

Horses: Behaviour, Cognition and Welfare

Introduction

The relationship between humans and horses has developed over thousands of years. The earliest record of human use of horses comes from cave paintings in France and Spain from around 15000 years ago, when horses were hunted for food and hides (Goodwin, 2002). Archaeological evidence for the domestication of horses dates back to around 6000 years ago in the Ukraine, Egypt and Western Asia (*Ibid.*).

Through breeding and training, horses have been persuaded to assist in diverse fields of human endeavour. Horses have played a major role in human history, from providing draught power in agriculture and transport to influencing the outcomes of war. Today, they are valued for their use in recreation, competition and sport, whilst in many parts of the world they continue to provide an important source of draught power, meat and milk.

Whilst horses are undoubtedly one of the species most highly valued by humans, all too often the way in which we keep, train and use them can have serious detrimental consequences for their welfare. How much do we actually know about their natural behaviour and the inner workings of the horse's mind and how can this knowledge be used to improve their welfare?

Natural Behaviour

Horses are adapted for life on open grasslands and will range up to 80km per day (Davidson and Harris, 2002). Horses prefer to graze, although they will also browse on a wide variety of vegetation (*Ibid.*). Feral and free-ranging horses spend around 16 to 18 hours a day foraging (*Ibid.*), consuming over 50 varieties of forage daily (Goodwin *et al*, 2005).

Studies of feral horses indicate that they organise themselves into two different types of herd: the family or harem band and the bachelor band (Crowell-Davis, 1993; Waran, 1997). The family band typically consists of a single stallion, several mature mares and their foals and juvenile offspring. In some cases there may be more than one stallion, with the dominant stallion mating more than the subordinate ones. Colts leave, or may be expelled by the stallion, when they are one to two years old and form bachelor bands, whilst most fillies leave when they are one and a half to two and half years old and join other existing harems or form new ones with males from bachelor bands (Goodwin, 1999).

In the wild, membership of a herd is such an important survival strategy that the social behaviour of the horse functions to minimise conflict within the group and so promotes its stability (Goodwin, 2002). Subordinate individuals avoid moving close to dominant ones and overt aggression is relatively rare (Goodwin, 1999). Thus, dominance relationships or hierarchies result in reduced aggression and increased cohesion of the group (Waran, 1997). Once the dominance hierarchy is established, aggression becomes more ritualised, with threats largely replacing actual attacks (Crowell-Davis, 1993). The dominance order is unidirectional between individuals but is not necessarily always linear so that horse 'A' may be dominant over horse 'B' who may be dominant over horse 'C', but horse 'C' may be dominant over horse 'A' (Haupt *et al*, 1978).

A central mechanism of herd cohesion is the formation of pair bonds and mare-foal bonds. Within the herd, individuals have preferred associates with whom they spend most of their time and these are usually horses of similar social rank (Kimura, 1998). Within peer groups,

close pair bonds develop between individuals and can persist throughout life, especially in mares (Goodwin, 2002). These bonds are mutually supportive and bonded pairs graze and rest together and engage in mutual grooming, affiliative neck overlapping and resting head-to-tail fly swishing (Goodwin, 1999 and 2002).

The mare-foal bond begins to develop shortly after birth when the mare licks the foal for up to half an hour (Goodwin, 2002). Foals are able to stand and suckle within two hours of birth and stay very close to their dam's side during the first weeks of life (*Ibid.*). Between one and two months of age, foals make exploratory trips away from their dam and engage in play with other foals (*Ibid.*). Foals tend to associate preferentially with the foal of their dam's most preferred associate (Weeks *et al*, 2000). From two to three months of age, foals begin to spend much of their time with other foals and form peer groups (Goodwin, 2002). Weaning takes place at between eight and nine months of age (*Ibid.*).

Horses are very playful animals. Play may involve running, frolicking, chasing, bucking, jumping, prancing, leaping, manipulation of an object, play fighting and play sexual behaviour (McDonnell and Poulin, 2002). Solitary and object-directed play develop within the first month of life when foals remain close to their dam and social play develops from around one month of age as foals begin to interact with their peers and other members of the social group (Goodwin, 2002). Play may be initiated by a nose-to-nose approach, nudging, nipping, tossing the head and pawing at the prospective play partner (McDonnell and Poulin, 2002).

Play behaviour is vital to the development of the young horse, with up to 75% of the kinetic activity of foals devoted to play (Goodwin, 2002). Play continues to be an important activity even in adulthood, especially for stallions (McDonnell and Poulin, 2002).

Perception and Communication

Vision

The retina of the horse contains a higher proportion of rods and a lower proportion of cones compared with the human retina. The higher proportion of rods means that horses' vision is very sensitive to light level and movement but is not optimal for colour vision and discerning detail (Saslow, 2002). Horses have excellent vision in dim light and are able to make simple visual discriminations and navigate around obstacles in conditions too dark for humans to see (Hanggi and Inversoll, in press). Horses' colour vision is not as good as that of humans but research suggests that it is at least dichromatic (Smith and Goldman, 1999). The horses' visual acuity is around 20/30 on the Snellan scale, which is not as good as that of a human (20/20) but better than that of a dog (around 20/50) or a cat (20/75 to 20/100) (Timney and Keil, 1992).

Compared with humans, horses possess a wider visual field because the eyes are positioned to the sides of the head, which is advantageous for spotting predators but reduces the frontal overlapping binocular field of vision (Saslow, 2002). Horses have a binocular field in an arc of around 60° in front of the head, which enables depth perception comparable with that of cats (Timney and Keil, 1999). Overall, as would be expected for a prey animal, horse vision appears to have evolved more for detection of predator approach from any angle than for accurate visual identification of stationary objects, especially those seen at a distance (Saslow, 2002).

Horses are primarily visual communicators (Goodwin, 2002). Body postures and outlines play an important role in communication and co-ordination of the herd's activities and horses are extremely sensitive to subtle changes in the body language of their companions (Goodwin, 1999). The tense alarm posture alerts the herd to possible danger; a high

rounded body outline indicates excitement and a low straight outline indicates relaxation (Goodwin, 2002). Many parts of the body, including the tail, ears, face and legs, can be used independently or in combination to signal tension, excitement, arousal, fear, irritation, aggression, relaxation and pleasure (*Ibid.*)

Hearing

The range of hearing in the horse may not extend to frequencies quite as low as humans can detect but it far exceeds the highest frequencies that can be heard by humans (over 33000Hz in the horse compared to under 20000Hz in humans) (Saslow, 2002). The area of best sensitivity of hearing in the horse is broad and covers the range of the human voice better than a dog's (*Ibid.*) The ears can be moved independently in the direction of the horse's attention (Goodwin, 2002).

Horses also communicate vocally and the meaning of individual vocalisations may be complex and context dependent (*Ibid.*). Vocal communication can serve to maintain contact over long distances, indicate excitement, deter contact in social interactions or initiate approach between a mare and her foal (*Ibid.*).

Chemoreception

Smell and taste are linked neurologically in the horse, as they are in many other species (McGreevy, 2004). The olfactory structures are very large in the horse compared with humans and it is likely that the horse's capacity for chemoreception and reliance on chemical information for identification are more similar to that of a dog (Saslow, 2002).

Horses familiarise themselves with foreign objects by smelling them and odours are important for recognition of group members (McGreevy, 2004). Nose-to-nose sniffing is an important part of greeting rituals between horses (*Ibid.*). Odours are used for communication over time through marking behaviour, in courtship and in establishing the mare-foal bond (Goodwin, 2002).

Taste is also important in the early bonding of the mare and foal (McGreevy, 2004). Taste allows horses to discriminate between different foods and they can learn to avoid a food if they become ill within a short time of consuming it (Haupt *et al*, 1990).

Touch

Horses are very sensitive to tactile stimuli and react to pressures that are too light for humans to feel (Saslow, 2002). Lansade *et al* (2008) found that most horses reacted to pressure from a filament on the skin at the withers that was too small to be detected by humans when applied to the index finger tip. This sensitivity is useful in detecting the presence of biting flies landing on the skin, which initiates vigorous responses to dislodge the insect, including skin rippling, tail swishing, ear flicking, head shaking, foot stomping and biting at the area (Saslow, 2002).

Touch is used for communication at close range: it promotes and maintains pair bonds during mutual grooming and can be a form of social support in stressful situations, for example, foals may press their body against their dam during novel or disturbing events (Goodwin, 2002).

Cognitive Abilities

Horses excel at simpler forms of learning such as classical and operant conditioning, which is not surprising considering their trainability when these principles and practices are applied (Hanggi, 2005). Horses have also shown ease in stimulus generalisation and discrimination learning and a number of recent studies have demonstrated their ability to solve advanced

cognitive challenges involving categorisation learning and some degree of concept formation (*Ibid.*)

There are two major categories of learning: non-associative learning and associative learning. In non-associative learning, the horse is exposed to a single stimulus to which they can become habituated or sensitised. This type of learning is important in horse training and early handling.

When faced with new experiences, many horses react with fear but, by introducing a potentially frightening stimulus incrementally, the horse becomes accustomed to it and learns to accept it. Habituation is said to have occurred when repeated presentations of a stimulus result in a decrease in response (McGreevy, 2004). This approach can also be used to re-train horses who have become fearful of a particular handling procedure or event through past negative experience (Hanggi, 2005).

Sensitisation is said to have occurred when there is an increase in response after repeated presentations of a stimulus (McGreevy, 2004). This is the means of achieving responsiveness and lightness to riding and handling aids (Hanggi, 2005).

Research suggests that horses show some degree of object generalisation during habituation. Christensen *et al* (2008) found that horses did not show a significant decrease in initial response towards a novel object when presented sequentially with six different objects (ball, barrel, board, box, cone and cylinder) when the objects were the same size but differently coloured. However, when the colour of the objects was the same, the horses showed a significant reduction in response with increasing object number, indicating that horses generalise between similarly coloured objects of varying shape.

In associative learning, the horse learns to make associations between different stimuli (classical conditioning) or between a stimulus and a response (operant conditioning).

Horses, like most animals, learn easily through classical conditioning, where an initially unimportant stimulus is regularly paired with a stimulus that initiates a response (Hanggi, 2005). Horses spontaneously learn that certain stimuli, such as the sound of the feed room door opening or the sound of grain pouring into a bucket, are signs that they are soon to be fed and may display anticipatory behaviour such as vocalising, pawing or kicking the stall door.

In operant conditioning, the horse learns to perform an action to obtain reinforcement (*Ibid.*). This type of learning is central to horse training. The reinforcement may be positive (receiving something desired such as a food reward) or negative (removing something unpleasant such as pressure on the reins or from the rider's legs). Positive and negative reinforcers can both be viewed as rewards in that they both lead to an increase in the performance of the desired response. Negative reinforcement is not the same as punishment because it enables the horse to control the experience (Waran *et al*, 2002).

In discrimination learning, the horse learns that one stimulus and not another will result in reinforcement (Hanggi, 2005). This may involve simple discriminations or more complex discriminations based on categorisation. The ability to categorise provides the basis for substantial higher cognitive function (Nicol, 1996). Hanggi (1999) trained horses to distinguish between two-dimensional black figures with open centres and solid centres. Horses learned the initial discriminations through operant conditioning but then acquired subsequent discriminations with fewer errors, in most cases choosing the correct image on first trial presentation. Rotating the stimuli, mixing the stimulus pairs and changing the relative sizes of the stimuli did not result in any marked decrease in performance, indicating

that the horses had learned to categorise the symbols on the basis of being 'open-centred'. This is an example of learning to learn, where the horses were able to apply knowledge learned in one task to more easily solve related tasks.

Unlike categorisation learning, where stimuli resemble each other, conceptualisation involves responding to certain stimuli because they represent the same idea, regardless of whether they physically resemble one another (Hanggi, 2005). Hanggi (2003) investigated the ability of horses to form concepts based on relative size ('larger than', 'smaller than'). After learning to choose the larger of two stimuli for six sets of two-dimensional symbols, the horses were tested using novel larger and smaller stimuli including three-dimensional objects (five two-dimensional sets and five three-dimensional sets with large, medium, small and tiny sizes). The horses correctly chose the larger of two or more stimuli regardless of novelty or dimension. A second experiment produced the same results for 'smaller than'. After learning the task, the horses responded correctly to new stimuli and were able to generalise across situations varying from flat black shapes to objects of different materials and colours including balls, flower pots and PVC connectors. The results demonstrate that the horses were capable of solving problems based on relative size concepts.

It appears that horses are able to understand that a three-dimensional object can be represented by a two-dimensional image. Hanggi (2001) found that at least some horses are able to recognise photographs of three-dimensional objects as well as recognising objects previously represented by photographs.

Under some circumstances, it has been shown that horses are able to reverse a discrimination they have learned. Martin *et al* (2006) found that horses were able to use spatial cues (left/right position of the goal box) to solve a simple discrimination task and that they were also able to solve the task when the location of the goal was reversed. As the number of reversals increased, the number of errors decreased, indicating that the horses were learning to learn.

The type of cue and the way in which it is presented can influence the outcome of an experiment. It appears that horses may be able to use spatial cues more successfully than visual cues alone. When visual cues (presence/absence of a light above the goal box) were used in the above study by Martin *et al* (2006), the horses were unable to solve the original discrimination. Other research suggests that horses are able to use visual cues more successfully when they are presented at ground level (Hall *et al*, 2003).

Social learning occurs when one horse learns from observing the behaviour of another (Waran *et al*, 2002). As a social species where the young remain with their dam for an extended period, it would be expected that much of what a young horse learns about finding and selecting food, as well as about social behaviour, would be through observation. To date there is little scientific evidence for horses learning in this way. However, this is probably because the methods used to study it in the horse have not yet been made biologically relevant (*Ibid.*). Experiments have generally been based on allowing a naïve horse (observer) to watch a trained horse (demonstrator) perform a task and looking for evidence that the observer horse is able to learn the appropriate response more quickly or more effectively than a control horse which has not watched the demonstrator (Nicol, 2002). However, little attempt has been made to control for the relationship between the demonstrator horse and observer horse and this may account for the lack of evidence for social learning. For example, it may be that the demonstrator horse needs to be closely related to, or at least known by, the observer horse (Waran *et al*, 2002) and the dominance relationship between the horses may influence the observer horse's responses (Krueger and Flauger, 2007). Experiments have looked for evidence of the observer horse matching the behaviour of the demonstrator horse and little attention has been paid to the fact that social

learning may have a variety of effects, which may include non-matching behaviour (*Ibid.*). For example, it is possible that a horse may choose to avoid a bucket where they have observed another horse feeding, either because they may choose not to feed from the same spot as another horse or because they may expect there to be no food left in the bucket (*Ibid.*). By incorporating social aspects into learning trials it will be possible to gain insight into horses' social learning abilities (*Ibid.*).

Memory is the retention of information and is the basis for all higher forms of learning (McGreevy, 2004). Horses are generally considered to possess excellent memory (Miller, 1995). Once horses have learned to negotiate a maze to obtain a food reward they are able to remember it on subsequent occasions, even when tested two months later (Marinier and Alexander, 1994). Similarly, when horses have learned to make the correct (rewarded) selection from twenty pairs of visual patterns, the reported frequency of correct choices when the same apparatus is presented six months later is around 85% (McGreevy, 2004).

Although horses have a well-developed procedural memory (memory of context-specific procedures or behaviours), research by McLean (2004) suggests that horses may not possess a prospective type of memory. In this study, horses chose between two goals, one of which contained feed. When the horses were released immediately after the feed had been deposited they were capable of learning the correct goal choice by attending to cues elicited by the personnel depositing the feed. However, when the horses were not released until 10 seconds after the presentation of the associated cue, they were unable to remember the correct goal choice. On the delayed release trials, some individual horses selected the correct goal on more than 60% of trials and one horse chose correctly on over 70% of trials, suggesting that some horses may be able to solve the delay problem. Further research is therefore warranted before firm conclusions can be made about prospective memory in horses.

Implications for Welfare

Lessons for the management of domestic horses

Many horses are kept in social isolation, fed concentrate-based diets with little forage and given insufficient opportunity for exercise. These conditions are far removed from the environment to which horses are adapted and can lead to poor welfare and abnormal behaviour.

Social isolation is stressful for horses (Mal *et al*, 1991a and 1991b). When young horses are individually stabled for the first time after previously living in groups, they show behavioural responses indicative of stress, including neighing, pawing, nibbling and snorting. Visser *et al* (2008) found that these behaviours were displayed significantly more by horses stabled alone compared with horses stabled in pairs and, after 12 weeks, over two thirds of the individually housed horses had developed stereotypies – apparently functionless repetitive behaviours which are considered to indicate poor welfare.

Stereotypical patterns of behaviour, such as weaving, crib-biting, and box-walking, affect between 10 and 40% of stabled horses and are associated with the feeding of low fibre/high grain content feeds and restrictions on social behaviour (Cooper and McGreevy, 2002). Studies of feral horses indicate that although the physical characteristics of domestic horses may have been altered from those of their wild ancestors, little of their species-specific behaviour has changed. Since horses have evolved to live in social groups and to spend the majority of their time seeking and consuming a wide variety of forages, it is unsurprising that denying them the opportunity to express these behaviours is detrimental to their welfare.

In attempts to prevent the performance of stereotypies, physically restricting devices, electric shock and even surgery have been used. These methods are distressing, harmful and ineffective because they address the symptoms rather than the cause (*Ibid.*). Affected horses may even be kept away from other horses because of concerns that other horses may copy the stereotypical behaviour. This is only likely to reinforce the behaviour (McBride and Long, 2001). Through an appreciation of the natural behaviour of horses, management can be modified to address the underlying motivations which lead to stereotypical behaviours. The welfare of domestic horses could be significantly improved by meeting the horses' need to perform important natural behaviours.

It is widely acknowledged that the most effective means of reducing the frequencies of all common stereotypies is to give the horse greater time in paddocks with *ad libitum* forage and social contact with other horses (Pell and McGreevy, 1999). Within the stable environment, the performance of stereotypies can be reduced by feeding high-forage diets with a minimal amount of concentrates and maximising opportunities for social contact (Cooper and McGreevy, 2002).

Provision of a foraging device, which releases feed pellets as it is pushed around the stable floor by the horse, increases time spent foraging and can improve welfare (Winskill *et al*, 1996) and reduce the performance of stereotypical behaviour (Henderson and Waran, 2001). Providing multiple forages to stabled horses can also be beneficial in increasing the frequency and duration of foraging behaviour compared with provision of a single forage (Thorne *et al*, 2005).

Cooper *et al* (2000) found that stereotypical weaving was significantly reduced by providing stabled horses with additional fields of view including a gridded opening between adjacent stables. No weaving at all was recorded in any of the 10 horses (including five horses who had been known to weave for at least two years) when they were kept in stables with openings on all four sides (front view of courtyard, back view of fields and view into both neighbouring stables).

Management conditions not only affect the welfare of horses but also their responses to handling and training and hence their performance. Research by Rivera *et al* (2002) suggests that pasture-kept horses adapt more easily to training than stabled horses. Søndergaard and Laedwig (2004) found that horses housed in groups performed better in training sessions and were less aggressive towards the trainer compared with individually housed horses. Hausberger *et al* (2007) found that learning abilities were impaired in stereotypic horses.

Lessons for the human-horse relationship

Our knowledge of the natural behaviour and cognitive abilities of horses should be used to inform our actions during handling, riding and training. Given what we know about how horses interact socially, Goodwin (1999) comments that equestrian traditions which are constantly concerned with exerting dominance over the horse could appear to be misguided and that, if human individuals repeatedly attempt to reinforce their dominance over the horses in their charge, it should be recognised that the natural equine response is avoidance. Equestrian traditions which have their basis in establishing a co-operative relationship with the horse would appear to more closely approximate the social relationships seen in free-ranging horse society and the tendency of horses to form pair bonds may be the basis of human-horse bonds which extend beyond the usual master-servant relationship (*Ibid.*).

Through an appreciation of the way in which horses communicate and interact with each other, it is possible to manage previously unhandled horses without coercion by mimicking their behaviour patterns (Sighieri *et al*, 2003). It is also possible to positively influence the behaviour of foals towards a handler by allowing the foal to observe positive interactions between the handler and the foal's dam. Henry *et al* (2005) found that foals of mares who had been softly brushed and fed by hand for short periods during the first five days of the foals' lives appeared less fearful when approached and accepted saddle pads on their backs more easily and more quickly compared with control foals. These effects lasted until foals were at least one year old.

Despite the long history of the human-horse relationship it appears that we have progressed little in the techniques used to train horses, with most contemporary techniques still being based on traditional methods and negative reinforcement (Waran *et al*, 2002). Through the application of our knowledge of the natural behaviour of horses and their cognitive abilities, more innovative methods that take into account the natural behaviour of the horse and use positive reinforcement are slowly developing (*Ibid.*). Goodwin (1999) concludes that by appreciating the adaptive significance of equine behaviour, sympathetic and effective management of the horse can be achieved.

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