EFFECTS OF NOISE ON TARGET DETECTION, TARGET IDENTIFICATION AND MARKSMANSHIP UNDER SIMULATED COMBAT CONDITIONS

by

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ABSTRACT

PURPOSE: This study examined the effects of noise on target detection, identification and marksmanship under simulated combat conditions. A secondary objective was to determine the effect of monetary incentive on performance. METHODS: There were 20 soldiers (mean +/- SD of 24.2 +/- 3.9 y, 182 +/- 5 cm, and 84.2 +/- 13.7 kg) that participated in an individual and one reward based trial. All trials consisted of six 20 min counterbalanced control and noise (87 dB SPL battlefield noise) conditions, which alternated throughout the trial. During each 20 min period, subjects walked on a treadmill while engaged on the shooting task. RESULTS: Only engagement time of foe targets was effected by time on task. CONCLUSIONS: It was concluded that subjects performed at maximal effort and emphasized accuracy over engagement time, although were not affected by noise, time on task or incentive during target detection, identification and marksmanship.

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1. INTRODUCTION

Optimal performance in a variety of mission related duties is critical, regardless of surrounding conditions in order for soldiers to succeed and survive their mission in battlefield conditions. For Canadian Forces (CF) infantry, battlefield conditions may jeopardize optimal performance by challenging the physical and mental capabilities of soldiers due to the multitudinous stressors that are unavoidably present (57). Such stressors, which can ultimately lead to physiological changes within soldiers, include sleep loss, dehydration, fatigue, physical exertion, and thermal stress. Indeed such stressors have been identified as factors that can alter military operational requirements, such as rifle marksmanship (8, 40, 69, 88, 99, 101, 169, 170). Rifle marksmanship is dynamic task that involves efficient performance in several complex tasks on the level of target detection and accurate shooting (89). Any alterations made to this dynamic system could potentially impair performance.

Noise has been a well-studied stressor for over 50 years (4, 2). Many studies on noise stress have demonstrated that it can affect performance in an array of tasks, many of which are key components in infantry operations, such as rifle marksmanship (28, 40, 131, 145, 180). For example, although no effects of noise on dexterity or strength were reported, Levy-Leboyer and Moser (116) showed that noise impairs highly cognitive tasks in addition to tasks that require a great amount of control and precision. Conversely, noise has been shown to improve recall of ordered information. Interestingly, free recall, whereby words are cognitively grouped and recalled in any order, has been impaired in the presence of noise (40). Furthermore, noise has been shown to impair overall work efficiency and the ability to communicate and learn (178, 185). In addition, noise has also been linked to an increased rate of view narrowing (113), possibly resulting in impaired target detection as many targets could potentially appear outside of the subject's field of view. In motor performance tasks, noise has been associated with an increase in reaction time and the number of errors committed, when multiple choices were available (92, 95). Although very few authors have investigated the effects of noise on infantry operations, it is quite possible that such a stressor could affect rifle marksmanship.

In addition, an often over looked area of research are the important rifle marksmanship components of target detection and identification. Marksmanship is a dynamic activity with many components that play an integral part of the whole task. This study will help clarify the effect that noise has upon the specific components of rifle marksmanship.

In addition to benefiting the Canadian Forces with essential information pertaining to the effects of noise and rifle marksmanship, soldiers participating in this study gained valuable marksmanship experience by experiencing stressful simulated battlefield conditions.

2. LITERATURE REVIEW

2.1. Rifle Marksmanship

Rifle marksmanship, which comprises target detection and shooting skills are necessary for a soldier engaging in target-oriented tasks (57). For a successful execution, both skills require the completion of many components. Target detection involves visual scanning, target detection and discrimination, while shooting involves steady positioning, aiming, breath control, and trigger squeeze (56). Overall, marksmanship is considered a psychomotor skill although its individual components fall into different task taxonomies. Soldiers can use marksmanship in a variety of different tasks. The most common are vigilance and friend-foe tasks. Vigilance tasks demand sustained attention to detect infrequent targets, presented to soldiers over relatively long periods of time (89). In contrast, friend-foe tasks involve the discrimination of frequently appearing targets, which are either friendly or enemy, over a relatively short duration. These two types of tasks rely on different components of target detection and shooting.

2.2. Components of Rifle Marksmanship

2.2.1. Target Detection

2.2.1.1. Visual Scanning

Although many sensory systems are used to process information during skilled tasks, vision is most relied upon during rifle marksmanship tasks (90). Vision, primarily a cognitive skill, involves visual scanning process associated with target detection. In addition to being a cognitive skill, the visual scanning process also requires several motor functions, such as moving and focusing the retina and eyes. Thus, visual scanning is classified as a psychomotor component (51). Two separate visual systems underlie visual scanning. Visual information travels from the retina of the eye along one of two neuronal pathways, reaching a region in the brain that interprets the information. The two pathways are called ambient and focal vision. In a well-known study, Bridgeman and colleagues (24) provided evidence for the existence of the two separate visual systems. In this experiment, subjects sat in a dark room as the outline of a rectangle with a dot of light in the middle was projected onto a screen. Simply, by systematically manipulating the rectangle outline followed by the manipulation of the dot, the existence of the two different visual systems, ambient and focal vision, was determined.

2.2.1.2. Ambient Vision

Ambient vision encompasses all of the field of view that can be detected through our eyes. Essentially, it involves both central vision and peripheral portions of the visual field. Data shows that this type of vision is specialized for movement control (157). It can detect motion and the position of objects in the environment as well as providing information about our own movements in relation to these objects and the environment (24). Ambient vision is usually the first visual system to pick up any changes in the environment and it can also discern location of the objects; thus it is very important for target detection (157).

When performing visual scanning during marksmanship tasks, light reflects off various objects in the environment and enters the eye. The different textures of the objects reflect the light differently causing it to enter the eye at slightly different angles. The different angles of reflected light provide the observer with information about the environment. When a target appears in the field of view it is detected by ambient vision because the angles of light reflected off the object entering the eye would differ from the angles of light that existed before the appearance of the target (146). The alterations in light entering the eye not only helps in the detection of targets, but can also provide general information about the targets before they are identified. For example, ambient vision can perceive size, distance, velocity, and direction of the newly detected targets. This information is acquired by means of a process called optical flow. This process, allows individuals to perceive target motion and position due to the rate of change in light rays from the environment over a person's retina (177). In summary, detecting a target depends on ambient vision and it is primarily a cognitive process. Targets are detected by changes in angles of light entering the eye, while additional information such as target motion and position are detected by the rate of change of the angles of light entering the eye. Once a change in the environment is processed and a target is detected, the eyes can centre the object of interest in the field of view, allowing focal vision to take over.

2.2.2. Target Discrimination

2.2.2.1. Focal Vision

Target discrimination is a process that is necessary in battlefield situations and friend-foe marksmanship tasks. The most common type of vision used during target discrimination is focal vision. This type of vision has a narrower field of view than ambient vision and can provide information from objects that lie in the centre of the eyes' field of view (157).

While ambient vision is commonly used for target detection, focal vision is most often used for object identification (146). Focal vision is a very specialized form of vision, which leads to the perception of the objects that are selected for focus or are in the centre of the eyes' field of view, also known as targets in the case of marksmanship tasks. Similar to ambient vision, focal vision is also sensitive to light and the information about the target is obtained by detecting changes in the angles of light entering the retina. The changes in light angles allow specific information about the target to be sent to the brain (142). Information that allows enemy and friendly targets to be distinguished from each other is a pertinent component of target detection. While targets in vigilance tasks are usually all enemy targets, friend-foe tasks involve both enemy and friendly targets. Friend-foe discrimination is a target detection task which requires cognitive processing as long-term memory is accessed in order to appropriately identify and categorize targets (56).

2.2.2.2. Memory

There are three discrete components of memory: short-term sensory store, short-term memory, and long-term memory (52). Long-term memory, which is the storage space for well-learned information, is considered to be the most essential type of memory used in target discrimination. This memory system is thought to have limitless storage capacity and storage duration, allowing the storage of many different target images, which aids in target discrimination (173). Before engaging in real or simulated battle condition, soldiers are commonly familiarized with the appearance of the targets they will be required to detect and identify. The learning process involves the shifting of the target information from short-term to long-term memory. This information is then stored in the brain, via abstract cognitive processes such as imagery, which is thought to involve elaborate neuronal networking, which is not completely understood (82). Thus, with repeated target appearances, marksmen memorize the appearance of friendly and enemy targets. The memorization of target appearance aids marksmen in target discrimination processes. Since both friendly and enemy targets are stored in long-term memory they can be used as templates to compare to targets that are present in the immediate environment. When a target appears during a target detection exercise, the marksmen must discover the similarities and differences between the observed target and the memorized targets in order to determine whether or not the observed stimulus is a friend or foe (32).

2.2.3. Action

Once the target is detected (i.e. vigilance) or identified (friend-foe) a response must be selected and an appropriate action can be taken. A common way to explain information processing leading up to the action phase is through discrete stages of processing. Many psychologists conceptualize task performance using a three-stage processing model that involves stimulus detection and discrimination, response selection, and response programming (157). Thus far, stimulus or target detection and discrimination, which give target information, have been discussed. The next two stages in the information-processing model: response selection and response programming, ultimately lead to an action (157). Once a target is identified an appropriate response can be decided upon. In friend-foe tasks there are two different types of targets: friendly and enemy. Friendly targets should result in no response. On the other hand, enemy targets should elicit the same response selection as a target in a vigilance situation. When an enemy target appears, it is identified by the two visual systems and memory processes. Then, an engagement response must be selected and forwarded to the response-programming phase of the information-processing model (123). This stage, depending on the decision made, organizes the motor system to produce the appropriate movement that involves the channelling of information along several steps down a specific pathway. The first step involved in the organization of the motor system prepares the brain stem and the spinal cord for action (123). Then a plan of action to control the movement is retrieved, structured and finally directed to specific motor units so that the appropriate muscles can contract in the correct order, with the correct amount of force and timing to produce the desired movement (123).

2.2.4. Shooting

The desired movement during enemy appearance is target engagement (i.e., shooting). Shooting involves several components including steady body position, aiming, breath control and trigger squeeze (47, 174). In the Canadian Forces, soldiers are instructed to assume a steady body position and a firm but steady grip on the rifle pointing it at a desired target without physical effort (56). When this position is achieved, soldiers are instructed to align their sights with the target and inhale deeply using controlled exhalation to minimize excess movement. Finally, with a controlled trigger squeeze a shot may be fired (56). An additional technique must be added to the shooting component of target detection and marksmanship when moving targets are encountered.

Two commonly used techniques are called tracking and trapping, although tracking is only used for elite shooters (155). Trapping is a method used by the Canadian Forces that is valuable because it enables shooters to maintain steady positioning. This technique requires soldiers to determine the speed, range and direction of target movement in order to anticipate its path and subsequently engage, giving the target an appropriate amount of lead (56). In summary, shooting components involve fine motor movements, but since many cognitive processes must occur concomitantly, shooting is classified as a psychomotor task (98). For example, the detection of moving targets depends heavily on cognitive skills as they are more difficult to engage than stationary targets (22).

2.3. Physical and Cognitive Difficulty of Marksmanship

2.3.1. Target Detection

It is believed that human attentional capacity is limited and only able to process a restricted amount of information (66). The Attentional Resource Capacity model is a system that describes how human attention is related to information processing and performance. The central dogma underpinning this theory is that attention is a drainable pool of limited size that is diminished upon use. Once these resources begin to drain, information processing is hindered and performance decrement is imminent (66).

Vigilance tasks, which have been shown to drain attentional resources to a great extent, demand sustained attention and alertness for long periods of time in order to detect infrequent targets (179). In contrast, friend-foe tasks are relatively short exercises involving the detection of frequent targets (approximately several targets per minute)

(56). Due to the sustained attention and alertness, vigilance tasks have shown performance decline as time increases. Thus, target detection during vigilance tasks is considered more cognitively demanding than during friend-foe tasks. The infrequent targets of vigilance have been suggested to be boring and lacking the appropriate stimulation to provide sustained alertness (80). Similarly, Warm (179) has shown that vigilance is psychologically stressful as it increases reaction time in visual vigilance tasks. Also, in one study, data showed that psychological stress increased with time on sentry duty (90). Subjects in this study were 24 soldiers, who were required to perform three hours of sentry duty on a Weaponeer rifle marksmanship-training device. In one group, target detection time increased as time on sentry duty increased. The increase in target detection time was thought to be related to high levels of psychological stress. In contrast, marksmanship was not affected by the increase in time on sentry duty, suggesting that it does not require the same amount of attention as target detection. In summary, the target detection component during vigilance tasks is more cognitively demanding than during friend-foe tasks. Due to the high frequency of target appearance and short duration of the exercise friend-foe tasks do not drain the attentional resources into such an extent and they do not induce a large amount of psychological stress (179). On the other hand, vigilance tasks require a great amount of attention due to the infrequency of target appearance and long duration of the exercise. Ultimately the highly intense cognitive demands of vigilance tasks drain attentional stores and result in high levels of psychological stress.

2.3.2. Target Discrimination

Reaction time is an important performance measure in target detection and marksmanship. It is the interval of time that elapses from the presentation of an unanticipated stimulus to the beginning of a person's response (182). Reaction time is a measure used to detect the speed at which a performer can detect a feature in the environment, decide what to do, and then begin an appropriate response (182). Thus, many researchers have used this measure as an indicator of the speed of information processing (59). Reaction time can serve as a measure of stimulus detection and identification, response selection, and response programming. Any factor that lengthens any of these components also lengthens reaction time (182). As a result, many scientists have used reaction time to deconstruct the information processing system (59). The various changes in reaction time can be used to discern the speed of processing that occurs in each stage.

One of the most important factors that influence reaction time is the number of possible stimulus choices, which are all coupled with specific responses. Reaction times increase when the number of stimulus response alternatives increase, due to increased cognitive processing (119). The shorter reaction times, which are associated with the least cognitive processing, are referred to as simple reaction time. This type of reaction time is the most basic because it involves only one stimulus and one response (119). In a landmark study, Hick (75) demonstrated that the relationship between reaction times and number of stimulus response pairs was a logarithmic function. The relationships demonstrate that reaction time increases by a constant amount when the number of stimulus response pairs is doubled. This relationship, also known as Hick's law, has been shown to apply for many situations, stimuli, and types of movements. During target detection, friend-foe tasks require more information processing during target discrimination than vigilance tasks. Friend-foe tasks involve a least two stimuli response pairs (foe targets require an engagement and friend targets require no response). In contrast, vigilance tasks, which are comprised of all enemy targets, only have one stimulus and one response and therefore demand less cognitive processing. In summary, friend-foe tasks compared to vigilance tasks are more cognitively intense during target discrimination due an increased number of stimulus response pairs and information processing.

2.3.3. Shooting

Shooting involves several components including steady position, aiming, breath control and trigger squeeze. It is a complex skill that involves both intense cognitive processing and fine motor movements. In a marksmanship study, Haufler and colleagues (71) examined EEG power spectral estimates of riflemen during shooting activity. This study analyzed brain wave frequencies and demonstrated that shooting performance is associated with both visuospatial cognitive processing and fine motor coordination. Similarly, another study displayed neuro-cognitive activity during shooting and suggested analytical and verbal processes occur during this psychomotor task (117). Furthermore, Hatfield et al (70) compared the brain activity of marksmen during shooting sessions to the brain activity associated with psychomotor skills. Data showed that the brain activity during shooting was similar to the activity observed in the processing and solving of geometric puzzles. Thus, the shooting component of target detection and marksmanship is indeed a psychomotor skill, as it involves both fine motor movements and intense cognitive processing.

Overall, target detection and shooting are both considered psychomotor skills, but when broken down its respective components fall into different categories. Target detection involves visual scanning, detecting, and discriminating components. In general, these all have large cognitive components. Visual scanning can be classified as a psychomotor task due to the motor activity needed to move and focus the eyes and cognitive activity needed to process all the incoming ambient information. Target detection and discrimination are considered cognitive tasks. Target detection processes information such as size, distance, velocity, and direction of the newly detected target. Target discrimination utilizes long-term memory stores and compares the similarities and differences between the observed target and the memorized targets in order to determine whether or not the observed stimulus is either a friend or foe. Shooting involves steady positioning, aiming, breath-control and trigger squeeze. These components are all classified as psychomotor components due to their high cognitive demands and the requirement of fine motor movements. In addition the intensity of these tasks relies on the different types of marksmanship tasks. Both vigilance and friend-foe tasks are cognitively demanding. However, during target detection, vigilance tasks are more cognitively intense because they require more attentional focus. During target discrimination, friend-foe tasks are more cognitively intense because they involve more central processing due to an increased number of stimulus-response alternatives. Finally, during shooting, both tasks are equally intense in their cognitive and motor components.

2.4. The Effect of Noise on Performance

In addition to health consequences, noise can alter performance in a variety of tasks (12, 18, 58, 106). For example, noise at moderate levels of 70 dB or greater have been reported to affect performance (2). Although the nature of its influence is not well understood, two basic trends can be identified regarding the effect of noise on performance. Firstly, the effect of noise depends on the precise type of task being performed (2). Noise has consistently produced decrement in task performance when the activity is largely cognitive as opposed to physical; both of which are extremes on a mental-physical task continuum. Indeed, it has often been reported that highly cognitive activities involving the continuous intake of new information are at the greatest risk for impairment in noise (66). Secondly, the intensity of noise can influence the amount of decrement that occurs. There is a negative relationship where increasing noise intensity usually results in greater performance decrements (40). However, noise has also been linked to performance enhancement (9, 78, 79). In these cases noise can improve performance if noise intensity and task difficulty work in concert to compliment each other appropriately, thus leading to an individual's increased performance. For example, when tasks are relatively simple, noise of moderate intensity has been shown to improve performance in tasks such as reaction time and ordered recall tasks (9, 95). Many studies have demonstrated the effects of noise in the field and gone further to identify how it affects different task taxonomies.

2.4.1. Efficiency

2.4.1.1. Efficiency in the Workplace

Research has demonstrated that stressors, such as noise, can affect physical and cognitive occupational performance, subsequently leading to decreased work efficiency and potential loses in revenue. The average noise level in an occupational environment is correlated with the frequency of errors in work performance (97, 185). Kerr (97) examined over 40 potential factors which were thought to affect job performance and found that mean noise levels were one of the best predictors for the frequency of accidents, but not their severity. Similarly, Cohen (37) found that more accidents occurred in an occupational setting when loud noise was present compared to quieter conditions. In addition, although no effects of noise on dexterity or strength were reported, Levy-Leboyer and Moser (116) stated that noise impairs highly cognitive tasks that require a great amount of control and precision.

In 1935, Weston and Adams (183) conducted one of the first studies on the effects of noise on efficiency they examined the work productivity of female cloth weavers. In a matched-subject study, an experimental group of 10 women weavers were matched with a control group of partners who wove similar cloth quality and quantity. One group of women were exposed to the factory noise of 96 dB. The other group was required to wear ear defenders, which lowered noise intensity to approximately 80 dB. After a period of one year, cloth output (i.e., quality and quantity) was assessed. The results showed that the women with hearing protection had better productivity than those exposed to the unattenuated workplace noise. Later, in a more comprehensive study, Broadbent and Little (26) examined the effects of moderate and high workplace noise on the error frequency associated with film production employees. Subjects were divided into two groups; a high noise group of workers were exposed to sound intensities of 99 dB, which were associated with everyday film production, and a low noise group of workers were exposed to sound intensities of 89 dB due to acoustic modifications made for their work bays. Although the quantity of production remained unchanged, the quality of production was lower in the group exposed to the highest level of noise. The results showed that the number of shut downs, broken film rolls and calls for maintenance over the period of one year was significantly lower in employees who used acoustically modified workstations. In another study, the effect of increasing noise intensity on the efficiency of postal employees was examined (103). The frequency of employee sorting errors was examined in free-field noise levels of 85, 90 and 95 dB. The results indicated that increasing noise levels were directly related to the number of sorting errors. After 5 hours, employees working in 95 dB noise, sorted nearly 3 thousand fewer letters (approximately 35%) than workers exposed to 80 dB.

2.4.1.2. Efficiency in the Classroom

The effect of noise in the classroom setting both directly and indirectly affects student achievement. Firstly, because classroom learning requires much attention, noise can drain the attentional capacity of students ultimately hindering the learning process. Secondly, noise has a masking effect, meaning that it can compete with other sounds, such as speech, and impair the communication process (181). Students attempting to learn when exposed to high levels of noise have exhibited less participation in class, while two-way communication is often ineffective and must be replaced by lectures (178).

In one study, Cohen and colleagues (35) demonstrated that schooling in areas with high levels of noise significantly affected cognitive and logical processes. Subjects were part of either a high noise group, exposed to high intensity aircraft noise or a low noise group, which simply used classrooms in a less noisy area. The use of attentional strategies, problem solving persistence and cognitive performance was assessed in both groups. The results showed that students chronically exposed to high noise levels were less persistent in problem solving. These individuals were not as resistant to irrelevant noises as students in low noise areas. These findings were supported by Cohen and Weinstein (36) when they showed that high noise levels can impair problem solving ability in children. High noise levels have also been shown to degrade student and child performance in visual search and reading comprehension exercises (60, 64, 73).

2.4.2. Vigilance

A vigilance task is one that requires sustained attention. It is often considered among the most difficult tasks to perform because its intense cognitive demands, which involve continuous processing of new information, and identification of significant, yet often-inconspicuous stimuli (67). When vigilance tasks are performed for extended periods of time, it is believed that visual scanning of the environment decreases as time on task increases (113).

In noise, stressors have consistently been shown to impair performance at a greater rate than is expected exclusively for time on task. For example, Broadbent (25) studied the effects of noise in two now classic vigilance experiments, called the Twenty Dials Test and the Twenty Lights Test. In the first study, subjects were required to watch twenty different steam pressure gauges for a period of 90 minutes. During this time, if a pressure indicator in a gauge moved higher than a position designated as dangerous, the subject was required to attenuate the dangerous pressure by turning a knob found below the pressure gauge. During each session, a total of 15 pressure indicator changes occurred at intervals spanning from 1 to 12 minutes.

The other vigilance experiment, the Twenty Lights Test, was similar to the first test save the dimly lit bulbs that substituted for the pressure gauges and a key that was pressed in lieu of turning a knob when a light bulb was lit. Over a period of 5 days, two separate groups of 10 young adults, both male and female, performed each vigilance test once per day in counterbalanced conditions of either noise (100 dB) or quiet (70 dB). Broadbent used a measure of performance called "quick founds" (i.e., response times less than of equal to 9 seconds), which he used to quantify vigilance level of subjects between trials. The results of the experiment indicated that the number of "quick founds" was significantly greater in the quiet condition of the Lights Tests as opposed to the Dials Test, which the author subsequently determined to have less conspicuous target events, making it more difficult to detect signals. However, in the noise condition a clear effect was established as the number of "quick founds" lessened (i.e., performance decrement) in the Light Test, as trial duration increased and cognitive fatigue set in.

2.4.3. Attentional Selectivity

A frequently observed behaviour that is consistently seen in highly cognitive exercises such as dual task paradigms and vigilance tasks is a behaviour called attentional selectivity or more simply, allocation of attention. Smith (162), for example, used a three-choice serial reaction time task to study the effects of noise on the allocation of attention. Results showed that attentional resources can be shifted to events which subjects deem high priority or relevant to the task at hand. In this study, moderate free-field noise levels of 85 dB surrounded 22 female members of the Oxford subject panel. The subjects were required to detect light occurrences on an apparatus that was mounted with three bulbs. After subjects had been performing their respective tasks one bulb was manipulated to light up more often than the other two. The results showed that reaction times were reduced when responding to the more probable light, but increased in response to the other two. Also, the results indicated that the difference in response times to high and low priority events was significantly greater in the noise condition compared to the control condition. This suggests that noise can exaggerate the difference in response times when high and low priority events exist.

Similarly, Eysenck (46) also found that moderate intensity noise (80dB) increased the difference in performance between high and low priority events. Also, Smith (162) cites an experiment by Hockey (79) in which the effect of noise on allocation of attention was studied. Subjects were asked to perform an attention sharing exercise that consisted of performing a tracking task in addition to a vigilance task that required the detection of lights, which appeared randomly in time and space. During the attention sharing exercise, subjects were exposed to noise levels of 100 dB and were asked to focus on performing well in the tracking task, thus designating it as high priority. Hockey (79) noted that high priority task performance was improved by noise, while the low priority task resulted in significantly decreased performance.

In another similar experiment, Hockey and Hamilton (78) studied the effects that moderate noise had on highly relevant and irrelevant signal detection. When exposed to 80 dB noise subjects performed significantly better in a highly relevant task (i.e., aided memory recall task) and worse in the irrelevant task as compared to a control group. Finally, Tafalla and Evans (166) suggested that 90 dB noise will negatively effect subjects by causing either impaired performance or physiological changes. Their data supports the adaptive costs hypothesis (59), which would predict, for example, that when noise is present and performance in a high priority and a low priority task is required, one task must be impaired for the other to be maintained or improved. Similarly, if both tasks are to be maintained, then physiological changes will occur such as increased norepinephrine levels, cortisol and heart rate. Thus, when moderate or high noise levels are present and performance in more than one task at any given time is required, attentional focus can be shifted. Indeed, when a task is considered high priority, a subject can redirect attention in order to maintain or even improve performance in a favoured or high priority task. However, the length of time an individual can maintain or improve performance is not completely clear because it depends on many factors such as individual attentional capacity and one's general state of readiness to respond to the environment (i.e., arousal) (66).

2.4.4. Reaction Time

Very few experiments have investigated the effects of noise on perceptual-motor performance. However, the limited numbers of studies have shown that noise affects reaction time (RT). RT can be measured in a variety of ways, the most popular being discrete or serial choice RT tasks (182). In discrete RT, as in all RT tasks, subjects are required to respond to target stimuli as they are presented. The discrete task consists of several RT trials presented in succession, by an interval set by the experimenter (182). In serial choice tasks, a subject is required to respond to a target stimulus that subsequently initiates the presentation of another stimulus shortly after (119). Therefore, the rate at which the experiment proceeds is dependent on the participating individual rather than the investigator. Furthermore, the number of stimuli used can distinguish RT experiments. When only one stimulus is used, reaction time tasks are called simple RT experiments and when more than one stimulus is used, they are called choice RT experiments because the subject must discriminate between targets and choose the appropriate response (119).

The results from RT studies have been inconsistent, although most agree that moderate to high levels of noise do impair performance in some way. For example, Kallman and Isaac (95) found that moderate noise levels of 69 dB (A) could increase simple RT. On the other hand, when investigating the effects of noise on serial RT, Jones (92) did not find sufficient evidence to show that RT increased. In this experiment, subjects were asked to respond to a light stimulus. The subject was presented with a display of four light bulbs, each attached to keys that were placed beneath each of the subject's fingers. Jones suggested that this experimental design would eliminate gross motor movements associated with most other RT experiments. For periods of 40 min, subjects performed the RT task in either a noise condition (90 dB) or in a quiet condition, achieved by ear defenders. The results indicated that in noise, response times did not significantly change, although frequency of error commission increased whereby the subject selected a response that did not correspond with the correct light stimulus in the wrong response. Similarly, Leonard (115) used five-choice serial RT task to test responses under conditions of high intensity noise. Subjects were required to tap a metal ring, which was attached to a light, when the bulb lit up. The task was self-paced, due to the serial choice RT design, and total performance times were consistently between 25 to 40 minutes. Leonard noted that noise did not affect RT, although it significantly increased the number of errors that were committed. Thus the main effect of continuous noise on serial choice RT tasks is the increase in error commission and not significant change in reaction time itself.

2.4.5. Memory

A number of studies have shown that noise affects memory recall (134, 176). Many experiments have investigated both short and long term memory. In short term recall experiments, subjects are required to recall a complete list of letters, words or digits in the order in which they were presented (78). These experiments are designed to ensure that the brief presentation of stimuli is registered. This is the first component of three that are commonly referred to as the three R's of memory; register, retain and retrieve. First, in order to process new information it must be understood or in some way learned (41). Second, information must be retained or put into 'storage' (82). Without this step information is classified as lost or forgotten. Finally, information must be readily available, so that it can be used when most needed. Thus, information must be retrievable (152).

Investigations on the effects of noise on memory recall have led to different conclusions. For example, some experiments have shown that noise does not affect short-term memory (20, 41, 159, 160), while others have reported enhanced performance (9, 78) or decreased performance (127, 153). Indeed, some of the inconsistent results are due to differences in noise type and intensity or task difficulty, factors that are hard to control and well known to affect performance outcome (41).

However, the majority of studies have demonstrated two main effects. Firstly, noise has been shown to improve recall of ordered information. Secondly, noise has been shown to decrease recall performance when subjects are also required to perform a secondary tasks such as reordering words cognitively or recalling the spatial location of words (11, 40). In a classic study, Hockey and Hamilton (78) studied the effect of moderate noise (80 dB) on short-term memory. They found that task relevant and incidental (task irrelevant) information was affected differently as compared to a quiet condition of 55 dB. Two groups of 34 subjects (N=68), placed into either a noise or control group, were required to recall words as they appeared at regular intervals (1 every 2 seconds) on a blank screen. Subjects were shown a series of eight different slides containing common bisyllabic adjectives that could appear in one of the four corners of the screen. Subjects completed their primary task by writing down the words they recalled. Subsequently, they were surprised and told that an additional task must be completed. The secondary, also called the incidental task, involved the recollection of the spatial location of the words. The results showed that noise tended to improve the percentage of words recalled in correct order, but impaired the percentage of word locations recalled. These findings suggest that moderate noise enhances relevant short-term memory tasks while impairing incidental short-term memory tasks. In addition, noise seems to enhance the ability to retain ordered information. This is an effect know as direct coding, which is the ability to selectively attend to the linkages between words (122).

In addition, noise has been reported to reduce category clustering when words must be recalled in any order (81). Generally, when subjects are given words to recall in any order they often do so by regrouping words in short-term memory, according to semantic categories. When moderate or higher levels of noise are introduced, category clustering becomes disrupted (40). This suggests that clustering of words via semantic relation requires a high level of cognitive processing. Indeed, words must not only be registered, retained and retrieved as is the case with ordered short-term memory recall, but they must be registered, retained, reordered and retrieved which could add to the task complexity of free order recall. Studies reporting that moderate to high intensity noise enhance ordered, and thus phonemically related recall, compared to semantically related recall lends support to this view (10, 78, 158).

Many studies have investigated the effects of short-term memory while alterations are made in the type of noise used. Colle and Welsh (37) were one of the first to report that short-term recall of verbal material is impaired if moderate noise in the form of speech is used, although not until recently have a wider variety of background noises been tested on recall tasks (149). In one study, different types of noise were used to investigate their effects on short-term memory performance. Several different experiments were used to determine the effects of 75 and 95 dB pink noise, foreign speech (Arabic) and quiet, on the recollection of series of sequences that were comprised of nine random digits successively displayed on a monitor for 500 ms with 250ms intervals between digit presentations. The results indicated that noise and quiet did not significantly change recall performance, although foreign speech was shown to impair performance (151).

Similarly, Salame (150) examined many types of background noise to determine its effect on short-term memory recall. In two separate experiments within this study, subjects were required to complete a written recall of visually presented sequences. The first experiment compared a quiet condition (37dB) with modern vocal music (75dB) and ancient instrumental music (75dBA). The results indicated that both musical and instrumental conditions impaired recall, although a much greater effect was observed with modern vocal music. The second experiment compared continuous Arabic speech, modern instrumental music, amplitude-modulated pink noise and quiet. The results indicated that only the speech and the musical conditions significantly impaired memory recall. Overall, these experiments have led to the following general conclusions, which are agreed upon by authors who have researched or reviewed this area (91, 152, 161). Firstly, moderate noise has often been reported to enhance short-term memory recall tasks, but moderate speech, independent of intensity, between the ranges of 55 and 95 dB has been shown to impaired recall. Secondly, the meaning of the moderate intensity speech is irrelevant. Indeed, impaired recall occurs equally when speech is foreign, meaningless or even backward. Most importantly, word articulation is the factor that determines recall impairment. When speech is phonologically similar to the material which must be recalled impairment can occur (150). This supports above results that articulated speech impairs performance to a greater extent than other background noises, while vocal music incurs greater impairment than instrumental music. Thus the exact nature of surrounding noise such as type, intensity and phonological character, is critical to predicting the reaction of recall performances.

2.5. Theories on the Effect of Noise

One of the first theories attempting to explain the effect of noise on task performance was the Theory of Blinks. Although evidence is not conclusive, Broadbent (25) proposed that noise can lead to an internal nervous system response. Noise can stimulate the perceptual nervous system via the auditory system, which is hypothesized to periodically compete for attention with other sensory perceptual systems. During these brief periods of noise distraction, also called 'blinks', tasks can become hindered, as all sensory systems used in specific performance cannot operate in full capacity.

Another explanation by Jerison and Smith (83), and Jerison and Arginteanu (84) suggest a theory based on estimation of time. Although the authors did not control for intensity or type of noise (i.e., intermittent or continuous), they came to the conclusion that noise-stressed subjects cannot accurately estimate time. The authors noted that noise could have the ability to expand the perceived real time scale. In the presence of sound, subjects would judge that less time has passed than actually has in reality. In addition, it was also stated that noise could contract the real time scale, where subjects would overestimate the passage of time, during task performance. Although it is not clear exactly how noise effects performance and in which direction it affects the real time scale, it is clear that noise can affect judgment of time.

The most widely accepted theory on the effects of noise on task performance is the theory of arousal. Although continuous and repetitive noise have been reported to cause sleepiness and drowsiness (21, 68, 100, 110, 111), it is more often considered to counteract fatigue and sleep deprivation by raising subjective arousal levels (100, 185). Many classic experiments have demonstrated that increased arousal can result in enhanced performance, although the level of arousal and difficulty of task are critical in determining improved performance (72, 43, 44, 121). The relationship between level of arousal and performance assumes an inverted U-shaped function, where performance improves to an optimal point, then declines as arousal increases. Indeed, the general trend observed with vigilance tasks supports this theory as moderate noise levels have been shown to increase arousal levels and enhance performance, while higher noise levels have been shown to consistently increase arousal levels past the optimal-performance point and therefore impair the task at hand (66).

2.6. Individual Differences

Psychology has dictated that throughout our lifetimes the traits that compose our basic personality stay fairly consistent (59). On the other hand inconsistency is the main trend that governs our interpersonal differences. Individual information processing is highly variable from one person to another. Indeed, it is well known that different people behave differently when exposed to similar scenarios (38, 59). It has been demonstrated that noise exposure affects individuals according to personality type (140). The gregarious nature of extroverts and the neurotic behaviour of introverts have been linked to different physiological reactions during noise stress exposure. In general, introverts often exhibit anxious behaviour. They are thought to continually participate in self-image analysis through internal thought. Furthermore, they are considered to have high levels of cortical activity and thus are chronically over-aroused (140). As a result, introverts are often sensitive to noise, which is known to increase arousal. Conversely, extroverts direct much of their thinking towards their external environment and as a result are highly aware of surrounding events (17). Unlike their counterparts, extroverts are often under-aroused or bored with the same tasks that are given to introverts and thus seek greater stimulation to increase their arousal (53). Therefore, extroverts prefer moderate to high level of noise intensity and it is not uncommon for this personality to dislike noise-less conditions (17).

Indeed, it has been noted that extroverts have asked for exposure to noise during task performance in order to work at an optimal level (39). In one study Geen et al (54) compared extroverts and introverts in a vigilance task, when exposed to different levels of noise. In the low-noise condition (65 dB), introverts scored better than extroverts. However, during a higher noise intensity condition (85 dB) the scores from both groups were not significantly different; suggesting that moderate intensity noise was not stressful enough to hinder performance in introverts, while it was stressful enough to allow extroverts to enter their optimal arousal level and therefore prevent performance decrement. In another study, medical students were asked to listen to recorded traffic noise 88 dB (A) versus a quiet condition (42 dBA) while performing a mental arithmetic task (16). The results showed that during noise exposure, extroverts scored higher in the task compared to introverts. Similarly, Morgensten and colleagues (136) found that introverts exhibited impaired recall, while extroverts had improved recall during exposure to high levels of noise. In conclusion, it is the preferred level of noise intensity, for each personality type, that is directly related to performance. For example, introverts perform tasks best when little to no noise is present, while extroverts perform best when moderate to high noise is present. Although no definitive limits can be set for each personality type it is understood that both have optimal ranges of performance. Most importantly, extroverts are individuals that can handle more stress and therefore exhibit a higher range of optimal performances values when compared to introverts.

2.7. The Effects of Noise on Marksmanship

Very little research has been done on the effects of noise on rifle marksmanship. However, some studies have investigated the effects of sudden acoustic stimuli and rifle aiming; a shooting component. Research has shown that intense noise of high intensity can initiate a startle reflex (109). Although it is not completely clear whether it is the noise or the reflex that causes disruption, it has been shown that intense sound bursts can cause impaired performance in reaction time, psychomotor and cognitive tasks (124, 186). For example, Foss et al. (49) investigated the effects of noise bursts on a psychomotor task. Subjects were required to aim rifles at a stationary target for 15-second blocks while exposed to a series of sound bursts at noise levels of 110, 120 or 130 dB. Results showed that subjects were less startled as the noise bursts approached the end of a series suggesting habituation. Despite the occurrence of habituation noise bursts affected aiming for period of 1 to 2 seconds at 110 dB. As sound levels increase the effect of noise bursts became more pronounced as aiming was disrupted for periods of 1 to 2.5 seconds. In another similar study, subjects were also required to aim their rifles at stationary targets for blocks of 15 seconds while being exposed to noise bursts at sound levels of 130 dB (50). Also, subjects were exposed to both expected and unexpected bursts. The unexpected noise bursts occured at random intervals, as did the expected noise bursts, which were preceded by an 80 dB preliminary stimulus that served to warn the subjects of the upcoming primary burst. Data revealed that aiming was disrupted due to the startle response for periods of 1 to 2 seconds following noise bursts. In addition, the authors noted that expected noise bursts impaired marksmanship performance to a lesser extent than unexpected noise. Therefore, despite the little research that has been done on the effects of noise on marksmanship, it can be concluded that noise bursts of short but high intensity can disrupt components of marksmanship (i.e., aiming), although the effects of noise on other components of marksmanship such as target detection and identification still remains unclear.

3. STUDY OBJECTIVES AND HYPOTHESES

3.1. Effect of Noise

The proposed study will investigate the effects of noise on rifle marksmanship (i.e., target detection and shooting). Noise is expected to impair target detection, but not target discrimination or shooting ability on the basis of how other stressors have effected marksmanship.

3.2. Effect of Incentive

The proposed study will determine if incentives will alter rifle marksmanship performance. External incentive is expected to improve target detection, but it is not clear whether target discrimination and shooting ability will be affected.

4. RESEARCH METHODOLOGY

4.1. Participants

Twenty participants were recruited from various companies within the Third Royal Canadian Regiment (3RCR) of the Canadian Forces (CF). All participants were fit, male infantrymen between the ages of 20-37 that had achieved a Personal Weapons Test qualification level 3 (PWT3), and had previous experience using the Small Arms Trainer (SAT). Additionally, subjects did not take any medication that could possibly have affected physical or cognitive performance, and they refrained from caffeine and/or tobacco use for the duration of each trial. All participants were briefed on the protocol, benefits and risks, and had the opportunity to inquire about the study before any experimentation.

4.2. Experimental Procedures

4.2.1. Overview

The participants were required to make three visits to the DRDC Toronto laboratory, involving a familiarization, an 'innocent' (I), and a reward (R) trial. All trials were 2 h in duration with counterbalanced control (C) and noise (N) conditions, which alternated throughout the trial. The noise was presented free-field (through speakers) at a level that does not exceed the criterion designated by the Canada Labour code (133) as safe for human hearing without protection. (i.e., the energy equivalent of 87 dBA [decibels A-weighted to model the frequency response of the human ear, and maximum allowable for continuous exposure up to 8 h]). It consisted of sporadic, but frequent, high intensity small and large arms battlefield fire. Each trial lasted until one of the termination criteria was met (detailed further on). They included shooting at simulated pop-up targets in a combat scenario of mixed complex terrain using the SAT. Target shooting was performed for 15 min every 20 min using a SAT-modified CF issue C79 scope and C7 rifle that used infrared light as virtual ammunition. SAT-modified rifles provided weapon recoil through the use of a compressed oxygen line, while rifle bursts no louder than 92 dB were played through the speakers. During each 20 min period of a 2 h trial, subjects walked on a treadmill for 15 min while engaged on the shooting task, rested for 5 min, and provided subjective ratings on their perceived effort. An additional questionnaire on task difficulty was given at the end of the trial.

Subjects underwent a familiarization trial on Day 1 prior to the two experimental trials (Days 2 and 3). The last trial (R on Day 3) was a repeat of the previous one (I on Day 2), but with a monetary incentive for the subject to outperform their earlier attempt. This incentive was designed to induce competitiveness and desire to extract the maximum possible performance from the subject in a safe setting. Similar incentives have been applied in the past (87). The incentive was disclosed to the subject only on the last day of the trial, and subjects were asked not to reveal the true nature of this last trial until after all subjects completed the study. On the protocol that the subject read, the last trial was disguised as a check on a possible 'order' or training effect, that is, whether improvement would occur with time spent on the trials.

Table 1. Order of trials for blocks of 8 subjects (repeat for subjects #9 – 16); C and N refer to the control and noise conditions, respectively, that were alternately applied.

Subject	Trial	
	Familiarization	I and R
1, 2, 5, 6	basic info & familiarization C + N	#1 0800 – 1000 #2 1030 – 1230 C + N
3, 4, 7, 8	basic info & familiarization N + C	#3 0800 – 1000 #4 1030 – 1230 N + C

4.2.2. Trials

Day 1 Familiarization Trial: The subject arrived at the laboratory approximately 1 h before their scheduled trial in a rested state, and having refrained from drinking alcohol and performing heavy exercise for 24 hours. Caffeine use was limited prior to arrival at the laboratory according to the subject's habitual consumption. The subject's weight and height were recorded before having an audiogram administered by DRDC medical staff. This procedure was performed on each subject to determine hearing threshold of both ears at different frequencies. During this test the subject entered a soundproof booth and was asked to press a button when a noise was heard. The frequencies used for testing were 500, 1000, 2000, 3000, 4000, 6000 and 8000 Hz respectively. The subject then read, signed, and completed a consent form and a personal information questionnaire. The subject prepared for the familiarization trial through the following procedure: i) zeroed and grouped the C7 rifle and C79 scope (i.e., standard calibration) that was used during the shooting session, ii) had a heart rate monitor (telemetry unit) strapped around the subject's chest, iii) changed into combat attire (including boots and tack vest), and iv) assumed a standing position on the treadmill. The subject began walking at a 3 km/h pace for 15 min and then rested for 5 min while consuming water, as desired. Shooting took place during the walking portion of each 20 min session (detailed below under Shooting Session).

The subject continued these 20 min cycles of walking and resting for 2 h or until one of the other termination criteria was met (outlined below). During the 2 h trial, the noise (N) condition and the control (C) condition with normal background sound were presented alternately. At the end of the trial, the subject completed the NASA Task Load Index (TLX) questionnaire, was de-instrumented, offered refreshment, and released.

Days 2 (Innocent) and 3 (Reward): Trial preparation and procedure were conducted as described above for the familiarization trial except for the completion of the consent form, personal information questionnaire and hearing test. After the first two shooting sessions (40 min) during R, the subject was informed that they would receive additional payment based on how well they performed beyond their earlier attempt on Day 2. This amount was also relative to the improvements of all subjects (see Remuneration).

4.2.5. Physiological Measure

Heart rate was recorded at the beginning and end of each experimental session and 10 min after the beginning of each shooting session using a Polar® Accurex Plus. Also, the monitor continuously recorded the beat-to-beat variations in heart rate for the first 40 min of each day, which was used for heart rate variability post analysis.

4.2.6. Shooting Session

Subjects used the C7 rifle with the C79 scope for all shootings, and were presented with a CGI (computer generated imagery) rendering of complex environments in a battlefield scenario. During each 15 min session, the subject first advanced through a field terrain for 5 min, moved through an urban terrain for 5 min, and then exited through a second field terrain over 5 min, all at a rate synchronous with their walking speed of 3 km/h (considered a casual pace). While the terrains and course of movement through them did not vary, the appearance of 4 friend and 8 foe pop-up stationary targets in each was randomized in time and location. Targets appeared for 6 s along an arc at a fixed distance (60m) from the subject so that target identification and engagement was uniformly difficult. All target appearances between trials were randomly dispersed, yet counterbalanced, to avoid repetition between trials.

Subjects were instructed to immediately fire their weapon away from the screen to signal when a target (friend or foe) was detected and to step up onto a stationary platform (inverted U-shaped) attached to the treadmill to facilitate a stable shooting position. The 'detection' firing of the rifle stopped the motion on the screen for greater realism.

Subjects were instructed to take deliberate aim at foe targets only and fire as soon as they perceived to have the best chance of a direct hit; they were also instructed to fire their weapon at perceived foe targets even when the targets disappeared for friend/foe verification. Following engagement of the target, subjects stepped down onto the treadmill and resumed walking. A digital video recording of the SAT screen over the 2 h trial was used to assess detection times and shooting accuracy.

4.2.7. Termination Criteria

The trial ended when one of the following first occurred: i) 2 h had elapsed since the start of the trial, ii) the subject requested withdrawal, or iii) upon the discretion of the investigating team.

4.3. Remuneration

Incentive pay on the last session (Day 3) was based on the subject's improvement in performance relative to all subjects. Improvement in performance, as a percentage, was based on a composite of improvements in target detection time, number of correct target identifications, and number of foe targets hit. The best improvement among all subjects was rewarded with $100; remaining subjects were rewarded monetary amounts relative to their improvement as a percentage of the best improvement.

4.4. Data Analyses

4.4.1. Measures of Performance (MOP)

Performance measures included i) detection time (time between target appearance and first round fired), ii) friend-foe discrimination (evaluating correct and false identifications using signal detection theory), iii) engagement time (time between target detection and hit), and iv) accuracy (percentage of successful foe hits and number of shots required to hit a foe target).

4.4.2. Statistical Analysis

The data were analyzed in three separate steps.

4.4.2.1 Analysis I

This analysis was conducted to examine the effects of noise and task duration on performance during the I trial. Consequently, data were analyzed using a 2 (stressor) x 3 (time) way within-subjects repeated measures (ANOVA) design, where the stressor levels refer to Control (normal background sound) and Noise (loud battlefield fire), and time levels refer to the first, second and third sequential time blocks (TB1, 2 and 3) during the trial.

4.4.2.2. Analysis II

The second analysis was performed to check for a learning/order effect using a 2 (trial: I trial vs. R trial) x 2 (stressor: control vs. noise) way within-subjects repeated measures ANOVA design, where the mean values of TB2 and 3 of the I trial are compared against

TB1 of the R trial. The reason for combining TB2 and 3 of the I trial and not including TB1 stems from a time effect uncovered in Analysis I, to be discussed further on.

4.4.2.3. Analysis III

The last inquiry concerned the influence of incentive pay for improving individual performance. Data were analyzed using a 2 (stressor) x 3 (time) way, within-subjects repeated measures analysis of variance (ANOVA) design, where stressor refers to normal background sound (C) vs. noise (N), and time refers to TB1, TB2 and TB3.

Table 2. Chronology of events during individual trials (Day 2 or 3, and 4)

Time	Event
0700 h	Subjects arrived at DRDC Toronto Breakfast Dressed into combat clothing
0740 or 1000 h	Subjects arrived at SAT room Subject zeroed/grouped rifle Subject instrumented with HR monitor
0800 or 1020 h	Subject began 2h trial (6x20min shooting sessions) HR recorded 10min after beginning of each session
1000 or 1220 h	Subject was de-instrumented Subject filled out NASA Task Load Index form Subject released

5. RESULTS

5.1. Participants

Twenty Canadian Forces male infantry from 3RCR participated in this study, which was approved by the Human Research Ethics Committee at DRDC-Toronto and the University of Toronto Health Sciences I Research Ethics Board. Each subject was rifle-trained, fit, and had no greater than mild hearing loss in either ear (i.e., less than 20 dB). The subjects, whose characteristics are given in Table I, were ranked either private or corporal and had between 1 and 7 years of military training. Twelve of the subjects had combat experience as they completed at least one six-month tour of duty, while 5 of these subjects were involved with two or more tours.

Table 3. Participant characteristics (N = 20)

Characteristic	Mean ± SD
Height (cm)	181.6 ± 5.0
Weight (kg)	84.2 ± 13.4
Age (yrs)	24.2 ± 3.8
Number of Tours	0.9 ± 0.9
Years of Service	3.3 ± 1.5

5.2. Performance data

Complete data were obtained for all subjects (n=20) except for the R-R STD (n=18) and LF/HF ratio (n=18) results. Missing physiological data for two participants were due to difficulties with the heart rate variability recording equipment. All data in the text and tables are reported as mean ± SD and in figures as mean ± SE.

The performance data were analyzed in three separate investigations. See Tables 4, 5 and 6 for a summary of all statistical results and Table 7 for a summary of all significant results.

Table 4. Analysis I (see 4.4.2.1 for description of analysis) summary of statistical results.

	TB1		TB2		TB3	
Variable	Control	Noise	Control	Noise	Control	Noise
% of foe targets detected	97.29 ± 5.11	95.97 ± 5.57	95.64 ± 4.61	97.71 ± 5.14	96.46 ± 4.12	95.90 ± 5.17
% of friendly targets detected	94.17 ± 6.68	97.36 ± 4.98	96.62 ± 5.06	96.67 ± 5.07	96.25 ± 6.88	94.72 ± 8.69
% of all targets detected	96.25 ± 4.53	96.39 ± 4.78	95.97 ± 3.98	97.22 ± 4.60	96.39 ± 3.62	95.69 ± 5.14
% of late shots	2.36 ± 3.40	2.53 ± 3.93	2.86 ± 4.58	1.65 ± 3.38	1.95 ± 3.23	2.01 ± 3.61
Detection time-friendly targets (s)	1.08 ± 0.33	1.30 ± 0.48	0.95 ± 0.23	0.95 ± 0.20	0.94 ± 0.12	1.06 ± 0.17
Detection time-foe targets (s)	1.15 ± 0.24	1.01 ± 0.13	0.99 ± 0.24	1.09 ± 0.25	1.05 ± 0.11	1.02 ± 0.22
% of foe correctly ID	91.65 ± 6.02	95.74 ± 3.93	96.07 ± 4.85	97.50 ± 3.78	97.41 ± 3.47	96.20 ± 4.07
% of friendly correctly ID	100.00 ± 0.00	97.50 ± 7.09	100.00 ± 0.00	95.02 ± 10.28	99.58 ± 1.86	96.40 ± 8.09
% of all targets correctly ID	94.42 ± 4.00	96.12 ± 4.31	97.37 ± 3.29	96.16 ± 5.96	98.10 ± 2.40	95.86 ± 5.06
Engagement time (s)	4.49 ± 0.33	4.45 ± 0.32	4.63 ± 0.35	4.68 ± 0.30	4.63 ± 0.40	4.64 ± 0.39
% Accuracy	76.59 ± 11.62	79.46 ± 11.71	81.43 ± 13.24	79.86 ± 11.75	78.33 ± 10.97	78.31 ± 13.30

Table 5. Analysis II (see 4.4.2.2 for description of analysis) summary of statistical results.

	I Trial		R Trial	
Variable	Control	Noise	Control	Noise
% of foe targets detected	96.05 ± 3.76	96.81 ± 3.78	96.30 ± 4.38	96.88 ± 5.29
% of friendly targets detected	96.43 ± 4.63	95.69 ± 5.98	95.18 ± 6.11	97.22 ± 6.68
% of all targets detected	96.18 ± 3.12	96.46 ± 4.33	95.96 ± 4.27	96.94 ± 5.69
% of late shots	2.41 ± 2.60	1.83 ± 2.95	0.91 ± 1.87	1.42 ± 3.03
Detection time-friendly targets (s)	0.94 ± 0.13	1.00 ± 0.12	0.99 ± 0.39	0.94 ± 0.18
Detection time-foe targets (s)	1.02 ± 0.14	1.06 ± 0.19	0.96 ± 0.20	0.99 ± 0.23
% of foe correctly ID	96.74 ± 3.70	96.85 ± 3.13	97.09 ± 3.74	97.54 ± 3.15
% of friendly correctly ID	99.79 ± 0.93	95.71 ± 8.87	99.58 ± 1.86	95.18 ± 11.14
% of all targets correctly ID	97.73 ± 2.51	96.01 ± 5.25	97.88 ± 2.59	96.28 ± 5.28
Engagement time (s)	4.63 ± 0.35	4.66 ± 0.33	4.94 ± 0.13	4.90 ± 0.13
% Accuracy	79.88 ± 10.66	79.09 ± 10.56	81.58 ± 15.47	79.06 ± 14.98

Table 6. Analysis III (see 4.4.2.3 for description of analysis) summary of statistical results.

	TB1		TB2		TB3	
Variable	Control	Noise	Control	Noise	Control	Noise
% of foe targets detected	96.30 ± 4.38	96.88 ± 5.29	95.42 ± 9.36	97.40 ± 4.13	96.09 ± 5.05	96.60 ± 5.44
% of friendly targets detected	95.18 ± 6.11	97.22 ± 6.68	96.67 ± 6.84	96.67 ± 10.10	94.88 ± 6.70	98.19 ± 5.28
% of all targets detected	95.96 ± 4.27	96.94 ± 5.69	95.83 ± 8.28	96.79 ± 6.34	95.69 ± 5.13	97.22 ± 5.18
% of late shots	0.91 ± 1.87	1.42 ± 3.03	2.23 ± 2.67	1.34 ± 2.41	1.61 ± 2.27	0.42 ± 1.28
Detection time-friendly targets (s)	0.99 ± 0.39	0.94 ± 0.18	1.00 ± 0.34	0.96 ± 0.24	0.89 ± 0.20	0.97 ± 0.19
Detection time-foe targets (s)	0.96 ± 0.20	0.99 ± 0.23	1.04 ± 0.16	1.05 ± 0.26	0.93 ± 0.10	0.88 ± 0.11
% of foe correctly ID	97.09 ± 3.74	97.54 ± 3.15	94.99 ± 6.05	96.51 ± 4.11	96.70 ± 4.58	97.43 ± 3.16
% of friendly correctly ID	99.58 ± 1.86	95.18 ± 11.14	100.00 ± 0.00	96.39 ± 11.15	99.17 ± 3.73	94.97 ± 11.81
% of all targets correctly ID	97.88 ± 2.59	96.28 ± 5.28	96.73 ± 3.85	96.11 ± 5.91	97.49 ± 3.38	96.13 ± 6.96
Engagement time (s)	4.94 ± 0.13	4.90 ± 0.13	4.90 ± 0.19	4.91 ± 0.21	4.95 ± 0.16	5.00 ± 0.16
% Accuracy	81.58 ± 15.47	79.06 ± 14.98	83.75 ± 12.01	82.67 ± 12.96	84.14 ± 12.35	84.34 ± 11.18

Table 7. Summary of trends and significant findings (p < 0.05) for Analyses I, II and III. C and N refer to control and noise conditions, respectively, I and R refer to the Innocent and Reward trials, respectively, and 1, 2, and 3 refer to the time blocks.

	Analysis I	Analysis II	Analysis III
% foe detected		Trend: C < N	Trend: C < N
% all targets detected			Main effect: C < N
% foes identified	Main effect: TB1 < TB2, TB3 Interaction: C1 < C2, C3, N1, N2, N3		Trend: C < N
% friendly identified		Trend: C > N	Trend: C > N
% all targets identified	Main effect: TB1 < TB2, TB3 Interaction: C1 < C2, N1, N2, N3 < C3	Trend: C > N	Trend: C > N
Friendly DT (s)	Main effect: TB1 < TB2, TB3; C < N		
Foe DT (s)	Interaction: N1 < N2, N3, C1, C2, C3	Trend: C < N	Main effect: T3 < T1, T2
ET (s)	Main effect: TB1 < TB2, TB3	Main effect: I < R	

5.2.1. Target detection

Analysis I and II revealed no effect of time block, stressor condition or trial on the percentage of late shots or percentage of targets detected, regardless if they were friendly or foe. Analysis III demonstrated a main effect of noise on the percentage of all targets detected, $F(1, 19)=6.70$, $p=.02$, whereby more targets were detected during noise (96.99±5.66 %) as compared to the quiet condition (95.83±6.04 %) (see Figure 1). Similarly, although not statistically different, analysis III showed that a higher percentage of foe targets tended to be detected during noise (96.96±4.91 %) vs. the control condition (95.94±6.54 %).

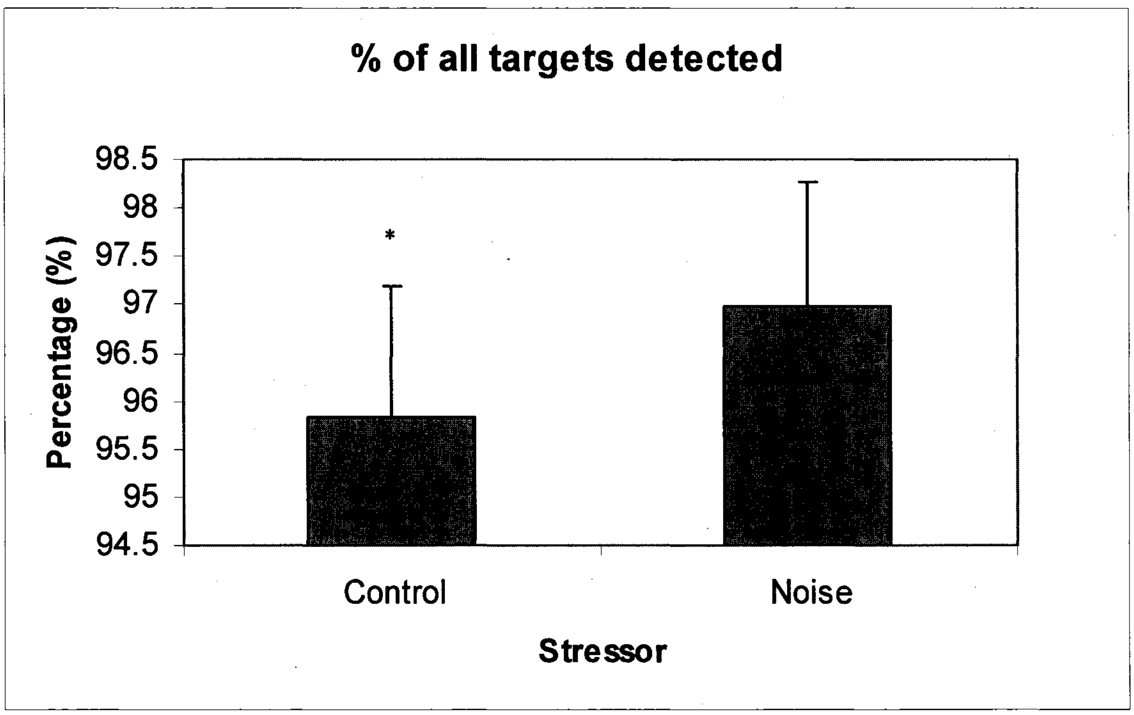

Figure 1. Percentage of all targets detected across N and C of the R trial.

5.2.2. Detection time

In Analysis I, there was a main effect of time, $F(2,38)=7.17$, $p<.01$, and stressor, $F(1,19)=4.86$, $p=.04$, on the detection time of friendly targets (see Figure 2 and 3). During the first time block, detection time of friendly targets (1.19±0.42 s) was significantly longer than during TB2 and 3 (0.95±0.22 s and 1.00±0.15 s respectively). Similarly, during the noise condition detection times were longer (1.10±0.34 s) than the control condition (0.99±0.25 s). In addition, there was a stressor by time interaction of the detection time of foe targets, $F(2,38)=6.39$, $p<.01$, whereby detection time was shorter during the noise condition of TB1 as compared to the control condition of TB1. (see Figure 4). There were no significant differences between stressor conditions during TB2 and 3.

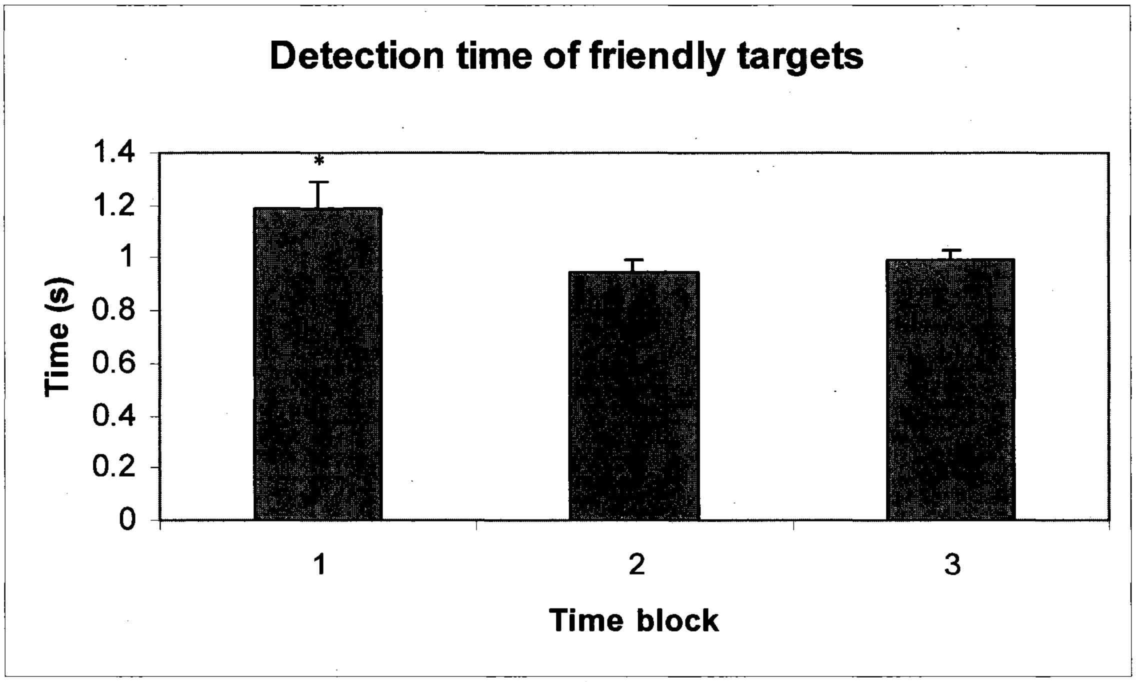

Figure 2. DT of friendly targets across TB1, 2 and 3 during the I trial.

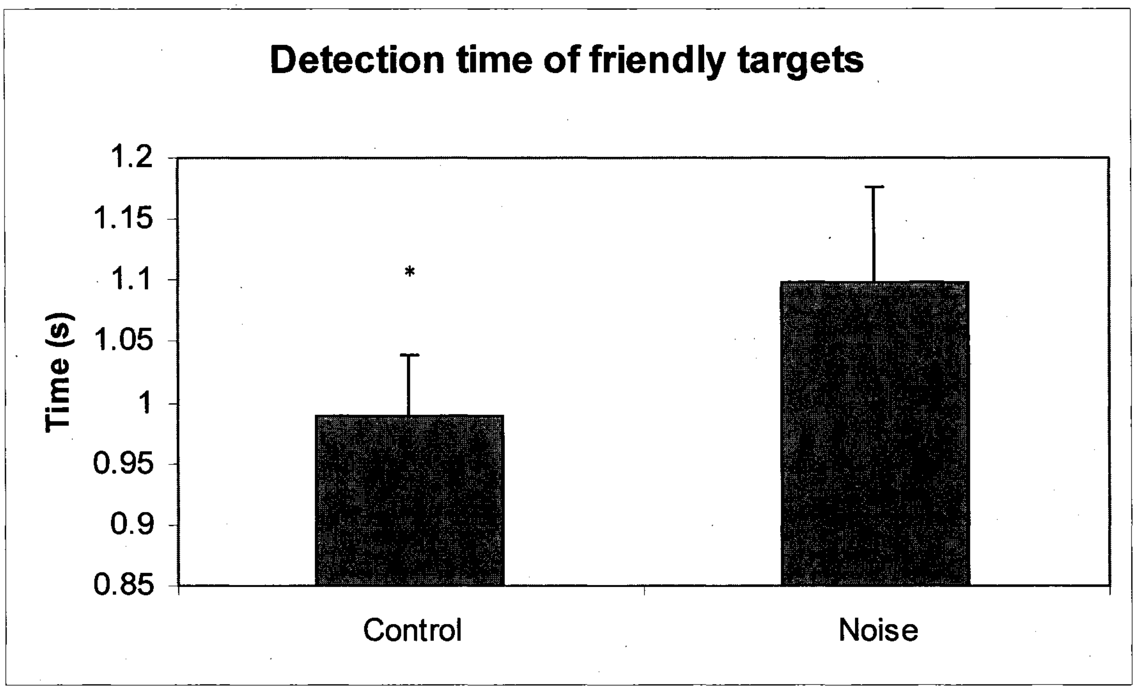

Figure 3. DT of friendly targets during N and C of the I trial.

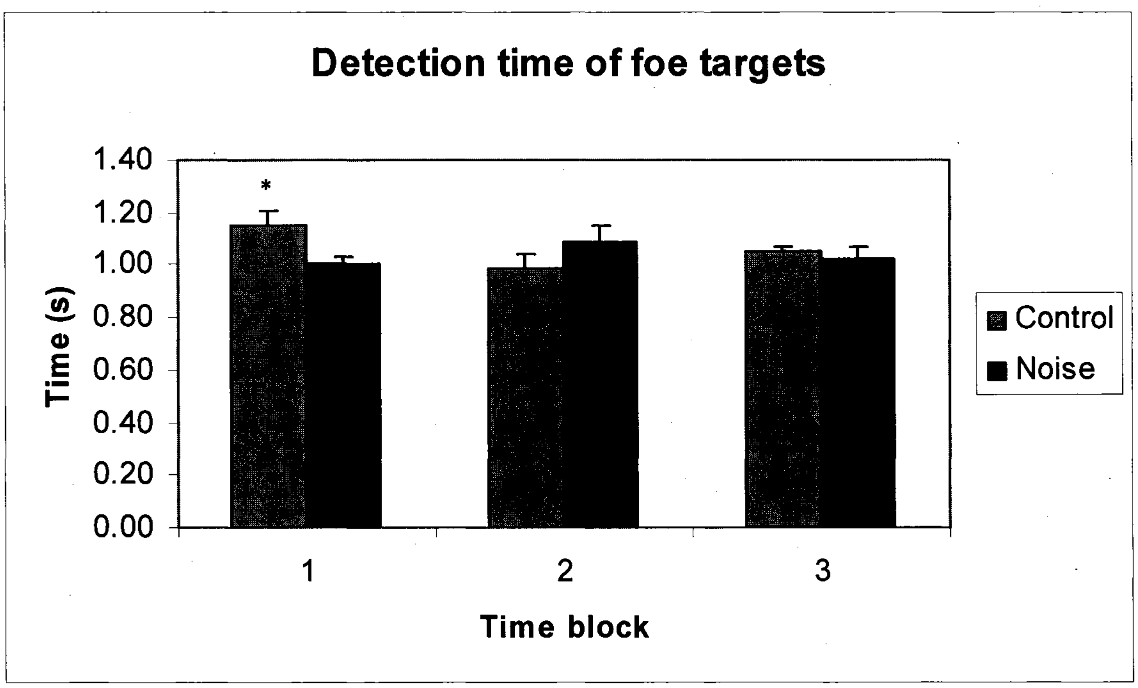

Figure 4. Stressor by time interaction of DT of foe targets during the I trial.

Analysis II revealed no effect of stressor condition or trial on the detection times of friendly and foe targets. Analysis III revealed a main effect of time on the detection time of foe targets, $F(2,38)=7.68$, $p<.01$, where detection times during TB3 (0.90±0.10 s) were significantly faster than TB1 (0.97±0.22 s) and 2 (1.04±0.21 s). (see Figure 5).

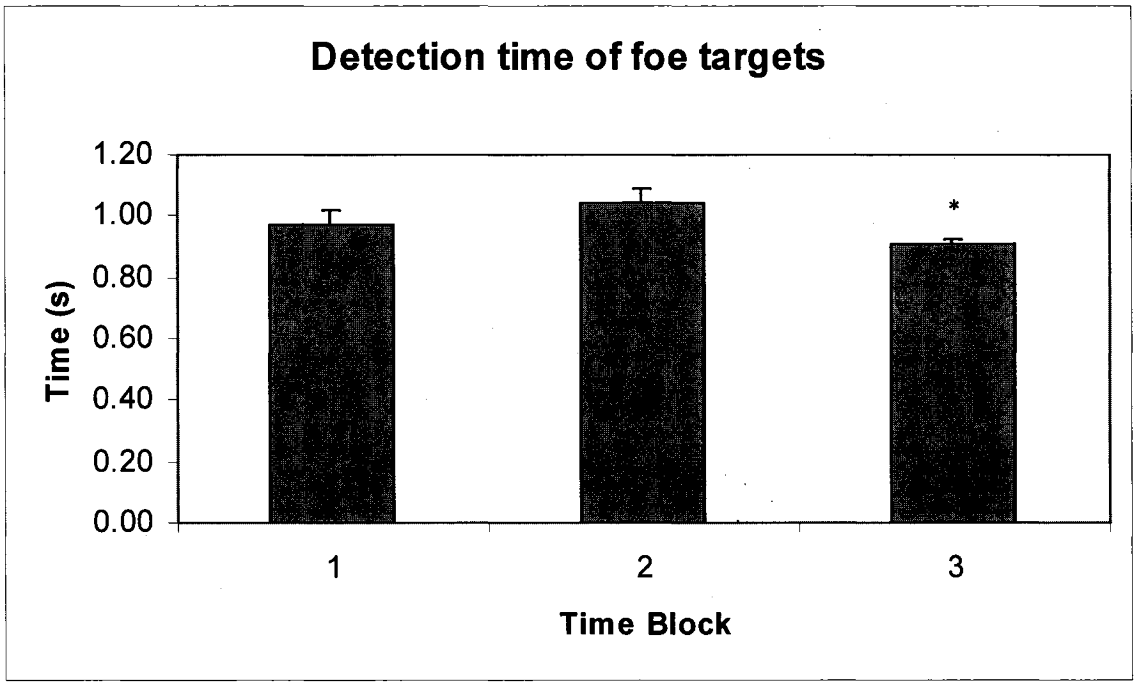

Figure 5. DT of foe targets across TB1, 2 and 3 during the R trial.

5.2.3. Target identification

Analysis I revealed a time main effect on the percentage of foe targets correctly identified, $F(2,38)=7.97$, $p<.01$, where identification percentage was lower during TB1 (93.70±6.02%) as compared to TB2 (96.78±4.34%) and 3 (96.80±3.92%), which were not significantly different (see Figure 6). There was also a significant stressor by TB interaction for the percentage of foes correctly identified (see Figure 7), $F(2,38)=8.35$, p<.01, and no effect of stressor or TB for the percentage of friendly targets correctly identified.

Furthermore, in Analysis I there was a main effect of time of the percentage of all targets correctly identified, $F(2,38)=5.25$, $p=.01$. Performance during TB1 (95.27±4.42 %) was significantly lower than TB2 and 3 (96.77±5.01 % and 96.98±4.25 %, respectively), which were not different from each other (see Figure 8). In addition, there was a stressor versus time interaction for the percentage of all targets correctly identified, $F(2,38)=8.60$, $p< 0.01$ (see Figure 9). Target identification during noise of TB1 was significantly better than during the control condition. While performances during noise and control conditions were not significantly different during TB2, performance during the control condition performance was significantly better than performance during noise in TB3.

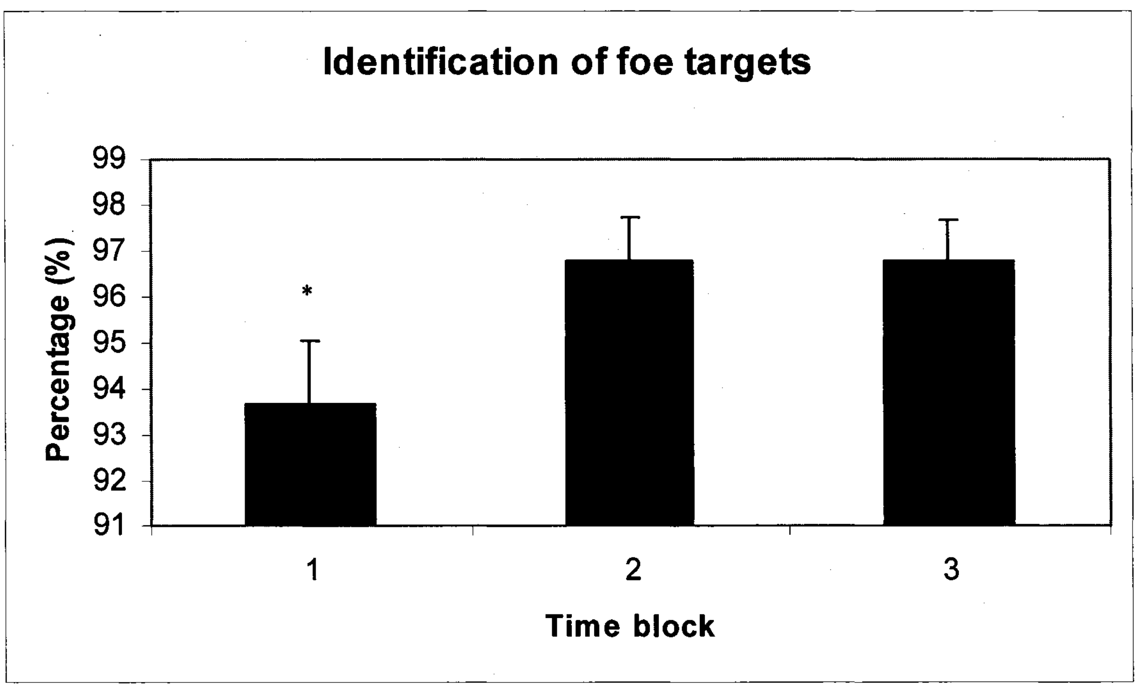

Figure 6. The percentage of foe targets identified across TB1, 2 and 3 of the I trial.

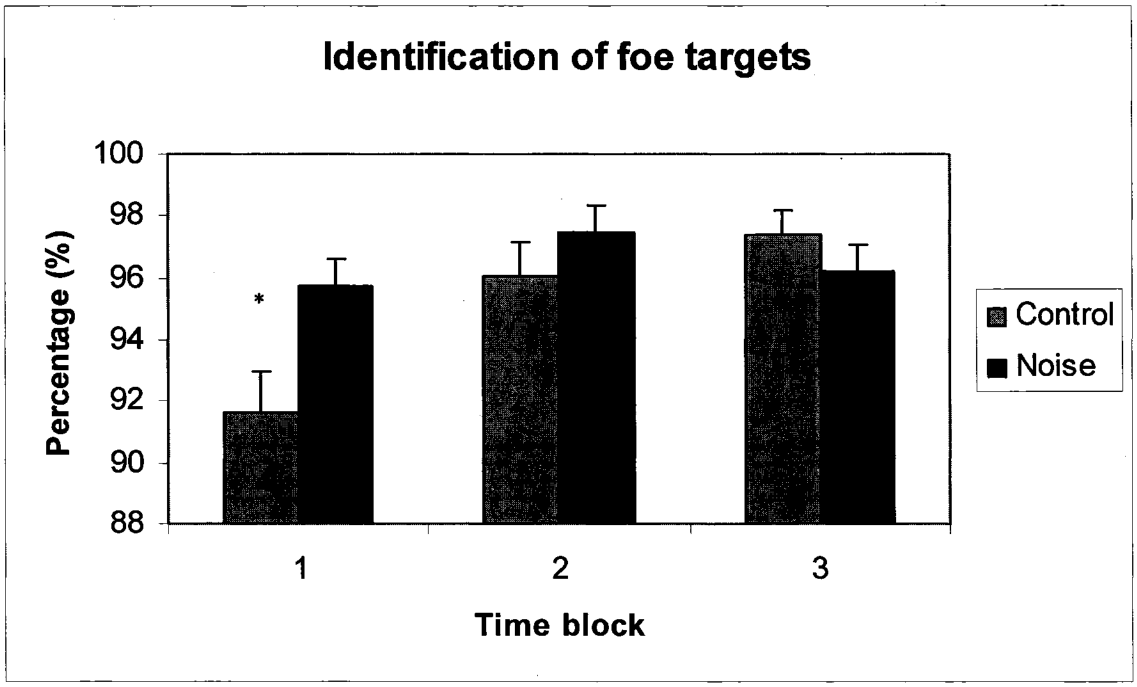

Figure 7. The percentage of foe target ID across stressor and time of the I trial.

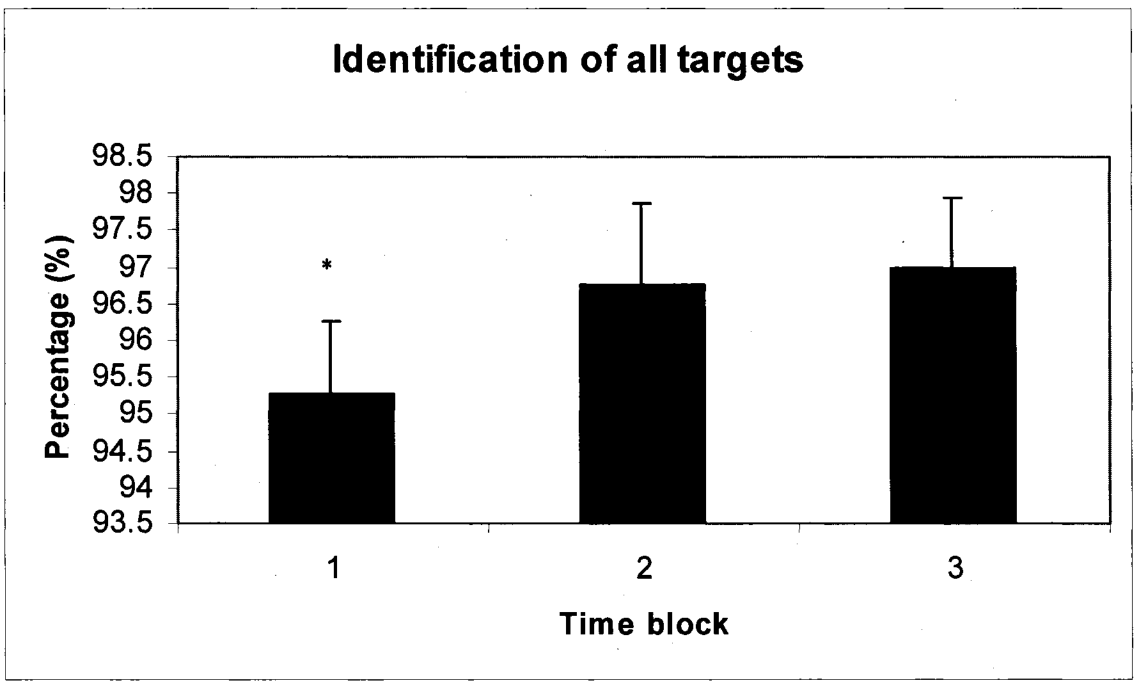

Figure 8. The percentage of all target ID across TB1, 2 and 3 of the I trial.

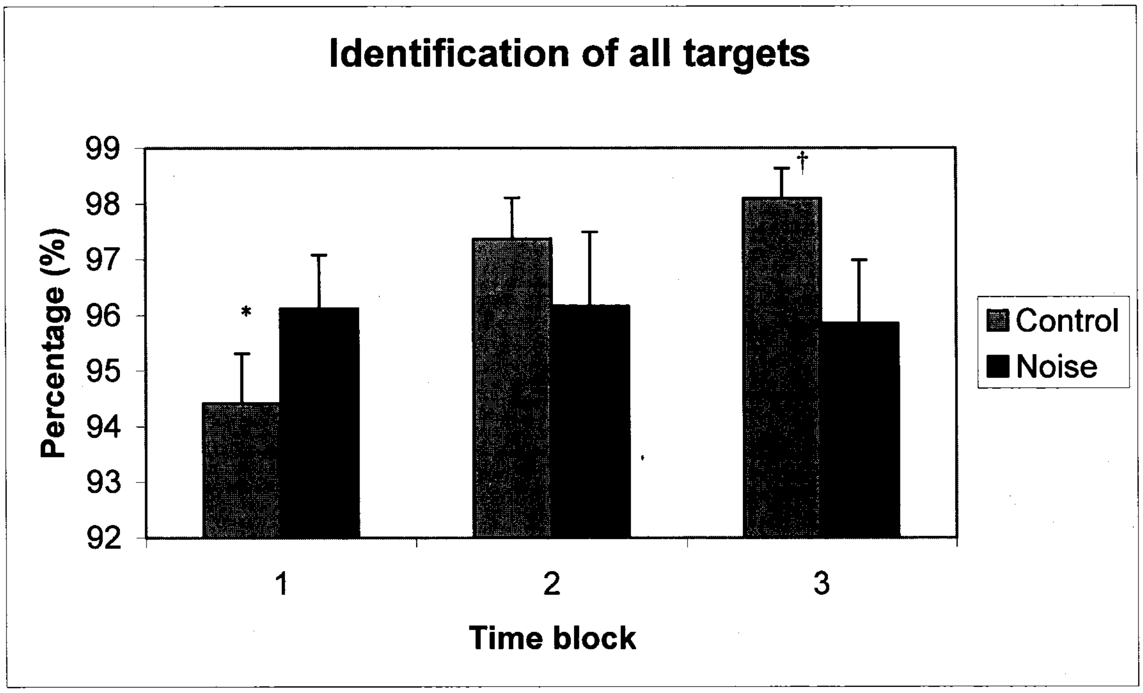

Figure 9. The percentage of all target ID across stressor and time.

Analysis II and III did not show any significant effects of TB, stressor condition or trial on the identification of friend or foes targets, although several tendencies of better performance during noise were noted. Analysis II revealed that the percentage of friendly targets tended to show better performance during the control condition (99.69±1.46 %) compared to noise (95.45±9.93 %). Similarly, analysis III demonstrated that the percentage of friendly targets showed the tendency of better performance during the control (99.49±2.64 %) versus the noise condition (96.33±10.38 %). In contrast, analysis III showed that more foe targets tended to be identified during noise (96.72±3.60 %) as compared to the control condition (96.05±5.22 %).

5.2.4. Engagement time

There was a TB main effect of engagement time in Analysis I, $F(2,38)=14.81$, $p<.01$ (see Figure 12). During TB1, engagement times were significantly faster (4.47±0.45 s) than TB2 and 3 (4.65±0.45 s and 4.63±0.49 s).

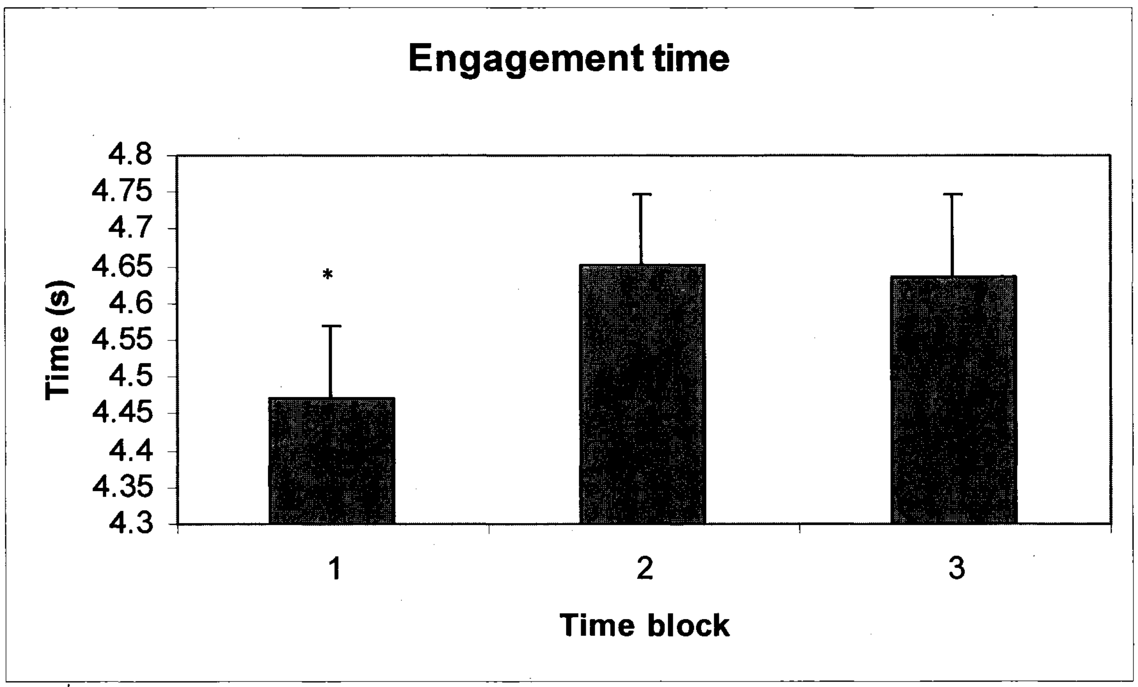

Figure 10. ET across TB1, 2 and 3 during the I trial.

Analysis II revealed a trial main effect of engagement time, $F(1,19)=15.89$, $p<.01$ (see Figure 13). Engagement times during the I trial were significantly faster (4.64±0.45 s) as compared to the R trial (4.92±0.13 s).

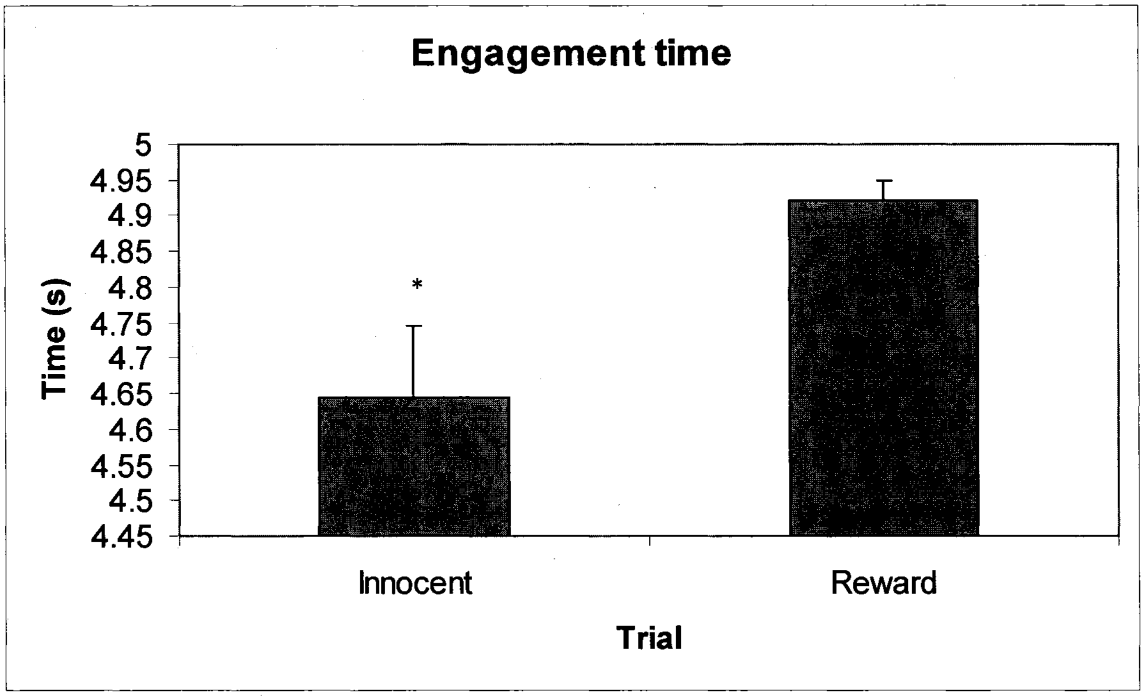

Figure 11. ET of TB2 and 3 during the I trial and TB1 during the R trial.

Analysis III did not reveal and significant effects of stressor or trial duration on engagement time.

5.2.5. Accuracy

Analysis I, II and III produced no significant effects of TB, stressor condition or trial on shooting accuracy.

5.3. Physiological data

Analysis I, II and III produced no significant effects of TB, stressor condition or trial on heart rate or heart rate variability, although heart rate tended to be elevated during the I trial (102.36±9.37 b/min) compared to the R trial (100.82±9.91 b/min).

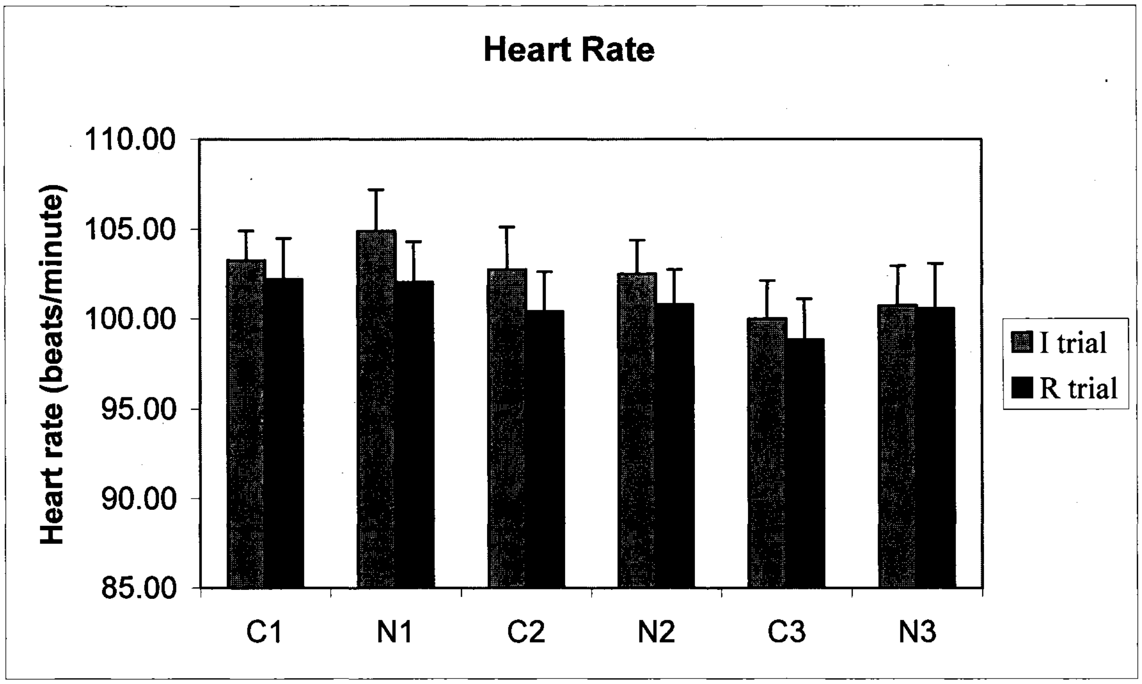

Figure 12. Heart Rate across stressor and time during the I trial and R trials.

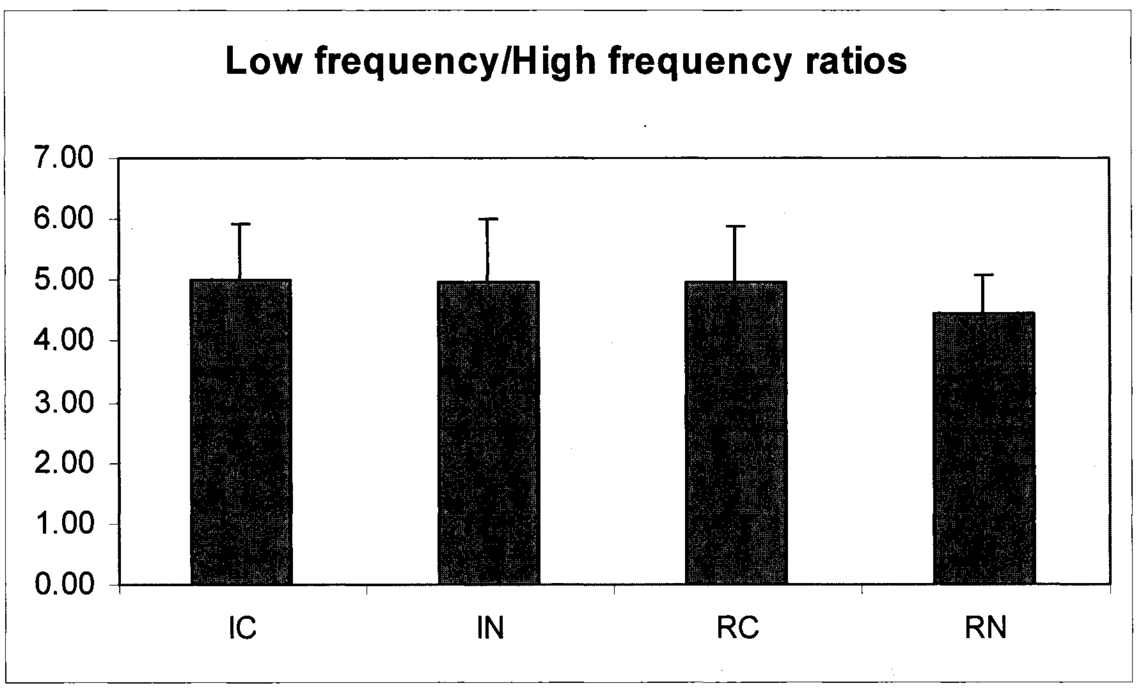

Figure 13. LF/HF ratios across N and C of the I and R trials.

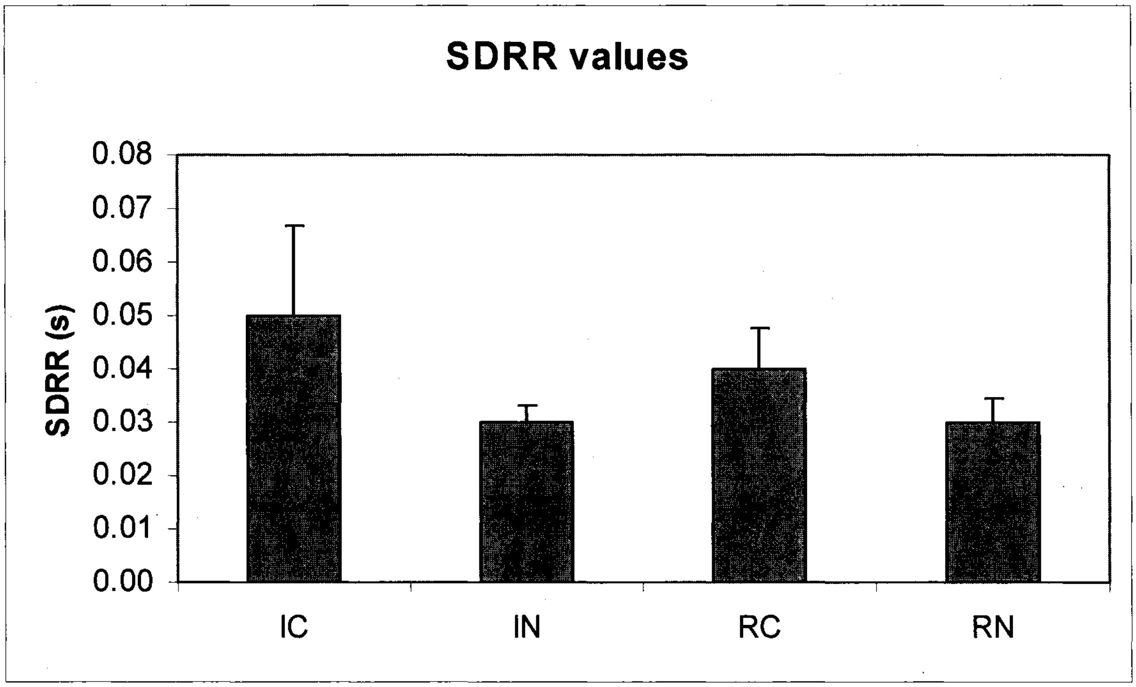

Figure 14. SDRR values across N and C of the I and R trials.

5.4. Subjective data

None of the six NASA TLX subscales were significantly affected across trial conditions.

Table 8. Mean ± SD of the six subscales of the Nasa Task Load Index for the I and R trials.

	I trial	R trial	p-value
Mental	4.17±2.7	4.1±3.0	0.98
Physical	2.5±1.8	2.1±1.6	0.44
Temporal	2.4±1.6	3.2±2.3	0.18
Performance	3.3±2.5	4.3±2.6	0.27
Effort	4.2±2.1	4.2±2.2	0.89
Frustration	3.6±2.7	4.5±3.1	0.34

6. DISCUSSION

Previous research has shown that noise can either inhibit or enhance performance depending on the type and intensity of noise, as well as the type of task that is being performed (2), although little information has been provided on the effects of noise on military tasks. The studies that have investigated the direct effects of this stressor on military tasks focused primarily on the effects of noise on aiming and accuracy (49, 50), whereby target detection and identification have largely been overlooked. Furthermore, the effects of offering an incentive to improve performance in a simulated combat environment are not known. Given the potential for noise to affect TDI&M, as well as the lack of research in this area, this study was focused on the effects of noise on TDI&M. Additionally, a monetary incentive was examined as a potential performance enhancer.

This investigation demonstrated that battlefield noise of 87 dBA did not cause essential changes in TDI&M. Although some results suggested that noise enhanced performance, other results implied the opposite, showing mixed results for the overall effects of noise,. Significant findings involved small differences of no practical concern.

The detection of targets (irrespective of type, whether friendly or foe) was unaffected by noise during the I trial while significantly better performance with noise was found during the R trial. Although the differences between the two conditions during the R trial were significant, they were also very slight as only about 1% more targets were detected during the noise condition. Analyses II and III indicated a non-significant trend of more foe targets detected during noise than during the control condition. Even though these results consistently point out that noise enhanced target detection ability, the small magnitude of this effect is not likely to be a practical military concern. Interestingly though, these findings are contrary to the expected performance degradation, which can often be observed when noise is present.

Previous studies have shown that tasks involving target detection (i.e., vigilance) are perturbed by the addition of a stressor such as noise. For example, Broadbent (25) found that noise of 100 dB impaired vigilance (i.e., target detection) in an experiment called the Twenty Lights Test. Broadbent quantified vigilance performance by using a measure called "quick founds" (i.e., response times less than or equal to 9 s), whereby the number of quick founds was significantly less in noise as opposed to the control (quiet) condition. That the results in the present study differ from previous findings might be because different noise intensities were used. Broadbent's (25) use of 100 dB might have been intense enough to sufficiently impair his subjects while the noise level used in the current study (87 dB) may not have been stressful enough to cause performance degradation. According to arousal theory (66), performance and stress level typically demonstrate an inverted U-shaped relationship. Noise in the present study may have been insufficiently disturbing and facilitated performance by raising it to a more optimal level, instead of acting as a performance inhibitor as seen in previous research (25, 40).

Target detection time also showed mixed results as there was an increased detection time of friendly targets during noise of the I trial, yet no significant effect was found during noise of the R trial. However, post hoc analysis revealed that the lengthened detection time of friendly targets during the I trial was mainly due to the exceptionally slow detection times during the noise condition of TB1. Subsequently, detection times during this trial plateaued for the remainder of the trial regardless of the presence of noise. The similar performances during TB2 and 3, which are clearly different from detection times during TB1, suggest a couple of possibilities. It might suggest that subjects were still becoming accustomed to the experimental environment even after completing the familiarization trial previously that was designed to ameliorate this very effect. Perhaps, the slower detection time of friendly targets during the I trial indicates a post-familiarization adjustment period due to the rigor of actual experimental trials, which are arguably more stressful than familiarization trials.

Another possibility is that the slower detection time of friendly targets reflects a statistical anomaly since no significant effects of noise during the detection time of foe targets occurred during the I and R trials. It appears that noise played no significant effect on the detection time of targets, which concurs with previous research. Indeed, some studies have shown that noise degrades target detection time (25), yet the majority found no such difference. For example, in Broadbent's twenty lights (25) test, noise of 100 dB clearly impaired signal detection time. Broadbent postulated that noise caused an increased amount of cognitive fatigue as trial duration increased, resulting in a lower number of "quick founds" (i.e., slower detection times). Although not exceeding high, the sound intensity used by Broadbent (100 dB) was much higher than the intensity used in the current study (87 dBA) and is likely the reason for the differing results. Indeed, most studies using less intense noise have not produced similar results (115). In one such study, Jones (92) concluded that moderate noise (90 dB), which was close to the level used in the current study, did not significantly change signal detection time (i.e., target detection time).

Although subjects were put through an extensive familiarization trial that allowed sufficient time to become comfortable with the target detection, identification and marksmanship task during noise and control conditions, certain performance metrics improved significantly after TB1 of the I trial. For example, the detection time of friendly targets was significantly slower during TB1 as compared to TB2 and 3. However, as mentioned previously, the slower performance can be attributed to the noise condition during TB1. Other performance measures showed comparable patterns. During the I trial, the percentage of correctly identified targets significantly improved after TB1, and plateaued thereafter. On closer inspection, performances during noise were initially high (approximately 96%) and remained constant, while during the control condition, performances began slightly lower during TB1 (approximately 94%) before reaching a value of approximately 98% during TB3. However, the improvement in total target identification during the I trial can be accounted for by the improvements in the percentage of foes targets correctly identified, as the percentage of friendly targets correctly identified did not change during the trial. The percentages of correctly identified foe targets during control conditions plateaued and remained constant after TB1, whereas performances in all TBs during noise were consistent.

Since performance during TB2 and 3 was consistent with and without the presence of noise, it appears to have facilitated target discrimination performance when compared to performance under the control condition, but only during TB1. This might suggest that the subjects were not fully adjusted to the rigors of an actual experimental trial, despite the familiarization process. It is possible that noise increased arousal levels to an optimal point and therefore improved performance as the subjects were still adjusting to their first experimental trial (66).

Other research has shown that noise can increase focus and thus facilitate certain cognitive functions. Smith (162) for example, studied the effects of moderate noise (85 dB) on the allocation of attention and showed that attentional resources can be shifted to high priority events. Target discrimination was the high priority decision event in the current study and was accentuated when noise was present. Perhaps the attentional shift coupled with of the difficulty of the first experimental trials was responsible for the increased performance during noise of TB1. Whether the current results can be explained by increased arousal or heightened focus is unknown; however, the fact remains that certain performances did improve after TB1 of the I trial and remained unchanged for the remainder of the trials. Conversely, other performance measures such as the percentage of friendly targets correctly identified, percentage of all targets correctly identified, accuracy and average detection time of foe targets were not significantly affected by task duration (with or without noise). Furthermore, some measures such as the percentage of friendly targets correctly identified and the percentage of all targets correctly identified demonstrated tendencies, albeit weakly, whereby performance was slightly worse (~3%) during noise than the control condition. In any case, the duration of time on task after TB1 did not cause performance decrement and is therefore not considered a debilitating factor.

One final case that was related to task duration involves the significant changes in engagement time. This measure, like many others that were already mentioned, also displayed a significantly different performance after TB1 of the I trial, whereby engagement times during TB2 and 3 were almost 0.2 s slower than TB1. However, engagement time results were unique because no performance plateau was observed after TB1 of the I trial. Indeed, engagement time continued to increase to become approximately 0.3 s slower during the R trial. Rather than performing poorly, it appears that subjects purposely adjusted their engagement times in order to maximize their time on target in order to improve shooting accuracy. This is not surprising since this is the emphasis placed on Canadian Forces soldiers in the marksmanship-training program (see appendix marksmanship training). Hence, a successful hit was the desired goal when the subjects in the current study encountered a foe target, despite being informed that all experimental measures of target detection, engagement time, and marksmanship were to be considered equally important.

Surprisingly, however, was no significance in the R trial on the percentage of foe targets hit (i.e., shooting accuracy). This suggests that the accuracy over speed trade-off strategy failed. The level of difficulty associated with hitting targets may explain this result. For example, in a previous study, Gillingham (56) examined the effects of caffeine on certain shooting measures during another marksmanship task. Subjects were divided into Poor and Good shooting groups. Those in the Poor group consistently improved their shooting accuracy across the trials. Conversely, shooting precision remained constant across trials for those in the Good group. It appears that poor shooters underwent a learning effect, which was not present among the good shooters. Similarly in the present study, all subjects possessed high proficiency in weapons training. During testing, computer generated targets appeared along an arc at a fixed distance of 60 m from the subject, while the target range is typically much further (up to 300 m) in the Canadian Forces marksmanship training program. Thus, the shooting accuracy of our subjects was likely already at a peak despite lengthening their engagement time.

The incentive of a performance-based reward during the R trial had no overwhelming effect. However, the average detection time of foes targets during TB3 of the R trial was significantly faster than all others. Although this result was inconsistent with much of the other data, which showed no significant effect of incentive on performance, it is possible that subjects were more motivated at the end of the trial for another reason. Research has shown that external incentives may not influence performance as powerfully as internal incentives such as goal achievement or task completion, in which seLF-satisfaction can be a greater reward than a monetary one (13, 14). In one study, Aiello and Grodkeiwicz

(6) gave spurious feedback to subjects who were participating in a simple computer data entry task regarding their distance from a pre-determined goal. They found that the distance between the pre-determined goal and subjective motivation was inversely proportional whereupon subjects who thought they were close to the end of the task performed with higher motivation than those who thought they were far from the goal. It is therefore possible that improved target detection time was due to subjects' awareness that they were approaching the final portion of the experimental trial, which might have increased their motivation. Overall, because no effect of incentive was observed, it can be concluded that the participants were putting forth their best effort, although one must be careful to draw parallels between the synthetic environment used in the current experiment and the real battlefield. The results in the current study may not be applicable to the combat arena because of dissimilar levels of anxiety.

The current study measured heart rate and two heart rate variability measures (i.e., LF/HF ratio and standard deviation of R-R intervals) to assess subjective levels of acute internal stress. While there were no significant effects of noise, task duration or incentive, it was found that heart rate and LF/HF were elevated, and the SDRR was reduced when compared to their standard norms (5). The changes in these measures all suggest higher stress levels during experimental testing. Indeed, research has shown that heart rate and the LF/HF ratio can increase while the SDRR can decrease, compared to baseline values, in subjects who are physiologically stressed (107, 125). These changes are due to the central nervous system's response to a stressor, which often results in increased sympathetic activity (LF) and decreased or maintenance of the parasympathetic activity (HF) (156).

However, the effects of exercise in this study (i.e., walking at 3 km/h and engaging 36 targets every 20 min) cannot be overlooked because it can also affect the sympathetic-parasympathetic activity of the heart. Moderate exercise causes an increase in heart rate and the LF/HF ratio and a decrease in the SDRR (125). Hence, physiological stress due to anxiety, which is associated with being in the battle arena, was likely elevated in the current study although it was more likely that exercise was primarily responsible for the increase in LF/HF and decrease in SDRR. Furthermore, it is fair to assume that physiological stress, due to increased anxiety, during actual combat would surpass that experienced in the laboratory setting. However, how the higher levels of anxiety would impact performance differently by its nature and extent is unknown.

According to the subjective ratings of the task load index (TLX), the experimental conditions were not considered physically demanding whereby values averaged just over 2 (out of a maximum of 10) between both trials. Furthermore the subjects were not particularly pressed for time, as the average score for temporal demand was approximately 3. Given that the soldiers felt comfortable enough to lengthen their engagement time in accordance with the appearance time of targets, it is reasonable to expect that time was not a particularly concerning factor. However, mental demand, effort and frustration each averaged about 4, which suggests that the task was not taken lightly. The most important observation is the lack of TLX differences between the I and

R trials. The consistent scores suggest, in concurrence with previous discussion, that the subjects were already highly motivated and put forth their 'best effort' from the beginning of experimentation, which attenuated any potential effect of an incentive. Finally the subjects' perception of performance was not different between trials. This is somewhat surprising considering that previous research demonstrated that incentives usually affect the subjective indication of performance (6). That this did not occur might reflect the high motivation that professional soldiers brought and maintained throughout the study.

7. CONCLUSION

The present study evaluated the effects of noise and incentive, on target detection, identification and marksmanship (TDI&M). It found that:

1. Noise had no significant effect on TDI&M.

2. Time on task had no significant effect on TDI&M measures except foe target engagement time, which increased in a failed bid to improve shooting accuracy.

3. Monetary incentive had no significant effect on TDI&M.

Accordingly, it is concluded that loud battlefield noise of 87 dBA, time on task and monetary incentive did not significantly affect target detection, identification and marksmanship. Subjects performed at 'best effort' and increased their target engagement time across the duration of both trials in order to increase shooting accuracy, but failed to do so.

8. RECOMMENDATIONS FOR FUTURE RESEARCH

Given that research has consistently shown noise to alter mental and physical performances, this study's objective was to determine if similar changes in performance could be observed in a realistic battlefield environment. Although noise did not appreciably affected TDI&M in the present study it is recommended that if a similar task is to be employed in the future, it must increase the level of noise intensity. By increasing the level of free field battlefield sounds participants would be stressed to an even greater extend, thereby increasing the chance of observing altered performance.

Furthermore, despite the purported findings that incentive often improves performance, the current study did not demonstrate any significant effects. In future it is recommended that a larger incentive should be offered in order to potentially motivate participants to a greater level. Also further investigation into the participants' self-perceived value of incentive, both type and quantity, would be helpful to validate that the amount of monetary incentive offered in the current study was sufficient to motivate participants to the maximal extent.

With regards to the presentation of targets and the realism of the synthetic environment, several modifications are recommended. Although targets were presented at a rate of two per minute it is recommended that a slower rate be implemented in the future in order to create a less stimulating environment. This rate of target presentation would create a truly vigilant activity, which would mirror sentry/patrol duty, a task that is one of the most common for Canadian soldiers in combat situations. Finally, more realistic targets and scenery are recommended in order to create a true synthetic battlefield environment. In the future, targets should be more lifelike in behaviour, movement and appearance to improve the realism of the synthetic environment, as would a different setup of the virtual environment itself. For example, certain synthetic environments, which are currently available, increase realism by fully immersing participants in a sphere that projects 360 degrees of virtual environment. Finally, it is recommended that a rifle that fires rubber ammunition with similar ballistics to ammunition used with standard C7 rifle used by Canadian soldiers. Not only would soldiers be using real ammunition, they would be using non-pneumatic rifles, which are less cumbersome than the weapons used in the current study and more similar to the rifles on which they were trained.

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APPENDIX A. VARIABLE LEGEND

1	Percentage of foe targets detected
2	Percentage of friendly targets detected
3	Percentage of all targets detected
4	Percentage of foe targets correctly identified
5	Percentage of friendly targets correctly identified
6	Percentage of all targets correctly identified
10	Percentage of foe targets hit
12	Percentage of late shots
13	Average detection time (DT) of friendly targets
14	Average detection time (DT) of foe targets
15	Average engagement time (ET)
27	Heart rate (HR)
28	Task load index (TLX): Mental demand
29	Task load index (TLX): Physical demand
30	Task load index (TLX): Temporal demand
31	Task load index (TLX): Performance
32	Task load index (TLX): Effort
33	Task load index (TLX): Frustration
35	Standard deviation of R-R intervals (SDRR)
36	Low frequency/High frequency (Lf/Hf) ratio

APPENDIX B. I TRIAL DATA (see Appendix A for variable index)

Subject	Variable	C1	C2	C3	N1	N2	N3
1	1	87.50	100.00	100.00	88.89	100.00	83.33
2	1	95.83	95.83	95.83	94.44	100.00	83.33
3	1	100.00	100.00	100.00	94.44	100.00	100.00
4	1	100.00	100.00	100.00	100.00	100.00	94.44
5	1	100.00	95.65	91.67	100.00	100.00	94.44
6	1	100.00	86.96	91.67	100.00	100.00	100.00
7	1	100.00	95.83	91.67	100.00	95.83	100.00
8	1	100.00	100.00	100.00	100.00	95.83	95.83
9	1	95.83	87.50	100.00	95.83	100.00	100.00
10	1	87.50	91.67	95.83	100.00	100.00	95.83
11	1	83.33	92.31	87.50	87.50	79.17	91.67
12	1	100.00	96.15	95.83	100.00	91.67	95.83
13	1	100.00	95.83	100.00	100.00	100.00	100.00
14	1	95.83	95.83	100.00	79.17	100.00	100.00
15	1	100.00	100.00	100.00	95.83	100.00	100.00
16	1	100.00	100.00	100.00	100.00	100.00	95.83
17	1	100.00	87.50	91.67	95.83	100.00	91.67
18	1	100.00	91.67	95.83	100.00	100.00	100.00
19	1	100.00	100.00	91.67	91.67	91.67	100.00
20	1	100.00	100.00	100.00	95.83	100.00	95.83
1	2	83.33	91.67	75.00	83.33	88.89	94.44
2	2	100.00	100.00	91.67	88.89	94.44	88.89
3	2	91.67	100.00	100.00	100.00	100.00	100.00
4	2	100.00	100.00	100.00	100.00	100.00	100.00
5	2	91.67	92.31	100.00	100.00	100.00	94.44

Subject	Variable	C1	C2	C3	N1	N2	N3
6	2	91.67	100.00	100.00	100.00	100.00	100.00
7	2	100.00	100.00	100.00	100.00	91.67	100.00
8	2	100.00	91.67	100.00	100.00	91.67	100.00
9	2	100.00	91.67	100.00	100.00	100.00	100.00
10	2	91.67	83.33	100.00	100.00	91.67	91.67
11	2	91.67	90.00	83.33	91.67	83.33	66.67
12	2	100.00	100.00	100.00	100.00	100.00	100.00
13	2	100.00	100.00	100.00	100.00	100.00	100.00
14	2	91.67	100.00	91.67	100.00	91.67	100.00
15	2	100.00	100.00	100.00	100.00	100.00	100.00
16	2	91.67	100.00	100.00	100.00	100.00	100.00
17	2	75.00	91.67	100.00	100.00	100.00	83.33
18	2	91.67	100.00	91.67	91.67	100.00	100.00
19	2	91.67	100.00	100.00	91.67	100.00	83.33
20	2	100.00	100.00	91.67	100.00	100.00	91.67
1	3	86.11	97.22	91.67	86.11	94.44	88.89
2	3	97.22	97.22	94.44	91.67	97.22	86.11
3	3	97.22	100.00	100.00	97.22	100.00	100.00
4	3	100.00	100.00	100.00	100.00	100.00	97.22
5	3	97.22	94.44	94.44	100.00	100.00	94.44
6	3	97.22	91.67	94.44	100.00	100.00	100.00
7	3	100.00	97.22	94.44	100.00	94.44	100.00
8	3	100.00	97.22	100.00	100.00	94.44	97.22
9	3	97.22	88.89	100.00	97.22	100.00	100.00
10	3	88.89	88.89	97.22	100.00	97.22	94.44
11	3	86.11	91.67	86.11	88.89	80.56	83.33
12	3	100.00	97.22	97.22	100.00	94.44	97.22

Subject	Variable	C1	C2	C3	N1	N2	N3
13	3	100.00	97.14	100.00	100.00	100.00	100.00
14	3	94.44	97.22	97.22	86.11	97.22	100.00
15	3	100.00	100.00	100.00	97.22	100.00	100.00
16	3	97.22	100.00	100.00	100.00	100.00	97.22
17	3	91.67	88.89	94.44	97.22	100.00	88.89
18	3	97.22	94.44	94.44	97.22	100.00	100.00
19	3	97.22	100.00	94.44	91.67	94.44	94.44
20	3	100.00	100.00	97.22	97.22	100.00	94.44
1	4	80.95	83.33	87.50	93.75	100.00	100.00
2	4	95.65	91.30	100.00	100.00	100.00	93.33
3	4	91.67	100.00	91.67	100.00	100.00	94.44
4	4	91.67	95.83	95.83	94.44	100.00	100.00
5	4	95.83	90.91	95.45	94.44	88.89	94.12
6	4	91.67	95.00	95.45	94.44	100.00	94.44
7	4	100.00	100.00	100.00	95.83	100.00	100.00
8	4	91.67	100.00	100.00	100.00	100.00	100.00
9	4	86.96	100.00	100.00	91.30	100.00	91.67
10	4	85.71	86.36	95.65	91.67	100.00	100.00
11	4	80.00	95.83	95.24	85.71	94.74	86.36
12	4	95.83	100.00	95.65	95.83	95.45	95.65
13	4	95.83	100.00	100.00	100.00	95.83	100.00
14	4	91.30	95.65	95.83	94.74	100.00	91.67
15	4	87.50	100.00	100.00	100.00	100.00	100.00
16	4	83.33	95.83	100.00	100.00	100.00	100.00
17	4	100.00	100.00	100.00	100.00	91.67	90.91
18	4	100.00	95.45	100.00	95.83	91.67	100.00
19	4	95.83	100.00	100.00	95.45	100.00	95.83

Subject	Variable	C1	C2	C3	N1	N2	N3
20	4	91.67	95.83	100.00	91.30	91.67	95.65
1	5	100.00	100.00	100.00	100.00	100.00	94.12
2	5	100.00	100.00	100.00	100.00	100.00	93.75
3	5	100.00	100.00	100.00	94.44	94.44	100.00
4	5	100.00	100.00	100.00	100.00	100.00	100.00
5	5	100.00	100.00	100.00	72.22	66.67	70.59
6	5	100.00	100.00	100.00	83.33	66.67	77.78
7	5	100.00	100.00	100.00	100.00	100.00	100.00
8	5	100.00	100.00	100.00	100.00	100.00	100.00
9	5	100.00	100.00	100.00	100.00	100.00	91.67
10	5	100.00	100.00	100.00	100.00	100.00	100.00
11	5	100.00	100.00	100.00	100.00	90.00	100.00
12	5	100.00	100.00	100.00	100.00	91.67	100.00
13	5	100.00	100.00	100.00	100.00	100.00	100.00
14	5	100.00	100.00	100.00	100.00	90.91	100.00
15	5	100.00	100.00	100.00	100.00	100.00	100.00
16	5	100.00	100.00	100.00	100.00	100.00	100.00
17	5	100.00	100.00	100.00	100.00	100.00	100.00
18	5	100.00	100.00	100.00	100.00	100.00	100.00
19	5	100.00	100.00	91.67	100.00	100.00	100.00
20	5	100.00	100.00	100.00	100.00	100.00	100.00
1	6	87.10	88.57	90.91	96.77	100.00	96.88
2	6	97.14	94.29	100.00	100.00	100.00	93.55
3	6	94.29	100.00	94.44	97.14	97.22	97.22
4	6	94.44	97.22	97.22	97.22	100.00	100.00
5	6	97.14	94.12	97.06	83.33	77.78	82.35
6	6	94.29	96.97	97.06	88.89	83.33	86.11

Subject	Variable	C1	C2	C3	N1	N2	N3
7	6	100.00	100.00	100.00	97.22	100.00	100.00
8	6	94.44	100.00	100.00	100.00	100.00	100.00
9	6	91.43	100.00	100.00	94.29	100.00	91.67
10	6	90.63	90.63	97.14	94.44	100.00	100.00
11	6	87.10	96.97	96.77	90.63	93.10	90.00
12	6	97.22	100.00	97.14	97.22	94.12	97.14
13	6	97.22	100.00	100.00	100.00	97.22	100.00
14	6	94.12	97.14	97.14	96.77	97.14	94.44
15	6	91.67	100.00	100.00	100.00	100.00	100.00
16	6	88.57	97.22	100.00	100.00	100.00	100.00
17	6	100.00	100.00	100.00	100.00	94.44	93.75
18	6	100.00	97.06	100.00	97.14	94.44	100.00
19	6	97.14	100.00	97.06	96.97	100.00	97.06
20	6	94.44	97.22	100.00	94.29	94.44	97.06
1	10	58.33	70.83	79.17	83.33	88.89	55.56
2	10	79.17	70.83	75.00	77.78	72.22	50.00
3	10	62.50	95.65	70.83	88.89	83.33	72.22
4	10	58.33	75.00	66.67	61.11	83.33	83.33
5	10	70.83	69.57	70.83	77.78	77.78	61.11
6	10	79.17	60.87	58.33	77.78	88.89	61.11
7	10	66.67	33.33	66.67	70.83	50.00	52.17
8	10	75.00	87.50	79.17	79.17	91.67	75.00
9	10	62.50	83.33	70.83	50.00	79.17	87.50
10	10	58.33	54.17	75.00	58.33	91.67	87.50
11	10	45.83	57.69	54.17	41.67	41.67	54.17
12	10	87.50	73.08	79.17	87.50	70.83	70.83
13	10	66.67	83.33	83.33	75.00	91.67	87.50

Subject	Variable	C1	C2	C3	N1	N2	N3
14	10	62.50	79.17	87.50	58.33	83.33	87.50
15	10	62.50	91.67	91.67	83.33	83.33	87.50
16	10	70.83	75.00	75.00	79.17	79.17	70.83
17	10	54.17	58.33	45.83	58.33	58.33	41.67
18	10	87.50	83.33	83.33	79.17	66.67	83.33
19	10	45.83	70.83	54.17	62.50	58.33	75.00
20	10	79.17	87.50	79.17	79.17	66.67	79.17
1	12	11.76	10.00	0.00	0.00	5.56	0.00
2	12	0.00	0.00	0.00	0.00	0.00	0.00
3	12	0.00	0.00	4.55	0.00	0.00	0.00
4	12	0.00	0.00	4.35	5.88	0.00	0.00
5	12	4.35	0.00	0.00	0.00	0.00	0.00
6	12	0.00	0.00	4.76	0.00	0.00	0.00
7	12	8.33	17.39	0.00	13.04	13.04	4.35
8	12	4.55	4.17	12.50	8.33	4.35	13.04
9	12	5.00	0.00	0.00	4.76	0.00	0.00
10	12	0.00	0.00	0.00	0.00	0.00	0.00
11	12	0.00	4.35	0.00	5.56	5.56	5.26
12	12	0.00	8.00	0.00	4.35	0.00	0.00
13	12	0.00	4.35	0.00	0.00	0.00	4.17
14	12	4.76	0.00	0.00	0.00	0.00	0.00
15	12	0.00	0.00	0.00	0.00	0.00	0.00
16	12	0.00	0.00	4.17	0.00	0.00	0.00
17	12	4.17	4.76	0.00	8.70	4.55	5.00
18	12	0.00	0.00	0.00	0.00	0.00	8.33
19	12	4.35	4.17	4.55	0.00	0.00	0.00
20	12	0.00	0.00	4.17	0.00	0.00	0.00

Subject	Variable	C1	C2	C3	N1	N2	N3
1	13	1.76	0.84	0.82	0.86	0.86	0.95
2	13	1.22	0.84	0.84	0.85	0.86	0.98
3	13	1.32	1.36	0.89	1.52	1.03	1.07
4	13	1.34	1.40	0.89	1.52	1.03	1.07
5	13	0.76	0.89	1.20	1.00	0.98	1.38
6	13	0.78	0.89	1.20	1.00	0.98	1.38
7	13	0.80	1.24	0.96	0.68	0.73	0.96
8	13	0.80	1.25	0.96	0.68	0.74	0.96
9	13	0.71	0.85	0.82	0.99	0.80	1.11
10	13	0.72	0.73	0.82	0.99	0.81	0.86
11	13	1.10	0.82	0.88	1.78	1.41	1.11
12	13	1.07	0.80	0.84	1.86	1.21	1.09
13	13	1.52	0.70	0.90	0.99	0.80	1.25
14	13	1.61	0.68	0.92	0.99	0.81	1.25
15	13	0.86	0.90	0.90	1.88	1.29	0.80
16	13	0.89	0.90	0.90	1.88	1.29	0.80
17	13	0.80	0.73	0.93	1.13	0.86	1.10
18	13	0.81	1.35	0.95	1.19	0.86	1.11
19	13	1.35	0.89	1.09	1.99	0.80	0.94
20	13	1.38	0.89	1.08	2.16	0.80	0.92
1	14	1.08	0.95	0.95	0.82	1.42	0.68
2	14	1.02	0.71	0.96	0.80	1.42	0.68
3	14	1.13	1.49	1.13	1.20	1.47	1.54
4	14	1.13	1.52	1.13	1.18	1.47	1.58
5	14	0.81	1.19	0.87	0.98	1.31	1.08
6	14	0.81	1.20	0.87	0.98	1.31	1.08
7	14	1.09	1.09	1.07	0.85	1.30	1.01

Subject	Variable	C1	C2	C3	N1	N2	N3
8	14	1.09	1.10	1.37	0.85	1.30	1.00
9	14	1.62	0.77	1.05	1.11	0.90	1.01
10	14	1.42	0.77	1.06	1.11	0.90	1.03
11	14	1.09	0.87	1.08	1.04	0.90	0.90
12	14	1.07	0.89	1.15	1.02	0.87	0.89
13	14	1.20	1.15	1.01	1.10	0.90	0.94
14	14	1.22	1.14	1.01	1.20	0.90	0.94
15	14	1.16	0.85	1.12	1.02	0.78	1.06
16	14	1.16	0.85	1.12	1.01	0.78	1.06
17	14	1.58	0.74	1.03	1.04	0.87	0.87
18	14	1.58	0.78	1.01	1.04	0.87	1.01
19	14	0.91	0.85	0.89	0.87	1.09	1.01
20	14	0.91	0.85	1.02	0.87	1.07	1.03
1	15	4.89	4.86	4.96	4.98	5.06	4.90
2	15	5.13	4.81	4.95	4.98	5.06	4.92
3	15	3.77	3.66	3.72	3.68	3.92	3.72
4	15	3.81	3.66	3.71	3.61	3.92	3.74
5	15	4.40	4.53	5.20	4.53	4.91	4.80
6	15	4.40	4.47	5.22	4.49	4.91	4.76
7	15	4.56	4.71	4.77	4.45	4.65	5.20
8	15	4.50	4.79	4.80	4.51	4.61	5.22
9	15	4.58	4.84	4.76	4.39	4.62	4.43
10	15	4.58	4.89	4.80	4.44	4.62	4.42
11	15	4.29	4.62	4.37	4.38	4.85	4.82
12	15	4.35	4.63	4.32	4.42	4.80	4.78
13	15	4.72	4.85	4.78	4.44	4.60	4.55
14	15	4.78	4.82	4.78	4.40	4.62	4.53

Subject	Variable	C1	C2	C3	N1	N2	N3
15	15	4.55	4.67	4.45	4.57	4.86	4.83
16	15	4.48	4.67	4.50	4.57	4.86	4.83
17	15	4.76	4.86	4.82	4.47	4.61	4.37
18	15	4.76	4.85	4.82	4.44	4.63	4.39
19	15	4.29	4.68	4.47	4.63	4.69	4.83
20	15	4.27	4.71	4.43	4.64	4.72	4.80
1	27	95.00	87.00	92.00	90.00	87.00	93.00
2	27	101.00	113.00	94.00	102.00	94.00	94.00
3	27	94.00	92.00	93.00	94.00	92.00	92.00
4	27	100.00	91.00	88.00	96.00	98.00	87.00
5	27	103.00	101.00	96.00	102.00	100.00	103.00
6	27	100.00	101.00	94.00	108.00	99.00	88.00
7	27	111.00	111.00	108.00	114.00	115.00	113.00
8	27	99.00	105.00	102.00	106.00	104.00	105.00
9	27	107.00	109.00	109.00	117.00	109.00	109.00
10	27	95.00	103.00	110.00	102.00	110.00	114.00
11	27	96.00	94.00	94.00	98.00	99.00	93.00
12	27	104.00	105.00	92.00	100.00	106.00	99.00
13	27	104.00	121.00	124.00	123.00	112.00	113.00
14	27	105.00	104.00	102.00	115.00	112.00	109.00
15	27	103.00	87.00	84.00	102.00	93.00	85.00
16	27	98.00	90.00	104.00	85.00	92.00	90.00
17	27	119.00	121.00	108.00	109.00	108.00	107.00
18	27	101.00	96.00	94.00	108.00	98.00	99.00
19	27	122.00	116.00	107.00	125.00	115.00	110.00
20	27	108.00	108.00	105.00	102.00	107.00	112.00
1	28	27.00					

Subject	Variable	C1	C2	C3	N1	N2	N3
2	28	41.00					
3	28	50.00					
4	28	67.00					
5	28	61.00					
6	28	40.00					
7	28	69.00					
8	28	30.00					
9	28	8.00					
10	28	32.00					
11	28	88.00					
12	28	93.00					
13	28	9.00					
14	28	16.00					
15	28	6.00					
16	28	8.00					
17	28	46.00					
18	28	80.00					
19	28	11.00					
20	28	51.00					
1	29	14.00					
2	29	20.00					
3	29	0.00					
4	29	25.00					
5	29	36.00					
6	29	33.00					
7	29	34.00					
8	29	19.00					

Subject	Variable	C1	C2	C3	N1	N2	N3
9	29	7.00					
10	29	34.00					
11	29	75.00					
12	29	36.00					
13	29	2.00					
14	29	16.00					
15	29	6.00					
16	29	5.00					
17	29	47.00					
18	29	48.00					
19	29	15.00					
20	29	31.00					
1	30	15.00					
2	30	26.00					
3	30	13.00					
4	30	10.00					
5	30	48.00					
6	30	22.00					
7	30	60.00					
8	30	13.00					
9	30	7.00					
10	30	31.00					
11	30	45.00					
12	30	36.00					
13	30	3.00					
14	30	21.00					
15	30	4.00					

Subject	Variable	C1	C2	C3	N1	N2	N3
16	30	5.00					
17	30	46.00					
18	30	33.00					
19	30	10.00					
20	30	27.00					
1	31	14.00					
2	31	16.00					
3	31	16.00					
4	31	19.00					
5	31	31.00					
6	31	44.00					
7	31	89.00					
8	31	5.00					
9	31	10.00					
10	31	56.00					
11	31	17.00					
12	31	75.00					
13	31	2.00					
14	31	43.00					
15	31	6.00					
16	31	11.00					
17	31	65.00					
18	31	35.00					
19	31	47.00					
20	31	67.00					
1	32	45.00					
2	32	40.00					

Subject	Variable	C1	C2	C3	N1	N2	N3
3	32	23.00					
4	32	44.00					
5	32	53.00					
6	32	39.00					
7	32	63.00					
8	32	61.00					
9	32	37.00					
10	32	44.00					
11	32	77.00					
12	32	65.00					
13	32	3.00					
14	32	28.00					
15	32	5.00					
16	32	14.00					
17	32	60.00					
18	32	66.00					
19	32	9.00					
20	32	54.00					
1	33	54.00					
2	33	90.00					
3	33	22.00					
4	33	24.00					
5	33	24.00					
6	33	73.00					
7	33	76.00					
8	33	16.00					
9	33	2.00					

Subject	Variable	C1	C2	C3	N1	N2	N3
10	33	33.00					
11	33	39.00					
12	33	51.00					
13	33	17.00					
14	33	22.00					
15	33	7.00					
16	33	3.00					
17	33	78.00					
18	33	68.00					
19	33	4.00					
20	33	21.00					
1	35	0.07			0.04		
2	35	0.02			0.01		
3	35	0.03			0.03		
4	35	0.03			0.03		
5	35	0.02			0.02		
6	35	0.03			0.03		
7	35	0.02			0.02		
8	35	0.02			0.03		
9	35	0.06			0.06		
10	35	0.34			0.02		
11	35	na			na		
12	35	0.04			0.03		
13	35	0.02			0.01		
14	35	0.02			0.06		
15	35	0.04			0.04		
16	35	0.04			0.05		

Subject	Variable	C1	C2	C3	N1	N2	N3
17	35	0.03			0.03		
18	35	0.05			0.04		
19	35	0.00			0.01		
20	35	0.02			0.03		
1	36	0.99			2.03		
2	36	4.92			9.30		
3	36	3.78			4.63		
4	36	5.95			7.61		
5	36	4.58			5.60		
6	36	18.42			19.43		
7	36	4.95			0.88		
8	36	10.51			8.15		
9	36	0.93			0.53		
10	36	2.95			5.42		
11	36	na			na		
12	36	2.26			6.27		
13	36	8.53			8.16		
14	36	4.16			0.50		
15	36	1.72			0.86		
16	36	3.55			2.65		
17	36	1.72			3.15		
18	36	6.41			5.97		
19	36	4.16			0.93		
20	36	4.79			2.57		

APPENDIX C. R TRIAL DATA (see Appendix A for variable index)

Subject	Variable	C1	C2	C3	N1	N2	N3
1	1	100.00	100.00	96.15	100.00	94.44	94.44
2	1	100.00	100.00	84.62	100.00	100.00	100.00
3	1	80.77	58.33	86.96	88.89	88.89	83.33
4	1	96.15	100.00	91.30	94.44	100.00	100.00
5	1	95.83	95.83	100.00	100.00	94.44	94.44
6	1	95.83	95.83	95.83	100.00	100.00	88.89
7	1	100.00	100.00	100.00	100.00	100.00	100.00
8	1	95.83	100.00	100.00	100.00	95.83	95.83
9	1	95.24	100.00	100.00	95.83	100.00	100.00
10	1	95.65	100.00	100.00	95.83	95.83	100.00
11	1	95.83	91.67	87.50	79.17	86.96	83.33
12	1	100.00	91.67	91.67	95.83	100.00	95.83
13	1	100.00	95.83	100.00	95.83	100.00	100.00
14	1	96.15	91.67	100.00	91.67	91.67	100.00
15	1	95.83	100.00	100.00	100.00	100.00	100.00
16	1	100.00	100.00	96.15	100.00	100.00	100.00
17	1	95.83	95.83	100.00	100.00	100.00	100.00
18	1	100.00	91.67	100.00	100.00	100.00	100.00
19	1	91.30	100.00	95.83	100.00	100.00	100.00
20	1	95.65	100.00	95.83	100.00	100.00	95.83
1	2	91.67	100.00	90.00	100.00	94.44	100.00
2	2	100.00	100.00	90.00	94.44	88.89	100.00
3	2	80.00	75.00	76.92	83.33	55.56	77.78
4	2	90.00	100.00	100.00	100.00	94.44	100.00
5	2	100.00	100.00	91.67	100.00	100.00	94.44

Subject	Variable	C1	C2	C3	N1	N2	N3
6	2	100.00	100.00	100.00	100.00	100.00	100.00
7	2	100.00	100.00	91.67	100.00	100.00	100.00
8	2	100.00	100.00	100.00	100.00	100.00	100.00
9	2	100.00	100.00	100.00	100.00	100.00	100.00
10	2	92.31	100.00	100.00	100.00	100.00	100.00
11	2	91.67	83.33	83.33	75.00	100.00	91.67
12	2	91.67	91.67	91.67	100.00	100.00	100.00
13	2	100.00	91.67	100.00	100.00	100.00	100.00
14	2	90.00	91.67	100.00	91.67	100.00	100.00
15	2	100.00	100.00	100.00	100.00	100.00	100.00
16	2	91.67	100.00	90.00	100.00	100.00	100.00
17	2	100.00	100.00	100.00	100.00	100.00	100.00
18	2	100.00	100.00	92.31	100.00	100.00	100.00
19	2	100.00	100.00	100.00	100.00	100.00	100.00
20	2	84.62	100.00	100.00	100.00	100.00	100.00
1	3	97.22	100.00	94.44	100.00	94.44	97.22
2	3	100.00	100.00	86.11	97.22	94.44	100.00
3	3	80.56	63.89	83.33	86.11	72.22	80.56
4	3	94.44	100.00	94.44	97.22	97.22	100.00
5	3	97.22	97.22	97.14	100.00	97.22	94.44
6	3	97.22	97.22	97.22	100.00	100.00	94.44
7	3	100.00	100.00	97.22	100.00	100.00	100.00
8	3	97.22	100.00	100.00	100.00	97.22	97.22
9	3	97.06	100.00	100.00	97.22	100.00	100.00
10	3	94.44	100.00	100.00	97.22	97.22	100.00
11	3	94.44	88.89	86.11	77.78	91.43	86.11
12	3	97.22	91.67	91.67	97.22	100.00	97.22

Subject	Variable	C1	C2	C3	N1	N2	N3
13	3	100.00	94.44	100.00	97.22	100.00	100.00
14	3	94.44	91.67	100.00	91.67	94.44	100.00
15	3	97.22	100.00	100.00	100.00	100.00	100.00
16	3	97.22	100.00	94.44	100.00	100.00	100.00
17	3	97.22	97.22	100.00	100.00	100.00	100.00
18	3	100.00	94.44	97.22	100.00	100.00	100.00
19	3	94.44	100.00	97.22	100.00	100.00	100.00
20	3	91.67	100.00	97.22	100.00	100.00	97.22
1	4	95.83	95.83	100.00	94.44	82.35	100.00
2	4	95.65	100.00	90.91	88.89	100.00	94.44
3	4	85.71	78.57	100.00	93.75	93.75	93.33
4	4	100.00	100.00	100.00	100.00	94.44	100.00
5	4	100.00	86.96	100.00	100.00	94.12	94.12
6	4	95.65	95.65	100.00	100.00	100.00	93.75
7	4	100.00	100.00	100.00	100.00	95.83	100.00
8	4	100.00	100.00	95.83	95.83	100.00	100.00
9	4	95.00	95.83	100.00	100.00	95.83	100.00
10	4	95.45	95.83	86.96	100.00	95.65	100.00
11	4	91.30	90.91	85.71	94.74	95.00	90.00
12	4	95.83	95.45	95.45	95.65	95.83	95.65
13	4	100.00	100.00	100.00	100.00	100.00	100.00
14	4	96.00	86.36	91.67	100.00	100.00	95.83
15	4	100.00	95.65	96.15	100.00	95.65	100.00
16	4	100.00	100.00	100.00	95.83	95.83	100.00
17	4	100.00	86.96	100.00	95.83	100.00	100.00
18	4	100.00	100.00	95.65	100.00	95.83	100.00
19	4	100.00	100.00	100.00	100.00	100.00	95.83

Subject	Variable	C1	C2	C3	N1	N2	N3
20	4	95.45	95.83	95.65	95.83	100.00	95.65
1	5	100.00	100.00	100.00	100.00	100.00	100.00
2	5	100.00	100.00	100.00	100.00	100.00	100.00
3	5	100.00	100.00	100.00	93.33	100.00	100.00
4	5	100.00	100.00	100.00	100.00	100.00	100.00
5	5	100.00	100.00	100.00	61.11	61.11	64.71
6	5	100.00	100.00	100.00	66.67	66.67	61.11
7	5	100.00	100.00	100.00	100.00	100.00	100.00
8	5	100.00	100.00	83.33	100.00	100.00	100.00
9	5	100.00	100.00	100.00	100.00	100.00	100.00
10	5	100.00	100.00	100.00	100.00	100.00	100.00
11	5	100.00	100.00	100.00	100.00	100.00	81.82
12	5	100.00	100.00	100.00	100.00	100.00	91.67
13	5	100.00	100.00	100.00	91.67	100.00	100.00
14	5	100.00	100.00	100.00	90.91	100.00	100.00
15	5	100.00	100.00	100.00	100.00	100.00	100.00
16	5	100.00	100.00	100.00	100.00	100.00	100.00
17	5	100.00	100.00	100.00	100.00	100.00	100.00
18	5	91.67	100.00	100.00	100.00	100.00	100.00
19	5	100.00	100.00	100.00	100.00	100.00	100.00
20	5	100.00	100.00	100.00	100.00	100.00	100.00
1	6	97.14	97.22	100.00	97.22	91.18	100.00
2	6	97.14	100.00	93.55	94.29	100.00	97.22
3	6	89.66	86.96	100.00	93.55	96.15	96.55
4	6	100.00	100.00	100.00	100.00	97.14	100.00
5	6	100.00	91.43	100.00	80.56	77.14	79.41
6	6	97.14	97.14	100.00	83.33	83.33	76.47

Subject	Variable	C1	C2	C3	N1	N2	N3
7	6	100.00	100.00	100.00	100.00	97.22	100.00
8	6	100.00	100.00	91.67	97.22	100.00	100.00
9	6	96.97	97.22	100.00	100.00	97.22	100.00
10	6	97.06	97.22	91.43	100.00	97.14	100.00
11	6	94.12	93.75	90.32	96.43	96.88	87.10
12	6	97.14	96.97	96.97	97.14	97.22	94.29
13	6	100.00	100.00	100.00	97.14	100.00	100.00
14	6	97.06	90.91	94.44	96.97	100.00	97.22
15	6	100.00	97.22	97.22	100.00	97.14	100.00
16	6	100.00	100.00	100.00	97.22	97.22	100.00
17	6	100.00	91.43	100.00	97.22	100.00	100.00
18	6	97.22	100.00	97.14	100.00	97.22	100.00
19	6	100.00	100.00	100.00	100.00	100.00	97.22
20	6	96.97	97.22	97.14	97.22	100.00	97.14
1	7	3.42	3.46	3.63	3.50	2.82	3.80
2	7	3.44	3.75	2.93	3.11	3.77	3.50
3	7	2.60	2.38	3.59	3.03	3.18	3.30
4	7	3.63	3.75	3.74	3.80	3.48	3.82
5	7	3.74	2.86	3.70	2.19	1.84	1.94
6	7	3.44	3.44	3.74	2.34	2.34	1.81
7	7	3.75	3.75	3.71	3.75	3.46	3.75
8	7	3.74	3.75	2.69	3.46	3.74	3.74
9	7	3.41	3.46	3.75	3.74	3.46	3.75
10	7	3.42	3.46	2.86	3.74	3.44	3.75
11	7	3.05	2.98	2.71	3.21	3.37	2.19
12	7	3.42	3.38	3.38	3.44	3.46	3.09
13	7	3.70	3.70	3.75	3.39	3.75	3.75

Subject	Variable	C1	C2	C3	N1	N2	N3
14	7	3.34	2.79	3.11	3.32	3.72	3.46
15	7	3.74	3.48	3.41	3.75	3.44	3.75
16	7	3.71	3.77	3.63	3.46	3.46	3.75
17	7	3.74	2.86	3.77	3.46	3.75	3.75
18	7	3.40	3.72	3.44	3.75	3.46	3.75
19	7	3.74	3.75	3.74	3.75	3.75	3.46
20	7	3.38	3.46	3.44	3.46	3.75	3.44
1	10	83.33	91.67	84.62	83.33	66.67	77.78
2	10	91.30	91.67	65.38	77.78	66.67	83.33
3	10	69.23	45.83	65.22	72.22	66.67	77.78
4	10	80.77	62.50	73.91	83.33	72.22	72.22
5	10	54.17	58.33	86.96	55.56	55.56	77.78
6	10	83.33	79.17	83.33	77.78	100.00	61.11
7	10	70.83	66.67	83.33	66.67	79.17	79.17
8	10	83.33	87.50	91.67	70.83	95.83	91.67
9	10	61.90	79.17	91.67	95.83	91.67	95.83
10	10	65.22	79.17	47.83	70.83	45.83	66.67
11	10	33.33	50.00	41.67	54.17	52.17	58.33
12	10	83.33	66.67	66.67	58.33	91.67	58.33
13	10	100.00	87.50	95.83	83.33	91.67	91.67
14	10	73.08	62.50	83.33	79.17	75.00	87.50
15	10	91.67	86.96	80.77	100.00	78.26	83.33
16	10	95.83	91.30	92.31	87.50	79.17	95.83
17	10	83.33	75.00	86.96	79.17	87.50	91.67
18	10	75.00	58.33	82.61	79.17	70.83	91.67
19	10	69.57	75.00	58.33	45.83	83.33	62.50
20	10	65.22	91.67	87.50	50.00	91.67	79.17

Subject	Variable	C1	C2	C3	N1	N2	N3
1	12	4.35	0.00	4.00	0.00	0.00	0.00
2	12	0.00	0.00	0.00	0.00	0.00	0.00
3	12	0.00	0.00	5.00	6.67	6.67	0.00
4	12	0.00	0.00	0.00	0.00	5.88	0.00
5	12	0.00	0.00	4.35	0.00	0.00	0.00
6	12	0.00	0.00	0.00	0.00	0.00	0.00
7	12	4.17	4.17	4.17	8.33	0.00	4.17
8	12	4.35	8.33	0.00	0.00	0.00	0.00
9	12	5.26	4.35	0.00	0.00	4.35	0.00
10	12	0.00	4.35	0.00	0.00	4.55	0.00
11	12	0.00	5.00	5.56	0.00	5.26	0.00
12	12	0.00	0.00	4.76	9.09	0.00	0.00
13	12	0.00	0.00	0.00	4.35	0.00	4.17
14	12	0.00	5.26	0.00	0.00	0.00	0.00
15	12	0.00	0.00	0.00	0.00	0.00	0.00
16	12	0.00	0.00	0.00	0.00	0.00	0.00
17	12	0.00	0.00	4.35	0.00	0.00	0.00
18	12	0.00	4.55	0.00	0.00	0.00	0.00
19	12	0.00	4.17	0.00	0.00	0.00	0.00
20	12	0.00	4.35	0.00	0.00	0.00	0.00
1	13	0.75	0.63	0.71	0.80	1.22	0.93
2	13	0.75	0.63	0.75	0.81	1.18	0.93
3	13	0.89	1.32	1.13	0.88	0.71	0.96
4	13	0.89	1.32	1.13	1.22	0.71	0.96
5	13	1.13	1.04	1.28	0.94	0.99	0.93
6	13	1.22	0.62	0.78	1.05	1.54	0.94
7	13	1.07	0.70	0.62	1.34	1.19	1.10

Subject	Variable	C1	C2	C3	N1	N2	N3
8	13	1.07	0.70	0.65	1.34	1.19	1.10
9	13	1.83	1.27	0.71	0.86	0.76	0.67
10	13	1.95	1.27	0.71	0.86	0.76	0.67
11	13	0.60	1.40	0.73	0.82	1.19	0.87
12	13	0.61	1.40	0.88	0.77	1.19	1.04
13	13	1.40	0.62	0.78	1.04	0.76	0.93
14	13	1.40	0.63	0.78	0.97	0.76	0.93
15	13	0.73	1.36	1.13	0.76	0.72	1.10
16	13	0.74	1.36	1.24	0.76	0.72	1.10
17	13	0.72	0.63	0.99	0.86	1.00	1.36
18	13	0.72	0.63	1.03	0.86	1.00	1.36
19	13	0.79	1.19	0.89	0.91	0.86	0.76
20	13	0.61	1.19	0.89	0.91	0.86	0.76
1	14	1.27	0.99	0.99	0.87	1.48	0.90
2	14	1.30	0.99	1.00	0.87	1.18	0.90
3	14	0.81	1.05	0.82	1.02	1.03	0.87
4	14	0.81	1.05	0.82	1.02	1.03	0.87
5	14	0.74	0.89	0.78	0.79	0.61	1.05
6	14	1.02	1.07	0.99	0.68	0.73	0.90
7	14	0.73	1.35	1.08	1.01	0.76	0.80
8	14	0.74	1.35	1.08	1.01	0.77	0.79
9	14	0.80	0.72	1.04	0.83	1.36	1.05
10	14	0.79	0.72	1.05	0.79	1.36	1.05
11	14	0.95	1.05	0.82	1.40	0.83	0.80
12	14	0.95	1.05	0.82	1.28	0.76	0.85
13	14	1.02	1.07	0.97	0.75	1.36	0.91
14	14	1.03	1.05	0.97	0.76	1.36	0.93

Subject	Variable	C1	C2	C3	N1	N2	N3
15	14	0.91	1.06	0.86	1.31	1.04	0.80
16	14	0.89	1.06	0.87	1.31	1.01	0.80
17	14	1.33	0.99	0.87	0.79	1.25	0.68
18	14	1.33	0.95	0.89	0.82	1.25	0.68
19	14	0.88	1.14	0.95	1.23	0.93	0.99
20	14	0.88	1.14	0.95	1.23	0.93	0.91
1	15	5.17	4.74	4.92	4.96	5.22	5.03
2	15	5.14	4.74	4.94	4.93	4.98	5.03
3	15	4.83	5.07	4.95	4.91	4.70	4.97
4	15	4.83	5.07	5.04	4.99	4.86	4.97
5	15	4.82	4.52	4.31	5.08	4.26	4.39
6	15	5.09	4.86	4.99	4.69	4.86	5.14
7	15	4.88	5.16	4.99	4.95	4.84	5.06
8	15	4.79	5.16	4.99	5.00	4.93	5.08
9	15	4.77	4.74	4.95	4.74	5.14	5.17
10	15	4.77	4.72	4.99	4.72	5.09	5.17
11	15	4.86	5.04	4.90	5.10	5.02	5.04
12	15	4.89	5.04	5.01	5.02	4.93	4.99
13	15	5.07	4.86	4.97	4.91	5.09	5.11
14	15	5.09	4.85	4.90	4.83	5.09	5.09
15	15	4.92	5.09	5.06	4.86	4.84	5.04
16	15	4.92	5.06	5.09	4.91	4.74	5.04
17	15	4.98	4.74	4.91	4.72	5.04	4.92
18	15	4.98	4.62	4.90	4.73	5.04	4.92
19	15	4.98	4.96	5.04	4.98	4.81	4.91
20	15	5.01	4.96	5.04	5.04	4.81	4.91
1	27	91.20	91.00	96.00	89.10	92.00	91.00

Subject	Variable	C1	C2	C3	N1	N2	N3
2	27	96.00	95.00	86.00	93.00	89.00	87.00
3	27	95.00	92.00	88.00	98.00	99.00	95.00
4	27	109.00	111.00	105.00	99.00	112.00	105.00
5	27	98.00	103.00	95.00	101.00	96.00	101.00
6	27	99.00	108.00	108.00	101.00	105.00	97.00
7	27	126.00	116.00	115.00	119.00	122.00	116.00
8	27	98.00	99.00	101.00	100.00	104.00	98.00
9	27	103.00	105.00	109.00	104.00	107.00	113.00
10	27	96.00	105.00	109.00	101.00	104.00	105.00
11	27	93.00	94.00	84.00	98.00	101.00	92.00
12	27	108.00	94.00	94.00	104.00	103.00	91.00
13	27	115.00	108.00	111.00	109.00	104.00	132.00
14	27	97.00	94.00	92.00	109.00	84.00	95.00
15	27	94.00	86.00	81.00	97.00	87.00	82.00
16	27	102.00	92.00	100.00	92.00	105.00	99.00
17	27	125.00	125.00	115.00	126.00	100.00	105.00
18	27	94.00	89.00	93.00	92.00	99.00	104.00
19	27	109.00	105.00	97.00	119.00	106.00	104.00
20	27	98.00	96.00	98.00	88.00	97.00	100.00
1	28	47.00					
2	28	12.00					
3	28	81.00					
4	28	66.00					
5	28	67.00					
6	28	59.00					
7	28	70.00					
8	28	9.00					

Subject	Variable	C1	C2	C3	N1	N2	N3
9	28	8.00					
10	28	36.00					
11	28	60.00					
12	28	82.00					
13	28	3.00					
14	28	23.00					
15	28	4.00					
16	28	5.00					
17	28	51.00					
18	28	26.00					
19	28	21.00					
20	28	98.00					
1	29	17.00					
2	29	13.00					
3	29	0.00					
4	29	22.00					
5	29	70.00					
6	29	17.00					
7	29	36.00					
8	29	21.00					
9	29	7.00					
10	29	30.00					
11	29	42.00					
12	29	32.00					
13	29	2.00					
14	29	20.00					
15	29	3.00					

Subject	Variable	C1	C2	C3	N1	N2	N3
16	29	3.00					
17	29	32.00					
18	29	22.00					
19	29	7.00					
20	29	19.00					
1	30	27.00					
2	30	81.00					
3	30	34.00					
4	30	32.00					
5	30	75.00					
6	30	53.00					
7	30	42.00					
8	30	7.00					
9	30	4.00					
10	30	27.00					
11	30	60.00					
12	30	48.00					
13	30	4.00					
14	30	18.00					
15	30	3.00					
16	30	3.00					
17	30	41.00					
18	30	22.00					
19	30	21.00					
20	30	47.00					
1	31	67.00					
2	31	54.00					

Subject	Variable	C1	C2	C3	N1	N2	N3
3	31	73.00					
4	31	67.00					
5	31	55.00					
6	31	26.00					
7	31	61.00					
8	31	5.00					
9	31	31.00					
10	31	80.00					
11	31	52.00					
12	31	53.00					
13	31	2.00					
14	31	56.00					
15	31	0.00					
16	31	7.00					
17	31	7.00					
18	31	76.00					
19	31	47.00					
20	31	36.00					
1	32	35.00					
2	32	52.00					
3	32	48.00					
4	32	69.00					
5	32	61.00					
6	32	42.00					
7	32	68.00					
8	32	36.00					
9	32	12.00					

Subject	Variable	C1	C2	C3	N1	N2	N3
10	32	30.00					
11	32	64.00					
12	32	54.00					
13	32	7.00					
14	32	42.00					
15	32	2.00					
16	32	11.00					
17	32	64.00					
18	32	60.00					
19	32	16.00					
20	32	76.00					
1	33	79.00					
2	33	77.00					
3	33	77.00					
4	33	64.00					
5	33	64.00					
6	33	20.00					
7	33	46.00					
8	33	0.00					
9	33	24.00					
10	33	59.00					
11	33	84.00					
12	33	98.00					
13	33	7.00					
14	33	14.00					
15	33	0.00					
16	33	2.00					

Subject	Variable	C1	C2	C3	N1	N2	N3
17	33	26.00					
18	33	62.00					
19	33	29.00					
20	33	77.00					
1	35	0.05			0.04		
2	35	0.05			0.04		
3	35	0.02			0.02		
4	35	0.03			0.04		
5	35	0.02			0.02		
6	35	0.03			0.04		
7	35	0.01			0.02		
8	35	0.02			0.04		
9	35	0.03			0.02		
10	35	0.03			0.02		
11	35	0.05			0.04		
12	35	0.03			0.03		
13	35	0.02			0.02		
14	35	0.03			0.03		
15	35	0.06			0.04		
16	35	na			na		
17	35	0.03			0.03		
18	35	0.04			0.04		
19	35	0.17			0.10		
20	35	0.05			0.05		
1	36	1.45			1.46		
2	36	0.72			2.29		
3	36	2.28			3.42		

Subject	Variable	C1	C2	C3	N1	N2	N3
4	36	13.06			4.41		
5	36	5.58			6.52		
6	36	8.11			11.08		
7	36	6.45			4.28		
8	36	8.31			1.48		
9	36	2.09			3.23		
10	36	6.90			7.40		
11	36	2.41			2.01		
12	36	14.40			7.17		
13	36	6.05			6.54		
14	36	3.76			6.36		
15	36	1.03			2.58		
16	36	na			na		
17	36	1.23			1.89		
18	36	6.53			7.17		
19	36	0.47			0.64		
20	36	3.46			4.73		

APPENDIX D. SOLDIER MARKSMANSHIP-TRAINING PROGRAM

Instead of emphasizing shooting accuracy as the first fundamental, the Canadian Forces (CF) marksmanship-training program stresses shooting precision (56). In literary terms, the words "precision" and "accuracy" are considered synonymous because they can be used interchangeably. The CF, however, have slightly different, yet important, interpretations of these two terms. Here, rifle precision is a measure of how close successive shots will hit to the same point as before. In other words it is a measure of the tightness of a group of shots and determines a soldier's ability to shoot with consistency and reproducibility. Rifle accuracy is mean distance of a group of shots from the center mass. This measures the proximity of a soldier's shots from the desired aiming point. A soldier may therefore be very precise but inaccurate by displaying a tight group of shots that are far from the given target's center of mass. Conversely, if a marksman fires two shots and hits the target 6 in to the left and 6 in to the right of its center of mass, the performance would be defined as accurate but imprecise. When soldiers become part of an infantry unit, as was the case with all subjects in the current study, they require more advanced rifle training. The emphasis then shifts from shooting precision to shooting accuracy because well-trained soldiers are expected to have mastered the process of precise shooting to the point where it becomes an automatic skill, thus allowing more focus and attention to be allocated to accurate shooting (56).

APENDIX E. SOLDIER DATA

Subject	Years of service	Rank	# of tours	Age	Teammate familiarity	Height (cm)	Weight (kg)
1	2.5	Private	1	21	0.33	182.88	74.1
2	2.5	Private	0	21	0.33	180.34	73
3	3	Private	1	23	0.25	180.34	105.5
4	1	Private	0	23	0.33	175.26	58.4
5	2	Private	1	24	0.75	177.8	100
6	2	Private	0	20	0.75	182.88	74.6
7	2.5	Private	0	21	0.5	180.34	80.45
8	4.5	Corporal	3	26	0.5	193.04	113.95
9	3.5	Private	0	21	1	185.42	84.1
10	6	Corporal	2	26	1	180.34	87.7
11	2	Private	0	22	2	172.72	75.6
12	2.5	Private	0	22	2	182.88	66.1
13	3.5	Private	1	21	0	175.26	74.8
14	2	Private	0	37	0	187.96	87.4
15	5	Corporal	2	24	3	182.88	81.4
16	6	Corporal	1	25	2	185.42	92.1
17	3.5	Private	1	24	0.5	180.34	74.2
18	2	Private	2	27	0.5	190.5	99.6
19	4	Private	1	26	1.5	180.34	90.8
20	6.5	Corporal	2	29	1.5	175.26	89.4
mean(u)	**3.3**		**0.9**	**24.2**	**0.9**	**181.6**	**84.2**
SD	**1.5**		**0.9**	**3.8**	**0.8**	**5.0**	**13.4**

APPENDIX F. NASA TASK LOAD INDEX

Task Load Index (TLX) – Please mark your response on the line.

MENTAL DEMAND
How much mental and perceptual activity (e.g., thinking, deciding, looking, searching) was required of you during the session today?

Low ______________________________ High
Mental Demand

PHYSICAL DEMAND
How much physical activity (e.g., lifting, pulling, walking, standing) was required of you during the session today?

Low ______________________________ High
Physical Demand

TEMPORAL DEMAND
How much pressure did you feel due to the rate at which things occurred during the session today? Was the pace slow and leisurely or rapid and frantic?

Low ______________________________ High
Temporal Demand

PERFORMANCE
How successful do you think your shooting was today? How would you rate your overall performance?

Good ______________________________ Poor
Performance

EFFORT
How hard did you have to work (e.g., mentally, physically) to achieve this level of performance today?

Low ______________________________ High
Effort

FRUSTRATION
How frustrated (e.g., discouraged, stressed, annoyed, etc.) as opposed to calm (e.g., gratified, relaxed, satisfied) did you feel during the session today?

Low ______________________________ High
Frustration