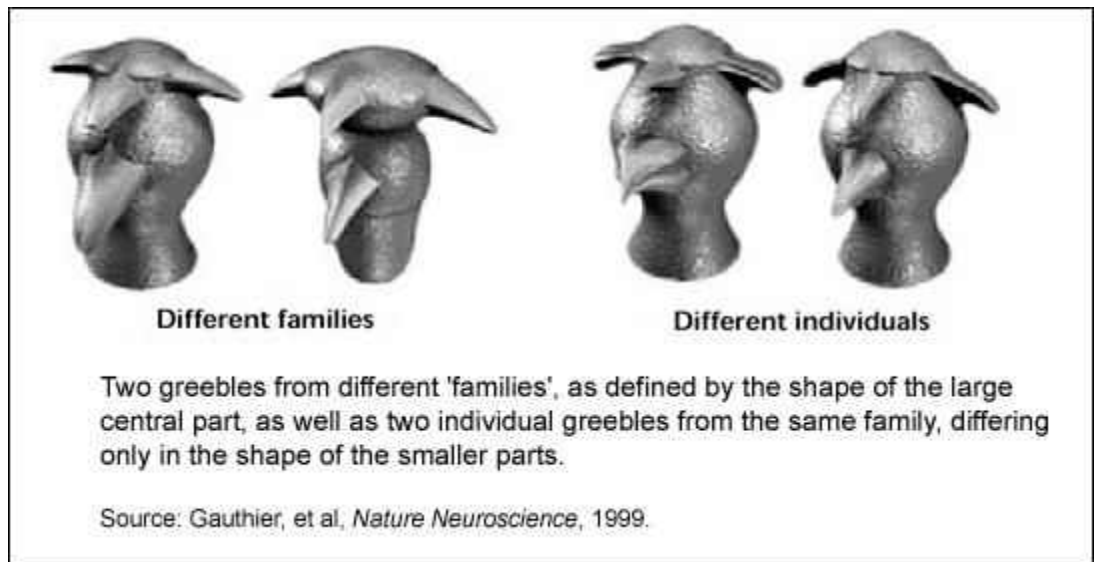


Figure 6. A set of four greebles from Gauthier's work.

Recognition

The way an object is stored in memory may greatly affect the accuracy and type of information about the object that can later be remembered at the time of performance. Throughout our research (Keebler, et al. 2007; Keebler et al., 2009; Keebler et al. 2010), we have distinguished between *recognition* and *identification*. These two indices of learning an object, although similar at a surface level, are different from one another in the amount of detail that must be remembered at the time of performance. *Recognition* is a state of knowing whether an object has been seen before or not (Keebler et al., 2007). *Recognition* is also classification at a basic level (Tanaka & Taylor, 1991).

Identification

Identification is instead a decision about an object's unique identity, and is usually a classification at the sub-ordinate level (Palmeri & Gauthier, 2004, Tanaka & Taylor, 1991). Gauthier goes on to state that "identification requires subjects to discriminate between similar objects and involves generalizations across some shape changes as well as physical translation,

rotation, and so on” (Palmeri & Gauthier, 2004). Therefore, *identification* requires a clear and detailed mental representation of an object. It is assumed that being able to *identify* an object compared to *recognizing* an object which may indicate a much clearer, detailed memory of the object in question (Keebler et al., 2007; Keebler et al., 2009).

Dimensionality of Training for Object Memorization

Three dimensional technologies may be effective training tools. There are a few key properties that set 3D objects apart from 2D objects. The major differences between 3D objects and 2D objects are stereopsis (being viewed from two eyes at different angles), binocular depth cues, and presentation of multiple viewing angles (Levine, 2000). This section reviews the literature that has identified the cognitive and psychological factors involved in 3D. The physiological nature of 3D is examined through the relationship between 3D stereoscopy and the visual system via binocular depth cues and cortical mechanisms. Finally, research demonstrating the beneficial application of 3D training is discussed.

Stereopsis and Binocular Depth Cues

The visual system interprets 3D imagery through monocular and binocular depth cues. Even though most of the 3D world is interpreted based on monocular depth cues, there are certain binocular depth cues that cannot be replaced by monocular cues. This section focuses on binocular depth cues and how 3D information can influence SBT.

Convergence

The first binocular depth cue, *convergence* and *divergence* are the physical movement of the eyes towards or away from each other. An example of convergence is when an object moving towards the observer is visible between both eyes. This leads to a gaze pattern that is not parallel but instead converges on the point of interest (Levine, 2000). As an object moves closer, the eyes rotate in towards each other. Conversely, if the object in question moves farther from the

observer, the eyes may also rotate away from each other. The amount of convergence or divergence that the eyes are experiencing is important. There is strong evidence in support of convergence being used as a depth cue (Henemann, 1935; Komoda & Ona, 1974; Lebowitz, 1971). Other studies have also tried to remove variance in perceived depth information that may be due to accommodation (Gogel & Tietz, 1973; Ritter, 1977) and have found that convergence is more important for depth information than accommodation (Levine).

Binocular Disparity

The second binocular depth cue, binocular disparity, is based on the fact that human eyes receive differing retinal images, due to their distance apart from one another. This slight variation in visual imagery presented to the two eyes leads to binocular disparity (a.k.a., binocular parallax). Binocular disparity provides important depth information to the visual system by providing information about objects based around a point of fixation. This point of fixation is referred to as the horopter (Figure 7; Levine, 2000), and its properties have implications for stereoscopic vision. The horopter is a curve that, for a given fixation distance, determines where objects appear stereoscopically or as dual images.

The horopter (Figure 7) determines where an object must be in one's visual field to be perceived in stereo (given an individual's eyes are far enough apart). Through determining where the horopter line is in the visual field, it can be deduced where objects are seen stereoscopically and where they are perceived as two blurred images. An object falling inside the horopter (determined by the point of fixation of the viewer) will be merged with both eyes into a stereoscopically viable image. This area of vision has been named *Panum's fusion area* (Levine). In this area, the two images are made into one image. This fusion is important to understanding how stereoscopy can be created artificially (Nagata, 1996). If the proper images are provided to

both eyes with 2D visuals, the perception of a 3D object occurs even though there is no “true” 3D object being perceived.

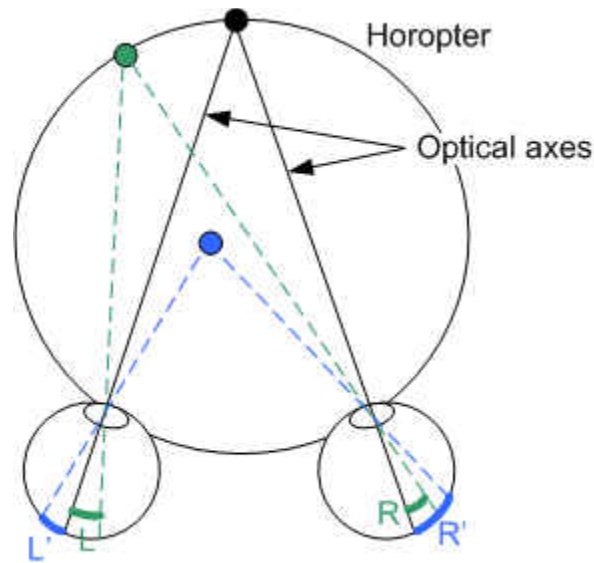


Figure 7. Depiction of the Horopter

Research has shown that there are also binocular cortical cells with both non-disparity (2D) and (3D) disparity fields. These cells react differently depending on an object's location in relation to the horopter (Hubel & Wiesel 1962). 3D stereoscopic imagery, compared to 2D imagery, activates different cortical cells in the visual cortex. This demonstrates that stereoscopic processes integrate information in a uniquely different way in the brain when compared to non-stereoscopic processes. If 3D stereoscopic imagery creates unique processing in the cerebral cortex, the argument could be made that objects perceived in 3D should be fundamentally different from comparable 2D objects.

Effects of 3D on Training Outcomes

In this section, empirical evidence that supports the use of 3D as a valid visual training method was explored. There has been an initiative in the medical field to remedy the issue of students having an insufficient ability to visualize anatomical structures (Heylings, 2002). This

has led to research on the use of 3D visualization tools to enhance learning in vision-based tasks. Although many of the studies conducted in 3D visual training are related to medical domains, their results can be extended to other domains that benefit from visual memory training.

Multiple studies have been conducted to examine the effects of 3D stereoscopic training, especially in the domain of anatomical learning. Although the evidence regarding the effectiveness of 3D representations in real world tasks is mixed, research has found beneficial effects of 3D technology for learning visual information. One study investigating the effects of using 3D to study wrist anatomy found that the multiple views provided in 3D enhanced participant's learning outcomes, but only if trainees had high spatial ability as measured by the mental-block rotation test (Garg et al., 2002). Participant's studied a simulated wrist, and were prompted to identify names of bones that were localized by an on-screen pointer. Participants were placed into one of two groups: a multiple-view group or a key-view group. This study found that certain key viewpoints were important for learning, which is in agreement with the cognitive standpoint of Bulthoff. Garg et al.'s research also demonstrated an advantage for participants who are able to control which key view they were observing, and that such control may be an optimal way to study 3D objects.

A study investigating familiar versus novel views of 3D objects found that binocular stereoscopic information led to significant reductions in error rates in a visual identification task (Edelman & Bulthoff, 1992). Their research argues that storing multiple views of an object is greatly affected by 3D training. A study designed to investigate the utility of using Web3D, a non-stereoscopic 3D visualization tool for anatomy students, found that 3D led to an enhanced ability to view spatial relationships between structures from numerous viewpoints. This may support a crucial educational need, namely that of practicing to develop the ability to visualize in 3D (Brenton et al., 2007). The authors believed that 3D training would help with mental

transposition of 2D imagery onto a 3D patient. Although this study did not use stereoscopic training, it clearly demonstrates that non-stereoscopic 3D training can have beneficial outcomes. A study designed to investigate the effects of 3D planning on surgical outcomes found that the use of a 3D visualization tool led to reductions in planning time by 30%, reductions in workload by 50%, and increased accuracy by 20% in a lung surgery simulation (Hu, 2005). Hu argued that the presentation of multiple viewing angles; easy manipulation of structures; and reduction of mental load due to complex computation were all reasons for the apparent performance gains. Again, although this study did not use true 3D stereoscopic imagery, it shows that 3D visualizations made a positive impact on performance.

Some research from outside the field of anatomy has found positive performance outcomes for 3D stereoscopic training. Kim (2006) found that using a 3D stereoscopic system for viewing plate tectonics enhanced students' learning outcomes. When compared to 2D visualizations, the group who received the 3D training had higher performance outcomes as well as positive attitude changes to the topic of plate tectonics and science in general (Kim). A study designed to investigate the effects of 3D training on understanding of a diagram (Irani & Ware, 2000) found that a 3D based diagram led to faster and more accurate identification of diagram substructures as well as a 50% reduction in errors compared to a 2D diagram group. Litwiller and LaViola (2011) have recently found evidence that, even though participants preferred 3D stereoscopic display systems, these systems did not lead to performance advantages compared to 2D displays.

Previous work on military vehicle identification has found support for 3D training. Although this research did not use a 3D stereoscopic visualization system, such as many of the studies mentioned in this section, effective training outcomes were found when using 1:35 scale die-cast physical scale models (Keebler et al., 2007; Keebler et al. 2009; Keebler et al. 2010). Although further research needs to be conducted to find if effects were due in part to information provided

by the haptic and proprioceptive senses, it is plausible that the use of physical models and the 3D information they provide can lead to higher identification performance outcomes.

Given that (a) 3D stereoscopic mediums have demonstrated positive effect on training outcomes, (b) stereoscopy provides depth information about objects when compared to non stereoscopic information, and (c) the human brain uniquely processes stereoscopic information, the following hypotheses were formulated:

Hypothesis 2- 3D stereoscopic training on quantity of objects retained

It was expected that 3D stereoscopic training would be positively and significantly related to the quantity of objects retained.

Hypothesis 3- Interaction effect of VWSM and 3D training on quantity of objects retained

It was expected that individuals with high VSWM who also learned using 3D stereoscopy would remember a higher quantity of objects, due to these individuals having a better capacity to memorize the detailed features presented within a 3D stereo SBT.

Individual Differences in the Training Experience

This section highlights attitudinal and experiential differences that could have influenced the outcome of the proposed training. Specifically, individual characteristics in how individuals reacted to the training technology were important in clearly determining the outcomes of the training. Factors including enjoyment, fascination, engagement, technology acceptance, and perceived usefulness of technology were assessed because they may have allowed for co-variation of individual differences, therefore leading to stronger analyses of the 3D training conditions.

Flow State and Optimality of Experience

Flow state is a concept born out of positive psychology in the 1970s. Interested in optimal experience, Csikszentmihalyi (1990) studied concentration, deep enjoyment and total absorption

in an activity. Although the definition has changed as the construct developed, flow state is still based around the idea of entering a state of optimal experience while performing certain tasks (Csikszentmihalyi, 1990; Novak & Hoffman, 1997). One definition is that flow is specifically optimal experience accompanied by high levels of intrinsic motivations towards a certain task (Jackson & Marsh, 1993). Other researchers have defined flow as a linear combination of control, attention, curiosity and intrinsic interest (Trevino & Webster, 1992). Flow state can be induced in tasks where an individual's skill is matched by an appropriate level of challenge. Being in a flow state is accompanied by high levels of enjoyment and engagement in a task (Csikszentmihalyi, 1990). If placed within the framework of Kirkpatrick's model (1959), flow may emerge as an important factor in understanding training reactions grounded in SBT. Two questions arise concerning the impact of flow in this dissertation: First, does stereoscopic SBT help induce a flow state in individuals? Second, is entering a flow state associated with stronger learning outcomes in the individual?

Experience of flow is usually described as an immersive state with total concentration on task. This is often accompanied by a perceived loss of time and sense of intense enjoyment (Csikszentmihalyi, 1990; Novak & Hoffman, 1997). Although the literature has defined flow in multiple ways, the definition of flow used by Ghani & Deshpande (1993) may be the most valuable for this proposed investigation. In their article on flow and human-computer interaction, Ghani and Deshpande defined flow as containing two key elements: total concentration in an activity and enjoyment derived from that activity. They add that a sense of control over one's environment is another key factor to achieving optimal experience. In their analysis using Confirmatory Factor Analysis/Structural Equation Modeling, they also found that perceived control and level of challenge for a given task both led to significant predictions of flow state (Ghani & Deshpande, 1993). Flow also led to higher levels of exploratory behavior. Through

measuring flow state, it may be possible to capture the amount of fascination, attention, and enjoyment that is brought about through interacting with the proposed training technology.

3D Training, Flow State and Engagement

One way in which the 3D stereoscopic training used in this dissertation should have induced flow is through curiosity. Curiosity has been argued to be a key component of intrinsically motivating instruction (Malone, 1981). Another conduit through which the 3D stereoscopic training may have induced flow stems from the fact that individuals tend to pay more attention to complex stimuli (Berlyne & Lawrence, 1964). As described throughout the previous section, 3D imagery does not only present a more complex stimulus, but also trigger neurons in the visual cortex specifically associated with perceiving only stereoscopic stimuli. This demonstrates that stereoscopy can garner the attention of individuals through initiating unique cortical processing. Measuring the experiential aspect of interacting with 3D training is fundamental to understanding the psychological fascination that humans exhibit with said technology. Therefore, 3D stereoscopic training could have aroused and satisfied curiosity in individuals above that induced by a similar 2D training, arguably leading to higher levels of intrinsic motivation during training.

Hypothesis 4- Effect of 3D Training on Flow

It was expected that there would be a positive and significant relationship between 3D stereoscopic training and flow state, such that participants who received 3D training would experience the highest levels of flow during training.

Flow State and Learning

Although entering a flow state may have induced curiosity and made the experience more enjoyable for the learner, it is important to investigate whether it also led to stronger learning outcomes, as predicted by the proposed model. Flow state is tied very closely to intrinsic motivation (Deci, Ryan & Koestner, 1999). In its most basic form, Flow state may be considered

an outcome of high levels of intrinsic motivation. Intrinsic motivation is defined as drive by interest or enjoyment in a given task, and exists within the individual rather than relying on external forces for motivation (Deci, Ryan & Koestner). In their research on using flow as a predictor for website usage, Hoffman and Novak (1996) proposed that flow had a number of positive consequences, including increased learning. Therefore, entering a flow state should have had a positive impact on long term memory and retention. Due to flow state indicating higher levels of intrinsic motivation, and therefore leading to higher levels of learning and retention, this led to the following set of hypotheses:

Hypothesis 5 - Effect of Flow on Quantity of Objects Retained

It was expected that there would be a positive and significant relationship between flow state and retention of objects, such that individuals who experienced high levels of flow would retain the highest quantity of objects.

Hypothesis 6 - 3D/Flow Mediation on Quantity of Object Retained

It was expected that Flow would act as a mediator between training dimensionality and retention, such that individuals who received 3D training and experienced high levels of flow would retain the highest quantity of the studied objects.

Hypothesis 7a - VSWM/Flow Moderation on Quantity of Object Retained

It was expected that VSWM would act as a moderator of the relationship between flow and retention, such that individuals who had high levels of VSWM and high levels of flow would retain the highest quantity of the studied objects.

Acceptance of Training Technology

Other related factors were measured because flow has conceptual overlap with closely aligned constructs. In this section, the Technology Acceptance Model (TAM) is discussed in relation to the proposed SBT. According to Kirkpatrick (1959), the way that individuals accept

the training system is an important factor in predicting their performance in using the system. The technology acceptance model (TAM) is often used to examine how well a system is accepted by the individual interacting with that system (Lee, Kozar, & Larsen, 2003). TAM provides a parsimonious model to examine factors that lead to information system acceptance (Lee, Kozar & Larsen).

TAM was measured using a modified version of a scale developed by Agarwal and Karahanna (2000). This scale measures multiple aspects of technology acceptance including: cognitive absorption, perceived ease of use of the system, perceived usefulness, personal innovativeness, playfulness, behavioral intention of use and self efficacy (Agarwal & Karahanna, 2000). Usually technology acceptance is measured through manipulating the usability of the system. Within the scope of this dissertation, the system used was only manipulated through the interface's level of stereoscopy.

3D Training and Engagement

Measuring the experiential aspect of interacting with 3D training is fundamental to understanding the psychological fascination that humans exhibit with said technology. Also, the novelty in using 3D may have induced curiosity, which has been shown to lead to higher levels of intrinsic motivation during instruction. Therefore, it was thought that 3D stereoscopic training may arouse and satisfy curiosity in individuals above that induced by a similar 2D training, leading to higher levels of intrinsic motivation during training (Deci, Ryan & Koestner, 1999).

Presence and Immersion

The variables of presence and immersion, although widespread in use, have been ill-defined in the literature. Along with flow and technology acceptance, these factors measure a variety of user reactions to simulations and technology systems, but tend to frequently overlap with one another. According to Slater and Wilbur (1997), immersion is based around objective interface

technology qualities, while presence is a user-based subjective experience. Although often distinguished from one another, it is highly possible that they are two sides of the same coin, as investigated by Witmer and Singer (1998). This argument is still unresolved to this day in the literature. This makes it relevant to measure both presence and immersion, and see if they are coupled to one another. The amount by which these two variables co-vary with one another may be indicative of the quality of a given simulations “believability”.

Relationship between Presence/Immersion and Learning

Whether presence and immersion are one in the same or completely separate constructs was outside of the scope of this dissertation. What is important is whether measuring either or both of these variables should contribute to understanding learning outcomes using 3D displays for human-virtual interactions. Although the level of presence or immersion within a given simulation might depend on the fidelity and realness of the simulation, other aspects of the individual, such as propensity for presence, may also influence these outcomes. Therefore, it was integral to pre-measure trainees on their incoming levels of presence/immersion propensity to gain a strong understanding of the effects of these variables on performance. As mentioned above, even a construct such as general technology acceptance may be predictive of how readily an individual can feel immersed in a given VE simulation.

The relationship between presence and performance has been investigated, and like research on presence and immersion, it has led to inconclusive results. Snow (1996) found a weak relationship between presence and performance in tasks involving distance estimation, object manipulation, movement in a virtual environment, and target selection. Others have found incongruent relationships between presence and performance, denoting that individual factors could be mediating the relationship between the two (Witmer & Singer, 1998).

To better understand how the proposed hypotheses related to the initial construct model, the model was reproduced (Figure 9) below with each hypothesis shown next to its appropriate linkage in the model:

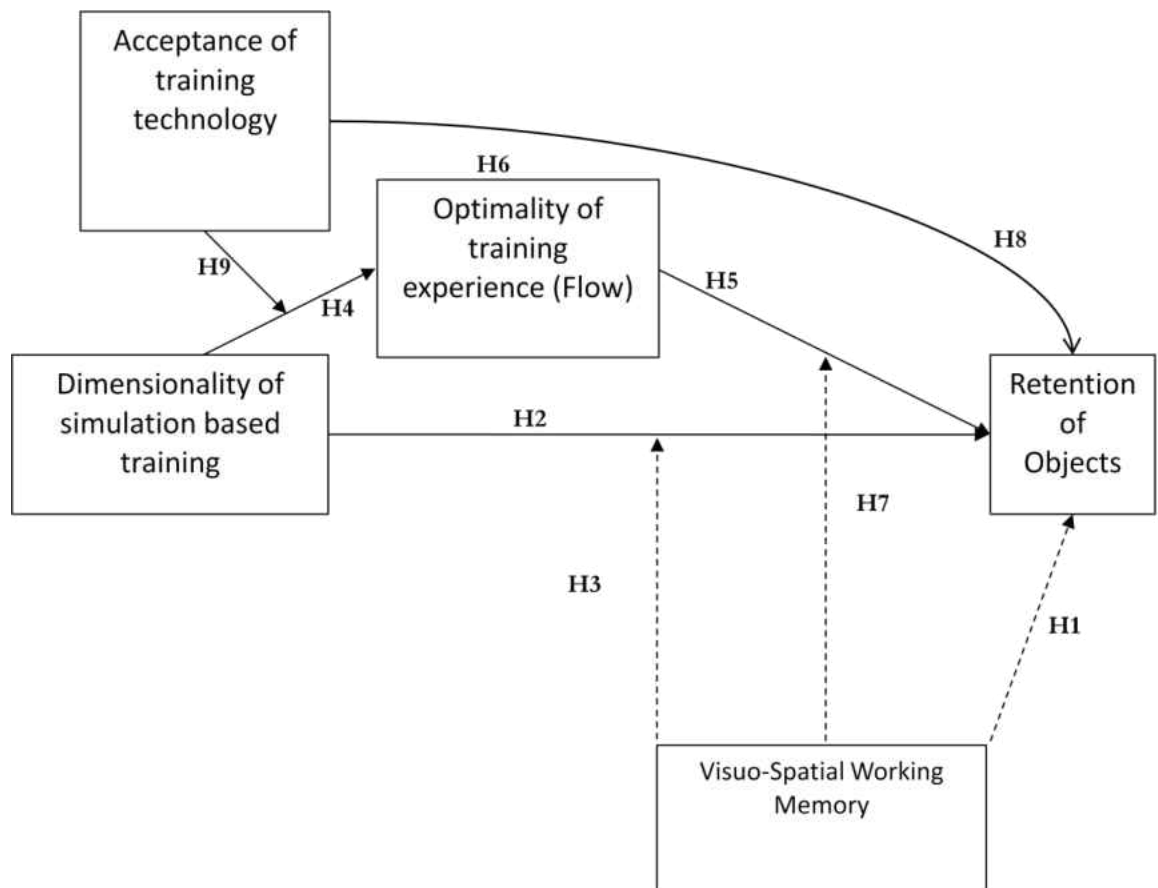


Figure 8. The construct relationships described using proposed hypotheses.

Table 2

Constructs

CONSTRUCT NAME	SUB CONSTRUCTS	IMPACT TYPE DIRECTIONALITY	SIZE OF EFFECT	MANIFEST VARIABLES	PROPOSED ANALYSIS	REFERENCES
Retention	Long Term Memory Learning Number of Objects Retained Quality of Objects Retained	N/A *dependent variable	N/A	<i>performance on final identification measure 2 week post training measure</i>	Dependent variable	Keebler et al. 2010; Cornoldi and Vecchi, 2003
Dimensionality of Training	3D Stereoscopic Training 2D Perspective Training Simulation Based Training	Positive Effect H2	Medium Effect	<i>Use of NVIDIA 3D System</i>	Multiple regression	Keebler et al. 2007; Kim, 2006
Visuo Spatial Working Memory	Visual Memory Working Memory Associative Memory Visual Learning	Positive Effect H1 Interactive Effects H3 H7	Medium/Large Effect	<i>Visual Performance Test (VPT) Card Rotation Test (CR) Paper Folding Test (VZ) Military Vehicle Quality of Retention Measure (MVQRM)</i>	Multiple regression	Keebler et al. 2010; Cornoldi and Vecchi, 2003
Optimality Experience	Interest Engagement Immersion Enjoyment Fascination Interest	Mediation Effect H4 H5 H6	Medium Effect	<i>FSS-2 Interest in Training Survey Biographical data form</i>	Barron and Kinney	Jackson and Marsh, 1996 Cziksentmihayli, 1990 Tabachnik & Fiddell, 2007
Acceptance of Training Technology	Learning Goal Orientation Usability of Simulation Based Training Individual Differences in Technology Usage Interest in Simulation Based Training	Positive Effect H8 Moderation Effect H9	Medium Effect	<i>TAM Interest in training survey</i>	Bivariate Correlation	Tabachnik & Fiddell, 2007

Table 3

Confounding Variables

CONFOUND NAME	CONSTRUCTS AFFECTED	IMPACT TYPE/ DIRECTIONALITY	SIZE OF EFFECT	MANIFEST VARIABLES	METHOD FOR CONTROL	REFERENCES
Military Experience	Dimensionality of Training Number of Objects Retained Quality of Objects Retained Acceptance of Technology	N/A *dependent variable	N/A	<i>Biographical data form</i>	covary	Keebler et al. 2007; Cornoldi and Vecchi, 2003
Automobile & Military Expertise	Visuo spatial working memory Number of Objects Retained Quality of Objects Retained	Positive Effect	Medium Effect	<i>Biographical data form</i>	covary	Keebler et al.; Kim,
Individual Differences in Visuo Spatial Working Memory	Number of Objects Retained Quality of Objects Retained	Positive Effect Interactive Effect	Medium/Large Effect	<i>Shape Memory Test MV-1 Military Vehicle Working Memory Test Visual Performance Test</i>	Multiple regression	Cornoldi and Vecchi, 2003
Beliefs about Warfare Training	Acceptance of Technology Flow	Positive Effect Mediation Effect	Medium Effect	<i>FSS Self Efficacy for video games Interest in Training Survey Biographical data form</i>	attrition	Shadish, Cooke, & Campbell, 1993
Intrinsic Motivation	Flow/ Acceptance of Technology/ Number of Objects Retained Quality of Objects Retained	Positive Effect Direct Effect	Medium Effect	<i>TAM Interest in training survey</i>	Barron & Kinney mediation	Tabachnik & Fidell, 2007
Video Game Experience	Acceptance of Technology, retention	Positive Effect	Medium Effect	Biographical data form	covary	N/A
Complexity of Vehicles	Retention, Flow experience	Negative Effect	Medium Effect	Complexity rating for individual vehicles	Biederman's confusion research	Biederman, 1986
Visual Acuity	Retention, Acceptance of Technology, Flow experience	Mediation Effect	Large Effect	Self-report	Pre-screening	N/A
Color Blindness	Retention	Negative Effect	Small Effect	Ishihara's Color Blindnes Test	covary	Ishihara, 2008
CONFOUND NAME	CONSTRUCTS AFFECTED	IMPACT TYPE/ DIRECTIONALITY	SIZE OF EFFECT	MANIFEST VARIABLES	METHOD FOR CONTROL	REFERENCES

Stereopsis	3D training, acceptance of technology, Flow experience	Mediation Effect	Large Effect	RANDOT Test	Pre-screening	N/A
Effectiveness of Training	3D training, acceptance of technology, Flow	Postiive Effect	Large Effect	Military Vehicle Quality of Retention Measure (MVQRM)	covary	N/A

CHAPTER 3: METHOD

Military Vehicle Identification and Fratricide

The domain of military vehicle identification was used for the application of the theoretical model proposed in this dissertation. Military vehicle identification is one domain that requires the individual to memorize and later identify a large number of objects. This area is consequently plagued by problems in precisely identifying objects. This issue manifests itself as the phenomenon of friendly fire (i.e., fratricide, amicide, a.k.a. "blue-on-blue" Reagan, 1995). As an example, estimated combat vehicle losses due to fratricide in the first Gulf war range from 30% (McCarthy, 2003) to 77% (Reagan). One factor involved could be individual soldier's inability to correctly identify vehicles. Friendly fire has been an integral part of military life since men first became civilized enough to kill one another with something other than their bare hands (Reagan). Although technology has advanced exponentially since the earliest battles, even in modern warfare fratricide is a persistent threat. There are a multitude of factors that may influence fratricide: the environment, the training of individual soldiers, the nature of military operations, and a lack of planning in the higher levels of the military. While the fault sometimes falls on the commanding officer(s), the fatal decision is usually left to individual soldiers (Reagan).

Therefore, this study strove to apply the proposed theoretical model as well as devise simulation based-training (SBT) to tackle the problem of fratricide. Given that armored vehicles are a discreet class of objects and that a multitude of them look very similar, they fall within a rare category of objects. Armored vehicles are an example of objects that are difficult to tell apart (Briggs & Goldberg, 1995), much like the objects used in Gauthier's research, discussed above. Due to this unique nature, training can be effectively evaluated in an applied setting. Specifically, through introducing training that aids in distinguishing similar vehicles and gives individuals

better retention of learned vehicles, we were able to reduce error associated with fratricide alongside testing the theory proposed. Through integration of the model of constructs in Figure 8 into a simulation based training (SBT), this dissertation provided powerful insight and guidelines into training for any task that requires the memorization and later identification within a class of objects.

Power Analysis and Design

A power analysis was conducted using the G-power software (Erdfeiler, Faul, & Buchner, 1996). The design for this experiment was a hierarchical regression, with VSWM, perceptions of simulation experience, and dummy-coded SBT type (2D or 3D) as the between subjects variables and test type (alliance categorization, identification, transfer identification) as the within subjects variables. The dependent variables were derived from scores achieved during the two testing phases of the experiment. Two score from post-training (alliance categorization and CID) and one score from the transfer measure (transfer CID). Given a medium effect size (0.2), an alpha level of .05, and a power level of 0.8, the estimated appropriate sample size calculated was $N = 48$. Because Multiple Regression Correlations was used for later exploratory analyses, a larger sample size was collected after the initial 48 participants to maintain a high N to k ratio.

Participants and Recruitment

Seventy-one participants were recruited using the University of Central Florida's SONA system. This online site hosted by the University of Central Florida allowed undergraduate psychology students to participate in experimental research for course credit. Upon signing up, participants were informed of the time and location of the study. They were also emailed with directions to the appropriate location. Due to possible confounding effects of female visuo-spatial aptitude (Cornoldi & Vecchi, 2003; Halpern & Collaer, 2005), only data from male participants was collected in the initial sample.

Setting

The setting of this research was a typical laboratory room. This allowed for data collection at a site where data can be coded and stored safely, while also providing participants with a comfortable environment for the 2 - 2.5 hour experiment. The room was fitted with a desktop PC.

Apparatus

The system used in this study was an ASUS (Appendix C) i5 computer. This system was coupled with an NVIDIA 3D Kit that allowed for the 3D/2D manipulation of the display. Only when the NVIDIA system was turned did the participants see three dimensional objects. This allowed for a very clear manipulation of 3D stereoscopy. What differentiated this system from inactive 3D systems is that it used voltaic LED cells that darken the lenses of the glasses. When shutter glasses are synchronized with alternating images of individual binocular viewpoints of an onscreen object, the object appeared to the viewer as if it were 3 dimensional. The NVIDIA system allowed for the rendering of computer images into stereoscopic images through the use of an active display integrated with shutter glasses. The NVIDIA system does this through creating a 3D image on the participant's retina(s) by synchronizing the image between both eyes with a set of glasses that only let the correct eye see its side of the image at any given time. This made the image stereoscopic, bringing imagery out of the screen into a third dimension towards the observer. The simulation received an infrared (IR) signal from the glasses, and depending whether the glasses are being used or not, rendered the simulation accordingly (i.e., in 3D stereo or 2D).



Figure 9. Image of a participant viewing the Challenger vehicle during the 3D stereoscopic training

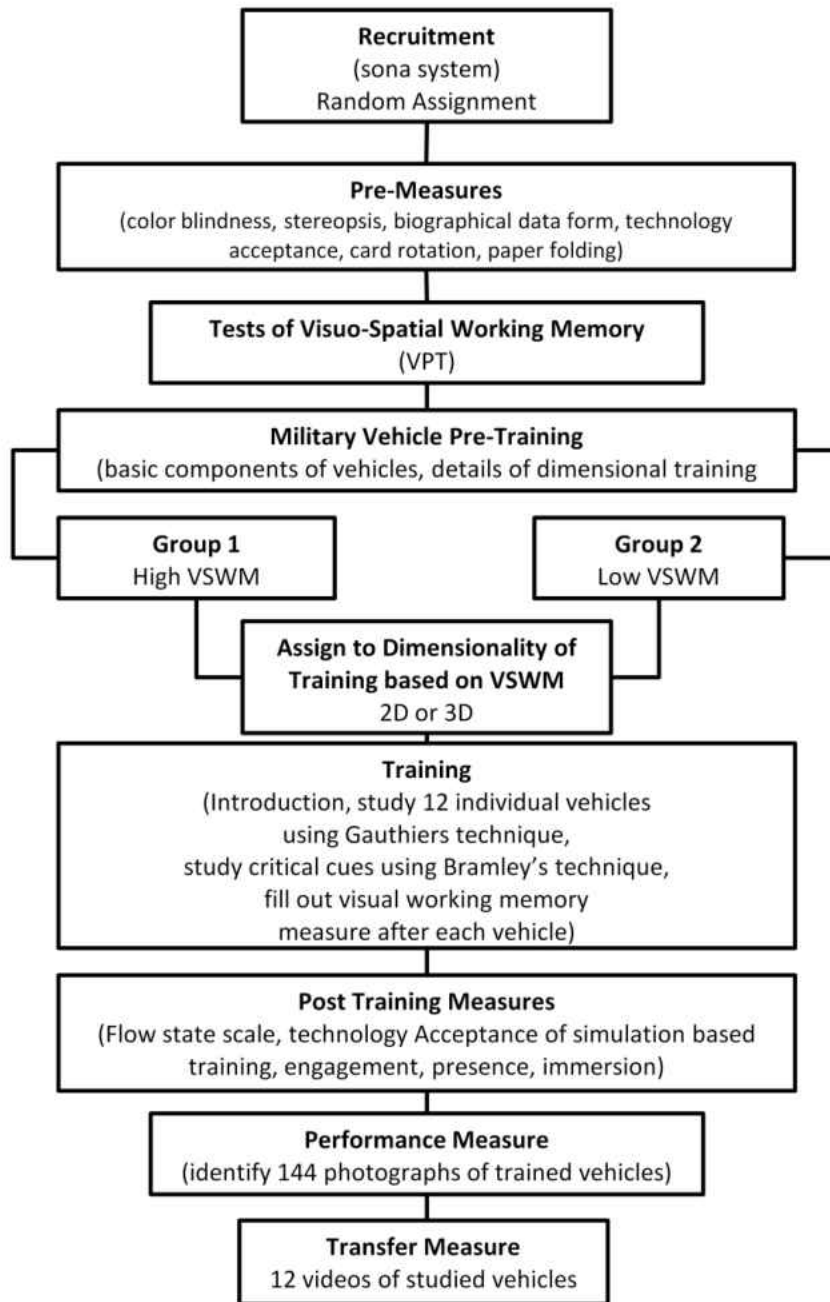


Figure 10. Flow chart outline of study progress

Measures

Informed consent

Participants were greeted on the 3rd floor of the Psychology building. They were then taken to the experimental laboratory located in room 303G. Once seated, participants were handed an informed consent describing the purpose of the study and any risks associated with participating in this research. Upon completion of the informed consent, participants were told that this study is designed to train them and later test them on a set of objects, and that they should try to take the research seriously and try their best.

Pre-training measures

Upon completing the informed consent, participants were given a battery of pre-training measures to assess individual differences. The biographical data form was given first as a general measure of individual differences (Appendix A). After completing this form, participants were then tested on color blindness using Ishihara's tests for color deficiency. Participants were then given two visuo-spatial pre-tests: the Card Rotation Test (CR-1) and the Paper Folding Test (VZ-2).

RANDOT test of stereopsis

Participants were first given the RANDOT test of stereoscopy. This test was initially going to be a determining factor in whether they may proceed in the experiment. Due to the nature of the major manipulation in this study (3D stereoscopy) it was pertinent that all participants were measured on their level of stereoscopic vision, in case differing levels of stereoscopic perception interacted with the manipulation of 3D.

Ishihara Color Deficiency Test

Ishihara's test for color deficiency (Ishihara, 2008) was used to assess participants for color blindness. This test consists of a set of colored plates containing numbers. Each plate is created

with a set of pixilated dots. Individuals with healthy color perception are able to see numbers in the plates, while those individuals with certain color deficiencies saw the plates as blank instead. Although color did not play a role in how well an individual memorized the vehicles in this study, there could have been certain cues that are colored that could render differences in performance.

Biographical data form

After participants consented to the experiment and their stereopsis had been tested, they were issued a biographical data form. This form asked questions concerning a multitude of individual differences. This questionnaire is concerned with personal information including the following items: age, major, year in school, military service and time in military service, gender, eyesight acuity, corrected eyesight acuity, current GPA, familiarity with military vehicles and cars, and multiple questions addressing familiarity with video games.

Card Rotation Test (CR-1)

The card rotation test is a validated measure of spatial relations (Carroll, 1993), and has also demonstrated psychometric properties related to mental rotation of objects. The test required participants to match an object to its rotated counterparts, among which some are mirror images. This test was used as a secondary measure to assess general spatial abilities as well as support the validity of the VPT as a measure of VSWM.

Paper Folding Test (VZ-2)

The Paper Folding Test (VZ-2) has been shown to load onto factors of visualization and general visual abilities (Carroll, 1993). This test required participants to mentally “fold” a piece of paper using three dimensions. Therefore, it may have measured individual differences in 3D spatial abilities. This test was also used as a secondary measure of spatial ability, as well as to validate the VPT as a measure of VSWM.

Visual Patterns Test (VPT)

The Visual Patterns Test (VPT; Della Sala, Gray, Baddeley, & Wilson, 1997) was given to participants before the training begins. This test has been shown to be a valid measure of visuo-spatial working memory (VSWM). Scores derived from this measure were used to ascertain which condition the participant was assigned to. Upon completion of the visual patterns test, participants were handed a pre-training explanation form, describing in detail the importance of military vehicle training, and the tasks associated with the training they are about to enter. During this time, the experimenter graded the participants VPT, and then assigned them to the appropriate condition based on their score (High or Low VSWM; 2D or 3D stereoscopic).

Training

Introductory training

Before studying individual vehicles, participants were given an introduction to military vehicle components training. This training consisted of a review of the major components found on military vehicles (e.g. turret, treads, and chassis) as well as the features that distinguish Main Battle Tanks (MBTs) and Personnel Carriers (PCs).

Participants were then given an explanation of what they could expect from the training and the remainder of the experiment. Specifically, they were told that they would be studying, in depth, a set of military vehicles that they had to later recognize and identify from a series of photographs and videos.

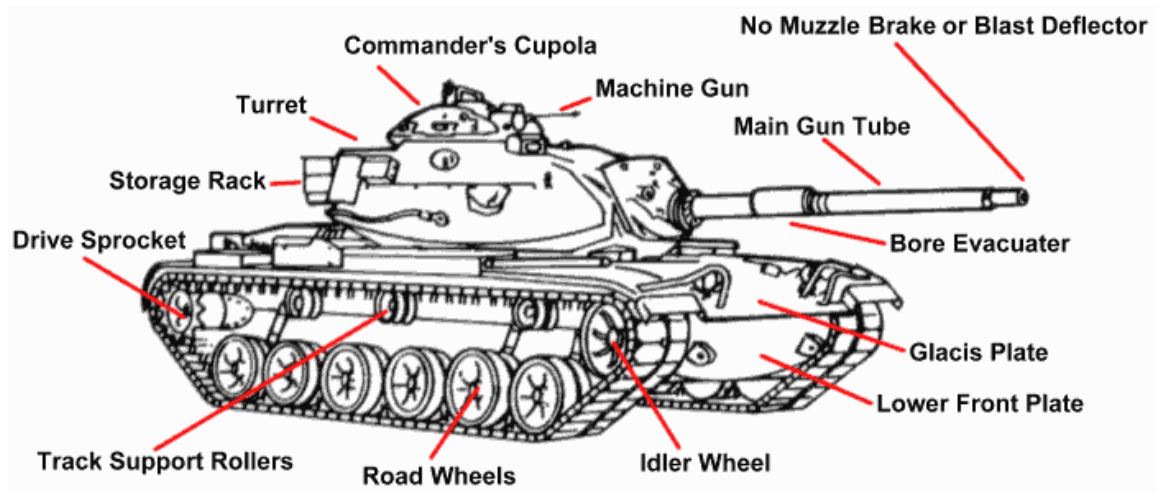


Figure 11. U.S. M60 demonstrating the components of a MBT

Training manipulation

The training manipulation was based on using the NVIDIA 3D stereoscopic system explained above. Participants in the 3D stereoscopic condition were sat in front of the simulation computer and asked to place the NVIDIA 3D shutter glasses on. Once they had found a comfortable fit, the training was initiated. Participants in the 2D condition instead viewed the simulation without the NVIDIA shutter glasses.

Participants were trained in a First Person Shooter (FPS) style simulation built using UNITY software. The simulation consisted of a small platform (approximately 4 acres) in which participant's controlled an avatar. This platform had each of the vehicles placed within as 3ds model renderings. The participant controlled an avatar that can "walk" up to each vehicle for studying individual vehicle characteristics. All studied vehicles were in the simulation simultaneously, but were occluded from one another using fences. Participants studied each vehicle according to the training developed from Biederman, Bramley, and Gauthier's training paradigms, presented below. The layout of the simulation is presented in Figure 12 from a bird's eye view. Figure 13 presents an image from the avatar's perspective as well.



Figure 12. A close approximation of the simulation being used in this study without occluding objects.



Figure 13. An example of an AAV transport vehicle as it would be seen from the Avatar's viewpoint in the simulation.

Specific vehicle training

The vehicles

The twelve vehicles used in this study consisted of a mixture of U.S. and foreign vehicles. Line drawings of the vehicles from military issued cards are depicted below. This set of vehicles has been used in previous research (Keebler et al., 2009), and is the same set of vehicles that was used to develop the military vehicle identification measure. The twelve vehicles consisted of a mixture of MBTs and PCs, with each subset containing half of U.S./U.S. ally or foreign opposing military (M1A1, Challenger, M60, T80, T72, ZSU; BTR, BRDM, BMP, Bradley, LAV, M113).

Critical cues training

Visual training based around critical cues has demonstrated valuable results in the domain of military vehicle identification (Biederman & Shiffrar, 1987; Bramley, 1973). Therefore, this training strove to make critical cues salient. Bramley's experiment determined that highlighting critical through a question and answer format led to the strongest training outcomes (Bramley). Bramley found that performance was enhanced through having participants answer questions about details in a photograph. An example is provided in Figure 14. Biederman's training was designed through a separate domain: chicken sexing. Biederman found that he could train novices to expert levels of chicken sexing by simply providing a list of exemplary photographs. Through this training, he was able to have novices perform above experts, some of who had been sexing chickens for 20+ years (Biederman & Shiffrar, 1987). Biederman adapted this training to military vehicle recognition. Using the critical cue of a notched turret, he devised a method for identifying MBT that were Warsaw Pact vehicles compared to NATO vehicles (Figure 15). By using a simple heuristic, that of whether the back of the vehicles turret is notched or not, Biederman found a way to easily identify between vehicles from these two separate forces.

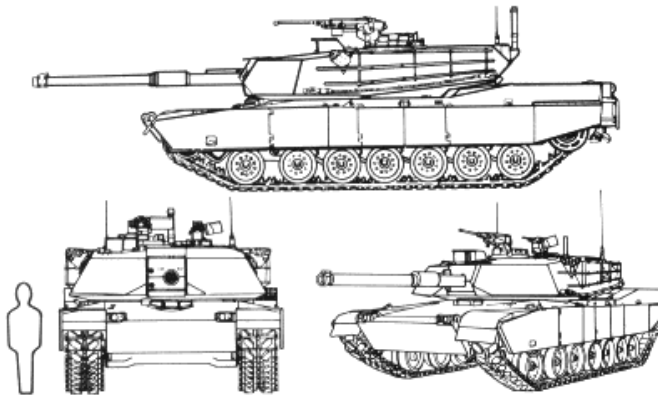


Figure 14. An adaptation of Bramley’s critical cue training.

- A) There is a set of rails that encircle the M1’s turret. These are used as grips for crewmen, as well as attachment points for equipment. How many rails are there?
- B) Although the M1 is a treaded vehicle, it still has a set of wheels that rotate the tread. These are called road wheels. How many road wheels does the M1 have?

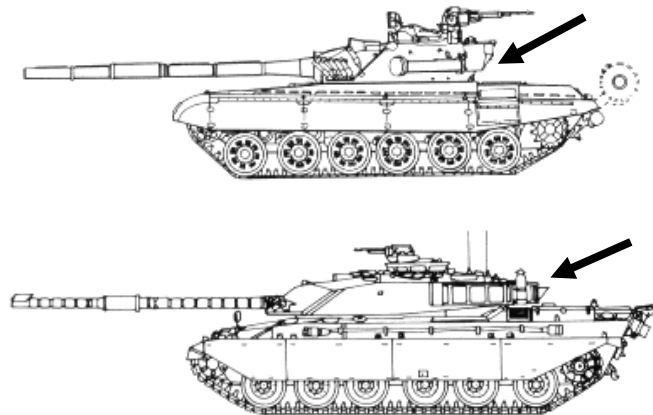


Figure 15. A demonstration of Biederman’s training showing the area (indicated by a black arrow) where the presence of a notch deems a vehicle as a Warsaw Pact vehicle (top, Russian T-72), and the absence of a notch a NATO vehicle (bottom, UK Challenger).

Training Critical Cues

Participants interacted with the simulation via the ASUS computer during this phase of training. Depending on condition, participants entered the simulation and learn about each vehicle

and the visual features that make it unique (*see* Appendix B). Participants were verbally guided by an experimenter, using the training described above. As they were guided, they were in full control of the avatar. They learned each of the twelve vehicles, and were tested on their visual knowledge of each vehicle immediately after studying it using the MVWMM.

Confusability training

There is room for confusability between any set of military vehicles used (Figure 17), especially vehicles within the same class. To avoid this issue, participants were trained to tell vehicles apart that are within subclasses (MBTs and PCs). Mixing this training with the critical cues training helped alleviate mistakes due to confusion. Using logic from research on military vehicle confusion (O’Kane, Biederman, Cooper, & Nystrom, 1997), a confusability tree was created (Figure 16). The tree is constructed by simply placing a node between every vehicle for major points of visual difference. These methodologies lead to clustered groupings of similar vehicles. The vehicles used in this study were placed within the tree using major features such as turret size, treaded vs. wheeled, and vehicle type (e.g. main battle tank, personnel carrier). O’Kane et al.’s research found that vehicle confusability trees make a reliable predictive model of how confusing the vehicles are to observers. Specifically, the closer two vehicles are in nodes, the harder they are to tell apart from one another.

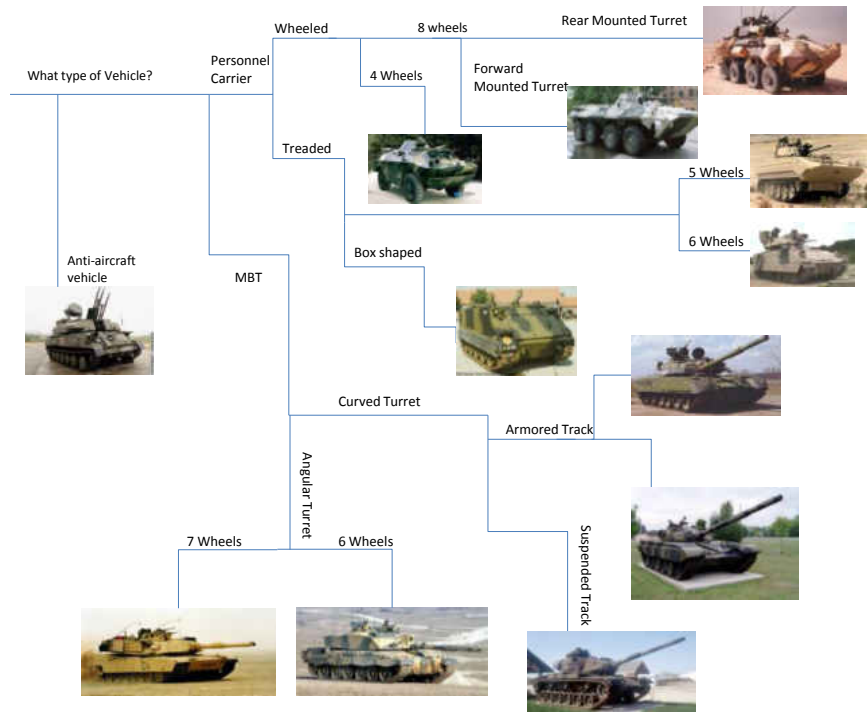


Figure 16. A confusability tree containing the vehicles that were used in this study.

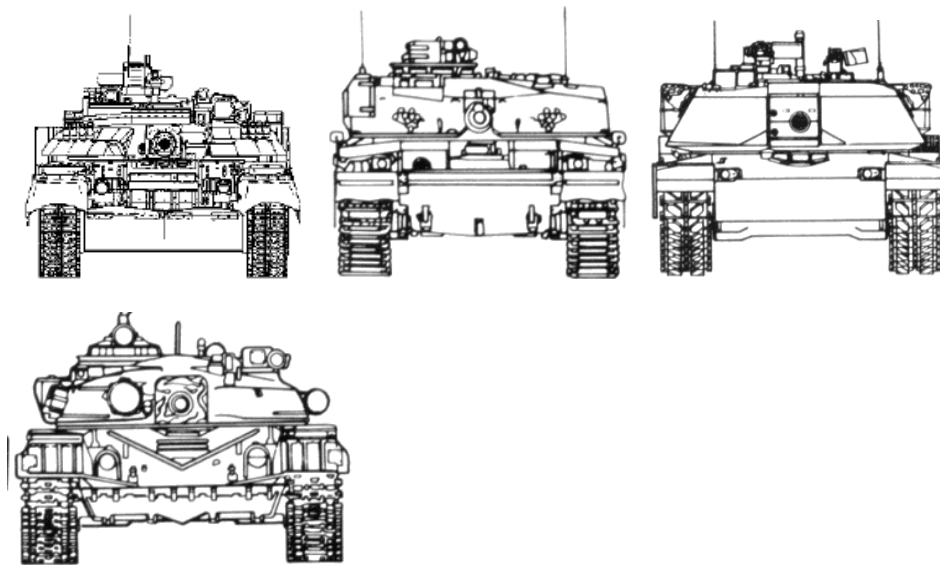


Figure 17. MBT frontal view similarities. Clockwise from top left: Russian T-80, UK Challenger, U.S. M1A1 and a Russian T-72.

Gauthier's training

Isabel Gauthier created expertise training for a set of novel, yet confusable objects (Gauthier et al., 1997). Gauthier used seven training methods, across 3769 trials in approximately nine hours, to bring participants to expert like levels for a set of 30 similar objects. This dissertation instead used twelve objects, so it therefore was feasible to train in much less time. Although the training proposed here paralleled Gauthier's training, it had substantive differences due to the nature of the training materials and the fact that the objects used in this study are real world objects (military vehicles), unlike the fictitious "greebles" used by Gauthier. Please see Appendix A for a list of the training segments used by Gauthier, metamorphosed to instead train individuals on similar features for a set of military vehicles. Once participants have started the simulation, they were guided through the following training segments for each of the twelve vehicles. Appendix (X) contains a description and example of each training criteria, with a line drawing of an U.S. M1A1 *Abrams* for demonstration purposes.

Applying Gauthier's training

Participants entered the simulation again using the ASUS computer. This time they were asked a set of questions adapted from Gauthier's training (Appendix). They were then put through 12 trials (a trial was one set of questions; *see* Appendix) for each vehicle. As in training phase 1, they were able to control their avatar, but they had to follow the instructions given to them by an experimenter. At the end of this phase, participants were once again tested on flow state.

Military vehicle retention training assessment

Participants were administered a measure during each section of the training to assess how effective the training was. This test was administered after each of the twelve individual vehicles was studied. The test contained items showing de-articulated components of the vehicles (Appendix A). Participants had to choose which of the shapes presented components of the vehicle they had just studied. This measured individual differences in retention for each of the vehicles studied.

Military vehicle identification measure

The military vehicle identification measure was one of the final performance measures in this study. The military vehicle identification measure is a questionnaire that was answered while the participants viewed a set of sixty-six photographs of various military vehicles. Each vehicle studied was presented from three views (facing left, facing right, and frontal) using photographs from a MOUT simulation (1:35 scale models) and photographs of the actual vehicles. This led to a total of six images for each vehicle studied, with a total of forty two stimuli that match the vehicle training. There were four distracter vehicles included in this measure, also presented from three views in each of the photograph types, leading to twenty four distracter photographs. Between studied vehicles and distracters, the measure contained a total of sixty-six items. Each photograph was presented for five seconds, followed by a slide asking participants to write down the name of the vehicle they just observed, and whether they believe it was friend or foe. This measure has been used in previous work (Keebler et al. 2009; Keebler, Curtis, Sciarini, & Jentsch, 2010) and has been found to have a high reliability, with a Chronbach's alpha level of .89.

Transfer Military vehicle identification measure

The transfer military vehicle identification measure consisted of 12 video clips of each of the studied vehicles performing live operations. Each clip lasted approximately 20 seconds. Participants had to identify each vehicle by name when that vehicle's clip was finished playing, and scores were calculated out of a possible total of 12 correct responses.

Flow State Scale (FSS-2)

The FSS (Jackson and Marsh, 1996) is a validated measure of flow state. A shorter version, the FSS-2 (Jackson, Martin, & Eklund, 2008) was developed to make the measure easier to fill out (9 items vs. 36 items) and help avoid effects of survey fatigue. Jackson, Martin, and Eklund found the measure to be valid (2008). This measured the amount of flow achieved by participants after interacting with the training of their given condition.

TAM

A measure of technology acceptance was given to the participants both pre and post-training. The pre-training version of the test was used to assess what each individual thinks about technology in general, while the post test instead reflected participant's judgments of the training system after they have used it.

Testing

Testing for identification was conducted using the military vehicle identification measure (Keebler et al., 2007; Keebler et al., 2009; Keebler, Curtis, Sciarini, & Jentsch, 2010). This measure consisted of photographs of 144 items containing 12 images of each studied military vehicle. All items were randomized prior to the beginning of the study. Following, a transfer measure made of 12 videos of each vehicle in live operations was presented asking participants to decide on whether to shoot or not shoot the vehicle as well as identifying the vehicle by name.

CHAPTER 4: RESULTS

Experimental data collection led to a final N of 71 participants (100% male; age range = 18-33, $M = 20.3$ years old). A table (Table 4) is provided below, and includes means, standard deviations, reliability estimates and correlations for all analyzed variables. The three initial dependent variables used in this analysis (alliance categorization, identification and transfer identification) were all examined for normality. Histograms of the outputs for these three dependent variables are provided (*see* Appendix E). All values for the first two dependent variables were calculated from responses to questionnaires while observing the 144 photographs in the military vehicle identification measure. The last transfer variable was calculated from responses to questionnaires while viewing twelve videos of armored vehicles during live operations.

Upon examination, it is clear that the initially measured dependent variables are different from one another, specifically in relation to the number of correct responses. Alliance categorization had a seemingly normal distribution, indicating it is easier to remember whether a vehicle is friendly or enemy than it is to identify a vehicle by name. Identification, or the explicit naming of a vehicle, demonstrated positive skew, with a large number of participants unable to correctly answer a single question concerning identification ($N = 22$). This indicates that this was harder than the corresponding alliance categorization for the same vehicles. The ability to name a vehicle after such a short time of study indicates the most optimal level of performance possible. The transfer identification task was also skewed in the positive direction, indicating that, like the identification measure using photographs, it was also a difficult task.

Exploratory Factor Analysis to Reduce Experiential Variables

Although flow was originally proposed to be the sole mediating factor in this design, later factors were added that measured similar latent constructs as the FSS-2. Due to the high number of individual measures (11 total scales), an exploratory factor analysis (EFA) was conducted to collapse the large number of variables (Flow, Presence, Immersion, Engagement, and the 12 subscales of Technology Acceptance) into a more suitable form for further analyses. All measures of the simulation experience were subjected to a principal components analysis (PCA) with a one-factor solution. This initial EFA contained twelve items with 40.13% of the variance predicted by a single factor (Eigenvalue = 4.82) across the twelve items. Pruning was conducted using communalities of .4 or higher as a cutoff point. This led to the next EFA containing six items, with 51.5% of the variance predicted by the single factor (Eigenvalue = 3.1). Pruning was conducted again, using communalities of .5 or higher. This led to a final single factor predicting 59.7% (Eigenvalue = 2.4) of the variance in the 4 items left (i.e., heightened enjoyment, curiosity, perceived usefulness and flow experience). Due to the conceptual relationship between these items and the sufficient amount of variance prediction provided by the single factor solution, a new variable entitled PERCEPTIONS OF SIMULATION EXPERIENCE was calculated using the Bartlett factor score variable creation method in PASW 19.0.

To assess the suitability of this factor for further analysis, a correlation was conducted that included the new perceptions of simulation experience factor and all dependent variables (Table 5). The correlation table displayed significant medium-strength relationships between the perceptions of simulation experience factor and some of the dependent variables. Therefore, this variable was used in place of flow, as originally proposed. This leads to a more simplified and parsimonious model (Figure 18).

Table 4

Effects of 2D & 3D on dependent variables

Variable Name		Mean	SD	Level of significance
Alliance Total	3D	80.66	17.1	$p < .033$
	2D	83.1	27.9	
Combat Identification	3D	22.1	21.5	$p = .13$
	2D	33	30.9	
Transfer Identification	3D	1.83	1.9	$p < .006$
	2D	3.2	3.2	

Table 5

Reliability Estimates, Means, Standard Deviations, and Correlations for Analyzed Measures

Variable Name	<i>M</i>	<i>SD</i>	DI M	VSWM	TA- FI	TA- HE	TA- CON	TA- CUR	TA- PEOU	TA- PU	TA- P	PRE	ENG	IMM	FLOW	TR	CI D	AC	TI D
DIM	.49	.5	N/A																
VSWM	21.1	4.5	-.02	(.74)															
TAFI	29	4.8	.17	.00	(.82)														
TAHE	19.5	5.8	.17	-.01	.41	(.88)													
TACON	17	3.7	.09	.08	.41	.23	(.82)												
TACUR	14.1	4.3	.18	-.07	.21	.59	.21	(.91)											
TAPEOU	26	4.1	.22	-.01	.5	.34	.34	.34	(.95)										
TAPU	21	4.6	.00	-.14	.33	.39	.39	.39	.34	(.92)									
TAP	32	7	.12	.19	.16	.37	.47	.47	.47	.39	(.90)								
PRES	108	14.6	.14	-.04	.26	.36	.34	.34	.31	.38	.15	(.88)							
ENGAG	22.1	5	-.13	-.02	.19	.59	.56	.56	.16	.26	.28	.30	(.85)						
IMM	119	16	.02	-.00	.07	.22	.32	.39	.22	.11	.25	.11	.19	(.73)					
FLOW	41.3	6.8	.14	-.05	.50	.49	.41	.41	.50	.51	.35	.52	.26	.19	(.71)				
TRAIN	26.6	5.6	-.15	.47	.11	.25	.13	.20	.13	.05	.28	.14	.29	.05	.15	(.77)			
CID	27.6	27.1	-.25	.26	.17	.25	.19	.14	.14	.23	.22	.17	.34	-.08	.18	.51	(.88)		
AC	81.9	23.1	-.05	.29	.14	.18	.22	.21	.24	.09	.25	.30	.38	-.06	.18	.43	.70	(.85)	
TID	2.5	2.8	-.26	.18	.14	.21	.17	.11	.16	.25	.17	.19	.32	.01	.20	.48	.89	.64	(.83)

Notes: The diagonal contains reliability estimates (Chronbach's alpha). Bold-italicized numbers indicate a significant correlation ($p < .05$). Key: DIM- dimensionality of training; VSWM- visuo-spatial working memory; TA- technology acceptance; TAFI- focused immersion, TAHE- heightened enjoyment, TACON- control, TACUR- curiosity, TAPEOU- perceived ease of use, TAPU- perceived usefulness, TAP- playfulness; PRE- presence; ENG- engagement; IMM- immersion; FLOW- flow; TR/TRAIN- training performance; CID- combat identification performance; AC- alliance categorization performance; TID- transfer identification performance

Table 6

Correlations between dependent variables and Enjoyment Factor (renamed Perceptions of Simulation Experience)

		Correlations						
		Enjoyment Factor	Recognition TOTAL	Alliance TOTAL	Identification TOTAL	Total reaction time average	Performance on Shoot/Don't Shoot TransferTask	Performance on Trasfer Task ID
EnjoymentFactor	Pearson Correlation	1	.041	.310**	.310**	.021	.293*	.294*
	Sig. (2-tailed)		.733	.008	.008	.861	.013	.013
	N	71	71	71	71	71	71	71
Recognition TOTAL	Pearson Correlation	.041	1	.711**	.383**	-.040	.288*	.325**
	Sig. (2-tailed)	.733		.000	.001	.739	.015	.006
	N	71	71	71	71	71	71	71
Alliance TOTAL	Pearson Correlation	.310**	.711**	1	.700**	.037	.531**	.639**
	Sig. (2-tailed)	.008	.000		.000	.757	.000	.000
	N	71	71	71	71	71	71	71
Identification TOTAL	Pearson Correlation	.310**	.383**	.700**	1	.231	.462**	.892**
	Sig. (2-tailed)	.008	.001	.000		.052	.000	.000
	N	71	71	71	71	71	71	71
Total reaction time average	Pearson Correlation	.021	-.040	.037	.231	1	-.109	.222
	Sig. (2-tailed)	.861	.739	.757	.052		.367	.063
	N	71	71	71	71	71	71	71
Performance on Shoot/Don't Shoot TransferTask	Pearson Correlation	.293*	.288*	.531**	.462**	-.109	1	.590**
	Sig. (2-tailed)	.013	.015	.000	.000	.367		.000
	N	71	71	71	71	71	71	71
Performance on Trasfer Task ID	Pearson Correlation	.294*	.325**	.639**	.892**	.222	.590**	1
	Sig. (2-tailed)	.013	.006	.000	.000	.063	.000	
	N	71	71	71	71	71	71	71

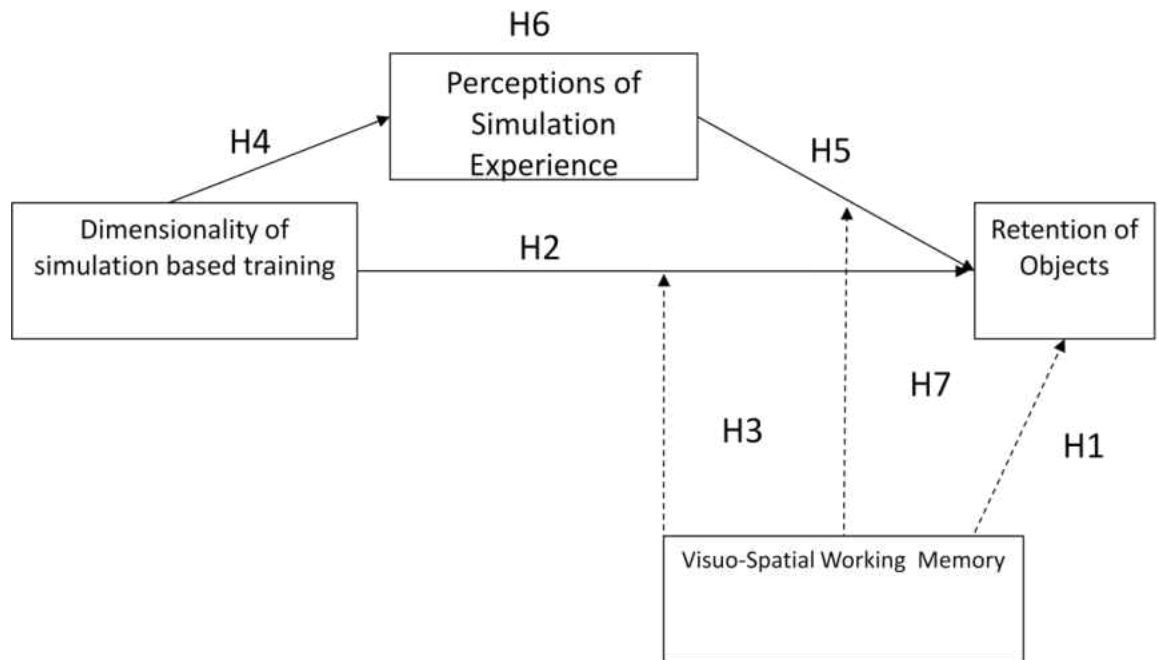


Figure 18. Refined model replacing flow and technology acceptance with the new factor of perceptions of simulation experience

Regression Analyses and Model Testing

As proposed, the model above (with the collapsed experience factor) was tested across the three dependent variables using multiple regression correlation. The model was predictive for the dependent variables (i.e. alliance categorization, identification, and transfer identification). As described in the methodology and proposed analysis, a mediation model using the Barron and Kenney (1986) method was also conducted to test for whether enjoyment mediated the relationship between the dimensionality of training and final outcomes of retention for the learned vehicles. Also, a Sobel test (Sobel, 1982) was conducted on each complete model, which provides an independent alternative significance test for mediation analysis. Although neither method demonstrated a significant mediation, indicating a failure of **H6**, the model was robust, predicting approximately 25%-28% of the total variance in each of the three dependent variables. Hypotheses were supported for the major predictors in the model, including the individual

differences in VSWM (H1) and enjoyment (H5), and the interaction between enjoyment and VSWM (H7). Dimensionality of training was in fact not predictive of final outcomes (H2); it did not interact with VSWM (H3), and was not predictive of enjoyment in the simulation (H4).

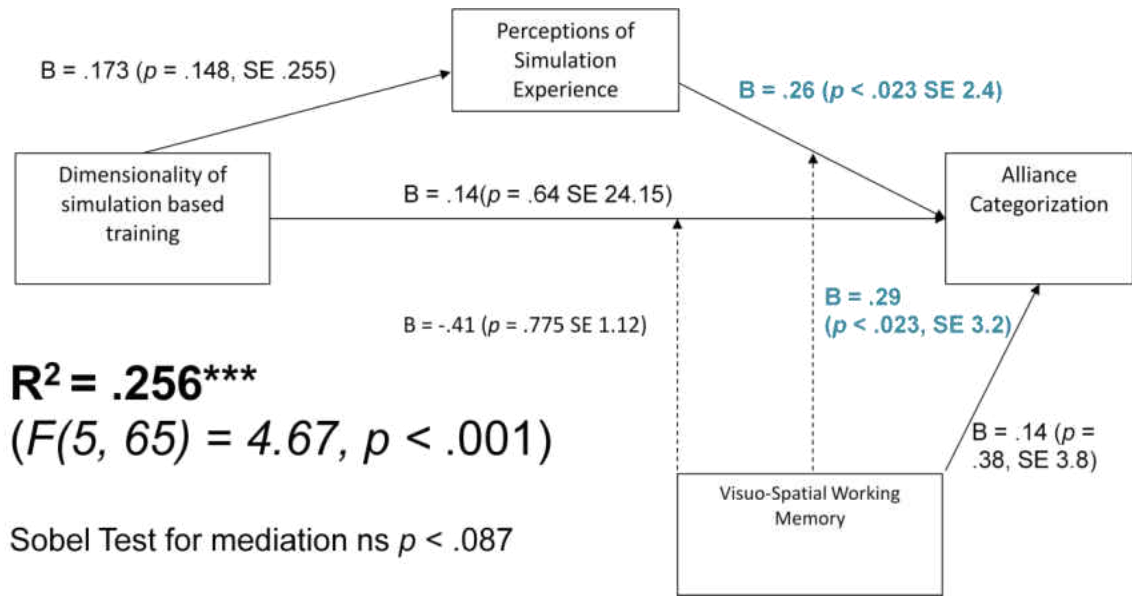


Figure 19. Regression and mediation analysis predicting alliance categorization

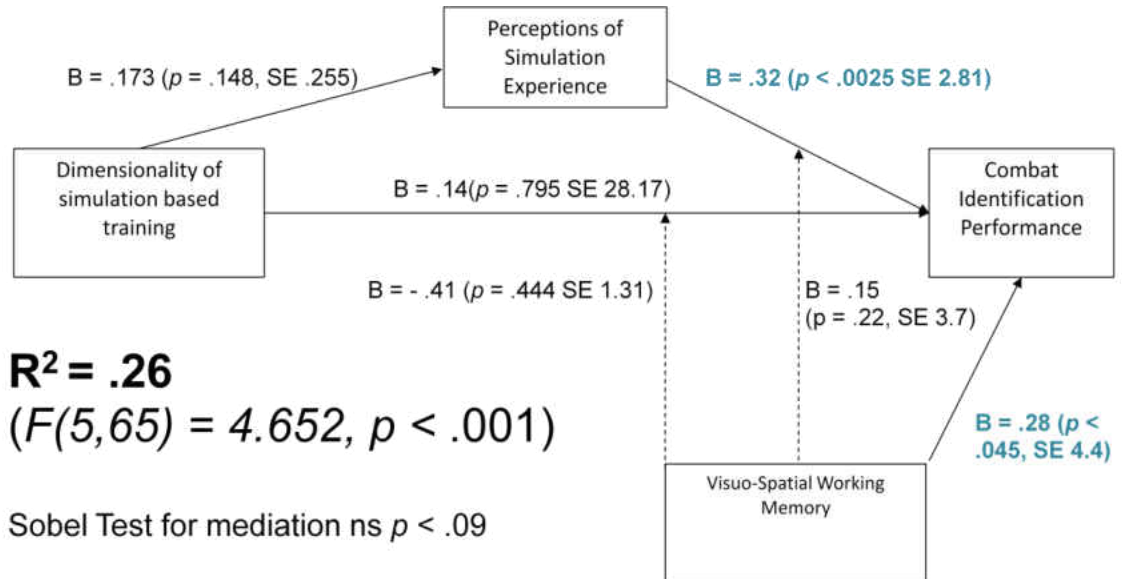


Figure 20. Regression and mediation analysis predicting combat identification performance

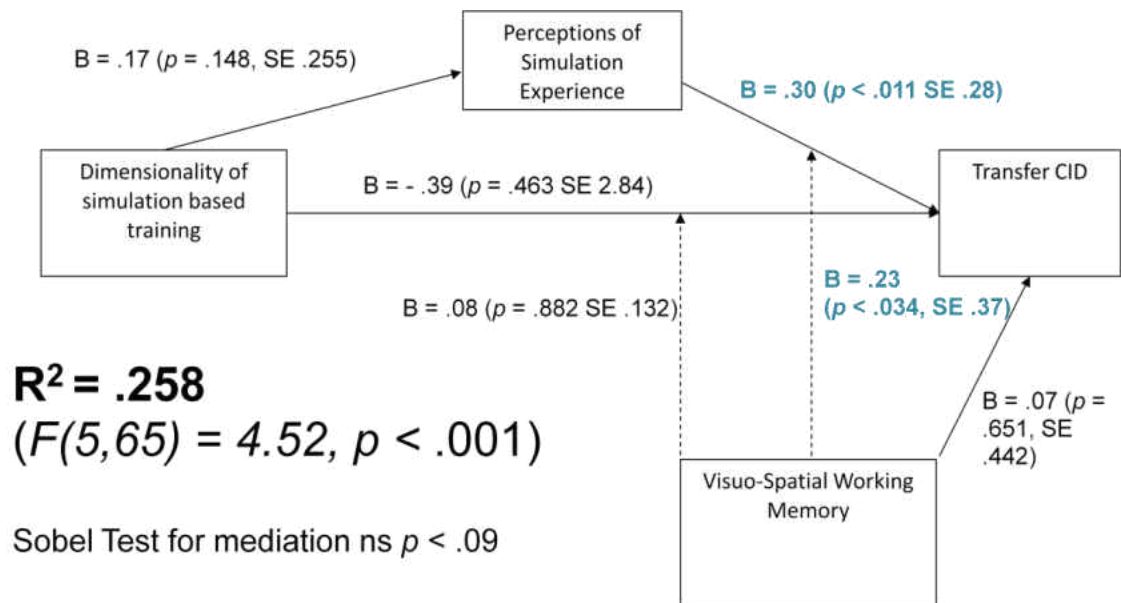


Figure 21. Regression and mediation analysis predicting transfer combat identification performance

Training Analyses

Due to a major impetus of this experiment being aimed at examining the effectiveness of the SBT developed during this dissertation, the final measures of performance were regressed onto the variables above with the addition of performance on the training assessment. During training, participants were measured on their ability to recognize isolated components of the vehicles they studied using a military vehicle working memory measure (described in the method). It must be mentioned that this measure was only in 2D (line-drawings) and therefore could be problematic at measuring 3D learning. An exploratory regression was conducted examining the effects of the training assessment included in predicting the CID performance measure and the final transfer CID outcome measure. No hypotheses were formulated for this portion of the analysis, due to the entirely exploratory nature of the regression models used. Findings indicate that dimensionality of training, VSWM, enjoyment, training performance and post-training performance were able to predict over 80% of the variance in the transfer task.

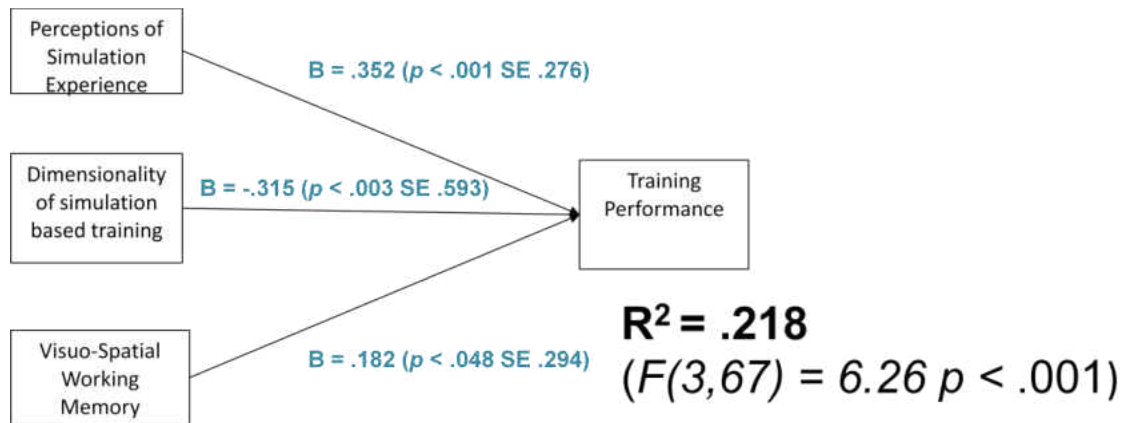


Figure 22. Regression analysis predicting training performance

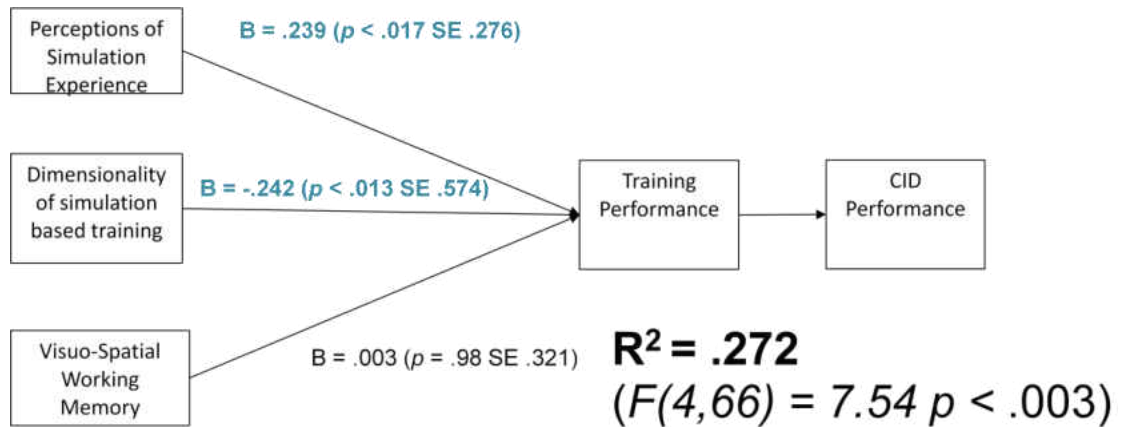


Figure 23. Regression analysis predicting combat identification performance

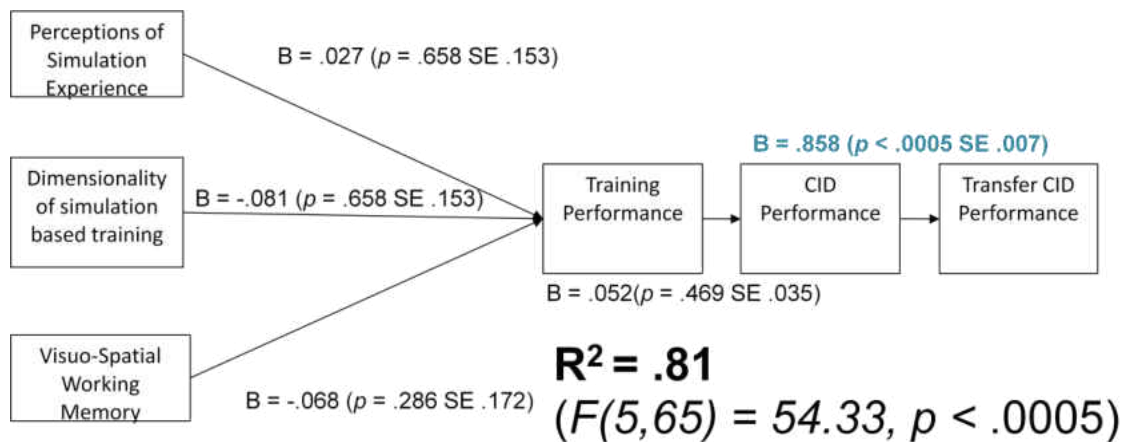


Figure 24. Regression analysis predicting transfer combat identification performance

CHAPTER 5: DISCUSSION

In this study the effects of individual differences in visuo-spatial working memory and simulation enjoyment, alongside their interactions with a 2D/3D display system, were assessed in an object learning task. Specifically, individuals were trained, through a SBT, on twelve distinct armored combat vehicles and then asked to categorize and identify images and videos of these vehicles. A theoretical model based on information processing and previous work on object identification was constructed and analyzed to better understand the relationship between the measured factors.

The original proposed model containing flow and technology acceptance as separate variables was collapsed using an EFA to a large amount of related variables being added to the study after the original dissertation. Testing of the model was conducted across the dependent variables associated with photographs (alliance categorization and identification) and videos (transfer identification). The proposed model was a significant predictor of performance on all analyzed outcome variables. Major findings indicate that VSWM is a relevant individual difference and significant predictor in the performance tasks; enjoyment of the simulation-based training was also a consistent significant predictor, and may be the most important factor in predicting outcomes. Also, training effectiveness measures proved to be predictors of later performance, with an overall model including dimensionality of training, enjoyment, VSWM, training and initial testing predicting over 80% of the variance in the final transfer task.

Overall, three out of the seven proposed hypotheses were supported. **H1**, or the prediction of retention by VSWM, was supported across the three analyzed variables: alliance categorization, combat identification, and transfer combat identification. VSWM was consistently a significant predictor of all of the measured DV's. **H2**, which examined the interaction between VSWM and perceptions of simulation experience, was also significantly predictive in the case of alliance

categorization and transfer combat identification. H5, which was associated with effects of perceptions of simulation experience on retention, was also a significant predictor, and was the strongest of the predictors across the proposed analyses.

All hypotheses associated with the manipulation of 3D were either not-supported, or were significant in the opposite direction. This led to a failure in H2 (dimensionality to retention); H3 (interaction between VSWM and dimensionality to retention); H4 (dimensionality to perceptions of simulation experience); and H6 (perceptions of simulation experience mediation between dimensionality and retention). As discussed later, the fact that the effects of 3D were not significant, or in some cases opposite of what was predicted, has important implications for future work.

The exploratory analyses presented at the end of the results section demonstrate the effectiveness of the during-training assessments on later performance. One sub-goal of this dissertation was to develop a comprehensive object training based on the small body of extant literature focused on this type of task. Given the results of the exploratory analysis, this system seems suitable for effective training in the domain of combat identification. Also, the high amount of prediction provided by the combat identification measure (144 photographs) on the transfer combat identification measure (12 videos) shows there may be value in these tasks for estimating training outcomes before operational performance occurs.

Theoretical Implications

Implications for 3D training

All hypotheses associated with 3D systems proposed in this dissertation failed or indicated results that were in the opposite direction of predicted patterns. Therefore, 3D may not be as important or relevant as it seems to have become in both scientific and cultural realms. In fact, 2D demonstrated significantly better outcomes on multiple dependent variables, indicating that 3D in

many ways can detract from learning and later performance. This evidence is in support of previous research by Cockburn and McKenzie (2002), in which they found interfaces containing 3D were more “cluttered” and less efficient. Also, the lack of support for 3D enhancing performance outcomes is in-line with the findings of Garg and colleagues (2002), in which 2D training outperformed 3D training using visualizations of wrist anatomy.

Unlike previous work conducted by the author (Keebler et al., 2007; Keebler et al. 2009) in which 1:35 scaled models were used, this study used computer generated images that were forced into stereoscopy through a COTS shutter glass system created by NVIDIA. The implications of this are that there are fundamental differences between an on-screen 3D object and an actual 3D object.

Initially, it could be argued that the stereoscopic properties of an on-screen object do not equate to the stereoscopic properties of an actual object. Furthermore, 1:35 scale objects, which have consistently been found to lead to stronger training outcomes compared to “2D” materials (e.g. training cards, on-screen computer images) also contain other cues that could aid in learning, such as: scaled size, leading to observation of viewpoints not available even on an actual full size vehicle (e.g. bird’s eye view); physicality, allowing individuals to hold and manipulate the object, and therefore, learn through possible haptic or proprioceptive channels; entrance of the training material into the confines of the horopter, where objects can be brought through the horizontal asymptote of the horopter and out again, leading to control over the level of stereopsis and associated depth cues. The latter is fundamentally different from the SBT used in this study, whereas simulated vehicles on-screen are arguably *outside* the horopter due to perceived distances in the simulation.

Implications for cognitive training techniques

The techniques for training novel objects/armored vehicles developed by Gauthier, Bramley and Biederman have shown to be a sound methodology for use as a basis for the training developed in this dissertation. Specifically, an amalgam of previous work by all three authors led to an emergent gestalt methodology that led to quick acquisition times (< approximately 40 minutes) of the visual details of the vehicles. Those who trained well in the simulation performed well, and this could be mostly predicted before performance ever occurs in the operational environment. Also, the training assessment used in the exploratory analysis described at the end of the results was specifically developed to test critical cue knowledge (Biederman, 1986). Performance on this measure was a key indicator of learning and later performance on both the combat identification measure and the transfer identification measure.

Implications for the VPT and VSWM in SBT

The Visual Patterns Test (VPT; Dell Salla, et al. 2007) proved to be a valuable measure of individual differences in VSWM. Even though this test was created to measure deficiencies in individuals with agnosia and traumatic brain injuries (TBI's) and other types of visuo-cognitive impairments, it should be applied to measure individual differences in healthy adults as well. This measure was predictive of performance in a domain specific task (armored vehicle identification), and therefore, results of this test actually measure individual differences in VSWM capacity, and should generalize to other domains as well. Future work will need to utilize this test for other operational/applied domains that use visual resources to find if this indicator of external validity is substantive across multiple domains.

The fact that VSWM was a predictor across multiple tasks in this experiment also supports the theory of Information Processing. Indeed, individuals with a higher VSWM outperformed individuals with lower VSWM, demonstrating that memorization of novel objects requires the use of the visuo-spatial sketchpad for construction of deeper memory stores.

Implications for perceptions of simulation experience in SBT

This dissertation examined multiple measures of the human interaction-experience in a SBT. Although presence, immersion, engagement, technology acceptance and flow were all measured throughout this study, only technology acceptance and flow were used in the creation of a factor of perceptions of simulation experience for further analysis. This factor proved to be the most predictive construct throughout the proposed analysis, demonstrating the perceptions of simulation experience of training is relevant at least in memorization tasks.

Practical Implications

The MAVERICK (Military Armored Vehicle Expertise, Recognition, Identification, Classification and Knowledge) training system

The creation of a SBT to train military armored-vehicle recognition and identification was a sub-goal for this dissertation. Not only did this simulation provide acceptable learning outcomes, but metrics that measured performance, both throughout training and pre-transfer task, were highly predictive of final performance on a very realistic (videos of vehicles) transfer ID task. This indicates that the simulation can be used to train individuals to memorize and later identify military armored vehicles, and that performance within the framework of this simulation appears to have externally valid applications in the operational environment, given the performance on the video transfer task. This SBT and associated measures of performance were able to predict over 80% of the variance in the final transfer measure, and this could indicate that the simulation created within this study could provide guidelines for more effective training in object identification tasks.

In summary, this study examined the effects of individual differences (VSWM and simulation perceptions of simulation experience), and 3D stereoscopy on a highly visual learning task. Results indicated that individual differences played a much more important and predictive role

then the manipulation of stereoscopic training information. In fact, stereoscopy in some instances actually detracted from performance. The SBT used for this study contained metrics that were able to predict vast amounts of variance in a final transfer task, creating evidence that this simulation could be a practical solution for training armored vehicles.

Limitations of the Current Study

Limitations related to construct validity

Due to the nature of some of the measures used in this experiment (specifically the perceptions of simulation experience factor), there could be some threats present to the construct validity of the measured variables. Specifically, the EFA conducted in this study assumed that the high amount of overlap between the FSS-2 and the scales of the TAM indicated that they were both measuring a latent construct, namely perceptions of simulation experience. Due to the low sample size of this study and the use of exploratory factor analysis, this isn't necessarily true. Future research would need to further examine the relationship between these variables using stronger methodologies (CFA, SEM) and larger sample sizes.

Another threat to construct validity is in relation to the measurement of VSWM using the VPT. Although it seems that the VPT does measure variability in individual VSWM capacity, no other measures of this construct were present in the study. This leads to a lack of convergent/divergent construct validity, and could indicate that the VPT is in fact measuring either another construct entirely that leads to the same outcomes, or only measuring a component of VSWM.

Limitations related to external validity

There are many limitations of the current research in regards to its ability to generalize to other populations. Issues related to the sample of only males could limit the generalizability of this research, especially to a female population. Given this, it is still uncommon, at least in U.S.

conflicts, for females to be involved in combat operations (Center for Military Readiness, 2004 www.cmrlink.org/WomenInCombat.asp?DocID=237). Nevertheless, having a comprehensive model for human cognition of objects requires measurement of females as well, and this was not provided in the research study presented here.

Another issue related to the external validity of the findings is that associated with the transfer task used in this study (12 videos). The simulation provided robust predictive value on this final measure, but watching videos of vehicles in live operations is nowhere near the actual experience of live combat. Many more factors contribute to the confusion associated with the battle field (e.g. the fog of war, Raegan, 1995) and therefore, this work is limited in its capacity to generalize to these types of situations. Given this, it is important to realize that the training system proposed within this document does demonstrate strong predictive value for the memory formation needed to attain expert-like performance, and therefore, could serve as a guide for future robust simulations that could include highly realistic combat operations.

A third issue with the generalizability of this study is related to the population used. College students were sampled for this study, and although their average age was very similar to that of incoming military recruits (21.3 in this sample vs. 22 for military personnel in 2009), college students do not equate to military personnel. Further research would have to be conducted to investigate learning differences between these two unique populations. This would allow for the training devised here to be readily transferred to a more realistic population.

Yet another limitation of this study, and one that was originally captured in the initial proposal, is that of long-term retention. Although this study provided evidence for short length retention (approximately 1 hour) after studying, it is vital to ensure that training effects last for extended periods of time. This allows for a connection to be made between training and the operational environment over long time intervals. The original proposal of this dissertation

contained another set of dependent measures that were to be assessed at a two week interval. Unfortunately, only one individual in the first sixty participants signed-up to take part in this segment of the study, making it an un-attainable goal for this research. Hence it was canceled during the process of data collection. Future research on this topic could largely benefit from understanding the long term retention outcomes brought about by the training proposed in this dissertation.

Limitations related to results of 3D hypotheses

The null and negative results provided by the 3D condition were unexpected, and there are multiple reasons that 3D could have led to a decrement in performance. First, the 3D condition could have been distracting. Although the participants were supposed to be memorizing the vehicles, the individuals in 3D could have simply had their attention diverted due to the nature of the system. It is important to note here that 3D did not lead to more perceptions of simulation experience, so it is not clear that this distraction was enjoyable. In fact, if the participants believed the 3D training was distracting while participating, this could have definitely detracted from later performance. Also, the NVIDIA kit uses shutter-glass technology. The simple darkening of the lenses that occurs while interacting with this technology could have led to decrements in performance. A third variable that could have affected the outcomes related to the 3D system is that the training assessment used line drawing (2D) materials. If there is a fundamental difference between the 2D and 3D systems, the systematic studying of objects in 2D would be reinforced by the 2D assessment. Future work will need to create assessments in both 2D and 3D to reduce the confounding nature of this outcome.

Another issue with the 3D hypotheses results is that this was a SBT, and not a gaming environment. The fact that this study was aimed at strictly training memory could demonstrate that 3D may not be good for tasks of memorization. The addition of narrative, game play,

movement, etc. could all lead to entirely different outcomes in respect to the use of a 3D environment. Research that has been conducted on the effects of 3D stereoscopy in a gaming environment have in fact found that 3D, although preferred by participants, did not lead to higher performance outcomes than a comparable 2D environment (Litwiller & LaViola, 2011). Further research would need to examine the effects of 3D across a multitude of different gaming environments to further validate the study mentioned above, and to find whether there are differential effects based in games of different genres.

Directions for Future Research

There are many directions for future research given the findings of this study. Most importantly, the extension of this type of simulation based training to other domains would be a validating vein of research. If the model supported here could be supported in other fields of object expertise, it could aid in building a stronger comprehensive theory for object recognition expertise. Training in medical anatomy and screening, tool memorization, quality control of toys, etc., could all be assessed using the model proposed within this research. Future work would have to translate the findings and simulation based training technology to these new areas to ensure that the constructs measured do in fact remain valid predictors across differing areas of practice and knowledge.

Another venue for future research would be a need to re-examine the fundamental differences between 3D stereoscopy of digital displays compared to both 1:35 scale physical models and augmented reality objects. Augmented reality (*see* Azuma, 1997) is an emerging technology that allows computer generated imagery to be overlaid onto physical reality. This could allow for an examination of the differences between AR objects and actual objects, and could highlight the effects of haptic and proprioceptive learning. AR objects contain no mass or physicality aside from the fiducial marker which indicates their location, but they are fully

rendered visually onto an actual surface, making them manipulate-able as if they were a real object. AR objects are basically physical objects minus haptic/proprioceptive information. Also, contrasting these technologies to the 3D stereoscopic technology presented in this study would allow for effects of true stereoscopy associated with real objects to be studied against simulated stereoscopy within a digital display.

Future research will need to examine the experiential measures used in this dissertation, and specifically examine the validity of the results of the EFA used to construct the measure of perceptions of simulation experience. Through larger sampling and use of more powerful methods (CFA, SEM), a better grasp of the latent variables underlying perceptions of simulation experience within a simulation could be realized. Due to the high overlap between technology acceptance and flow, research will need to focus on whether these measures are actually unveiling the same latent constructs.

Probably the most important facet of future work would be moving the SBT into actual usage within a field setting. Studying the results of the proposed training on actual soldiers in more realistic field operations and training scenarios could aid in understanding how well the training transfers to an actual operational environment. Not only would this remedy the issue of knowing if this training is valid outside of the laboratory, but it would also inform the differences between college students and military personnel.

APPENDIX A MEASURES

A.1.1 Biographical Data Form

Identification Number _____

Biographical Data Form

Please complete the following questions. Any information you provide is voluntary and will be kept strictly confidential. A participant number will be assigned to your responses and in no way will your name be associated with the data. The information you provide will be used only for the purposes of this study. If you have any questions, please ask.

1. Age _____
2. Gender: M _____ F _____
3. Handedness: Right-handed _____ Left-handed _____ Ambidextrous (Both) _____
4. College GPA _____
5. SAT: Verbal _____ Math _____
6. Year in school (circle one) Freshman / Sophomore / Junior / Senior / Graduate
7. Major _____
8. Military experience (including ROTC), branch and length of time: _____
(Check all that apply) Active duty ___ National Guard ___ Reserve ___
9. Native language (if not English) _____
10. Do you wear prescription glasses? Yes ___ No ___
If yes, are you wearing them now? Yes ___ No ___
11. Do you wear prescription contact lenses? Yes ___ No ___
If yes, are you wearing them now? Yes ___ No ___
If yes, do you have *nearsightedness* (myopia) ___ or *farsightedness* (hypermetropia) ___?
Please indicate your *uncorrected* visual acuity _____
Please indicate your *corrected* visual acuity _____

12. Using the scale below, please indicate how you would rate your knowledge of *models of automobiles* (i.e. Ford Focus, Toyota Camry, Honda Civic, etc.):

1	2	3	4	5	6	7
NOT AT ALL FAMILIAR			SOMEWHAT FAMILIAR			VERY FAMILIAR

13. Using the scale below, please indicate how you would rate your knowledge of *models of military vehicles* (i.e. Leopard A6, M-3 Stuart, Stryker, etc.):

1	2	3	4	5	6	7
NOT AT ALL FAMILIAR			SOMEWHAT FAMILIAR			VERY FAMILIAR

14. Using the scale below, please indicate how you would rate your experience with *seeing* or *working with* any type of *video games*:

1	2	3	4	5	6	7
NOT AT ALL FAMILIAR			SOMEWHAT FAMILIAR			VERY FAMILIAR

15. Using the scale below, please indicate how you would rate your experience with *using* console type (PS2, XBOX, Etc.) *video game controllers*:

1	2	3	4	5	6	7
NOT AT ALL FAMILIAR			SOMEWHAT FAMILIAR			VERY FAMILIAR

A.1.2 Biographical Data Form (2)

16. Using the scale below, please indicate how you would rate your experience with *seeing or working with video games in a first person shooter format*:

1	2	3	4	5	6	7
NOT AT ALL FAMILIAR			SOMEWHAT FAMILIAR			VERY FAMILIAR

17. Using the scale below, please indicate how you would rate your level of knowledge regarding *US military vehicles*:

1	2	3	4	5	6
NOT AT ALL FAMILIAR					VERY FAMILIAR

18. Using the scale below, please indicate how you would rate your level of knowledge regarding *Foreign allied military vehicles (i.e. Polish, United Kingdom, etc.)*:

1	2	3	4	5	6
NOT AT ALL FAMILIAR					VERY FAMILIAR

19. Using the scale below, please indicate how you would rate your level of knowledge regarding *Foreign opposing military vehicles (i.e. Iraq, Iran, Bosnia, etc.)*:

1	2	3	4	5	6
NOT AT ALL FAMILIAR					VERY FAMILIAR

20. If you consider yourself familiar with military vehicles of any sort, please indicate on the lines below how you became familiar with them:

A.2.1.1 Card Rotation Test (CR-1)

Name _____

CARD ROTATIONS TEST — S-1 (Rev.)

This is a test of your ability to see differences in figures. Look at the 5 triangle-shaped cards drawn below.



All of these drawings are of the same card, which has been slid around into different positions on the page.

Now look at the 2 cards below:



These two cards are not alike. The first cannot be made to look like the second by sliding it around on the page. It would have to be flipped over or made differently.

Each problem in this test consists of one card on the left of a vertical line and eight cards on the right. You are to decide whether each of the eight cards on the right is the same as or different from the card at the left. Mark the box beside the S if it is the same as the one at the beginning of the row. Mark the box beside the D if it is different from the one at the beginning of the row.

Practice on the following rows. The first row has been correctly marked for you.

B										
		S <input checked="" type="checkbox"/> D <input type="checkbox"/>	S <input type="checkbox"/> D <input checked="" type="checkbox"/>	S <input checked="" type="checkbox"/> D <input type="checkbox"/>	S <input checked="" type="checkbox"/> D <input type="checkbox"/>	S <input type="checkbox"/> D <input checked="" type="checkbox"/>	S <input type="checkbox"/> D <input checked="" type="checkbox"/>	S <input type="checkbox"/> D <input checked="" type="checkbox"/>	S <input type="checkbox"/> D <input checked="" type="checkbox"/>	S <input type="checkbox"/> D <input checked="" type="checkbox"/>
C										
		S <input type="checkbox"/> D <input type="checkbox"/>	S <input type="checkbox"/> D <input type="checkbox"/>	S <input type="checkbox"/> D <input type="checkbox"/>	S <input type="checkbox"/> D <input type="checkbox"/>	S <input type="checkbox"/> D <input type="checkbox"/>	S <input type="checkbox"/> D <input type="checkbox"/>	S <input type="checkbox"/> D <input type="checkbox"/>	S <input type="checkbox"/> D <input type="checkbox"/>	S <input type="checkbox"/> D <input type="checkbox"/>
B										
		S <input type="checkbox"/> D <input type="checkbox"/>	S <input type="checkbox"/> D <input type="checkbox"/>	S <input type="checkbox"/> D <input type="checkbox"/>	S <input type="checkbox"/> D <input type="checkbox"/>	S <input type="checkbox"/> D <input type="checkbox"/>	S <input type="checkbox"/> D <input type="checkbox"/>	S <input type="checkbox"/> D <input type="checkbox"/>	S <input type="checkbox"/> D <input type="checkbox"/>	S <input type="checkbox"/> D <input type="checkbox"/>

Your score on this test will be the number of items answered correctly minus the number answered incorrectly. Therefore, it will not be to your advantage to guess, unless you have some idea whether the card is the same or different. Work as quickly as you can without sacrificing accuracy.

You will have 3 minutes for each of the two parts of this test. Each part has 1 page. When you have finished Part 1, STOP. Please do not go on to Part 2 until you are asked to do so.

DO NOT TURN THIS PAGE UNTIL ASKED TO DO SO.

A.2.1.2 Card Rotation Test (CR-1)

Part 1 (3 minutes)

1.								
		SODD	SODD	SODD	SODD	SODD	SODD	SODD
2.								
		SODD	SODD	SODD	SODD	SODD	SODD	SODD
3.								
		SODD	SODD	SODD	SODD	SODD	SODD	SODD
4.								
		SODD	SODD	SODD	SODD	SODD	SODD	SODD
5.								
		SODD	SODD	SODD	SODD	SODD	SODD	SODD
6.								
		SODD	SODD	SODD	SODD	SODD	SODD	SODD
7.								
		SODD	SODD	SODD	SODD	SODD	SODD	SODD
8.								
		SODD	SODD	SODD	SODD	SODD	SODD	SODD
9.								
		SODD	SODD	SODD	SODD	SODD	SODD	SODD
10.								
		SODD	SODD	SODD	SODD	SODD	SODD	SODD

DO NOT TURN THIS PAGE UNTIL ASKED TO DO SO.

STOP.

A.2.1.3 Card Rotation Test (CR-1)

Part 2 (3 minutes)

11.									
	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
12.									
	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
13.									
	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
14.									
	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
15.									
	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
16.									
	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
17.									
	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
18.									
	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
19.									
	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
20.									
	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

DO NOT GO BACK TO PART 1 AND

DO NOT GO ON TO ANY OTHER TEST UNTIL ASKED TO DO SO.

STOP.

A.2.1.4 Card Rotation Test (CR-1)

Card Rotation Test Answer Key- Part 1

1. D	S	S	D	D	S	D	S
2. S	S	S	D	S	S	S	S
3. S	D	D	D	S	S	S	D
4. S	S	D	S	D	D	D	S
5. D	S	D	D	S	S	D	S
6. S	D	S	S	S	S	D	D
7. S	D	S	D	D	S	S	S
8. D	D	S	S	D	S	D	D
9. D	D	S	S	D	S	S	D
10.S	D	D	S	D	D	S	S

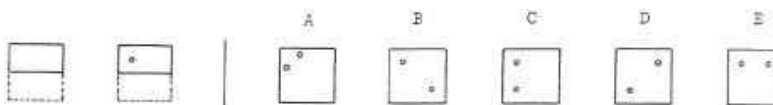
A.2.2.1 Paper Folding Test (VZ-2) (Instructions)

Name _____

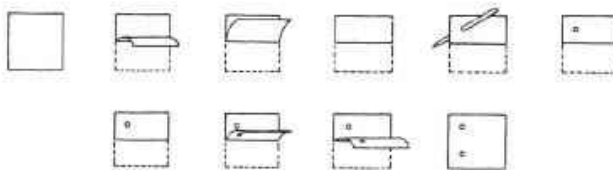
PAPER FOLDING TEST — VZ-2

In this test you are to imagine the folding and unfolding of pieces of paper. In each problem in the test there are some figures drawn at the left of a vertical line and there are others drawn at the right of the line. The figures at the left represent a square piece of paper being folded, and the last of these figures has one or two small circles drawn on it to show where the paper has been punched. Each hole is punched through all the thicknesses of paper at that point. One of the five figures at the right of the vertical line shows where the holes will be when the paper is completely unfolded. You are to decide which one of these figures is correct and draw an X through that figure.

Now try the sample problem below. (In this problem only one hole was punched in the folded paper.)



The correct answer to the sample problem above is C and so it should have been marked with an X. The figures below show how the paper was folded and why C is the correct answer.



In these problems all of the folds that are made are shown in the figures at the left of the line, and the paper is not turned or moved in any way except to make the folds shown in the figures. Remember, the answer is the figure that shows the positions of the holes when the paper is completely unfolded.

Your score on this test will be the number marked correctly minus a fraction of the number marked incorrectly. Therefore, it will not be to your advantage to guess unless you are able to eliminate one or more of the answer choices as wrong.

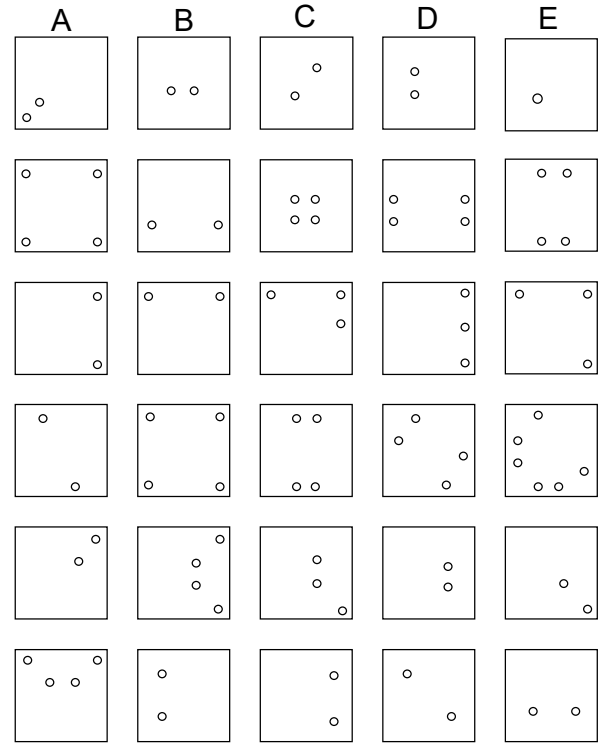
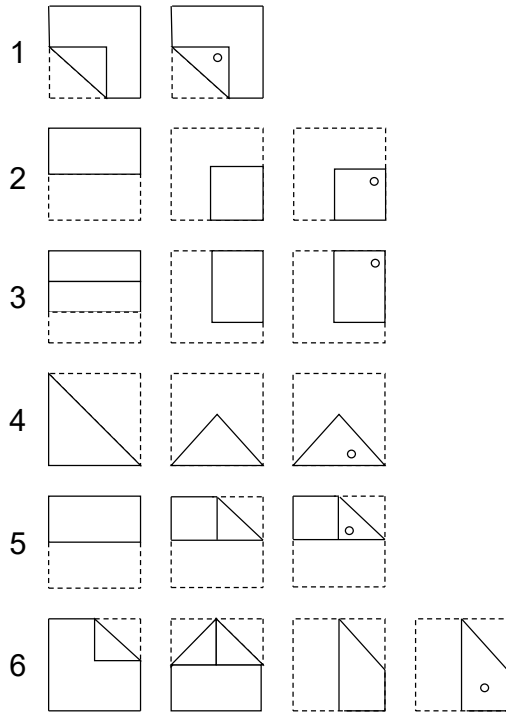
You will have 3 minutes for each of the two parts of this test. Each part has 1 page. When you have finished Part 1, STOP. Please do not go on to Part 2 until you are asked to do so.

DO NOT TURN THIS PAGE UNTIL ASKED TO DO SO.

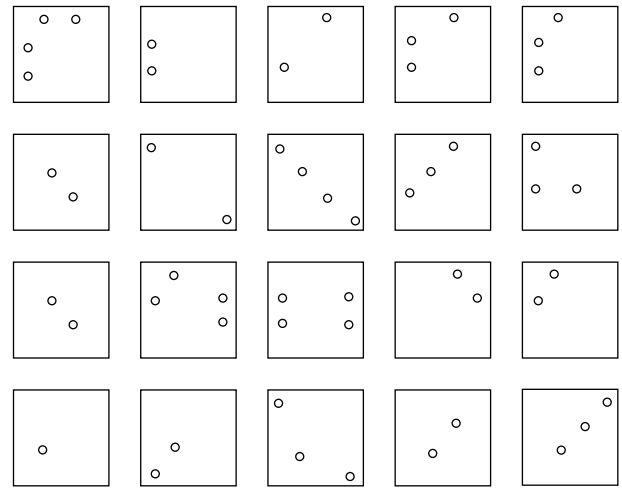
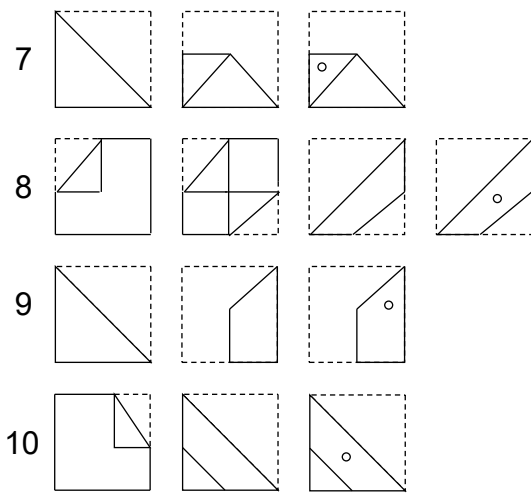
Copyright © 1962 by Educational Testing Service. All rights reserved.

A.2.2.2 Paper Folding Test (VZ-2)

Part 1 (3 minutes)



A.2.2.3 Paper Folding Test (VZ-2)



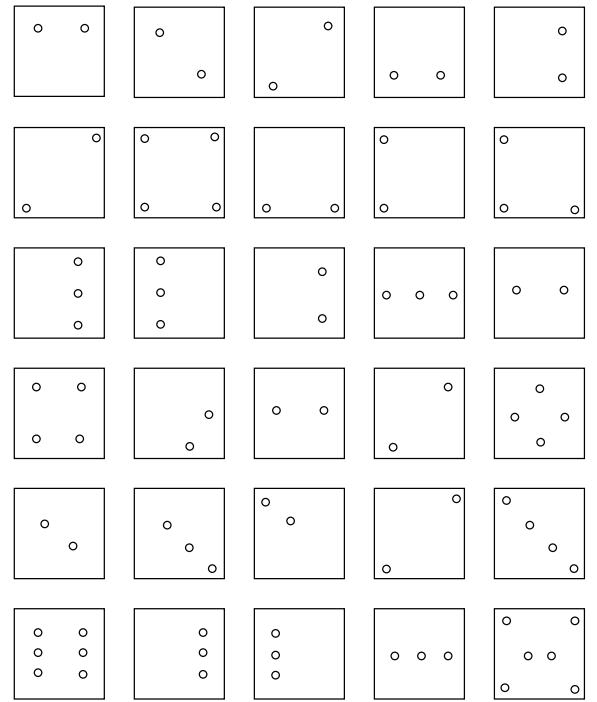
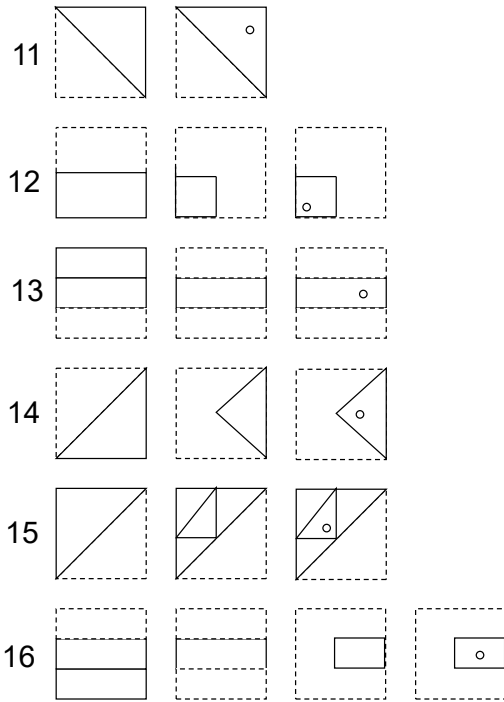
STOP.

DO NOT GO BACK TO PART 1, AND DO NOT GO ON TO ANY OTHER TEST UNTIL ASKED TO DO SO.

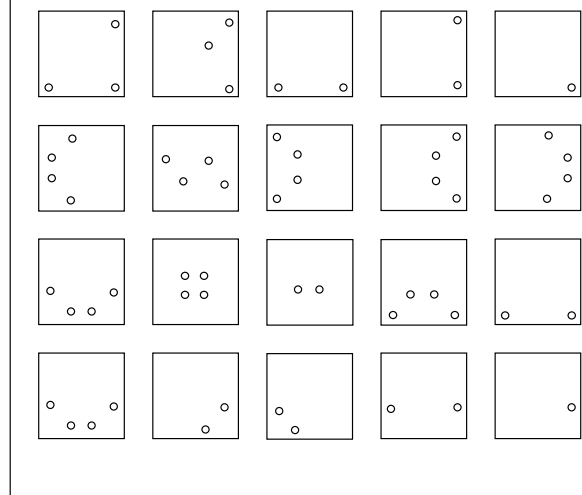
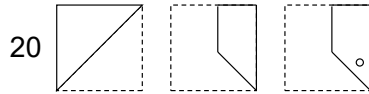
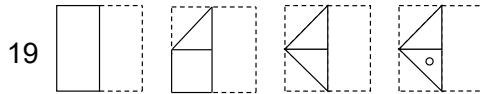
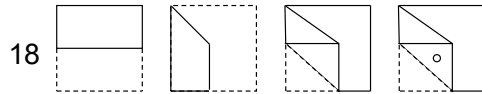
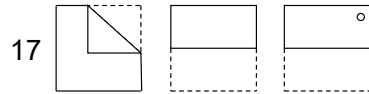
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A.2.2.4 Paper Folding Test (VZ-2)

Part 2 (3 minutes)



A.2.2.5 Paper Folding Test (VZ-2)



STOP.

DO NOT GO BACK TO PART 1, AND DO NOT GO ON TO ANY OTHER TEST UNTIL ASKED TO DO SO.

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A.2.2.6 Paper Folding Test (VZ-2) (Answer Key)

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Paper Folding Test -- VZ-2

Part 1

1. A
2. D
3. B
4. D
5. B
6. E
7. A
8. C
9. E
10. E

Part 2

11. C
12. B
13. A
14. E
15. B
16. A
17. E
18. D
19. D
20. C

A.3.1.1 Visual Performance Test (VPT)

Instructions

8 Visual Patterns Test

Using the VPT

3 Using the VPT

3.1 Test materials

In the vpt, the subject is presented with checkerboard patterns, which are designed to be difficult to code verbally (Phillips, 1983). There are two parallel sets of patterns, Set A and Set B, corresponding to two parallel forms of the test, version A and version B, respectively. The material used in both versions was developed in a series of pilot studies aimed at producing similar overall levels of memorability for the two sets.


A visual pattern is created by filling in half the squares in a grid. The grids progress in size from the smallest, a 2×2 matrix (with two filled squares), to the largest, a 5×6 matrix (with 15 filled squares), complexity being steadily increased by adding two more squares to the previous grid. The level of complexity of a pattern is defined as the number of filled squares in a grid, and thus ranges from a minimum of 2 (for the 2×2 matrix) to a maximum of 15 (for the 5×6 matrix). In each set of patterns, there are three patterns at each level of complexity, carried in three grids of the same size and shape.

The patterns are displayed in a series of stimulus cards, numbered sequentially, each card bearing, on either side, an equivalent matrix belonging to one of the two parallel versions (A or B) of the test.

Each card is presented to the subject for three seconds, and then removed from view by placing it at the bottom of the pile, in order to preserve the order of the patterns.

In front of the subject is a response sheet, on which are printed blank grids corresponding exactly to the dimensions of those containing the patterns on the cards. (The response sheets are copied by the tester and folded longitudinally before being positioned in front of the subject.)

The materials include two blank cards, one of which is used to cover the tester's pile of stimulus cards, the other to cover the subject's completed responses as each is made.



tester

blank card to cover the subject's responses as they are completed

subject's response

folded response sheet

desk or table

subject

3.2 Testing procedure

The subject is presented with the response sheet, shown a practice card bearing a pattern, and given the following instructions, which can be repeated and amplified if necessary until they have been understood.

'This is a test of visual memory for patterns. You will be shown a pattern like this [indicate the example on the card] and asked to recall it by making marks in these blank squares [show the subject the appropriate blank grid]. You will only be shown the pattern for a short time, so you will have to concentrate hard in order to remember it. As soon as I cover up the pattern, you may start to respond. The patterns are simple to start with and become more complicated later.'

After each pattern has been presented, the subject attempts to reproduce it on a blank grid of the same size (and shape) as the one bearing the pattern. There are three patterns at each difficulty level. Each pattern is presented for three seconds, after which it is taken away or covered up and the subject responds by marking squares in the appropriate blank grid on the response sheet. There is no time limit for responding, and subjects may correct responses if they wish. Should the total number of squares filled in not equal the number of filled squares in the stimulus pattern, the subject should be encouraged to add or delete filled squares until the numbers agree.

After the subject has finished marking the squares, the target pattern should be uncovered. A pattern has been correctly recalled if all squares have been marked in the appropriate positions. The subject should be given feedback by the tester on each trial. Testing continues until the subject fails to recall correctly any of the three patterns at a given level of complexity; beyond that point, no further patterns are presented.

The entire testing procedure takes about ten minutes.

3.3 Scoring procedure

3.3.1 The raw visual span score

The subject's raw visual span is taken to be the level of complexity of (that is, the number of filled squares contained by) the largest grid with at least one of the three patterns correctly recalled. (For scientific research purposes, a more sensitive measure of recall would be provided by the mean of the complexities of, say, the last three patterns recalled. With the clinical setting in mind, however, the present convention of scoring recall on the basis of a success rate of at least one in three patterns at each difficulty level was followed, and the norms are based on that scoring system.)

3.3.2 Using the fifth percentile as a cut-off for identifying unusually low scores

Table 6 gives the percentiles of the distribution of vpt scores in the healthy population, corrected for age and education. Where a patient is of an age and level of education near the means of the sample (that is, about 42 years old, with about 13 years of formal education),

A.3.1.2 Visual Performance Test (VPT)

the raw vpt score can safely be located in the distribution by considering the percentiles in Table 6, rounded to the nearest whole number. (Should, however, the patient be elderly and with little formal education, an adjustment should be made to the raw vpt score, as described in Section 3.3.3 below.)

The clinician may decide to regard a score (duly corrected, if necessary, for age and education) as suggestive of a short-term visual memory impairment if it falls at or below the 5th centile. Indeed, should a score fall anywhere below the 10th centile, further investigation may be thought desirable.

3.3.3 Adjustment of the VPT score for age and number of years of formal education

With patients over 50, it is advisable to adjust the raw vpt score to allow for the effects of age and number of years of formal education. By regression methods (see the Appendix), a quantity K is calculated and the raw vpt score is adjusted by adding the value of K to the raw vpt score thus:

$$\text{Newscore} = \text{Rawscore} + K$$

The formula for K is discussed in the Appendix. For the convenience of the clinician, however, Table 8 gives the values of K for selected ages and numbers of years of formal education. For example, consider a patient, whom we shall call John, who has a raw score of 4 on the vpt. Let us also assume that John is 82 years of age and has had only 9 years of formal education. Entering Table 8 at the row and column for 82 years of age and 9 years of education respectively, we obtain the entry 2.6, which is the value of K. Applying the correction formula, we have

$$\text{Newscore} = \text{Rawscore} + K = 4 + 2.6 = 6.6$$

It can be seen from the table of percentiles (Table 6), that John's adjusted vpt score (6.6) lies between the 10th and 15th centiles of the distribution, and therefore outside the range of values within which a score raises the question of pathological impairment.

Although John's raw score on the vpt (4) is very low, the correction takes into consideration the fact that elderly

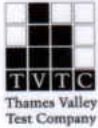
people generally have lower vpt scores than do young people; and this is also true of those who have had less formal education than is usual in the general population. A low score from such a person, therefore, need not occasion the concern that it would if the patient were young and well educated.

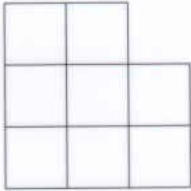
Age	Number of years of formal education					
	8	9	10	11	12	13
50	1.2	1.1				
51	1.3	1.1				
52	1.3	1.2	1.0			
53	1.4	1.2	1.1			
54	1.4	1.3	1.1			
55	1.5	1.3	1.2	1.0		
56	1.5	1.4	1.2	1.1		
57	1.6	1.4	1.3	1.1		
58	1.6	1.5	1.3	1.2		
59	1.7	1.5	1.4	1.2	1.0	
60	1.7	1.6	1.4	1.2	1.1	
61	1.8	1.6	1.5	1.3	1.1	
62	1.8	1.7	1.5	1.3	1.2	1.0
63	1.9	1.7	1.5	1.4	1.2	1.1
64	1.9	1.8	1.6	1.4	1.3	1.1
65	2.0	1.8	1.6	1.5	1.3	1.2
66	2.0	1.9	1.7	1.5	1.4	1.2
67	2.1	1.9	1.7	1.6	1.4	1.3
68	2.1	1.9	1.8	1.6	1.5	1.3
69	2.2	2.0	1.8	1.7	1.5	1.3
70	2.2	2.0	1.9	1.7	1.6	1.4
71	2.3	2.1	1.9	1.8	1.6	1.4
72	2.3	2.1	2.0	1.8	1.7	1.5
73	2.3	2.2	2.0	1.9	1.7	1.5
74	2.4	2.2	2.1	1.9	1.8	1.6
75	2.4	2.3	2.1	2.0	1.8	1.6
76	2.5	2.3	2.2	2.0	1.8	1.7
77	2.5	2.4	2.2	2.1	1.9	1.7
78	2.6	2.4	2.3	2.1	1.9	1.8
79	2.6	2.5	2.3	2.2	2.0	1.8
80	2.7	2.5	2.4	2.2	2.0	1.9
81	2.7	2.6	2.4	2.2	2.1	1.9
82	2.8	2.6	2.5	2.3	2.1	2.0
83	2.8	2.7	2.5	2.3	2.2	2.0
84	2.9	2.7	2.6	2.4	2.2	2.1
85	2.9	2.8	2.6	2.4	2.3	2.1
86	3.0	2.8	2.7	2.5	2.3	2.2
87	3.0	2.9	2.7	2.5	2.4	2.2
88	3.1	2.9	2.7	2.6	2.4	2.3
89	3.1	3.0	2.8	2.6	2.5	2.3
90	3.2	3.0	2.8	2.7	2.5	2.4
91	3.2	3.1	2.9	2.7	2.6	2.4
92	3.3	3.1	2.9	2.8	2.6	2.5
93	3.3	3.1	3.0	2.8	2.7	2.5
94	3.4	3.2	3.0	2.9	2.7	2.6
95	3.4	3.2	3.1	2.9	2.8	2.6

Table 8: Correction increments for VPT scores of subjects of selected ages and numbers of years of formal education. (To apply the correction, enter the table at the row and column corresponding to the subject's age and number of years of formal education, respectively, and add the value given in the cell to the raw VPT score.)

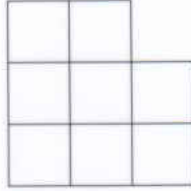
A.3.2.1 Visual Performance Test (VPT)

Answer Sheet

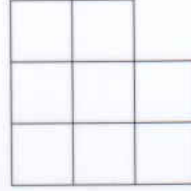
	Visual Patterns Test a test of short-term visual recall
RESPONSE SHEET	
<ul style="list-style-type: none">• You should photocopy each laminated response sheet.• Please remember to fold each photocopied response sheet along the dotted vertical line before presenting to the subject.• Please also use the long card provided to cover up the subject's responses as each is made.	
Name	<input type="text"/>
Age	<input type="text"/>
Gender	<input type="text"/>
Education level	<input type="text"/>
Date of test	<input type="text"/>
<hr/>	
Raw score	<input type="text"/>
Adjusted score	<input type="text"/>
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Pearson Assessment 80 Strand London WC2R 0RL	
ISBN 978 0 749133 092	




PRACTICE 1



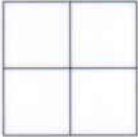
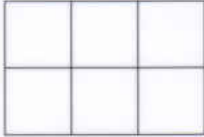
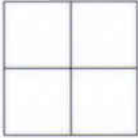
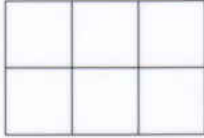
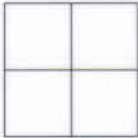
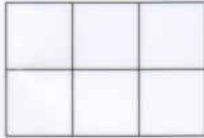
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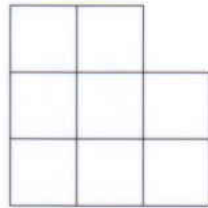
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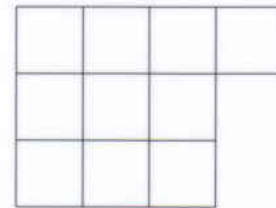
A3.2.2 Visual Performance Test (VPT)

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 <p>2(2)</p>	 <p>5(3)</p>
 <p>3(2)</p>	 <p>6(3)</p>

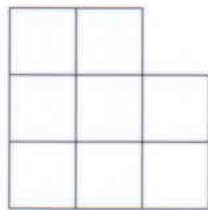
A.3.2.3 Visual Performance Test (VPT)



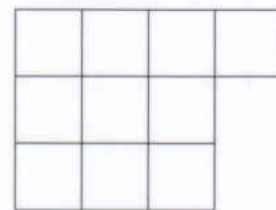
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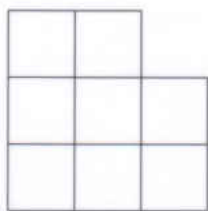
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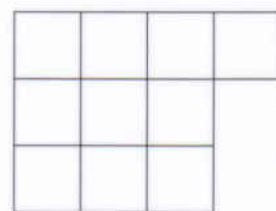
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11(5)

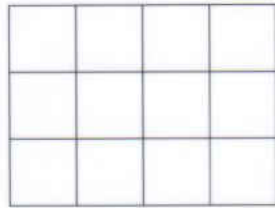


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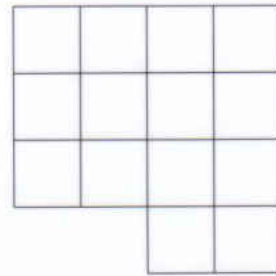


12(5)

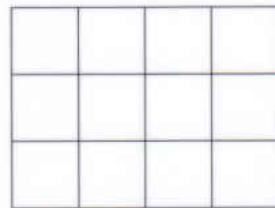
A.3.2.4 Visual Performance Test (VPT)



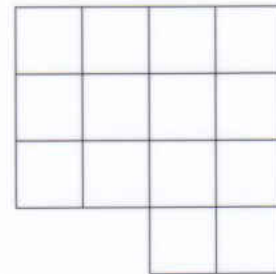
13(6)



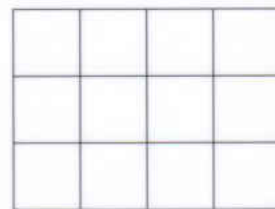
16(7)



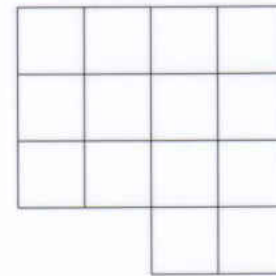
14(6)



17(7)

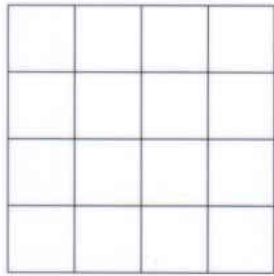


15(6)

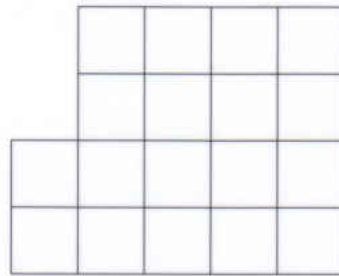


18(7)

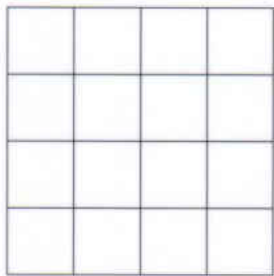
A.3.2.5 Visual Performance Test (VPT)



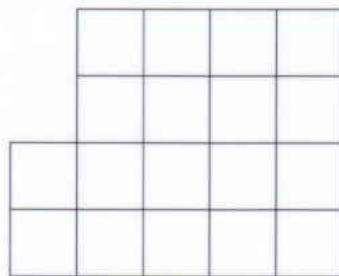
19(8)



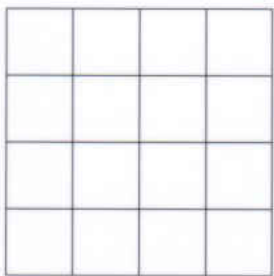
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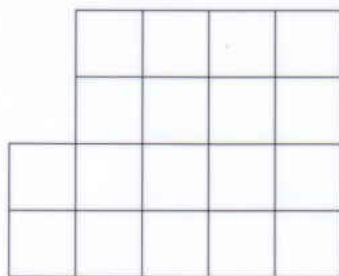
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23(9)

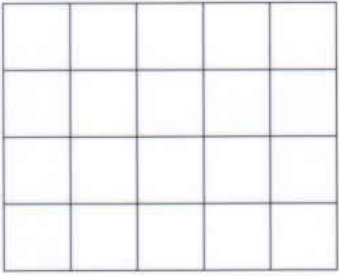
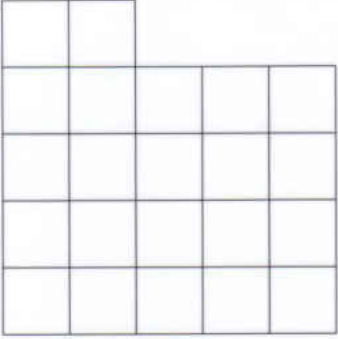
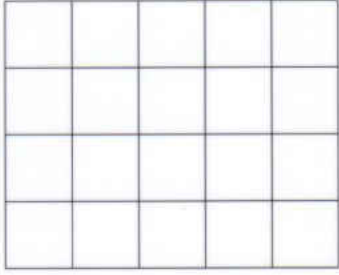
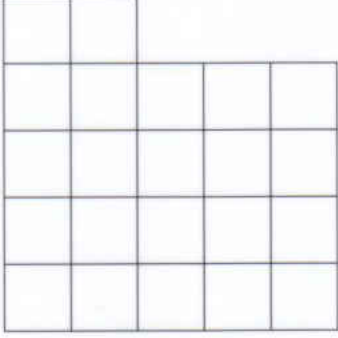
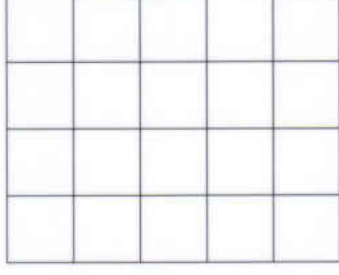
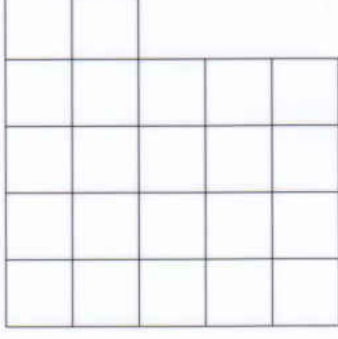


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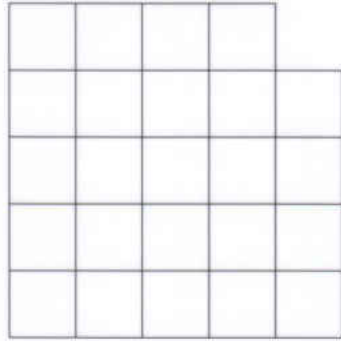


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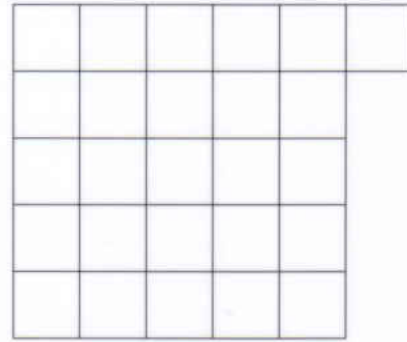
A.3.2.6 Visual Performance Test (VPT)

	
25(10)	28(11)
	
26(10)	29(11)
	
27(10)	30(11)

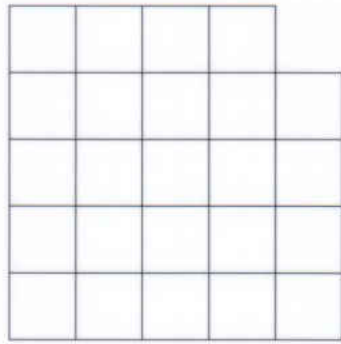
A.3.2.7 Visual Performance Test (VPT)



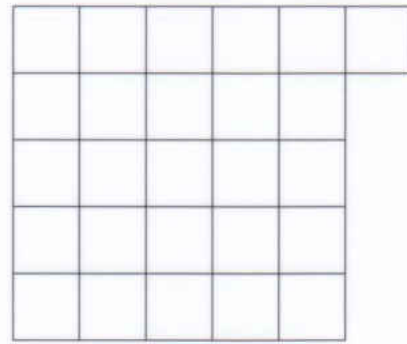
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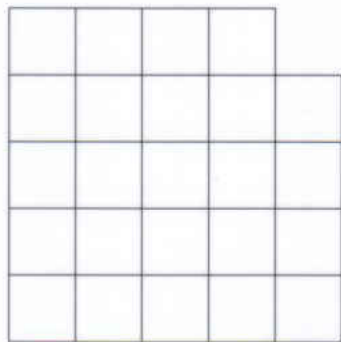
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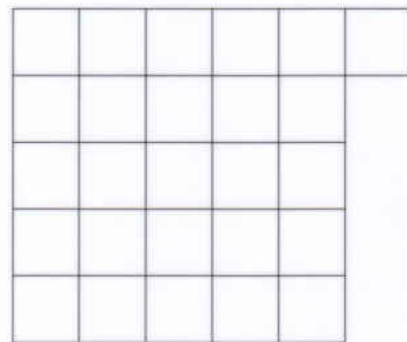
32(12)



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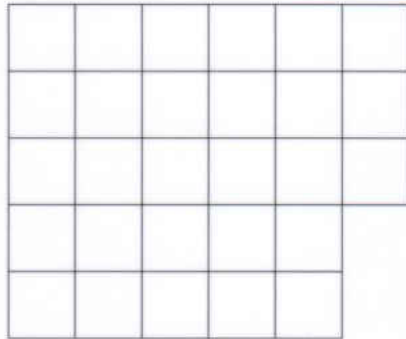


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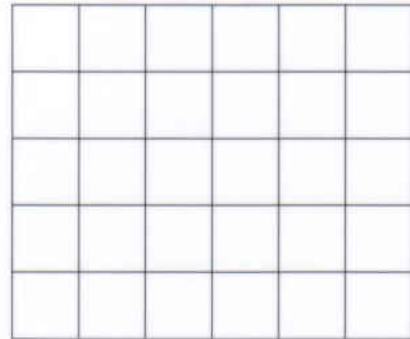


36(13)

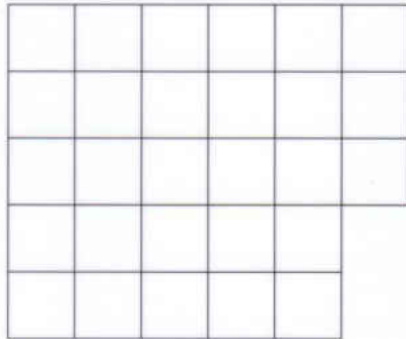
A.3.2.8 Visual Performance Test (VPT)



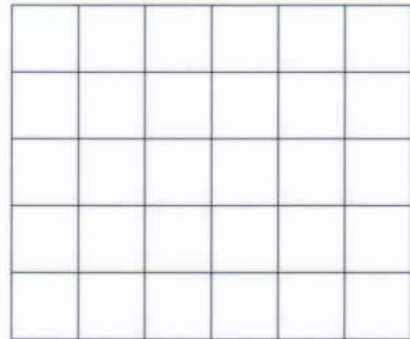
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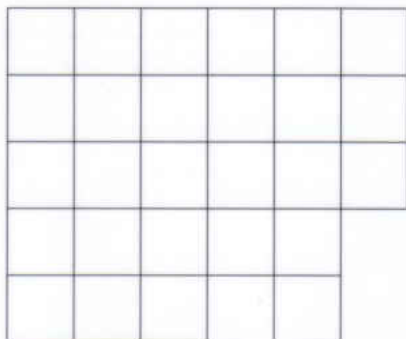
40(15)



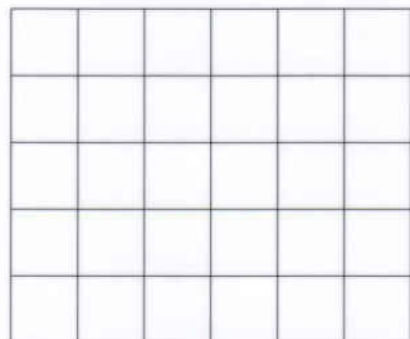
38(14)



41(15)



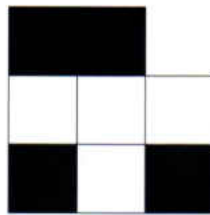
39(14)



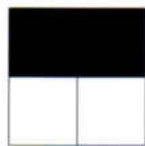
42(15)

A.3.3.1 Visual Performance Test (VPT)

Items

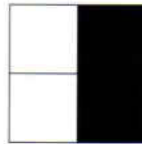


VISUAL PATTERNS TEST
VERSION A, PRACTICE CARD

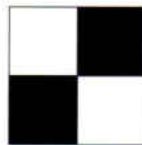


A1(2)

A.3.3.2 Visual Performance Test (VPT)



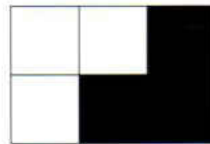
A2(2)



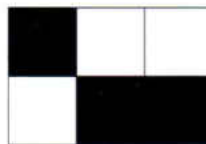
A3(2)



A.3.3.3 Visual Performance Test (VPT)

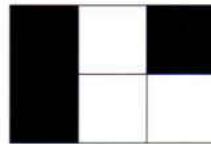


A4(3)

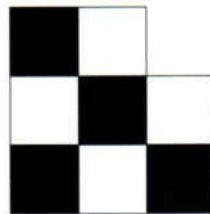
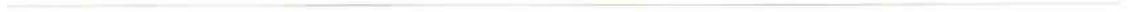


A5(3)

A.3.3.4 Visual Performance Test (VPT)

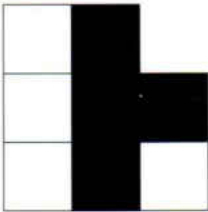


A6(3)

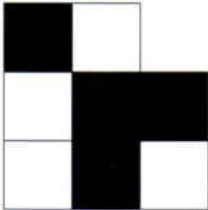


A7(4)

A3.3.5 Visual Performance Test (VPT)

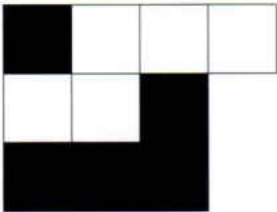


A8(4)

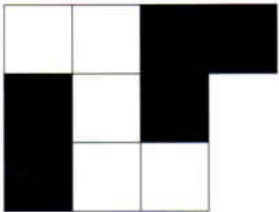


A9(4)

A3.3.6 Visual Performance Test (VPT)

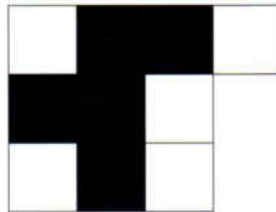


AIO(5)

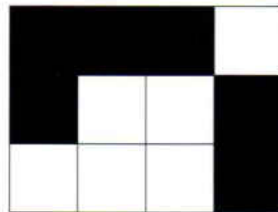


AII(5)

A3.3.7 Visual Performance Test (VPT)

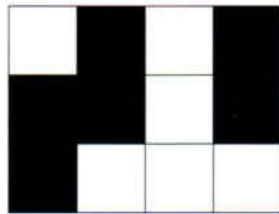


A12(5)

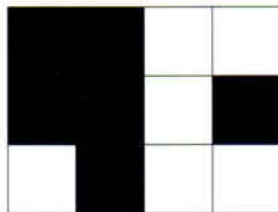


A13(6)

A3.3.8 Visual Performance Test (VPT)

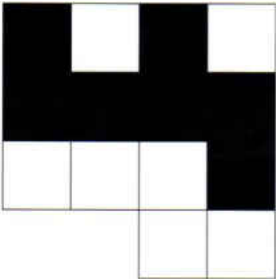


A14(6)

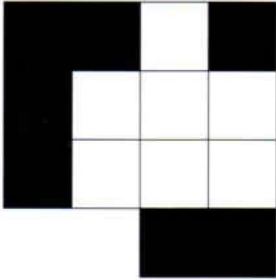


A15(6)

A3.3.9 Visual Performance Test (VPT)

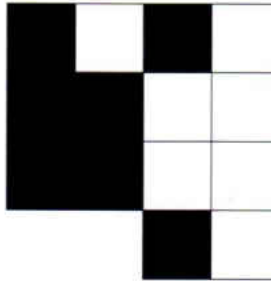


A16(7)

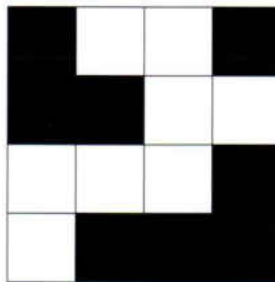


A17(7)

A3.3.10 Visual Performance Test (VPT)

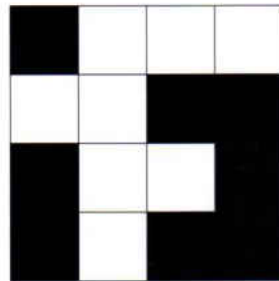


A18(7)

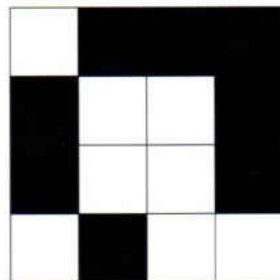


A19(8)

A3.3.11 Visual Performance Test (VPT)

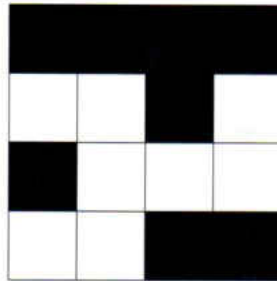


A20(8)

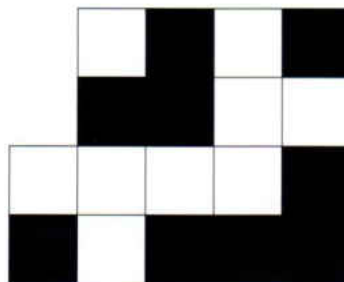


A21(8)

A3.3.12 Visual Performance Test (VPT)

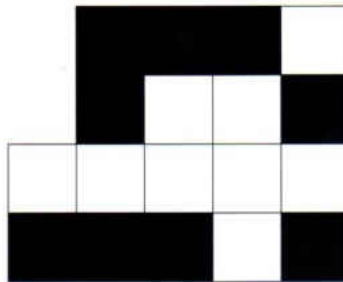


B21(8)

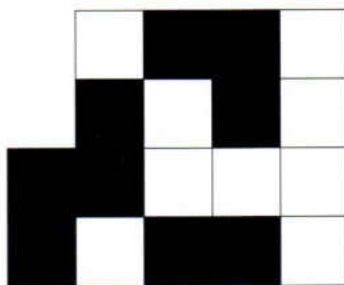


B22(9)

A3.3.13 Visual Performance Test (VPT)

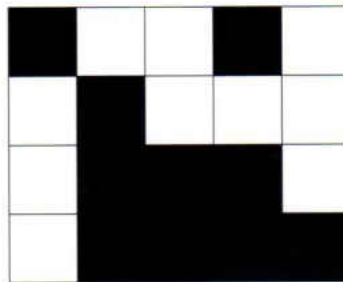


B23(9)

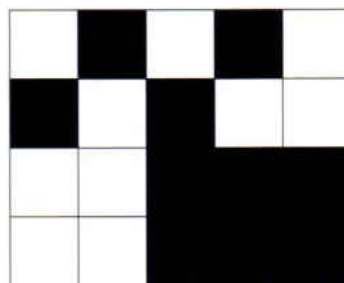


B24(9)

A3.3.14 Visual Performance Test (VPT)

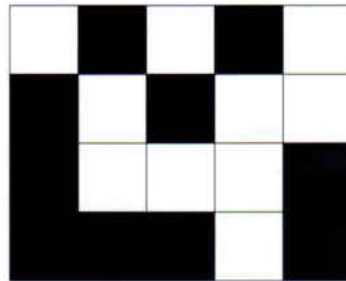


B25(10)

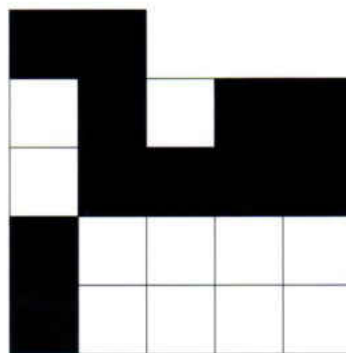


B26(10)

A3.3.14 Visual Performance Test (VPT)

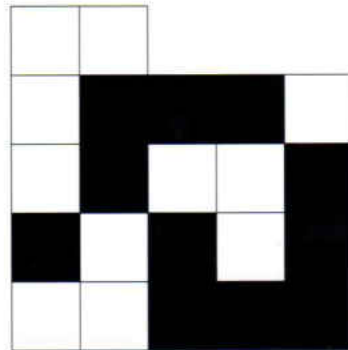


B27(10)

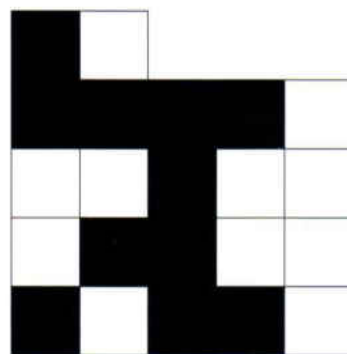


B28(11)

A3.3.15 Visual Performance Test (VPT)

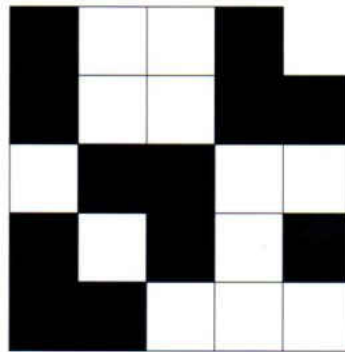


B29(II)

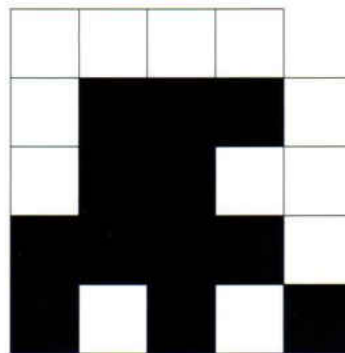


B30(II)

A3.3.16 Visual Performance Test (VPT)

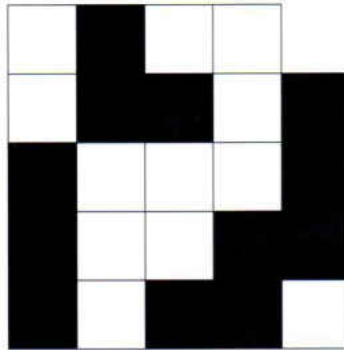


B31(12)

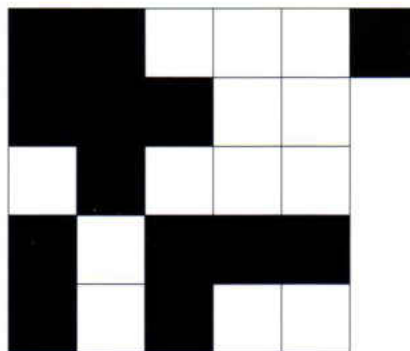


B32(12)

A3.3.17 Visual Performance Test (VPT)

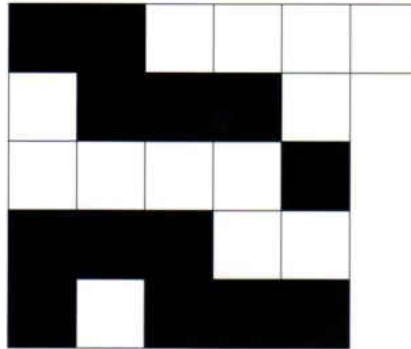


B33(12)

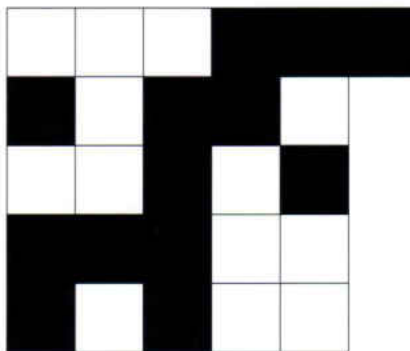


B34(13)

A3.3.18 Visual Performance Test (VPT)

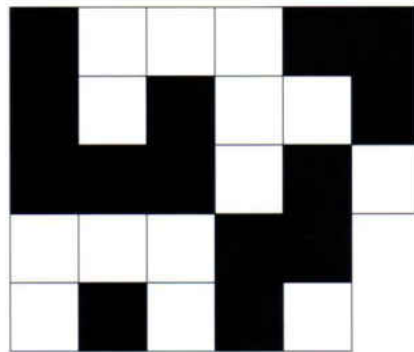


B35(13)

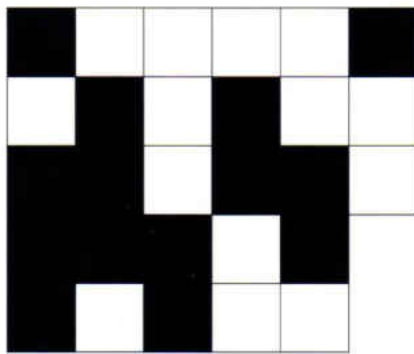


B36(13)

A3.3.19 Visual Performance Test (VPT)

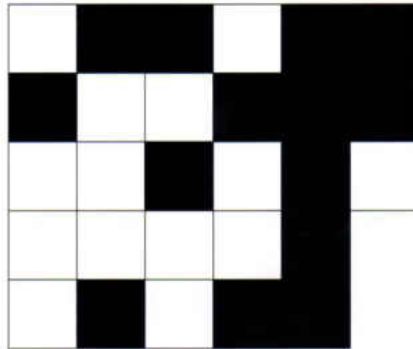


B37(I4)

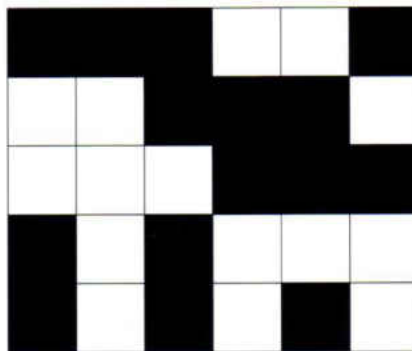


B38(I4)

A3.3.20 Visual Performance Test (VPT)

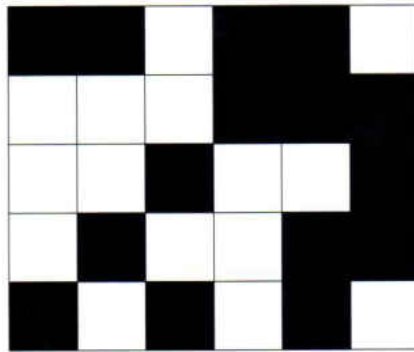


B39(14)

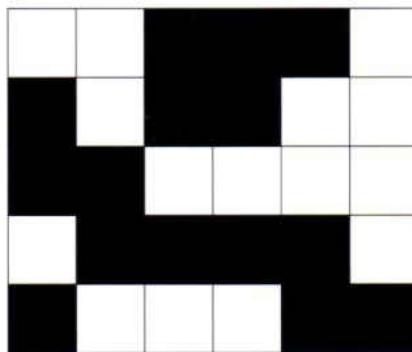


B40(15)

A3.3.21 Visual Performance Test (VPT)

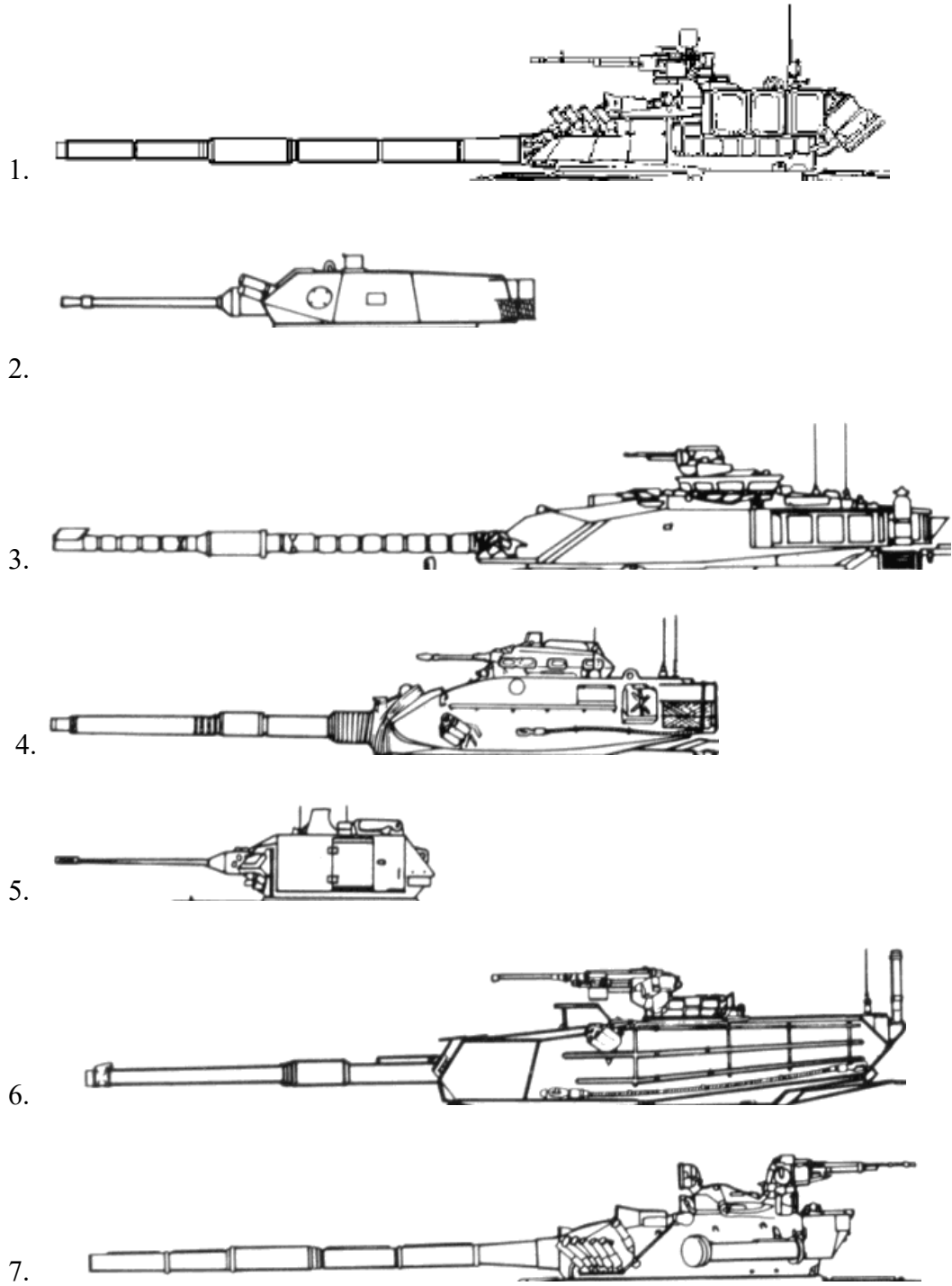


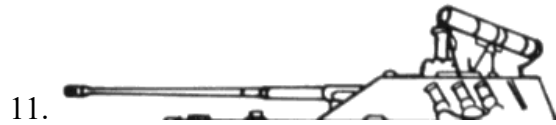
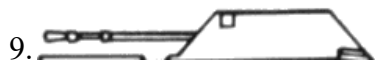
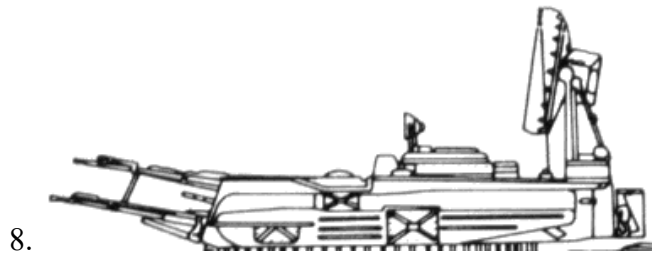
B41(15)



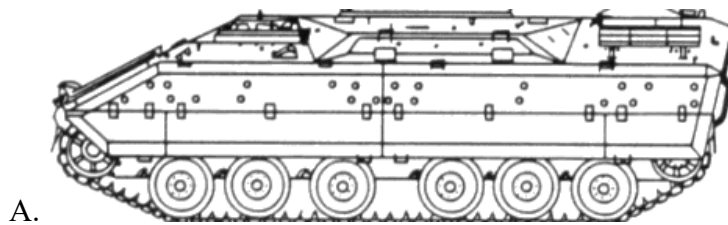
B42(15)

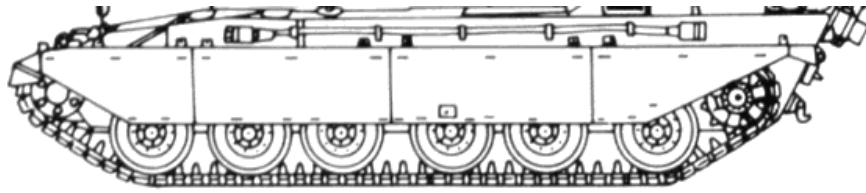
A.4.1.1 Military Vehicle Working Memory Measure (MVWWM) Turrets



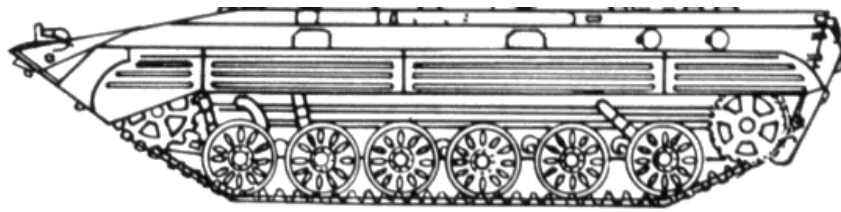


A.4.1.2 Military Vehicle Working Memory Measure (MVWWM) Chassis

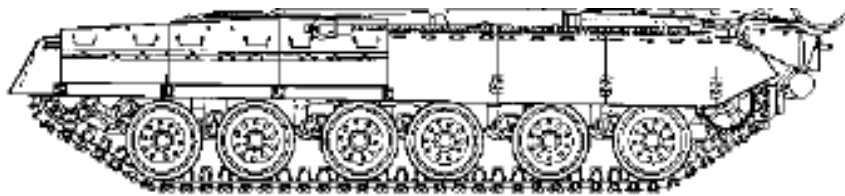




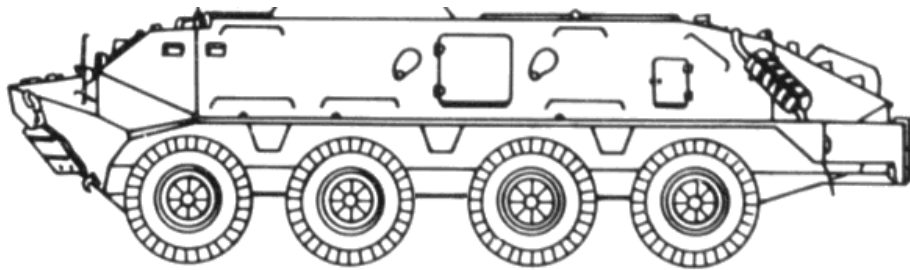
B.



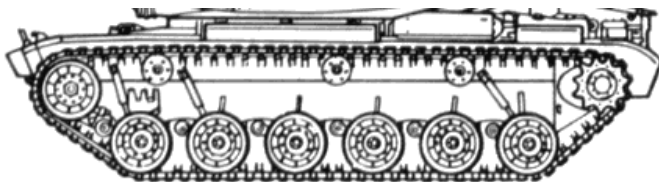
C.



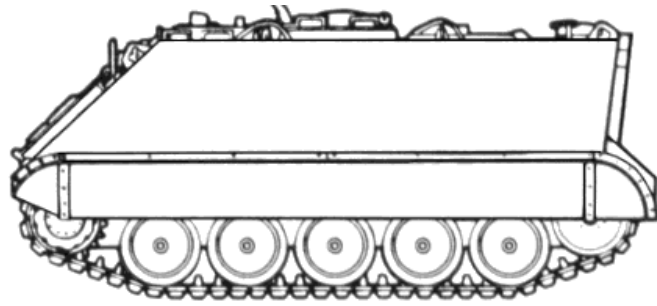
D.



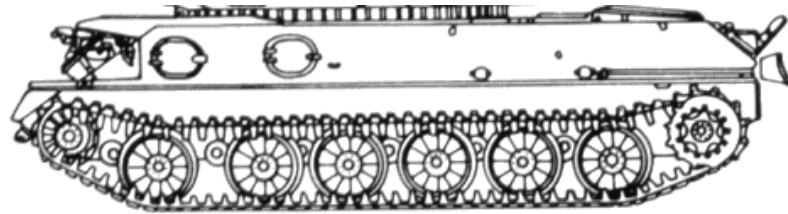
E.



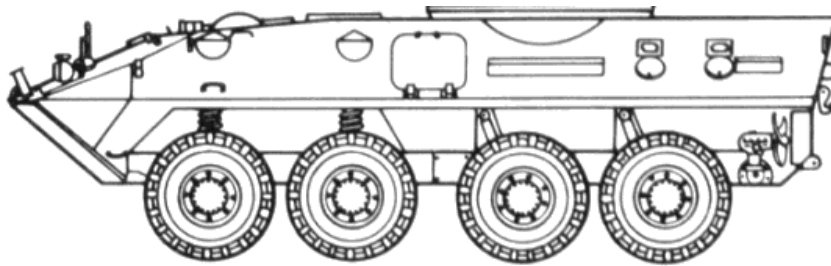
F.



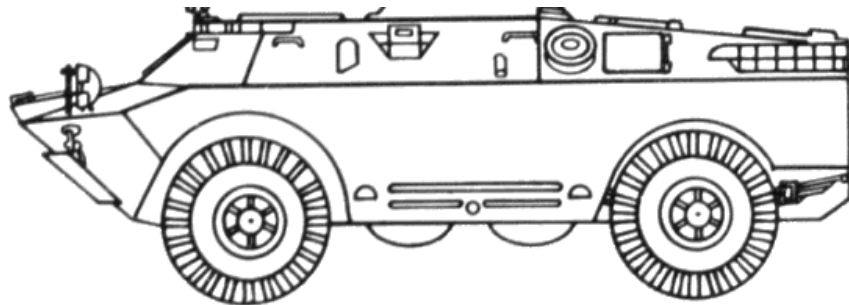
G.



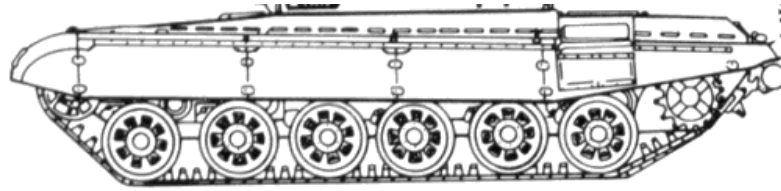
H.



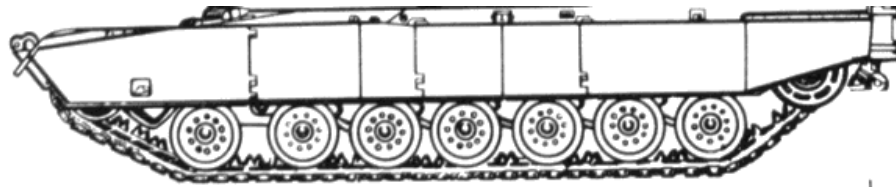
I.



J.

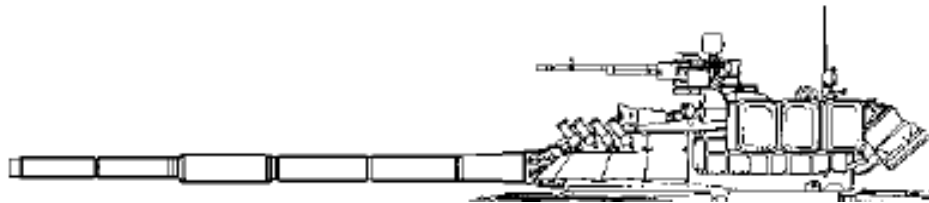


K.



L.

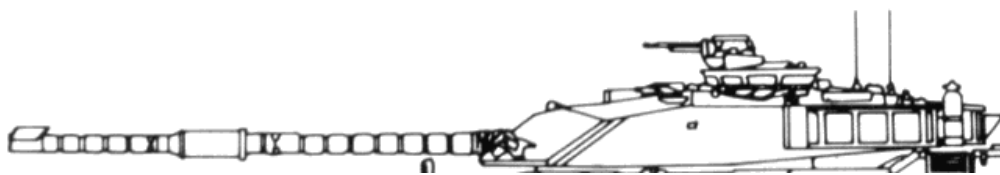
A.4.2.1 Military Vehicle Working Memory Measure (MVWWM) Turret Answers



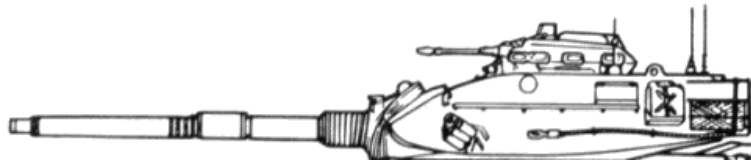
T-80= 1



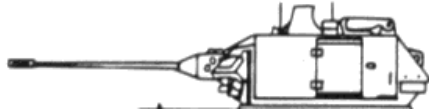
LAV =2



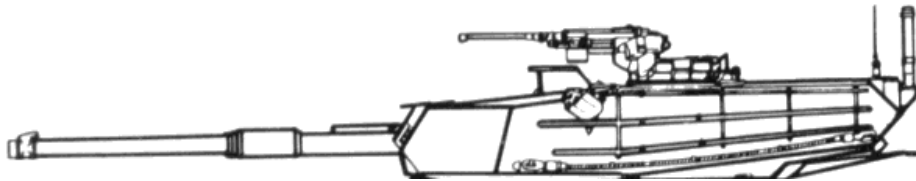
Challenger= 3



M60 = 4



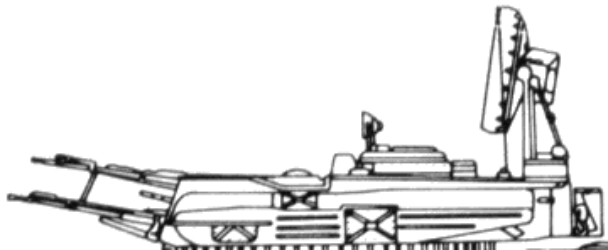
Bradley = 5



M1A1 = 6



T-72 = 7



ZSU = 8



BRDM = 9



M113 = 10

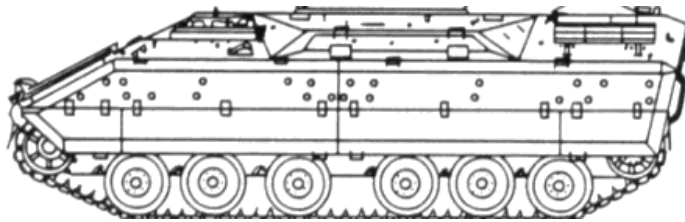


BMP = 11

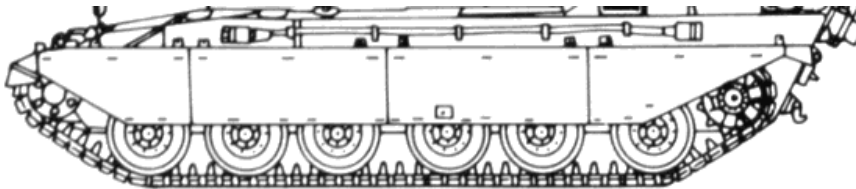


BTR = 12

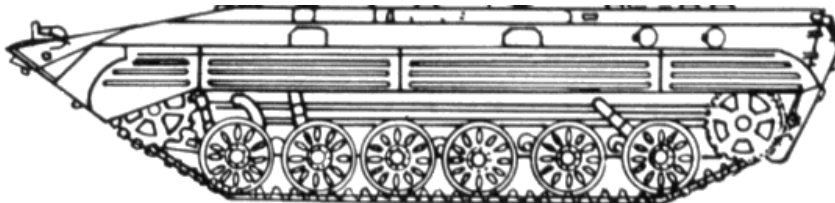
A.4.2.2 Military Vehicle Working Memory Measure (MVWMM) Chassis Answers



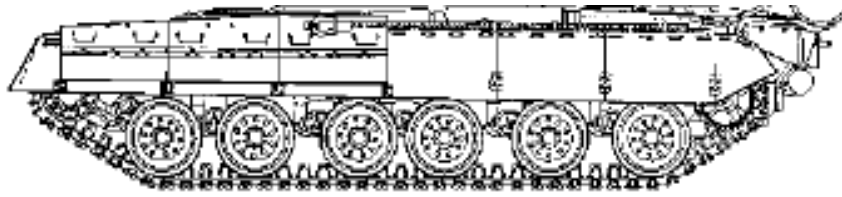
Bradley = A



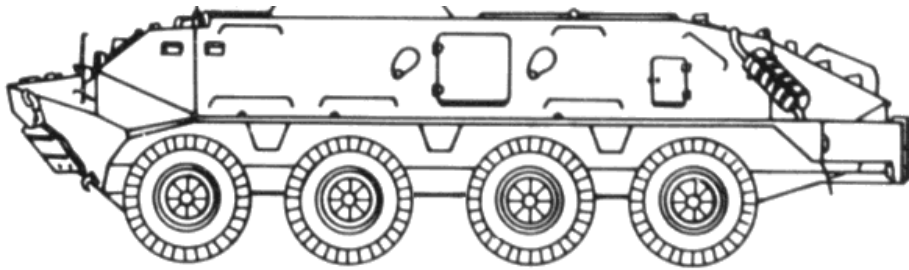
Challenger = B



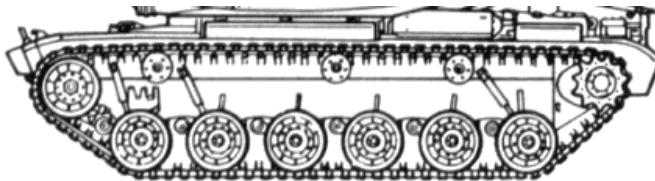
BMP = C



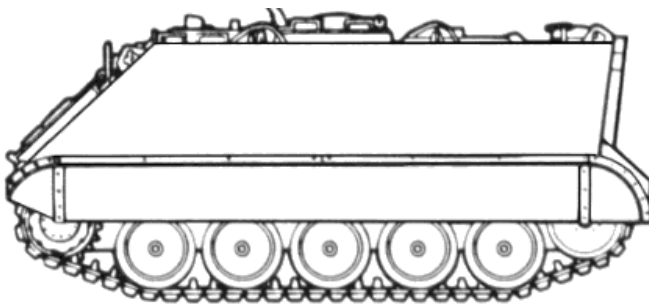
T-80 = D



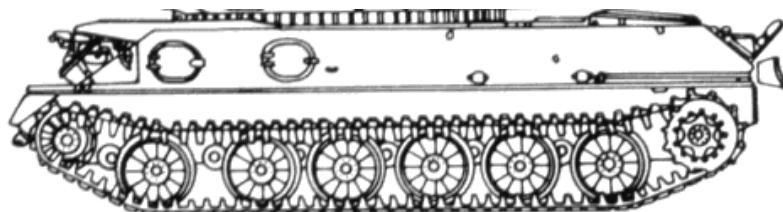
BTR = E



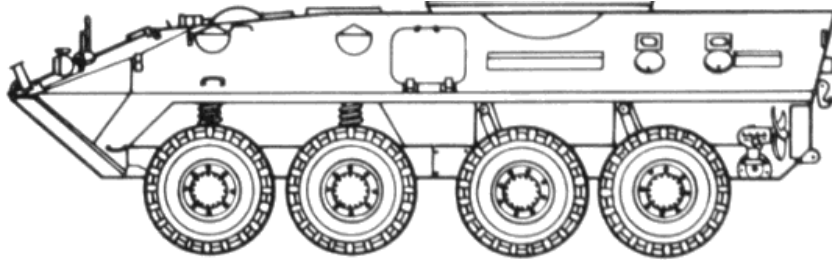
M60 = F



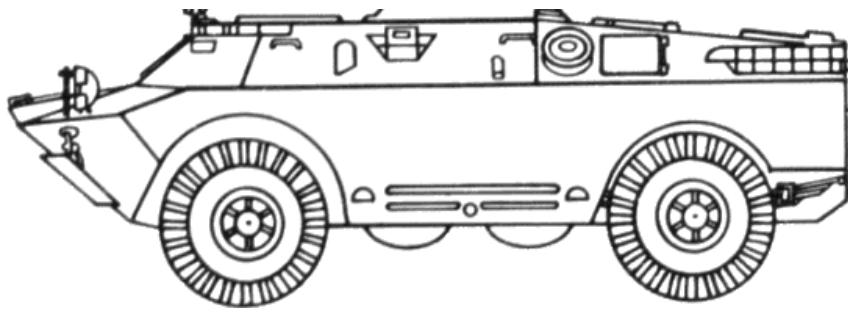
M113 = G



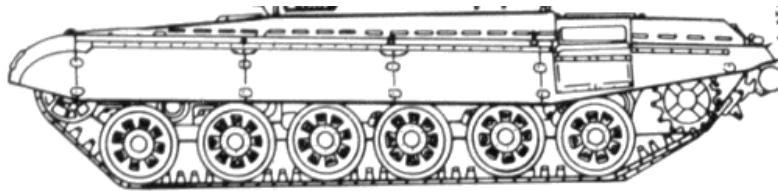
ZSU = H



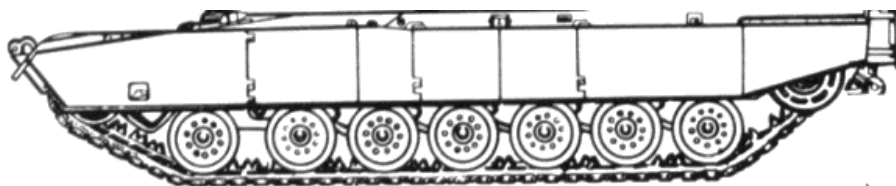
LAV-I



BRDM = J



T-72 = K



M1A1 = L

A.4.3 Military Vehicle Working Memory Measure (MVWMM) Response Sheet

Response Sheet

1. _____

2. _____

3. _____

4. _____

5. _____

6. _____

7. _____

8. _____

9. _____

10. _____

11. _____

12. _____

A.5.1 Flow State Short Scale (FSS-2) (1)

Scale

1 - (Strongly Disagree) to 6 - (Strongly Agree)

Items

Please answer the following questions in relation to your experience with the activity. These questions relate to the thoughts and feelings you may have experienced. There are no right or wrong answers. Think about how you felt during the training game and answer the questions using the rating scale below.

1. - I felt I was competent enough to meet the high demands of the situation. [Challenge-Skill Balance]
2. - I did things spontaneously and automatically without having to think. [Action-Awareness Merging]
3. - I had a strong sense of what I want to do. [Clear Goals]
4. - I had a good idea while I was performing about how well I was doing. [Unambiguous Feedback]
5. - I was completely focused on the task at hand. [Concentration]
6. - I had a feeling of total control over what I was doing. [Sense of Control]
7. - The way time passed seemed to be different from normal. [Transformation of Time]
8. - The experience was extremely rewarding. [Autotelic Experience]
9. - I was not worried about what others may have been thinking of me or my performance. [Loss of Self-Consciousness]

A.5.2.1 Technology Acceptance Measure

1 (Strongly Disagree) – 7 (Strongly Agree)

Cognitive Absorption

Temporal Dissociation

TD1. Time appears to go by very quickly when I was using the simulation

TD2. Sometimes I lost track of time while using the simulation

TD3. Time flies when I'm using the simulation

Focused Immersion

FI1. While using the simulation I was able to block out most other distractions

FI2. While using the simulation I was absorbed in what I was doing

FI3. While using the simulation, I was immersed in the task I was performing

FI4. While using the simulation, I was distracted by other attentions easily

FI5. While using the simulation, my attention did not get diverted very easily

A.5.2.2 Technology Acceptance Measure

Heightened Enjoyment

- HE1. I had fun interacting with the simulation
- HE2. Using the simulation provided a lot of enjoyment
- HE3. I enjoyed using the simulation
- HE4. Using this simulation bored me

Control

- CO1. When using the simulation I felt in control
- CO2. I feel that I have no control over my interaction with the simulation
- CO3. The simulation allows me to control my computer interaction

Curiosity

- CU1. Using the simulation excites my curiosity
- CU2. Interacting with the simulation makes me curious
- CU3. Using the simulation arouses my imagination

A.5.2.3 Technology Acceptance Measure

Perceived Ease of Use

PEOU1. Learning to operate the simulation was easy for me

PEOU2. I found it easy to get the simulation to do what I wanted it to do

PEOU3. It was easy for me to become skillful at using the simulation

PEOU4. I find the simulation easy to use

Perceived Usefulness

PU1. Using the simulation enhanced my ability to memorize the vehicles

PU2. Using the simulation was one of the best ways I could have studied the vehicles

PU3. I would find this type of simulation useful if I needed to study vehicles

PU4. Using the simulation improved my performance on the final task

Personal Innovativeness

PIIT1. If I heard about a new simulation or game, I would look for ways to try it out

PIIT2. In general, I am hesitant to try out new simulations, games, and technologies

PIIT3. Among my peers, I am usually the first to try out new simulations, games, and technologies

PITT4. I like to experiment with new simulations, games, and technologies

A.5.2.4 Technology Acceptance Measure

Playfulness

CPS1. When I am using new technology, I am spontaneous

CPS2. When I am using new technology, I am imaginative

CPS3. When I am using new technology, I am creative

CPS4. When I am using new technology, I am playful

CPS5. When I am using new technology, I am original

CPS6. When I am using new technology, I am inventive

A.5.2.5 Technology Acceptance Measure

Self Efficacy

Yes/No + 1-10 Confidence score

Imagine if you were a soldier and that you needed to use the simulation to actually study military vehicles. Please indicate if you would use the simulation to complete your training by referring to

the following questions:

I could complete my training using the simulation...

SE1. If there was no one around to tell me what to do as I go

SE2. If I had never used a simulation like it before

SE3. If I had only the simulation manual for reference

SE4. If I had seen someone else using it before I tried it myself

SE5. If I could call someone for help if I got stuck

SE6. If someone else helped me get started

SE6. If I had a lot of time to complete the training

SE7. If I had just the built-in help facility for assistance

SE8. If someone showed me how to do it first

SE9. If I had used a similar simulation or game before I had to train using this simulation

APPENDIX B TRAINING MATERIALS

B.1.1 Military Vehicle Introductory Training

Telling military vehicles apart from one another is a difficult task. This experiment has been designed to help devise better learning strategies for training soldiers to identify vehicles. We ask that you take this training seriously and try your best to remember and later identify the vehicles you have studied. Please follow the instructions your experimenter dictates to you to finish the experiment. Your data will be valuable in developing future simulations to aid in identification tasks.

Classes:

There are 2 classes of vehicles you will be learning:

Main Battle Tanks (MBTs)

Personnel Carriers (PCs)

Main battles tanks are usually referred to simply as tanks. All MBTs share the same generic shape. Their main purpose is to provide armored protection to their occupants and perform fast, powerful combat maneuvers.

Always treaded (never wheeled) with 6 to 7 road wheels (the wheels inside the treads)

MBTs consist of road wheels and treads, chassis, and turret (the gun and armor surrounding it)

Some MBTs may have a cupola (a miniature turret on top of the main turret) which is usually armed with a machine gun

All MBTs have an entrance hatch on the top of the turret

Most MBTs have a single, large main cannon; some can be equipped with anti-aircraft weaponry and mortars. The main cannon and turret tend to sit in the middle of the vehicle for better weight distribution



An example of the general shape of an MBT

B.1.2 Military Vehicle Introductory Training

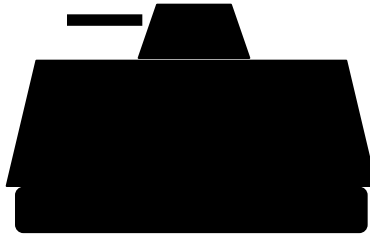
Personnel Carriers are more diverse in shape than MBTs. Their main purpose is to safely transport a large number of soldiers as well as enter combat with other light vehicles and/or infantry. They also tend to be semi-aquatic.

PCs can be treaded or wheeled

PCs consist of wheels or tread and road wheels, chassis with personnel carrying capacity, and a small armament or turret

PCs usually have doors on the rear or top of the vehicle for moving large numbers of soldiers quickly

PC turrets, on average, are smaller than MBT turrets. Their main cannons also tend to be smaller as well. Due to being smaller and lighter, the turrets on PCs can be located in the front, middle, or back of the vehicles



An example of the general shape of a PC

B.1.3 The Individual Vehicles and their Critical Cues

Personnel Carriers

Enemy BTR-BDRM

Please point to the BTR's unique "duck-billed" front

Please point to the two armored driver windows

Please point to the BTR's unique "fang-like/triangular" panels on the front of the vehicle

How many wheels does this vehicle have? 4

Where is the small turret located? Front mounted small turret

Enemy BDRM- BTR

The BRDM is the only vehicle that has a unique "car-like" shape

Please point to the BDRM's unique duck-billed front

Please point to the two armored driver windows

Please point to the BDRM's square front panels *unlike BTR's "fangs"

This vehicle is wheeled, how many wheels does it have? 2

Where is the small turret located? Mid mounted small turret

U.S. LAV

Please point to the LAV's "wedge-shaped" front

How many wheels does this vehicle have? Has 3 BUT usually has 4

Where is the medium sized turret located? Mid mounted medium turret

Please point to the two side rear view mirrors

U.S. M113-Bradley

The M113 is the only vehicle that has a unique "box-like" shape

Where is the small turret located? Front mounted small turret

Enemy BMP

The BMP has the flattest profile of all of the vehicles

Please point to the BMP's unique "triangular" front

Where is the medium turret located? Rear mounted medium turret

Please point to the BMP's turret mounted rocket launcher

U.S. Bradley-M113

This vehicle is treaded, how many road wheels does it have? 6

Please point to the rocket launcher housing on the Bradley's turret

Where is the medium turret located? Mid mounted medium turret

B.1.4 Military Vehicle Introductory Training

Main Battle Tanks

**note that unlike the PCs, many MBTs resemble one another. Next to each vehicles name will be a second vehicle name if the vehicles are close in resemblance.*

U.S. M1A1- Challenger

There is a box shaped optics unit, where is it located? Front of tank

Please point to the M1A1's large trapezoidal turret

How many road wheels does the M1A1 have? 7- (M1A1 is the only MBT with 7 road wheels)

Please point to the M1A1's armored suspension

How many mortar launchers does the M1A1 have? - 2 (one on each side of turret)

The M1A1 has railings for gear and troops, where are the railings? – Side of turret

U.S. Challenger- M1A1

Where is the optics unit located? Optics unit is centered over the main cannon

Please point to the Challenger's streamlined trapezoidal turret

Please point to the Challenger's armored suspension

Enemy T80- T72

Please point to the T80's medium, flat round turret

Please point to the T80's plated armor

Please point to the T80's armored suspension

Enemy T72- T80

Please point to the T72's medium, flat round Turret (note, like T80 but no armor)

Please point to the T72's armored suspension

The T-72 has multiple mortar launchers, how many are there? 11 mortar launchers

U.S. M60

Please point to the M60's large, ellipsoid turret

The M60 has is the only vehicle with a **cupola** (small turret) where is it located?

Top left

Please point to M60's large open suspension

Enemy ZSU

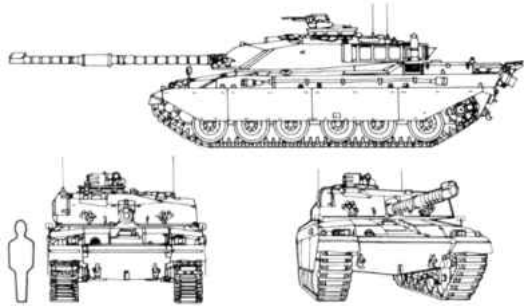
Only anti-aircraft MBT

How many AA weapons does the ZSU have? It has four AA weapons

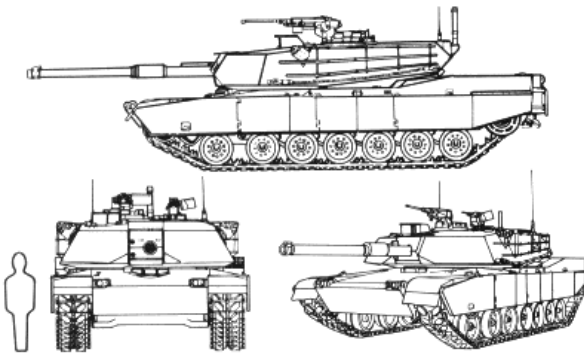
Where is the aircraft radar located? Large aircraft radar on top of turret-

Please point to the ZSU's open suspension

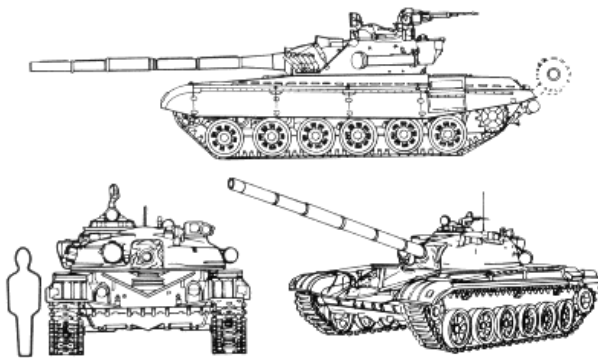
B.2.1 Military Vehicles



UK Challenger

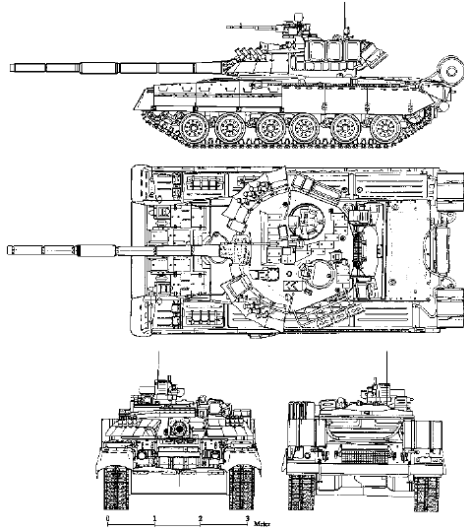


U.S. M1A1 Abrams

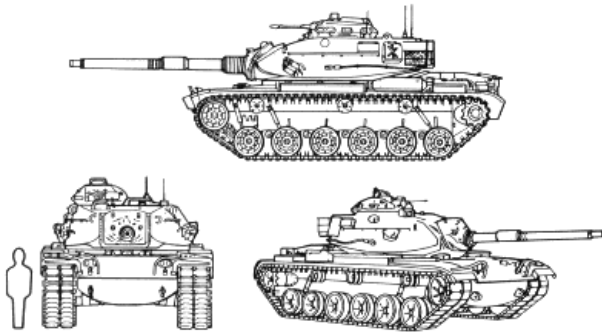


Ex Soviet T-72

B.2.2 Military Vehicles

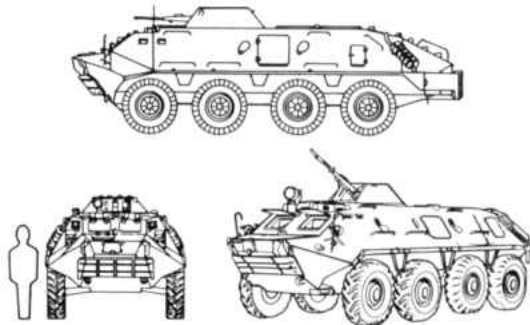


Ex Soviet T-80

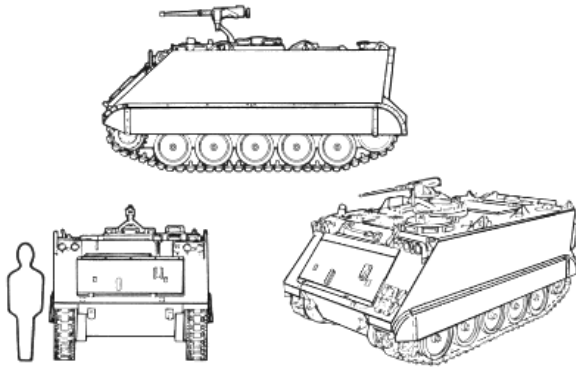


U.S. M60

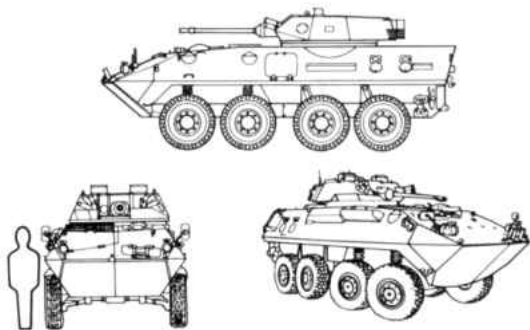
B.2.3 Military Vehicles



Ex Soviet BTR-60

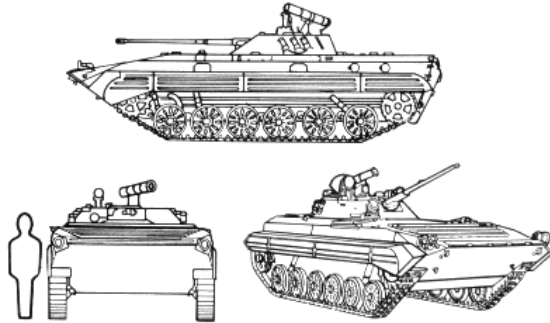


U.S. M113

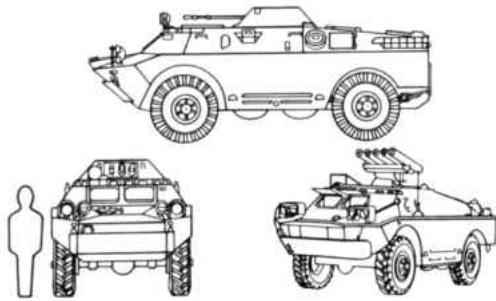


U.S. LAV

B.2.4 Military Vehicles



Ex Soviet BMP



Ex Soviet BRDM



Ex Soviet ZSU

B.2.5 Military Vehicles

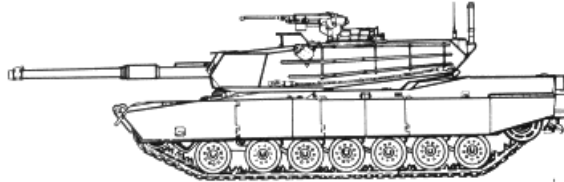


U.S. Bradley

B.3.1 Gauthier's Training

Round 1- Naming and response/Individual vehicle inspection

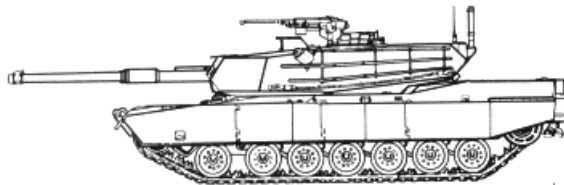
Participants will be shown the vehicle, told its name, and have to state the first letter of the vehicles name.



M1A1 (Participants would respond M)

Round 1 - Alliance inspection

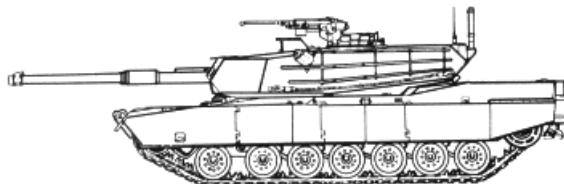
Participants will be shown the vehicle and told that vehicles alliance (U.S. or Enemy).



U.S. Vehicle

Round 2- Naming with feedback

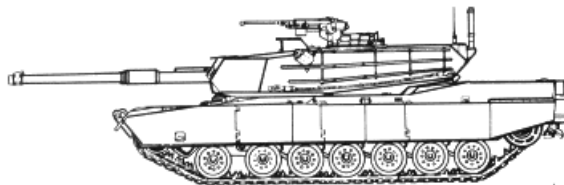
Participants will be shown the vehicle and will have to name it. If the participant names the vehicle incorrectly, the participant will be told the vehicles name



(Participants would respond M1A1)

Round 2- Alliance categorization

Participants will be shown the vehicle, and then will have to state whether the vehicle presented is a NATO or Warsaw Pact vehicle



Is this vehicles U.S. or Enemy? (U.S.)

APPENDIX C SYSTEMS

C.1.1 NVIDIA 3D Vision Kit Specs

3D Vision Specifications

Glasses

Wireless

Infrared receiver	Receive signal between 1.5 and 15 feet
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Power

Battery Life	40 hours of stereoscopic 3D
Power button	On button
Rechargeable battery connector	USB 2.0 mini-B power connector

Indicator Lights

Battery Level	Green and red indicator lights
Charging	Amber light

Dimensions

Product Dimensions,	20.3''x 16.6''x 8.2''
----------------------------	-----------------------

Weight

Product Weight	50 grams/1.76 ounces
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C.1.2 NVIDIA 3D Vision Kit Specs

IR Emitter

Wireless

Infrared transmitter	Transmit signal between 1.5 and 15 feet
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Buttons

NVIDIA backlit button	GeForce 3D Vision on/off
Depth Adjustment	Thumbwheel on the back of IR emitter

Connectors

USB 2.0 mini-B	Connect to the PC for enabling GeForce 3D Vision
VESA Stereo Cable Port	For use with DLP HDTV only

Dimensions

Product Dimensions	2.5" X 2.5" X 1.5" tall
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Weight

Product Weight	47 grams/1.66 ounces
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C.2 ASUS i5 Computer

Product Features

Intel Core i5-650 3.2 GHz Dual Core Processor
8GB DDR3 SDRAM
1TB SATA Hard Drive
DVD±RW DL Optical Drive
Microsoft Windows 7 Home Premium with HDMI
Processor, Memory, and Motherboard
Processor: 3.2 hertz
RAM: 8 GB
Memory Slots: 4
Hard Drive
Size: 1000 GB
Speed: 7200 rpm
Graphics and Display
Graphics RAM: 32 MB
Ports and Connectivity
USB Ports: 10

APPENDIX D IRB OUTCOME LETTER

Approval of Human Research

From: **UCF Institutional Review Board #1**

FWA00000351, IRB00001138

To: **Florian G. Jentsch and Joseph R. Keebler**

Date: **November 23, 2010**

Dear Researcher:

On November 23, 2010, the IRB approved the following modifications/human participant research until 11/16/2011 inclusive:

Type of Review: UCF Initial Review Submission Form / Convened Board Review

Project Title: Effects of Training Media on Retention of Objects

Investigator: Florian G. Jentsch

IRB Number: SBE-10-07184

Funding Agency: RDECOM-STC

Grant Title: Human Agents for Training and Simulation (HATS) Contract

Change Proposal

Research ID: N/A

The Continuing Review Application must be submitted 30 days prior to the expiration date for studies that were previously expedited, and 60 days prior to the expiration date for research that was previously reviewed at a convened meeting. Do not make changes to the study (i.e., protocol, methodology, consent form, personnel, site, etc.) before obtaining IRB approval. A Modification Form **cannot** be used to extend the approval period of a study. All forms may be completed and submitted online at <https://iris.research.ucf.edu>.

If continuing review approval is not granted before the expiration date of November 16, 2011, approval of this research expires on that date. When you have completed your research, please submit a Study Closure request in iRIS so that IRB records will be accurate.

Use of the approved, stamped consent document(s) is required. The new form supersedes all previous versions, which are now invalid for further use. Only approved investigators (or other approved key study personnel) may solicit consent for research participation. Participants or their representatives must receive a copy of the consent form(s).

In the conduct of this research, you are responsible to follow the requirements of the Investigator Manual.

On behalf of Joseph Bielitzki, DVM, UCF IRB Chair, this letter is signed by:

Signature applied by Janice Turchin on 11/23/2010 03:53:16 PM EST

University of Central Florida Institutional Review Board

Office of Research & Commercialization

12201 Research Parkway, Suite 501

Orlando, Florida 32826-3246

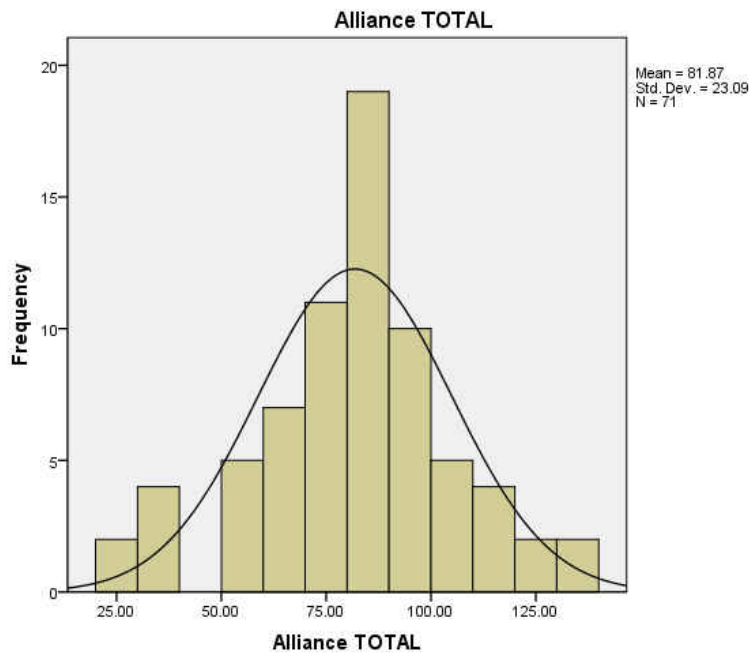
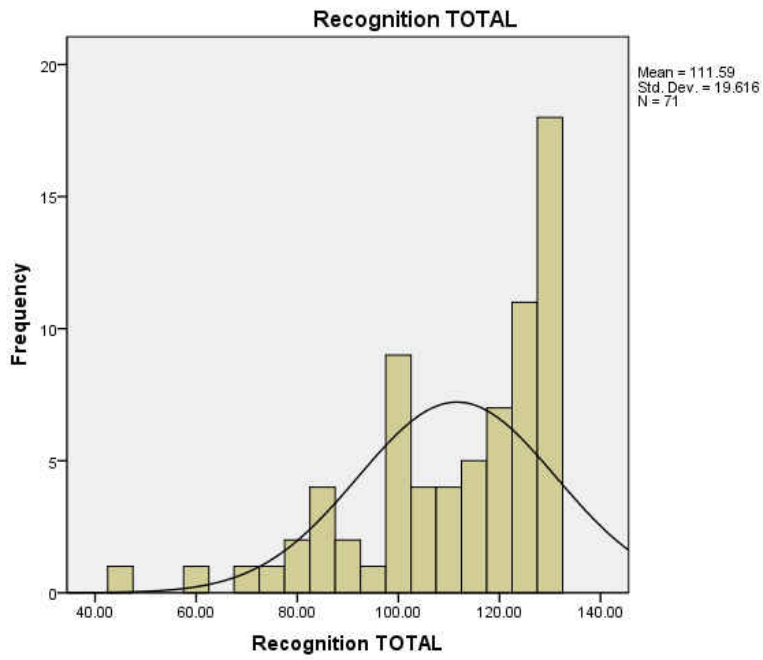
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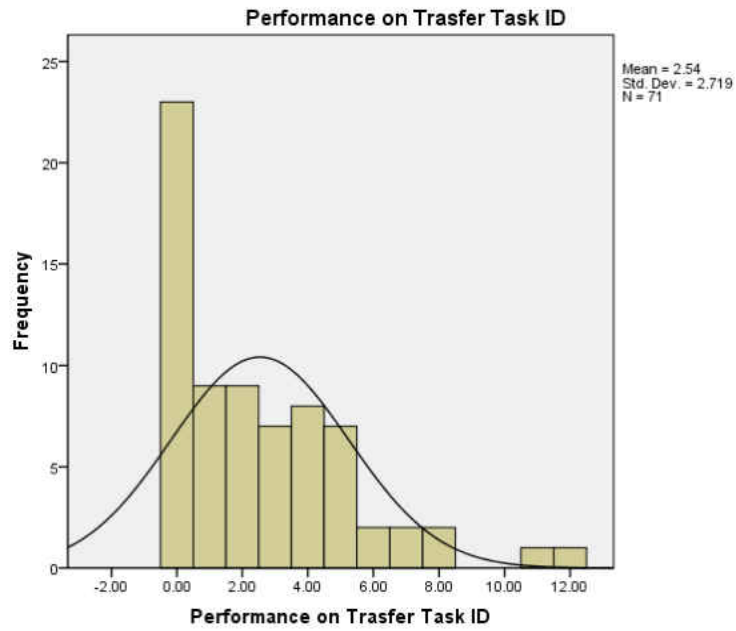
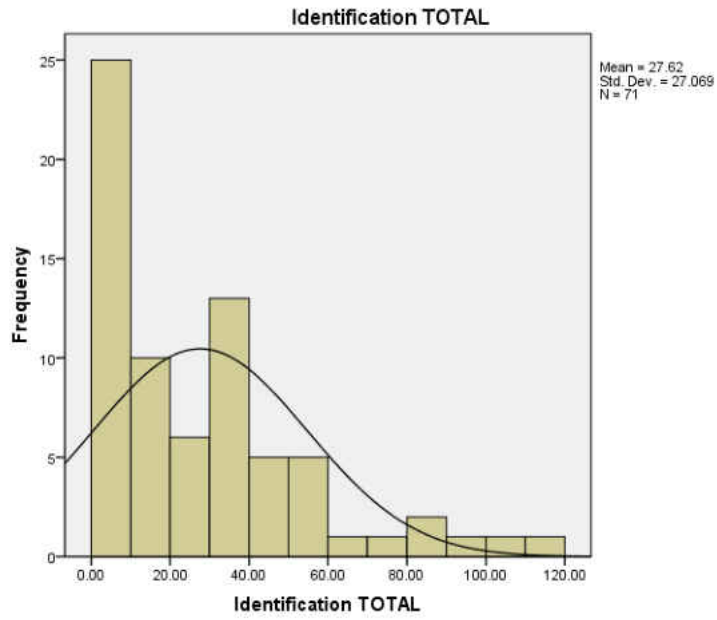
www.research.ucf.edu/compliance/irb.html

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IRB Coordinator

APPENDIX E RESULTS TABLES & CHARTS





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