AN INVESTIGATION INTO THE RESPONSE OF
EQUUS CABALLUS
WHEN PRESENTED WITH
VISUAL AND TACTILE DISCRIMINATION TESTS

BY KATHRYN ELIZA KING

Submitted as part of the requirement for the Degree of BSc (Hon's) Equine Studies, Writtle College, in partnership with the University Of Essex.

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ABSTRACT

Humane training of horses in both ridden and non-ridden situations is dependent on the ability of the trainer to communicate their intentions with minimum physiological and psychological damage to the horse, and the horse's ability to perceive and interpret these commands. Limited research has been conducted on the visual discriminative capabilities of horses and although much training literature exists informing the trainer on how to train and ride horses, scientifically valid appraisals of existing training methods have rarely been published. The aim of this thesis was to investigate the response, recognition and retention abilities of horses when presented with a series of instrumentally conditioned visual (non-ridden) and tactile (ridden) discrimination tests, over a period of three weeks. The visual test used a continuous changeover design and primary positive reinforcement. The tactile test used negative and secondary positive reinforcement during the exercise of reinback. It was decided to carry out the tactile discrimination test by applying and evaluating the Dodwell Horse Morse Code training system which claims to provide the trainer with a series of messages as concise and consistent as those of the Morse Code. The visual discrimination test initially showed a response variation of $P < 0.05$, between tests with regard to the stimulus response within week 1; consistently good recognition and retention of stimuli in week 2, but a lack of consistency in week 3. The tactile discrimination test showed a highly significant response variation of $P < 0.001$ over the three weeks, which on subsequent analysis suggested a strong learning curve.

CONTENTS

Materials

Methods

APPENDICES

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

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CHAPTER 1

INTRODUCTION

The usefulness of horse to man depends entirely on trainability. Therefore an increased knowledge about the potential ability for horses to learn offers benefits to both horse and trainer (Marinier & Alexander, 1993; Kiley Worthington, 1977). Horses are usually ridden by trainers in recreational activities, racing and competitive disciplines e.g. show jumping, dressage, endurance, each requiring specialised training. Despite this diverse range of activities, equine training is fundamentally based on effective communication from the trainer to the horse and the horse's psychological and physiological ability to respond (Blake, 1977; Mills & Nankervis, 1999). A range of equine training literature exists explaining different methods of handling and riding the horse, and over the centuries a wide variety of training techniques have been employed (Fiske & Potter, 1979). However, the psychological basis of equine learning has traditionally been ignored and formal investigations into equine learning potential in non-ridden and ridden situations are commonly neglected (Mader & Price, 1980; Houpt, 1995; Langley, 1989). There are a number of reasons why a gap exists in equine learning and trainability research:

1) Lack of funding - horses are expensive to maintain in controlled research environments
2) Increased emphasis on the horse's physiological health i.e. fitness and nutrition and its effect on athletic performance for competition fitness (Caanitz, O'Leary, Houpt, Petersson & Hintz, 1991)
3) The level of tolerance and compliance horses commonly show to the unnatural lifestyles and suboptimal training conditions that they are subjected to (Kiley Worthington, 1987). This may be due to their subservient nature (Rees, 1997) which ensures they are particularly vulnerable to exploitation and cruelty (Atwood Lawrence, 1996), rather than representative of their enjoyment of a training situation.

Historically equine trainers have shown limited knowledge or concern over the manner in which horses learn and their methods of communicating to the horse, with little interest in avoiding resistant behaviour (May, 1995) e.g. symptoms of confusion/pain

(Appendix 1). Traditionally, this lack of communication and listening to the horse has resulted in trainers masking the levels of external resistant behaviour by applying flash/grackle/drop nose-bands, strong bits and gadgets (Kidd, 1977; Marshall, 1996; Bentley, 1995) (Appendix 2). The situation is aggravated by the increased pressures on trainers to succeed in the world of competition where failure to conform is perceived to be a reflection on a trainer's ability to ride and teach (Kiley Worthington, 1997).

Although some horses provided with a consistently good learning environment do not show signs of confusion, many exhibit marginal adaptation and prolonged resistances (Ewing, Lay, Borel, 1999; Kiley Worthington, 1998), shown in a reluctance to co-operate and/or exhibition of stereotypies (Fraser, 1992; Rushen, 1993). Recently however, concern has grown over these traditional approaches of concealing the symptoms rather than listening to the horse and assessing their cause (Ewbank, 1985; Balance, 1996). This trend has been largely influenced by 'horse whisperers' such as Monty Roberts (Horse & Rider, 1997), Pat Parelli (McBane, 1998) and David Dodwell (Marks, 1998). These trainers utilise knowledge on equine sensory perception and learning abilities (Rees, 1997) to effectively communicate with the horse and promote the horses reaction as the most reliable indicator of a successful response (Kiley Worthington & Randle, 1997).

> *"What must a horse feel like, confronted with creatures who do not seem to speak his language, who simply 'yell louder' or worse in attempts to 'communicate' without the communion?"*
>
> *(Creiger, 1998)*

The largest proportion of scientific equine learning research can be seen in discrimination tests, used to assess horses perceptual abilities (Mader & Price, 1980; Potter & Yeates, 1990), maze performance (Kratzer, Netherland, Pulse & Baker, 1977) and reinforcement methods (Tarpy, 1975) in non-riding situations. There have however been few, if any, scientifically valid, objective ridden research tests to assess ability to learn and the most appropriate method of ridden stimuli presentation remains untested.

One way of increasing knowledge in the area of discrimination learning is to devise a visual (non-ridden) and tactile (ridden – using rider's messages) discrimination test under a stimulus response reinforcement procedure (Budiansky, 1997; McCall, 1990; Warren & Warren, 1962). Monitoring discriminatory responses over a series of weeks and recording the incidence of errors made and time taken to learn allows assessment of the recognition and retention ability of the horse, which may indicate whether or not the applied methods were appropriate (Fiske & Potter, 1979). Increasing knowledge about the horse's visual discrimination ability may be of practical benefit to both horse and trainer where acquisition of 'visual discriminatory cues' may be required e.g. RDA, riding schools, circus training, vaulting, in-hand show horses, youngstock handling (prior to riding), forestry use.

In addition the evaluation of a ridden training system that has clear communication channels and decreases levels of resistant behaviour, without the use of gadgets, would also prove beneficial to the horse industry. The relatively new ridden training system, the 'Dodwell Horse Morse Code', provides an ideal basis on which to conduct a ridden research test, as the system is devised around a series of unambiguous messages (Dodwell, 1995), allowing a consistent assessment of learning within a group of horses. The most quantifiable exercise to use to condition the horses to respond to the Dodwell Horse Morse Code messages appears to be the movement of reinback (Appendix 3) as it is easily visually recorded and many horses find the exercise difficult (Houpt, 1995; Miller, 1996a).

The main aims of this study are to investigate the response, recognition, and retention abilities of a random sample of horses when exposed to a visual and a tactile discrimination test and to evaluate the use of a ridden training method. This will be placed in the context of current knowledge about how horses learn and current training methods. The specific objectives are;

1) To review the process of equine learning

2) To review previous learning trials.

3) To devise a visual and a tactile discrimination test. The hypothesis states that there is no response, recognition or retention within the group, with regard to a decrease in errors when presented with visual and tactile stimuli.

4) To formulate an objective method of analysing the tactile discrimination test.

5) To review the suitability of the Dodwell Horse Morse Code in relation to training the riding horse to reinback.

The following chapter examines how horses learn using sensory input and how this may influence the presentation of stimuli under test conditions.

CHAPTER 2

EQUINE LEARNING

Neuroethology

Neuroethology examines the physical processes that monitor, evaluate and co-ordinate internal functions, allowing the horse to respond and adapt to its external environment (Rowland, 1992). The nervous system comprises a variety of integrated structures that condense to form the Peripheral Nervous System (PNS) and the Central Nervous System (CNS), collectively utilising a multitude of neurones that facilitate the exchange of information. An understanding of the mechanisms involved in equine learning is fundamental to establishing equine stimulus response capabilities as it enables training sessions to be conducted in an appropriate manner. This chapter explores the neural structures that enable the horse to perform discrimination tasks.

2.1 The Neurone Network

Highly specialised cells called neurones, which consist of a cell body, dendrite extensions and an axon, transmit nerve impulses. Dendrites receive chemical information from adjoining neurones and convert the information into electrical signals. Intensive impulses are then transmitted along the axon, where synaptic knobs (bulbs on end of axon) release chemical transmitters i.e. acetylcholine, onto the target neurone across a gap known as a synapse. Dendrites on the adjoining neurone detect the impulse and the cycle is repeated (Rossdale, 1976). There are two main classes of neurone:

1) Macroneurones - principal nerve fibre trajectories, involving long axons (REF), allowing neurones, sensory receptors and muscle fibres to form neurone circuits that interpret and transfer sensory information via the PNS to the spinal cord then back to the PNS
2) Microneurones - predominantly found in areas of the brain involving short axons. They ensure behavioural modification (learning) arises by facilitating or inhibiting macroneurone activity from the PNS allowing specific areas of the brain to respond to impulses in a variable manner (Fraser, 1992).

Neurones can also be classified on the basis of their function:

i) receptor (sensory / afferent) - transmit impulses from sense organs (PNS) to the CNS

ii) effector (motor / efferent) - transmit impulses from the CNS to muscles (PNS)

iii) relay (association) - link receptor and effector neurones within the CNS (Huntingford & Turner, 1987).

In order for an electrochemical impulse to be initiated, sense organs must provide the neurones with a particular stimulus threshold so they can become activated and react. The ability of the sense organs to detect stimuli should therefore be evaluated.

2.2 The Sense Organs

Visual and tactile discrimination tests involve exogenous stimuli, which normally initiate a response (Lehner, 1996). The sensory system comprises five sense organs highly specific in stimuli detection; olfactory (smell), taste, auditory, visual and tactile. A series of visual and tactile discrimination tasks will involve all five senses at various levels of intensity, but the eyes and the skin will receive the highest level of stimulation.

2.2.1 The Equine Eye

The equine eye is amongst the largest of any living mammal, which may be indicative of its environmental sensory importance. The eye consists of a layer of light receptors, known as photoreceptors, which conduct impulses via optic nerves directly to the brain (Huntingford & Turner, 1987). The amount of detail the horse perceives is determined by the density of photoreceptors, which predominantly occur across the horizontal axis of the eye in a wide band known as the 'visual streak'. This shows the central area of the eye to be the most sensitive, so any unfamiliar objects should be presented centrally to the horse to reduce the chance of startling and initiating the flight response (Mills & Nankervis, 1999). The horse also has a narrow binocular field of vision, only 30 – 70 degree angle, which means that the horse's head must be facing forwards to ensure stimuli presented in front of the horse can be thoroughly evaluated (Kiley Worthington, 1987). The 'lens' within the equine eye appears to fairly inflexible which suggests horses may find focusing on close objects difficult. However this does not appear to limit the horse's ability to perceive visual signals (Budd, 1996).

2.2.2 The Skin

The horse's skin contains an array of specialised sensory receptors; mechanoreceptors are the ones mostly stimulated in the ridden horse as they respond to touch and pressure (Rossdale, 1976). The relative sensitivity of horses to tactile stimuli appears to rely on individual responsiveness which varies depending on the thickness of the coat and skin and the quantity of specific receptors in different body areas (Williams, 1990). Mechanoreceptors have a relatively high threshold of stimulation and appear to become less responsive if the stimulus is repeated at intervals of less than 30 seconds i.e. the tolerance threshold increases. A rider who constantly pulls on the horse's mouth will decrease the likelihood of a response as the receptors in the mouth become less responsive and if the stimuli remain consistent the horse may habituate to the sensation. A common remedy is to apply a stronger message to the horse if it does not respond, yet this may in fact increase habituation to the stimuli and the need for stronger messages in the future (Kiley Worthington, 1987).

2.3 The Peripheral Nervous System (PNS)

The PNS consists of the Autonomic Nervous System (ANS) which co-ordinates involuntary activities using sympathetic and parasympathetic divisions and the Somatic Nervous System (SNS) which co-ordinates voluntary activities. The latter system and its associated functions are most prevalent within the learning process, and thus are described in greater detail below.

2.3.1 The Somatic (Voluntary) Nervous System

The SNS is responsible for the movement of skeletal muscle utilising receptor and effector neurones. Information is received through the photoreceptors and the mechanoreceptors and carried by receptor neurones (cranial and spinal nerves) along afferent tracts to the CNS. Once evaluated in the CNS, the appropriate response travels back to the muscles via efferent tracts to initiate muscular performance. A process known as the 'reflex arc' conducts this response in the muscles. If stimuli are presented to the PNS in a manner that initiates an instinctive response, an unconditioned reflex occurs involving receptor and effector neurones. This response is known as a spinal reflex as it does not involve the brain and no conscious thought is required to respond. If stimuli are presented in a manner that requires an innate (learned) response a conditioned reflex occurs, involving receptor, effector and relay neurones (Rowland, 1992). This response is processed via tracts in the spinal cord which intercept or control the reflex arc by sending information to the brain for analysis and preparation for an appropriate response e.g. presentation of an unfamiliar message which requires the horse to step backwards (Osbourne, 1985). The brain can control reflex arcs by weakening or even overriding cerebral commands e.g. reassuring the horse that stepping backwards into an area it cannot see very well will not harm it (Budd, 1996).

2.4 The Central Nervous System

The central nervous system (CNS) consists of the spinal cord and the brain.

2.4.1 The Spinal Cord

The spinal cord acts as an intermediary nerve station facilitating the exchange of impulses by utilising two types of tracts:

1) ascending tracts which carry receptor impulses from the spinal cord to the necessary region of the brain
2) descending tracts which carry effector impulses from the brain to the relevant area of the spinal cord.

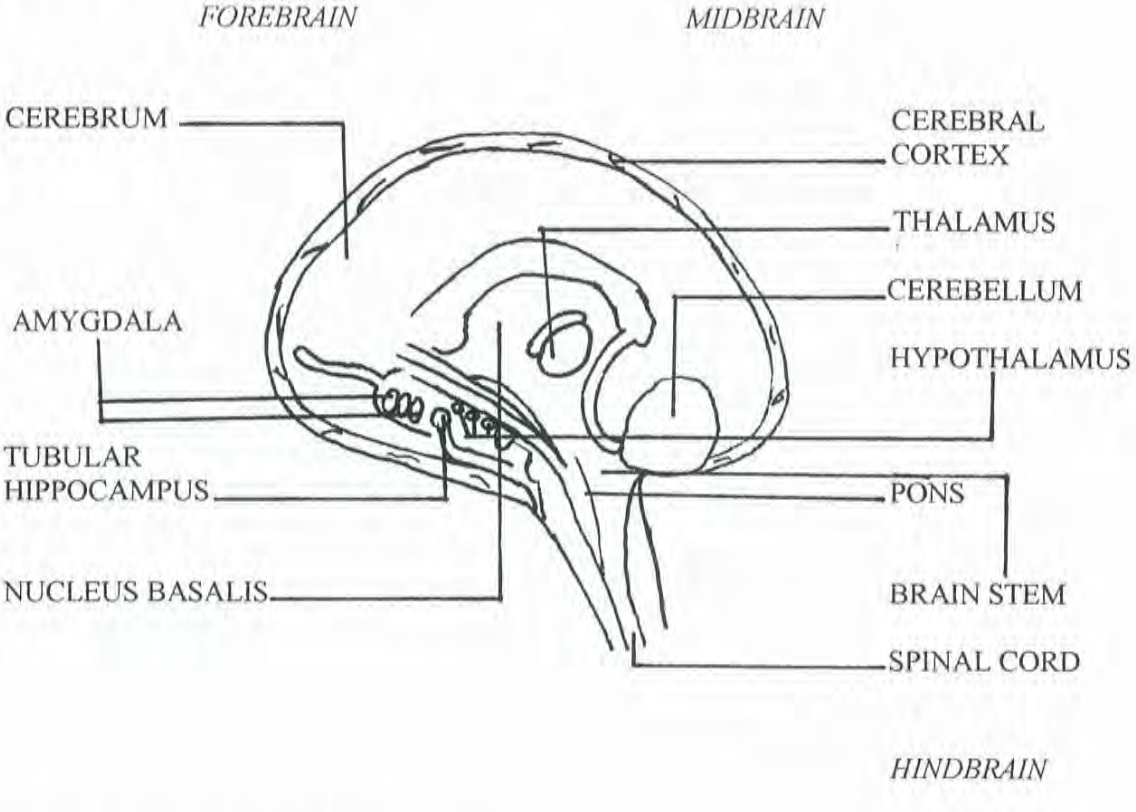
In order to ensure receptor and effector impulses travel in the appropriate direction, the spinal nerves are separated into dorsal and ventral roots prior to entering the spinal cord. However, the tracts within the cord cross, resulting in impulses from the left side of the body being controlled by the right hemisphere of the brain and impulses from the right side of the body being controlled by the left hemisphere of the brain. The restricted amount of crossover inhibits the horse's ability to cross-refer information and thus necessitates training both sides of the horse equally (Brega, 1995; Osbourne, 1985).

2.4.2 The Brain

The brain, enclosed within the cranial cavity, co-ordinates the body's activities and forms one percent of the body's weight (Rossdale, 1976). Many attempts have been made to evaluate whether brain size in relation to body size is an indicator of intelligence, but no studies have formed conclusive results (Ewing, Lay & Borel, 1999). The equine brain uses similar learning mechanisms to humans with regard to sensory acuteness and memory and although it is not able to rationalise or form concepts it has developed a large cerebral cortex which allows evaluation of multiple sensory inputs (Budiansky, 1997).

The brain can adapt to the activities that it is required to perform, but the formation of new neural connections takes repetition and time (Osbourne, 1985). The brain is composed of three main areas, the forebrain, midbrain and hindbrain that can be divided into three main segments, the cerebrum (cerebral hemisphere), cerebellum and the brain stem. These segments are subdivided into secondary areas, which perform specific, although closely linked functions. Figure 1 shows the areas of the equine brain involved in a visual and tactile discrimination learning process and Appendix 4 summarises their specific involvement.

Figure 1 The equine brain



Source: Huntingford & Turner, 1987
Rowland, 1992

NOT TO SCALE

The following chapter discusses learning paradigms and how they relate to the observed behaviour of horses.

CHAPTER 3

LEARNING BEHAVIOUR

Learning i.e.conditioning involves an interaction between a stimulus and its reinforcing properties, which initiate a short and/or long-term behavioral modification (Kimble, 1961; Miller, 1996a). The strength and type of interaction may affect animals and individuals within a species differently, resulting in variation in their predisposition and ability to learn from particular experiences (Voith, 1986; Houpt, 1995). Individual learning and cognitive abilities (mental capacity to perceive external events) (Ewing, Lay & Borel, 1999) depend upon numerous variables i.e. age, gender, weight, breed etc (Appendix 4); however, for all individuals the same areas of the brain categorize and store the experiences and when future stimuli are presented the response is either to ignore (no perceptual change in behaviour) or to reinforce (a behavioural change). Behaviour falls into two classes:

1) respondent behaviour
2) operant behaviour

Each one results in a different form of learning: respondent behaviour results in classical learning; operant behaviour results in instrumental learning, both of which are described in greater detail later in this chapter. Distinction between these two learning paradigms is primarily made in terms of the stimulus presentation procedure, and the extent to which the underlying processes differ is an open issue (Houpt, 1998; Hinde, 1970; Manning & Stamp Dawkins, 1992).

3.1 Stimulus Generalization and Discrimination

Stimulus generalization occurs when similar stimuli, under both classical and instrumental conditions produce the same response (Hemsworth, Verge & Coleman, 1996) e.g. a dog conditioned to salivate on an auditory signal of 1000Hz would also salivate when other tones were presented, although to a lesser extent (Manning & Stamp Dawkins, 1992). This can be applied to training the horse where a lack of message and reinforcement clarity may result in message generalization which would not produce refined responses. The opposite process to generalization is discrimination i.e. the dog will naturally salivate equally to all sounds but discrimination becomes refined after repeated trials when only one particular tone is followed by a reward. In training, learning to discriminate between stimuli involves the ability to discriminate between various commands (Manning & Stamp Dawkins, 1992). The potential strength of horses' perceptivity was highlighted by a nineteenth century Arabian stallion, 'Clever Hans' who was reported to perform mathematical problems by tapping out the answer with his hooves. It was eventually discovered that the horse was perceiving/interpreting the tiny changes in the trainer's body language which cued him in to the correct answers (Henwood, 1981)

3.2 Intelligence

Intelligence is a multifaceted capability that cannot be quantified by any one test and is not synonymous with learning ability (Hagerbaumer, 1995). Horses vary a great deal in their ability to respond (Williams, 1995) and slower learners require a higher percentage of repetition reinforcers than more intelligent ones (Marshall, 1996). Langley (1989) suggests that intelligence may be inhibited if the horse exists in an environment that inhibits decision making ability i.e. daily confinement to stables and domineering training environments.

3.3 Learning to Learn

Learning to learn involves the application of previously learned behaviour (past experience) to a new learning situation, which in the wild increases chances of survival (Salthouse, 1996). Kiley Worthington (1987) reported this phenomenon when teaching a horse 'tricks' as each new trick took successively less time to condition, although stimuli must provide equal physiological difficulty. Mader & Price (1980) and Drea & Wallen (1995) both found rapid learning in horses exposed to a second series of discrimination tests. Many researchers (Fiske & Potter, 1979;McCall, Potter, Friend & Ingram, 1981; Baker, Potter, Friend & Beaver, 1983) have also reported that their equine subjects have 'learned to learn'. This has important implications for the practical training of horses as the more tasks a horse learns to perform the easier it becomes for that horse to learn a new task.

3.4 Classical Conditioning

The main distinguishing factor of classical conditioning is that only innate or reflex responses are conditioned; the learning process involves little or no cognitive input, and the subject cannot control its response (Ewing, Lay & Borrel, 1999; Budiansky, 1997;

Hagerbaumer, 1995; Salthouse, 1996). Classical conditioning was first demonstrated by the Russian physiologist Ivan Pavlov who discovered using dogs that stimuli that offer reinforcing benefits to an animal, known as unconditioned stimuli (UCS) e.g. food or bright light always produce an unconditioned response (UCR) e.g. salivation or blinking (Kiley Worthington, 1987; Hemsworth & Coleman, 1998; Manning & Stamp Dawkins, 1992). He then discovered that introduction of a stimulus that does not instinctively produce an UCR e.g. a bell could, if repeatedly paired with the UCS, produce the UCR on its own i.e. salivating or blinking on hearing the bell (Hinde, 1970, Houpt, 1995; Houpt, 1998). To increase response acquisition the CS should precede the UCS by 2 seconds (Houpt, 1998). If the CS follows the UCS learning will not occur. If the CS precedes the UCS by more than 3 - 4 seconds, the number of trials to learning will greatly increase (Spreat & Rogers Spreat, 1982).

Application of the classical conditioning paradigm to training horses only appears to occur if the acquired response is based upon an innate reflex reaction. For example the word 'trot' (CS) is presented 2 seconds prior to the snap of a whip (UCS); the horse then trots forwards (UCR) to avoid the aversive stimulus behind it. Successive pairings of CS and UCS should produce trot (UCR) when the word alone (CS) is used (Voith, 1986). Conditioning a horse to reinback (UCR) utilizing this form of learning only appears relevant if aversive stimuli are presented in front of the horse, inducing the flight reflex response (running backwards). Presentation of a reinforcement method (UCS) would not induce the horse to reinback (UCR) and pairing of the reinforcement (UCS) and specific hand and leg messages for reinback (CS) would only elicit reinback if, by random chance, reinback occurred and were reinforced. It therefore appears likely that the reinback response would initially be discovered through trial and error (instrumental learning) which eventually becomes a conditioned reflex.

3.5 Instrumental (Operant) Conditioning

An instrumental conditioning paradigm involves no explicit pairing of conditioned and unconditioned stimulus (Hemsworth & Coleman, 1998). Instead the animal initiates a series of voluntary responses and discovers the desired response through trial and error, which then generates a reward (Hagerbaumer, 1995; Ewing, Lay & Borel, 1999; Manning

& Stamp Dawkins, 1992). Instrumental conditioning differs from classical conditioning as the individual discovers the stimulus/ response relationship for itself (Lehner, 1996, Hinde, 1970). Instrumental conditioning can be used to test both visual shape discrimination (Houpt, 1998; Budiansky, 1997) and ridden tactile discrimination e.g. conditioning a horse to reinback (Miller, 1996b; Budiansky, 1997; Houpt, 1995).

Instrumental conditioning was first demonstrated by Thorndike in 1911. However Skinner extended his work and defined the instrumental paradigm as containing three basic components (Voith, 1986): a stimulus, a response and immediate reinforcement. Reinforcement is discussed in greater detail in Chapter 4.

Through this stimulus – response – reinforcement chain animals learn to repeat actions that have in the past led to a pleasant experience or avoided an unpleasant experience (Huntingford & Turner, 1987). The sequence is however contingent on a horse continuing to perform to enable the reinforcement to occur (Houpt, 1995). Initially, a horse will not associate its behaviour with the reinforcement and in further presentations errors will continue to be made until the desired response occurs again. Eventually the relationship between the action and the reinforcement becomes conditioned. Instrumental conditioning paradigms can teach horses to push levers for a food reward and investigate their sensory capabilities and environmental preferences e.g. push a panel when they hear a sound and turn on heaters when it's cold (Meyers & Mesker, 1960; Houpt & Houpt, 1995; Kiley Worthington, 1977).

The above analysis of learning paradigms is helpful in placing the individual discrimination tests in context. As it has shown that horses can be influenced in their learning, the following chapter investigates different reinforcement contingencies and their effects on establishing a learning curve.

CHAPTER 4

REINFORCEMENT CONTINGENCIES

Learning is considered to be an incremental process as the strength of an animal's response depends solely on the number of times the stimuli are reinforced – generally, the more often a behavior is reinforced, the stronger the response becomes (Spreat & Rogers Spreat, 1982). The reinforcement contingencies effective in producing a modification in the horse's behavior are: positive reinforcement, which is often used in conjunction with fixed and variable ratios and interval schedules: negative reinforcement: punishment and extinction (Lehner, 1996).

4.1 Positive Reinforcement

A positive reinforcer rewards behaviour after the desired response has occurred and increases the probability of the response occurring again. Positive reinforcement takes two forms, primary positive and secondary positive reinforcement. Primary reinforcers fulfil the horse's basic needs e.g. water, food, return to herdmates (Mills & Nankervis, 1999) and secondary reinforcers depend upon the animal's perception of a pleasurable stimulus e.g. vocal praise, pat, scratch on the withers or ultimately stopping the training session (Fiske & Potter, 1979). Secondary reinforcers are not primarily reinforcing but through paired association with primary reinforcers they gain reinforcement properties e.g. the presentation of a new secondary reinforcement e.g. verbal praise and an appropriate tone to the voice is followed by a familiar primary reinforcement e.g. food (Arrowsmith Brown, 1998). After a number of pairings the horse associates the voice with the rewarding properties of the food; reports suggest that verbal praise used carefully and consistently enables rapid learning and also encourages horses to perform for praise (Alferink, Crossman & Cheney, 1973). One study using primary positive reinforcers found the rewards enhanced performance although it suggests secondary positive reinforcers are more practical within equine training (Hagerbaumer, 1995). The benefit of ensuring the horse understands both forms of positive reinforcement is that when food is used as a reinforcer, a delay between the occurrence of the desired behaviour and administration of the food may occur. Praise used in conjunction with the food reinforcer ensures the behaviour is immediately reinforced (Miller, 1996b) as in order to ensure the reinforcement offers maximum effectiveness it should quickly follow the behaviour. Horses cannot respond to delayed reinforcement and research has shown that the optimum time for reinforcing instrumental behaviour is less than half a second after every desired response occurs (Blake, 1977; Rees, 1997). If the reinforcement is delayed by a couple of seconds then other behaviours may be inadvertently rewarded (Voith, 1986).

4.2 Schedules of reinforcement

There are predominantly two schedules in which to present (positive) reinforcement methods, referred to as continuous and intermittent schedules. Within the intermittent schedule two further categorizations can be made: ratio (number of responses between reinforcement) and interval (time between reinforcements).

4.2.1 Continuous reinforcement schedule

Continuous reinforcement is normally involved in conditioning a new response by positively rewarding every slightest attempt towards the required behaviour. This technique has been shown to be the fastest method of conditioning desired behaviour in rats. However, once the desired behaviour has been conditioned the schedule of reinforcement should be changed to one of intermittent reinforcement (Dougherty & Lewis, 1991).

4.2.2. Intermittent reinforcement schedules

An intermittent reinforcement schedule involves positively reinforcing a certain number of responses, in either a fixed or variable ratio and interval schedules. Reinforcing a set number of responses is known as a fixed ratio (FR) schedule e.g. every 5th response and a fixed interval (FI) schedule e.g. every 5 minutes. A variable ratio (VR) schedule is based upon a varying number of responses before reinforcement e.g. on the 3rd, 7th, 11th response and a variable interval (VI) schedule relates to random duration of time. Both FR and VR schedules produce relatively good results with regards to encouraging the desired response, but FI and VI schedules can produce different response rates (Tarpy, 1975). Meyers & Mesker (1960) found that horses could respond to different fixed ratio and fixed interval positive reinforcement schedules. They reported that few reinforcements were required under each new presentation schedule to get stable response rates from the horse. Overall, reinforcement using intermittent schedules is shown to be the most effective in ensuring an energetic and motivated response as it is thought that animals work harder to obtain reinforcements when the reinforcement is not on a predictable (continuous) schedule (Bloom, Williams & Metze, 1973).

4.3 Negative reinforcement

A negative reinforcer involves presentation of aversive stimuli before the desired response is performed and terminates the aversive stimuli when the horse makes the desired response (McLean, 1999b). Aversive stimuli in the riding horse are used in both negative reinforcement and punishment, although the two forms of reinforcement are entirely distinct. Aversive stimuli commonly presented in negative reinforcement presentations are pressure from the rider's hand (bridle) and leg (horse's flanks) which, in order to be effective, should be released within a second of the desired response occurring. There are two types of negative reinforcement, referred to as escape and avoidance responses, which are based upon the horse's response to a cue or message. If an escape response is employed the horse's response terminates the aversive stimulus e.g. the horse performs reinback after the aversive stimulus (pressure from rider's legs) is applied. If the horse performs reinback on the first sign of the aversive stimulus the behaviour would represent avoidance training; it is therefore wise to employ a warning message prior to stimulus presentation to provide the horse with an opportunity to avoid the aversive stimulus (Kratzer, 1969). It has been suggested that the quickest method of conditioning a new behaviour is by combining negative and secondary positive reinforcement (Kiley Worthington, 1987) which strengthens the connection between a specific stimulus and the desired response and encourages memorable formation of a correct stimulus – response - reinforcement chain (Tarpy, 1975).

4.4 Punishment

Punishment refers to administration of aversive stimuli after an incorrect response arises in order to suppress or eliminate the response occurring in the future. Aversive stimuli within a punishment situation are suggestive of "cruel, vengeful applications" using a whip or spurs (Miller, 1996c). However, any stimulus that causes discomfort to the horse immediately after a response occurs could be regarded as punishment, even if the punishment is unintentional e.g. negative reinforcement utilizing leg pressure that is not released when a desired response is achieved – this ultimately leads to confusion (Budd, 1996). If punishment is used as a training tool it must be administered consistently, there must be an alternative behaviour available and it must be carried out immediately. Delaying punishment even by a few seconds may lead to the punishable offence being ignored and the wrong response being punished (Hagerbaumer, 1995). It has been shown that under certain circumstances punishment actually increases the strength of the behaviour (Spreat & Rogers Spreat, 1982) e.g. a horse who will not move forward reacts to being smacked with a whip by slowing down and bucking. Evidence of the reoccurrence of behaviour after punishment has also been shown to occur in rats that cease pressing a bar for food when they are punished for doing so, only to continue pressing the bar the following day (Kiley Worthington, 1987). Cooper (1991) found active punishment to be the least successful method of correcting wrong behaviour.

Kratzer, Netherland, Pulse & Baker (1977) discovered that horses subjected to punishment in a single point choice maze made fewer errors than previously when primary positive reinforcement occurred. However they appeared to spend a greater percentage of time deciding which side of the maze to enter, indicating a possible manifestation of anxiety about choosing the wrong turning. The person, object and/or location of administration of the punishment may also become 'punishing' conditioners, with the horse learning to avoid cooperating with the punishing trainer, producing performances that are obedient but suppressed with regards to flare and motivation (Hagerbaumer, 1995) or antagonistic behaviour. If conflict does become a permanent feature in training between man and horse, it is often summarized by the terms dominance and submission which invariably lead to lack of harmony within the training relationship (Huntingford & Turner, 1987).

4.5 Extinction Schedule

Extinction of a particular response often occurs when reinforcement schedules are no longer utilized. This procedure is often used when a horse is initially learning a new response as many incorrect responses occur before the desired response is achieved. If the trainer ignores the incorrect responses and only reinforces the correct responses, the frequency of the incorrect responses will decrease until they are rarely exhibited. At the same time the correct response increases in frequency to replace the incorrect responses (Tarpy, 1975). However, if a response is over stimulated i.e. over practised, the learning curve can decrease and finally become extinct. (Kiley Worthington, 1987).

This chapter has evaluated the most suitable methods and means for reinforcing horses in training situations. The following chapter looks at routine ways in which horses are trained and suggests a different approach.

CHAPTER 5

PRACTICAL EQUINE TRAINING

Many training methods exist to elicit a performance from the horse; however no single method of training the horse to effectively discriminate tactile stimuli and condition appropriate responses is uniformly employed. Presenting tactile stimuli in a manner that evokes a harmonious, symbiotic relationship with no musculoskeletal tension in either horse or rider is of paramount importance (Lester, 1998), yet the incidence of gadgets and prolonged resistant behaviour within many riding horses suggests that the training methods employed may not be as appropriate as the horse industry might believe.

5.1 Stimulus Presentation

Through evolution the horse, as a prey species, has developed a unique perceptivity which allows accurate discrimination, categorization and memory of many forms of visual and tactile stimuli (Miller, 1997a). Training the riding horse to perform a desired response is dependent on conditioning the horse to respond to tactile (cutaneous) stimulation, conveyed by messages (aids), which result in negative reinforcement (pressure) and establish an increasingly consistent (learned) behavioural response (Miller, 1995a). The rider conveys these messages to the horse by combining the hand (on the rein to the bit in the horse's mouth) and leg (on the horse's flanks) in a variety of sequences (Bennet, 1995; Miller, 1995b). The messages should be clear and unambiguous to ensure the horse can respond to the applied pressure quickly enabling the pressure to be relaxed as soon as a response is achieved (Marshall, 1996). The rider must understand the most appropriate manner of applying the messages (and how quickly to release them) in order to initiate and maintain the desired response.

If the stimuli are presented in an appropriate manner and work within the boundaries of the horse's physiological frame response rates should be high (Moffett, 1997). If the aids are not understood or are over applied the horse becomes confused and responds by either ignoring the aids or resisting. Both reactions often evoke the rider to produce a stronger application of the message (Kyrkland, 1997), which is akin to shouting at a foreigner to get them to understand when they don't speak English (Kiley Worthington, 1987; Creiger, 1998).

5.2 Resistance

When a horse understands the required response from particular tactile stimuli sequences and they enjoy their work progress can be rapid. However if the horse does not understand the required response they can behave antagonistically and show resistant behaviours (Moffett, 1997b; Roony, 1985). Decreases in either predictability or controllability present horses with a confusing situation, referred to as 'mismatch concept' (Ewing, Lay & Borel, 1999). Antagonistic behaviour in the riding horse may thus arise from inconsistent or conflicting tactile stimuli where the horse is unable to respond through confusion compounded by negative reinforcement as riders often increase their pressure when the horse does not respond. The horse's primary instinct is to flee from negative reinforcement (pressure from the rider's hands and legs). However, being ridden often disables the horse's ability to flee from a situation, and its secondary instinct is to fight (Tellington Jones, 1996). A clear distinction must however be made between resistance when stimulus presentation initially occurs i.e. conditioning a new response and resistance that continually occurs and escalates into long standing behavioural problems as a result of horse-rider conflict (McLean, 1999b). Horses do not intentionally resist; it is a neurological reaction and as the horse becomes habituated to the stimulus and conditioned to the required response the fight instinct should dissipate (Budd, 1996).

5.3 Type of handling

The effect of positive and negative human/horse interaction and its effect on learning abilities has not been well studied, however many studies have been carried out in farm livestock. These studies have shown that boars, pigs and cattle learn to associate rewarding or aversive elements of the handler and their relative handling procedure (Hemsworth, Price & Borgwardt, 1996) and that aversive handling can evoke a chronic stress response and depressions in growth and reproductive abilities (Hemsworth, Verge & Coleman, 1996). It is well established that animals learn to avoid conditioned stimuli that are paired with aversive events and that through the process of stimulus generalization, the behavioural response of an animal to the aversive handler may extend to all handlers

(Hemsworth, Verge & Coleman, 1996). Any trainer with a preconceived notion concerning their ridden subject often behaves towards the animal with these expectations, inadvertently demonstrating this through body language to the highly perceptive equine. These cues are often acted upon by the equine thus fulfilling expectations by becoming cautious, frightened or attacking (Kiley Worthington & Rendle, 1997). Tarpy (1975) suggests that an increase in positive human intervention within the training programe may benefit horses by increasing informative stimuli, and improving performance in negative reinforcement avoidance learning.

5.4 Gadgets

The British Dressage Group Rulebook (Hartley Edwards, 1990) refers to training aids (gadgets) as 'auxiliaries and adjuncts intended to aid the rider in achieving an improved head carriage in the horse'. Gadgets take many forms e.g. draw reins, chambon and de-gogue (see Appendix 2). Appendix 6 illustrates practically and theoretically the effect of draw reins upon the horse's physiological frame, with possible interference in the spontaneous feedback of impulses and responses required in the learning process (Bentley, 1995). The earliest transcriptions of training the riding horse are depicted in 430–355 BC in the writings of Xenophon (Athenian philosopher and cavalry leader) who observed "the head to be advanced and the neck not short; let him (horse) have a high poll and a head light", suggesting freedom to the head and neck with no restrictions imposed upon them (cited in Morgan, 1993). The aim of training the riding horse is to achieve a responsive ride that shows increased balance and suppleness which should be achieved without force (Denoix & Pailloux, 1998)) or rider strength (Barlow, 1996).

Unfortunately, the use of gadgets that "force the horse to comply with their rider's demands" can be seen within the training programmes of some of the top riders (Dodwell, 1995) where bullying sometimes replaces real communication (Kilby, 1987). Hartley-Edwards (1990) stated that "gadgets are for experts and experts don't use them" . However many reports suggest this to be untrue. Kendal (1996) illustrates the widespread use of gadgets such as draw reins in the competition world where many high profile riders applaud their use. When 'successful competition riders' publicly broadcast their approval of such techniques it can prove influential on those riders seeking to attain similar success.

The widespread use of gadgets questions whether there is a flaw in the user's system of training and whether gadgets would be necessary if a thoughtful, unambiguous training system existed (Dodwell, 1995).

Bentley (1996) suggests that the competition world often produces horses that mimic "switched off machines", an attitude that develops as a coping mechanism to the mentally and physically restricted, disciplined training programs they endure. However, Britton (1995) claims that gadgets are a useful piece of equipment which make the 'job' of training easier. She also states that gadgets may even help the horse to understand the trainer's requirements. Hartley-Edwards (1996) also states that 'one man's gadget is another man's system', which may suggest that the entire ethos of gadget application within the training of the riding horse applies to riders and trainers who lack knowledge on the psychological comprehensive abilities of equines to learn and perform. The application of a gadget therefore appears the only option when the horse does not perform through a lack of understanding of the presented stimuli; the horse becomes trained through dominance, punishment and force rather than a consistent, concise training system.

Training the horse encourages athleticism and a more gymnastic manner of moving. The aim should be to develop the natural ability of the horse to move with greater ease, balance and elegance. All movements required of a dressage horse are based on those he would naturally perform; how this training is achieved, however, is a matter of contention (Kidd, 1977). One trainer, whose training system is based on the application of clear, concise, unambiguous messages is David Dodwell who claims to show how and why all gadgets are unnecessary within the education process (Dodwell, 1995).

5.5 The Dodwell Horse Morse Code

Dodwell claims to have developed a complete system of training the riding horse by enhancing rider – horse communication through a system he has called the Dodwell Horse Morse Code. The system originated from the lack of clarity and consistency and the many anomalies exhibited within most traditional equine training systems. It is based upon the teachings of 5 great 'past-masters' (Appendix 6). The system comprises 15 unequivocal messages (aids) composed of specific combinations of rider's hand and leg, which are taught carefully and clearly, reinforcing only the desired response (Dodwell, 1995). Conditioning the horse to respond to all 15 messages produces a dressage horse capable of performing all required Grand Prix and high school movements, although most riders' activities require only 9 of them. (Dodwell, 1995). The messages provide the horse with specific, consistent tactile stimuli ensuring each message presentation possesses the same clarity as the Morse Code – allowing equine discrimination capabilities to be optimized. The system fulfills the Federation Equestre Internationale (FEI's) seven basic requirements for the dressage horse, it strongly opposes the use of gadgets and claims to be almost 'foolproof', benefiting all horse and rider combinations, regardless of the equines age/type/breed/level of training or previous training system used (Dodwell, 1995).

5.6 Emotion and motivation – effects on training

The existence of emotions in animals is a common subject of debate and although anthropomorphism should be guarded against, it is believed that all mammals possess emotions and emotional reactivity (Ewing, Lay & Borel, 1999; Toates, 1997). It is also generally accepted that the measurement of motivation is very important when assessing animal welfare (Petherick, Sutherland, Waddington & Rutter, 1991). The effect of self esteem (emotional confidence) and motivation in humans is taken for granted but self-esteem and motivation in the horse training environment is less recognized. Professional dog trainers have a good understanding of the correlation between positive attitude and performance as dogs thrive on affection and praise (Loch, 1998) and studies in rats (Potter, Yeates and Fiske, 1977) and elephants (Koene & Jansen, 1994) have also shown that the attitude of the animal is important to its speed of learning (Potter et al, 1977). The latter study also indicated more experienced handlers had sufficiently fewer training problems than less experienced handlers – based on improved communication skills by the handlers rather than increased fear of reprimand or lack of respect. It could thus be deduced that the emotional reactivity of a horse may affect its performance and that motivation to perform must be encouraged.

5.7 Session Duration

The number of trials per training session appears to vary depending on the type of training method used (McCall, Salters & Simpson, 1993) although it is unclear which method best suits which trial replicate. Most equine training literature suggests repetition to improve performance in the horse; however, massing trials and prolonged practice can lead to inefficient learning as overtraining can cause horses to become demotivated and to perform in a mediocre fashion (McCall, 1988; Potter & Yeates, 1990). Training programmes are characterised by:

i) the number of replicates per training session; this appears to vary enormously as shown in a variety of studies involving discrimination tasks e.g. 5 trials (replicates) (Baker & Crawford, 1986), 20 trials (Baker, Potter, Friend & Beaver, 1983) and 30 trials (Fiske & Potter, 1979) and equine avoidance conditioning e.g. 10 trials (Haag, Rudman & Houpt, 1980) and 20 trials (Rubin, Oppegard & Hintz, 1980) per training session.

ii) the interval between training sessions. The importance of breaking training sessions up into shorter sessions with longer intervals was emphasized in one study where ponies taught to avoid a mild electric shock in 1, 2 and 7 day a week sessions learnt to avoid the shock at a faster rate when trained once a week – although the total training time was consequently much longer (Budiansky, 1997; Houpt, 1995). Houpt and Salthouse (1996) found spacing training bouts to be more efficient than crowding them into a few days as the biomechanical process of learning does not require speed; it requires consolidation.

Rubin et al (1980) found that temporal distribution of training trials positively influenced equine learning abilities although varying the total number of trials given within each training session (replicates) did not affect learning performance. Combining this knowledge and the number of training sessions enables application of a suitable training schedule for horses to optimize performance.

The following chapter describes the formulation of a suitable training methodology for a series of visual and tactile discrimination tests, using information gained from this and previous chapters.

CHAPTER 6

MATERIALS AND METHODS

6.1 Materials: Trial Horses

Ten horses (H1-10) in total were used for the tests. For reasons explained in Chapter 8, only H1-8 were used in the visual discrimination test and H1-10 used in the tactile discrimination test. The subjects were chosen on availability and physiological health; their individual details are shown in Appendix 8. Independent assessors conducted emotion and training scores for each subject prior to the visual and tactile tests (see Appendix 9). Before commencing the tactile discrimination tests all subjects were tested for soundness in trot on a straight line; reinback uses the same sequence of legs as trot so soundness in trot should indicate an ability to reinback (Caden Parker, 1999). The subjects were also assessed on their ability to move backwards with a saddle on to ensure no physiological factor would inhibit them from stepping backwards during the test.

METHODS

6.1 Pilot Study

A series of pilot studies were conducted on four horses during the months of December 1998 and January 1999 in order to establish the most suitable methodology for both visual and tactile discrimination tests. These horses were not used in the final discrimination tests. Findings from the pilot study are shown in Appendix 10 where the reasons for the chosen methodology are explained in greater detail. However due to the large amount of information each section of the pilot study is lettered (A-O). In the following description of the actual discrimination tests, any reference to the pilot study will be made using these letters.

6.2 Discrimination Tests

From information gathered during the pilot studies, a series of tests were devised to ensure the best chance of establishing a conditioned response to the offered stimulus, based on the instrumental learning paradigm (see Chapter 3). The tests were presented to the subjects over a series of three weeks and the schedule is shown in Table 1.

Table 1 Test schedule for visual and tactile discrimination tests

	WEEK 1		WEEK 2		WEEK 3	
	WED	THUR	WED	THUR	WED	THUR
Visual Test	Tests 1-6		Test 6		Test 6	
Tactile Test		Test 7A Test 7B		Test 7A Test 7B		Test 7A Test 7B

6.3.1. Visual Discrimination Test

The experimental design was initially based upon visual discrimination tests cited in Salthouse (1996) and Allin (1998). However, after conducting the pilot studies it was concluded that the most suitable protocol should initially comprise a series of 5 progressive tests, referred to as Tests 1–5. These would progressively introduce the subjects to the card stimuli and offer an opportunity to recognise the star card stimulus as the desired response. This would optimise performance in the actual 'visual discrimination test', referred to as Test 6, based on a continuous changeover design (Appendix 10: Section I).

Table 2 A summary of the formation of the visual discrimination test

H1-8	VISUAL TEST	Appendix 10 Section
STIMULUS	Four white A3 cards (portrait presentation): two blank cards; one black star card (intended conditioned stimulus); one black moon card	B
LOCATION	Subject's own stable	C
STAFFING LEVEL	Handler inside the stable and an assistant outside the stable	
MEASUREMENT	Total number of errors made and total time taken to reach test criterion; when applicable (Test 2) the card chosen was recorded	D
REINFORCEMENT	i) Secondary positive, using vocal praise ii) Primary positive using a small carrot both on a continuous reinforcement schedule	E

The visual discrimination tests are described below:

Test 1 One blank card presented to the subject. The subject is reinforced immediately as shown in Table 2 when the card is touched. This familiarizes the response reward scenario and is repeated for five attempts (Appendix 10: Section F).

Test 2 Two blank cards presented to the subject. The subject is reinforced when either card is touched and in addition the side the chosen card is on is recorded. This enables detection of side bias and is repeated for five attempts.

Test 3 Star card present on the subject's right, blank card present on the left. The subject is positively reinforced when touching the right card only. This is very important as it gives the subject an opportunity to imprint onto the star stimulus card. This is repeated for ten attempts (Appendix 10: Section G).

Test 4 Star card present on the subject's left, blank card present on the right. The subject is positively reinforced when touching the left card only. This evaluates whether side preference is occurring i.e. if the subject continually responds to the right (blank) card rather than the star stimulus now present on the left. This is repeated for ten attempts.

Test 5A Moon card present on the subject's right, blank card on the left. The subject is **not** positively reinforced. This is repeated for five attempts (Appendix 10: Section H).

Test 5B Moon card present on the subject's left, blank card on the right. The subject is **not** positively reinforced. This should be repeated for five attempts.

Test 6 Continuous Changeover Design: both star and moon cards are present and rotated on each attempt following the stated sequence (Appendix 10: Section I). The subject is positively reinforced when touching the star stimulus **only**, regardless of its right or left position. This follows the same sequence, being repeated for 16 attempts.

Test 6: Weeks 2 and 3

Continuous Changeover Design is the **only** test repeated in weeks two and three and follows exactly the same rotation sequence (Appendix 10: Section I), criteria for response (Appendix 10: Section D) and method of reinforcement (see Table 2).

Information on how horses perceive visual stimuli (see Chapter 2) highlighted the importance of the position of visual stimuli. The positions of the assistant, cards, handler and subject were tested extensively during the pilot studies in order to optimise success rates. The following criteria were therefore applied during the final visual discrimination test:

i) The assistant stands 1.0 metre outside the stable, centrally facing the stable door (bottom door closed top door open).

iii) The assistant holds the cards at arm's length, resting them on top of the stable door with a gap of approximately 30 cm between them (to ensure that two cards are clearly seen but stop the horse from pestering the assistant).

iv) The handler stands 1.0 metre inside the stable, facing towards and to the far edge of the stable door.

v) The subject wears a headcollar and is positioned between the handler and the wall facing towards the door at a distance of 1.0 metre. Prior to the beginning of each attempt the subject is restrained from moving towards the door to ensure that the cards are always presented to all subjects at the same distance.

v) The handler remains motionless whilst the stimuli are presented (to avoid 'cues' to the horse). The handler also positioned so as not to inhibit the subject's vision and movement.

Recording Results

The results of each test were recorded on separate sheets. Appendices 11-16 show the format of these. The handler counted the total number of errors made and measured the time taken to reach test criterion using a stop-watch. During reinforcement, the handler passed this information on to the assistant who recorded it on the appropriate sheet.

6.3.2 Tactile Discrimination Test

Formulating a suitable protocol for the ridden discrimination test presented some difficulties as very few research studies exist where statistically valid and objective ridden methodology is available. Consequently, a reliable ridden methodology had to be devised that would generate the required data. The Dodwell Horse Morse Code system of training was used because the method of training offered specific, consistent messages from rider to horse. This was necessary in order to quantify the rider's messages and establish consistency for each subject over the duration of the experiment.

Tactile stimuli were presented in the form of rider's hand and leg messages to discover if the horse could discriminate a reinback message (Test 7B) from an initial sequence of messages including "walk forwards" (Test 7A) and then recognize and retain the message over the three weeks. The sequence of messages in 7A was repeated five times (Appendix 10: Section J).

Table 3 A summary of the formation of the tactile discrimination test

H1-10	TACTILE TEST	Appendix 10 Section
STIMULUS	Dodwell Horse Morse Code, giving a series of messages from the rider to the horse *	J
LOCATION	Writtle College indoor riding arena	K
RECORDING METHOD	Lapel microphone/tape recorder, cassette recorder, video camera	
MEASUREMENT	Total resistances made, number and type of reinback attempts using an algorithm and the total time taken to reach test criterion	L
REINFORCEMENT	Negative reinforcement: release of pressure from rider applying the reinback message Secondary positive reinforcement: vocal praise and pat on neck	M

*Each applied message has its own number held within the Dodwell Horse Morse Code Training System therefore combinations of messages may not always fall in numerical order.

The tactile discrimination tests, including the message series, are described below:

Test 7A Conducted at letters A, E, C, B and A in the indoor riding arena utilizing messages 6,1, 3 and 4. The messages should run consecutively and each series applied five times (Appendix 10: Section J). The rider's hands always remain closed around the reins 3 inches above the horse's withers and the rider's legs remain in the normal position by the horse's girth.

Message 6: **'Warning'**

This warns the horse that on their next stride a change of message is coming. The lightest of taps with both legs on the girth but NO movement from the hands i.e. still reins.

Message 1: **'Walk forwards'**

Tapping once with the calf of the right leg on the girth

Message 3: **'Slow down and collect'**

Small squeezes (and release) on the left rein and simultaneous tap with the calf of the right leg (Appendix 10: Section N). For the duration of the research very light taps as initially the horse may perceive the leg tap as a requirement to increase the pace – not decrease.

Message 4: **'Halt'**

Increase pressure with both legs in the normal position and small squeezes on both the reins in a slightly upward direction (to decrease pressure on the horse's mouth and avoid resistance). The pressure from the rider's hands and legs is released as soon as the halt is established (Dodwell, 1995).

Test 7B Test 7B should run immediately after the fifth attempt of test 7A and should commence at letter E in the indoor riding arena. Messages 3 and 4 are re-applied and the halt maintained for 2 seconds before the rider applies Message 9.

Message 9: **'Reinback'**

a) 'Warning' with a very light squeeze of both reins as legs warn of a forward moving change. The warning is administered by squeezing and releasing the reins consecutively 4 times and on the fourth release the hands remain still.

b) Both the rider's lower legs slide back 4 inches with a firm contact. The rider's legs remain in position until the horse has finished responding or a period of 30 seconds has elapsed – to avoid over stimulating the mechanoreceptors (Kiley Worthington, 1987). Both the rider's legs then simultaneously slide back to their normal position on the girth and Messages 6 and 1 are re-applied (Appendix 10: Section O).

If the desired result is not achieved the subject walks around the school without halting, returning to halt at letter E to commence another attempt. This is repeated until the desired result is achieved. However a maximum of five attempts should be made and if the desired result is still not achieved, the sixth attempt requires assistance from the observer (Appendix10: Section J). When assisting attempt six the observer stands facing the horse with the hand resting on the horse's point of shoulder. As the rider applies Message 9 the observer pushes back on the horse's shoulder and stops when two diagonal strides backwards are achieved. Once this is accomplished the rider applies positive and negative reinforcement and returns the legs to the normal position at the girth. If this procedure is necessary, it could be argued that classical conditioning is being introduced. However, as the observer assisting is not inducing the flight instinct, the overall effect of the instrumental conditioning should not be compromised.

Recording Results

The most important element of Test 7B was the method of recording objective rather than subjective data. This was thoroughly investigated and achieved by means of:

i) a lapel microphone and tape recorder attached to the rider, verbally recording resistances 'felt'

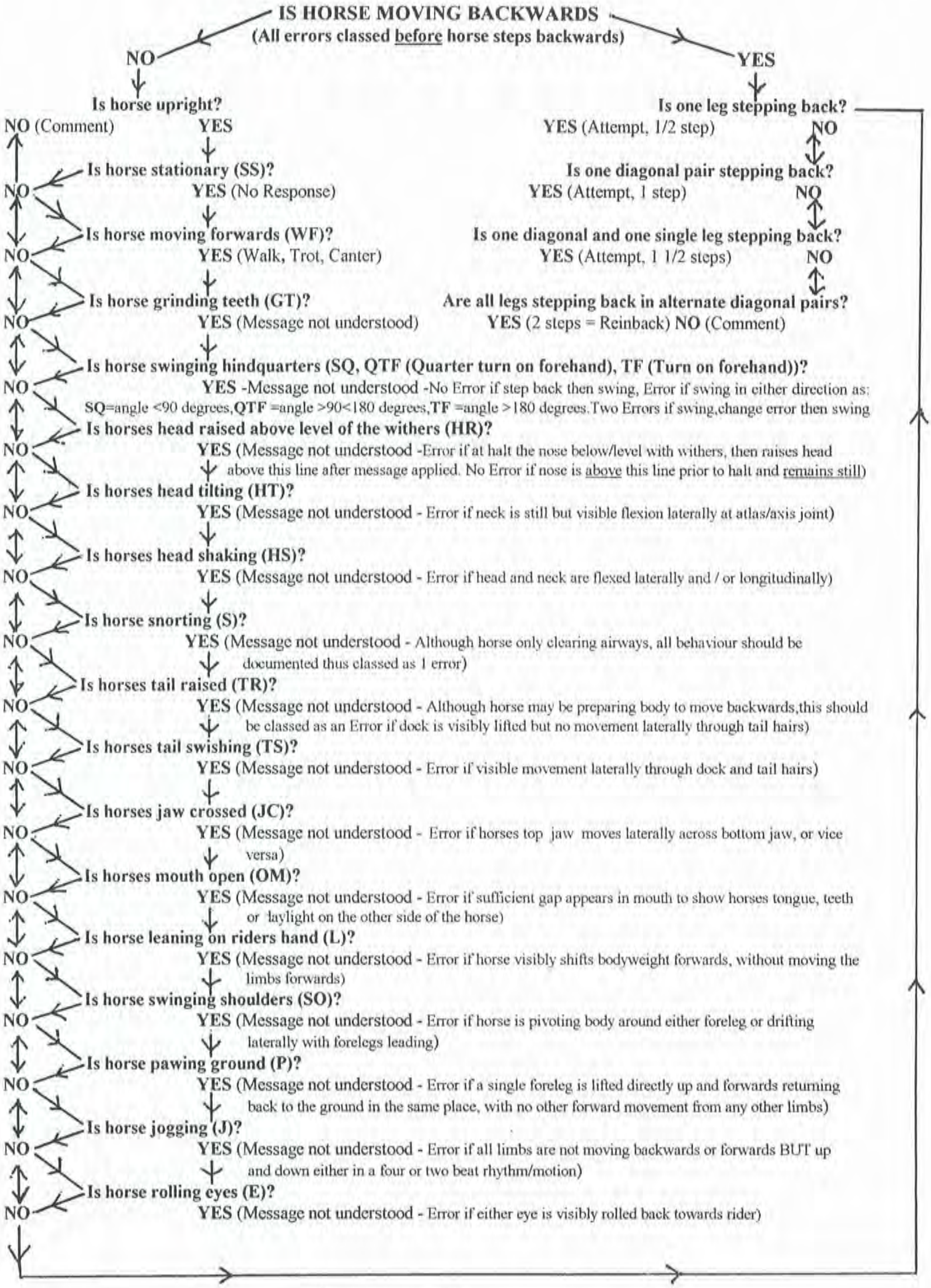
ii) an independent observer positioned opposite E, operating a hand held tape recorder, to record observed resistances and a stop watch to record time duration (see Appendix 17)

iii) a video camera on a tripod, recording all behavioural events

To ensure the method of recording the time duration of an attempt remained the same for all subjects, initially the rider told the observer when to commence and cease the stop-watch; however it was felt that this might affect the subject's response by allowing a pre-vocal warning so it was not used. It was decided instead that the stop-watch should commence as soon as the rider's legs moved 4 inches back (reinback message) and cease when the rider's legs moved 4 inches forwards to the girth area (end of message). The video tape and audio tape were analysed in conjunction with the algorithm (Appendix 10: Section L) after the conclusion of the test. The algorithm appears on the following page.

The following chapter analyses the data which was collected during the visual and tactile discrimination tests described above.

An algorithm defining possible behaviours that may be experienced when conditioning the horse to the Reinback response



IS HORSE MOVING BACKWARDS
(All errors classed before horse steps backwards)

NO

Is horse upright?
NO (Comment) **YES**

Is horse stationary (SS)?
NO **YES** (No Response)

Is horse moving forwards (WF)?
NO **YES** (Walk, Trot, Canter)

Is horse grinding teeth (GT)?
NO **YES** (Message not understood)

Is horse swinging hindquarters (SQ, QTF (Quarter turn on forehand), TF (Turn on forehand))?
NO **YES** -Message not understood -No Error if step back then swing, Error if swing in either direction as: SQ=angle <90 degrees,**QTF** =angle >90<180 degrees,**TF** =angle >180 degrees.Two Errors if swing,change error then swing

Is horses head raised above level of the withers (HR)?
NO **YES** (Message not understood -Error if at halt the nose below/level with withers, then raises head above this line after message applied. No Error if nose is above this line prior to halt and remains still)

Is horses head tilting (HT)?
NO **YES** (Message not understood - Error if neck is still but visible flexion laterally at atlas/axis joint)

Is horses head shaking (HS)?
NO **YES** (Message not understood - Error if head and neck are flexed laterally and / or longitudinally)

Is horse snorting (S)?
NO **YES** (Message not understood - Although horse only clearing airways, all behaviour should be documented thus classed as 1 error)

Is horses tail raised (TR)?
NO **YES** (Message not understood - Although horse may be preparing body to move backwards,this should be classed as an Error if dock is visibly lifted but no movement laterally through tail hairs)

Is horses tail swishing (TS)?
NO **YES** (Message not understood - Error if visible movement laterally through dock and tail hairs)

Is horses jaw crossed (JC)?
NO **YES** (Message not understood - Error if horses top jaw moves laterally across bottom jaw, or vice versa)

Is horses mouth open (OM)?
NO **YES** (Message not understood - Error if sufficient gap appears in mouth to show horses tongue, teeth or daylight on the other side of the horse)

Is horse leaning on riders hand (L)?
NO **YES** (Message not understood - Error if horse visibly shifts bodyweight forwards, without moving the limbs forwards)

Is horse swinging shoulders (SO)?
NO **YES** (Message not understood - Error if horse is pivoting body around either foreleg or drifting laterally with forelegs leading)

Is horse pawing ground (P)?
NO **YES** (Message not understood - Error if a single foreleg is lifted directly up and forwards returning back to the ground in the same place, with no other forward movement from any other limbs)

Is horse jogging (J)?
NO **YES** (Message not understood - Error if all limbs are not moving backwards or forwards BUT up and down either in a four or two beat rhythm/motion)

Is horse rolling eyes (E)?
NO **YES** (Message not understood - Error if either eye is visibly rolled back towards rider)

YES

Is one leg stepping back?
YES (Attempt, 1/2 step) **NO**

Is one diagonal pair stepping back?
YES (Attempt, 1 step) **NO**

Is one diagonal and one single leg stepping back?
YES (Attempt, 1 1/2 steps) **NO**

Are all legs stepping back in alternate diagonal pairs?
YES (2 steps = Reinback) **NO** (Comment)

CHAPTER 7

RESULTS

During the course of the visual and tactile discrimination tests, individual scores were obtained for all horses tested (Appendices 11-16). A full analysis of this individual data is not possible within the constraints of this study. Consequently, scores have been aggregated to obtain an overall group response. This still allows conclusions to be drawn about the group's recognition and retention of visual and tactile stimuli. The program used for statistical analysis was Unistat Version 4.0, 1993.

Initial Evaluation of Results

Tables 4-6 show the groups overall total, mean, range and standard deviation values for the number of errors and time duration (seconds) recorded throughout the visual and tactile discrimination tests. The individual visual discrimination results are shown in Appendices11-15, the tactile discrimination test results in Appendix 16 and the video evidence in Appendix 17.

Table 4 **Visual discrimination tests: total, mean, range and standard deviation values on number of errors**

ERRORS							
TESTS	**ONE**	**TWO**	**THREE**	**FOUR**	**SIX (1)**	**SIX (2)**	**SIX (3)**
TOTAL	44	25	58	56	73	49	84
MEAN	5.5	3.125	7.25	7	9.125	6.125	11.125
RANGE	0 – 13	0 – 8	0 – 13	0 –33	1 - 21	4 –11	5 - 7
STANDARD DEVIATION	5.2	3.0	5.2	17.6	6.0	2.0	3.4

H1 - 8

Table 5 **Visual discrimination tests: total, mean, range and standard deviation values on time duration (seconds)**

	TIME						
TESTS	**ONE**	**TWO**	**THREE**	**FOUR**	**SIX (1)**	**SIX (2)**	**SIX (3)**
TOTAL	469	290	346	259	367	560	472
MEAN	60	36.25	43.2	32.32	45.9	70.05	59
RANGE	9 – 100	10 - 86	22.6 – 65	10 – 78	33 - 55	35.4 – 116	27.9 - 99
STANDARD DEVIATION	28.5	24.0	13.0	24.3	7.4	31.3	23.7

H 1 - 8

Table 6 **Tactile discrimination test: total, mean, range and standard deviation values for number of errors and time duration (seconds)**

	ERRORS			TIME		
WEEKS	**ONE**	**TWO**	**THREE**	**ONE**	**TWO**	**THREE**
TOTAL	110	43	45	286	133	82
MEAN	11	4.3	4.5	28.6	13.3	8.2
RANGE	0 – 22	1 – 14	1 – 14	4 - 55	2 – 59	2 – 23
STANDARD DEVIATION	5.7	2.4	3.8	15.5	15.7	6.1

H 1-10

Total errors and times for week 1, 2 and 3 are also represented graphically in Table 7 for Test 6 and Table 8 for Test 7.

Table 7 The total number of errors and time (seconds) in Test 6, weeks 1, 2 and 3

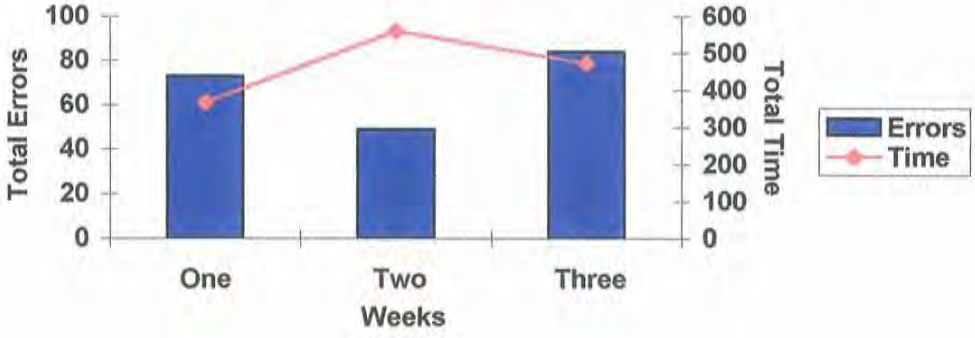
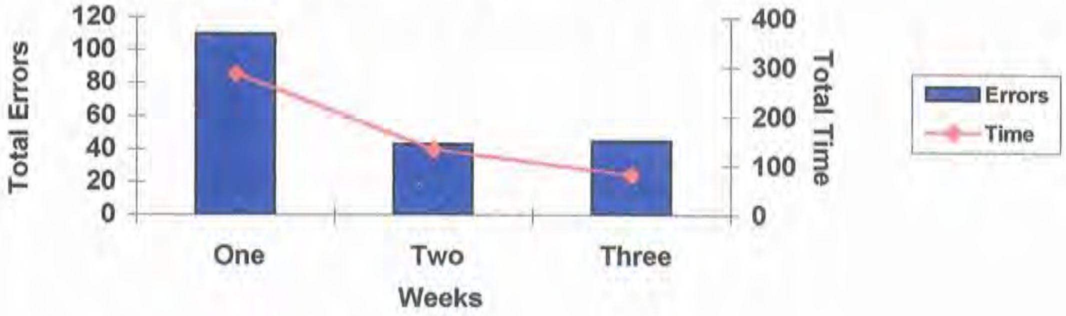


Table 8 The total number of errors and time (seconds) in Test 7, weeks 1, 2 and 3



Chi^2 Analysis: Tests 2 - 7

Table 9 shows the results obtained from chi^2 analysis on Tests 2 - 7. Chi^2 analysis on Test 2 (Appendix 18) compared the frequency of subjects responding to the right card (blank stimuli) against a null hypothesis predicting *no difference between right or left card preference with results due to random chance,* to establish the existence of side preference. Chi^2 on Test 3 (Appendix 19) compared the frequency of subjects responding to the star stimulus card on the right with zero errors to a null hypothesis predicting *no difference between right or left card preference, with results due to random chance not side preference or star stimulus recognition.* Chi^2 on Test 4 (Appendix 20) compared the frequency of responses to the star stimulus card on the left with zero errors to the same null hypothesis as Test 3. These chi^2 results may establish whether responses were due to side preference or star stimulus recognition. Chi^2 analysis on Test 6 (Appendix 21) compared the total number of errors in each series set within weeks 1, 2 and 3, against a null hypothesis of *no differences between the total number of errors made in individual series sets within each week, with results due to random chance.* Chi^2 analysis on Test 7 (Appendix 22) compared the total number of errors and total time duration (seconds) in individual weeks to a null hypothesis *of no differences between total number of errors made and time taken over weeks one, two and three, with results due to random chance.* Results from chi^2 should be used in conjunction with other methods of analysis in order to establish the distribution of the errors/time during individual tests (using relative cumulative frequency) and their different values between the different discrimination tests.

Table 9 Chi^2 results summary for Tests 2–7

TESTS	TWO	THREE	FOUR	SIX (W1)	SIX (W2)	SIX (3)	SEVEN (Error)	SEVEN (Time)
EXPECTED	2.5	5	5	18.25	12.25	21	66	167
DEGREES FREEDOM	7	7	7	3	3	3	2	2
CHI SQUARED	13.6	13.0	25.4	9.5	5.7	7.8	44	135
TABLE VALUE	14.07	14.07	24.32	7.815	6.125	7.815	15.20	15.20
SIGNIFICANCE	NS	NS	P<0.001	P<0.05	NS	P<0.05	P<0.001	P<0.001

Relative Cumulative Frequency: Tests 1-7

Relative cumulative frequencies were calculated to show the distribution of errors and time within the visual and tactile discrimination tests:

Test 1: total errors and time for each replicate - Table 10 (Appendix 23)

Test 2: total errors and time for each replicate - Table 11 (Appendix 24)

Test 3: total errors and time for each replicate - Table 12 (Appendix 25)

Test 4: total errors and time for each replicate - Table 13 (Appendix 26)

Test 6: total errors for each series set over week 1, 2 and 3 - Table 14
total time - Table 15 (Appendix 27)

Test 7: total errors for each replicate over weeks 1, 2 and 3 - Table 16
total time - Table 17 (Appendix 28)

Table 10 The Relative cumulative frequency of total errors and time in Test 1

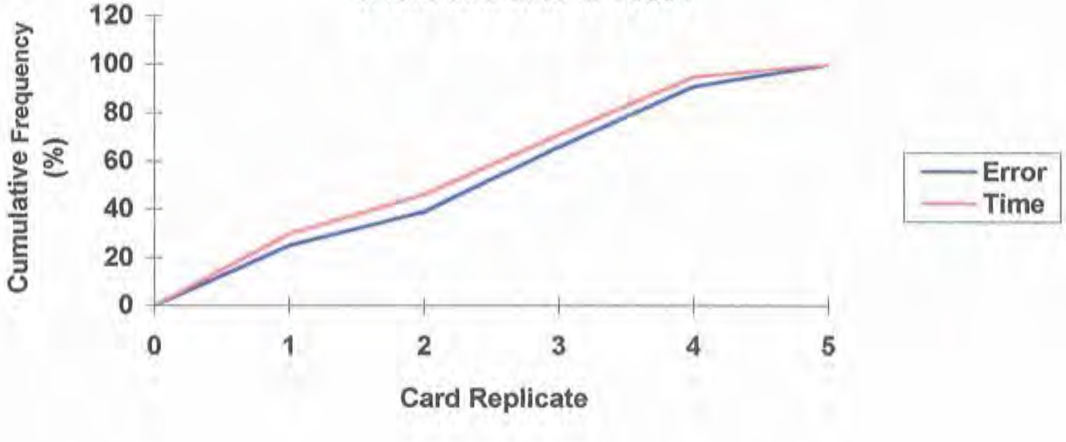


Table 11 The Relative cumulative frequency of total errors and time in Test 2

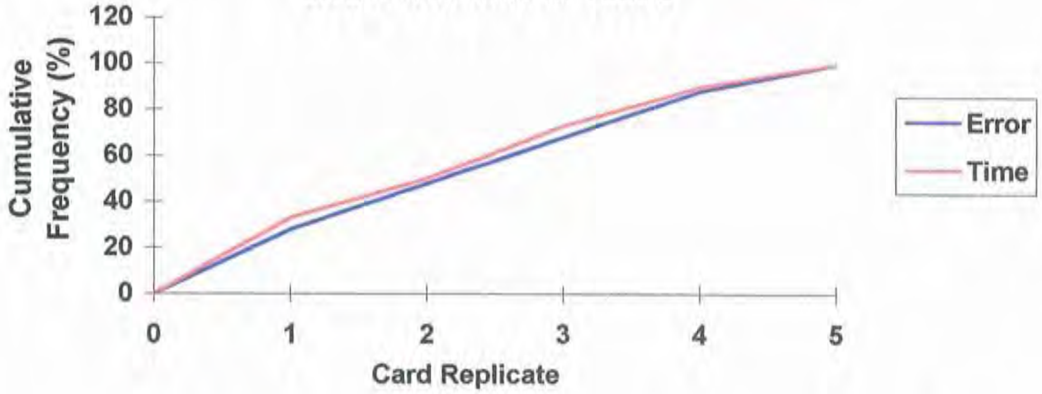


Table 12 The Relative cumulative frequency of total errors and time in Test 3

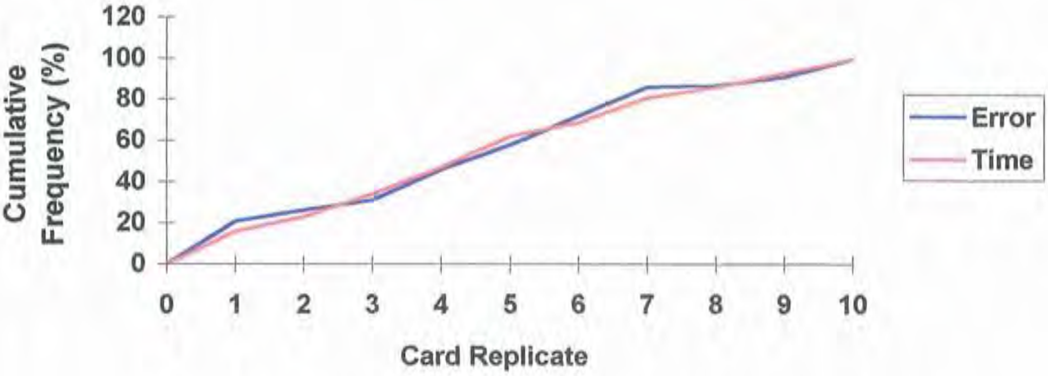


Table 13 The Relative cumulative frequency of total errors and time in Test 4

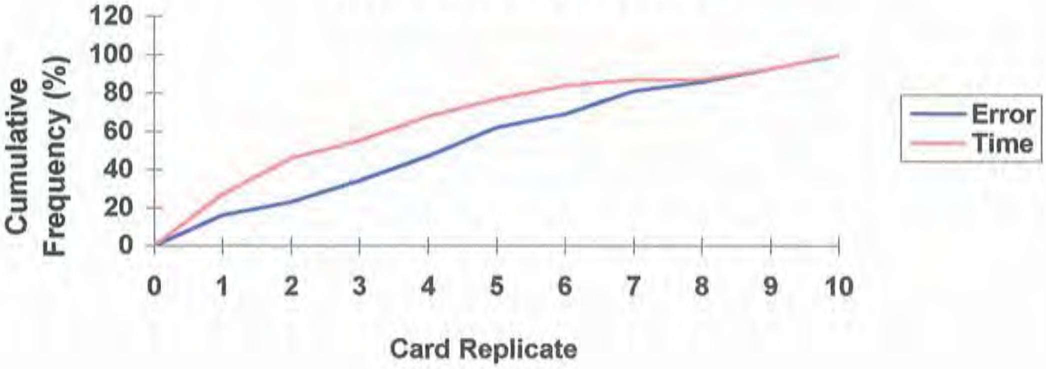


Table 14 The Relative cumulative frequency of total errors in Test 6, weeks 1, 2 and 3

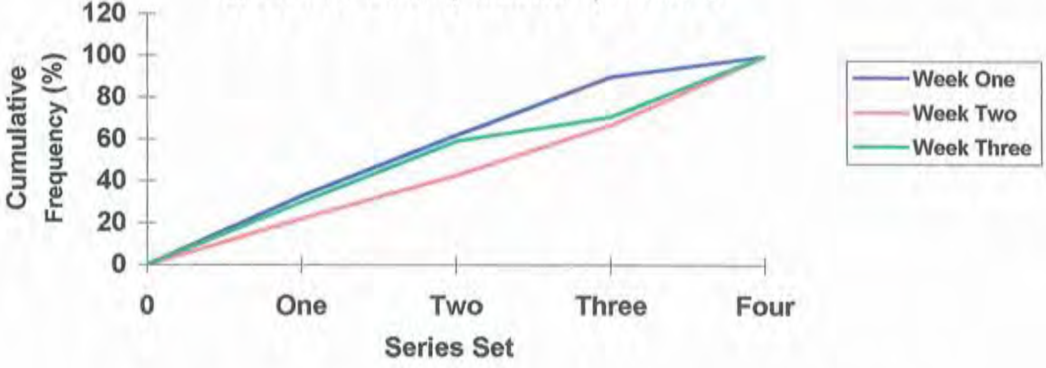


Table 15 The Relative cumulative frequency of total time (seconds) in Test 6, weeks 1, 2 and 3

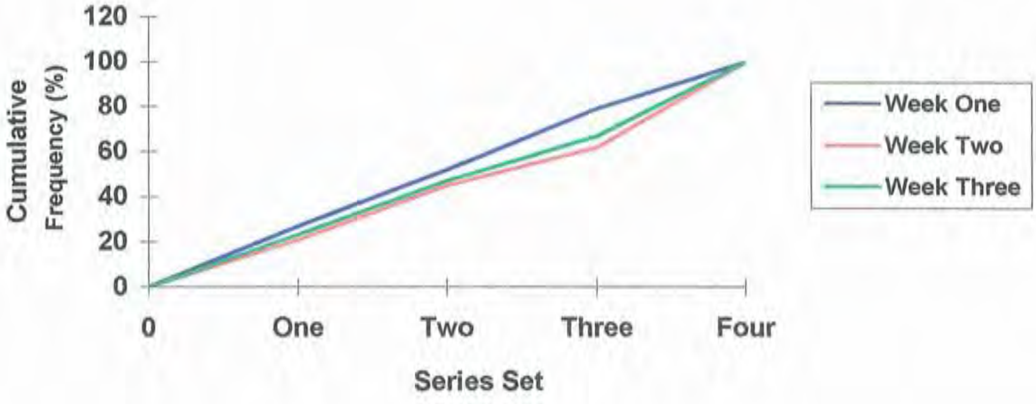


Table 16 The Relative cumulative frequency of total errors in Test 7, weeks 1, 2 and 3

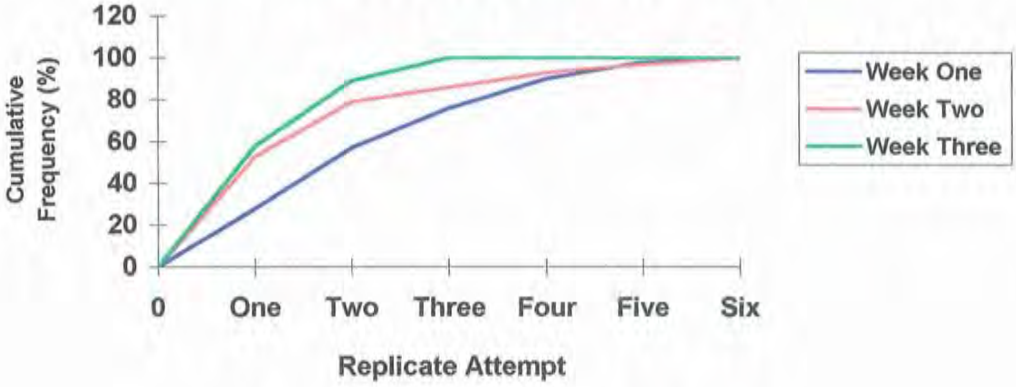
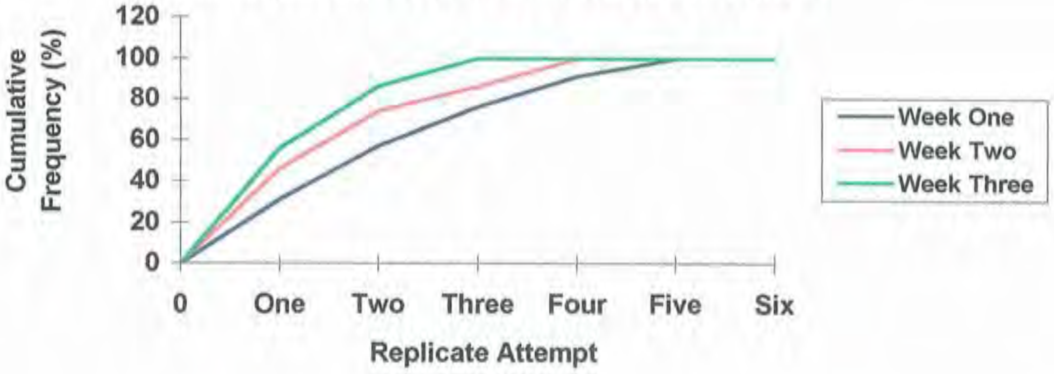


Table 17 The Relative cumulative frequency of total time (seconds) in Test 7, weeks 1, 2 and 3



Analysis of Variance (ANOVA): Tests 1, 6, 7

One way analysis of variance analysed total error patterns (error effect) and total time patterns (time effect) of the group of horses in Test 1 (Appendix 29) and in Test 7, where total errors and total time were over week 1, 2 and 3 (Appendix 30). Three way analysis of variance analysed individual horse (subject) effect, the effect of the continuous changeover sequence and the effect of time over weeks 1, 2 and 3 (Appendix 31); all are summarised in Table 18.

Table 18 Analysis of variance summary for Tests 1, 6 and 7

TESTS	ONE		SEVEN	
EFFECT	ERROR	TIME	ERROR	TIME (Weeks)
P – VALUE	0.0108	0.191	0.011	0.012
SIG	P < 0.05	NS	P < 0.05	P < 0.05

TEST	SIX						
EFFECT	HORSE	SEQ	TIME (Weeks)	HORSE X SEQ	HORSE X TIME	SEQ X TIME	HORSE X SEQ X TIME
P – VALUE	0.4600	0.0084	0.0412	0.000	0.0392	0.0515	0.0690
SIG	NS	P <0.01	P <0.05	P <0.001	P <0.05	NS	NS

SIG = Significance

SEQ = Sequence

X = Relationship between particular effects

Spearmans Rank Correlation

The individual rank of each subject in relation to individual total errors and time in Tests 6 and 7, weeks 1, 2 and 3 can be seen in Appendix 32. Rank 1 refers to the lowest number of errors and the least amount of time. Assessment of a change in subject rank during successive weeks can then be deduced using Spearmans Rank Correlation. Correlations are shown for error and time rank results within Test 6 and Test 7 in Appendix 33 and 34. Comparison between the ranks of the subjects total errors and total time within Test 6 and within Test 7 (Appendix 35) show whether individuals with high ranks for error are also those taking the shortest time. Table 19 summarises the significance within the results.

Table 19 Individual and comparative subject rank for error and time in Tests 6 and 7

	ERROR		**TIME**	
WEEKS	**1 – 3**	**2 – 3**	**1 – 3**	**2 – 3**
TEST	**SIX**		**SIX**	
SIGNIFICANCE	NS	NS	NS	NS
TEST	**SEVEN**		**SEVEN**	
SIGNIFICANCE	NS	$P < 0.05$	NS	$P < 0.05$
WEEKS	**1 - 3**		**1 - 3**	
TEST	**SIX – ERROR/TIME**		**SEVEN – ERROR/TIME**	
SIGNIFICANCE	NS		$P < 0.01$	

Emotion and Training Scores

The mean emotion and training scores of the subjects, assessed by 3 independent assessors with prior knowledge of handling and training the subjects, are shown in Table 20 (see Appendix 9). The emotion and training scores of the subjects were assessed by the researcher before and after Tests 6 and 7 (Appendix 36) and are shown in Table 21 (Test 6) and Table 22 (Test 7). The results from Tables 20-22 ensure analysis of the normal emotional state of the subjects in non-research situations and allows their relative emotional state during the research tests to be compared and abnormalities or similarities detected within individual test performance.

Table 20 Mean emotion and training scores of the subjects, recorded by independent assessors

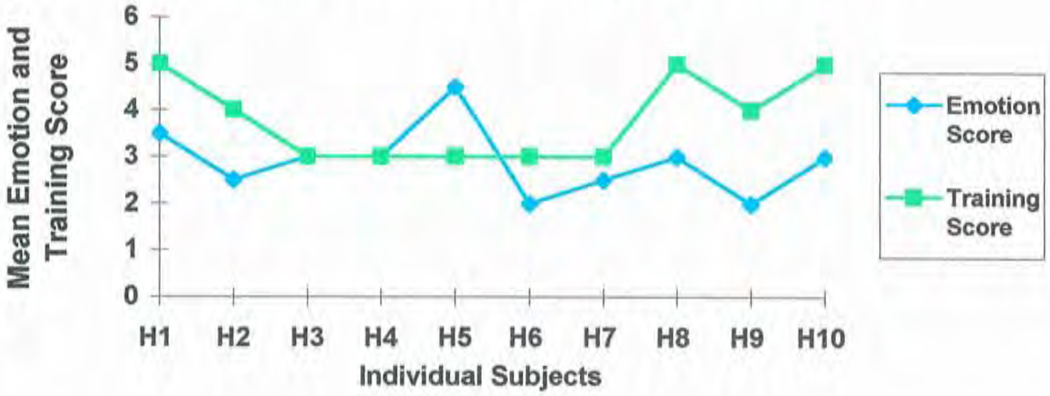


Table 21 Subject emotion score before and after Test 6, recorded by the researcher

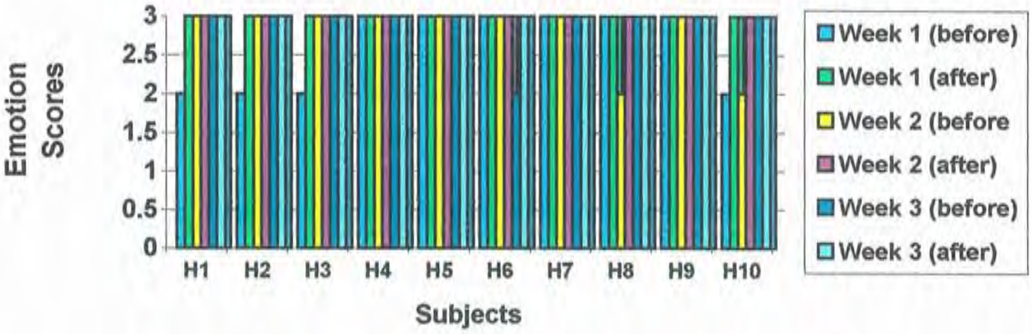
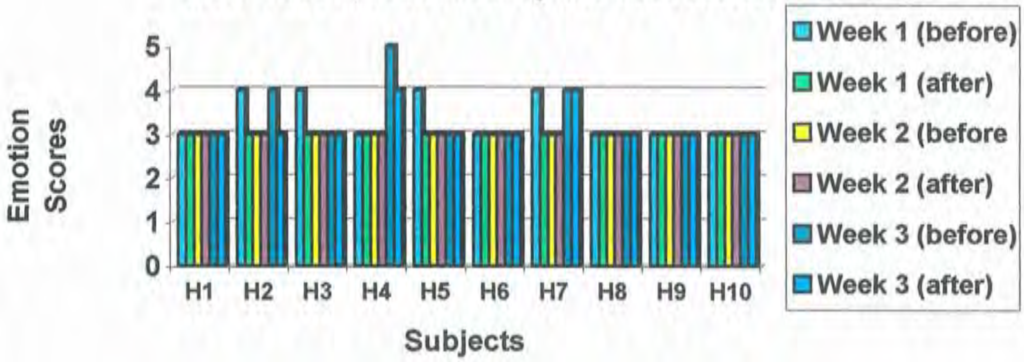


Table 22 Subject mean emotion score before and after Test 7, recorded by the researcher



CHAPTER 8

DISCUSSION

When Test 1 of the visual discrimination test was initially presented to the test subjects, two horses could not be motivated to co-operate (H9-10) therefore they had to be excluded from the remainder of the visual discrimination tests. Although H9-10 showed interest in the carrot as a motivating factor prior to commencing the tests, H9 appeared particularly suspicious of the cards with limited interest in the carrot and H10 immediately began to exhibit stereotypic behaviour (windsucking) and could not be enticed by the carrot. Sluckin (1972) found a lowered reactivity (motivation to presented stimuli) in older animals and Dougherty & Lewis (1991) found a similar occurrence in a discrimination test where one aged horse was excluded from completing the test as his response rate fell, inexplicably, to zero. The subject horses in the visual discrimination test were both elderly, ex-affiliated competition horses.

Initial analysis of the results (refer to Tables 4 & 5) shows no clear reduction in the total or mean number of errors or time taken during the visual discrimination tests (Tests 1-6). However, this does not suggest a lack of stimuli response, recognition or retention. The nature of the progressive tests, which were unfamiliar stimuli (excluding week 2 and 3) may have resulted in an increase in the number of errors the horses initially made prior to familiarising to the protocol response i.e. moving and touching the cards and recognising the star stimulus card. Indeed Gardner (1937a) found horses adapted relatively quickly to presentation of different stimuli and Sherry, Walters, Rodney & Henry (1994) found that goats readily adapt to alterations in stimulus presentation. The tactile discrimination test did however show a more obvious decrease in total and mean errors and time over the three weeks (refer to Table 6). This may have resulted from the consistency of the presented stimuli i.e. rider's messages and the familiarity of being ridden. The results may also have been due to the manner of reinforcement, which through negative reinforcement may intensify reaction times. Gisquet-Verrier & Alexinsky (1990) found evidence in rats to suggest that the strength of the initial training session has a direct relationship on long term improvements in performance. Indeed, other studies have found in rats that recent learning fades out more rapidly than older learning (Devenport, 1989), partially due to the role of the tubular hippocampus. This further highlights the importance of a solid foundation in schooling which if conducted correctly in early learning by thoroughly conditioning particular messages with particular movements should always prove possible to combine simple well learned instructions to obtain more advanced movements (Kiley Worthington, 1987). Due to these initial in-conclusive results, analysing the response of the group within each test and over successive weeks is very important in order to evaluate whether a learning curve developed within each discrimination test.

Chi Squared Analysis (Refer to Table 9)

The chi^2 analysis results determine whether the tested group's responses were due to random chance, side preference or response/recognition/retention to the rewarded stimulus.

Test 2

The results showed no statistical significance ($P < 0.10$). However, examination of the raw data (Appendix 12) shows 72.5% of the attempts were to the right, suggesting a very strong trend to right side preference exists when matching (blank) stimuli on both sides. Houpt (1998) suggested 'handedness' in 53 observed horses, where 77% showed preference for 'pawing' leg and 67% showed preference in the leg that initiates walking. Kratzer, Netherland, Pulse & Baker (1977) also found side preferences in a maze test to vary among individuals where 27% of tested horses showed an initial preference for right or left side preference. This phenomenon is also shown in monkeys, where significant differences exist between right and left handedness (Hopkins & Washburn, 1994).

Test 3

Although there was no statistical difference ($P < 0.10$) the result shows similarity with Test 2 suggesting a strong trend to the right card existed. Examination of the raw data (Appendix 13) shows 85% of the attempts were to the right (where the star stimulus card was presented), but this could either be due to stimulus recognition or the side preference indicated in Test 2. Groups of horses have shown to repeatedly choose the same side of a maze, regardless of where the food reward was placed, suggesting the existence of side preference (Hierd, Lennon & Bell, 1981). McCall, Salters & Simpson (1993) also found horses to always start from the same side of a test pen and Fitzgerald, Glick & Carlson (1990) found a marked right sided population bias in a group of horses tested in a maze.

Test 4

The star stimulus card was moved to the horse's left side in this test. If these results were due to side preference the right side (blank card) would be expected as the favoured response, regardless of the primary positive reward (due to possibility of right side preference in Test 2 and Test 3 results). Instead the results are highly significant ($P < 0.001$) suggesting the response was due to star stimulus card recognition (this may also indicate Test 3 results were due to star stimulus recognition). Probability theory does not however conclusively mean the response was due to recognition of the star stimulus card. Dellu, Fauchey, Moal & Simon (1997a) suggest animals possess the ability to recognise stimuli, either through novelty or on a cognitive basis. Dougherty and Lewis (1991) state that different features in stimulus presentation can be learnt which is supported by Hanson (1959) and Entsu, Dohi & Yamada (1992) who found horses, pigeons and cattle respectfully, could discriminate between positively reinforced and non-reinforced visual stimuli.

Test 6

Results show significant differences ($P< 0.05$) exist within series sets in week 1 and week 3. However no statistical significance ($P< 0.10$) was found within series sets in week 2. A statistical significance may indicate the subjects were making fewer errors during the duration of the test, suggesting response and recognition of the star stimulus card was occurring. Experiments have shown that horses show a rapid reduction in the number of errors initially made in responding to discrimination tests (Gardner, 1937a; Warren & Warren, 1962). Similar results have been obtained by comparable experiments in rats (Dufort, Guttman & Kimble, 1954), cat (Cronholm, Warren & Hara, 1960) a racoon (Warren & Warren, 1962), chickens (Warren, Brookshire, Ball & Reynolds, 1960). The lack of significant difference in week two may indicate that an even number of errors occurred throughout the series set i.e. consistently good results, therefore the individual weeks total errors should be assessed.

Comparison of Total Errors in Test 6 (refer to Tables 4 & 5)

Although the chi^2 results from week two showed no significant difference, the total number of errors was 49. In comparison to total errors in week one (73), this represents a large decrease in errors supporting the theory that a consistent (vast) improvement occurred from week one to week two. Week three however, showed the largest number of total errors = 84, coupled with $P < 0.05$ chi^2 significance in error distribution. These results are synonymous with formation of a new behavioural methodology where the subjects response may initially appear to indicate stimulus recognition yet can become inexplicably erratic (Kerlinger, 1973). Similar results have been obtained in several species of fish and crabs (Data, Milstein & Bitterman, 1960) where results show a progressive deterioration in performance as relative discrimination tasks are performed. There are however many neurological differences between higher vertebrates (horses), fish and invertebrates so the results must be further assessed, analysing the proportion of week threes errors (relative cumulative frequency) which highlight where these differences occurred. One non controllable variable that may have accounted for week 3 results was a decrease in the subject's motivation to perform which may have occurred as they had less time to digest their evening hard feed. The tests normally commenced one hour after the horses had had their evening meals to allow digestion. However only ½ hour was left on week 3 as the feeds had been fed later than normal. This may have decreased the subject's interest in the primary positive food reinforcer which is supported by Day, Kyriazakis & Rogers (1998) who found that food satiation can act as a de-motivating factor. McCall, Salters & Simpson (1993) found that although 16 trials per training session in their discrimination test facilitated response acquisition, different session lengths may or may not produce an optimum number for stimulus recognition and retention i.e. more or less replicates within Test 6.

Test 7 (Chi^2 Analysis – refer to Table 9)

The results show $P < 0.001$ in error and time difference over weeks 1, 2 and 3. The results imply that the reinback message (tactile stimulus) was recognised and retained over the weeks. The degree of the responses can be assessed by evaluating the relative cumulative frequency for error and time effect (refer to Tables 16 & 17). Although no tactile discrimination test research results were discovered to support these error and time effects, visual and auditory discrimination results reinforced Test 7 results. Kratzer, Netherland, Pulse & Baker (1977) found horses to show a decrease in errors and time as trials progressed in a maze test and Heffner & Heffner (1984, 1986) successfully maintained behavioural responses to an auditory discrimination test. Horses do show a high ability to discriminate between tactile stimuli as seen in the numerous horses trained with no incidence of resistance (Salthouse, 1996); indeed Chance (1988) found in most animals that well-established avoidance responses (negative reinforcement) were very difficult to extinguish.

Discussion of Chi^2

The results from Test 2 show that right card side preference may exist and may be responsible for the generated results in Test 3. The results from Test 4 strongly indicate that the horses were recognising the star stimulus card irrespective of the existence of side preference. Test 6 analysed the occurrence of stimulus recognition during the duration of the experiments, which required a decrease in the number of errors made during successive series sets and over consecutive week. The results indicated star stimulus recognition during series sets in weeks 1 and 3. However, learning between weeks is not as conclusive in Test 6 due to the large increase in total errors in week; this may have been caused by a loss in motivation. Test 7 showed a significant decrease in errors and time.

Relative Cumulative Frequency

This highlights the location of errors within the test, allowing a learning curve to be deduced. Assessing chi^2 and total error/time test scores establishes overall differences and/or improvements between weeks, but doesn't show where horses learn within the test. If most of the total number of errors occurred in early parts of the test (steep curve), and fewer at the end (flatter curve), a learning curve is suggested.

Tests 1 and 2 (refer to Tables 10 & 11)

Test 1 showed a relatively even distribution of errors and time through each replicate i.e. proportional errors made and time taken within each replicate. Test 2 showed a slightly larger proportion of errors and time (50%) occurring by replicate 2 indicating subjects took longer with more errors in the first half of the replicates, but improved later with fewer errors towards the end of the replicate set. A correlation also appears to exist between errors made and time taken to complete each replicate.

Tests 3 and 4 (refer to Tables 12 & 13)

Test 3 showed a relatively even distribution of errors and time through the test. Test 4 showed similar error distribution as Test 3 but the time taken to complete the first half of the replicates was much longer (80% of time) than Test 3. This suggests subjects took longer to decide which stimulus card to initially react to i.e. star stimulus card on the left (rewarded) or blank stimulus on the right (non rewarded, although offered the opportunity of right side preference). The decrease in time taken for replicates as the test progressed may suggest an increase in the group's confidence (motivation) to correctly recognise the star stimulus.

Test 6 (refer to Tables 14 & 15)

In weeks 1 and 3 half the number of errors occurred by series set 2, suggesting slightly more errors were made before series set 2, with less being made in series set 2, 3 and 4 indicating possible uncertainty initially but stimulus recognition as the test progressed. In comparison to weeks 1 and 3, week 2 showed a more even distribution in the number of errors through the series sets which indicates star stimulus retention from week 1 and consistent star stimulus recognition. Comparatively, time taken in week 1 and 3 appears relative with the number of errors recorded i.e. increased errors indicates increased time. Generally, studies involving visual discrimination problems report that horses become progressively more adept at solving successive problems (Houpt, 1998).

However, analysis of total errors and time in week 2 (refer to Table 7) reveals that time increased as errors decreased. This was paired with a consistently longer amount of time spent in each series set (refer to Table 15). This suggests subjects may not have initially retained and recognised the stimuli from week one, but took care in their choice possibly remembering a desired response was required. The results do not support a consistently poor performance scenario as the total errors were lowest over all three weeks and the relative cumulative frequency of errors in week 2 showed even distribution. It has been suggested that once weekly sessions may increase responses due to the novelty of the stimuli which may motivate the horses to take an interest and perform (Hillman, Hunter & Kimble, 1953). Fiske & Potter (1979) found in a group of yearling horses a reduction in the number of trials (replicate attempts) and errors over time, indicative of "learning how to learn". This reduction in errors as time progresses has also been shown in an escape conditioning (Kratzer, Netherland, Pulse & Baker, 1977)

Dixon (1970) taught a pony to learn 20 pairs of visual discrimination cards and when tested for memory retention, scored 81% correct results 1 month later, 78% 3 months later and 77.5% after 6 months. However the pony took over 1000 trials to learn the first pair of cards; indicating many trials may initially be required (solid foundation) before retention abilities can be thoroughly established (Kiley Worthington, 1987). Houpt (1998) found retention of visual discrimination ability could be retained for up to one year. Test 6 shows the importance of assessing relative cumulative frequency as well as total errors in understanding the subject's recognition and retention abilities and corresponding behaviour.

Test 7 (refer to Tables 16 & 17)

In week 1, half the total errors occurred by attempt 2. In weeks 2 and 3 half the total errors occurred during attempt 1. However total errors were reached by attempt 5 in weeks 1 and 2, and attempt 3 (halfway) in week 3, strongly indicating that stimulus recognition occurred. The total number of errors made within each replicate attempt appears to correlate with the amount of time taken i.e. as errors increased so did time (also refer to Table 8). Thus similar learning curves are shown for both errors and time with progressively steeper curves seen from weeks 1 to 3.

The shape of the learning curves indicates a rapid reaction/response from the subjects to the stimuli. This may be due to the Dodwell Horse Morse Code's specificity of messages which also includes a warning message – enabling the subject an opportunity to avoid the negative reinforcement in an avoidance response (see Chapter 4). The use of negative reinforcement undoubtedly presented a more demanding discrimination test (in comparison to the visual test) as in order to release the pressure, the subjects had to have a more rapid response rate. The decrease in total errors and time over the three weeks are supported by Kratzer, Netherland, Pulse & Baker (1977) who found ponies and Quarter horses' errors decreased significantly from the first maze learning trial to the ninth trial.

In overall total errors (refer to Table 8), week 3 shows an increase in total errors, although Table 15 shows most occurred in early replicate attempts. This may have been due to the adverse weather conditions (gales) which caused some of the subjects to behave in a very unsettled manner, increasing the initial number of resistances (errors) made until they began to relax and settle; this was especially prevalent in H4 (see Appendices 16 & 17 and Table 22).

Discussion of Relative Cumulative Frequencies

Overall, similar curves are shown in Tests 1-3, then a steeper initial curve in Test 4 (possibly indicating learning). Weeks 1 and 3 in Test 6 seem to show evidence of confusion initially in series sets then star stimulus recognition, with week 2 showing far fewer overall errors. McCall, Potter, Friend & Ingram (1981) found horses made most of their errors in the first four trials of each discrimination task which they state reflects a rapid rate of learning. Kiley Worthington (1977) also suggests 4 trials to the desired response to reflect a rapid learning ability. Test 7 has the strongest evidence for stimulus recognition and retention, with weeks 1-3 all showing steep initial curves that flatten, progressively becoming steeper during consecutive weeks; this indicates the possibility of enhanced stimulus retention between weeks. These findings link with the chi^2 for Tests 6 and 7, which also indicated stimulus recognition and retention as represented by a decrease in the number of errors during the series sets and replicate attempts. The level of stimulus recognition in the visual test does not support the findings of McCall, Potter, Friend & Ingram (1981) who found horses to be more efficient at learning to discriminate visual tasks over non visual tests.

Hypothesis

Although errors and time were recorded and analysed throughout the majority of tests, the study's overall hypothesis was formed in relation to recorded errors as it was felt that errors were a better indicator when assessing both tests. The results from chi2 and relative cumulative frequencies now enable the hypothesis to be evaluated. The hypothesis can be rejected for visual discrimination Test 6 in week 1 as stimulus-response ($P<0.05$) and recognition (decreased errors as series set progressed) occurred. This also allows rejection of the hypothesis in week 2 where response recognition and retention is highlighted by consistently low errors throughout the series sets. The hypothesis can only be partially rejected in week 3 as similar results were shown to week 1, where decreased errors and the level of consistency shown in week 2 was not maintained.

The overall study's hypothesis for the tactile discrimination test can be rejected as evidence clearly shows response, recognition and retention and a good learning curve over successive weeks.

Analysis of Variance (refer to Table 18)

Test 1 (One way analysis of variance)

The results show that some horses made significantly ($P <0.05$) more errors than others, indicating individuality within the group i.e. age, breed, visual acuity (see Appendix 5). No significance was shown in the time taken by the subjects to respond to the card replicates. These results may be due to the one card presentation where there was limited choice i.e. touch the card or not. The variable of distance to travel to touch the card was controlled, so the results may indicate a uniform reaction time by the group to one blank stimulus presentation.

Test 7 (One way analysis of variance)

Both the error and time effect in Test 7 show a significant difference ($P <0.05$) in relation to the individual subjects data variance over weeks 1, 2 and 3. This again indicates the occurrence of individual performances i.e. some horses significantly better/worse than others, which could have been due to a number of variables. Comparatively this effect does not appear to have altered the overall learning curve as shown in relative cumulative frequency and total errors and time tables, were a decrease in error and time (in total and between replicate attempts) suggests that tactile discrimination response, recognition and retention occurred. McCall (1990) reported the incidence of practice (memory retention) increased the percentage of correct responses from 42 – 70% and Hierd, Lennon & Bell (1981) found a range of 39% correct responses on day one with 78% correct responses on day 19. Hierd, Lokey & Cogan (1985) found horses learned rapidly and reached higher levels of performance in each successive discrimination task, indicating the subjects may be learning to learn. These results may suggest a more complicated tactile discrimination test should be used in the future e.g. figure of eight in reinback. Marinier & Alexander (1993) found once horses had learned a maze test they remembered it perfectly on subsequent occasions, although Wolff & Hausberger (1995) found horses who learned to open a chest were not necessarily faster in the memorisation task.

Test 6 (Three way analysis of variance)

Horse Effect

No significance effect was shown ($P < 0.4600$). Significance would be indicative of an individual subject influencing the results rather than the group as a whole. It therefore shows that the results are not due to an individual subject. McCall, Salters & Simpson (1993) found huge variations in horses presented with an avoidance response test with large variations present in session bouts and trials to criteria highlighting the individualities of horses and how they could potentially affect the results.

Sequence Effect (4 sets, 16 replicates)

The variation in the results show $P < 0.01$ correlation with the sequence presentation. A relationship may therefore exist between the various data sets (i.e. sets 1-4) and the performance of the individual horses over these sequences, which may be a result of increased performance in later data sets.

Time Effect

These results indicate $P < 0.05$ significant effect between the results and the time duration of the tests over the three weeks

Horse Sequence Effect

This shows a very strong effect $P < 0.001$, showing horses respond differently to the different sequences.

Horse Time Effect

This shows that a few horses respond differently in time recording as the weeks progress. It indicates that some horses retain information better whilst others do not and make significantly more errors. McCall, Potter, Friend & Ingram (1981) found wide variations between individuals in their ability to learn a Hebb Williams closed field maze test.

Sequence x Time and Horse x Sequence x Time

This shows no significance thus the response to the sequence within time is the same, and the results are therefore due to the horse - sequence effect and horse - time effect.

The analysis of variance tests highlights that individual differences in the horses were detected throughout most tests, but the overall results were not due to one individual horse's influence. These individualities (non-controllable variables) are to be expected given the nature of the tested subjects, and indeed a large variation both within individuals and between individuals is commonly found (Forkman, Furuhaug & Jensen, 1995). However it was not possible to thoroughly evaluate these variables as the discrimination tests were evaluating the groups overall learning curve (information regarding these individualities can be seen in Appendix 5).

Spearmans rank correlation (refer to Table 19)

This showed the incidence of changing correlations in the rank order of subjects (Bernstein, 1964) with regard to error and time over Tests 6 and 7. The individual error and time ranks show no correlation in Test 6 over weeks 1–3 and 2–3. However a significant difference is seen between weeks 2 and 3 for error rank and time rank in Test 7 ($P < 0.05$). Comparisons between error and time rank in Test 6 showed no correlation. However Test 7 showed a significant correlation of $P<0.01$, indicating if subjects made a high number of errors they also took a long time, thus their ranks correlated. Non-significant results indicates the subject's rank remains consistent throughout i.e. some horses perform consistently better than other subjects (shown generally throughout the visual discrimination tests) – this could be attributed to the type of reinforcement strategy, visual acuity, motivation. A significant result indicates some horses changed their rank in relation to error and time responses which may indicate a higher/lower tolerance threshold to tactile stimuli when ridden; emotional reactivity could also effect rank thus emotion and training scores should be interpreted e.g. distractions caused by the weather. These results do not support the findings of

Haag, Rudman & Houpt (1980) who recorded a significant correlation between a pony's rank in a maze test (positive reinforcement) and a shock avoidance test (negative reinforcement). This may be due to differences in experimental protocol. However, in contrast Hammell, Kratzer & Bramble (1975) found no correlation in the rank of pigs in different tests, which is also supported by studies involving rats (Robustelli, McGough & Boret, 1963).

Emotion and training scores

Potter, Yeates & Fiske (1977) suggest that the emotional reactivity of a horse can affect its performance in a learning task so the 'normal' mean emotional and training scores were recorded by independent assessors (refer to Table 20). The results highlighted variation in the subjects emotion and trainability scores which could result in potentially different reactions from the subjects in the tests. The emotion scores before and after Test 6 (Table 21) and Test 7 (Table 22) indicated some variation between individuals but generally the scores were consistent throughout. This indicates all horses started and finished the tests in a similar emotional state (controlled variable) although it does not indicate uniformity in the subject's performance ability. Differences in the individual subject's discrimination abilities, as shown in the mean trainability scores, were present throughout the tests. However as shown in ANOVA these individualities did not interfere with the overall trend of the group i.e. the learning curve. Interestingly, those subjects who scored low mean trainability scores exhibited greater fluctuations in emotional levels prior to commencing Test 7 and showed a decrease in performance in particular weeks – possibly indicative of excitability of being ridden or adverse weather conditions (gales) as seen in Test 7, week 3. Hierd, Whitaker, Bell, Ramsey & Lokey (1986) found pre-test training and emotion scores to be a reliable indicator of a horses relative performance within a maze test, supported by Houpt (1998) who further indicates the possibility of predicting learning abilities during a pre-conditioning emotion and training score period.

Limitations of the Study

The study' major limitation was that although a broad range of horses was used, they possessed a diverse range of variables i.e. age, gender, breed and the numbers were small, making generalisation of results difficult. The horses were chosen on their availability, muscular performance and limited training history of reinback. Although the amount of previous training the subject horses had received was considered when making a choice, it is difficult to eliminate its effects entirely and in fact the horse which scored the lowest number of errors in the tactile discrimination test (H10) was in fact an affiliated dressage horse.

Quantifying the extent to which individualities may positively or negatively affect the different tests is important and although variables of breed, age and gender were recorded, limited time and length of the study ensured they could only be quantified categorised and not investigated further. However, although these variables were not tested and may have affected individual performances, the effect of testing a varied random group may be of benefit to the horse industry.

This is especially applicable to training the riding horse where the Dodwell Horse Morse Code training system appeared to work well on all subjects. The lack of ridden research means that the learning curve expressed by the horses to the Dodwell Horse Morse Code training system cannot be compared to other training systems. Ideally, the Dodwell Horse Morse Code training system should have been run concurrently with a different method of training reinback and comparing the levels of resistance.

Measuring time taken to complete the tests proved difficult to accurately assess in the visual discrimination tests as the horses would often not stand still, and only a limited amount of constraint could be placed on the horses for fear of jeopardising the stimulus response. It is recommended that in future testing the horses be placed in stocks to ensure their attention is directed solely at the cards increasing the reliability of time.

The measurement of side preference in Test 2 may not be conclusive as the subjects may have been influenced by the food reward which had to be presented to maintain motivation. However, this limitation does not explain the high incidence from all subjects of their initial right side response.

The majority of equine learning investigations are carried out with minimal human interaction in order to assess the horse in a controlled manner (Kratzer, Netherland, Pulse & Baker, 1977). The discrimination tests in this study did however involve the presence of the researcher and assistant/observer; although this approach is more practical it is unclear what effect this human interaction had on the horses' learning curve.

The tactile discrimination test involved testing subjects on the right rein only i.e. a clockwise direction of travel in the indoor school. This may have enhanced or decreased the response of the subjects as relationships were proven to exist between subjects and right side preference in the visual test. Further studies are required to determine the effect of side preference by testing the subjects in an anticlockwise direction in the indoor school i.e. on the left rein.

The type of recording equipment used must be chosen very carefully, as after an immense amount of editing the equipment used for the tactile discrimination test resulted in a *very* poor quality video of the horses performing each test and extremely poor audio tapes of rider and observer. It is recommended that in future testing, each individual horse is allocated its own video and audiotape for the test duration to increase the ease of editing and ensure quality control remains.

This discussion of the results obtained in the tests cannot, within the limitations of this study, do full justice to the wealth of data generated. However, the main objectives of the study have been met and allow certain conclusions to be drawn.

CHAPTER 9

CONCLUSIONS

A great deal of data was generated from both the visual and tactile discrimination tests; however due to the constraints of the study, only those elements specifically relating to the study objectives and hypothesis were analysed in depth to enable general conclusions to be drawn.

Although the progressive visual tests (Tests 1-4) proved to be expensive in relation to time and data analysis considerations, they enabled a detailed evaluation of the types of response shown by the group. This allowed the occurrence of a strong trend in side preference (to the right) to be detected and established the incidence of star stimulus card recognition irrespective of bias.

Evidence was provided in the visual discrimination test to reject the study's overall hypothesis in weeks 1 and 2 as although week 1 showed initial variation in stimulus recognition between series sets with $P < 0.05$, no significant variation was found in week 2 indicating consistently good results and the incidence of recognition and retention. The hypothesis was only partially rejected in week 3, as the consistency shown in week 2 was replaced by $P < 0.05$ increase in variation in initial series sets. It was suggested that satiation and de-motivation may have been responsible for results in week 3.

The visual discrimination tests generated data which could present an interesting area for further research. However, because the results were not entirely conclusive it proved difficult to accurately predict their practical application to training horses.

Evidence was provided in the tactile discrimination test to reject the study's overall hypothesis over the weeks with indications that stimulus recognition and retention occurred with highly significant values ($P< 0.001$). The results must be viewed in the light of the small number of test subjects used and the non-controllable variables e.g. levels of pre-training, which are not always possible to ascertain.

The tactile discrimination study also provided an opportunity to evaluate the Dodwell Horse Morse Code system of training. The test results suggested that this system could be effectively applied to a variety of horses, producing a rapid reduction in resistances within a relatively short time duration, when teaching the exercise of reinback. This may suggest that Dodwell's training system provides an unambiguous series of messages that do not require the use of gadgets and can enhance trainer–horse communication by minimising confusion. How these results would compare to more traditional methods of training the riding horse is a matter for further investigation.

This study showed the feasibility of devising a suitable methodology for collecting, recording and analysing data in a tactile (ridden) discrimination test, and has provided more information in an under-researched area. It indicates that evaluation of training systems is possible and may encourage future research into methods that combine effective training with equine welfare, with consequent implications for both trainer and horse.

CHAPTER 10

FURTHER RESEARCH

Further visual discrimination testing could investigate whether or not the horses can learn to discriminate the star stimulus shape from a variety of other shapes, including shapes of a similar design, so increasing the discriminatory intensity. Investigations based around the visual discrimination test could also be used to test the abilities of equines to form concepts.

To complement the tactile discrimination research, the Dodwell Horse Morse Code should be compared to a traditional method of training, analysing a variety of exercises to discover if the Dodwell system offers a faster reduction in resistances. For maximum benefit this should be carried out on a group of 4-year-old horses (blank canvas) to rule out the effects of pre-training. The Dodwell Horse Morse Code should also be applied to a number of notoriously resistant horses to discover if the system can work on them, when traditional approaches may have failed.

The interval between training sessions (greater than or less than 1 week) should be assessed to discover the optimum dispersal of time between sessions. The effect of instantaneous replication of the desired result should also be investigated i.e. Test 7 ceased as soon as the desired result was achieved. The effect of continuing the test may have an affect on the horse's motivation to carry on responding and/or an increase or decrease in their memory retention in following presentations.

The effect of different reinforcement contingencies i.e. the effect of changing from a continuous reinforcement contingency to an intermittent schedule of reinforcement with various fixed or variable ratio or interval schedules should be investigated. This predominantly concerns the visual discrimination tests as the tactile discrimination test is dependent upon negative reinforcement, which should always run on a continuous schedule i.e. pressure is always released immediately the desired response is achieved.

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Appendix 34 Error and time rank in Test 7, using Spearmans Rank Correlation

ERRORS	95% CONFIDENCE INTERVAL	T- STATISTIC	DEGREES OF FREEDOM	1 – TAIL PROBABILITY
WEEK 1	-0.1669	1.7085		0.0630
WEEK 3	0.8651		8	
WEEK 2	-0.1540	2.8872	8	0.0101
WEEK 3	0.9270			
TOTAL	**0.2895**	**3.4961**	**8**	**3.4961**
	0.9447			
TIME				
WEEK 1	-0.4620	0.6880	8	0.2554
WEEK 3	0.7538			
WEEK 2	-0.0971	2.6583	8	0.0144
WEEK 3	0.9184			
TOTAL	**-0.4092**	**0.8796**	**8**	**0.0144**
	0.7806			

Appendix 35 A comparison of the subject's error and time rank in Test 6 and Test 7, using Spearmans Rank Correlation

TEST 6	95% CONFIDENCE INTERVAL	T - STATISTIC	DEGREES OF FREEDOM	1 – TAIL PROBABILITY
WEEK 1	-0.7600	-0.2937	6	0.3894
WEEK 3	0.6393			
TEST 7				
WEEK 1	0.2183	3.1632	8	0.0067
WEEK 3	0.9358			

Appendix 36 Subject emotion scores before and after Test 6 and Test 7, recorded by the researcher

SUBJECT	VISUAL EMOTION SCORE (prior)			VISUAL EMOTION SCORE (presiding)			RIDDEN EMOTION SCORE (prior)			RIDDEN EMOTION SCORE (presiding)		
WEEKS	W1	W 2	W3	W1	W2	W3	W1	W2	W3	W1	W2	W3
H1	2	3	3	3	3	3	3	3	3	3	3	3
H2	2	3	3	3	3	3	4	3	4	3	3	3
H3	2	3	3	3	3	3	4	3	3	3	3	3
H4	3	3	3	3	3	3	3	3	5	3	3	4
H5	3	3	3	3	3	3	4	3	3	3	3	3
H6	3	3	2	3	3	3	3	3	3	3	3	3
H7	3	3	3	3	3	3	4	3	4	3	3	4
H8	3	2	3	3	3	3	3	3	3	3	3	3
H9	3	3	3	3	3	3	3	3	3	3	3	3
H10	2	2	3	3	3	3	3	3	3	3	3	3

APPENDICES

APPENDICES

Appendix 1 Resistant Behaviour

Resistance (deviation) in the horse shows itself in many forms and is due mainly to;

1) Unclear presentation of the message to the horse from the rider, which leads to confusion
2) Physiological pain
3) Lack of motivation to perform

Regardless of the cause of the resistance it can be summarized as a horse who is not compliant with the trainer's wishes and evades the messages in a variety of ways e.g. setting or crossing the jaw, tongue over the bit, kicking out at the rider's leg, swishing the tail, bucking, rearing, napping etc.

Appendix 2 Tack and Gadgets

To allow the trainer to communicate with the horse when riding, the horse is fitted with a saddle (comfort of horse and trainer) and a bridle to increase the amount of control the trainer has over the horses speed and direction of travel. The bridle places pressure on a number of sensitive areas of the horse's head, predominantly in the mouth through the action of the bit. If resistant behaviour is shown the trainer can increase their level of control on these pressure points by utilizing:

Nosebands

Prevent the horse from opening and or crossing the jaw/mouth to evade the action of the bit if the bit is used too strongly (depending on its fitting).

A variety of designs (flash, drop, grackle, kineton) each providing an increased intensity, to prevent the horse from externally resisting

Gadgets (also referred to as training aids)

Used as corrective devices (short term) to increase the control the trainer has over the horse by applying greater leverage to various pressure points on the horse's body (predominantly the head and neck). The most frequently used gadgets are draw reins and de-gogue, which should both be used with an independent rein. They work on drawing the head and neck in and down by placing pressure on the horses poll through leverage (Britton, 1995)

Appendix 3 Reinback

During the movement of reinback the horse steps backwards in a definite diagonally paired leg sequence (for a required number of steps). The movement should be straight and should always be followed by riding the horse straight into walk again. Reinback is commonly used to improve the horse's balance by strengthening the hindlegs/quarters and back (MacIntyre, 1996). Horses are often reluctant to step backwards as they possess a blind spot directly behind them when the head is facing forwards and as a prey species their innate reaction is not to move where they cannot see. The reinback should be rewarded immediately and gradually the movement becomes transformed into backing with alacrity and rhythm (Miller, 1996a).

Appendix 4 Summary of the effects of specific regions in the equine brain that initiate, process and maintain learning

Forebrain

Nuclear Basalis

A cluster of neurons located deep in the brain monitors incoming messages and releases a chemical messenger, Acetylcholine to prepare relevant nerves and muscles for impeding action. It also prepares other brain neurons in the limbic system for indelible memories (Mills & Nankervis, 1999)

Cerebrum

Controls sensory response, passing on impulses that require further assessment to enable learning and memory formation and retention

Cerebral Cortex

Split into lobes; impulses from cerebrum and thalamus are passed to temporal and occipital lobes for visual information and parietal lobes for tactile information, where they are analysed and redirected along a multitude of neural paths which allow response impulses (coupled with information from the limbic system and cerebellum) to be channelled down respective efferent tracts to the muscles (Fraser, 1992)

Limbic System

A group of CNS components that assist the animal's emotional persona. The thalamus, hypothalamus, cerebral cortex, amygdala and tubular hippocampus form the components

Amygdala

Ensures visual and tactile impulses from the thalamus and in the cerebral cortex is coded with the particular emotion of the moment and ensures they remain memorable. Also monitors reward and punishment ensuring training techniques either aid or inhibit performance dependent upon the amygdalas interpretation (Osbourne, 1985)

Tubular Hippocampus

Ensures visual and tactile messages from the thalamus and the lobes of the cerebral cortex are perceived, understood and maintained in a short-term memory bank. Presentation of the visual or tactile stimuli in the cerebral cortex, at a later date, would stimulate and relay remembrance of the initial information (the response and the outcome of the choice) to the hypothalamus for permanent memory storage (Rossdale & Wrexford, 1989)

Midbrain

Thalamus

Processes visual and tactile impulses from spinal and cranial receptor nerves and passes them onto specific lobes in the cerebral cortex. Also perceives pain and pleasure, passing impulses onto amygdala

Hypothalamus

Manufactures two essential memory neurotransmitters 'norepinephrine' and 'serotonin', which are essential for long term storage of memories and are responsible for integrating and regulating the horse's adaptive behaviour. A temporary depletion in these neurotransmitters may be responsible for a limited attention span and a decreased ability to retrieve information from the memory (Osbourne, 1985)

Hindbrain

Pons

Contains neural centres, which detect receptor impulses and relay them to the cerebellum

Cerebellum

Receives information from pons and receptor neurons in the muscles regarding posture, movement and complex motor patterns i.e. balanced co-ordination of limbs to move backwards when the rider requires (Rowland, 1992).

Appendix 5 Individual variables that may affect equine learning abilities

Age

Houpt, Parsons & Hintz (1982) found younger horses learned more rapidly than older horses in a maze test, supported by Mader & Price (1980) who found the trainability in a visual discrimination test appeared to be governed by the age of the horse i.e. younger = quicker. Kratzer (1969) found young pigs learned to avoid a shock at a faster rate over older pigs and similar trends have been noted in rats (Devenport, 1989). However Crady & Quinton (1989) found older mice established the same level of performance as younger mice, although they took longer to do so and Harrison & Pavlick (1985) found age related performance decreases may not necessarily reflect a decrease in memory retention in mammals. Indeed, Dellu, Mayo, Vallee, Mole & Simon (1997b), testing rats, suggested that aging impairs control over response. However aging may not necessarily be accompanied by a decline in performance.

Gender

Gardner (1937a) found sex differences in the rate of discrimination learning to be negligible. However studies in rats have shown females to learn at a faster rate, although as the female rats grow older a decrease in correct responses occurred (Alliot & Giry, 1991).

Weight

In avoidance learning tests in pigs, it was found that heavier pugs within litters were the better learners (Kratzer, 1969). In horses however no correlation between body condition and ability to learn a maze were found in either foals or mares (Houpt, Parsons & Hintz, 1982) although some studies have found that thinner horses made fewer horses than fatter ones, as fat horses show less motivation for food as a reward (McCall, 1988).

Breed

Gardner (1937a) and Mader & Price (1980) found different breeds of horses performed at different rates depending on the type of tests presented i.e. draught horses learned to discriminate visual signals more readily than thoroughbreds. Kratzer (1969) who found different breeds of pigs to vary in their relative learning abilities showed similar results.

Affiliated Competition Horses

Studies have shown affiliated horses to rank highly in visual discrimination tests. Indeed, Allin (1998) found affiliated horses to have high group rankings to complete the tests in above average times and to have increased performance oon re-testing. This may suggest affiliated competition horses have increased physiological and psychological abilities to learn and perform – but whether they were pre-disposed to increased learning potential or are responding to higher levels of training is debatable.

Handling

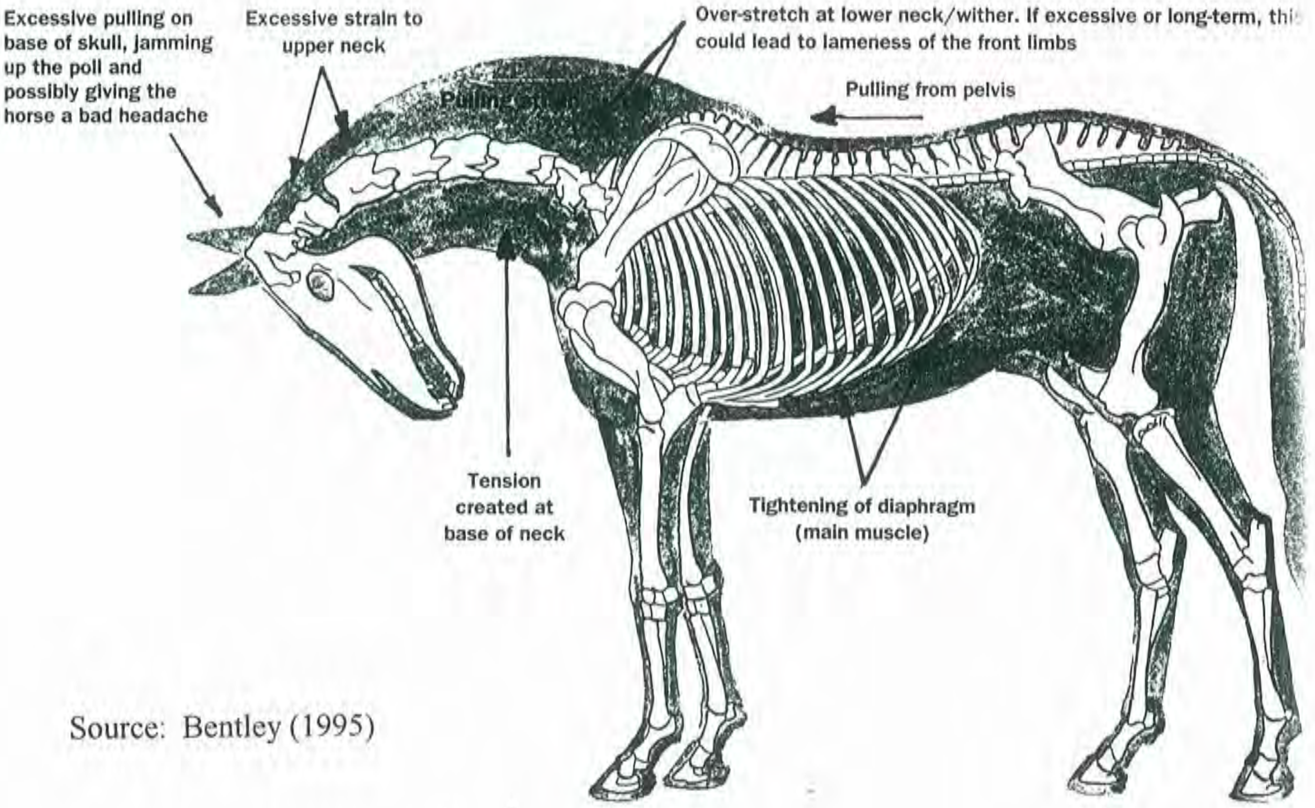
The effect of handling foals prior to them being weaned does not indicate a significant improvement in their later ability to learn (Mal, McCall, Cummins & Newland, 1994). However in latter tests Mal & McCall (1996) found a critical handling period existed during the first 42 days of a foal's life.

Dominance Hierarchy

Hagg, Rudman & Houpt (1980) found that dominant horses might show a greater number of resistances (deviations) when asked to submit to the rider's messages. Therefore a horse that is normally placed at a lower rank in the hierarchy may be more submissive to the rider's commands.

Appendix 6 Theoretical and practical effect of gadgets on the horses physiological frame

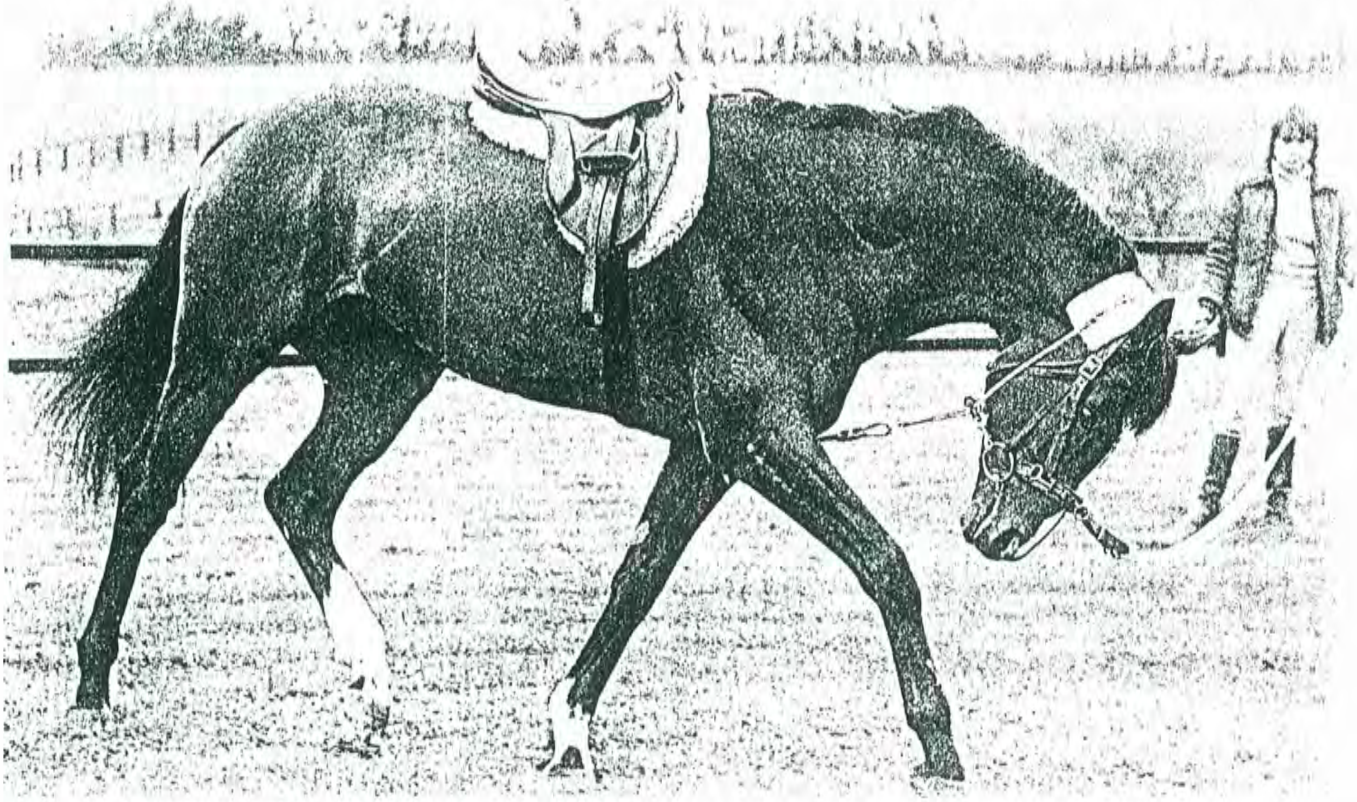
Theory



Source: Bentley (1995)

Practical Effect of Gadgets

“*He may be tensing those neck muscles, but this gadget-bound youngster is working almost blind. His expression shows his lack of enjoyment of the whole process.*”



Source: Budd (1996)

Appendix 7 Riding masters

1) Francois Robichon De La Gueriniere (died 1751), produced the book Ecole de Cavalerie (first logical riding instructions) were repeated emphasis is placed on perfect co-ordination of the messages to ensure no resistance in training. His teachings are still used by the Spanish Riding school of Vienna
2) James Fillis, a riding master of the last century who was one of the first riding masters to try to demonstrate how equine psychology and ability affects ridden training
3) General Albert De Carpentry, early nineteenth century training master of the French School of riding

4) Alois Podhahjsky, former director of the Spanish Riding School had an easy, intuitive, commonsense approach to riding and stressed the importance of correctly reinforcing.

5) Dr Reine Klimke, present day sympathetic German Olympic rider

(Langley, 1989; The Official Instruction Handbook of the German National Equestrian Federation, 1992)

Appendix 8 Individual subject profiles

1) For the purposes of the tactile test, the subjects (excluding horse 10) had not been previously conditioned to reinback

2) The horse subjects were breed categorised as either WB (Thoroughbred, Arab and warmblood pure or cross) or Native (Welsh, Dales, Fell, Draught, pure or native cross).

Table to show information regarding the 10 individual test subjects

SUBJECTS NUMBER AND NAME	AGE (Year)	GENDER G = gelding M = Mare	BREED	HEIGHT (Hands)	BODY CONDITION SCORE	PAST TRAINING
H = Horse						
H1 (Lordy)	5	G	Native	16.1	5	Affiliated
H2 (Jade)	5	M	WB	16.3	6	Unaffiliated
H3 (Holly)	5	M	WB	15.3	6	Unaffiliated
H4 (Calico)	6	M	Native	15.1	7	Unaffiliated
H5 (Rosie)	10	M	WB	16.1	6	Unaffiliated
H6 (Mole)	18	G	Native	15.2	4	Unaffiliated
H7 (Tess)	5	M	WB	15.3	5	Unaffiliated
H8 (Bess)	13	M	Native	15.2	7	Unaffiliated
H9 (Jamie)	18	G	Native	15.2	6	Affiliated
H10 (Pinky)	21	G	WB	16.3	3	Affiliated

3) Body Condition scores were assessed for each individual using the Jackson and Pagon condition scoring layout (cited in Allin, 1998).

4) Information on the individuals training history was gathered and categorised into either affiliated or unaffiliated training groups. Affiliated training refers to individuals who have participated in affiliated competition above Novice Dressage, Pre-Novice Horse Trials and British Novice Show Jumping.

5) On experimental test days the subjects were ridden for 1 hour by the college students

Appendix 9 Subjects' emotion and training scores, recorded by independent assessors

Emotion Scores

Based on a scale of 1-6, assessed by two independent assessors with previous detailed handling knowledge of all subject horses. Each scale number represents the individual subject's general demeanor in their stable prior to handling on a daily basis

1. **Tranquil** i.e. Lying down with eyes closed and ears still, snoring
2. **Very Relaxed** i.e. Standing with eyes closed, head down, bottom lip hanging
3. **Relaxed** i.e. Standing, eyes open, eating, normal respiration
4. **Unsettled** i.e. Intermittent food picking and box walking
5. **Excitable** i.e. Not eating, whinnying, loose droppings, damp neck
6. **Very Excitable** i.e. As 5, sweat on neck, continuous pacing

(Based on Fiske & Potter, 1979)

Training Score

Based on a scale of 1-6, assessed by three independent assessors with previous ridden training knowledge of all subject horses. Each Scale number represents the individual equines perceived trainability when correctly presented with a particular exercise i.e. a combination of physiological and psychological ability and attitude;

1. **Very difficult to train** i.e. always resistant, no message acceptance, very slow progress
2. **Difficult to train** i.e. often resistant, some acceptance of messages, slow progress

3. **Inconsistent** i.e. intermittently resistant, reaction to messages and progress unpredictable
4. **Relatively easy to train** i.e. accepts most messages, occasionally resistant, steady progress
5. **Easy to train** i.e. accepts all messages, occasionally resistant, steady progress
6. **Very easy to train** i.e. accepts all messages, never resistant, rapid progress

(Based on Fiske & Potter, 1979)

Table to show the training and emotion scores of the 10 individual subjects prior to handling and during riding, recorded by independent assessors

SUBJECTS NUMBER	EMOTION SCORE		TRAINING SCORE	
	Prior to Handling	Mean Score	Riding Score	Mean Score
H1	4,3	**3.5**	6,5,5	**5**
H2	3,2	**2.5**	4,4,3	**4**
H3	3,3	**3**	3,3,3	**3**
H4	3,3	**3**	4,3,3	**3**
H5	4,5	**4.5**	3,2,3	**3**
H6	2,2	**2**	4,4,2	**3**
H7	2,3	**2.5**	3,3,4	**3**
H8	3,3	**3**	5,5,2	**5**
H9	2,2	**2**	4,4,3	**4**
H10	4,2	**3**	5,5,5	**5**

Appendix 10 PILOT STUDY

A It was decided that repeatability of the tests was necessary in order to assess whether stimulus recognition and memory retention had arisen. Initially it was proposed to conduct the trials over consecutive weekends. However due to the number of possible distractions at the yard it was decided that the tests should be carried out during the evening when the yard was quiet, to limit these non-controllable variables.

B A variety of sizes for the stimulus cards were tested, the greatest response being achieved with cards of A3 size. It was intended to present the stimulus cards on the stable wall, but the horses did not respond favourably to this approach. Best results were achieved using an assistant who held the cards and to avoid the assistant's hands detracting from the subject's attention of the stimulus shapes, handles were placed on the back of the cards. A combination of spatial and brightness cues have been demonstrated to maximise the rate of discrimination learning in rats and chickens (Warren, Brookshire, Ball and Reynolds, 1960). Therefore the stimulus shapes were designed to be suitably different from each other so increasing the chance of response recognition (Houpt, 1998: Gardner, 1937a; Allin, 1998) i.e. a black star (height approx.12ins; width approx. 8ins) on a white background and a black moon (height approx 12ins; width approx 8ins) on a white background.

C To limit the environmental variables it was proposed to carry out all visual tests in one stable. However, Lester (1998) found that without an initial acclimatising period to a new environment, concentration levels may decrease in some subjects. Due to the researcher's time constraints the subjects consequently remained in their own stables for all visual discrimination tests.

D (Visual performance criterion) An error was classed as a single movement of the subject's nose that resulted in:

i) Touching the wrong card
ii) Placing the nose between the cards
iii) Touching the ground
iv) Touching the stable door
v) Touching the stable wall
vi) Touching the handler
vii) Touching the assistant
viii) No response, after 30 seconds of card presentation.

The desired response was classed as a single movement of the subject's nose which resulted in the appropriate card being touched, irrespective of the 'touch' location. The time duration for each attempt should commence when the stimuli are presented to the subject and cease as soon as the subject has performed the desired response.

E One small carrot was administered to each subject immediately after the desired reponse as a means of primary positive reinforcement. This was found to be the most appropriate method of reinforcement as it maintained the subject's motivation and possible response to the stimuli. Salthouse (1996) found apples and whole carrots to demotivate subjects and Houpt (1995) found sugary foods e.g. mints to be unsuitable as increased sugar satiation decreased levels of motivation.

A variety of reinforcement sequences were tested to discover the most appropriate method of administering the carrot without the subject becoming distracted by detecting the origin of the reward. It was concluded that the handler should place the carrots in the left pocket of the jacket, clean both hands with wet wipes and place the left hand back into the pocket before entering the stable. The handler, standing on the left side of the horse should, when the desired response occurred, immediately reward the horse with secondary positive reinforcement (vocal praise – to overcome time delay and familiarise vocal praise with reward for the tactile test) whilst quickly administering the carrot with the left hand, placing the hand straight back into the pocket immediately afterwards. This ensured that the horse could not detect the smell of the carrot on the handler's right hand (closest to the horse).

F It was intended to initially check the subjects for directional response bias by introducing two blank cards with no positive reinforcement and observing which card they consistently touched (left or right). However, after touching each card once, motivation to respond decreased as there was no reward and the subjects quickly stopped responding. It thus proved necessary to always use primary positive reinforcement and commence the test with presentation of one blank card, reinforcing when the desired response was achieved; two blank cards could then be introduced and the directional bias recorded. Previous visual discrimination tests are inconclusive as to the optimum number of trials to criterion (individual replicate presentations). Through the pilot trials of this study, it was discovered that five replicates were sufficient in Test 1 and Test 2 to obtain a response.

G It was found that Tests 3 and 4 required a greater number of replicate attempts to enable the star card stimulus a chance to become conditioned, so ten replicate attempts were used for each test.

H The subjects required an opportunity to visually see the moon card stimulus. However to enable discrimination in the continuous changeover design, the moon card stimulus should not provide reinforcement. It was initially decided that Tests 5A and 5B should be presented for ten attempts each (ensuring both star and moon stimuli had been viewed the same number of times). However the subject's motivation decreased when no reward was present which decreased the initial response in the following continuous changeover test. Instead, five replicate attempts for Tests 5A and 5B were shown to be of sufficient number to allow the horse to differentiate between the moon stimulus (no reward) and the star stimulus (reward), whilst still maintaining motivation to respond. It was also found that the moon card stimulus should be presented for two seconds and then removed for two seconds (repeated for 5 replicates) which helped to maintain the subject's interest in the test.

I The method of the visual discrimination test was based on the theory of a continuous changeover design sequence. This was chosen as the most appropriate method as theoretically it presented the star and moon stimuli in a random sequence, although practically the sequence ran continuously in a specific formation of 16 individual replicates (Cochran & Cox, 1957); the sequence was also categorised into 4 series sets (of 4 replicates) to aid later analysis. This design enabled thorough evaluation of the subject's discriminatory abilities allowing accurate detection of the subject's responses and possible star stimulus recognition abilities. The continuous changeover design sequence of star and moon stimuli cards are presented below

Series Set 1	**Series Set 2**	**Series Set 3**	**Series Set 4**
R	**L**	**L**	**L**
L	**L**	**R**	**L**
R	**R**	**L**	**R**
R	**R**	**L**	**R**

R = Star stimulus positioned to the subject's right and moon stimulus positioned to the subject's left

L = Star stimulus positioned to the subject's left and moon stimulus positioned to the subject's right

J It was decided that an initial test (7A) prior to the reinback test (7B) should be conducted. This involved the rider applying a sequence of preliminary messages to the horse that required the subjects to walk forwards, slow down and halt. Replicating this sequence for five attempts allowed the subjects to warm up their muscles before reining backwards, acclimatise themselves to the rider, provide the subjects with sufficient knowledge of the walk forwards message and enable tactile discrimination when the 'reinback' message was applied.

Blake (1979) found six attempts to be an appropriate method of analysing the relative learning speed of an individual i.e. the sixth attempt representing a subject who may show a lower ability to learn the task. Dodwell (1999) also found five attempts to be of most benefit when initially teaching the horse to respond to a new stimulus; however both references are based upon personal observation and experience, not scientific validity.

Test 7B (reinback test) involved the rider applying a sequence of messages to the horse to initiate reinback. A maximum number of trials was also required to ensure that the test did not continue indefinitely, thus the approach of five replicates was again decided upon. It was decided that if the subjects did not respond on the sixth attempt then an observer would be required to provide assistance from the ground in order that the session concluded in a positive manner with the subject motivated and aware of the desired response rather than confused.

K It was felt that Tests 7A and 7B should be carried out indoors to minimise the risk of distraction. Writtle College indoor riding arena was used, measuring 23 x 54 metres. Utilising the schooling letters situated at specific locations around the walls of the arena allowed standardisation of distances when performing the preliminary ridden test and ensured a video camera could be located in the correct position for the reinback test. The direction of travel was also tested and was found to be most beneficial if conducted in a clockwise direction (from the entrance), controlling the variable of visual external distractions.

L Tactile performance criterion: an error was tallied on the recording sheet every time an individual deviation occurred immediately **after** the reinback message was applied but **before** the horse stepped backwards. Initially, the desired response to the reinback test was one step backwards with either foreleg. However it became apparent that concluding the session with only this response was not sufficient for the horse to associate the message with the desired response the following week, especially as the size of the subjects' steps varied. It was therefore decided that the desired response should be two diagonal strides backwards; half, one and one and a half strides backwards should also be appropriately reinforced although the test should continue until the desired response was achieved within the maximum number of permitted attempts.

The resistances were categorised using an algorithm (flow diagram), a form of ethogram which enabled the results of the rider and observer to be combined (and any discrepancies checked on the video camera). An ethogram is a standard unit of measuring , categorising and describing behaviour exhibited in a particular species of animal, in this instance the horse (McGlone, 1995; McDonnell and Haviland, 1995). The application of an algorithm allows a high degree of accuracy in relation to continuous recording of type and frequency of the specified behaviour (Mills & Nankervis, 1999). An algorithm was therefore developed and utilised for the ridden reinback test ensuring all behaviour resistances (tallied as errors) were non-overlapping, unambiguous and could provide replicable results. The algorithm is shown at the end of Chapter 6.

M A combination of secondary positive reinforcement and negative reinforcement has been suggested to be the most effective method of reinforcement in the riding horse (Kiley Worthington, 1987) and reinforcement should occur within one second of accomplishing the desired response. The desired response should immediately receive secondary positive reinforcement (vocal praise "Good Girl" or "Good Boy" and patting on the neck) and simultaneous negative reinforcement (release of leg pressure).

N When initially training the horse to respond to Message 3, the number of slowing steps required before a balanced halt is achieved may take up to eight steps, but should progressively decrease until only three or four steps occur (Dodwell, 1999). Message 3 should thus be applied until the rhythm is gauged slow enough by the rider to feasibly expect the horse to halt in a balanced manner. The scientific calculation of this relative speed is not practical as each horse varies in their stride pattern, rhythm and tempo (speed of the rhythm). In this instance, rider experience prevails over scientific accuracy.

O If the horse's response to Message 9 is to walk forwards, the rider's legs should slide forwards to the girth and Message 3 be applied until the pace slows enough to allow Message 4 to be effectively applied and a halt established. Once in halt the rider should then apply Messages 6 and 1.

Appendix 11 Field results; Test 1 - One blank stimului

SUBJECT	REPLICATE	ERROR	TIME (SEC)	SUBJECT	REPLICATE	ERROR	TIME (SEC)	SUBJECT	REPLICATE	ERROR	TIME (SEC)
H1	1	0	10	**H4**	1	7	37	**H7**	1	2	20
	2	0	2		2	2	10		2	1	10
	3	0	1		3	3	17		3	3	28
	4	3	20		4	0	4		4	1	28
	5	1	3		5	1	5		5	2	4
TOTAL		**4**	**36**	**TOTAL**		**13**	**73**	**TOTAL**		**9**	**90**
H2	1	0	10	**H5**	1	0	4	**H8**	1	1	14
	2	0	5		2	0	2		2	3	12
	3	1	3		3	0	1		3	5	31
	4	4	36		4	0	1		4	3	10
	5	0	1		5	0	1		5	1	2
TOTAL		**5**	**55**	**TOTAL**		**0**	**9**	**TOTAL**		**13**	**69**
H3	1	0	5	**H6**	1	0	40				
	2	0	17		2	0	18				
	3	0	5		3	0	31				
	4	0	8		4	0	5				
	5	0	2		5	0	6				
TOTAL		**0**	**37**	**TOTAL**		**0**	**100**				

Appendix 12 Test 2 - Two blank stimuli

SUBJECT	REPLICATE	ERROR	CARD	TIME (SEC)	SUBJECT	ERROR	CARD	TIME (SEC)	SUBJECT	ERROR	CARD	TIME (SEC)
H1	1	0	R	5	H4	1	R	4	H7	1	R	8
	2	0	R	5		1	R	16		1	R	6
	3	0	R	3		2	R	16		1	R	7
	4	0	R	2		2	R	19		1	R	8
	5	1	R	2		0	R	5		1	R	4
TOTAL		**1**		**17**		**6**		**60**	TOTAL	**5**		**33**
H2	1	5	L	54	H5	0	R	4	H8	0	L	4
	2	1	L	5		0	R	2		2	R	10
	3	2	L	23		0	R	2		0	R	6
	4	0	L	2		0	R	1		2	R	12
	5	0	L	2		0	L	1		1	L	11
TOTAL		**8**		**86**	TOTAL	**0**		**10**	TOTAL	**5**		**43**
H3	1	0	R	15	H6	0	R	2				
	2	0	R	3		0	L	3				
	3	0	R	3		0	R	5				
	4	0	R	3		0	L	4				
	5	0	R	2		0	L	1				
TOTAL		**0**		**26**	TOTAL	**0**		**15**				

R = SUBJECT TOUCHED CARD ON THEIR RIGHT
L = SUBJECT TOUCHED CARD ON THEIR LEFT

Appendix 13 Field results; Test 3 - Star stimuli right , blank stimuli left

SUBJECT	REPLICATE	ERROR	TIME (SEC)	SUBJECT	REPLICATE	ERROR	TIME (SEC)	SUBJECT	REPLICATE	ERROR	TIME (SEC)
H1	1	1	2	H4	1	0	3	H7	1	0	5
	2	0	4		2	0	4		2	1	4
	3	0	2		3	0	3		3	1	3
	4	0	3		4	0	5		4	1	5
	5	0	2		5	2	13		5	3	7
	6	0	2		6	2	6		6	3	6
	7	0	3		7	1	2		7	3	4
	8	0	3		8	1	4		8	0	3
	9	0	2		9	1	6		9	1	3
	10	2	3		10	1	4		10	0	4
TOTAL		**3**	**26**	TOTAL		**8**	**50**	TOTAL		**13**	**44**
H2	1	6	24	H5	1	2	3	H8	1	3	8
	2	1	2		2	0	1		2	1	4
	3	1	2		3	0	1		3	1	7
	4	1	3		4	2	15		4	5	10
	5	0	2		5	2	14		5	0	4
	6	0	1		6	1	7		6	2	6
	7	0	1		7	4	20		7	0	4
	8	0	1		8	0	2		8	0	1
	9	0	1		9	0	1		9	0	2
	10	1	2		10	0	1		10	1	4
TOTAL		**10**	**39**	TOTAL		**11**	**65**	TOTAL		**13**	**50**
H3	1	0	2	H6	1	0	7				
	2	0	1		2	0	3				
	3	0	8		3	0	11				
	4	0	1		4	0	5				
	5	0	1		5	0	8				
	6	0	0.8		6	0	2				
	7	0	3		7	0	3				
	8	0	1		8	0	2				
	9	0	0.8		9	0	5				
	10	0	4		10	0	3				
TOTAL		**0**	**22.6**	TOTAL		**0**	**49**				

Appendix 14 Field results; Test 4 - Star stimuli left , blank stimuli right

SUBJECT	REPLICATE	ERROR	TIME (SEC)	SUBJECT	REPLICATE	ERROR	TIME (SEC)	SUBJECT	REPLICATE	ERROR	TIME (SEC)
H1	1	11	23	**H4**	1	0	2	**H7**	1	0	1
	2	4	7		2	0	1		2	0	2
	3	3	4		3	0	2		3	0	2
	4	4	6		4	0	1		4	0	1
	5	2	4		5	0	1		5	0	1
	6	4	5		6	0	1		6	0	1
	7	2	5		7	0	2		7	0	1
	8	0	2		8	0	1		8	0	1
	9	1	2		9	0	0.8		9	0	1
	10	2	5		10	0	1		10	0	1
TOTAL		33	63	TOTAL		0	12.8	TOTAL		0	12
H2	1	0	2	**H5**	1	0	1	**H8**	1	0	1
	2	0	1		2	0	1		2	1	10
	3	2	3		3	0	1		3	0	7
	4	1	2		4	0	1		4	0	3
	5	1	2		5	0	1		5	2	16
	6	0	1		6	0	1		6	0	0.8
	7	0	1		7	0	1		7	0	1
	8	0	1		8	0	1		8	0	2
	9	0	2		9	0	1		9	0	1
	10	2	7		10	0	1		10	0	1
TOTAL		6	22	TOTAL		0	10	TOTAL		3	42.8
H3	1	4	7	**H6**	1	0	2				
	2	6	44		2	0	2				
	3	0	2		3	0	2				
	4	2	5		4	0	2				
	5	0	3		5	0	1				
	6	0	3		6	0	2				
	7	0	3		7	0	3				
	8	0	1		8	0	1				
	9	2	9		9	0	1				
	10	0	1		10	0	2				
TOTAL		14	78	TOTAL		0	18				

Appendix 15 Field results; Test 6 , Week 1 - Continuous changeover design

SUBJECT	SERIES SET	ERROR	TIME (SEC)	SUBJECT	SERIES SET	ERROR	TIME (SEC)	SUBJECT	SERIES SET	ERROR	TIME (SE
H1	R	0	1	H4	R	1	4	H7	R	3	7
	L	1	5		L	0	2		L	0	1
	R	0	0.9		R	3	4		R	0	2
	R	0	1		R	3	4		R	4	9
1. TOTAL		1	7.9	1. TOTAL		7	14	1. TOTAL		7	19
	L	1	2		L	0	2		L	0	1
	L	1	1		L	0	1		L	0	1
	R	0	1		R	2	6		R	1	4
	R	0	0.4		R	0	1		R	4	10
2. TOTAL		2	4.4	2. TOTAL		2	10	2. TOTAL		5	16
	L	1	2		L	1	3		L	1	4
	R	1	7		R	3	6		R	1	4
	L	2	9		L	2	5		L	0	1
	L	1	1		L	0	2		L	0	1
3. TOTAL		5	19	3. TOTAL		6	16	3. TOTAL		2	10
	L	0	2		L	1	3		L	0	1
	L	0	3		L	0	2		L	0	2
	R	0	2		R	2	4		R	0	1
	R	0	9		R	3	6		R	0	2
4. TOTAL		0	16	4. TOTAL		6	15	4. TOTAL		0	6
CUMULATIVE TOTAL		8	47.3	CUMULATIVE TOTAL		21	55	CUMULATIVE TOTAL		14	51
H2	R	0	2	H5	R	2	19	H8	R	1	4
	L	0	2		L	0	27		L	0	1
	R	0	2		R	1	4		R	1	6
	R	0	1		R	1	5		R	0	3
1. TOTAL		0	7	1. TOTAL		4	10	1. TOTAL		2	14
	L	0	1		L	0	2		L	1	6
	L	0	1		L	0	1		L	0	1
	R	3	6		R	1	3		R	1	4
	R	1	3		R	0	3		R	1	4
2. TOTAL		4	11	2. TOTAL		1	9	2. TOTAL		3	15
	L	0	2		L	0	1		L	0	6
	R	1	1		R	0	1		R	0	4
	L	0	2		L	3	7		L	0	4
	L	0	2		L	2	3		L	0	1
3. TOTAL		1	7	3. TOTAL		5	12	3. TOTAL		0	15
	L	0	2		L	0	1		L	0	1
	L	0	1		L	0	1		L	0	3
	R	0	2		R	0	3		R	0	1
	R	1	3		R	0	2		R	0	3
4. TOTAL		1	8	4. TOTAL		0	7	4. TOTAL		0	8
CUMULATIVE TOTAL		6	33	CUMULATIVE TOTAL		10	38	CUMULATIVE TOTAL		5	52
H3	R	0	0.9	H6	R	0	4				
	L	3	13		L	0	3				
	R	0	2		R	0	3				
	R	0	1		R	0	2				
1. TOTAL		3	16.9	1. TOTAL		0	12				
	L	1	2		L	0	2				
	L	2	6		L	0	3				
	R	0	3		R	0	3				
	R	0	1		R	1	4				
2. TOTAL		3	12	2. TOTAL		1	12				
	L	0	4		L	0	1				
	R	2	10		R	0	1				
	L	0	1		L	0	2				
	L	0	1		L	0	2				
3. TOTAL		2	16	3. TOTAL		0	6				
	L	0	2		L	0	2				
	L	0	2		L	0	2				
	R	0	1		R	0	3				
	R	0	1		R	0	3				
4. TOTAL		0	6	4. TOTAL		0	10				
CUMULATIVE TOTAL		8	50.9	CUMULATIVE TOTAL		1	40				

KEY

R = STAR STIMULI POSITIONED TO SUBJECTS RIGHT AND MOON STIMULI POSITIONED TO SUBJECTS LEFT

L = STAR STIMULI POSITIONED TO SUBJECTS LEFT AND MOON STIMULI POSITIONED TO SUBJECTS RIGHT

Appendix 15 Field results; Test 6 , Week 2 - Continuous changeover design

SUBJECT	SERIES SET	ERROR	TIME (SEC)	SUBJECT	SERIES SET	ERROR	TIME (SEC)	SUBJECT	SERIES SET	ERROR	TIME (SEC
H1	R	1	4	H4	R	1	4	H7	R	1	9
	L	0	1		L	0	1		L	0	1
	R	1	2		R	1	4		R	0	2
	R	0	1		R	0	2		R	0	2
1. TOTAL		2	8	1. TOTAL		2	11	1. TOTAL		1	14
	L	0	2		L	0	3		L	0	1
	L	1	3		L	0	3		L	0	1
	R	0	2		R	1	4		R	1	4
	R	1	5		R	0	2		R	0	2
2. TOTAL		2	12	2. TOTAL		1	12	2. TOTAL		1	8
	L	0	1		L	0	1		L	0	1
	R	0	0.4		R	1	3		R	1	3
	L	0	2		L	0	1		L	0	1
	L	0	2		L	0	1		L	0	2
3. TOTAL		0	5.4	3. TOTAL		1	6	3. TOTAL		1	7
	L	0	1		L	0	15		L	0	3
	L	0	2		L	0	2		L	0	1
	R	0	2		R	1	2		R	0	2
	R	1	5		R	1	6		R	1	3
4. TOTAL		1	10	4. TOTAL		2	25	4. TOTAL		1	9
CUMULATIVE TOTAL		5	36.4	CUMULATIVE TOTAL		6	64	CUMULATIVE TOTAL		4	38
H2	R	0	7	H5	R	0	3	H8	R	1	15
	L	0	7		L	0	2		L	0	6
	R	1	7		R	0	2		R	0	5
	R	1	5		R	0	2		R	2	1
1. TOTAL		2	26	1. TOTAL		0	9	1. TOTAL		3	27
	L	0	4		L	0	2		L	0	7
	L	0	4		L	0	2		L	0	6
	R	2	8		R	0	5		R	0	8
	R	0	6		R	0	2		R	1	8
2. TOTAL		2	22	2. TOTAL		0	11	2. TOTAL		1	29
	L	0	4		L	4	3		L	0	5
	R	1	7		R	0	1		R	0	3
	L	0	2		L	2	5		L	0	3
	L	0	2		L	0	1		L	1	8
3. TOTAL		1	15	3. TOTAL		6	10	3. TOTAL		1	19
	L	0	2		L	5	20		L	0	1
	L	0	2		L	0	1		L	0	3
	R	0	8		R	0	2		R	0	2
	R	0	46		R	0	1		R	0	4
4. TOTAL		0	58	4. TOTAL		5	24	4. TOTAL		0	10
CUMULATIVE TOTAL		5	121	CUMULATIVE TOTAL		11	54	CUMULATIVE TOTAL		5	85
H3	R	0	2	H6	R	0	3				
	L	1	6		L	0	2				
	R	0	1		R	0	3				
	R	0	1		R	0	4				
1. TOTAL		1	10	1. TOTAL		0	12				
	L	0	1		L	0	2				
	L	1	8		L	2	20				
	R	0	1		R	0	6				
	R	0	2		R	0	2				
2. TOTAL		1	12	2. TOTAL		2	30				
	L	0	5		L	0	2				
	R	0	2		R	0	6				
	L	1	4		L	0	6				
	L	1	4		L	0	2				
3. TOTAL		2	15	3. TOTAL		0	16				
	L	3	11		L	3	33				
	L	0	2		L	0	15				
	R	0	4		R	1	5				
	R	0	3		R	0	5				
4. TOTAL		3	20	4. TOTAL		4	58				
CUMULATIVE TOTAL		7	57	CUMULATIVE TOTAL		6	116				

KEY

R = STAR STIMULI POSITIONED TO SUBJECTS RIGHT AND MOON STIMULI POSITIONED TO SUBJECTS LEFT

L = STAR STIMULI POSITIONED TO SUBJECTS LEFT AND MOON STIMULI POSITIONED TO SUBJECTS RIGHT

Appendix 15 Field results; Test 6 , Week 3 - Continuous changeover design

SUBJECT	SERIES SET	ERROR	TIME (SEC)	SUBJECT	SERIES SET	ERROR	TIME (SEC)	SUBJECT	SERIES SET	ERROR	TIME (SEC)
H1	R	4	2	H4	R	0	0.9	H7	R	1	5
	L	1	2		L	0	3		L	0	1
	R	0	2		R	0	2		R	1	2
	R	0	2		R	0	2		R	1	3
1. TOTAL		5	8	1. TOTAL		0	7.9	1. TOTAL		3	11
	L	1	2		L	0	2		L	0	1
	L	1	2		L	2	5		L	0	1
	R	0	3		R	0	2		R	3	6
	R	0	2		R	1	6		R	1	3
2. TOTAL		2	9	2. TOTAL		3	15	2. TOTAL		4	11
	L	0	1		L	0	1		L	0	2
	R	3	8		R	0	1		R	0	0.1
	L	0	1		L	0	1		L	0	0.1
	L	0	5		L	0	1		L	0	1
3. TOTAL		3	15	3. TOTAL		0	4	3. TOTAL		0	3.2
	L	1	2		L	0	1		L	0	1
	L	0	4		L	0	1		L	0	1
	R	0	2		R	2	6		R	2	6
	R	1	8		R	0	1		R	1	2
4. TOTAL		2	16	4. TOTAL		2	9	4. TOTAL		3	10
CUMULATIVE TOTAL		12	48	CUMULATIVE TOTAL		5	35.9	CUMULATIVE TOTAL		10	35.2
H2	R	0	1	H5	R	1	3	H8	R	2	6
	L	0	2		L	0	1		L	0	4
	R	1	3		R	4	1		R	7	27
	R	1	5		R	0	3		R	1	5
1. TOTAL		2	11	1. TOTAL		5	8	1. TOTAL		10	42
	L	0	1		L	0	1		L	0	2
	L	0	3		L	0	1		L	0	5
	R	2	9		R	0	1		R	1	4
	R	0	4		R	0	1		R	1	2
2. TOTAL		2	17	2. TOTAL		0	4	2. TOTAL		2	13
	L	0	3		L	1	3		L	0	7
	R	1	3		R	0	0.9		R	1	3
	L	0	6		L	0	1		L	0	4
	L	0	6		L	1	6		L	0	3
3. TOTAL		1	18	3. TOTAL		2	10.9	3. TOTAL		1	17
	L	0	15		L	1	2		L	0	3
	L	0	2		L	0	1		L	0	5
	R	2	9		R	0	1		R	3	15
	R	0	4		R	0	1		R	1	4
4. TOTAL		2	30	4. TOTAL		1	5	4. TOTAL		4	27
CUMULATIVE TOTAL		7	76	CUMULATIVE TOTAL		8	27.9	CUMULATIVE TOTAL		17	99
H3	R	0	1	H6	R	0	8				
	L	0	4		L	0	2				
	R	0	2		R	0	1				
	R	0	2		R	0	1				
1. TOTAL		0	9	1. TOTAL		0	12				
	L	8	25		L	0	2				
	L	1	5		L	0	1				
	R	0	2		R	1	2				
	R	1	4		R	1	4				
2. TOTAL		10	36	2. TOTAL		2	9				
	L	1	7		L	0	1				
	R	2	7		R	0	1				
	L	0	1		L	0	3				
	L	0	4		L	0	2				
3. TOTAL		3	19	3. TOTAL		0	7				
	L	1	1		L	5	36				
	L	1	6		L	0	2				
	R	2	5		R	0	3				
	R	1	3		R	0	2				
4. TOTAL		5	15	4. TOTAL		5	43				
CUMULATIVE TOTAL		18	79	CUMULATIVE TOTAL		7	71				

KEY

R = STAR STIMULI POSITIONED TO SUBJECTS RIGHT AND MOON STIMULI POSITIONED TO SUBJECTS LEFT

L = STAR STIMULI POSITIONED TO SUBJECTS LEFT AND MOON STIMULI POSITIONED TO SUBJECTS RIGHT

Appendix 16 Field results; Test 7 , Week 1 , 2, 3 - Tactile (ridden) discrimination test

WEEK ONE						WEEK TWO					WEEK THREE				
SUBJECT	REPLICATE	ERR0R	DEVIATION TYPE	ATTEMPT	TIME (sec)	SUBJECT	ERROR	DEVIATION TYPE	ATTEMPT	TIME (sec)	SUBJECT	ERROR	DEVIATION TYPE	ATTEMPT	TIME (sec)
H1	1	5	SQ,GT,JC,L,TS	1 step	7	H1	3	OM,TS,L	2 steps	6	H1	2	TS,HR	2 steps	4
	2	3	SQ,OM,TS	2 steps	8										
	3														
	4														
	5														
	6														
TOTAL		8			15	TOTAL	3			6	TOTAL	2			4
H2	1	2	SS,L	0	11	H2	2	OM,TS	2 steps	10	H2	3	SQ,HR,OM	1 step	6
	2	5	JC,OM,HR,SS,TS	1 step	8							3	HR,TS,OM	2 steps	7
	3	2	HR,TR	1 step	10										
	4	3	OM,TR,HR	2 steps	11										
	5														
	6														
TOTAL		12			40	TOTAL	2			10	TOTAL	6			13
H3	1	4	HR,WF,TS,JC	0	6	H3	1	TS	2 steps	2	H3	2	HR,TS	2 steps	4
	2	7	HR,TS,JC,HT,WF,E,QTF	0	13										
	3	4	HR,TS,SQ,HT	1 step	6										
	4	2	HR,TS	1 step	5										
	5	2	HR,TS	2 steps	5										
	6														
TOTAL		19			35	TOTAL	1			2	TOTAL	2			4
H4	1	4	JC,SQ,HS,WF	0	11	H4	3	HR,SQ,OM	1 step	5	H4	4	HR,TS,JC,SQ	0	5
	2	3	SQ,HS,JC	1 step	7		3	HR,OM,TS	2 steps	3		5	HR,JC,TS,SQ,QTF	0	7
	3	5	HR,JC,WF,QTF,SQ	0	15							5	JC,HR,SQ,TS,SS	2 steps	11
	4	5	SQ,JC,QTF,HS,SO	1 step	11										
	5	4	HR,JC,HS,SQ	1.5 steps	11										
	6	1		2 steps											
TOTAL		22			55	TOTAL	6			8	TOTAL	14			23
H5	1	4	HR,HT,SQ,TR	1 step	8	H5	4	TS,GT,OM,J	1 step	4	H5	3	SQ,HR,TS	1 step	4
	2	4	HR,SQ,E,TR	1 step	5		3	HR,TS,OM	2 steps	4		3	SQ,HR,TS	2 steps	3
	3	3	HR,QTF,TS	1 step	5										
	4	2	SQ,S	2 steps	6										
	5														
	6														
TOTAL		13			24	TOTAL	7			8	TOTAL	6			7

DEVIATION TYPE = RESISTANCE (ABBREVIATED) AS SHOWN IN RELATION TO THE ALGORITHM (P32)

Appendix 16 Field results; Test 7, Week 1, 2, 3 - Tactile (ridden) discrimination test

WEEK ONE						WEEK TWO					WEEK THREE				
SUBJECT	REPLICATE	ERROR	DEVIATION TYPE	ATTEMPT	TIME (sec)	SUBJECT	ERROR	DEVIATION TYPE	ATTEMPT	TIME (sec)	SUBJECT	ERROR	DEVIATION TYPE	ATTEMPT	TIME (sec)
H6	1	3	OM,SS,P	0	17	H6	2	WF,OM	0	7	H6	3	SQ,OM,SO	0	7
	2	1	OM	2 steps	10		1	OM	2 steps	8		1	OM	2 steps	4
	3														
	4														
	5														
	6														
TOTAL		4			27	TOTAL	3			15	TOTAL	4			11
H7	1	3	WF,GT,HR	0	10	H7	2	SS,OM	1 step	11	H7	5	WF,HR,OM,TS,JC	0	7
	2	3	GT,CM,SS	1 step	9		3	SS,OM,WF	1 step	13		2	HR,TR	2 steps	4
	3	3	SS,OM,HR	0	10		3	SS,OM,WF	0	17					
	4	3	OM,WF,SS	1 step	10		3	SS,WF,OM	0	10					
	5	3	JC,HR,SS	0	8		2	WF,MO	0	8					
	6	1		2 steps			1	1	2 steps						
TOTAL		16			47	TOTAL	14			59	TOTAL	7			11
H8	1	2	HR,OM	1 step	5	H8	1	JC	1.5 steps	4	H8	1	HS	2 steps	4
	2	2	HS,OM	2 steps	4		0		2 steps	5					
	3														
	4														
	5														
	6														
TOTAL		4			9	TOTAL	1			9	TOTAL	1			4
H9	1	4	HR,SQ,OM,WF	0	11	H9	4	WF,SQ,HT,OM	0	9	H9	2	TR,OM	2 steps	2
	2	4	WF,JC,HT,SQ	0	10		1	OM	2 steps	4					
	3	4	HR,SQ,OM,SS	2 steps	9										
	4														
	5														
	6														
TOTAL		12			30	TOTAL	5			13	TOTAL	2			2
H10	1	0		2 steps	4	H10	1	HR	2 steps	3	H10	1	HR	2 steps	3
	2														
	3														
	4														
	5														
	6														
TOTAL		0			4	TOTAL	1			3	TOTAL	1			3
CUMULATIVE TOTALS		110			286		43			133.		45			82

Appendix 17 Tactile discrimination video (as enclosed)

Appendix 18 Calculations for chi squared - Test 2

SUBJECT	OBSERVED	EXPECTED	$\frac{(O - E)^2}{E}$
H1	5	2.5	2.5
H2	0	2.5	2.5
H3	5	2.5	2.5
H4	5	2.5	2.5
H5	4	2.5	0.9
H6	2	2.5	0.1
H7	5	2.5	2.5
H8	3	2.5	0.1
TOTAL			**13.6**

Observed = Frequency of right card response in 5 replicates

Appendix 19 Calculations for chi squared - Test 3

SUBJECT	OBSERVED	EXPECTED	$\frac{(O - E)^2}{E}$
H1	8	5	1.8
H2	5	5	0.0
H3	10	5	5.0
H4	4	5	0.2
H5	5	5	0.0
H6	10	5	5.0
H7	3	5	0.8
H8	4	5	0.2
TOTAL			**13.0**

Observed = Frequency of right card response with zero error in 10 replicates

Appendix 20 Calculations for chi squared - Test 4

SUBJECT	OBSERVED	EXPECTED	$\frac{(O - E)^2}{E}$
H1	1	5	3.2
H2	6	5	0.2
H3	6	5	0.2
H4	10	5	5.0
H5	10	5	5.0
H6	10	5	5.0
H7	10	5	5.0
H8	8	5	1.8
TOTAL			**25.4**

Observed = Frequency of left card response with zero error in 10 replicates

Appendix 21 Calculations for chi squared - Test 6, weeks 1, 2 and 3 (total errors)

SERIES SET	**OBSERVED**	**EXPECTED**	$\frac{(O - E)^2}{E}$
WEEK 1			
1	24	18.25	1.8
2	21	18.25	0.4
3	21	18.25	0.4
4	7	18.25	6.9
TOTAL	**73**		**9.5**
WEEK 2			
1	11	12.25	0.1
2	10	12.25	0.4
3	12	12.25	5.1
4	16	12.25	0.1
TOTAL	**49**		**5.7**
WEEK 3			
1	25	21	0.8
2	25	21	0.8
3	10	21	5.8
4	24	21	0.4
TOTAL	**84**		**7.8**

Observed = The total number of errors in each series set
n = 8

Appendix 22 Calculations for chi squared - Test 7, weeks 1, 2 and 3 (total errors and time)

ERRORS	**OBSERVED**	**EXPECTED**	$\frac{(O - E)^2}{E}$
WEEK			
1	110	66	29.3
2	43	66	8.0
3	45	66	6.7
TOTAL	**198**		**44**
TIME (seconds)			
1	286	167	84.8
2	133	167	6.9
3	82	167	43.3
TOTAL	**501**		**135**

Observed = The total number of errors and time duration (seconds) in each week
n = 10

Appendix 23 The relative cumulative (cum) frequency (freq) of total errors and time (seconds) for each replicate in Test 1

ERRORS					TIME			
REPLICATE	**TOTAL ERRORS**	**MEAN FREQ**	**CUM FREQ**	**%**	**TOTAL TIME**	**MEAN FREQ**	**CUM FREQ**	**%**
1	11	0.25	0.25	**25**	140	0.299	0.299	**30**
2	6	0.136	0.386	**39**	76	0.162	0.461	**46**
3	12	0.27	0.656	**65**	117	0.249	0.71	**71**
4	11	0.25	0.906	**91**	112	0.239	0.949	**95**
5	5	0.113	1.019	**100**	24	0.051	1.0	**100**
TOTAL	**44**				**469**			

n = 8
% = Percentage

Appendix 24 The relative cumulative (cum) frequency (freq) of total errors and time (seconds) for each replicate in Test 2

ERRORS					TIME			
REPLICATE	**TOTAL ERRORS**	**MEAN FREQ**	**CUM FREQ**	**%**	**TOTAL TIME**	**MEAN FREQ**	**CUM FREQ**	**%**
1	7	0.28	0.28	**28**	96	0.331	0.331	**33**
2	5	0.20	0.48	**48**	50	0.172	0.503	**50**
3	5	0.20	0.68	**68**	65	0.224	0.727	**73**
4	5	0.20	0.88	**88**	51	0.176	0.903	**90**
5	3	0.12	1.0	**100**	28	0.096	0.999	**100**
TOTAL	**25**				**290**			

n = 8
% = Percentage

Appendix 25 The relative cumulative (cum) frequency (freq) of total errors and time (seconds) for each replicate in Test 3

ERRORS					TIME			
REPLICATE	**TOTAL ERROR**	**MEAN FREQ**	**CUM FREQ**	**%**	**TOTAL TIME**	**MEAN FREQ**	**CUM FREQ**	**%**
1	12	0.206	0.206	**21**	54	0.156	0.156	**16**
2	3	0.051	0.257	**26**	23	0.066	0.222	**22**
3	3	0.051	0.308	**31**	37	0.107	0.329	**33**
4	9	0.155	0.463	**46**	47	0.135	0.464	**47**
5	7	0.120	0.583	**58**	51	0.147	0.611	**61**
6	8	0.137	0.72	**72**	30.8	0.089	0.7	**70**
7	8	0.137	0.857	**86**	40	0.115	0.815	**81**
8	1	0.017	0.874	**87**	17	0.049	0.864	**86**
9	2	0.034	0.908	**91**	20.8	0.060	0.924	**92**
10	5	0.086	0.994	**100**	25	0.072	0.996	**100**
TOTAL	**58**				**345.6**			

n = 8
% = Percentage

Appendix 26 The relative cumulative (cum) frequency (freq) of total errors and time (seconds) for each replicate in Test 4

	ERRORS				TIME			
REPLICATE	**TOTAL ERROR**	**MEAN FREQ**	**CUM FREQ**	**%**	**TOTAL TIME**	**MEAN FREQ**	**CUM FREQ**	**%**
1	15	0.268	0.268	**27**	39	0.150	0.150	**15**
2	11	0.196	0.464	**46**	68	0.262	0.412	**41**
3	5	0.089	0.553	**55**	23	0.088	0.5	**50**
4	7	0.125	0.678	**68**	21	0.081	0.581	**58**
5	5	0.089	0.767	**77**	29	0.112	0.693	**69**
6	4	0.071	0.838	**84**	14.08	0.057	0.75	**75**
7	2	0.036	0.874	**87**	17	0.065	0.815	**82**
8	0	0	0	**87**	10	0.038	0.853	**85**
9	3	0.054	0.928	**93**	17.08	0.068	0.921	**92**
10	4	0.071	0.999	**100**	19	0.073	0.994	**100**
TOTAL	**56**				**258.6**			

n = 8
% = Percentage

Appendix 27 The relative cumulative (cum) frequency (freq) of total errors and time (seconds) for each series set in Test 6, weeks 1, 2 and 3

	ERRORS				TIME			
SERIES SET	**TOTAL ERROR**	**MEAN FREQ**	**CUM FREQ**	**%**	**TOTAL TIME**	**MEAN FREQ**	**CUM FREQ**	**%**
WEEK 1								
1	24	0.328	0.328	**33**	100.8	0.274	0.274	**27**
2	21	0.287	0.615	**62**	89.4	0.243	0.517	**52**
3	21	0.287	0.902	**90**	101	0.275	0.792	**79**
4	7	0.095	0.997	**100**	76	0.206	0.998	**100**
TOTAL	**73**				**367.2**			
WEEK 2								
1	11	0.224	0.224	**22**	117	0.208	0.208	**21**
2	10	0.204	0.428	**43**	136	0.246	0.454	**45**
3	12	0.244	0.672	**67**	93.4	0.166	0.62	**62**
4	16	0.326	0.998	**100**	214	0.381	1.001	**100**
TOTAL	**49**				**560.4**			
WEEK 3								
1	25	0.297	0.297	**30**	108.9	0.230	0.230	**23**
2	25	0.297	0.594	**59**	114	0.241	0.471	**47**
3	10	0.119	0.713	**71**	94.1	0.199	0.67	**67**
4	24	0.269	0.982	**100**	155	0.328	0.998	**100**
TOTAL	**84**				**472**			

n = 8
% = Percentage

Appendix 28 The relative cumulative (cum) frequency (freq) of total errors and time (seconds) for each replicate in Test 7, weeks 1, 2 and 3

	ERRORS				TIME			
REPLICATE	**TOTAL ERROR**	**MEAN FREQ**	**CUM FREQ**	**%**	**TOTAL TIME**	**MEAN FREQ**	**CUM FREQ**	**%**
WEEK 1								
1	31	0.281	0.281	**28**	90	0.314	0.314	**31**
2	32	0.290	0.571	**57**	74	0.258	0.572	**57**
3	21	0.190	0.761	**76**	55	0.192	0.764	**76**
4	15	0.136	0.897	**90**	43	0.150	0.914	**91**
5	9	0.081	0.978	**98**	24	0.083	0.997	**100**
6	2	0.018	0.996	**100**	0	0	0.997	**100**
TOTAL	**110**				**286**			
WEEK 2								
1	23	0.534	0.534	**53**	61	0.458	0.458	**46**
2	11	0.255	0.789	**79**	37	0.278	0.736	**74**
3	3	0.069	0.858	**86**	17	0.127	0.863	**86**
4	3	0.069	0.927	**93**	10	0.075	0.938	**100**
5	2	0.046	0.973	**97**	8	0.060	0.998	**100**
6	1	0.023	0.996	**100**	0	0	0.998	**100**
TOTAL	**43**				**133**			
WEEK 3								
1	26	0.577	0.577	**58**	46	0.560	0.560	**56**
2	14	0.311	0.888	**89**	25	0.304	0.864	**86**
3	5	0.111	0.999	**100**	11	0.134	0.998	**100**
4	0	0	0.999	**100**	0	0	0.998	**100**
5	0	0	0.999	**100**	0	0	0.998	**100**
6	0	0	0.999	**100**	0	0	0.998	**100**
TOTAL	**45**				**82**			

n = 10

% = Percentage

Appendix 29 One way analysis of variance for error and time effect in Test 1

ERROR	**SUM OF SQUARES**	**DEGREES FREEDOM**	**MEAN SQUARE**	**F - STAT**	**P - VALUE**
MAIN EFFECT	43.600	7	6.229	3.125	0.0108
ERRORS	43.600	7	6.229	3.125	0.0108
TOTAL	87.2	14	12.458		
TIME					
MAIN EFFECT	0.128	7	0.018	1.533	0.1919
TIME	0.128	7	0.018	1.533	0.1919
TOTAL	0.256	14	0.036		

n = 8

Appendix 30 One way analysis of variance for error and time effect in Test 7, weeks 1, 2 and 3

ERROR	**SUM OF SQUARES**	**DEGREES FREEDOM**	**MEAN SQUARES**	**F - STAT**	**P-VALUE**	**F - CRIT**
BETWEEN GROUP	290.6	2	145.3	5.340457	0.011111	3.354131
WITHIN GROUP	734.6	27	27.20741			
TOTAL	**1025.2**	**29**				
TIME						
BETWEEN GROUP	1920.61	2	960.3048	5.22066	0.012111	3.35413
WITHIN GROUP	4966.461	27	183.943			
TOTAL	**6887.07**	**29**				

n = 10

Appendix 31 Three way analysis of variance for horse, sequence and time effect in Test 6, weeks 1, 2 and 3

EFFECT	**SUM OF SQUARES**	**DEGREE OF FREEDOM**	**MEAN SQUARES**	**F-STAT**	**P - VALUE**
HORSE	5.977	7	0.854	0.961	0.4600
SEQUENCE	6.253	1	6.253	7.035	0.0084
TIME	5.724	2	2.862	3.220	0.0412
HORSE X SEQUENCE	37.435	7	5.348	6.017	0.0000
HORSE X TIME	22.234	14	1.588	1.787	0.0392
SEQUENCE X TIME	5.318	2	2.659	2.992	0.0515
HORSE X SEQUENCE X TIME	20.307	14	1.451	1.632	0.0690
ERROR	298.625	336	0.889		
TOTAL	**401.872**	**383**	**1.049**		

n = 8

Appendix 32 The subject's rank in relation to individual total errors and individual total time for Test 6 and Test 7, weeks 1, 2 and 3

TEST		**6**			**7**	
ERRORS	**WEEK 1**	**WEEK 2**	**WEEK 3**	**WEEK 1**	**WEEK 2**	**WEEK 3**
H1	4	2	6	4	5	3
H2	3	2	2	5	4	7
H3	4	7	8	9	1	3
H4	7	5	1	10	8	10
H5	6	8	4	7	9	7
H6	1	5	2	2	5	6
H7	8	1	5	8	10	9
H8	2	2	7	2	1	1
H9	-	-	-	5	7	3
H10	-	-	-	1	1	1
TIME						
H1	3	1	4	3	3	3
H2	1	8	6	9	5	9
H3	5	5	7	7	2	4
H4	7	3	3	10	4	10
H5	8	4	1	4	7	6
H6	2	7	5	5	9	7
H7	6	2	2	8	10	8
H8	4	6	8	2	6	5
H9	-	-	-	6	8	1
H10	-	-	-	1	1	2

H = Subject number

Appendix 33 Error and time rank in Test 6, using Spearmans Rank Correlation

ERRORS WEEK	**95% CONFIDENCE INTERVAL**	**T- STATISTIC**	**DEGREES OF FREEDOM**	**1 - TAIL PROBABILITY**
WEEK 1	-0.7287	-0.1211	6	0.4538
WEEK 3	0.6789			
WEEK 2	-0.7501	-0.2372	6	0.4102
WEEK 3	0.6526			
TOTAL	**-0.7429**	**-0.1973**	**6**	**0.4251**
	0.6618			
TIME				
WEEK 1	-0.9036	-1.6031	6	0.0800
WEEK 3	0.2557			
WEEK 2	-0.9217	-1.9308	6	0.0509
WEEK 3	0.1519			
TOTAL	**-0.1885**	**1.8145**	**6**	**0.0598**
	0.9158			