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Inescapable Aversive Stimulus Decreases Subsequent Escape Responding in Humans: An Investigation of the Learned Helplessness Effect in a 3D Virtual Environment

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INESCAPABLE AVERSIVE STIMULUS DECREASES SUBSEQUENT ESCAPE RESPONDING IN HUMANS:
AN INVESTIGATION OF THE LEARNED HELPLESSNESS EFFECT IN A 3D VIRTUAL ENVIRONMENT

by

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(Under the direction of Kent D. Bodily)

ABSTRACT

Exposure to an inescapable aversive stimulus decreases escape responses to subsequent escapable aversive stimuli. This is known as the learned helplessness effect. In the present experiment, human participants were trained in an immersive, 3D virtual environment analog of an operant chamber using an inescapable aversive stimulus, an escapable aversive stimulus, or no aversive stimulus. Then, all participants were tested using an immersive, 3D virtual environment analog of a shuttle box using an escapable aversive stimulus. Participants trained with an inescapable aversive stimulus were slower to escape during testing than participants trained with an escapable aversive stimulus. The current results demonstrate that the learned helplessness effect can be established in humans using 3D virtual environments and a mild aversive stimulus.

INDEX WORDS: learned helplessness, escape learning, virtual environment

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DEDICATION

I would like to dedicate this book to my friends, family, and everyone in the department who have been exposed to *MF Doom* over the past three years. Your support means the world to me, and I would not be where I am today without you.

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I would first like to thank Dr. Kent Bodily for his guidance and support over the past few years. I don’t think I could have asked for a better mentor. Thank you for all the advice and opportunities you have given me, but even more so for pushing me. You’ve always seen what I’m capable of and have never settled for anything less than my best. I would also like to thank Dr. Bradley Sturz. The research opportunities you have provided in your lab have led to not just to a few publication but more importantly to a crash course in spatial orientation. I only wish that we had gotten the chance to work together sooner. Last but certainly not least, I would like to thank Dr. Janice Steirn. Not only did I learn a tremendous amount in your classes, but you took a chance on me when I first wanted research experience. Without that, I may not be where I am today. Again, thank you all for everything. This book would not be a reality without each of you pushing me to better myself.

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CHAPTER 1

INTRODUCTION

Organisms exposed to an inescapable aversive stimulus are less likely to escape when subsequently presented with an escapable aversive stimulus. This effect is known as learned helplessness (for a review, see Maier & Seligman, 1976). Two theories about the mechanisms controlling this effect have been posited: learned helplessness theory (Maier & Seligman, 1976) and the two-process reinforcement theory of escape learning (Levis, 1976).

Purpose of the Study

Past research has attempted to elicit the learned helplessness effect using either specific behavioral instructions (Thornton & Jacobs, 1971) or intense aversive stimuli (Hiroto, 1974). Given that the learned helplessness effect has yet to be tested in humans without specific behavioral instructions or a mild aversive stimulus, it is necessary to further investigate if the learned helplessness effect can occur without such stimuli. The current research attempts to fill this research gap through the use of a non-traumatic aversive stimulus and without providing participants with instructions on how they should behave. The paper begins with an overview of the learned helplessness literature followed by a discussion of stimuli and the current study.

CHAPTER 2

REVIEW OF PAST LITERATURE ON LEARNED HELPLESSNESS

Learned Helplessness Effect in Non-Humans

To test whether exposure to inescapable aversive stimuli would affect subsequent escape responding, Overmier and Seligman (1967) first exposed a group of dogs to inescapable shock through pads attached to the dogs' hind feet. Another group was not exposed to inescapable shocks. Next, testing was conducted in a shuttle box, a chamber divided into two rooms by an adjustable barrier. A subject starts in one of the rooms and is prompted to move to the other side through the introduction of an aversive stimulus in the subject's side of the box. This move constitutes an escape response. Twenty-four hours after the initial shock treatment, dogs were given ten trials inside the shuttle box. Dogs that had previously received inescapable shocks were significantly slower to escape and had a greater number of failures to escape shock than the dogs that did not have prior exposure to the inescapable shocks. These results demonstrate that prior experience with inescapable shock reduces subsequent escape learning. The learned helplessness effect has been reproduced in other animals (e.g., cats: Seward & Humphrey, 1967; rats: Maier, Albin, & Testa, 1973; fish: Padilla, Padilla, Ketterer, & Giacolone, 1970).

Learned Helplessness Effect in Humans

Using three groups (Inescapable aversive stimulus during training, Escapable aversive stimulus during training, and No Training), Hiroto (1974) discovered that the learned helplessness effect is also found in human subjects. In this procedure, training consisted of pressing a button to turn off a loud noise. This onset and offset of the noise was independent of responses for the Inescapable group, but the offset was contingent upon responding for the Escapable group. During testing, all subjects participated in a hand shuttling task developed by Turner and Solomon (1962). This is similar to the shuttle box in that participants were required to move a knob from one side of box to the other with their hand to make a response. The Escapable and No Training groups responded steadily to escape the noise, but the Inescapable group did not. Instead, they allowed the noise to continue without responding. This result is consistent with those reported in the non-human literature (for a review, see Maier & Seligman, 1976).

Thornton and Jacobs (1971) tested whether humans, when exposed to a response-independent aversive stimulus, will show greater latencies when later given a reaction time task compared to participants who received an escapable aversive stimulus. A range of mild shocks was used as the aversive stimulus for this experiment. One group of participants (ERT; experimental reaction time) was given a reaction time task. A latency greater than .5 seconds resulted in a brief shock. Another group (YRT; yoked reaction time) completed the same task as the ERT group, however their shocks were dependent upon the behavior of a previously determined member of the ERT group (their yoked counterpart). The yoked group (Y) received inescapable shocks independent of their behavior throughout training and did not experience the reaction time task during the training portion of the experiment. A control reaction time (CRT) group completed the reaction time task without shock presentation. During testing, all participants were given the reaction time test. The results showed that the yoked participants (Groups YRT and Y) had greater response latencies than participants trained with avoidable shock.

Natural examples of learned helplessness have been found in humans. During World War II, guards at concentration camps told the prisoners, described as "walking corpses," that there was no hope for the future and that they could do nothing to change their environment (Seligman, Maier, & Greer, 1968, p. 258). Apparent loss of hope has also been observed in mental patients. When a hospital caught fire, some patients had to be forcibly removed from the building because they would have stayed and died rather than escape the fire (Seligman, et al., 1968). This failure to escape from something that should be considered harmful when given the opportunity is learned helplessness.

Learned Helplessness Theory

The central idea behind learned helplessness theory is that the aversive stimulus is uncontrollable. This means that the presence or absence of the aversive stimulus is not under the control of any behavior. Uncontrollability is most prominent when the probability of an outcome is equal in the presence and absence of behavior (Maier & Seligman, 1976). The effects of uncontrollability can be broken down into three parts: motivational deficits, cognitive deficits, and emotional deficits.

Decreased responding to an escapable aversive stimulus after exposure to an inescapable aversive stimulus is labeled as a decrease in motivation in the first stage of the learned helplessness theory (Maier & Seligman, 1976). After exposure to uncontrollable shocks, subjects not only fail to escape but also fail to avoid (prevent) shocks when given the opportunity. Thus, uncontrollability appears to undermine the motivation to perform preventative behavior in addition to inhibiting the production of escape behavior. This effect was demonstrated by Overmier and Seligman (1967). Dogs that were first exposed to inescapable shocks were less successful in escaping later escapable shocks than dogs that were not first exposed to inescapable shocks.

The uncontrollability of the aversive stimulus may lead to a failure in realizing that a response has been successful in terminating the aversive stimulus even if the response was successful (Maier & Seligman, 1976). This failure in one-trial learning is labeled as a cognitive deficit. The authors use the lack of one-trial learning as evidence that one correct response is not sufficient to produce learning for subjects who have experience with an inescapable aversive stimulus. This is especially striking when one considers that a single correct response is enough to bring about learning in experimentally naïve subjects. Uncontrollability predicts that, even after an escape response has been made, the subject will have a difficult time recognizing that the escape response was successful at removing the aversive stimulus and thus will not be likely to continue making escape responses. This effect has been empirically established by Seligman, Overmier, and Greer (1968). Dogs who had been previously exposed to inescapable shocks failed to show escape behaviors when later tested with escapable shocks inside of a shuttle box. In order to alleviate the effects of the uncontrollable aversive stimulus, the dogs were leashed and forced to make an escape response by being dragged from one end of the shuttle box to the other. This tactic was effective at reducing the learned helplessness effect though it took substantially more than one escape trial for the dogs to learn.

The final effect of uncontrollable aversive stimulation, emotional deficits, involves a fear response to the aversive stimulus. Maier and Seligman (1976) predict that, in the presence of an uncontrollable aversive stimulus, a fear response will continue until the subject learns that the aversive stimulus is either controllable or uncontrollable. Fear responses are manifested physiologically in many ways including weight loss, the production of stomach ulcers, increased defecation, and increased drinking. If the subject learns that they can control the aversive stimulus, then the fear is reduced leading to decreased general movement following an escape response. However, if the subject learns that they cannot control the aversive stimulus, then fear may be replaced by depression which leads to decreased responding.

Evaluation: Learned Helplessness Theory

Levis (1976) claims that the deficits produced by uncontrollability have alternate explanations. In regards to the motivational deficits put forth by Maier and Seligman (1976), it is argued that the lack of performing a given response in no way suggests a deficit in motivation. Instead, a lack of responding can be more parsimoniously explained by a lack of reinforcement for producing the response.

Learned helplessness theory predicts that once the subject learns that responses and outcomes are independent, the subject develops a cognitive expectancy that responses and outcomes will remain independent. According to Levis, the cognitive deficits described by Maier and Seligman (1976) may account for the results found with humans but not for non-humans due to the difference in cognitive ability among species. The learned helplessness effect has been shown in many species including *Paramecium aurelia* (Levis, 1976). This implies that a single-celled organism (along with a broad range of non-human species) has equal expectancy to humans. However, according to the learned helplessness theory, brain capacity and cognitive ability are not considered to be instrumental in determining whether or not a species will show the learned helplessness effect. The theory itself does not make different predictions about different species.

The emotional deficit component of the learned helplessness theory was challenged by Weiss et al. (1975; as cited in Levis, 1976). They argued that the emotional effects were produced through stress created by the inescapable shock. Weiss et al.'s (1975) definition of the stress effects (e.g. production of stomach ulcers, weight loss, fearfulness) were nearly identical to that of Maier and Seligman's emotional deficit effects. It is difficult to determine who is correct in their argument as both outcomes are the same and the only difference is whether the effect is due to stress produced by the simple presentation of inescapable shocks or the uncontrollability of the aversive stimulus. However, this author argues that the two ideas are not mutually exclusive as both arguments involve zero contingency between aversive stimulation and responding.

Levis (1976) argues against Maier and Seligman's (1976) learned helplessness theory. Levis (1976) states that the learned helplessness theory's motivational deficits can be more parsimoniously explained by reinforcement effects from the removal of the aversive stimulus following a successful escape response. He also argues that Maier and Seligman's (1976) cognitive deficits are meaningless without considering the differences in cognitive ability between species. However, Levis's (1976) argument appears to come from a lack of understanding about the causal variables behind learned helplessness theory. It is not the deficits that cause behavior. Rather, the deficits are merely a label placed on the outcomes of behavior. The causal variable driving learned helplessness theory is the uncontrollability of the aversive stimulus, and the deficits are the outcomes brought about by the aversive stimulus.

Two-Process Reinforcement Theory of Escape Learning

Aversive stimulation elicits two different responses: a reflexive movement away from the area affected by the aversive stimulus and an emotional reaction which takes the form of increased general movement (Levis, 1976). Drawing from the two-process learning theory put forth by Rescorla and Solomon (1967), Levis (1976) theorized that the removal of aversive stimulation is reinforced through two separate processes. First, when an escape response is made, the aversive stimulus is immediately removed which also immediately removes the pain associated with the stimulus. Second, the emotional reaction (fear) elicited by the aversive stimulus is gradually reduced. The first outcome, immediate removal of aversive stimulation, is considered to have the strongest trial-to-trial reinforcement effect. If the response necessary to escape the aversive stimulus is similar to the responses naturally evoked by the aversive stimulus (e.g. increased activity), then there is a high probability that the escape response will occur (Levis, 1976). Conversely, if the escape response is not similar to what is naturally produced by the aversive stimulus, then the probability of making the escape response lowers.

The escape response is immediately reinforced by pain reduction. The second reinforcement class, fear reduction, will strengthen the escape response only if the escape response is fixed throughout the experimental session (i.e. does not change from trial to trial). Reduction in fear can be evaluated by measuring the amount of activity following the removal of the aversive stimulus. If the escape response involves movement, then immobility following removal of the aversive stimulus is considered to be reinforced by fear reduction because the presence of a fear involves a general increase in movement. Therefore, a reduction in fear is shown through a reduction in movement.

For subjects who experience an inescapable aversive stimulus, the pain reduction gained from the removal of the aversive stimulus is still present. However, due to the independence of the aversive stimulus and behavior, the probability of a given response being systematically reinforced is low since different responses will likely be paired with the removal of the aversive stimulus. This means that the reinforcement of pain reduction will likely be distributed across a number of response types, especially if the duration of the aversive stimulus varies across trials. Additionally, because the presentation of the aversive stimulus elicits responses involving movement, its repeated presentation across trials may result in a systematic punishment of moving. As the number of trials increases, the probability that immobility will occur increases (Levis, 1976). Once the frequency of immobility increases in the presence of the aversive stimulus, immobility will come under the adventitious control of the removal of the aversive stimulus (pain reduction). If the two reinforcement processes (pain and fear reduction) produce similar responses (immobility), then the reinforcement received from the two processes should add to each other. This is expected to occur only when movement is paired with both the onset and removal of the aversive stimulus. When subjects exposed to these contingencies are then given a task which includes an escapable aversive stimulus, they will have a greater tendency to remain motionless in the presence of the escapable aversive stimulus. Consequently, they will have a high probability of failing to escape, thus producing the learned helplessness effect.

Evaluation: Two-Process Reinforcement Theory of Escape Learning

The primary issue with this theory is that it was developed using shock as the aversive stimulus. The practice of using shock as an aversive stimulus is less common with human subjects than non-human subjects. However, the theory can still be applied to experiments that do not use shock as other aversive stimuli still provide punishment to the subject.

Levis (1976) acknowledges that it is possible that fear reduction may actually increase activity rather than decrease it which may lead to a removal of the second process of reinforcement for immobility rather than adding to it. This can be looked at as a fatal flaw in the theory, but fear reduction is not seen as the strongest mechanism through which trial-to-trial reinforcement is received. Pain reduction caused by the removal of the aversive stimulus due to an escape response is still present and can provide reinforcement for immobility regardless of the type of response shown after the removal of the aversive stimulus.

Comparison: Learned Helplessness Theory and Two-Process Reinforcement Theory of Escape Learning

At first glance, these two theories can be viewed as competing. However, this seems largely due to Levis's (1976) distorted view of learned helplessness theory. Upon closer inspection, the theories are not mutually exclusive. The two-process reinforcement theory of escape learning merely provides a more detailed view of the motivational and emotional deficit effects described by Maier and Seligman (1976).

The first reinforcement process, pain reduction, is analogous to the motivational deficits described by learned helplessness theory. Levis (1976) predicts that a failure to make escape responses after being exposed to an inescapable aversive stimulus is due to a punishment of movement. This is most likely to occur when the aversive stimulus is uncontrollable. Levis argues that a simple stimulus-response explanation is a more parsimonious explanation than a deficit in motivation. If motivational deficits are described as causing the lack of escape responses seen in subjects who are exposed to an inescapable aversive stimulus, then this argument makes sense as the concept of motivation is not directly observable. However, a deficit in motivation is merely the label applied to the behavior caused by the uncontrollable aversive stimulus. Therefore, it is the zero-contingency aversive stimulus which causes both immobility and motivational deficits, and the effect, decreased escape responding, is the same. Reinforcing immobility by punishing movement is potentially the causal link between the uncontrollable aversive stimulus and motivational deficits.

The second reinforcement process, fear reduction, is similar to the emotional deficits described by learned helplessness theory. The outcomes associated with fear reduction include immobility following the offset of the aversive stimulus. Levis (1976) notes that fear reduction can also increase movement following the offset of the aversive stimulus. This is actually explained by the emotional deficits of the learned helplessness theory which are caused by the aversive stimulus. Movement is predicted to increase if the aversive stimulus is controllable. Conversely, if the aversive stimulus is uncontrollable, then movement should decrease which is also predicted to occur through pain reduction by the two-process reinforcement theory.

In summary, these two theories do not appear to be in competition with one another. The two-process reinforcement theory of escape learning simply provides a more detailed view of the effects of the uncontrollable aversive stimulus described by learned helplessness theory. Differing uses of terminology has separated these theories, but both theories predict that, in the presence of a zero-contingency aversive stimulus, escape responding should decrease.

Aversive Stimulus

As seen in the experiments described above, shock is the aversive stimulus used throughout the majority of past learned helplessness experiments. Traumatic shock has been used to bring about escape/avoidance behavior from human subjects (Turner & Solomon, 1962; for a review, see Higgins & Morris, 1984). However, the use of traumatic shock brings the possibility of harming the subjects, so an alternative aversive stimulus should be investigated.

Azrin (1958) used white noise ranging from 95-110 decibels (dB) for 15-90 minutes, depending on the participant's escape/avoidance behavior, which shows that, even though the noise was quite intense, stimuli other than shock can be used as the aversive stimulus for escape/avoidance behavior. In his demonstration of learned helplessness in human subjects, Hiroto (1974) used a tone set to 90 decibels as the aversive stimulus. The tone was very effective at producing escape responses for all of the subjects except those previously exposed to an inescapable tone. This method was further developed by Hiroto and Seligman (1975) who used the tone to bring about learned helplessness effects in humans using different tasks (instrumental and cognitive). These experiments show that loud noise is an effective alternative to shock.

Instruction

One issue with previous experiments using escape/avoidance procedures with human subjects is that of instruction. Prior escape/avoidance research has instructed participants about the contingencies surrounding the unconditioned aversive stimulus delivery (e.g. Yoked groups were told that "they would receive inescapable shocks unrelated to their task", Thornton & Jacobs, 1971, p. 369) and also how to respond in order for the researchers to obtain the results for which they are looking (e.g. "You are going to be a figure in a box…If you are on the wrong side or go to the wrong side at certain times you will be punished by a buzzer coming on. Your task is to try to reduce or prevent the punishment as much as possible.", Freedman, 1991, p. 207). This relates back to the uncontrollability of the aversive stimulus governing learning. If instructions provide a subject with information about the aversive stimulus that would otherwise not be available, then participants may extrapolate a context in which the aversive stimulus is more or less likely to occur, effectively giving them more verbal control rather than control by experimental contingencies.

Through increased controllability due to instruction, responding itself may come under the control of instructions rather than the experimental manipulation. For example, verbal instruction can affect responding for different subjects even when all subjects are reinforced on the same schedule. Kaufman, Baron, and Kopp (1966) gave three different sets of instructions: reinforcement will occur once every minute, reinforcement is contingent upon the number of responses, or reinforcement will occur, on average, once every minute. Subjects who were told that reinforcement will occur once every minute made very few responses. Those who were told that reinforcement is contingent upon responding made a very high number of responses. Finally, subjects who were correctly informed that reinforcement would occur, on average, once every minute, made a moderate amount of responses. If instructions such as these are given, there is no way of determining whether a participant's responses are due to the instructions or the experimental manipulations, which threatens internal validity. Therefore, the only way to ensure that instructions do not influence responding is to give no instructions at all about the task.

Previous research has shown that humans can successfully acquire an escape/avoidance response without the use of instruction within a 3D virtual environment shuttle box (Kilday et al., 2012) and a 3D virtual environment operant chamber (Kilday & Bodily, 2013). Half of the participants were given instructions about a distractor task ("Your task is to earn as many points as you can. You earn 1 point for each invisible orb that you collect. The invisible orbs may be located in front, behind, or to either side of you."). The other half received no instructions ("Complete the task to the best of your ability"). Participants who did not receive instructions were able to learn the escape/avoidance response and maintain a higher level of escape and avoidance than those who were instructed about the distractor task. Participants who did not receive instructions also stayed near the response location (e.g., the door in the shuttle box or the response buttons in the operant chamber) significantly more than participants who received instructions about the distractor task. Taken together, these results indicate that the behavior of the participants who were instructed about the distractor task came under the control of the verbal rules rather than the experimental rules.

Signaled v. Unsignaled

Signaled escape/avoidance paradigms offer more information about the contingencies surrounding the aversive stimulus than unsignaled paradigms (Badia, Culbertson, & Harsh, 1974; for a review, see Higgins & Morris, 1984). Under a signaled paradigm, another stimulus (e.g., a light or tone) is presented before the aversive stimulus. Over trials, the subjects learn to avoid the aversive stimulus by responding when the signal is presented. Responding in the absence of the signal decreases but remains at a high, steady rate in the presence of the signal (Matthews & Shimoff, 1974; Sidman, 1955). However, in an unsignaled paradigm, responding is maintained at a high, steady rate throughout an experimental session (Sidman, 1953a). Therefore, in order to ensure that responding remains at a high, steady rate throughout the experimental session and not just in the presence of a signal, an unsignaled paradigm should be used.

Current Experiment

Past research has tested learned helplessness in a variety of species (dogs: Overmier & Seligman, 1967; Seligman & Maier, 1967; rats: Maier, Albin, & Testa, 1973; cats: Seward & Humphrey, 1967). After being exposed to an inescapable aversive stimulus, these non-human subjects failed to respond to escapable aversive stimuli. Though Thornton and Jacobs (1971) believed they had reproduced the learned helplessness effect with human subjects, their internal validity was compromised by the use of instructions, casting doubt on the accuracy of their conclusions. Hiroto (1974) effectively used an aversive tone to show learned helplessness through a hand shuttling procedure, demonstrating that the effects can be reproduced with human subjects. However, there has yet to be an experiment that directly replicates the immersive environments in which the non-human subjects were trained and tested.

The current experiment attempts to fill this research gap. A previously-validated (Kilday et al., 2012; Kilday & Bodily, 2013) complex, multi-frequency tone was used as the aversive stimulus in this experiment. Because instructions can affect internal validity, participants in this experiment were only told to complete the task to the best of their ability. Without detailed instructions, responding will more likely be controlled by the experimental manipulations. To provide participants the best chance of producing and maintaining a high, steady rate of avoidance responding an unsignaled escape schedule will be used.

To test the learned helplessness effect, participants completed two experimental sessions (training and testing) in two immersive, 3D virtual environments (free-operant chamber and shuttle box). Static 2D images have been used to examine escape/avoidance learning inside of a shuttle box (e.g., Freedman, 1991). However, to this author's knowledge, the current experiment is the first to test the learned helplessness effect inside of an immersive 3D virtual environment. The argument can be made that this sort of environment is not analogous to real-world environments. If this argument were of substance, then the external validity of any results found in the current experiment could be called into question. However, using a 3D virtual environment analog of the pigeon foraging task (see Blaisdell & Cook, 2005), Sturz, Bodily, and Katz (2006) found that the spatial search mechanisms used by human participants in a 3D virtual environment task were analogous to the search mechanisms used in the real world. A follow-up study used an identical real-world search task and found similar results (Sturz, Bodily, Katz, & Kelly, 2009). These results indicate that the immersive 3D virtual environment used in the current experiment is indeed analogous to real-world environments, and, thus, should have little to no effect on external validity.

Participants were first trained in a virtual free-operant chamber (see Figure 1). Participants were be randomly assigned to one of three groups: Inescapable aversive stimulus (Group I), escapable aversive stimulus (Group E), or no aversive stimulus (naïve; Group N). Group I received the aversive stimulus independently of responses. Group E was able to remove the aversive stimulus by making the appropriate escape response. Group N completed the same amount of time in the virtual operant chamber as the other groups with no aversive stimulus.

Following training, participants were tested in a virtual shuttle box (see Figure 2). All groups were able to escape the aversive stimulus by making the correct escape response of crossing over from one side of the shuttle box to the other. Table 1 provides a summary of training and testing conditions and predicted results for each group.

I hypothesize that participants who are first exposed to an inescapable aversive tone will respond significantly less when later tested with an escapable tone compared to participants who are initially exposed to an escapable tone. Participants that receive no aversive stimulus during training should respond a moderate amount during later exposure to the escapable aversive stimulus compared to the other two groups.

Table 1

Group Summaries and Testing Predictions

Group	Training	Testing	Prediction
Inescapable	Inescapable	Escapable	No Escape
Escapable	Escapable	Escapable	High Escape
Naïve	No Aversive Stimulus	Escapable	Low Escape

Table 1. Group summaries and testing predictions.

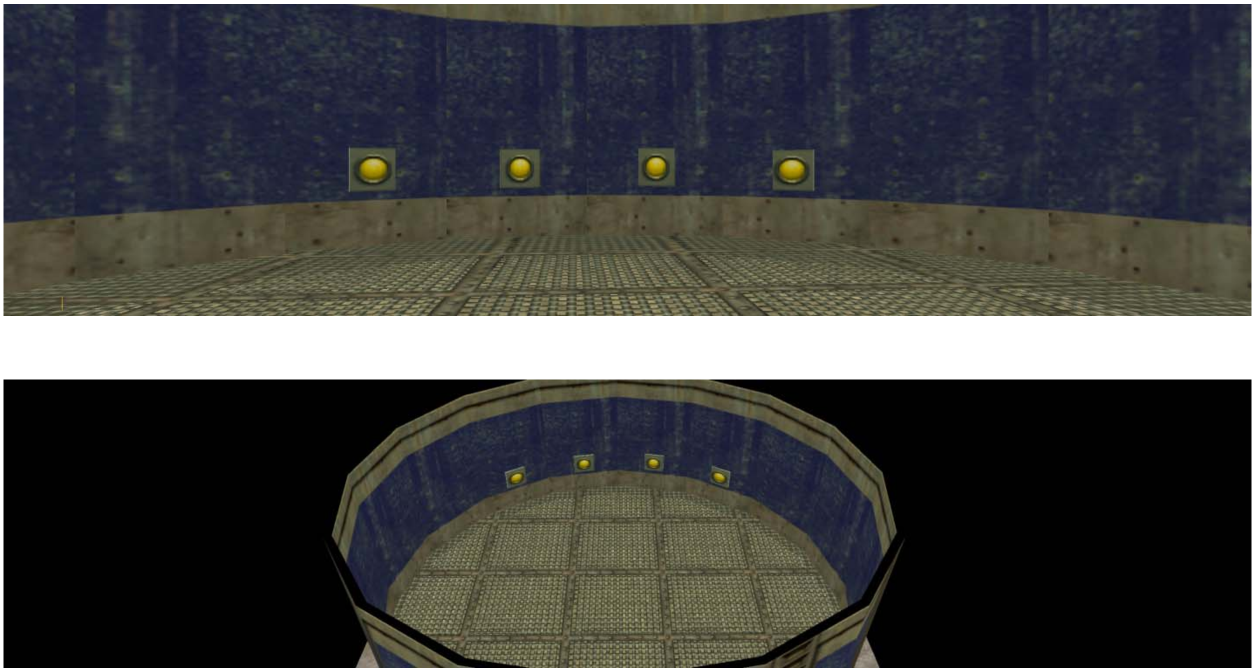

Figure 1. The top panel shows participant's view while facing the buttons in the operant from the start location. The bottom panel shows an overhead view of the training environment.

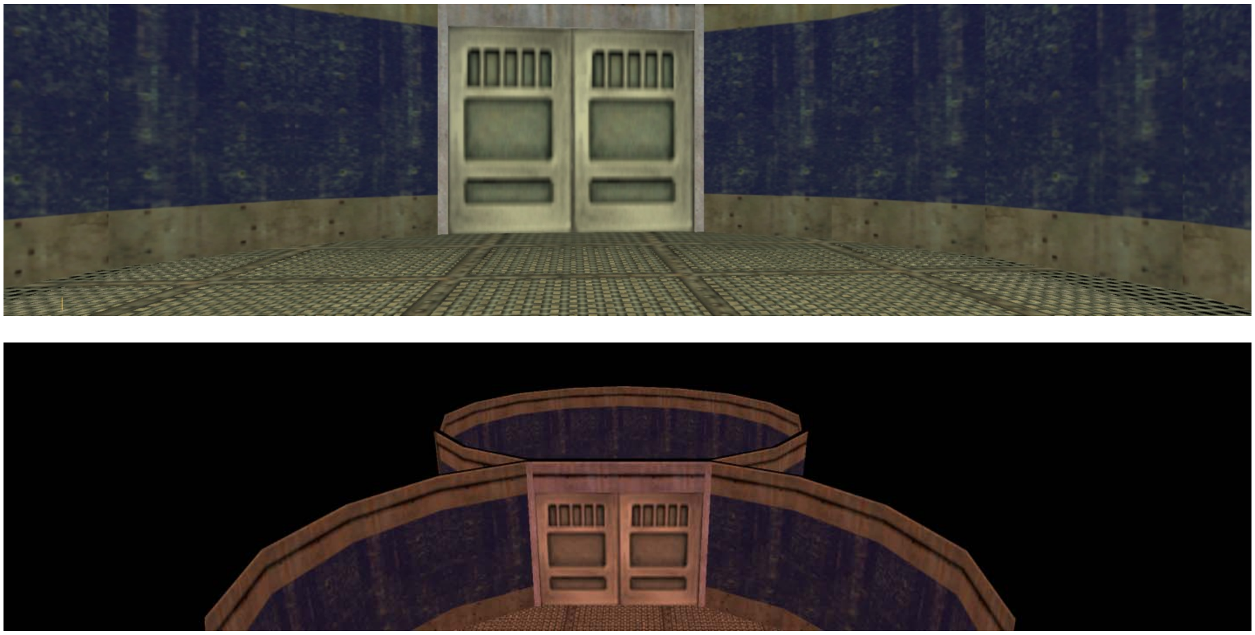

Figure 2. Then top panel shows participant’s view facing the door in the shuttle box from the start location. The bottom panel shows an overhead view of the testing environment.

CHAPTER 3

METHOD

Participants

Twenty-four male and thirty female undergraduates (8 males and 10 females per group) participated in this study. The participants were recruited from Psychology courses and were awarded with either class credit or extra credit for their participation.

Apparatus

The interactive 3D virtual environments were developed using Valve Hammer Editor and run on the Half-Life Team Fortress Classic platform. A personal computer with a triple display flat screen monitor (2400 x 600 pixels, with a projected field of view of 115°) and speakers served as the interface for the virtual environment. Participants experienced the virtual environment in first person perspective and used a Logitech Dual Action gamepad to navigate and make a selection in the virtual environment. The left joystick allowed for navigation (forward, backward, left, and right). No other buttons on the controller were functional. Data were collected and recorded with Half-Life Dedicated Server on an identical personal computer in the experimental room.

Stimuli

Two virtual environments were used for this experiment. The first was a 16-sided shuttle box (SB), which is made up of two rooms, each 608 x 608 x 240 virtual units (vu), divided by a door (see Figure 1). The second was an operant chamber (OC) identical in size to one of the rooms in the shuttle box (608 x 608 x 240 vu) with multiple response locations available (see Figure 2). Each virtual unit is roughly equal to 2.54 cm.

The aversive stimulus was a complex tone containing a variety of sounds at different frequencies layered into one sound clip set to 75 decibels. Duration of exposure must be considered when using intense noise. In order to protect participants, the noise levels used in this experiment were safe for up to 8 hours of continuous exposure per day (Occupational Safety & Health Administration, 2008).

Procedure

There were two phases of the experiment: training and testing. Each phase lasted for approximately 13 and a half minutes. A triadic group design (Maier & Seligman, 1976) including Inescapable (Group I), Escapable (Group E), and Naïve (Group N) groups was employed. Groups differed only in their response contingencies and exposure to the aversive stimulus during training. Group I experienced an inescapable aversive stimulus. Group E experienced an escapable aversive stimulus. Group N was not exposed to the aversive stimulus at all during training. Testing for all groups contained an escapable aversive stimulus (see Table 1 for summary).

Training. Training took place in the virtual free-operant chamber and lasted for approximately 13 and one half minutes. Participants began in the center of the room facing four response locations (see Figure 1). For Group I, the alarm was presented and removed according to a randomized schedule and was independent of responding. The total duration of alarm exposure for Group I was equal to half of the experimental session. In order to control the predictability of the alarm and, consequently, superstitious behavior (i.e., behavior surreptitiously reinforced through a coincidental pairing with the offset of the aversive stimulus), both the alarm (US) duration and inter-trial interval (ITI) varied from 10-20 seconds in increments of 5 seconds with a mean of 15 seconds (15 ± 5 seconds). The variable ITI and US times created 9 trial types randomly assigned without replacement into three blocks to create a total of 27 trials. Responses to the buttons made by the Group I did not result in a change in the environment. For Group E, four response locations (1 correct and 3 incorrect – counterbalanced across participants) were available. A response to the correct button in the presence of the alarm turned off the alarm and reset the alarm timer. For Group N, the response buttons were visibly available, but responses to the buttons did not bring about a change in the environment. Group N remained in the operant chamber for an equal amount of time as the other groups, but did not experience the alarm.

Testing. Once the training phase of the experiment was complete, participants immediately moved into the testing phase which was conducted in the virtual shuttle box. Testing lasted for 13 and one half minutes. Participants began in the back of the room facing a locked door (see Figure 2). The locked door served as the response location with participants needing to walk through the door into the other side of the shuttle box in order to make a response. In order to reduce the predictability of the alarm and, consequently, superstitious behavior, both the alarm duration and inter-trial interval (ITI) varied from 10-20 seconds in increments of 5 seconds with a mean of 15 seconds (15 ± 5 seconds). The variable ITI and US times created 9 trial types randomly assigned without replacement into three blocks to create a total of 27 trials. For all groups (I, E, and N), the duration of the alarm was partially dependent upon responding. If a crossover response was made in the presence of the alarm, the alarm was removed and duration of the alarm timer ran to completion without the alarm. However, if a response was not made, the alarm was not removed until the duration timer expired. During the time in which the aversive stimulus was absent, the door leading to the other half of the environment was locked. If a participant moved towards the door, it would remain closed unless the aversive stimulus was present. Once a crossover was made, the door closed behind the participant and remained locked until the next presentation of the aversive stimulus. If a participant opened the door without making a crossover (e.g., opening the door but not moving into the other half of the shuttle box), the door remained open for the duration of the aversive stimulus and then closed and locked at the offset of the aversive stimulus.

CHAPTER 4

RESULTS

Training

Three separate measures were used to determine the amount of learning during training: number of responses per minute, proportion of responses to the correct button, and proportion of time spent near the response locations.

Number of responses per minute. The number of responses per minute for each group was analyzed using a 3 (Escapable, Inescapable, Naive) x 13 (minutes 1-13) repeated measures analysis of variance (ANOVA). The analysis revealed a main effect of minute, $F(2, 53) = 2.37$, $p < .005$. No other main effects or interactions were significant. A trend analysis revealed a linear trend of minute approaching significance, $F(2, 53) = 4.00$, $p = .051$ (see Figure 3). Pairwise comparisons showed a significant difference between Minute 1 and Minute 2, $p < .01$. A spike in responding occurred in Minute 6 followed by a general decrease in responding throughout the remainder of the training session. Planned comparisons were performed on the number of responses per minute for each group. For Groups E and N, there was no effect of minute, $Fs(1, 17) < 1.66$, $ps > .05$. For Group I, there was a significant effect of minute, $F(1, 17) = 1.80$, $p < .05$. These planned comparisons revealed that the main effect of minute in the omnibus ANOVA test may have been due to the increased variation in response per minute from Group I compared to Groups E and N (see Figure 4).

Proportion of responses to the correct button. The second analysis focused on how well the groups learned to escape from the aversive stimulus. A one-way ANOVA revealed a significant effect of group, $F(2, 53) = 7.50$, $p < .001$. Pairwise comparisons showed that this significant difference was due to the difference between Group E and Groups I ($p = .003$) and N ($p = .001$). This measure indicates that Group E responded more to the correct button than Groups I and N did to their yoked "correct" button. Because only one of the four available buttons removed the alarm for Group E, the proportion of responses to the correct button was compared to chance (.25). This analysis revealed that Group E allocated their responses to the correct button significantly greater than chance ($M = .39$, $SEM = .04$), $t(17) = 3.50$, $p < .005$ (see Figure 5). The above-chance performance of Group E provides strong evidence of the learning of the escape response during training. Participants from Groups I and N were yoked to a participant from Group E to determine which would be the "correct" button for them even though button responses produced no outcomes. For example, the first participant in Group E was randomly assigned to Button 1. The first participants from Groups I and N would have Button 1 assigned as the "correct" button. This was done to control for potential biases in button placement. Both Groups I ($M = .25$, $SEM = .01$) and N ($M = .27$, $SEM = .02$) were not different from chance in their responding to the yoked "correct" button, $ts(17) < .79$, $ps > .05$, showing that there were no biases in the placement of the buttons as both Groups I and N responses at chance levels to the yoked "correct" button (see Figure 5).

To further analyze the proportion of correct responding, a 3 (Escapable, Inescapable, Naïve) x 13 (Minutes 1-13) repeated-measures ANOVA on the proportion of responses per minute to the correct button was performed. Again, participants in Groups I and N were yoked to participants from Group E using the same method described above. The analysis revealed main effects of both Group, $F(2, 53) = 13.04$, $p < .001$, and Minute, $F(2,53) = 3.35$, $p < .001$. The main effects were qualified by a significant Group x Minute interaction, $F(2, 53) = 3.16$, $p < .001$. The interaction was caused by two factors. First, participants responding significantly more in the latter minutes of training than they did in the first few minutes (see Table 2). Second, Group E had a higher proportion of correct responding than Groups I and N (see Figure 6). This result is important because it shows that Group E learned to respond at the higher proportion to the button which turned off the alarm while Group I and Group N responded equally to all buttons because none brought about a change in the environment.

Proportion of time spent near response locations. As a final measure of learning, the proportion of time spent near the response locations was measured. The environment measured from -275 to 275 on the x-axis. The environment was divided into eleven 25-point sections (e.g., -275 to -251, -250 to -226, etc.), and the proportion of time spent in each section was recorded. “Nearness” was defined as the half of the environment closest to the buttons but not including the middle section of the environment. Nearness was obtained by adding the proportions of time spent in the sections closest to the response locations.

A 3 (Escapable, Inescapable, Naïve) x 3 (Block 1, Block 2, Block 3) repeated-measures ANOVA was used to examine the proportion of time spent near the response locations across three 9-trial blocks. The trial blocks were created in order to examine any differences in proportion of time spent near the response locations at the beginning, middle, and end of training. The analysis revealed a significant main effect of block, *F*(2,

53) = 3.26, $p < .05$. The analysis also showed a significant linear trend of block, $F(2, 53) = 5.64$, $p < .05$. Pairwise comparisons show that the main effect of block was due to a difference between Block 1 and Block 3 ($p = .02$) and a difference between Block 2 and Block 3 ($p = .05$). No other main effects or interactions were significant. This analysis showed that Group E spent an increasing amount of time near the response locations across training blocks. This increase was likely due to the learning that only the response locations brought about a change in the environment (i.e., turning off the alarm). Groups I and N, however, decreased in their amount of time spent near the response locations throughout training. This decrease could have been due to the learning that responses brought about no change in the environment, so the participants in these groups spent more time away from the response locations possibly attempting to find some other response (see Figure 7).

Planned comparisons were conducted on the proportion of time spent near the response locations to determine if participants stayed near the response locations at a greater proportion than would be predicted by chance. Chance was obtained by dividing a perfect proportion (1.00) by the number of sections in the environment (11) and adding together the proportions defined by "nearness". One-sample *t*-tests were used to compare the proportion of time spent near the response locations to chance (.45). Results revealed that Group E ($M = .69$, $SEM = .04$) and Group I ($M = .63$, $SEM = .05$) spent significantly more time near the response locations than would be predicted by chance, $ts(17) > 3.89$, $ps < .001$ (see Figure 8). Group N ($M = .52$, $SEM = .06$) was not different from chance, $t(17) = 1.28$, $p > .05$.

Testing

Three separate measures were used to assess the occurrence of the learned helplessness effect during testing: escape latency, number of trials to escape criterion following the first escape, and proportion of time spent near the escape location.

Escape latency. The primary analysis for the testing portion of the experiment was the escape latency for each trial. Due to Group I's previous exposure to an inescapable aversive stimulus, it is expected that they would have higher escape latencies than both Groups E and N. Similarly, due to Group N's lack of exposure to any aversive stimulus during training, they were expected to have higher escape latencies than Group E. A 3 (Escapable, Inescapable, Naïve) x 27 (Trials 1-27) repeated-measures ANOVA was used to analyze the data. The analysis revealed a significant main effect of trial, $F(2, 53) = 5.72$, $p < .001$. This result was verified by a significant linear trend of trial, $F(2, 53) = 4.06$, $p < .05$, which was due to an overall drop in escape latencies throughout testing (see Figure 9).

The differences in escape latencies between groups appeared to cease after the first third of testing as evidenced by a lack of significant differences between Trial 9 and the majority of subsequent testing trials, *p*s > .05 (see Figure 10), so to further analyze the differences between groups, the testing session was broken down into three blocks of 9 trials each with an equal amount of aversive stimulus activations and duration (assuming no responses) in each block. A 3 (Escapable, Inescapable, Naive) x 3 (Block 1, Block 2, Block 3) factorial ANOVA was used to analyze the data. The analysis revealed a significant Group x Block interaction, $F(2, 53) = 2.77$, $p < .05$. No significant main effects were observed, *p*s > .05. Post-hoc one-way ANOVAs on each Block with Group as a factor were conducted to further investigate the significant interaction. In Block 1, there was a difference between the groups, $F(1, 53) = 3.70$, $p < .05$ (see Figure 11). This difference was due to Group I (*M* = 64.42, *SEM* = 7.76) exhibiting greater escape latencies than Group E (*M* = 34.17, *SEM* = 7.97), $t(35) = -2.68$, $p < .05$. There was no difference in escape latency between Group I and Group N (*M* = 49.28, *SEM* = 7.97). By Block 2, the differences between these groups was diminished, $F(1, 53) = .43$, $p > .05$. The similarity between groups continued through Block 3, $F(1, 53) = .17$, $p > .05$. This result was verified by a linear trend of Block for Group I, $F(1, 17) = 6.28$, $p < .05$, showing that Group I progressively spent less time in the presence of the aversive stimulus throughout the experiment.

Finally, planned comparisons were performed to examine the differences in mean escape latency for each group across blocks. Three separate 1 (Group: Escapable, Inescapable, or Naïve) x 3 (Blocks 1-3) repeated-measures ANOVAs were used to analyze the data. For Group E, there was no effect of Block, $F(1, 17) = .99$, $p > .05$, meaning that Group E did not differ in their mean escape latencies across blocks. For Group I, there was an effect of Block, $F(1, 17) = 3.42$, $p < .05$. Pairwise comparisons revealed that this effect of block for Group I was caused by a significant difference between the mean escape latency of Block 1 (*M* = 64.42, *SEM* = 9.4) and Block 3 (*M* = 41.37, *SEM* = 6.45), $p < .05$, meaning that Group I learned to escape faster during Block 3 than in Block 1. For Group N, there was no effect of Block, $F(1, 17) = .81$, $p > .05$, meaning that Group N did not differ in their escape latencies across blocks. Taken together, these results indicate that the only group to improve their performance during testing was Group I who significantly lowered their mean escape latencies from Block 1 to Block 3 (see Figure 11).

Trials to escape criterion. The differences in escape latencies between groups appeared to cease after the first third of testing as evidenced by a lack of significant differences between Trial 9 and the majority of subsequent testing trials, ps > .05 (see Figure 10), so to further analyze the differences between groups, the testing session was divided into three blocks of 9 trials each with an equal amount of aversive stimulus activations and duration (assuming no responses) in each block. A 3 (Escapable, Inescapable, Naive) x 3 (Block 1, Block 2, Block 3) factorial ANOVA was used to analyze the data. The analysis revealed a significant Group x Block interaction, $F(2, 53) = 2.77$, $p < .05$. No significant main effects were observed, ps > .05. Post-hoc one-way ANOVAs on each Block with Group as a factor were conducted to further investigate the significant interaction. In Block 1, there was a difference between the groups, $F(1, 53) = 3.70$, $p < .05$ (see Figure 11). This difference was due to Group I ($M = 64.42$, $SEM = 7.76$) exhibiting greater escape latencies than Group E ($M = 34.17$, $SEM = 7.97$), $t(35) = -2.68$, $p < .05$. There was no difference in escape latency between Group I and Group N ($M = 49.28$, $SEM = 7.97$). By Block 2, the differences between these groups ceased, $F(1, 53) = .43$, $p > .05$. The similarity between groups continued through Block 3, $F(1, 53) = .17$, $p > .05$. This result was verified by a linear trend of Block for Group I, $F(1, 17) = 6.28$, $p < .05$, showing that Group I progressively spent less time in the presence of the aversive stimulus throughout the experiment. This reduction in time spent in the presence of the aversive stimulus throughout the experiment lead to the cessation of group differences by the second 9-trial block meaning that Group I learned the escape response sometime during the first block and was as successful at escaping as Groups E and N during the second and third blocks.

An additional analysis was performed to investigate Maier and Seligman's (1976) cognitive deficits, specifically the failure of one-trial learning for participants previously exposed to an inescapable aversive stimulus. This was done by setting a criterion for learning. The criterion was set at three successful escape attempts in a row following the first escape, and the number of trials it took to reach that criterion recorded and analyzed using a one-way ANOVA. The results revealed that there were no significant differences between Group E (*M* = 4.67, *SEM* = 1.36), Group I (*M* = 6.11, *SEM* = 1.59), and Group N (*M* = 6.00, *SEM* = 1.81) in the number of trials to reach criterion, $F(2, 53) = .78$, $p > .05$. This lack of group differences provides evidence for one-trial learning as the groups did not differ in the number of trials to reach the escape criterion following the first successful escape.

Proportion of time spent near response location. As a final measure of learning, the proportion of time spent near the response location was measured. The environment measured from -575 to 575 on the x-axis. The environment was divided into twenty-three 25-point sections (e.g., -575 to -551, -550 to -526, etc.), and the proportion of time spent in each section was recorded. "Nearness" was defined as the half of the environment closest to the buttons but not including the middle section of the environment. Nearness was obtained by adding the proportions of time spent in the sections closest to the response locations.

A 3 (Escapable, Inescapable, Naïve) x 3 (Block 1, Block 2, Block 3) repeated-measures ANOVA was used to examine the proportion of time spent near the response locations across three 9-trial blocks. The trial blocks were created in order to examine any differences in proportion of time spent near the response locations at the beginning, middle, and end of testing. The analysis did not reveal any significant effects, Fs(2, 53) < 1.32, ps > .05 (see Figure 12).

One-sample t-tests were used to compare the proportion of time spent near the response locations to chance (.48). Chance was obtained by dividing a perfect proportion (1.00) by the number of sections in the environment (23) and adding together the proportions defined by "nearness". Similarly to the operant chamber in training, "nearness" was defined as the half of each room closest to the door in each room of the shuttle box but not including the middle section. One-sample t-tests were used to analyze the data. Only Group N (M = .60, SEM = .04) stayed near the response locations significantly more than would be expected by chance, $t(17) = 2.68$, $p < .05$. Group E (M = .57, SEM = .06) and Group I (M = .49, SEM = .06) were not different from chance, ts(17) < 1.34, ps > .05 (see Figure 13).

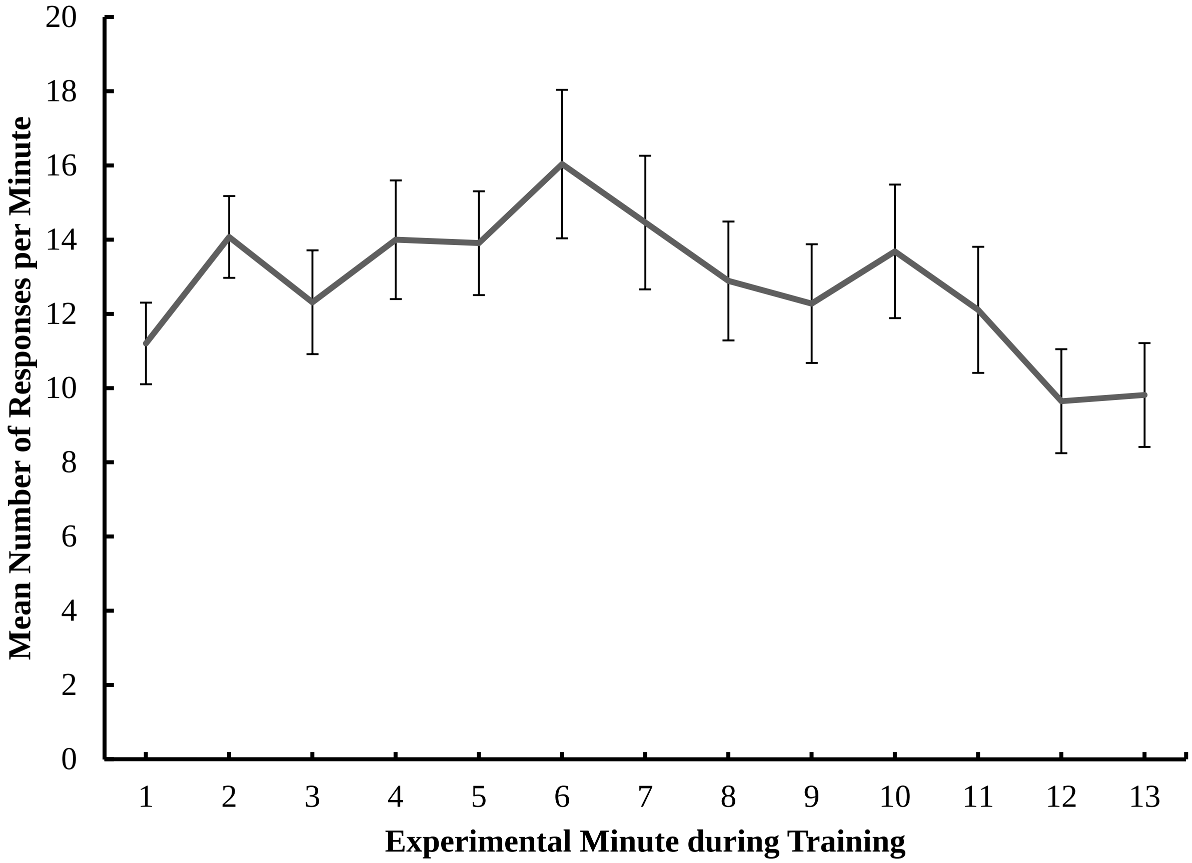

Figure 3. The mean number of responses per minute in training across all groups. Error bars represent standard error of the mean.

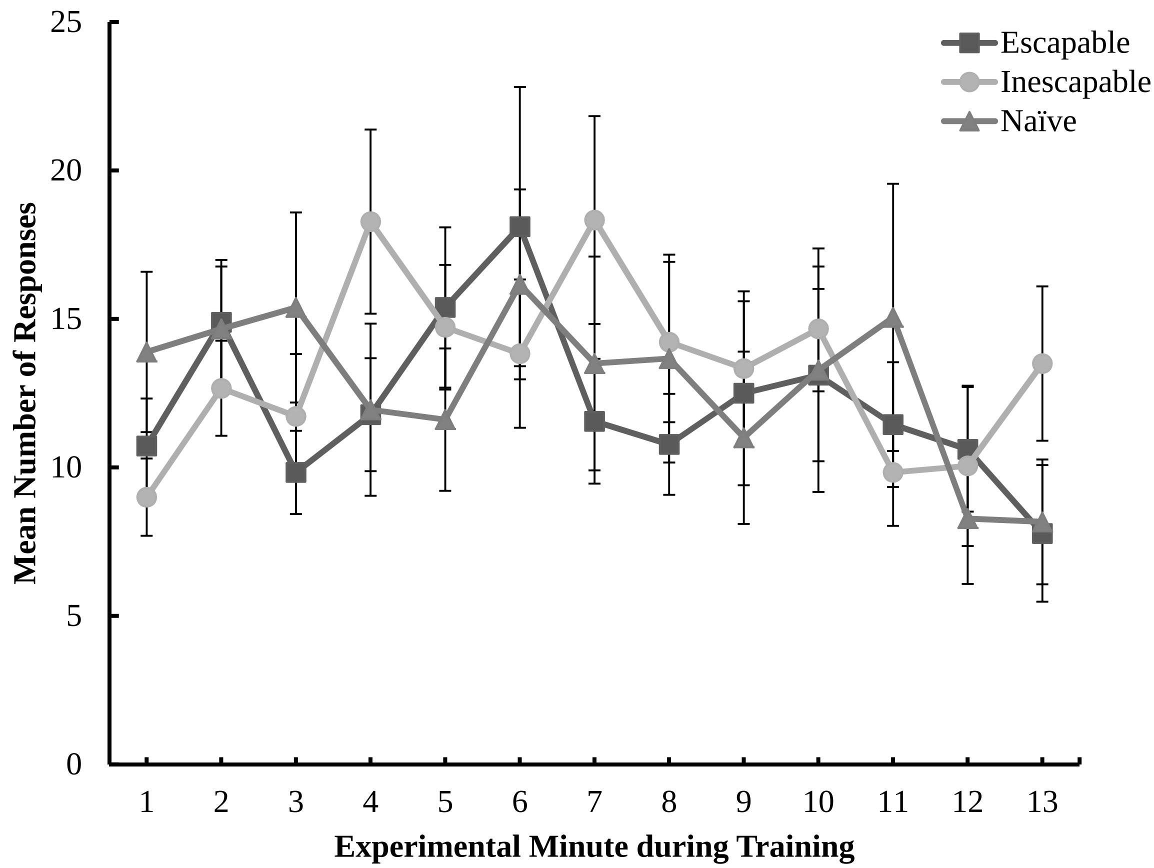

Figure 4. Mean number of responses per minute for each group during training. Error bars represent standard error of the means.

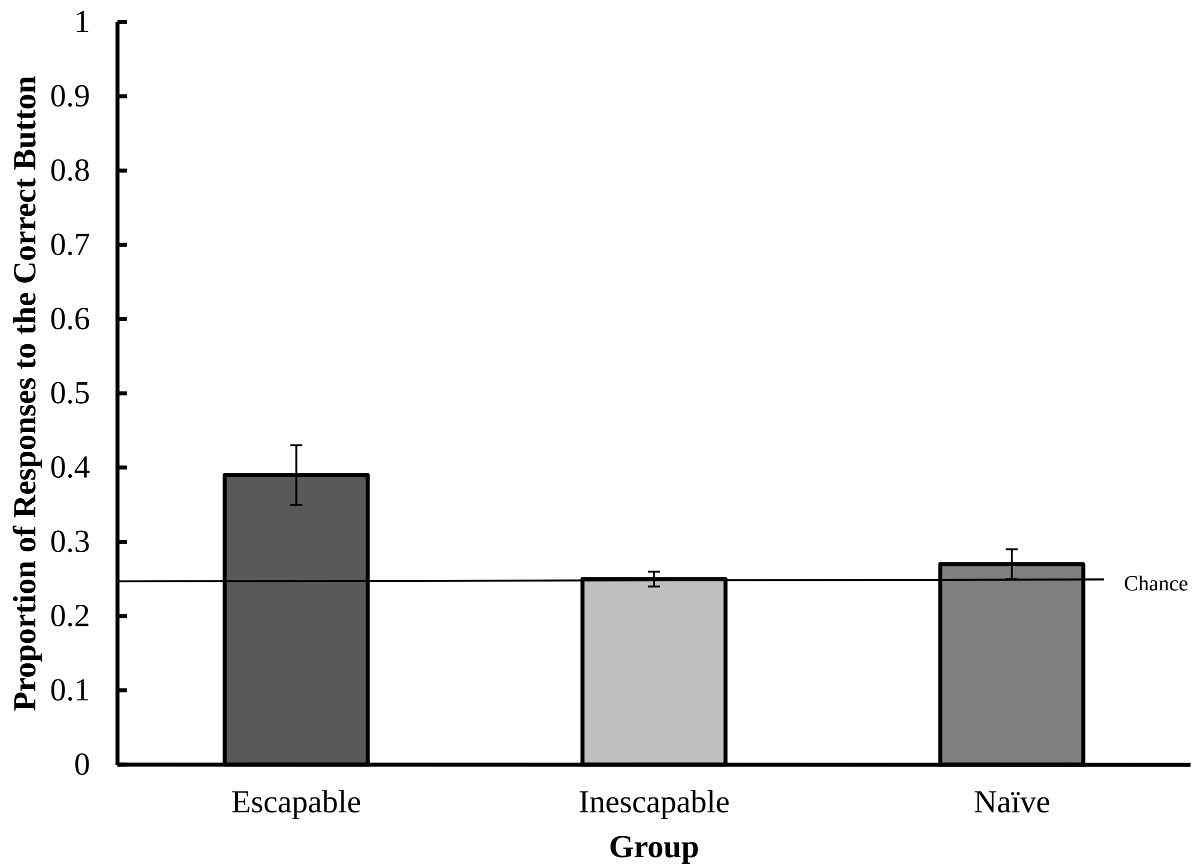

Figure 5. Proportion of responses to the correct button for all groups during training. Error bars represent standard error of the means. Solid line represents chance performance.

Table 2

Pairwise comparisons for Proportion of Responses to Correct Button during Training for Minutes 1-4

(A) Minute	(B) Minute	Mean Diff. (A - B)	Std. Error	Sig.
1	2	-0.044	0.031	0.159
	3	-0.053	0.032	0.105
	4	-0.019	0.022	0.371
	5	-0.086	0.04	0.037
	6	-0.09	0.032	0.007
	7	-0.115	0.034	0.001
	8	-0.089	0.038	0.025
	9	-0.062	0.04	0.13
	10	-0.087	0.045	0.058
	11	-0.093	0.044	0.038
	12	-0.136	0.041	0.002
	13	-0.199	0.05	0.000
2	1	0.044	0.031	0.159
	3	-0.009	0.032	0.777
	4	0.025	0.029	0.395
	5	-0.041	0.031	0.193
	6	-0.046	0.036	0.21
	7	-0.071	0.035	0.05
	8	-0.044	0.033	0.181
	9	-0.018	0.036	0.631
	10	-0.043	0.035	0.227
	11	-0.049	0.04	0.228
	12	-0.091	0.043	0.039
	13	-0.155	0.042	0.001
3	1	0.053	0.032	0.105
	2	0.009	0.032	0.777
	4	0.034	0.028	0.225
	5	-0.032	0.035	0.364
	6	-0.037	0.033	0.268
	7	-0.061	0.033	0.07
	8	-0.035	0.034	0.311
	9	-0.009	0.04	0.832
	10	-0.034	0.045	0.451

	11	-0.04	0.039	0.31
	12	-0.082	0.042	0.055
	13	-0.146	0.04	0.001
4	1	0.019	0.022	0.371
	2	-0.025	0.029	0.395
	3	-0.034	0.028	0.225
	5	-0.066	0.037	0.077
	6	-0.071	0.036	0.052
	7	-0.095	0.03	0.003
	8	-0.069	0.035	0.057
	9	-0.042	0.037	0.254
	10	-0.068	0.041	0.105
	11	-0.074	0.039	0.065
	12	-0.116	0.042	0.008
	13	-0.18	0.045	0.000

Table 2. Pairwise comparisons for Minutes 1-4 for the proportion of responses to the correct button across groups.

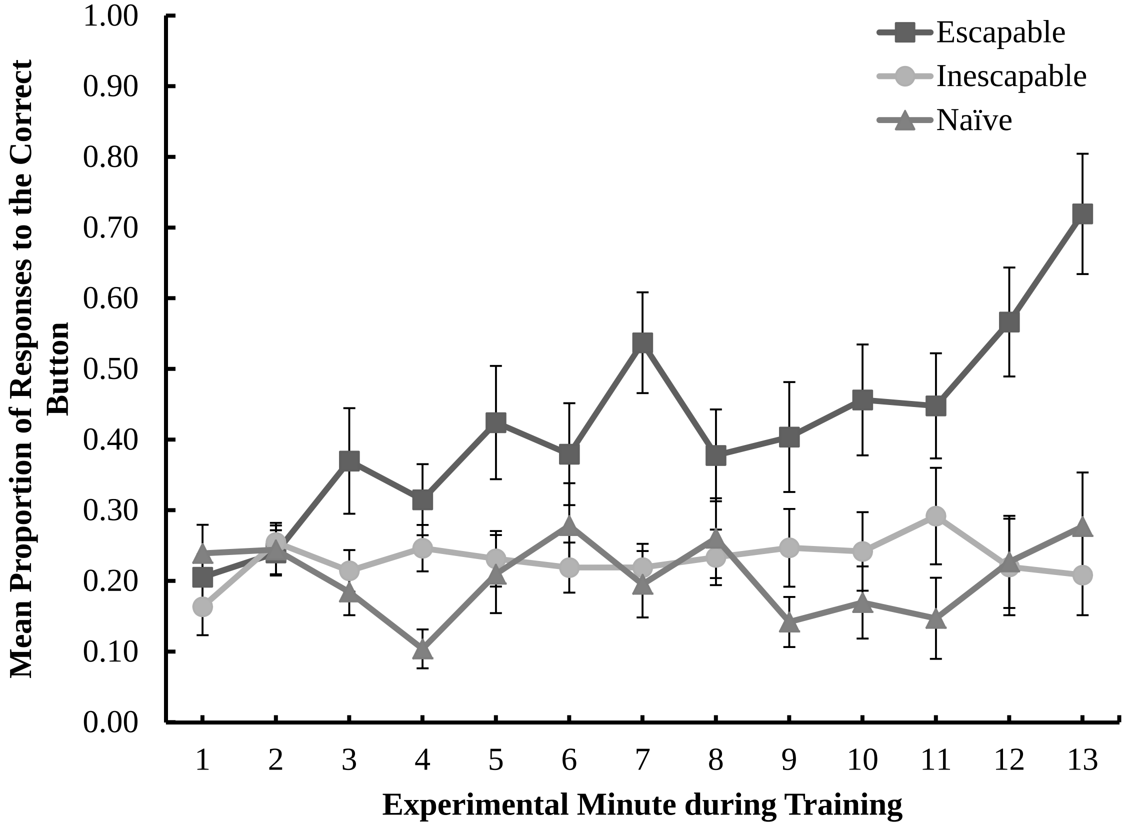

Figure 6. Mean proportion of responses to the correct button for each group across training minutes. Error bars represent standard error of the means.

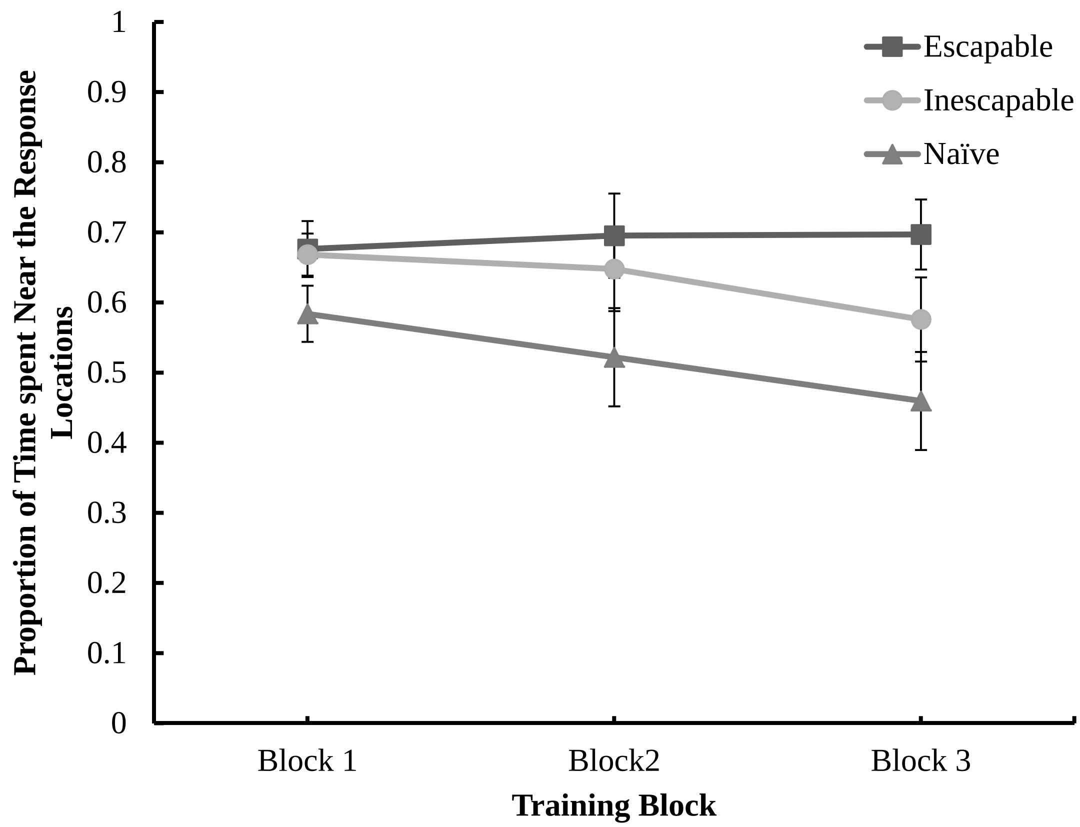

Figure 7. The proportion of time spent near the response locations during training for each group plotted across three 9-trial blocks. Error bars represent standard error of the means.

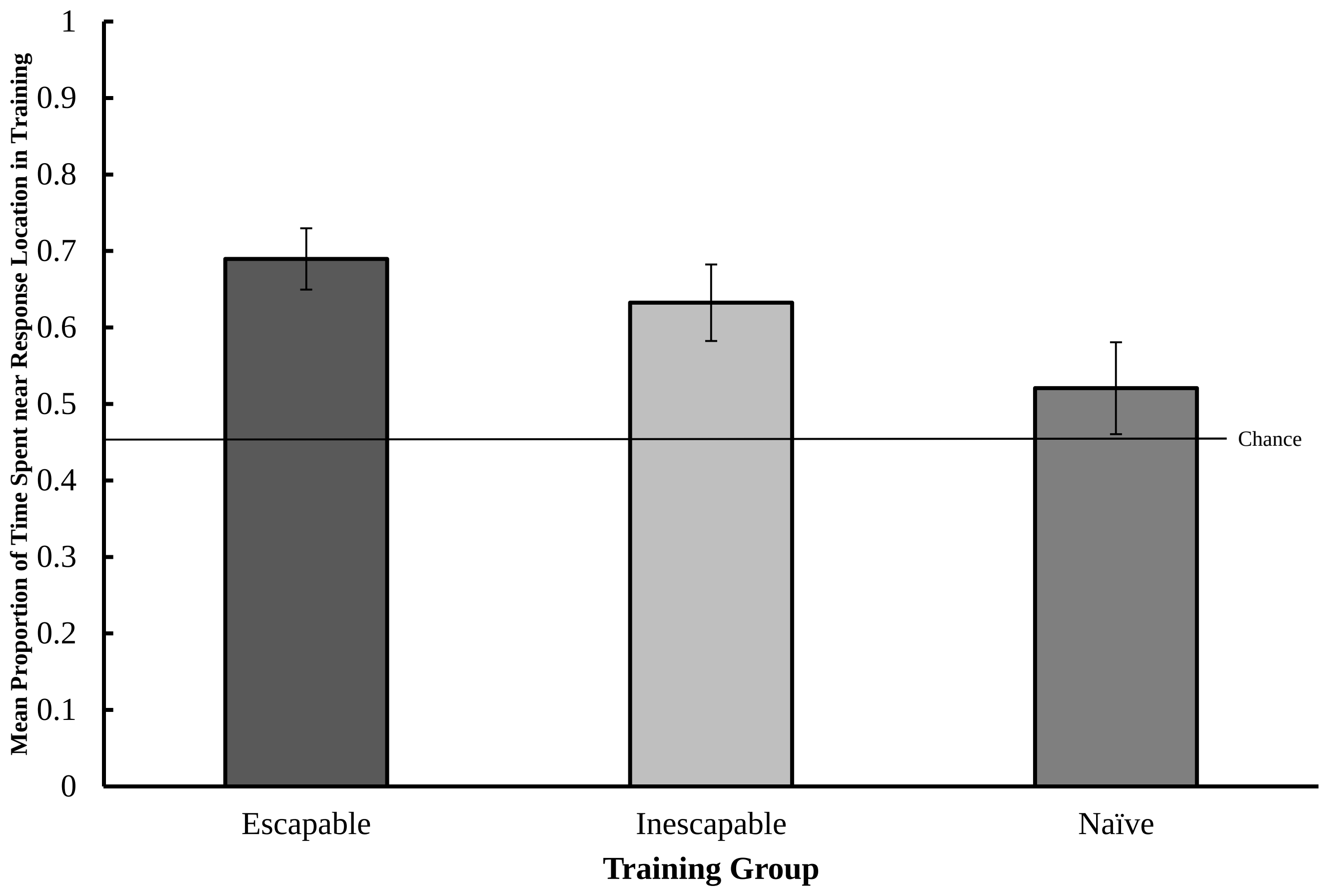

Figure 8. Proportion of time spent near the response locations during training. Error bars represent standard error of the means. Solid line represents chance performance.

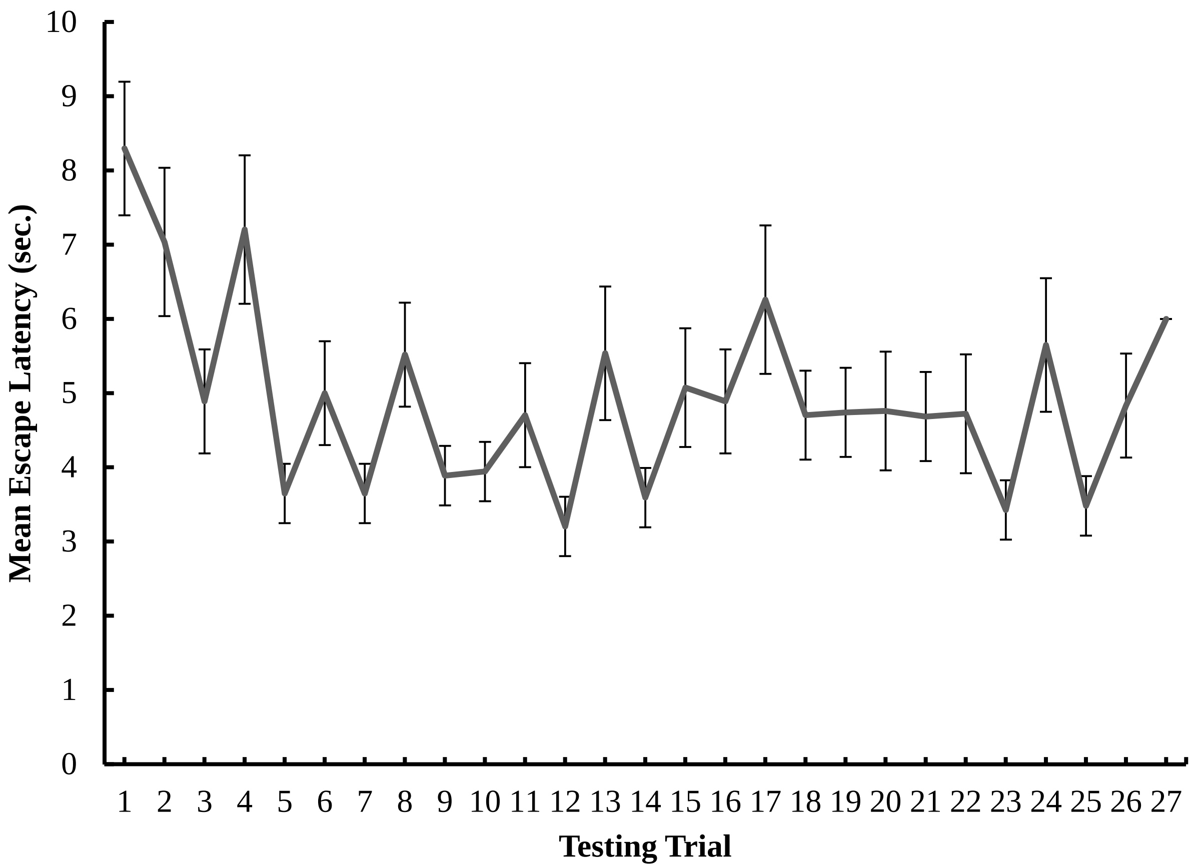

Figure 9. Escape latencies (in seconds) per testing trial collapsed across groups. Error bars represent standard error of the mean.

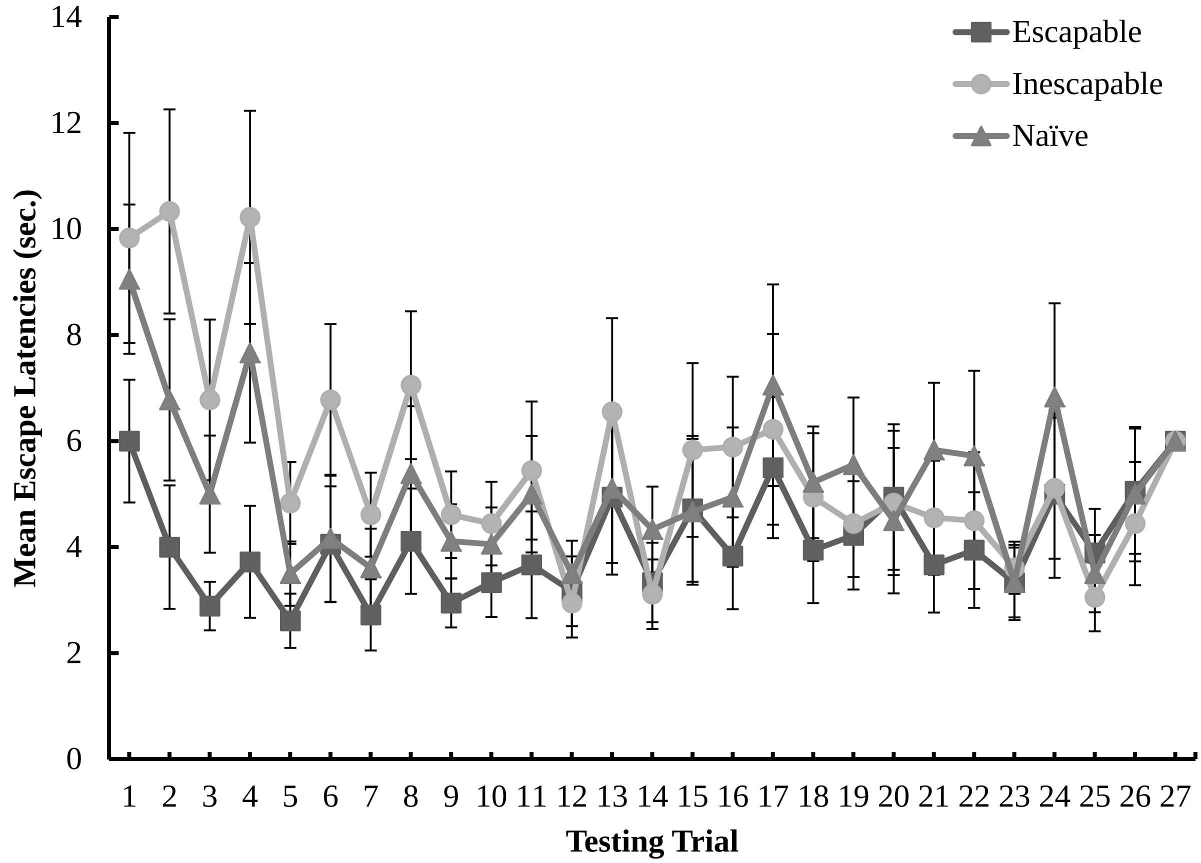

Figure 10. Mean escape latencies for each group across testing trials. Error bars represent standard error of the means.

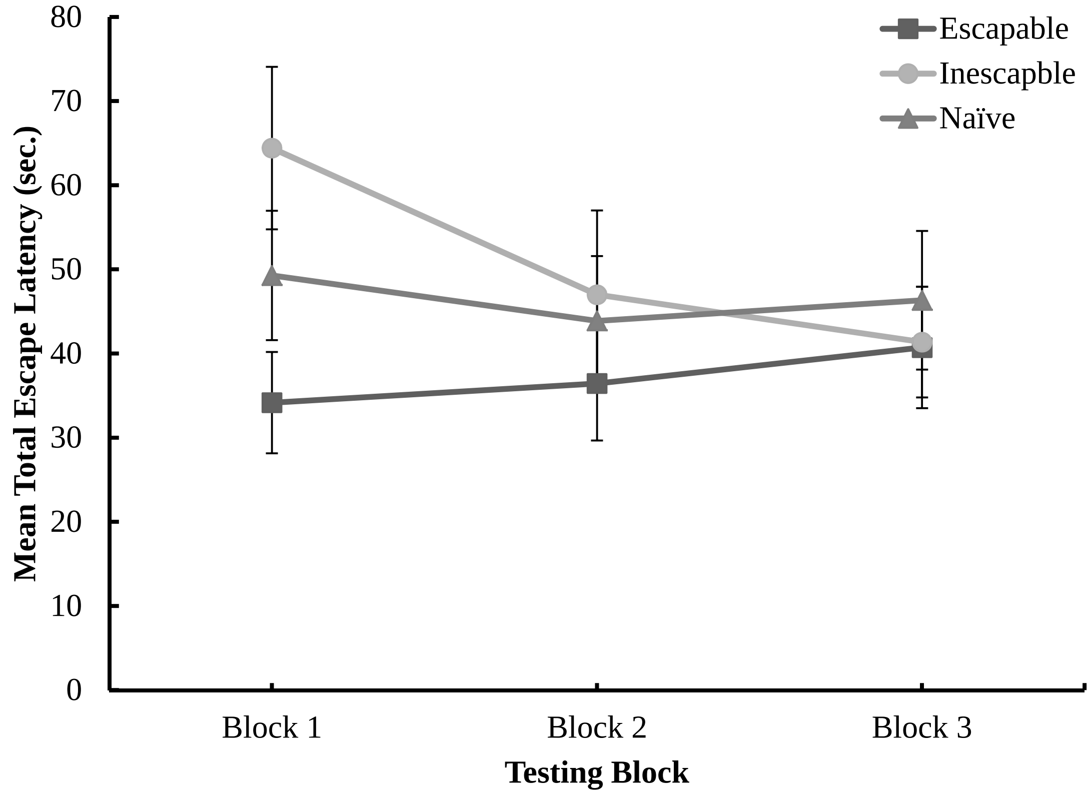

Figure 11. Mean escape latencies for each group plotted across three nine-trial blocks. Error bars represent standard error of the means.

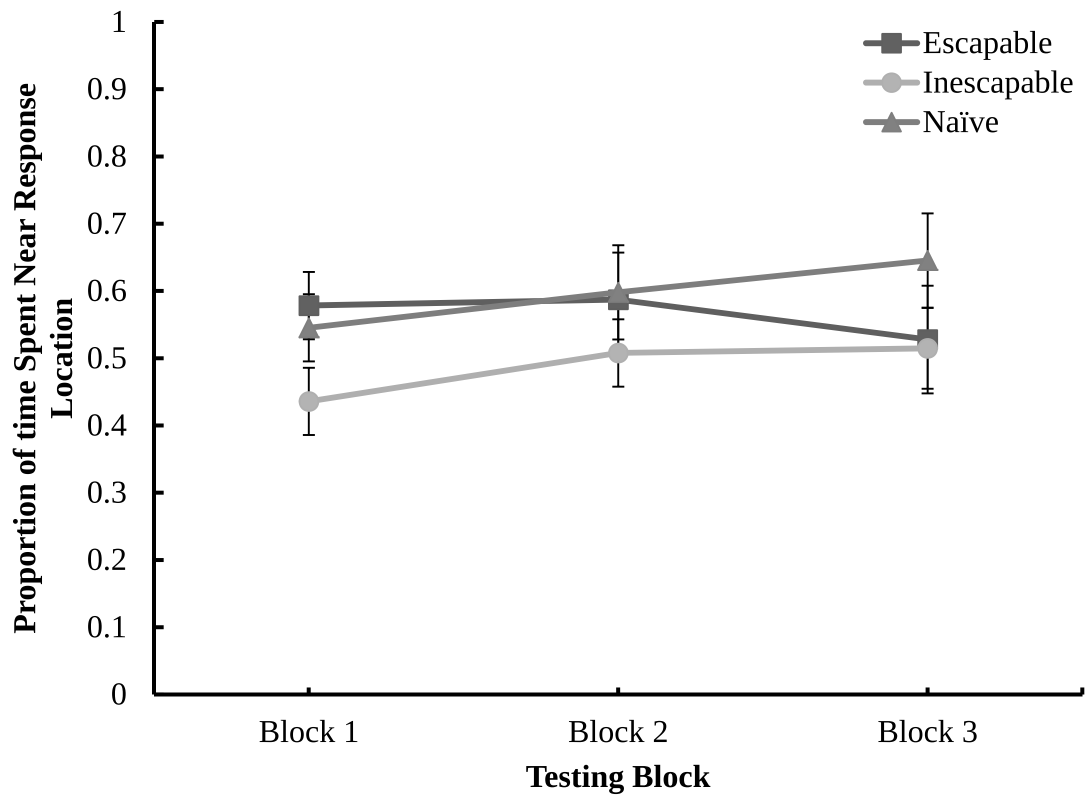

Figure 12. The proportion of time spent near the response location during testing for each group plotted across three 9-trial blocks. Error bars represent standard error of the means.

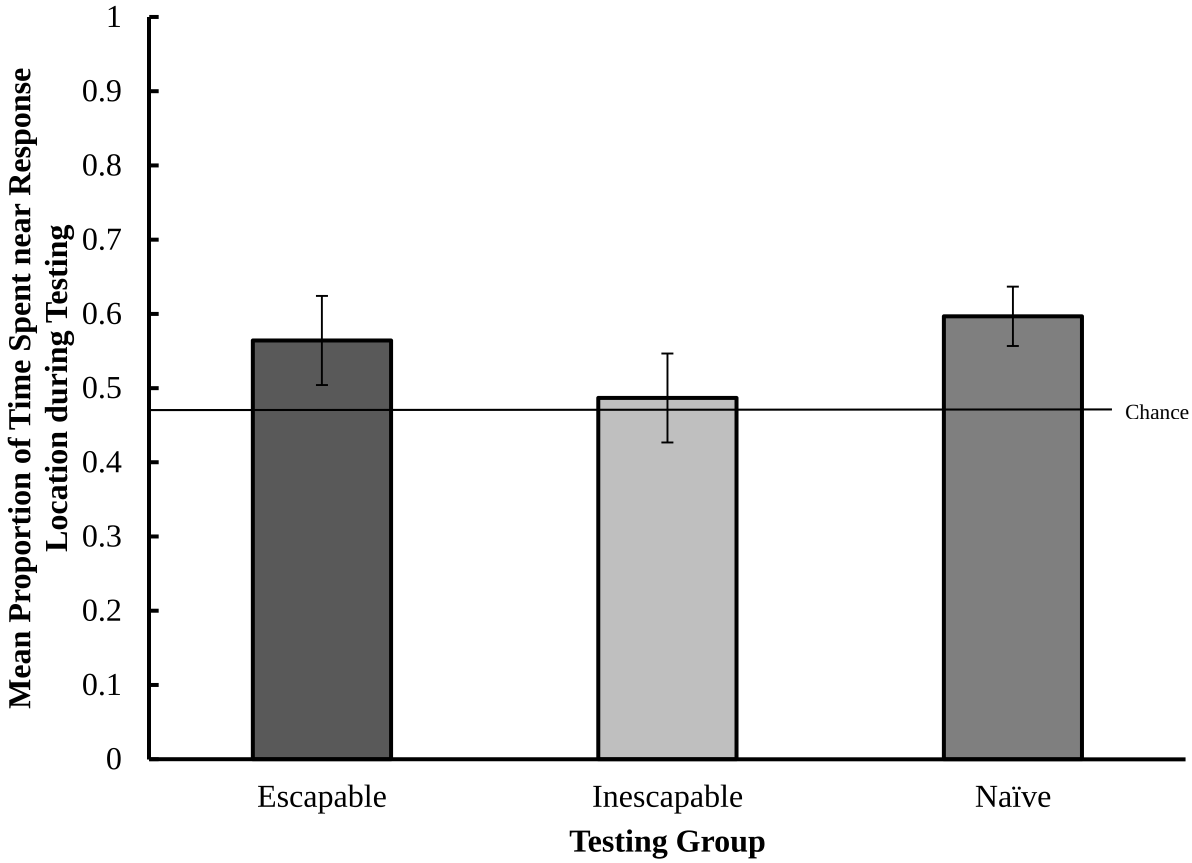

Figure 13. Mean proportion of time spent near the response locations during testing. Error bars represent standard error of the means. Solid line represents chance performance.

CHAPTER 5

DISCUSSION

Both Maier and Seligman's (1976) learned helplessness theory and Levis's (1976) two-process reinforcement theory of escape learning rely on an aversive stimulus that causes either fear (LHT and TPT) or pain (TPT) to induce the learned helplessness effect. The current experiment showed that the learned helplessness effect can be induced with only a mildly aversive stimulus (i.e., the 75 dB alarm) as opposed to the traumatic aversive stimuli used in previous experiments (e.g., non-humans: Overmier & Seligman, 1967; humans: Hiroto, 1974). During the first block of testing, participants who were previously exposed to an inescapable aversive stimulus were slower to escape than participants previously exposed to an escapable aversive stimulus. This new finding reveals that the learned helplessness effect is not just the result of fear and pain but rather that it is due to response-outcome contingencies as it can be induced with only a mild aversive stimulus.

Group I was trained with a zero-contingency aversive stimulus and made a significantly larger number of responses per minute during training than both Groups E and N. This increased number of responses could be due to a learned mastery effect (see Volpicelli et al., 1983). In learned mastery, an organism is first exposed to an escapable aversive stimulus followed later by an inescapable aversive stimulus. The organisms respond during the inescapable aversive stimulus because responding had been previously reinforced in the presence of the escapable aversive stimulus. The response during training in the current experiment was a button press, a response that all participants were familiar with. In life, pressing a button usually results in some outcome, so when presented with a button pressing task in the current experiment, participants in Group I persisted in responding because prior experience with button pressing brought about some outcome. It is also possible that Group I persisted in responding while Group N did not because Group I did have a change in their environment (the aversive stimulus) even though its onset and offset were independent of behavior. Group N experienced no such change in the environment and thus may not have persisted in responding due to the overall lack of change.

The results of the current experiment provide strong evidence that both Maier and Seligman's (1976) learned helplessness theory and Levis's (1976) two-process reinforcement theory do not capture all ranges in which the learned helplessness effect can occur. Both theories rely on an aversive stimulus that elicits either fear or pain. With only a mild inescapable aversive stimulus and two very simple, common escape responses (i.e., button pressing and walking through a door), the learned helplessness effect was induced in Group I. This result is an important finding for the field of clinical psychology because it aids in understanding that an aversive stimulus does not necessarily have to be traumatic in order to hinder escape attempts.

Maier and Seligman (1976) specifically predicted through cognitive deficits that a single escape response for participants previously exposed to an inescapable aversive stimulus is not sufficient for learning. The current results provide evidence against a failure in one-trial learning. Following the first escape response during testing, a criterion of three successful escape responses in a row was set. This criterion was chosen as it rules out the possibility of a false escape (e.g., moving towards the door and escaping either by accident or chance). According to the learned helplessness theory's cognitive deficits, Group I should take longer to reach criterion than both Groups E and N. However, the results revealed that Group I was not significantly different in trials to criterion following the first escape response from either Groups E or N. Therefore, the current experiment shows that one-trial learning can occur for participants previously exposed to an inescapable aversive stimulus.

Following an escape response during testing, both Maier and Seligman (1976) and Levis (1976) predict that overall movement should decrease due to fear and pain reduction. This measure was not including in the present analysis because of the mild aversive stimulus. The mild aversive stimulus means that a decrease in movement caused by fear and pain reduction is not a meaningful measure for the current experiment. Instead, the amount of time spent near the response locations was analyzed and compared to chance. During training, both Groups E and I spent a significant proportion of time near the response locations, but Group N did not. It is likely that Groups E and I stayed near the response locations while Group N did not because both Groups E and I experienced some change in the environment. Group E responded consistently to the correct button (see Figure 5), and Group I experienced a zero-contingency aversive stimulus. Surreptitious reinforcement was not measured in the current experiment, but it is possible that the offset of the aversive stimulus could have corresponded to an attempted response for participants in Group I which could have caused persistence in responding. During training, only Group N spent a significant proportion of time near the response locations (see Figure 8). Group E likely did not spend a significant proportion of time near the response location due to the learning that responses made in the absence of the aversive produce no outcome during training and that learning carried over into testing. Group I, on the other hand, did not spend a significant proportion of time near the response location due to the learned helplessness effect. They were slower to respond because responses produced no outcome during training. The testing portion of the experiment was Group N's first exposure to the aversive stimulus. This novel feature of the testing environment is likely the cause of their significant result. Participants in Group N stayed near the response locations in a similar fashion to Group E during testing because they learned that responses remove the aversive stimulus. However, it is worth noting that because the escape response was not compatible with SSDRs, the results of the current experiment may not be completely ecologically valid.

The current results reflected results previously found in both non-humans and human. Seligman and Maier (1967) demonstrated that dogs exposed to an inescapable aversive stimulus (shock) were slower to escape from subsequently presented escapable shocks inside of a shuttle box than dogs that had previously learned to escape the shock. Hiroto (1974) found a similar result with human participants. Participants previously exposed to an inescapable aversive stimulus (90 dB noise) responded at a lower rate in a subsequent hand-shuttling task (see Turner & Solomon, 1962) with an escapable aversive stimulus than participants who did not previously receive an inescapable aversive stimulus. In the current experiment, participants trained with an inescapable aversive stimulus were slower to respond to a subsequently presented escapable aversive stimulus than participants trained with an escapable aversive stimulus.

Of note with the current experiment is the lack of specific behavioral instructions. As previously discussed, past experiments have claimed to show escape behaviors, but closer examination of the methods revealed that the reported effects were likely due to specific instructions on how to respond (e.g., Thornton & Jacobs, 1971; Freedman, 1991). In the current experiment, no such instructions were provided to participants. The instructions "complete the task to the best of your ability" were included at the beginning of both training and testing, and no other instructions were given. This was done not only to control for verbal behavior but also to more accurately mirror the results found with non-human subjects as verbal instructions were not given in those experiments. The learned helplessness effect was still found for Group I without specific instructions, so it is most likely that the results were due to the effect of the inescapable aversive stimulus rather than behavior brought about by verbal instruction.

Bolles (1970) proposed that avoidance responses that are not a part of the species-specific defense reactions (SSDRs) would not be rapidly learned. SSDRs consist primarily of fighting, freezing, or adopting some kind of pseudo-aggressive behavior (e.g., an animal standing on its hind legs to make itself appear larger than it actually is). The escape response of moving forward into the response locations (i.e., button press in training and crossover in testing) is not a part of the human's SSDRs, however, Bolles (1970) notes that an avoidance response that is incompatible with SSDRs can be rapidly learned if it suppresses ineffective SSDRs. When the escape response necessary in the current experiment was performed, it suppressed the freezing response that is compatible with SSDRs. Therefore, it was expected that this response would be learned quickly. During the training portion of the current experiment, only responses made by Group E removed the aversive stimulus, however, all groups were able to escape the aversive stimulus during testing. Even though the testing portion of the experiment lasted only 13 and one half minutes, only one participant (a member of Group I) failed to make an escape response. Compared to the large number of exposures to an aversive stimulus that is sometimes necessary for non-humans to acquire an avoidance response (Bolles notes that this number can sometimes reach the thousands), participants in the current experiment were able to acquire the escape response in the shuttle box after only a small number of exposures. Therefore, the escape response required by the current experiment is not thought to have been affected by its lack of congruency with SSDRs.

In summary, participants who were previously exposed to a non-traumatic inescapable aversive stimulus demonstrated a lower level of responding compared to participants who were previously exposed to an escapable aversive stimulus. It is important to show that the 3D virtual environment used in the current experiment can induce the learned helplessness effect in order to investigate a way to reduce or prevent the effect. Future research can expand upon these findings by introducing a learned mastery task in which one learns to respond to an inescapable aversive stimulus by being previously trained with an escapable aversive stimulus (see Volpicelli et al., 1983 for a non-human example).

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