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Review

The importance of safety signals in animal handling and training

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ABSTRACT

This review considers the importance of safety for various species of domestic animals and explains how the need for safety may motivate them to offer a variety of unwelcome responses. We argue that the value of safety to animals is often overlooked by trainers and handlers. As a result, animal owners, handlers, trainers, and veterinarians are regularly injured, and training may fail. Reinforced responses that increase the animal's perceived sense of safety but simultaneously endanger the safety of handlers or trainers may lead to the inadvertent training of dangerous responses. This review offers suggestions about how safety can be used effectively and humanely as a resource in operant training. Training calmness in the presence of a specific stimulus that is associated with safety may deserve closer attention. The ethics of creating the need for safety in domestic animals as part of a training regime are discussed. It emerges that the highly prized attribute of so-called trust in animal–trainer dyads may, at least sometimes, be a manifestation of trainers acting as safety signals. Similarly, animals said to have confidence in and regard for their handlers may value the relative safety they afford.

Introduction

Animals are always learning, whether that is during human-guided training in domestic contexts, or simply finding ways to cope with their environment and coexist with the individuals with whom they associate. Given that we have embarked on a path of bending the will of animals to our own, it behooves us to consider the stimuli that motivate them beyond the obvious primary reinforcers: food (most common in contemporary dog training) and removal of pressure (most common in contemporary horse training) (McGreevy and Boakes, 2011). Good trainers suppress unwelcome responses and draw out desirable ones, eventually putting them under stimulus control so that they are offered only on cue. When fear motivates an unwelcome response, punishment aimed at suppressing such a response is less likely to be effective and far more likely to have a negative effect on emotional state, further confounding efforts to draw out desired responses. An understanding of fear responses is therefore central to making training decisions (McLean and McGreevy, 2010).

A safety signal is defined as a stimulus that predicts the nonoccurrence of an otherwise expected aversive stimulus and becomes a conditioned inhibitor of fear responses even in novel situations (Gray, 1987). The term is also used to label signals that inform an individual when it is safe (Seligman, 1968). The physiological response to a safety signal is sometimes broken down into relief and relaxation, where the former is an almost immediate and short-lived autonomic event and the latter a later-onset striatal muscle event (Denny, 1983), but both are still considered components of avoidance learning. A second common usage of the term "safety signal" implies a generalized absence of aversive stimuli and may be trained by association with relaxation and safety (e.g., Haug, 2008). It is not known whether these 2 uses of the term are analogous, particularly given that the former is linked with avoidance learning and the latter with a state of relaxation, making them seem unlikely bedfellows, despite the relaxation component of avoidance learning (Weisman and Litner, 1969). Instead of attempting to tease these concepts apart, in this article, we consider current uses of safety signals in avoidance training and potential uses of learned and ethological safety signals that develop naturally in training and management.

To these ends, this article provides a review of fear responses in animals, their adaptive purpose, how they are expressed, and how

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animals seek subsequent safety. Fear responses in domestic animals are discussed with reference to animal welfare and human safety. The function of natural safety signals is presented, along with possible ways to use safety signals strategically to improve animal welfare, human safety, and to obtain desired behaviors from animals in training, husbandry, and management. Although we focus on examples that come from horse and dog training, the principles apply very widely across species, including elephants as well as livestock and exotic animals.

Fear responses

Ethological context

Fear, as a reaction to perceived danger, is characterized by behavioral and physiological changes that enhance the animal's ability to deal with that danger (Fraser, 1992; Boissy, 1995; Randall et al., 2001). Fearful responses are adaptive to external factors affecting the animal's homeostasis (Fraser, 1975; Kilgour, 1978) and can thus be considered a subset of stress. Fear responses are strongly selected for because they promote biological fitness. For example, alarm signals reported in ungulates in response to predator stimuli (Caro, 2005) are said to function in various ways that include increasing group cohesion, alerting conspecifics, providing individual identification during flight, and as a distraction or decoy used against a predator (Dietland, 1991). However, excessive or prolonged exposure to stressors that elicit fear responses may impair fitness by imposing physiological costs and behavioral changes that interfere with immune competence, ontology, and reproductive success (Moberg and Mench, 2000). In many animal-training contexts, animals may react fearfully to stimuli that pose no actual threat to their homeostasis (Gaynor and Muir, 2009). Such reactions may endanger handlers and the animals themselves as well as hindering the success of training (Hawson et al., 2010).

Laboratory research on fear and avoidance learning

Laboratory studies of fear responses have largely focused on aversive conditioning. These reveal how associations with fear and, ipso facto, the absence of safety, develop. An enormous range of species has been studied from rodents and other mammals (Overmier and Seligman, 1967; Powell and Peck, 1969; Fenton et al., 1979; Zielinski and Plewako, 1980) to pigeons (Dinsmoor and Sears, 1973), fish (Bintz, 1971; Dunlop et al., 2006; Carpenter and Summers, 2009), to green crabs (Abramson et al., 1988), to headless cockroaches (Weiss and Penzlin, 1985), and to humans (Lovibond et al., 2013). The aversive stimuli applied may depend on the species being studied. On the whole, the noxious stimulus most frequently used in standard aversive conditioning procedures is electric shock. This can be precisely controlled and calibrated and even at low intensities resists habituation (McGreevy and Boakes, 2011).

Two broad experimental designs have been developed: discriminated and nondiscriminated (free operant) procedures. Discriminated procedures include temporally paired Pavlovian and operant conditioning. An arbitrary stimulus, labeled a warning or conditioned stimulus (CS), is temporally paired with the noxious or unconditioned stimulus (US). An association develops between the CS and US. In contrast, nondiscriminated or free operant designs omit the specific arbitrary stimuli and deliver the shock on a fixed schedule, the frequency of which can be reduced by the performance of the operant response (Sidman, 1953). Operant responses are usually simple, such as jumping (Mowrer and Lamoreaux, 1946; Candido et al., 1991; Smith and Levis, 1991) or pressing a lever, button, or panel (Seligman, 1968).

The outcomes of aversive-conditioning studies share many similarities, despite large differences among studies in species, devices, and experimental designs. Animals learn to perform a specific behavior to escape or terminate the US. Because of its pairing with the US, the CS warns the subject, which eventually learns to respond to it and avoid experiencing the US altogether. The response that terminates a CS and prevents the US from occurring is known as an avoidance response, to distinguish it from an escape response that terminates a US. As the noxious stimulus is not experienced, the avoidance response has no obvious source of reinforcement (Mowrer and Lamoreaux, 1946). This phenomenon puzzled researchers for much of the 20th century because the source of the reinforcement was unclear (Rescorla and Solomon, 1967; Herrnstein, 1969; Domjan, 2010).

Mowrer (1939) made the important and highly influential claim that pairing the CS (or warning signal) with the US produced conditioned fear of the CS and, consequently, the avoidance response that resulted in the termination of the CS (before the onset of the US) and enabled the animal to escape from the state of fear excited by the CS (Dinsmoor, 2001; Bouton, 2007). The theory as to how both Pavlovian and operant conditioning functioned in the acquisition of the avoidance response became known as 2-factor theory (Mowrer, 1939; Mowrer and Lamoreaux, 1942). This argued that an avoidance response resulted from both the Pavlovian association between the CS and US, and the operant response, which achieved either termination of the US in escape trials or the CS in avoidance trials. It identified the reinforcement for the avoidance response as the animal achieving offset of the CS and the fear conditioned to it (Rescorla and Solomon, 1967). Later research has shown that although behavioral and, in some cases, physiological states of fear were high during response acquisition, signs of fear attenuated once avoidance responses reached asymptote (Solomon et al., 1953; Mineka, 1979). Starr and Mineka (1977) found that rats trained to a criterion of 27 correct avoidance responses showed reduced fear of the CS compared with those trained to only 3 or 9 responses. As such, the acquisition of a successful avoidance response can have an inhibitory effect on fear responses.

And the finding that, after extensive training, the CS evoked little fear (Mineka, 1979), the original version of 2-factor theory (Mowrer, 1960) was also challenged by results indicating acquisition of avoidance behavior with nondiscriminated procedures that omitted any explicit CS/US pairing (for review, see Bouton, 2007; Domjan, 2010). However, after incorporating the concept of safety signals, the revised 2-factor theory provides a powerful theoretical framework for understanding the etiology of response acquisition in animal-training contexts and the performance of unwanted avoidance responses to seemingly innocuous cues. Horses are well known for developing conditioned fear toward random objects encountered in their environment, such as rubbish bins, feed bags, and umbrellas (McLean, 2003). If, on initial exposure to the item, the horse escapes and this is reinforced, it may thereafter demonstrate behavioral fear and perform avoidance responses when reexposed to the stimulus at lower intensities. In common with experimental findings, successful avoidance responses are highly resistant to extinction, which suggests that the inhibition of fear resulting from the avoidance response is reinforcing (Solomon et al., 1953).

Safety signals in laboratory research

Safety signals in avoidance learning

In some experiments on avoidance learning, providing a stimulus that occurred whenever—and as soon as—an animal made a successful avoidance response was found to increase the speed at which the avoidance response was acquired (D'Amato et al., 1968;