Multitasking and Learning in Virtual Environments

by

Connie Levina Yuen

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Department of Educational Psychology
University of Alberta

Abstract

Virtual environments are inherently social spaces where user productivity and collaborative learning can take place. However, the majority of existing studies to date investigate common behaviours such as multi-tasking within traditional face-to-face learning environments. As part of a thesis dissertation, this study investigated the importance of structuring learning environments to maximize learning and minimize virtual distractions. Using an OpenSim virtual environment, the researchers conducted an experimental study during the Fall 2013 and Winter 2014 terms with 91 undergraduate students at the University of Alberta. The study investigated the influence of participants' prior computer experience, cognitive learning styles and extroversion-introversion on the impact of passive and social distractor tasks during learning and recall of factual information in virtual environments. The results indicated that prior video game use is a significant predictor of lower overall test time and higher overall test score, but the software recognition test, social networking use and virtual world use did not have a significant impact on learning performance. While extroverted individuals tended to complete questions faster under the interactive-type distractor condition, they achieved higher accuracy scores under the passive or no distractor-type conditions. Introverted individuals tended to complete questions faster and more accurately under the no distractor-type condition. In addition, the study found that field-independent participants outperformed field-dependent counterparts by an average test score of 0.86 at approximately the same speed.

Keywords: multitasking, distractor, computer experience, extroversion, introversion, cognitive style, field independence, field dependence, virtual environment, learning, education, technology

Preface

This thesis is an original work by Connie Yuen. The research project, of which this thesis is a part, received research ethics approval from the University of Alberta Research Ethics Board, Project Name "Multi-tasking and Learning Performance in Virtual Worlds", No. Pro00041160, September 20, 2013 – October 20, 2015. At the time of defense, no part of this thesis has been previously published.

Some of the research conducted for this thesis forms part of a research collaboration, led by Professor Patricia Boechler at the University of Alberta and with the assistance of Erik deJong. The *Computer Experience Questionnaire* referred to in the study was designed by Professor Patricia Boechler. The data analysis and concluding analysis are my original work, as well as the literature review.

Dedication

This thesis is dedicated to my dearest family and friends, who have shown unconditional love and support throughout this journey:

My parents, John YC and Jamie CM, for your unwavering support, warmth and insights (thank you for always believing in me and instilling me with positive values);

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Introduction

Research Problem

With the ever-evolving ubiquitous technologies accessible by many individuals, the desire for immediate communication, multi-sensory stimulation and instant gratification continuously bombard students with a multitude of "wired" interruptions that are filtered and addressed predominantly through multi-tasking (e.g. Carrier, Cheever, Rosen, Benitez, & Chang, 2009, Gazzeley, 2014). As educational philosophies, systems and institutions attempt to keep up with the changing socio-cultural and technological landscape, many educators seek bottom-up approaches to bridge current educational practices and the communicative tools that engage students to learn. Motivating students to focus on the learning task at-hand is particularly challenging for educators because social communication tools are increasingly mobile and consequently encompass a greater capacity for users to simultaneously interact, network and perform other tasks. As more and more educational platforms move online, educators must be cognizant of their students' tendency shift or divide their attention among multiple stimuli. Thus, it is particularly important for educators to structure learning activities or the classroom in a way that maximizes learning and minimizes virtual interruptions.

Previous Studies Addressing the Problem

As students increasingly employ technology-based multi-tasking as an information management strategy (Chun, Golomb, & Turk-Browne, 2011), a growing body of concerned educators and researchers is examining the effects of frequent multimedia task-shifting on student learning, academic performance and overall attentiveness (e.g., Eby, Vivoda, & St. Louis, 2006). Previous literature indicates that there is a mismatch between students' perceived ability to multi-task with digital technologies and the reality that attending to multiple stimuli can significantly impair task performance (Fried, 2008; Grace-Martin & Gay, 2001; Hembrooke & Gay, 2003; Junco & Cotton, 2011; Kraushaar & Novak, 2010). Younger adults are especially prone to multi-tasking because they carry the misconception that multi-tasking with technologies is an easy or efficient approach to handle massive amounts of information (Junco & Cotton, 2011). To date, the majority of studies investigate the multi-tasking behaviours of post-secondary students using technologies and the resulting effects on their learning abilities within face-to-face environments.

Deficiencies in Previous Studies & Advancing the Literature

Currently few studies have approached the topic of multi-tasking by investigating the mediating factors— specifically, the level of interactivity or passivity of a secondary task— on learning performance, and no studies have examined multi-tasking within online virtual learning environments. By approaching this study using online virtual learning environments, educators and researchers can draw useful implications about multi-tasking behaviours and performance for alternate formats of delivery such as distance learning and blended education.

Purpose Statement

The purpose of this experimental study is to test the theory of Yerkes–Dodson Law, which proposes an "optimal level of arousal" is necessary for effective performance. Thus, levels of arousal above or below range impair task performance (Yerkes and Dodson, 1908). Presumably, distractions or simultaneously attending to multiple tasks results in significantly higher arousal and tends to decrease learning performance. Using a simulated online learning task, this study compares the interactivity or passivity of distractions during a learning task to the assessment performance (score) and speed (time). The frequency of distractions, interval times when distractions are presented, identical content presented during the learning task and assessment measures were controlled for the experiment.

Research Questions

This study will investigate three main research questions stemming from human multi-tasking behaviours including whether distractions have an effect on learning within a virtual environment. The first research question addresses computer experience, factual learning and cognitive load. Specifically, research question 1 was divided into two sub-questions: 1A) Can prior computer experience predict learning performance as measured by overall test time in a virtual environment? and 1B) Can prior computer experience predict learning performance as measured by *overall test score* in a virtual environment?

The second research question investigates the personality dimension of extroversion/ introversion on learning performance in the presence of interactive distractors, which are social in nature for this study. Since the data analysis will divide participants into two groups based on the category of extroversion/ introversion, research question 2 is divided into four sub-questions: 2A) Is there a difference for extroverts in time on task given the type of distraction (interactive, passive, none) that is present? 2B) Is there a difference for introverts in time on task given the type of distraction (interactive, passive, none) that is present? 2C) Is there a difference for extroverts in accuracy on task given the type of distraction (interactive, passive, none) that is present? and 2D) Is there a difference for extroverts in accuracy on task given the type of distraction (interactive, passive, none) that is present?

Finally, the third research question examines the relationship between field independence/dependence cognitive learning style on factual learning performance. Research question 3 is divided into two sub-questions: 3A) Do field-independent participants demonstrate better performance as measured by lower *overall test time* than field-dependent participants? and 3B) Do field-independent participants demonstrate better performance as measured by higher *overall test score* than field-dependent participants?

Literature Review

Multi-tasking, Attention and Distractors on Learning Performance

In order to examine the variables affecting multi-tasking, one must first address human attention and memory because these factors are inextricably linked. As far back as 1759, British author Samuel Johnson wrote an insightful essay about human attention and memory on learning. Johnson mused that "the true art of memory is the art of attention…no man will read with much advantage, who is not able, at pleasure, to evacuate his mind…if the repositories of thought are already full, what can they receive?" (p. 119). Broadly speaking, attention encompasses three main qualities: a) overall alertness or arousal, b) selectively attending to a particular stimulus, and c) limited processing when competing stimuli are present at the same time (Posner, 1990). Past researchers focused primarily on the consciousness of selective attention and acknowledge that there is both *controlled attention* and *stimulus-driven attention* (Glenn, 2010). The level of attention can be affected by the learner's internal state as well as environmental factors including the types of distractors present during the learning process. There are several studies that suggest intricate ties between attention, multi-tasking and distractors; for instance, Foerde, Knowlton & Poldrack's (2006) experiment investigated how distractors impact the learner's method of encoding. Specifically, the researchers discovered that different regions of the brain were activated when distractors were present, and that information would be encoded into *habit memory*. On the other hand, when distractors were not present and learning occurred under single-task conditions, learners would encode information via *declarative memory*, which allows for greater flexibility and adaptability of information into new contexts. Therefore, the human capacity of attention affects the quality of learning during *multi-tasking*, which is defined as doing more than one activity simultaneously (Pashler, 1994).

Adam Gazzaley (2014) also studied the relationship between attention, multi-tasking and distractors—or what he refers to as *interference*. Gazzaley expands on this idea by suggesting that interference can be divided into two types: *internal interference* or stimuli from within the person's mind, and *external interference* or environmental stimuli. Interference can be further categorized by the type of goal the individual is trying to perform; if the individual consciously and intentionally decides to do more than one task whether through external or internal stimuli, the individual experiences interference known as *multi-tasking*. When an individual allows an external, irrelevant stimuli to unintentionally interfere with the task at hand, he or she experiences interference known as *distraction*. On the other hand, if internal, irrelevant stimuli wander into the mind unintentionally, the individual experiences *intrusions*. Gazzaley (2014) then suggests that exercising *cognitive control*, or the perception shaped by competing, external, stimulus-driven attention (bottom up attention) and internal, goal-directed attention (top down attention), people can change the way information is encoded into short term and long term memory.

As described above, the vast majority of literature addressing multi-tasking is associated with decision-making processes and the effects of interference on overall performance. Historically, researchers in experimental and cognitive psychology have been examining the relationship between learning, attention and multi-tasking since the 1980s (Glenn, 2010). Many of these studies examined the effects of consciously and selectively attending to external stimuli as well as the learner's overall alertness when task-switching between various tasks (Glenn, 2010). There are two main streams of research stemming from these studies: the first wave of researchers believes that multi-tasking is analogous to the Bottleneck theories first proposed by Miller's (1956) study about limitations of the human brain. Supporters of the Bottleneck theory contend that the brain's cognitive processing mechanisms limit the capacity of information that can be attended to at the same time. Specifically, Miller suggested that the human capacity to process information in working memory within a short time span is restricted to the magical number of seven plus or minus two chunks of information. Expanding upon Miller's work, Sweller (1988) proposed the cognitive load theory, which posits that individuals utilize different levels of mental effort within working memory that correspond to the perceived task difficulty. Furthermore, since individuals are limited by a fixed capacity of working memory, as task difficulty or quantity increases, task performance decreases as the mental resources are spread thin (Sweller, 1988).

One potential strategy to reduce mental exertion and increase task performance while multi-tasking is to *task-shift*, which involves alternating attention from one stimuli to another (Jersild, 1927). While this approach may temporarily ensure greater focus on each individual task, task-shifting still disrupts the individual's focus or momentum and therefore presents a *switch cost* (Jersild, 1927). This switch cost may be especially apparent when the task at hand is multi-faceted and ultimately requires more time and attention to effectively complete the task. Therefore, when people claim they are multi-tasking, oftentimes they are actually task-shifting by dividing attention among competing stimuli and quickly shifting from one task to the next. By doing so, the individual toggles activity in the brain's anterior prefrontal cortex in order to selectively focus attention during these intervals while also keeping track of progress between multiple tasks, thereby interfering with the response performance and speed as opposed to when the tasks are performed in isolation (Wallis, Claudia, Cole et al., 2006). Similarly, Gazzaley (2014) contends that multi-tasking causes decreases in short-term and long-term memory encoding, particularly when external distractors are present in the environment because attentional resources will be divided. Thus, when a secondary task is introduced— especially one that is irrelevant to the primary task— attention will shift back and forth between these tasks, resulting in weaker encoding of the primary task into long-term memory (Bailey & Konstan, 2006; Ophira, Nass, & Wagner, 2009).

The second wave of researchers suggest humans are capable of filtering multiple stimuli simultaneously and can perform task-shifting quickly without decrements to performance as long as the person has ample practice. For instance, Bryan and Harter (1899) studied improvements in telegraphic communication and how humans allocate attentional resources among procedurals tasks. They found that repeated training facilitates automatism and therefore frees attention for more complex cognitive tasks. Supporting this finding, Ericsson and Smith (1991) discovered that performance and skill acquisition have a direct correlation to the time spent on deliberate practice and the application of knowledge or procedures. These early studies led many educators and researchers to believe that the detrimental effects of multi-tasking can be resolved by repeated practice.

More recent research deals with the middle ground between these two polar groups by suggesting there are distinct neurological systems that work interdependently to form one's attention and various degrees of multi-tasking behaviours (e.g. Glenn, 2010). For instance, Benbunan-Fich et. al. (2011) outlines two key components of multi-tasking: *task independence* and *performance concurrency*. *Task independence* is the degree to which the task is self-contained, and *performance concurrency* suggests the degree to which tasks can overlap for a specific time period. Benbunan-Fich et. al. (2011) suggests that these two elements of multi-tasking may help explain why some people can seemingly multi-task under certain circumstances depending on the secondary task that is introduced. One example is that automatic, repeatedly-practiced movements or habitual motor tasks— such as riding a bike along a familiar route— can sometimes be performed concurrently while having a conversation with a friend.

With the advent of mobile technologies and portable communication devices both inside and outside the classroom, the nature of multi-tasking has become increasingly complex for most people as multi-sensory technologies and distractors are prominent during daily activities (e.g. Wood et al., 2012, Gazzaley, 2014). In addition, as people acquire constant access to communication tools, data or technologies, societal expectations tends to shift towards a desire for immediate responsiveness and continual productivity (Gazzaley, 2014).   Gazzaley (2014) further emphasized that his research data indicates that 95% of participants, including both adults and young children, self-reported multi-tasking with media at least some of the time.

Personality Traits and Individual Differences on Multi-tasking Ability

While most studies of multi-tasking ability agree that digital technologies tend to be distracting and impair learning performance (e.g. Fried, 2008, Junco & Cotton, 2011, Kraushaar & Novak, 2010), few studies have investigated how personality traits and individual factors may impact multi-tasking ability on learning. One recent study by Sanbonmatsu, Strayer, Medeiros-Ward & Watson (2013) found a correlation between participants with high impulsivity and sensation-seeking scores to frequent multi-tasking while driving, however, they caution that these heavy multi-taskers tend to have lower executive control and are thus unable to block out distractions and focus on a single task as compared to light multi-taskers.

Using functional magnetic resonance image (fMRI), Gazzaley (2014) found that multi-tasking correlates with different levels of brain activity in the prefrontal cortex— the main information-filtering centre for the brain— thereby providing some evidence that multi-tasking may affect cognitive load or performance during learning and information processing in the brain. Gazzaley (2014) also speculates that age may be a factor in multi-tasking ability as younger people tend to be faster in switching attention from one task to another, likely because of higher brain plasticity during youth and young adulthood. In addition, today's youth are often digital natives who have grown up with technologies— thereby allowing repeated exposure and practice in multi-tasking with technologies, video games and media.

On the other hand, Stanford Professor Clifford Nass found in multiple studies that those who were heavy media multi-taskers performed poorly compared to light media multi-taskers. Specifically, heavy media multi-taskers were slower to switch from one task to another involving combinations of letters and numbers (Nass, 2010). Nass' studies suggest that there is a tendency for people to be over-confident in one's ability to multitask without negative effects on his or her performance. Similarly, Sanbonmatsu, Strayer, Medeiros-Ward & Watson's (2013) study also found that perceived multi-tasking ability was highly inflated as compared to actual multi-tasking performance. However, there maintained a slight positive correlation among those who self-reported greater multi-tasking ability and actual performance (Sanbonmatsu, Strayer, Medeiros-Ward & Watson, 2013).

Despite these preliminary findings, there is still a wide variability among individual abilities to filter relevant information and multi-task by attending to one task while ignoring others— as such, some researchers suggest that there are common personality factors and differences that correlate with working memory capacity or executive control— which may allow some people to control or attend to various stimuli or tasks better than other individuals (Sanbonmatsu, Strayer, Medeiros-Ward & Watson, 2013).

Cognitive Learning Style: Field Dependence-Independence.

Based on recent findings by Sanbonmatsu, Strayer, Medeiros-Ward & Watson (2013) that suggest a correlation between frequent multi-taskers and lower executive control or higher distractibility, part of this study sought to understand whether cognitive learning style, specifically field dependence-independence, may also be a predictor of multi-tasking tendencies or ability. To understand field dependence-independence, one must first clarify the definition of cognitive style. *Cognitive styles* are consistent tendencies that individuals utilize as a type of information processing strategy including cognitive activities related to perception differences, career choices and learning styles (Miller, 1987, Ford & Chen, 2000). Some characteristics of cognitive styles are: (a) a focus on form or how one perceives rather than the content of cognitive activity; (b) holistic, pervasive dimensions that can also be assessed by visual cues or non-verbal cues; and (c) being stable over time (Witkin, Moore, Goodenough & Cox, 1977).

The concept of field dependence-independence emerged as one of the most widely known cognitive styles (Witkin, Moore, Goodenough & Cox, 1977) and began in 1941 when Hy Witkin studied spatial orientation perception. Witkin collaborated with Solomon Asch to examine how visual cues changed one's perception of vertical direction in space with the Rod and Frame Test (Bertini, Pizzamiglio & Wapner, 1985). This test consisted of an experiment in which participants were presented a tilted square frame within a dark room and tasked with adjusting the rod into a vertical position. These early experiments allowed Witkin to observe consistent orientation perception patterns within individuals, and he surmised several theories including the Cue-Conflict Theory and introduced the construct of field dependence (Bertini, Pizzamiglio & Wapner, 1985). Initially, Witkin described field dependence as a cognitive style in which people relied more heavily on visual environmental cues rather than referencing sensations from within the body (Bertini, Pizzamiglio & Wapner, 1985). In his studies he also noted a high correlation between field independence and the success rates participants experienced in locating camouflaged or embedded figures, as well as the ability to ignore extraneous information.

As Witkin continued his research, he discovered strong ties linking field dependence to personality differences and suggested that perception is a fundamental factor in personality (Bertini, Pizzamiglio & Wapner, 1985). He suggested that field dependent people were more socially-oriented, attuned to interpersonal cues and had smaller personal space preferences. Field independent people, on the other hand, tended to be more abstract, autonomous, socially distant. By 1952, Witkin redefined field independence as the ability to disregard irrelevant stimuli and process information within an embedded context (Bertini, Pizzamiglio & Wapner, 1985). Later, the embedded figures test became readily available and used worldwide (Bertini, Pizzamiglio & Wapner, 1985). Witkin then reorganized this construct in a pyramid structure to distinguish inner attributes in juxtaposition with activities occurring in the outer world. Then, in 1974, another researcher found evidence that field dependence or movement in the visual field might be largely driven by the vestibular system (Bischof, 1974); this finding suggested that field perception could be changed by producing illusions of self-rotation. As such, Witkin redefined field independence as a component of autonomy demonstrated by the perception of the vertical orientation including during social contexts as well(Witkin, 1952). Later, Witkin's research regarding field dependence-independence shifted towards influences on cultural perception and career choices (Bertini, Pizzamiglio & Wapner, 1985).

Group Embedded Figures Test. One of the most prominent instruments for measuring the construct of field dependence-independence is Witkin's Group Embedded Figures Test (GEFT). This relatively inexpensive test is generally presented as a pen-and-paper format with specific instructions for proper administration and interpretation of scores (Jackson, 1956). The GEFT tasks subjects with locating basic shapes embedded within twenty-four larger, complex geometric shapes (See Appendix B). GEFT performance scores are then inferred as a measure of field dependence-independence, with low scores representing field-dependence cognitive style and high scores representing field-independence cognitive style. While the GEFT tool demonstrated a significant correlation with measuring perceived upright orientation and personality variables, it is important to note that males have typically been found to achieve higher GEFT scores (Jackson, 1956). Also important to note is the length of the GEFT— originally twenty-four items long— which requires considerable time to administer and complete (Jackson, 1956).

In order to reduce the time needed to complete the test, a short form of the GEFT was developed by performing an item analysis. The shortened version of the GEFT reduced the number of test items to twelve instead of twenty-four, and in Jackson's (1956) studies with 50 college students, showed a consistent correlation to the original GEFT of 0.96 to 0.98 for both men and women. Thus, the shortened version of the GEFT was also utilized in this study to accommodate for the various tasks and surveys that participants completed within the one-hour time limit. For this study, the GEFT was used to measure field dependence-independence so as to understand whether field-independent people would have shorter learning recall test times or higher test accuracy scores since they are able to exercise executive control and ignore distractors more easily than their field-dependent counterparts.

Applications in Education and Learning. Among the plethora of cognitive style applications in various fields including psychophysiology, personality theory, social psychology and cross-cultural psychology, one of the most significant implications and contributions have been in the field of education. For instance, field dependence-independence has been found to impact teacher and student interactions or rapport as well as the teachers' preferred instructional approaches. Mario Bertini (1986) noted in his studies that there is a high propensity for teachers to over-evaluate favourably or project their own personality and cognitive style onto their students. As one specific example, Bertini (1986) discovered field-dependent girls were usually perceived by teachers to be the most likable, and a notable sex bias was apparent as field-independent boys were perceived by teachers as being more mentally efficient than field-independent girls, while field-dependent girls were perceived to be more mentally efficient than field-dependent boys. From a student perspective, Bertini (1986) found similar tendencies in which boys preferred field-independent male or female teachers, whereas girls preferred field-dependent female teachers and field-independent male teachers.

Extroversion/Introversion Measures

One notable personality trait that has been linked to multi-tasking behaviours and capacity is impulsivity or sensation-seeking (Sanbonmatsu, Strayer, Medeiros-Ward & Watson, 2013). Since this study seeks to understand other personality traits that affect multi-tasking, extroversion/introversion became an area of interest because it is closely related to sensation-seeking tendencies. In fact, Eysenck characterized individuals high on extraversion scores as more sociable, sensation-seeking, impulsive, expressive, optimistic and have a higher arousal threshold that leads to a greater desire for external stimulation (Eysenck & Eysenck, 1964). First popularized by psychiatrist Carl Jung, extraversion and introversion became widely known personality traits used to describe individual differences between those who tend to be outgoing, energetic behaviour as compared individuals who are more reserved and autonomous. In other words, some individuals thrive in social environments and seek out interpersonal interactions, while others prefer more solitary, independent or reflective activities (not to be attributed to anti-social behaviour or shyness).

While many personality tests including the Big Five model, Raymond Cattell's 16 personality factors and the Myers-Briggs Type Indicator have incorporated extraversion /introversion as a fundamental dimension, this study builds primarily upon Hans Eysenck's Three-Factor Model. The Three-Factor model was generated via factor analyses of results drawn from personality questionnaires by two psychologists from England— Hans Jürgen Eysenck and Sybil B. G. Eysenck— who narrowed down three distinct dimensions of personality and used them to inform the development of the Eysenck Personality Questionnaire (EPQ). The Eysenck Personality Questionnaire was used to assess personality traits based on three dimensions of temperament: Extraversion/Introversion, Neuroticism/Stability, and Psychoticism/Socialisation (Eysenck & Eysenck, 1964). The test originally consisted of 100 questions that allowed subjects to answer either *yes* or *no* in response to statements that they perceived described them or they agreed/disagreed with. To increase the reliability of self-reported responses, the EPQ also includes similar, redundant questions throughout the test to check for consistency in responses. While these areas are typically measured on a continuum scale, the EPQ scores, also known as the Eysenck Personality Inventory (EPI), can also be analyzed as dichotomous, bipolar categorizations.

Eysenck extended the Extraversion/ Introversion dimension by suggesting an arousal theory of extraversion in which the optimal level of cortical arousal is higher in extraverts than in introverts, and therefore attributed some of the personality tendencies to biological makeup (Sato, 2005). A revised version of the EPQ was later published in 1985 with 90 test items of yes/no answers for adults (Sato, 2005) which is utilized in this research study. Continuing Eysenck's arousal theory of extraversion, one of the hypotheses for research question 2 of this study is that extroverted individuals would experience more significant decreases in learning performance (time and accuracy scores) during socially-interactive distractors because they seek and value social interaction more than their introverted counterparts.

Virtual Worlds for Education

The embodiment of technologies molds today's society into a world that thrives on the interconnectedness of global media and participatory culture (Jenkins, 2009). In particular, technology-mediated communications has become prominent in altering the way humans develop and understand the world. For instance, emails provide a mode of communication filled with few or ambiguous emotional and non-verbal cues (Smith & Kollock, 2003). Many technologies were developed in attempts to fill the missing elements of face-to-face interactions or simulate the human presence. One such technology involves the immersive experiences offered by virtual worlds or environments. Virtual worlds are generally characterized as simulated three-dimensional (3D) environments that are both immersive and scalable (New Media Consortium and EDUCASE Learning Initiative, 2007). Within these environments, players are typically represented as an avatar that can communicate or interact with the space and other avatars in real-time (New Media Consortium and EDUCASE Learning Initiative, 2007). Virtual worlds should not be mistakenly equated to video games: while the latter occurs within virtual worlds, there is typically an end-goal for the player while virtual worlds are open-ended sandbox environments that do not necessarily have a specific objective. Some widely-popular examples of virtual worlds include Minecraft, MapleStory, IMVU and Second Life (Boechler, 2014).

While a wide variety of virtual environments are available, the most pertinent spaces for investigating educational applications can be found in virtual communities such as OpenSim[1]. Within the education literature there have been some early attempts to utilize virtual environments to teach specific subjects via Second Life [2] for health education (e.g. Angie & Zane, 2011), teacher education, higher-level education (e.g. Serpil, Nurcan, Gamze & Fatih, 2012) and teaching languages. These studies highlight the benefits of utilizing virtual environments in education, citing realistic simulation of events or interactions that can be transferred beyond the virtual environment. These virtual environments simulate real-life scenarios and often closely resemble the user's appearance, communication style and interactions in the real world (e.g. Serpil et al., 2012). Serpil et al. (2012) also found remarkable success in maintaining student engagement with course content and project presentations in the Second Life environment, citing realism, flexibility in formats and self-directed pacing as significant benefits. Therefore, using OpenSim increases the external validity by simulating the real-world applications of virtual environments.

Computer Experience Measures

As technology and computers are in a state of flux, analysing and developing tools for measuring participants' prior computer experience or software recognition tends to be contextually-driven, population-specific or risks being obsolete upon its publication. Evidently, most measures of computer experience are presented in the form of a general survey with

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[1] OpenSimulator: an open source multi-user application server used to create virtual environments (www.opensimulator.org)

[2] Second Life: an online, three-dimensional virtual environment developed by Linden Labs in 2003 in which users interact and navigate the environment as avatars (www.secondlife.com)

questions and responses that change depending on the time the test is administered, as well as the pervasiveness of specific technologies or software titles within a small population. Therefore, computer experience results are generally utilized to gather information and make inferences or draw correlations about an individual's prior computer experience and familiarity in relation to other variables. In this particular study, the Computer Experience Questionnaire (Boechler, Leenaars & Levner, 2008) was used to collect information about the participants' prior experience with computers and software titles, with a specific emphasis on the hours spent during different stages while in school.

Methods

This study examined the impact of prior computer experience, extroversion/introversion and different types of distractors affecting learning recall within a virtual world. The research questions are as follows:

1) Can prior computer experience predict learning performance as measured by overall test time or overall test score in a virtual environment?
2) Does extroversion predict greater difficulty in focusing on a task when social distractors are present?
3) Do field-independent participants demonstrate shorter overall test time or higher overall test score than field-dependent participants?

Altogether, three instruments were used to measure these factors prior to the participant's engagement in the learning task. The following section outlines the data collection process, participants, instruments and procedures involved in the study.

Data Collection

Study Design. This study examined the impact of different types of distractors affecting learning recall within a virtual world. In the first part of the study participants completed the "General Survey"— a combined questionnaire which includes the Computer Experience Questionnaire and the complete Eysenck Personality Questionnaire (Adult version). The General Survey functions as a self-reported personal assessment of (1) familiarity with technology, software, prior computer experience, virtual worlds and social networking between Elementary school age to the present time, as well as (2) personality traits in relation to extroversion-introversion tendencies.

Participants. For the sake of time and efficiency, a convenience sample of 91 participants was recruited from the undergraduate Education program at the University of Alberta from September 2013 to October 2014. Participants received a 5% credit towards an Education course, EDU210: Technology Tools for Teaching and Learning, for voluntary participation in the two-hour combined study or completion of an alternate assignment. The data of two participants were removed from the analysis because the participants did not complete the survey. Therefore, the final sample for analysis was 89 participants, of which 63 were female (71%) and 26 were male (29%). The data collected from participants were anonymized to protect their privacy.

Instruments. To control for the validity and reliability of the experiment, two pre-surveys serve as covariate measures to assist with statistical data analysis.

Computer Experience Questionnaire. The first pre-survey, the Computer Experience Questionnaire (Boechler, Leenaars, & Levner, 2008; see Appendix A), is an instrument that measures computer use throughout elementary, junior high, high school and at present. This survey includes Likert-scale questions intended to account for individual differences and experience with software recognition, video games, social media and virtual learning environments. Students self-report the range of hours spent on each category from not at all to more than 10 hours a week.

Eysenck Personality Questionnaire (Adult version). The Eysenck Personality Questionnaire (Adult version) contains 90 questions measuring three personality temperaments, with 16 questions intended to measure the degree of extroversion-introversion on a scale of 1-16, with scores of 0-8 being indicative of introverted tendencies and 9-16 as having more extroverted tendencies. In accordance with the Eysenck Personality Questionnaire analysis procedures, only 16 out of the 90 questions were considered in calculating the final score for extroversion-introversion— the remaining questions acted as fillers in order to reduce the likelihood that participants would predict the intent of the survey and answer according to demand characteristics. While the results could be interpreted as scores across a continuum, using dichotomous categorizations of extroversion/introversion allows for a greater interpretation of its impact on the test score and time. According to Eysenck Personality Questionnaire Manual (Eysenck & Eysenck, 1964), scores can be categorized such that a score of "1" would indicate low extroversion levels, which could be interpreted as being "introverted", while a score of "14" would be considered high on the continuum of extroversion. A mid-score represents an intermediate level of extroversion. This interpretation approach allows for a more accurate reflection of personality traits within the sample. In order to allow for easy comparisons between extroverted and introverted participants, the categorical approach was used.

Group Embedded Figures Test (shortened version). The second pre-survey, Witkin's Group Embedded Figures Test (GEFT), will be used to determine the participant's cognitive processing style and level of field dependency and help predict behaviours related to multi-tasking or selective attention. This standardized instrument for psychological assessment requires the participant to isolate specific geometric figures integrated within composite backgrounds. The GEFT scores are then used to categorize a learner as either field-independent or field-dependent cognitive learning types. Since field dependence-independence cognitive style is largely regarded as a dichotomous quality, the data analysis for research question 3 of this study divides the participants into two categories, with each pole providing a clear distinction and comparison of the two cognitive styles (Witkin, Moore, Goodenough & Cox, 1977).

Field-independent learners tend to be more adept at restructuring information and developing skills based on internal references, but are generally less autonomous in developing interpersonal skills. On the other hand, those who exhibit field-dependence cognitive style tend to rely on information provided in the situated context and analyze problems based on interpersonal factors, but generally experience more difficulty ignoring background influences and will consequently find it harder to complete the test.

For the shortened version of the Group Embedded Figures Test (Jackson, 1956), GEFT scores are interpreted by calculating the total number of simple forms correctly traced in the Second and Third sections in the paper booklet. Any omitted items or incorrect responses are scored as incorrect. In Witkin et al.'s (1971) most recent work with smaller research groups, cognitive style groupings are determined by a median split with scores below the median interpreted as being field-dependent, and those with scores above the median treated as field-independent. The median score in this study was 6. Therefore, participants scoring below 6 on the GEFT were categorized as having a field-dependent cognitive learning style.

Procedures. For this quantitative study, an experimental design was used to “test [the] impact of treatment or intervention on [the] outcome” (Creswell, 2009, p. 145-146). To carry out the quantitative experiment, a within-subject design was utilized to control for variations among individual learning and assessment performance or speed. As such, the experiment included control variables and each participant encountered one of three randomly-ordered conditions – that is, distractor type – during the learning phase in virtual environment task. The first step involved recruiting 89 undergraduate students from the Educational Psychology research participant pool at the University of Alberta. These students received course credit for participating in the 1-hour session in a large classroom setting accommodating up to 20 students at a time. All participants were required to sign a consent form before the researcher gave specific instructions for each task.

The first task was to complete the General Survey which measures prior computer experience (Computer Experience Questionnaire) and degree of extroversion-introversion (Eysenck Personality Questionnaire). Then, the shortened version of the Group Embedded Figures Test was administered to assess cognitive learning styles and to help map possible factors affecting learning performance during multi-tasking and learning. Note that to avoid predisposing participants to the answer in a specific way or revealing the exact content being measured for the study, the researcher referred to these items as " General Survey" and "Paper Task."

Following the pre-surveys, participants were instructed how to navigate in the virtual environment using the keyboard arrows and follow the coloured arrows along a pathway. They were also tasked with reading all the windows or any instructions on the billboards they encounter. Participants were also informed that the virtual environment task had two phases and they would need to complete both to the best of their ability. These virtual tasks were, in fact, divided into a learning phase and testing phase. During the learning phase, participants navigated as an avatar along a directed pathway and read a billboard passage about the history of the London Tube Stations-- a fairly uncommon topic to prevent prior knowledge from becoming a confounded variable.

Experimental conditions. While reading each of these passages, one of three conditions randomly appeared: an interactive chat distractor, a passive text distractor or no distractors. Each participant experienced all three conditions exactly four times in random order. The *interactive distractor* is defined as a secondary, unrelated task that appears in a new window during the main learning task and prompts the participant to selectively attend to, process and input a response accordingly. Four different interactive distractors were used in the study that questioned, in random order, the following: What is your major area of studies? What year of studies are you currently in? What is the last class you went to? Have you eaten lunch yet? (see Appendix G for example of an interactive distractor used in the virtual world).

The *passive distractor* is defined as a secondary, unrelated task that appears in a new window during the main learning task but only prompts the participant to selectively attend to the stimulus without inputting any response. Four different passive distractors were used in the study that displayed the following conversational statements in random order: I'm majoring in Biology; I'm currently in my third year of studies; I just finished History class; and I just had lunch in the cafeteria (see Appendix G for example of a passive distractor used in the virtual world). Both the interactive and passive distractors were written in a conversational tone in order to make the distractors more authentic to external distractors found in real-life and virtual settings; this is in contrast to other distractor studies (e.g. Nass, 2010) that utilize math, image identification or vocabulary questions, for example, as a distractor.

The control condition in the study, *no distractor*, means that participants did not encounter a distractor while reading a billboard. This condition was also randomly selected during each session. Participants will be drawn from a convenience sample of undergraduate students enrolled in Education courses at the University of Alberta.

For each participant, the distractor type was recorded alongside each randomly-matched billboard in order to properly assess the mean scores for factual learning recall as influenced by each distractor type.

Learning task. Note that participants were not primed to learn the information for testing specifically but to simply read the billboards in order to reduce the impact of test-wiseness and demand-characteristics (See Baddeley, 1997; Hulstijn, 1989). During the testing phase, participants completed a multiple-choice test displayed on the final billboard to assess factual learning recall of the information previously presented. The OpenSim virtual environment allowed for time-tracking throughout each phase, including the specific time taken to navigate or walk within the virtual environment, reading time for each billboard and completion time for the test questions. Participants' learning performance on factual learning recall was assessed by analyzing the overall score out of 12 and total time taken to complete the multiple-choice test.

Enhancing validity and reliability. In an effort to enhance the internal validity of the experiment, the researcher purposefully excluded the use of a pre-test of the test topic about the history of the London Tube Stations in order to reduce potential threats caused by repeated testing. By doing so, the researcher can be more confident in the results since participants will not become more familiar with the outcome measure or potentially remember responses for the post-test.

Hypotheses. The three main research questions compare the effect of different research conditions (interactive, passive and no distractor) and existing personality traits (prior computer experience, extroversion/introversion, field independent/dependent cognitive learning style) on learning performance for undergraduate post-secondary students. As previous studies have yet to establish the relationships between these variables, it is difficult for the researcher to ascertain a specific directional hypothesis. Hence, the research questions for this study cumulate into the following null hypothesis: There is no significant difference between the introduction of an interactive distractor and a passive distractor on a user's factual learning performance within a virtual learning environment.

Results

Data Analysis

The main objective of this research study was to examine the relationship between prior computer experience, extroversion/introversion and field dependence-independence on learning performance in the presence of passive and interactive distractors. Based on the three research questions, this section reports the results of the multiple-regression and linear regression analyses performed on the data collected for the study.

In analysing the data drawn from the Computer Experience Questionnaire, the accumulative scores across each time period was deemed most useful in understanding the overall prior experience that students acquired regardless of whether the hours spent on a computer-mediated activity was more recent or occurred in High School, Junior High or Elementary School age. Thus, the Likert Scale values between 0 to 4 were treated as continuous data and accumulated to a total score of 16 for each category such as total video game use, total social networking use and total virtual world use. The Software Recognition Test provided a score out of 20 and measured the student recognition of common software titles interspersed with fictional titles; students scored 1 point for each correct answer and also penalized 1 score for each incorrect response. Extraversion/introversion scores were accounted for based on the number of extraversion and introversion questions in which the participant responded yes or no, up to a maximum score of 16. GEFT scores were calculated by the number of correctly traced figures, with incorrect and incomplete responses marked as incorrect, for a total possible score of 8 based on questions from relevant Sections 2 and 3.

Definition of Terms for Analysis

The following section is divided into three main research questions to describe the analyses carried out under various conditions, along with the descriptive statistics and interpretive statistics for each.

To begin, the following terms must be clarified. The "overall test time" refers to the time in minutes taken to complete the 12-item multiple choice test during the virtual world testing phase (phase two) of the study. Here, participants demonstrated their factual recall ability of the billboard information presented during the learning phase (phase one). The "overall test score" refers to the number of correct responses in the 12-item multiple choice test, with 1 score awarded for each correct response up to a maximum of 12 and no score added for incorrect or missing responses. For research question 2, "time on task" refers to the time taken to complete four multiple choice test questions based on the three types of distractors (interactive, passive or none) presented while participants read billboards during the learning phase. Similarly, "accuracy on task" refers to the number of correct responses up to a maximum of 4 multiple choice test questions based on these three types of distractors.

Research question 1. The first question examines whether prior computer experience predicts learning performance as measured by (A) overall test time, and (B) overall test score, in a virtual environment. Since research question 1A seeks to understand if prior computer experience predicts learning performance as measured by overall test time in a virtual environment, a multiple regression analysis was used. The independent variables include the components used in the Computer Experience Questionnaire including the software recognition test, total video game use, total social networking use and total virtual world use; the dependent variable is the overall test time for recalling information from the billboards, which is a continuous variable.

A number of assumptions for a multiple regression analysis must be met including an independence of errors (residuals). There was independence of residuals as assessed by a Durbin-Watson statistic of 1.636. A second assumption is that a linear relationship exists between the predictor variables and the dependent variable. By plotting the studentized residuals (SRE_1) against the unstandardized predicted values (PRE_1), a linear relationship can be observed and satisfies this assumption. A third assumption is that there is homoscedasticity of residuals (equal error variances) as evidenced by the spread of residuals. There is homoscedasticity since the spread of residuals do not increase or decrease as one moves across the predicted values. In addition, there are no leverage values (LEV_1) above the "safe" value of 0.2 and no Cook's Distance (COO_1) values above 1, thereby suggesting that no residuals would represent a significant outlier. In order to determine if the residuals are normally distributed, the histogram and P-P Plot was consulted to confirm that the points appear along a diagonal line and no data transformations were therefore required.

To ensure no multicollinearity exists with two or more independent variables that highly correlate with each other— which may lead to issues understanding which variable contributes to the variance explained in the multiple regression model— the correlation coefficients were consulted to determine any significance. Based on the Pearson correlation matrix displayed in Table 1, there was a statisically significant correlation of 0.45 and a weak positive correlation between Total Video Game Use (video_game_total) and Total Virtual World Use (virtual_world_total) at $p<0.01$. However, since the Variance Inflation Factor (VIF) is not greater than a value of 10 for either variables (video_game_total VIF=1.27 and virtual_world_tota VIF=1.28), there is no statistically significant multicollinearity. Henceforth, the first analysis included both Total Video Game Use and Total Virtual World Use as independent variables.

Table 1

Complete Correlation Matrix for All Variables

Measure	*1*	2	3	4	5	6	7	8	9	10	11
1. Software Recognition	1.00	0.19	0.12	0.14	0.23	0.31	0.05	0.20	0.14	0.24	0.11
2. Total Video Game Use		1.00	-0.05	0.45**	-0.15	0.17	-0.38	0.53	0.47	0.45	0.34
3. Total Social Networking Use			1.00	-0.15	0.15	-0.02	0.05	0.00	0.05	0.12	-0.18
4. Total Virtual World Use				1.00	-0.06	0.13	-0.21	0.22	0.18	0.26	0.09
5. Extroversion Score					1.00	-0.16	-0.04	-0.28	-0.17	0.00	-0.48
6. GEFT Score						1.00	-0.13	0.20	0.14	0.22	0.13
7. Overall Test Time							1.00	-0.04	-0.07	-0.14	0.12
8. Overall Test Score								1.00	0.82	0.79	0.74
9. Interactive Distractor Accuracy									1.00	0.53	0.35
10. Passive Distractor Accuracy										1.00	0.39

11. No Distractor Accuracy	1.00

**. Correlation is significant at the 0.01 level (2-tailed).

A multiple regression was run to predict overall test time (MC_test_time) from software recognition, total video games, total social networking and total virtual world experience. As described earlier, the assumptions of linearity, independence of errors, homoscedasticity, unusual points and normality of residuals were met. A summary of the descriptive statistics for computer experience on overall test time can be found in Table 2.

Table 2

Descriptive Statistics for Computer Experience Dimension

Computer Experience Dimension	*n*	M	SD
Software Recognition Test	89	11.38	2.348
Total Video Game Use	89	3.54	3.829
Total Virtual World Use	89	0.71	2.046
Total Social Networking Use	89	5.62	3.006

Note. CI = Confidence Interval

In order to determine how well the regression model fits the data, the multiple correlation coefficient, R = 0.401, which means there is a moderate correlation between the predictor variables and the dependent variable. The coefficient of determination, R Square = 0.161, indicates that 16.1% of the variance in the dependent variable can be explained by the predictor variables. In order to correct for the positively-biased estimate of R Square, the Adjusted R Square, adj. R square = 0.131 represents a 13.1% variance in the dependent variable that can be explained by the dependent variables or the estimate of the effect size. According to Cohen's (1988) classification, a value of 13.1% is a small effect size.

According to the ANOVA results when including all four computer experience dimensions as predictor variables, software recognition, video game use, social networking use and virtual world use statistically significantly predict the overall test time, $F(3, 84) = 4.112$, $p < .0005$. Despite the correlation between Total Video Game Use and Total Virtual World Use, a summary of the multiple regression analysis in Table 3 revealed that only Total Video Game Use significantly added to the prediction at $p < .05$.

Table 3

Summary of Multiple Regression Analysis for Computer Experience Dimension on Overall Test Time

Computer Experience Dimension	*B*	SE	β	Sig
Software Recognition Test	0.100	0.097	0.098	0.302
Total Video Game Use	0.332	0.065	0.530	0.000
Total Virtual World Use	-0.038	0.122	-0.032	0.757
Total Social Networking Use	0.005	0.075	0.006	0.948

Note. CI = Confidence Interval

During the second analysis, Virtual World Use was removed from the predictor variables in order to compare the significance of including highly correlated variables (Virtual World Use and Video Game Use) into the regression analysis. A hierarchal regression analysis was conducted to determine which portion of the total variance was contributed by Total Video Game Use as opposed to Total Virtual World Use by entering both variables into the regression equation in a different order. Changing the order helped control for the effects of co-variates in the results and account for possible casual effects of Total Video Game Use (video_games_total) and Total Virtual World Use (virtual_world_total).

Based on the hierarchal multiple regression analysis results found in Table 4, Total Video Game Use significantly predicted MC_test_time, $F(3, 85) = 5.419$, $p < .0005$. The Adjusted R Square is 0.131 or 13.1%, which is an estimate of the Effect Size. According to Cohen's (1988) classification, this value is indicative of a small effect size.

Table 4

Summary of Multiple Regression Analysis for Computer Experience Dimension on Overall Test Time with Total Virtual World Use Removed

Computer Experience Dimension	*B*	SE	β	t	Sig
Software Recognition Test	0.145	0.117	0.126	1.236	0.000
Total Video Game Use	-0.284	0.072	-0.403	-3.973	0.000
Total Social Networking Use	0.016	0.090	0.018	0.178	0.859

Table 5

Summary of Multiple Regression Analysis for Computer Experience Dimension on Overall Test Time

Computer Experience Dimension	*n*	M (SD)	*P value*
Software Recognition Test	89	0.15 (0.12)	0.21
Total Video Game Use	89	-0.26 (0.08)	0.00**
Total Social Networking Use	89	0.01 (0.09)	0.93
Total Virtual World Use	89	-0.08 (0.15)	0.57

Note. CI = Confidence Interval

Adjusted R-squared= 0.1237

Therefore, Total Virtual World Use can be removed from the regression equation on the basis that Total Video Game Use is the only statistically significant predictor of overall test time and therefore would account for the majority of the overlap in variance between these two independent variables. Furthermore, it is reasonable to remove Total Virtual World Use from this analysis as there may have been confusion among participants about the interpretation and definition of a virtual world— specifically since video games take place within virtual worlds and this information was not provided in the General Survey.

For Research Question 1B, a multiple regression analysis was conducted to determine if prior computer experience predicts learning performance overall test score in a virtual environment. Again, the Computer Experience Questionnaire scores for software recognition, video game use, social networking use and virtual world use were the independent variables used to determine if they could predict overall test scores. As seen in Question 1A, the first analysis included all four factors despite the high correlation between video game use and virtual world use, and the second analysis without the virtual world use predictor was used to check for any differences in significance between the two models.

Before running the analyses, a number of assumptions were checked to ensure the model was a good fit for the data. In the first analysis using all four predictors, there was an independence of residuals as assessed by a Durbin-Watson statistic of 2.279. Based on the scatterplot for the studentized residuals and the unstandardized predicted values, a linear relationship between the predictor variables was prevalent. There is homoscedasticity since the spread of residuals do not increase or decrease as one moves across the predicted values. Since all the cases have standardized residuals less than ±3 and no leverage values (LEV_1) above the "safe" value of 0.2 or no Cook's Distance (COO_1) values above 1, there are no residuals that would represent an outlier. Since the VIF is not greater than 10, there is no collinearity. No data transformations were required since the points along the P-Plot indicate the residuals are normally distributed.

In the second analysis with virtual world use removed as a predictor, the VIF ranged from 1.043 to 1.282, indicating no collinearity. The Durbin-Watson value was 2.279. The multiple correlation coefficient, which can be considered a measure of quality in predicting the dependent variable is R= 0.542, indicating a low to moderate level of prediction. The Adjusted R Square is 0.269 or 26.9%, which is an estimate of the Effect Size. According to Cohen's (1988) classification, this value is indicative of a small effect size. The F-ratio in the ANOVA table indicated that computer experience significantly predicted MC_test_score, F(3, 85) = 11.802, p < .0005. The summary of the multiple regression analysis for Computer Experience Dimension on Overall Test Score is found in Table 6. Based on the "Sig." column, video game use was statistically significantly different from 0. A multiple regression was run to predict MC_test_score from software recognition, total video games and total social networking. The assumptions of linearity, independence of errors, homoscedasticity, unusual points and normality of residuals were met. These variables statistically significantly predicted MC_test_score, F(3, 85) = 11.802, p < .0005., adj. R^2 = .269. All four variables added statistically significantly to the prediction, $p < .05$. Regression coefficients and standard errors can be found in Table 6.

Table 6

Summary of Multiple Regression Analysis for Computer Experience Dimension on Overall Test Score with Total Virtual World Use Removed

Computer Experience Dimension	*B*	SE	β	t	P
Software Recognition Test	0.098	0.096	0.096	1.022	0.309
Total Video Game Use	0.324	0.058	0.516	5.545	0.000
Total Social Networking Use	0.008	0.074	0.011	0.115	0.909

Research question 2. For the second research question, the sample group was further divided into a category of extroverts and introverts based on the scores obtained from the Eynseck Personality Questionnaire in order to determine if there were test time or test score differences for either group based on distractor types. As the sample was drawn from undergraduate education students on a voluntary basis without specific requirements, an uneven distribution of extroverts and introverts were already present (n= 64 and n=25, respectively). As such, this sample was an authentic reflection of the undergraduate education student population, which can be used to draw further implications for research in this specific context.

The first part, Question 2A, investigated if there was a difference for extroverts (n=64) in time on task given the type of distraction (interactive, passive, none) present. A repeated measures ANOVA test was used to determine the effect of the participant's extroversion/introversion on time to complete questions for different distractor types. Then, since there were no pre-determined hypotheses about the differences between the distractor types, a post hoc test was used to ensure all the pairwise comparisons were accounted for. For the ANOVA, three categorical levels or types of distractors (interactive, passive, none) were used as the independent variable. The dependent variable, which must be a continuous variable for a one-way repeated measures ANOVA, was the time taken to complete the set of questions in the presence of interactive distractors, passive distractors and no distractors.

Preliminary assumption checking revealed that data was normally distributed as assessed by the Shaprio-Wilk test ($p > .05$). There were also no univariate or multivariate outliers as assessed by the boxplot and Mahalanobis distance ($p > .001$). Furthermore, linear relationships were evident based on the inspection of the scatterplot. Mauchly's test of sphericity indicated that the assumption of sphericity had been violated, $\chi^2(2) = 8.730$, $p = .013$. No multicollinearity exists as revealed by r = .690, p = .000 and there was homogeneity of variance-covariance matrices, as assessed by Box's M test (p = .047).

The descriptive statistics for research question 2A is displayed in Table 7. Time on task for distractor type was highest for passive distractors (M = 4.2967 ± SD = 1.12 minutes), moderate for interactive distractors (M = 3.6206 ± SD = 0.93 minutes) and lowest for the constant condition or no distractors (M = 3.0947 ± SD = 0.90 minutes).

Table 7

Descriptive Statistics for Extroverts' Time on Task based on Presence of Distractor Type During Learning

Distractor Type	*n*	M (SD)
Interactive Distractor	64	3.6206 (0.92651)
Passive Distractor	64	4.2967 (1.12078)
No Distractor	64	3.0947 (0.90357)

Epsilon (ε) was 0.884, as calculated according to Greenhouse & Geisser (1959), which was used to correct the one-way repeated measures ANOVA. The ANOVA results revealed that time on task was statistically significantly different depending on the distractor type intervention, $F(1.768, 111.372) = 110.474$, p = .000 with a large effect size of partial η^2= .637. Therefore, the null hypothesis was rejected and the alternative hypothesis that time on task is not equal among distractor types was accepted.

The difference between extroversion/introversion on the combined dependent variables was statistically significant, $F(3, 85) = 29.255, p < .0005; Wilks' \Lambda = .492; partial\ \eta^2 = .508$. Follow-up univariate ANOVAs showed that there was a statistically significant difference in the time taken to respond after interactive distractions (time_interactive) between the participants who are extroverted as opposed to introverted, $F(1, 87) = 23.030$, $p < .0005$; partial η^2 = .235, using a Bonferroni adjusted α level of .025. However, there was no statistically significant difference in time taken to respond after passive distractors (time_passive) between the participants who are extroverted as opposed to introverted, $F(1, 87) = 1.191$, $p < .0005$; partial $\eta^2 = .012$. Further, there was no statistically significant difference in time taken to respond after no distractors (time_no_dist) between the participants who are extroverted as opposed to introverted, $F(1, 87) = 0.005$, $p < .0005$; partial $\eta^2 = .000$.

Table 8

Descriptive Statistics for Extroversion/Introversion (categorical variable) on Overall Test Time

Distractor Type	*n*	M (SD)	*P value*
Passive Distractor	89	1.14 (0.11)	8.26e-13**
Interactive Distractor	89	0.83 (0.15)	9.50e-08**
Interaction for Extro/Introversion	89	0.29 (0.14)	0.03**

Note. CI = Confidence Interval

Adjusted R-squared= 0.18

Question 2B seeks to understand if there was a difference for introverts (n = 25) in time on task given the type of distraction (interactive, passive, none) that is present. Once again, this question seeks to understand differences between conditions for a within-subjects design with multiple levels for the factor, so a repeated measures ANOVA and post-hoc test was used for the analysis.

First, the assumptions were checked to ensure no significant outliers exist in the data based on the inspection of the boxplot. The type of distractor was normally distributed, as assessed by Shapiro-Wilk's test (p > .05). Mauchly's test of sphericity indicated that the assumption of sphericity had been violated, $\chi^2(2) = 8.730$, $p = .013$.

The descriptive statistics are displayed in Table 9. In the analysis, time on task for distractor type was highest for interactive distractors ($M = 4.6880 \pm SD = 0.93126$ minutes), moderate for passive distractors ($M = 4.0544 \pm SD = 0.89709$ minutes) and lowest for the constant condition or no distractors ($M = 3.1468 \pm SD = 0.90638$ minutes).

Table 9

Descriptive Statistics for Introverts' Time on Task based on Presence of Distractor Type During Learning

Distractor Type	*n*	M (SD)
Interactive Distractor	25	4.6880 (0.93126)
Passive Distractor	25	4.0544 (0.89709)
No Distractor	25	3.1468 (0.90638)

Epsilon (ε) was 0.897, as calculated according to Greenhouse & Geisser (1959), and was used to correct the one-way repeated measures ANOVA. Time on task was statistically significantly different at the different time points during the distractor type intervention, $F(1.794, 43.050) = 84.777$, $p = .000$, partial $\eta^2 = .779$. Therefore, the null hypothesis was rejected and the alternative hypothesis that time on task is not equal among distractor types was accepted.

The post-hoc tests found that between passive and interactive distractors, there was a slight increase in time on task during interactive distractor types ($M = 4.688$, $SD = 0.931$ minutes) from time on task during passive distractor types ($M = 4.05$, $SD = 0.897$ minutes) of 4.69 minutes from 4.05 minutes, a statistically significant mean increase of 0.634 minutes (or 38.04 seconds), 95% CI [0.308, 0.960], $p < .001$.

A comparison between interactive and no distractors revealed that there was an increase in time on task during interactive distractor types ($M = 4.688$, $SD = 0.931$ minutes) from time on task during no distractors ($M = 3.149$, $SD = 0.906$ minutes) of 4.69 minutes from 3.15 minutes, a statistically significant mean increase of 1.541 minutes (or 92.46 seconds), 95% CI [1.205, 1.877], $p < .001$.

A final post-hoc test between passive and no distractors revealed that there was an increase in time on task during passive distractor types ($M = 4.05$, $SD = 0.897$ minutes) from time on task during no distractors ($M = 3.149$, $SD = 0.906$ minutes) of 4.05 minutes from 3.15

minutes, a statistically significant mean increase of .908 minutes (or 54.48 seconds), 95% CI [0.658, 1.157], $p < .001$.

According to the results discovered in research questions 2A and 2B, introverted participants took slightly more time to answer questions in the presence of interactive distractors ($M = 4.718$, $SD = 0.182$) and no distractors ($M = 3.109$, $SD = 0.176$), but took relatively less time in the presence of passive distractors ($M = 4.054$, $SD = 0.213$) than the extroverted participants (Interactive: $M = 3.600$, $SD = 0.117$; None: $M = 3.093$, $SD = 0.113$ and Passive: $M = 4.309$, $SD = 0.137$, respectively).

Question 2C seeks to understand if there was a difference for extroverts (n=64) in accuracy on task given the type of distraction (interactive, passive, none) that is present. A repeated measures ANOVA and post-hoc test was used for the analysis of differences between these conditions.

Assumptions were checked and no outliers in the data were found based on the inspection of a boxplot. Type of distractor was normally distributed, as assessed by Shapiro-Wilk's test ($p > .05$). Mauchly's test of sphericity indicated that the assumption of sphericity had been violated, $\chi^2(2) = 1.754$, $p = .416$.

The descriptive statistics are displayed in Table 10. For extroverts, accuracy on task for distractor type was highest for passive distractor ($M = 3.22 \pm SD = 0.888$ score), moderate for the control condition with no distractors ($M = 2.683 \pm SD = 0.997$ score) and lowest for the interactive distractors ($M = 2.32 \pm SD = 1.060$ score).

Table 10

Descriptive Statistics for Extroverts' Accuracy on Task based on Presence of Distractor Type During Learning

Distractor Type	*n*	M (SD)
Interactive Distractor	64	2.32 (1.060)

Passive Distractor	64	3.22 (0.888)
No Distractor	64	2.68 (0.997)

Epsilon (ε) was 0.972, as calculated according to Greenhouse & Geisser (1959), and was used to correct the one-way repeated measures ANOVA. Accuracy on task was statistically significantly different among the distractor type intervention, $F(1.945, 120.582) = 25.332$, p = .000, with a small effect size of partial $\eta^2 = .290$. Therefore, the null hypothesis was rejected and the alternative hypothesis that accuracy on task is not equal among distractor types was accepted.

In the post-hoc test comparing passive and interactive distractors, there was a decrease in accuracy on task during interactive distractor types ($M = 2.432$, $SD = 1.060$ score) from accuracy on task during passive distractor types ($M = 3.22$, $SD = 0.888$ score) of 2.43 average accuracy scores compared to 3.22 average accuracy scores for passive distractor types, a statistically significant mean decrease of 0.905 scores, 95% CI [0.601, 1.208], p =0.000.

The post-hoc test comparing interactive and no distractors, there was a decrease in accuracy on task during interactive distractor types ($M = 2.432$, $SD = 1.060$ score) from accuracy on task during no distractors ($M = 2.68$, $SD = 0.997$ score) of 2.43 average accuracy scores compared to 2.68 average accuracy scores for passive distractor types, a statistically significant mean decrease of 0.365 scores, 95% CI [0.25, 0.705], p =0.031.

In a comparison between passive and no distractors, there was an increase in accuracy on task during passive distractor types ($M = 3.22$, $SD = 0.888$ score) from accuracy on task during no distractors ($M = 2.68$, $SD = 0.997$ score) of 3.22 average accuracy scores. Compared to 2.68 average accuracy scores for no distractor types, there was a statistically significant mean increase of 0.540 scores for passive distractors, 95% CI [0.241, 0.839], p =0.000.

Question 2D seeks to understand if there was a difference for introverts in accuracy on task given the type of distraction (interactive, passive, none) that is present. For the repeated-measures ANOVA, several assumptions were checked beforehand. There were no outliers in the data, as assessed by inspection of a boxplot. Type of distractor was normally distributed, as assessed by Shapiro-Wilk's test ($p > .05$). Mauchly's test of sphericity indicated that the assumption of sphericity had been violated, $\chi^2(2) = 6.392$, $p = .041$.

The descriptive statistics are displayed in Table 11.

Table 11

Descriptive Statistics for Introverts' Accuracy on Task based on Presence of Distractor Type During Learning

Distractor Type	*n*	M (SD)
Interactive Distractor	25	2.44 (1.294)
Passive Distractor	25	3.28 (0.891)
No Distractor	25	3.72 (0.737)

The ANOVA revealed that for introverts, accuracy on task for distractor type was highest for the control condition of no distractors ($M = 3.72 \pm SD = 0.737$ score), moderate for passive distractors ($M = 3.280 \pm SD = 0.178$ score) and lowest for the interactive distractors ($M = 2.440 \pm SD = 0.259$ score). Epsilon (ε) was 0.805, as calculated according to Greenhouse & Geisser (1959), and was used to correct the one-way repeated measures ANOVA. Accuracy on task was statistically significantly different among the distractor type intervention, $F(1.609, 38.627) = 16.813$, $p = .000$, with a medium effect size of partial $\eta^2 = .412$. Therefore, the null hypothesis was rejected and the alternative hypothesis that time on task is not equal among distractor types was accepted.

In the post-hoc comparison between passive and interactive distractors, there was a decrease in accuracy on task during interactive distractor types ($M = 2.44$, $SD = 1.294$ score) from accuracy on task during passive distractor types (*M* = 3.28, *SD* = 0.891 score) of 2.44 average accuracy scores compared to 3.28 average accuracy scores for passive distractor types, a statistically significant mean decrease of 0.840 scores, 95% CI [0.332, 1.348], p =0.001.

A comparison between interactive and no distractors indicated that there was a decrease in accuracy on task during interactive distractor types (*M* = 2.44, *SD* = 1.294 score) from accuracy on task during no distractors (*M* = 3.72, *SD* = 0.737 score). The 2.44 average accuracy scores for interactive distractor types compared to 3.72 average accuracy scores for no distractor types indicated a statistically significant mean decrease of 1.280 scores, 95% CI [0.575, 1.985], p =0.000.

A comparison between passive and no distractors found there was a decrease in accuracy on task during passive distractor types (*M* = 3.28, *SD* = 0.891 score) from accuracy on task during no distractors (*M* = 3.72, *SD* = 0.737 score) as shown by the 3.28 average accuracy scores for passive distractor types compared to 3.72 average accuracy scores for no distractor types. However, the results were not statistically significant.

For question 3A and 3B, the sample was divided into two groups based on cognitive style to determine if there would be any effects on overall test time or overall test score. In the first part (question 3A), the researcher sought to understand if field-independent participants demonstrate lower overall test time, and therefore better performance, than field-dependent participants. In order to analyse the difference between groups, an independent samples t-test was used. Note that H_0: the cognitive style mean difference between the paired values was equal to zero (i.e., $\mu_{diff} = 0$) and H_A the cognitive style mean difference between the paired values was not equal to zero (i.e., $\mu_{diff} \neq 0$). The alternative hypothesis was that field-independent individuals would perform better with shorter overall test times. After running the analysis, a p-value of 0.2119 was found with a t= 0.8042 and df = 73.569. The 95% confidence interval was at -0.501. The mean for the field-dependent was 11.547, while the mean for the field-independent group was 11.079. Since the P-value > 0.05, test time did not depend on cognitive style.

For question 3B, an alternative hypothesis presumed that field-independence would lead to higher test scores. After the analysis, a p-value of 0.051 was found with t=-1.65 and df= 69.07. The 95% conference interval is 0.007, and the mean for the field-dependence group was 8.029 as compared to the field-independent group with a mean of 8.891. Since the P-value was on the border of 0.05, spastically speaking there was something to investigate further. Taken altogether, however, an average test score difference of 0.86 is not significant.

Table 12

Two Sample T-Test (One-Sided) of Cognitive Style on Overall Test Time

Cognitive Style	*n*	M
Field-Dependent	89	11.55
Field-Independent	89	11.07

Note. CI = Confidence Interval

Since the alternative hypothesis is that field-independence individuals had shorter test time and higher test scores, a one-sided two-sample t-test was used since was assumed that the means were going to be different and larger than the other. The P-value > 0.05 = 0.21 and therefore field dependence/independence was not a significant factor for overall test time. Further, the average test time difference was 11.55-11.07=0.48 minutes difference (28.8 seconds).

Table 13

Two Sample T-Test (One-Sided) of Cognitive Style on Overall Test Score

Cognitive Style	*n*	M
Field-Dependent	34	8.03
Field-Independent	55	8.89

Since the P-value= 0.05, there may be something further to investigate in terms of field dependence/independence on overall test scores. However, the average test score difference was 8.89-8.03= 0.86.

Findings of the Study

Discussion of Results

For research question 1, it was found that only video game use was a significant predictor of overall test time and test score. That is, more prior experience with video games predicts lower overall test time and higher test scores. Interestingly, the time in which prior video game experience was acquired did not affect overall time or accuracy. A probable explanation for this result is that video games require players to attend to multiple stimuli and task-shift quickly. For example, the game interface may have multiple gauges for health points, magic points, score, inventory, etc. displayed while players are engaging in interactive events during gameplay. Therefore, the repeated practice and exposure within video games likely decreased cognitive load for similar onscreen activities such as playing in a virtual environment. Also, since video games are often set in virtual environments, they may have already acquired skill sets that allow them to quickly skim material and recognize cues that aid information recall. As exposure and experience in video games is accumulated over time, the specific time period in which this experience occurred would be irrelevant. Software recognition and social networking use may not have had a significant effect because the skills required in these activities would be less relevant to the virtual environment tasks at-hand. For instance, the virtual world did not analyze the accuracy of social responses or require recognition of other types of software such as SPSS.

For research question 2, extroverts tended to take the most time to complete the test during the presence of passive distractors instead of interactive distractors. This result may reflect arousal theory in that extroverts may require more stimulation and have a higher threshold for social activity; thus the researcher speculates that there is an optimal level of arousal that benefits extroverted individuals when they learn in the presence of interactive distractors that are socially-oriented. In addition, extroverts may be more adept at managing social interactions while multi-tasking and may require less time formulating a response because of their predisposition to value social interactions over factual learning required for the test. Thus, the extroverts may have rushed through the test or were less concerned about the test performance. Also note that extroverts actually obtained the worst test scores for interactive distractors. This may indicate that while extroverts may be quick to complete the test, they did not process the primary task as effectively when information was presented in the presence of interactive distractors. Thus, while experience or comfort with social situations may predict faster response times, accuracy scores may decrease as the reduced time needed may require greater processing or mental exertion. Consequentially, less cognitive processing is allocated to the primary task.

On the other hand, introverts tended to take the most time to complete the test and had the lowest test scores during the presence of interactive distractors. In line with the arousal theory, introverts have a lower optimal level of arousal, which interactive distractors will likely overshoot. As a result, introverts perform relatively poorly in response to too much arousal. In addition, introverted participants may be more easily distracted by interactive messages or utilize more attentional resources to process interactive distractors because of less experience or greater discomfort in social situations. Furthermore, the extra time used for responding to the test questions may have been a reflection of more careful concentration or focus on the primary task.

For research question 3, field independence significantly predicted accuracy scores but not time on task. These results may be due to the fact that field-independent participants were better at ignoring extraneous information (ie. distractors) and focus more attentional resources towards the primary task. However, the average test score difference between the two cognitive style groups was only 0.86 scores out of 12, which indicates no real practical significance. While cognitive style may have been a factor on test scores, it is comparably less impactful than personality traits such as extroversion/introversion or computer experience.

Assumptions and Limitations

Some assumptions of this true experimental design include the internal validity of test scores and completion times as indicators of the quality of factual learning, as well as the fact that participants are moderately motivated to learn within the virtual environment to obtain course credit or to experience alternate delivery formats in education. The study did not account for test-wiseness or familiarity with the test topic. Furthermore, while the study examined three levels of distractors, distractions can come in many forms and contexts. For example, this study only investigated visual, social distractors. Future studies could examine distractors involving audio or kinaesthetic elements. These unexamined distractor types may reflect real-life situations an individual may encounter in cases such as receiving a video call, playing music while working on a task or being alerted to a message through the vibration of a phone. Other avenues for future exploration could address the hypothesis that learners may exert less cognitive effort when switching between tasks while using the same device or one computer in comparison to switching between various devices. In this case, the proximity or immediacy of the distractions may have an effect on the participant's performance when learning within the virtual environment. Another limitation of the study is that the results may not apply to other populations such as children, adults not in post-secondary education. Future research into different populations and fields may be required.

In addition, due to the specific context that participants were immersed in, the outcomes of the study should not be generalized to individuals in other settings such as face-to-face classrooms. Rather, further studies need to be conducted to determine if similar results would occur in other online environments apart from OpenSim, as well as distance learning or blended-delivery formats.

Conclusion

Based on the results of this study, video game experience may aid multi-tasking performance through familiarity of simultaneously attending to various stimuli on the computer screen. In addition, since video games take place in virtual environments, the transfer of skills and comfort with these platforms may translate to better performance on factual learning recall during distractions. However, more generalized experience with computers such as software recognition or familiarity with social media does not seem to have such an impact— perhaps because they train a different set of skills on a different platform.

Personality traits also seem to have some predictive value for the ability to effectively multi-task and recall factual information during a test. Specifically, extroversion may predict faster test times but lower accuracy scores compared to introverts due to the predisposition to value social or interactive tasks over factual applications.

Finally, while field independence may have a minimal impact on factual learning recall, it does not translate into any practical significance. That is, cognitive learning style may factor into multi-tasking performance but is overshadowed by other predominant personality traits of the individual as well as personal experience. Overall, while preliminary research in virtual learning environments has demonstrated that some personal factors may affect the impact of multi-tasking on factual learning, there is still much to undercover about the effect of distractors on various learning tasks and diverse populations. These insights may enhance one's understanding of learning in the technological, multi-tasking world.

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Appendix A: General Survey

(Section 2: Computer Experience Questionnaire,

Section 3: Eysenck Personality Questionnaire)

ELV305 (1 credit) - General Survey

Before we begin, we would like to know a little more about you.

Your responses will be kept confidential and reported anonymously; only the researchers for this project have access to your responses so we would ask you to answer the following survey as honestly as you can. You are free to not participate at all, or stop participating if you wish, at any time.

The survey will take less than 5 minutes. Thank you.
* Required

Section 1

First Name *

[ ]

Last Name *

[ ]

Student ID Number *

[ ]

Gender *

- ○ Male
- ○ Female
- ○ Other

Section 2

Video Games *
Please indicate how much time you spent PLAYING VIDEO GAMES, on average, PER WEEK, during the following:

	Not at all	1-3 Hrs	4-6 Hrs	7-10 Hrs	>10 Hrs
In recent weeks	○	○	○	○	○
While in Highschool	○	○	○	○	○
While in Junior High	○	○	○	○	○
While in Elementary	○	○	○	○	○

Social Networking *
Please indicate how much time you spent USING SOCIAL NETWORKING (eg. Facebook, Twitter, MSN, E-mail), on average, PER WEEK, during the following:

	Not at all	1-3 Hrs	4-6 Hrs	7-10 Hrs	>10 Hrs
In recent weeks	○	○	○	○	○
While in Highschool	○	○	○	○	○
While in Junior High	○	○	○	○	○
While in Elementary	○	○	○	○	○

Virtual World *
Please indicate how much time you spent INTERACTING WITHIN VIRTUAL WORLDS (eg. Second Life, Massive Multi-player Online Games, World of Warcraft), on average, PER WEEK, during the following:

	Not at all	1-3 Hrs	4-6 Hrs	7-10 Hrs	>10 Hrs
In recent weeks	○	○	○	○	○
While in Highschool	○	○	○	○	○
While in Junior High	○	○	○	○	○
While in Elementary	○	○	○	○	○

Software Recognition *

Please check off any of the following titles that you recognize

- ☐ Microsoft Word
- ☐ Gears of War
- ☐ WriterMate
- ☐ Towers
- ☐ CiteMagic
- ☐ Tetris
- ☐ PowerPoint
- ☐ Infinite Legend
- ☐ EndNote
- ☐ Forecast
- ☐ Smash 'n Grab
- ☐ Inspiration
- ☐ NotePack
- ☐ All Account
- ☐ Speech Complete
- ☐ Excel
- ☐ Spyder Web-weave
- ☐ Cal Math
- ☐ Blinkers
- ☐ Winzip
- ☐ Skype
- ☐ MatLab
- ☐ Halo
- ☐ Naturally Speaking
- ☐ KJ Rate
- ☐ Access
- ☐ Adobe Acrobat
- ☐ SPSS
- ☐ Final Shot
- ☐ Alpha Tank Division
- ☐ WordDirect
- ☐ Grand Theft Auto
- ☐ PowerGen
- ☐ SNRP
- ☐ Dreamweaver
- ☐ Metal Vangaurd
- ☐ The Sims
- ☐ World of Warcraft
- ☐ Secret Mind Garden
- ☐ Final Fantasy

Computer Activities *
Please check off any activities you have ENGAGED in.

- [ ] building a website
- [ ] creating a slide presentation
- [ ] creating a spreadsheet
- [ ] using formulas in a spreadsheet
- [ ] compressing files
- [ ] creating a PDF
- [ ] using library databases
- [ ] accessing online journals
- [ ] writing HTML code
- [ ] writing other programming code
- [ ] using statistical packages
- [ ] accessing digital books
- [ ] using a learning management system (ie. WebCT/Blackboard/Moodle)

Section 3

Please answer each question by marking "yes" or "no" based your personal tendencies or inclinations. There are no right or wrong answers, and no trick questions. Work quickly and do not think too long about the exact meaning of the question.

1. Do you have many different hobbies? *

- ◯ Yes
- ◯ No

2. Do you stop to think things over before doing anything? *

- ◯ Yes
- ◯ No

3. Does your mood often go up and down? *

- ◯ Yes
- ◯ No

4. Have you ever taken the praise for something you knew someone else had really done? *

- ◯ Yes
- ◯ No

5. Are you a talkative person? *

- ◯ Yes
- ◯ No

6. Would being in debt worry you? *

- ◯ Yes
- ◯ No

7. Do you ever feel "just miserable" for no reason? *

- ◯ Yes
- ◯ No

8. Were you ever greedy by helping yourself to more than your share of anything? *

- ◯ Yes
- ◯ No

9. Do you lock up your house carefully at night? *

- ◯ Yes
- ◯ No

10. Are you rather lively? *

- ◯ Yes
- ◯ No

11. Would it upset you a lot to see a child or an animal suffer? *

- ◯ Yes
- ◯ No

12. Do you often worry about things you should not have done or said? *

- ◯ Yes
- ◯ No

13. If you say you will do something, do you always keep your promise no matter how inconvenient it might be? *

- ◯ Yes
- ◯ No

14. Can you usually let yourself go and enjoy yourself at a lively party? *

- ◯ Yes
- ◯ No

15. Are you an irritable person? *

- Yes
- No

16. Have you ever blamed someone for doing something you knew was really your fault? *

- Yes
- No

17. Do you enjoy meeting new people? *

- Yes
- No

18. Do you believe insurance plans are a good idea? *

- Yes
- No

19. Are your feelings easily hurt? *

- Yes
- No

20. Are all your habits good and desirable ones? *

- Yes
- No

21. Do you tend to keep in the background on social occasions? *

- Yes
- No

22. Would you take drugs which may have strange or dangerous effects? *

- Yes
- No

23. Do you often feel "fed up"? *

◯ Yes

◯ No

24. Have you ever taken anything (even a pin or button) that belonged to someone else? *

◯ Yes

◯ No

25. Do you like going out a lot? *

◯ Yes

◯ No

26. Do you enjoy hurting people you love? *

◯ Yes

◯ No

27. Are you often troubled about feelings of guilt? *

◯ Yes

◯ No

28. Do you sometimes talk about things you know nothing about? *

◯ Yes

◯ No

29. Do you prefer reading to meeting people? *

◯ Yes

◯ No

30. Do you have enemies who want to harm you? *

◯ Yes

◯ No

31. Would you call yourself a nervous person? *

- ◯ Yes
- ◯ No

32. Do you have many friends? *

- ◯ Yes
- ◯ No

33. Do you enjoy practical jokes that can sometimes really hurt people? *

- ◯ Yes
- ◯ No

34. Are you a worrier? *

- ◯ Yes
- ◯ No

35. As a child did you do as you were told immediately and without grumbling? *

- ◯ Yes
- ◯ No

36. Would you call yourself happy-go-lucky? *

- ◯ Yes
- ◯ No

37. Do good manners and cleanliness matter much to you? *

- ◯ Yes
- ◯ No

38. Do you worry about awful things that might happen? *

- ◯ Yes
- ◯ No

39. Have you ever broken or lost something belonging to someone else? *

◯ Yes

◯ No

40. Do you usually take the initiative in making new friends? *

◯ Yes

◯ No

41. Would you call yourself tense or "highly-strung"? *

◯ Yes

◯ No

42. Are you mostly quiet when you are with other people? *

◯ Yes

◯ No

43. Do you think marriage is old-fashioned and should be done away with? *

◯ Yes

◯ No

44. Do you sometimes boast a little? *

◯ Yes

◯ No

45. Can you easily get some life into a rather dull party? *

◯ Yes

◯ No

46. Do people who drive carefully annoy you? *

◯ Yes

◯ No

47. Do you worry about your health? *

◯ Yes

◯ No

48. Have you ever said anything bad or nasty about anyone? *

◯ Yes

◯ No

49. Do you like telling jokes and funny stories to your friends? *

◯ Yes

◯ No

50. Do most things taste the same to you? *

◯ Yes

◯ No

51. As a child did you ever talk back to your parents? *

◯ Yes

◯ No

52. Do you like mixing with people? *

◯ Yes

◯ No

53. Does it worry you if you know there are mistakes in your work? *

◯ Yes

◯ No

54. Do you suffer from sleeplessness? *

◯ Yes

◯ No

55. Do you always wash before a meal? *

- ◯ Yes
- ◯ No

56. Do you nearly always have a "ready answer" when people talk to you? *

- ◯ Yes
- ◯ No

57. Do you like to arrive at appointments in plenty of time? *

- ◯ Yes
- ◯ No

58. Have you often felt listless and tired for no reason? *

- ◯ Yes
- ◯ No

59. Have you ever cheated at a game? *

- ◯ Yes
- ◯ No

60. Do you like doing things in which you have to act quickly? *

- ◯ Yes
- ◯ No

61. Is (or was) your mother a good woman? *

- ◯ Yes
- ◯ No

62. Do you often feel life is very dull? *

- ◯ Yes
- ◯ No

63. Have you ever taken advantage of someone? *

- ◯ Yes
- ◯ No

64. Do you often take on more activities than you have time for? *

- ◯ Yes
- ◯ No

65. Are there several people who keep trying to avoid you? *

- ◯ Yes
- ◯ No

66. Do you worry a lot about your looks? *

- ◯ Yes
- ◯ No

67. Do you think people spend too much time safeguarding their future with savings and insurances? *

- ◯ Yes
- ◯ No

68. Have you ever wished that you were dead? *

- ◯ Yes
- ◯ No

69. Would you dodge paying taxes if you were sure you could never be found out? *

- ◯ Yes
- ◯ No

70. Can you get a party going? *

- ◯ Yes
- ◯ No

71. Do you try not to be rude to people? *

- ◯ Yes
- ◯ No

72. Do you worry too long after an embarassing experience? *

- ◯ Yes
- ◯ No

73. Have you ever insisted on having your own way? *

- ◯ Yes
- ◯ No

74. When you catch a train do you often arrive at the last minute? *

- ◯ Yes
- ◯ No

75. Do you suffer from "nerves"? *

- ◯ Yes
- ◯ No

76. Do your friendships break up easily without it being your fault? *

- ◯ Yes
- ◯ No

77. Do you often feel lonely? *

◯ Yes

◯ No

78. Do you always practice what you preach? *

◯ Yes

◯ No

79. Do you sometimes like teasing animals? *

◯ Yes

◯ No

80. Are you easily hurt when people find fault with you or the work you do? *

◯ Yes

◯ No

81. Have you ever been late for an appointment or work? *

◯ Yes

◯ No

82. Do you like plenty of bustle and excitement around you? *

◯ Yes

◯ No

83. Would you like other people to be afraid of you? *

◯ Yes

◯ No

84. Are you sometimes bubbling over with energy and sometimes very sluggish? *

- ◯ Yes
- ◯ No

85. Do you sometimes put off until tomorrow what you ought to do today? *

- ◯ Yes
- ◯ No

86. Do other people think of you as being very lively? *

- ◯ Yes
- ◯ No

87. Do people tell you a lot of lies? *

- ◯ Yes
- ◯ No

88. Are you touchy about some things? *

- ◯ Yes
- ◯ No

89. Are you always willing to admit it when you have made a mistake? *

- ◯ Yes
- ◯ No

90. Would you feel very sorry for an animal caught in a trap? *

- ◯ Yes
- ◯ No

You have completed the General Survey. Please turn over your survey and wait at your table until the Facilitator introduces the next step.

Appendix B:

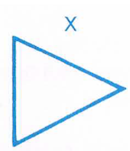
Group Embedded Figures Test (Shortened Version)

Part 2: Task

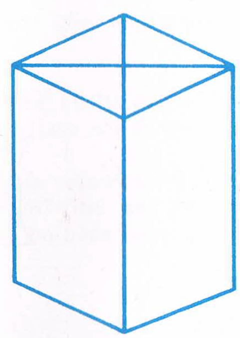
Name ________________________________

INSTRUCTIONS: Using a pencil, find and draw an outline around the simple form hidden within a complex pattern.

Example: Here is a simple form which we have labeled "X".

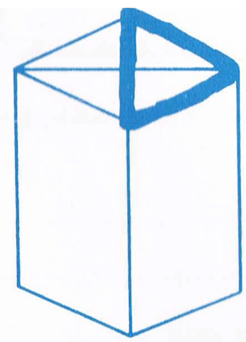


This simple form, named "X", is hidden within the more complex figure below:



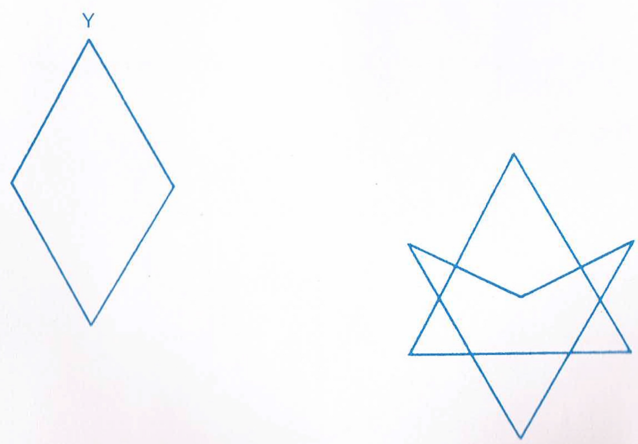
Try to find the simple form in the complex figure and trace it in pencil directly over the lines of the complex figure. It is the SAME SIZE, SAME PROPORTION, and FACES IN THE SAME DIRECTION within the complex figure as when it appeared alone.

This is the correct solution with the simple form traced over the lines of the complex figure:



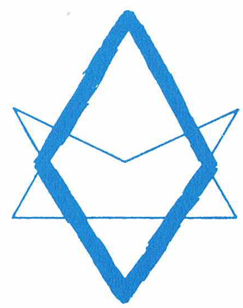
Note that the top right-hand triangle is the correct one: the top left-hand triangle is similar, but faces in the opposite direction and is therefore NOT correct.

Try another practice problem. Find and trace the simple form named "Y" in the complex figure below it:



Look at the next page to check your solution.

Solution:



In the following pages, problems like the ones above will appear. On each page you will see a complex figure, and under it will be a letter corresponding to the simple form which is hidden in it. For each problem, look at the BACK COVER of this booklet to see which simple form to find. Then try to trace it in pencil over the lines of the complex figure.

Note these points:

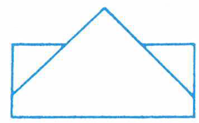
1. Look back at the simple forms as often as necessary.

2. ERASE ALL MISTAKES.

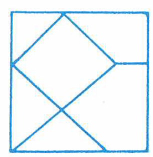
3. Do the problems in order. Don't skip a problem unless you are absolutely "stuck" on it.

4. Trace ONLY ONE SIMPLE FORM IN EACH PROBLEM. You may see more than one, but just trace one of them.

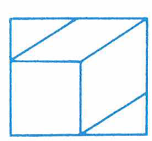
5. The simple form is always present in the complex figure in the SAME SIZE, SAME PROPORTIONS, and FACING IN THE SAME DIRECTION as it appears on the back cover of this booklet.



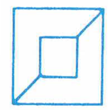
Find Simple Form "G"



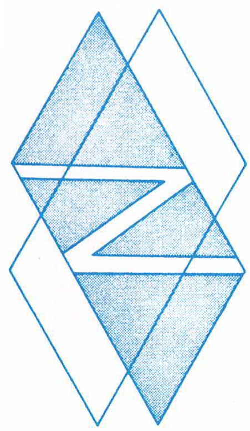
Find Simple Form "D"



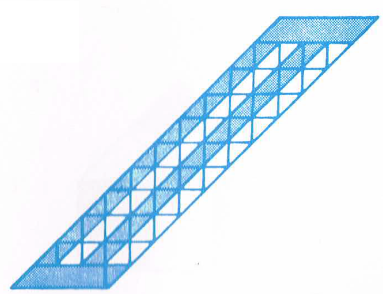
Find Simple Form "E"



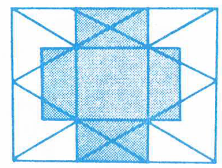
Find Simple Form "C"



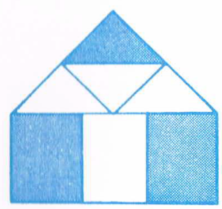
Find Simple Form "A"



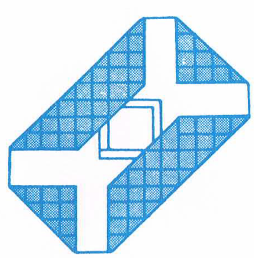
Find Simple Form "C"



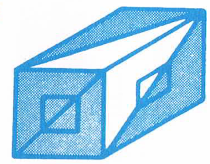
Find Simple Form "E"



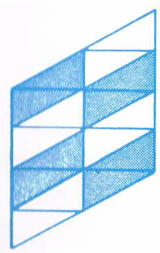
Find Simple Form "D"



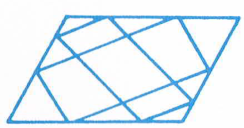
Find Simple Form "H"



Find Simple Form "C"

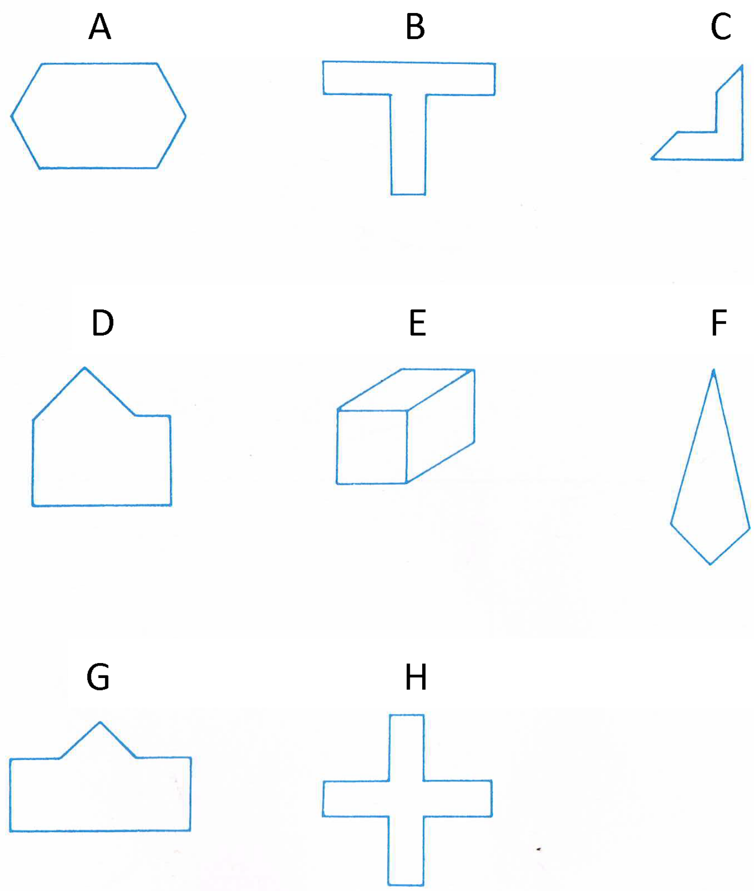


Find Simple Form "E"



Find Simple Form "A"

SIMPLE FORMS



Appendix C:

Ethics Approval

UNIVERSITY OF ALBERTA

RESEARCH ETHICS OFFICE

308 Campus Tower
Edmonton, AB, Canada T6G 1K8
Tel: 780.492.0459
Fax: 780.492.9429
www.reo.ualberta.ca

Notification of Approval

Date:	September 20, 2013
Study ID:	Pro00041160
Principal Investigator:	Connie Yuen
Study Supervisor:	Patricia Boechler
Study Title:	Multi-tasking and Learning Performance in Virtual Worlds
Approval Expiry Date:	September 19, 2014

Approved Consent Form:	Approval Date	Approved Document
	9/20/2013	Research Debrief FINAL
	9/20/2013	Participant Informed Consent Form FINAL

Thank you for submitting the above study to the Research Ethics Board 2. Your application has been reviewed and approved on behalf of the committee.

A renewal report must be submitted next year prior to the expiry of this approval if your study still requires ethics approval. If you do not renew on or before the renewal expiry date, you will have to re-submit an ethics application.

Approval by the Research Ethics Board does not encompass authorization to access the staff, students, facilities or resources of local institutions for the purposes of the research.

Sincerely,

Dr. Stanley Varnhagen
Chair, Research Ethics Board 2

Note: This correspondence includes an electronic signature (validation and approval via an online system).

Appendix D:

Participant Consent Form

UNIVERSITY OF ALBERTA

DEPARTMENT OF EDUCATIONAL PSYCHOLOGY
FACULTY OF EDUCATION

6-102 Education North | Edmonton, Alberta, Canada T6G 2G5 | Tel: 780.492.5245 | Fax: 780.492.1218 | www.ualberta.ca

Participant Informed Consent Form

Research Study Code: ELV 305

Research Investigator:
Connie Yuen (Graduate Student)
Technology and Learning Sciences Lab
(5-106 Education North)
11279 - 88 Ave.
Edmonton, AB T6G 2G5
E-mail: connie.yuen@ualberta.ca
Phone (780) 966-8681

Supervisor:
Dr. Patricia Boechler (Supervising Professor)
Office: 5-147 Education North
11279 - 88 Ave.
Edmonton, AB T6G 2G5
E-mail: patricia.boechler@ualberta.ca
Phone (780) 492-7273

Background

You are being asked to participate in a research study that will require you to operate an avatar around a virtual world. You are part of this study because you signed up for research participation credits in either an EDPY, EDIT, EDU or PSYCO course.

Purpose & Benefits

Other than receiving **1 credit** for your Research Participation, you will not benefit in any particular way from being in this study though you will have the opportunity to explore an interactive virtual environment. We hope that the information gathered from this study will help us advance our understanding of how individuals learn and function within virtual environments.

Study Procedures

This study consists of two parts and will take less than 1 hour to complete. In the first part of the study, you will be asked to fill out a paper survey and a cognitive learning styles task. In the second part of the study you will have the opportunity to control a digital avatar and navigate around the virtual environment.

Risk

There are no known risks to participating in this study.

Voluntary Participation

Participation in this study is completely voluntary and you have the option to discontinue participation at any time or refuse to answer any questions that may make you feel uncomfortable. There will not be any penalty for withdrawing from the study; you will still be rewarded research credit for your participation. You will also be given a signed copy of this consent form.

Confidentiality & Anonymity

All information gathered in this study will be kept confidential and anonymous and is used for research purposes only. Analyses of the data will be conducted on group responses and not individual responses. Once the study is completed, the data will be kept securely stored. Dr. Patricia Boechler of the University of Alberta will keep all collected data from this study in a locked facility. Identifying information will be removed as soon as the data is coordinated and entered. Once all data is assembled, your name will be replaced with alpha-numerical codes and your name will be removed from the database. After the allotted retention period (5 years), data from this experiment will be destroyed via shredding and the electronically stored data will be deleted. Any research assistants involved with this project will comply with the University of Alberta Standards outlined in the Human Research Ethics Policy and Procedures found at: https://policiesonline.ualberta.ca/PoliciesProcedures/Policies/Human-Research-Ethics-Policy.pdf.

Further Information

If you have questions about this research, and/or if you want to obtain copies of the results of this research upon its completion, please contact myself, Connie Yuen (email: connie.yuen@ualberta.ca) or Dr. Patricia Boechler (email: patricia.boechler@ualberta.ca, office: 5- 147 Education North). A Research Ethics Board at the University of Alberta has reviewed the plan for this study for its adherence to ethical guidelines. For questions regarding participant rights and ethical conduct of research, you may contact the Research Ethics Office at (780) 492-2615. This office has no direct involvement with this project.

I have read the Participant Consent Form, have had the nature of the study explained to me, and I agree to participate. All questions have been answered to my satisfaction.

___________________________	___________________________	____________
Participant's Name (Please Print)	Participant's Signature	Date
___________________________	___________________________	____________
Researcher's Name (Please Print)	Researcher's Signature	Date

(Please keep a copy for your own personal records)

Appendix E:

Written and Verbal Participant Preamble

UNIVERSITY OF ALBERTA

DEPARTMENT OF EDUCATIONAL PSYCHOLOGY
FACULTY OF EDUCATION

6-102 Education North | Edmonton, Alberta, Canada T6G 2G5 | Tel: 780.492.5245 | Fax: 780.492.1218 | www.ualberta.ca

ELV 305 Research Participation

To begin, thank you for coming today to participate in this research study. My name is Connie Yuen and I am the primary investigator for this study. I'll be outlining a few things before we start this session so that you can make an informed decision about whether you would still like to participate in this 1-hour study.

You are being asked to participate in a research study that will require you to complete a short survey, a paper task and then navigate as an avatar around a virtual environment. You are part of this study because you signed up for research participation credits in either an EDPY, EDIT or EDU course.

Other than receiving **1 credit** for your Research Participation, you will not benefit in any particular way from being in this study— though you will have the opportunity to explore an interactive virtual environment. We hope that the information gathered from this study will help us advance our understanding of how individuals learn and function within virtual environments.

This study consists of two parts and will take less than 1 hour to complete. In the first part of the study, you will be asked to fill out a paper survey and complete a task. There are no right or wrong answers for the survey, so we ask that you answer them as honestly as possible. This first part of the study should take no more than 15 min. to complete.

In the second part of the study, you will have the opportunity to control a digital avatar and navigate around the virtual environment. You will be using the arrow keys to move around the environment and the mouse cursor to interact with objects. While in the virtual environment, you will follow the pathway indicated by the **blue** arrows. Please read all the billboards that appear as you move along the pathway.

There are no known risks to participating in this study and your participation is completely voluntary. You have the option to discontinue participation at any time or refuse to answer any questions that may make you feel uncomfortable. There will not be any penalty for withdrawing from the study; you will still be rewarded research credit for your participation. You will also be given a signed copy of this consent form.

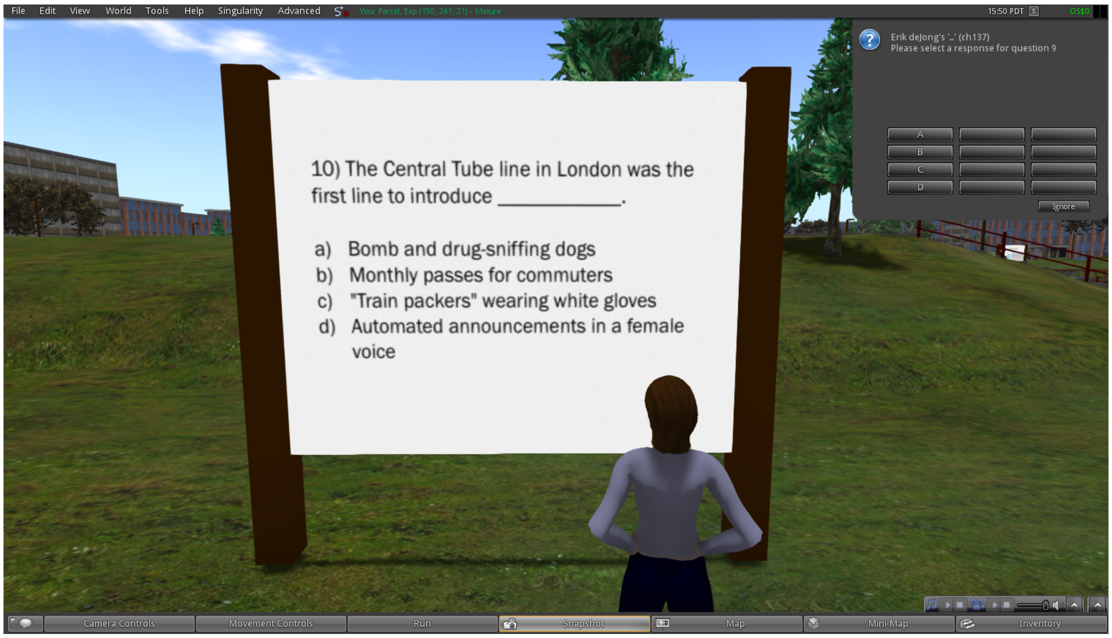
All information gathered in this study will be kept confidential, anonymous and used for research purposes only. The collected data will be coded and analyzed based on group responses and not individual responses.

If you have questions about this research, please let me know or you can also reach me using my contact information listed on the Participant Consent Form and the Research Debrief provided for you at the end of the session.

Any questions?
→ Sign both copies (one for participant, one for researcher)

Appendix F:

Billboard Slides



Appendix G:

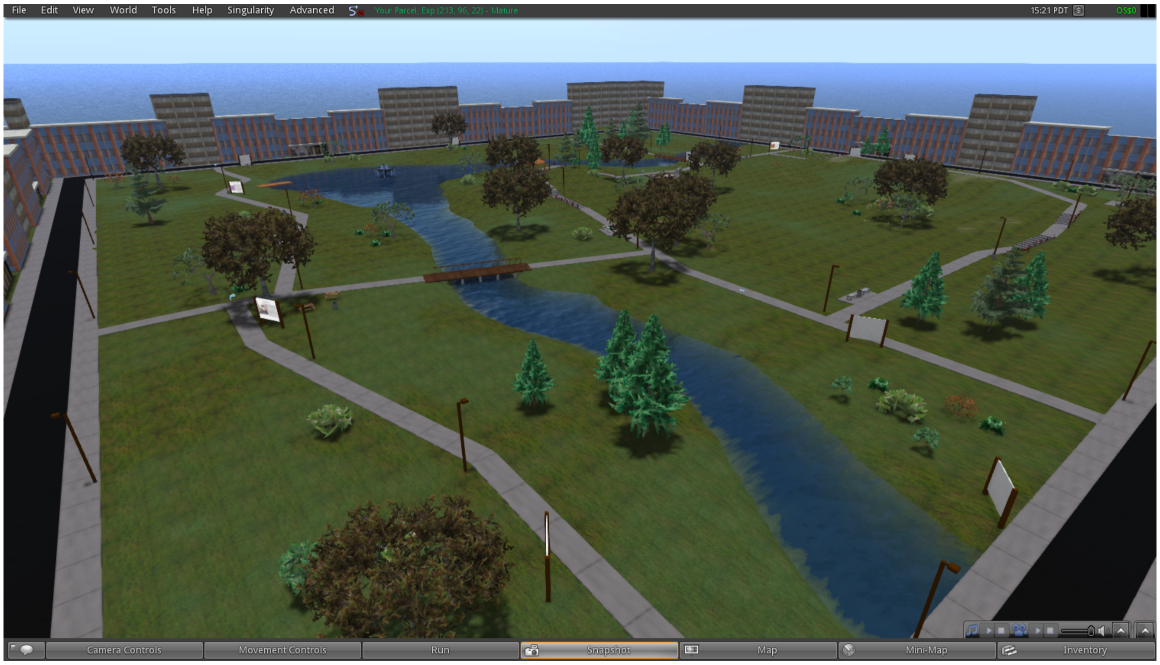
Distractor Windows

Interactive Distractor

Passive Distractor

Appendix H:

Screenshots from OpenSim Virtual Environment



Appendix I:

Study Debrief Form

UNIVERSITY OF ALBERTA

DEPARTMENT OF EDUCATIONAL PSYCHOLOGY
FACULTY OF EDUCATION

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Research Study Debrief

Title of Study: Place Learning and Multi-tasking in Virtual Environments

Research Investigators:

Connie Yuen (Graduate Student)
Technology and Learning Sciences Lab
(5-106 Education North)
11279 - 88 Ave.
Edmonton, AB T6G 2G5
E-mail: connie.yuen@ualberta.ca
Phone (780) 966-8681 492-9716

Dr. Patricia Boechler (Supervising Professor)
Office: 5-147 Education North
11279 - 88 Ave.
Edmonton, AB T6G 2G5
E-mail: patricia.boechler@ualberta.ca
Phone (780) 492-7273

This study examined two central themes: (a) environmental cues affecting learning recall, and (b) the impact of introducing various degrees of multi-tasking objectives on learning performance within a virtual world context. In the first part of the study you were asked to complete a survey in which you self-assessed your abilities and personality traits in a number of different areas related to prior computer experience and introversion-extroversion tendencies. Next, you completed a 12-item Embedded Figures Test to determine your cognitive learning style as either more field-dependent or field-independent. During the second part of the study, you were asked to perform some tasks in the virtual environment in four trials consisting of a *learning phase* followed by a *testing phase* to investigate each central theme of the research study. While in the virtual environment, the system automatically recorded the time taken for you to complete a task and move from one task to another. These recorded times help us analyze and compare your behaviour during the learning phases with the results obtained from the testing phases. Finally, you were asked to follow some instructions given by a research assistant.

The purpose of this research is to study factors affecting learning within virtual environments. The first two trials were designed to see whether or not the presence or placement of nearby environmental elements such as a distinctive tree or bench would help you recall information. For example, we wanted to know if you made connections or associations between the information originally presented during the learning phase with the environmental element that it was matched to. The final two trials were designed to see if introducing an interactive or passive secondary task would have any influence on your ability to learn and recall factual information. For example, if you needed to interact by responding to a chat message, would you be able to shift your focus and/or learn just as effectively than if you had just viewed a chat message on the side? The initial survey and Embedded Figures Test that you completed were to help us determine whether your previous computer experiences, cognitive learning style and/or introversion-extroversion tendencies are related to your learning performance and multi-tasking behaviours in the virtual environment. For example, a few research studies have connected introversion-extroversion tendencies to the likelihood of practicing multi-tasking and perceived effectiveness or distractibility when shifting between tasks.

If you have questions about this research, and/or if you want to obtain copies of the results of this research upon its completion, please contact Connie Yuen (email: connie.yuen@ualberta.ca) or Dr. Patricia Boechler (email: patricia.boechler@ualberta.ca, office: 5-147 Education North). A Research Ethics Board at the University of Alberta has reviewed the plan for this study for its adherence to ethical guidelines. For questions regarding participant rights and ethical conduct of research, contact the Research Ethics Office at (780) 492-2615.

Finally, we ask that you do not discuss what you did during this experiment for the next two weeks. This is because there will be many others doing the experiment after you and we want each person to have an equal and fair chance at completing it. Thank you for your understanding.