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Training as enrichment: A critical review

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Abstract

Husbandry training and environmental enrichment are both important advancements associated with current behavioural welfare practices. Additionally, the use of training procedures has been proposed as a form of enrichment, with the implication that training can produce beneficial behavioural welfare results. This paper examines the concept of training as enrichment through three distinct ways training procedures could enrich: (i) training facilitates enrichment usage; (ii) training modifies interactions, conspecific or otherwise; and (iii) training expands behavioural repertoires. Within each category, the paper focuses on past research that provides empirical support for training functioning as enrichment, as well as related areas of research that provide additional evidence. Previous studies support the claim that training is enriching, with additional research necessary to better understand how prevalent and under what conditions training procedures function as enrichment. Future training research should examine these potential enrichment effects, including methodology that allows for comparisons to traditional enrichment, the use of welfare diversity/variability indices, and the effects of learning on trainers and trainees alike.

Keywords: *animal welfare, enrichment, husbandry, learning, positive reinforcement, training*

Introduction

The modern existence of animals under human care is connected to two major behavioural welfare advances: The use of animal training procedures to promote the husbandry of animals (Forthman & Ogden 1992; Desmond & Laule 1994; Laule *et al* 2003; Melfi *et al* 2020), and the implementation of environmental enrichment (Markowitz 1982; Shepherdson *et al* 1998; Young 2003; Maple & Perdue 2013). Animal training can be defined by respondent and operant conditioning procedures used to elicit, evoke, or emit behaviour (Pryor 1999; Pierce & Cheney 2013; Domjan 2014; Pryor & Ramirez 2014; Ramirez 2020). For instance, in the case of an operant conditioning procedure, food or some other consequence is delivered as a reward for engaging in a selected response. It is also worth noting that most of the focus on modern animal training presented within this review emphasises positive reinforcement and similar force-free applications to effectively change behaviour. Environmental enrichment can be defined as stimuli and/or events that are added to or modify an animal's environment and result in some measurable improvement in behavioural and/or physiological well-being/welfare (Newberry 1995; Shepherdson 1998; Mellen & MacPhee 2001; Fernandez & Timberlake 2008; Hoy *et al* 2010; Fernandez *et al* 2021a). Some examples of enrichment include the use of foraging devices and feeding schedules, both automated and non-automated (Carlstead *et al* 1991; Shepherdson *et al* 1993; Fernandez 2010, 2021; Andrews & Ha 2014; Bashaw *et al* 2016), changes in enclosure presentations, including choice between enclosures (Carlstead *et al* 1993; Sherwin *et al* 1999; Coe 2004), and the presentation of auditory, olfactory, and/or visual stimuli (Carlstead & Seidensticker 1991; Platt & Novak 1997; Graham *et al* 2005; Wells & Irwin 2008; Fernandez & Timberlake 2019a).

While both training and enrichment advances have remained relatively autonomous, the concept of training as a form of enrichment itself has been proposed (Laule & Desmond 1998; Laule 2003; Laule & Whittaker 2007; Brando 2012; Melfi 2013, 2014; Westlund 2014; Melfi & Ward 2020). The implication is that enrichment is a means to improve the welfare of captive animals, and training is proposed to improve welfare, and is therefore enriching. However, what remains less clear are the ways animal training procedures could be empirically measured to have an enriching effect. Some authors, such as Laule and Desmond (1998) and Westlund (2014) have proposed training enriches by providing animals with greater choices and control over their environment, although are less specific about how such choice and control could be demonstrated through an observable metric. Alternatively, Melfi (2013, 2014) proposed several directly testable

hypotheses for an enrichment function of animal training procedures, which included training being enriching because it: (i) affords learning opportunities, and learning is considered to be enriching; (ii) can achieve the same results as enrichment; (iii) increases human-animal interactions; (iv) provides a dynamic change in the animals' day; and (v) facilitates the provision of enrichment. These hypotheses placed training itself as an independent variable, with the resulting response changes as dependent variables demonstrating an enriched outcome. Thus, although Melfi concluded that little published evidence existed at that time to demonstrate training could function as enrichment, the framework itself provided a means to achieve such results.

The following paper examines training as enrichment by first detailing a brief history of (i) modern animal training practices, with a focus on respondent and operant conditioning procedures, and (ii) the use of environmental enrichment to improve behavioural welfare. Most of the paper focuses specifically on learning theory applied to zoo animals, since the history and current evidence for training as enrichment primarily occurs within this field and setting. This review proposes three means (with supporting research) by which training could function as enrichment: (i) training facilitates enrichment usage; (ii) training modifies interactions, conspecific or otherwise; and (iii) training expands behavioural repertoires. For all the above, the review examines the relevant supporting literature based on a demonstrated ability to improve behavioural welfare. In addition, the review proposes areas of research that could provide further evidence for the ability of training to function as enrichment.

A brief history of modern animal training

Modern animal training procedures are linked to two major events: (i) Skinner's discovery of shaping, or the differential reinforcement of successive approximations to a target response (Skinner 1951; Peterson 2004; Pierce & Cheney 2013); and (ii) the creation of a field of Applied Animal Psychology by Keller and Marian Breland and based on Skinner's operant conditioning principles (Breland & Breland 1951; Bailey & Gillaspy 2005; Bihm *et al* 2010). It was the latter development that propelled the field of animal training into a modern era, with the Brelands training a wide variety of animal species for commercials, coin-operated fair/zoo acts, and public shows (Curtis 1957; Yin 2012; Gillaspy *et al* 2014). Many of these animal training procedures relied on the use of conditioned reinforcement to shape desired behaviour rapidly and precisely (Ramirez 1999; Fernandez 2001; Dorey & Cox 2018).

As a result of these advances in applied animal training procedures, particularly the use of positive reinforcement with marine mammals trained for public shows, zoos and other animal facilities began to explore using similar methods to train animals for routine husbandry practices. For instance, San Diego Zoo implemented a shaping protocol that allowed a diabetic drill (*Mandrillus leucophaeus*) to voluntarily receive insulin injections (Priest 1991). Denver Zoo trained nyala (*Tragelaphus angasi*) and bongo (*Tragelaphus eurycerus*) to voluntarily enter crates for blood draws and other veterinary procedures (Grandin *et al* 1995; Phillips *et al* 1998). Bloomsmith *et al* (1998) successfully used reward-based methods to train large groups of chimpanzees (*Pan troglodytes*) to voluntarily move (ie, 'shift') from outdoor areas to an indoor portion of their enclosures. The use of positive reinforcement-based training procedures are now commonplace in many zoos, with some organisations requiring standardised training protocols for a facility to receive accreditation (Savastano *et al* 2003; Young & Cipreste 2004; Dadone *et al* 2016; European Association of Zoos and Aquaria [EAZA] 2019; Association of Zoos and Aquariums [AZA] 2020; Mackie 2020).

Thus, modern animal training procedures have had the benefit of giving animals the choice to actively participate in interactions that result in improved veterinary care. However, using training to improve husbandry practices, (for examples, see Fernandez 2020; Fernandez & Dorey 2020; Fernandez & Rosales-Ruiz 2020; for a review, see Pfaller-Sadovsky *et al* 2020) and therefore the physiological welfare of an animal, is fundamentally different than saying that training itself is enriching. This distinction is why testable hypotheses and data-driven results are necessary for demonstrating whether training functions as a form of enrichment.

A brief history of environmental enrichment

The use of environmental enrichment in zoos can be traced to Hal Markowitz (1978, 1982), who served as Director of the Oregon Zoological Research Center, Associate Director of the Portland/Washington Park Zoo (now the Oregon Zoo), and Professor of Biological Science at San Francisco State University. While prior work in zoos and similar settings described the need for promoting the well-being of captive animals (Yerkes 1925; Hediger 1950; Breland 1962), Markowitz and his colleagues were the first to promote a systematic, functional approach to the behaviour of zoo animals through behavioural engineering (Schmidt & Markowitz 1977; Markowitz *et al* 1978; Markowitz & Stevens 1978). The term 'behavioural engineering' itself was taken directly from the application of Skinner's operant conditioning procedures, or the field of Applied Behaviour Analysis (Homme *et al* 1968; Capshew 1993; Martin 2017). Through the creation of contrived, reinforcement-based learning contingencies, Markowitz and his colleagues were able to produce mechanical levers that would require white-handed gibbons (*Hylobates lar*) to swing across their enclosure to activate the levers and receive a food reward, mandrills (*Mandrillus sphinx*) to compete against zoo visitors in a computerised arcade-like reaction game, and polar bears (*Ursus maritimus*) to vocalise into a voice-operated relay system that would result in a fish being catapulted into their exhibit (Markowitz 1978, 1982). All the above was done to produce desired behaviours (eg swinging) or reduce undesired responses (eg begging) as a form of artificial, mechanised 'occupational therapy' for the zoo animals.

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Among the criticisms of such applications were the artificiality of the procedures involved, as well as the inherent problems of mechanical apparatus being costly or requiring constant maintenance (Hancocks 1980; Hutchins *et al* 1984). Nonetheless, these enrichment practices produced an empirical approach to all aspects of exhibiting animals, including animal behaviour, exhibit design, and visitor perception and behaviour (Forthman-Quick 1984; Coe 1985; Maple & Finlay 1986, 1987; Markowitz & Spinelli 1986; Bitgood & Patterson 1987; Finlay *et al* 1988). Environmental enrichment as a modern practice would emerge, where all features of how an animal interacted with their environment would be examined for its welfare benefits (Mench 1998; Shepherdson 1998; Mellen & MacPhee 2001; Hoy *et al* 2010). This, in turn, would inspire several books dedicated to the concept of environmental enrichment for animals under human care, including zoos, labs, farms, and with pets (Shepherdson *et al* 1998; Young 2003; Markowitz 2011; Bender & Strong 2019).

The result is that environmental enrichment is now synonymous with changes that produce an observable, measurable improved state of well-being for an animal (Newberry 1995; Shepherdson *et al* 1998; Mellen & MacPhee 2001). Enrichment should therefore be defined as the interaction (ie contingency) between a response and a stimulus or event, not simply the object or event. In the case of training as enrichment, this must be demonstrated whereby the training procedure produces an observable, measurable enriched outcome. In other words, for training to be shown to be enriching, we must demonstrate that training itself enriched the welfare of the animal.

Training as enrichment: Literature review and categories

To conduct the literature review, two databases were searched: Google Scholar™ and Web of Science. Search terms were 'husbandry training' OR 'animal training' AND 'environmental enrichment' OR 'behavioural enrichment' AND 'animal welfare.' Searches were limited to articles published in English and were not limited by year of publication. The literature search yielded 636 results. Following a review of titles and abstracts, the search was narrowed to 114 results. Papers were restricted to studies that directly measured behaviour and incorporated a control (non-training) condition compared to at least one training condition. This produced 33 papers that attempted to empirically examine the effects of training on captive behavioural welfare.

The following section details how training could function as enrichment, dividing the outcome of the literature review into three specific categories: (i) training facilitates enrichment usage; (ii) training modifies interactions, conspecific or otherwise; and (iii) training expands behavioural repertoires. As noted previously, for each category the paper reviews the relevant supporting literature based on demonstrated ability to improve behavioural welfare.

Training facilitates enrichment usage

One of the most direct ways to demonstrate that training can function as enrichment is by using training procedures to increase interactions with enrichment devices. However, only a few studies have empirically examined this effect. In the first published research paper on the effects of enrichment, Yanofsky and Markowitz (1978) were able to show that two mandrills trained to compete in a reaction time activity against visitors (the game previously described, which the mandrills voluntarily participated in) resulted in a decrease in stereotypic behaviours and increase in overall exhibit use. Markowitz and LaForse (1987) were able to increase overall activity, including increased foraging/hunting behaviours, and reduce time spent inactive, by training and rewarding two African servals (*Leptailurus serval*) for chasing artificial prey through a constructed tube in their exhibit. Markowitz *et al* (1995) were able to train and reward an African leopard (*Panthera pardus pardus*) for stalking and chasing naturalistic acoustic prey (eg bird songs) along an artificial tree trunk, which resulted in increased time spent active (primarily foraging/hunting) and visibly on exhibit, as well as decreased time spent pacing while the enrichment device was operating. Finally, Fernandez *et al* (2019) were able to use an autoshaping procedure (stimulus-stimulus pairings to elicit voluntary behaviour; Brown & Jenkins 1968) to combine training plus enrichment (ie training enrichment item contacts) to increase time spent swimming and interacting with the devices post-training.

As noted, training animals to interact with enrichment devices is one of the most direct ways to demonstrate that training can enrich. Also, the use of computers or other technology are now readily available and can facilitate enrichment usage in the absence of direct human contact (Coe & Hoy 2020; Carter *et al* 2021). Nonetheless, the idea that training animals to interact with enrichment appears less natural or only produces temporary increases in such enrichment interactions may contribute to why this is a less-common practice (Fernandez *et al* 2019). Below, the review discusses two indirect methods of using training procedures to facilitate enrichment interactions.

Contrafreeloading and enrichment

Contrafreeloading describes the phenomenon where animals will choose to work for food (eg press a lever or operate similar operandum) over freely available food (Jensen 1963; Inglis *et al* 1997). The phenomenon has been observed across several different species and settings, including labs, farms, and zoos (Neuringer 1969; Jensen *et al* 2002; Young & Lawrence 2003; De Jonge *et al* 2008; Lindqvist & Jensen 2009; Ogura 2011). However, only a few studies have examined the contrafreeloading effect with respect to environmental enrichment. McGowan *et al* (2010) were able to demonstrate that captive grizzly bears (*Ursus arctos horribilis*) would spend at least a portion of their time retrieving

food from ice blocks or enrichment boxes over free food alone. Vasconcellos *et al* (2012) showed that captive maned wolves (*Chrysocyon brachyurus*) would spend more time searching for food scattered across vegetation, as well as consume approximately half their diet from scattered feedings when compared to food delivered on a tray in one section of their enclosures. Sasson-Yenor and Powell (2019) demonstrated that several zoo-housed giraffes (*Giraffa camelopardalis*) were more likely to contrafreeload when presented simultaneously with easily accessed or more time-consuming enrichment foraging devices. These studies provide indirect support that working for food, a similar activity to many training procedures, can provide more enriching opportunities for animals.

Preference assessments and enrichment

The use of paired-choice preference assessments, where choices of potential rewards are systematically evaluated by presenting all possible pairs to an animal for their selection, were first used in zoos almost two decades ago (Fernandez *et al* 2004). Since then, several studies have used similar preference assessments to evaluate their ability to determine potential enrichment activities/items (Fernandez & Timberlake 2005; Mehrkam & Dorey 2014; Fernandez & Timberlake 2019b; Clayton & Shrock 2020; Woods *et al* 2020). In one study, Dorey *et al* (2015) were able to demonstrate that two of their four subjects, zoo-housed wolves (*Canis lupus* and *C. l. arctos*), preferred training activities over enrichment items. Thus, all the above preference studies provide indirect evidence that a trained preference assessment could result in animals selecting more optimal enrichment activities. Furthermore, the latter Dorey *et al* study directly demonstrated that training procedures could, at least for some animals, function as the most preferred form of environmental enrichment.

Training modifies interactions, conspecifics or otherwise

Training procedures are presumed to be an important component for improving the interactions animals have with conspecifics and their human trainers. For instance, with companion animals, training procedures, including type of training method used, play an important role in decreasing aggression, minimising problem behaviours, or otherwise promoting proper dog-dog and dog-human interactions (for examples, see Batt *et al* 2008; Blackwell *et al* 2008; Haug 2008; Rooney & Cowan 2011; China *et al* 2020). Regardless, only a few studies in any animal setting have experimentally examined the effect of training procedures to promote social interactions that lead to enriched welfare outcomes. Bloomsmith *et al* (1994) were able to effectively use a positive reinforcement training procedure to reduce aggression during feeding times in group-housed chimpanzees. Schapiro *et al* (2001) showed positive reinforcement training increased the affiliative behaviours outside of training sessions for otherwise less social rhesus macaques (*Macaca mulatta*). Pomerantz and Terkel (2009) used positive reinforcement to increase chimpanzee prosocial behaviours (eg grooming and playing) outside of training sessions. Carrasco *et al* (2009) rewarded play behaviours in a group of zoo-housed lowland gorillas (*Gorilla gorilla gorilla*) and demonstrated an increase in affiliative behaviours and a decrease in aggression as a result. Spiezio *et al* (2016, 2017) trained individuals to enter a separate testing area and were able to show an increase in affiliative behaviours and decrease in aggression with zoo-housed vervet monkeys (*Chlorocebus aethiops*) and ring-tailed lemurs (*Lemur catta*), respectively. These studies provide support for the concept that training can function as enrichment by modifying the interactions animals have with their conspecifics. A sub-section of the use of training as enrichment through human-animal interactions is considered below.

Human-animal interactions and enrichment

Human-animal interactions (HAI) have become an increasingly popular topic of study for applied animal behaviour research. A subset of this area of research has focused on both positive and negative HAIs as animal-visitor interactions (AVIs) observed in zoos (for reviews, see Hosey 2000; Davey 2007; Fernandez *et al* 2009; Godinez & Fernandez 2019; Sherwen & Hemsworth 2019). More recently, the topic of HAIs as a form of enrichment, with an emphasis on zoos, has been discussed (Claxton 2011; Melfi 2013). Here, the review focuses specifically on the use of training procedures that result in both increased HAIs, as well as a demonstrated enriched effect on the behavioural welfare of those animals.

Anderson *et al* (2003) found that the use of an animal training demonstration with zoo-housed Asian small-clawed otters (*Aonyx cinereus*) increased the overall otter activity levels (a measure directly associated with enriched animal welfare), as well as increased overall visitor perceptions and stay times at the exhibit. Ward and Melfi (2013) demonstrated that multiple species of zoo-housed animals trained using positive reinforcement had lower latencies to keeper cues (eg being asked to move on- or off-exhibit), a measure they associated with less fear of humans. Leeds *et al* (2016) showed positive reinforcement training with a zoo-housed lowland gorilla led to a reduction in aggression to keepers in the times following training sessions. Fernandez *et al* (2021b) found that training zoo-housed Asian and African elephants (*Elephas maximus* and *Loxodonta africana*) to engage in public feedings were correlated with increased social interactions with the keepers/visitors, increased foraging, decreased inactivity, and decreased stereotypic behaviours when compared to non-public feed days, as well as the times following a public feeding. Therefore, all the above results provide evidence that training procedures can modify HAIs to enrich the welfare of the trained animals.

Training expands behavioural repertoires

The idea that training produces new behaviours that result in enriched welfare for those animals is the broadest category of the three described within this paper and, likewise, one of the more difficult to demonstrate empirically. Melfi (2013) described three separate hypotheses, all of which could contribute to training functioning as enrich-

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ment through such a phenomenon: (i) training affords learning, and learning is considered enriching; (ii) training achieves the same results as enrichment; and (iii) training provides a dynamic change in the animals' day. Since they are all related, the review focuses on the more broadly described category that encompasses all three of these hypotheses: Training functions as enrichment by expanding behavioural repertoires.

In Melfi's (2013) section on training being enriching because it achieves the same results as traditional environmental enrichment, she suggests two instances that further this concept. Hare and Sevenich (2001) provide an example of increasing tiger (*Panthera tigris*) tree scratching through enrichment or training. In the enrichment example, multiple scents are placed on a deadfall tree in the tigers' exhibit. In the training example, the tigers are rewarded for scratching the tree. The authors propose the same result of tree scratching could be obtained through either enrichment or training, although no data are presented to make such a direct comparison. Melfi also describes a study in which training and enrichment conditions for two zoo-housed elephants are directly compared (McCormick & Melfi 2003; as cited in Melfi 2013). The aim of the study was to increase behavioural diversity in the elephants, with the result being that enrichment increased behavioural diversity for one of the elephants, but training had no effect. Thus, while both examples provide a conceptual framework and method for making such training and environmental enrichment comparisons, neither provide evidence that training can produce similar effects to enrichment.

In a study by Pryor *et al* (1969), a rough-toothed dolphin (*Steno bredanensis*) was rewarded for engaging in a novel response not previously trained. During experimental sessions, a context cue (eg rung bell) was provided to indicate that only new, previously non-rewarded responses would be rewarded. During the study, the dolphin engaged in at least four distinct, novel responses. Pryor and Chase (2014) expand on the importance of these findings, including the use of training/shaping for creating behavioural variability. Behavioural variability is an important welfare/enrichment measure, as expanded repertoires can be measured more directly through such variability via behavioural diversity (see *Discussion*). Therefore, while the Pryor *et al* study does not provide evidence that training animals to engage in novel behaviour enriches their welfare, it is an important point to consider when examining evidence for training functioning as enrichment through expanded behavioural repertoires.

Two studies have examined the effects of training on the adoptability and behaviours presented in shelter animals. Luescher and Medlock (2009) examined the effects of training on the adoption rates of domestic shelter dogs. Through a combination of halter and clicker training (eg walking on a leash, approaching people without jumping on them, or sitting on command), the 92 dogs trained were 1.4 times more likely to be adopted than the non-trained control dogs. In a similar study, Grant and Warrior (2019) examined the effects of clicker training domestic shelter cats (*Felis silvestris catus*). As a result of clicker training, all 12 cats increased their time spent exploring, at the front of their enclosure, and being able to be contacted, as well as decreasing their time spent inactive. Combined, these two studies suggest that training can expand behavioural repertoires not only to improve behavioural welfare (and thus, enrich), but also to increase the likelihood of a shelter animal being adopted. While indirectly related to behaviour, the ability for many shelter animals to avoid being euthanased is dependent on their adoptability, and as a result is one of the most important welfare-related measures.

These studies provide partial evidence that training procedures can functionally enrich by expanding behavioural repertoires. While greater testing is necessary, particularly with respect to direct comparisons of training and traditional environmental enrichment conditions, there is moderate support for the use of training to increase variability and other measures associated with behavioural welfare, and therefore have an enrichment-like effect. Below, the review considers two sub-sections of this category: (i) the ability of training to reduce behaviours associated with sub-optimal welfare; and (ii) the use of training in animal shows to promote the behavioural welfare of those animals.

Training reduces undesired behaviours

Training procedures have effectively been used to minimise the occurrence of behaviours otherwise associated with deterred welfare (Bloomsmith *et al* 2007). Bassett *et al* (2003) found that common marmosets (*Callithrix jacchus*) trained to voluntarily give urine samples exhibited less stress-related responses (eg self-scratching and scent marking) following training and compared to non-trained marmosets. Baker *et al* (2009) found that some rhesus macaques trained for husbandry procedures showed significant reductions in abnormal behaviours such as self-injury or stereotypic behaviours. Pomerantz and Terkel (2009) demonstrated positive reinforcement training with chimpanzees resulted in a reduction in abnormal and stress-related behaviours during training sessions. Coleman and Maier (2010) showed that positive reinforcement training with a group of rhesus macaques reduced stereotypic behaviours outside of training sessions. Shyne and Block (2010) found that husbandry training procedures for African wild dogs (*Lycaon pictus*) led to a reduction in stereotypic behaviours following training sessions. These results demonstrate that training can enrich by reducing behaviours associated with lowered behavioural welfare. The implication for decreasing such responses is that the opportunities to engage in behaviours associated with positive welfare are increased.

Training for animal shows

A final sub-section worth considering is the effect of training animals for shows as a source of potential environmental enrichment. As described earlier, the training of marine mammals for shows played an important role in the promotion of regular husbandry training procedures in zoos (see *A brief history of modern animal training*). The use of positive reinforcement to promote both voluntary interactions and behavioural welfare has been a hallmark for show animals (Brando 2012; Eskelinen *et al* 2015). However, others have suggested that training animals for shows, or simply their existence as trained show animals, leads to a reduction in both the physiological and behavioural welfare of those animals (Rose & Parsons 2019). Only a few studies have directly investigated the results of training animals for shows or interactions on their overall welfare. Kyngdon *et al* (2003) found that short-beaked common dolphin (*Delphinus delphis*) trained to engage in a 'Swim-with-Dolphins' programme increased their surfacing and use of outside areas during programmes, but otherwise showed few behavioural changes before, during, or after the interactions. Similarly, Trone *et al* (2005) found few behavioural differences in bottlenose dolphins (*Tursiops truncatus*) in the times before or after interaction programmes, with an increase in play behaviours following interactions. Delfour *et al* (2020) used Qualitative Behavioural Assessments (QBAs) to assess trainer-dolphin interactions and the welfare of bottlenose dolphins located at five different European facilities. All six parameters tested in the QBA showed high levels of interest by the dolphins to interact with trainers and participate voluntarily in training sessions. Thus, preliminary evidence suggests that training some animals for and participating in shows may function as a source of enrichment for those animals.

Discussion

Training has been discussed as a form of enrichment, including the learning that may occur from interacting with potential enrichment items (Young *et al* 2020). While the broader enriching and welfare value of training procedures is often assumed, this review attempts to frame the concept of training as enrichment as an empirical question, with results from previous studies considered as forms of support for this claim. If training is said to be enriching, then we must first identify how training can function as enrichment and confirm the likelihood of such possibilities through observable, measurable results. This paper considers three such categories and their supporting evidence: (i) training facilitates enrichment usage; (ii) training modifies interactions, conspecific or otherwise; and (iii) training expands behavioural repertoires.

Training has been demonstrated to enrich by (i) facilitating the use of enrichment, with a limited number of studies directly training animals to use enrichment devices (Yanofsky & Markowitz 1978; Markowitz *et al* 1995; Markowitz & LaForse 1987; Fernandez *et al* 2019). In addition, animals demonstrating a desire to 'work for food' and animals selecting items in preference assessments to be delivered as enrichment both provide further evidence for training facilitating enrichment usage. For instance, Dorey *et al*'s (2015) implementation of preference assessments to allow wolves to select between traditional environmental enrichment or training procedures is a successful demonstration of how both scientists and practitioners can evaluate the potential enriching function of any training procedure.

Training has also been demonstrated to enrich by (ii) modifying interactions, conspecific or otherwise, with several studies demonstrating that training can result in decreased aggression and increased affiliation in primates (Bloomsmith *et al* 1994; Schapiro *et al* 2001; Carrasco *et al* 2009; Pomerantz & Terkel 2009; Spiezio *et al* 2016, 2017). Additionally, training has been used to modify human-animal interactions (HAIs), which is important because (i) HAIs are an emerging field of interest for applied animal behaviour research, and (ii) past research has demonstrated that HAIs can be a source of stress or otherwise result in decreased behavioural welfare for many animals. In one study, Fernandez *et al* (2021b) were able to train elephants to interact with keepers and visitors during public feeds, which resulted in increased keeper/visitor interactions, increased foraging, decreased inactivity, and decreased stereotypic behaviours. Thus, using training through public feedings or similar interactions is an effective way to demonstrate the enriching value of animal training procedures.

Finally, training has been suggested to enrich by (iii) expanding behavioural repertoires, with several studies showing that training can increase behavioural variability, increase behaviours associated with positive welfare, and/or decrease undesired behaviours (Pryor *et al* 1969; Hare & Sevenich 2001; Bassett *et al* 2003; McCormick & Melfi 2003; Bloomsmith *et al* 2007; Baker *et al* 2009; Leuscher & Medlock 2009; Pomerantz & Terkel 2009; Coleman & Maier 2010; Shyne & Block 2010; Grant & Warrior 2019). Training as enrichment also appears to play an important role in animal shows, with Delfour *et al* (2020) effectively demonstrating that dolphins displayed high interest in both participating in shows and interacting with trainers. The use of training within animal shows is one of the most important illustrations of the training as enrichment effect, since it involves an animal's willingness to 'work for food', desire to interact with trainers and, ultimately, whether the show itself produces an overall improvement in behavioural welfare.

Taken together, the studies reviewed in this paper support the assertion that training can function as enrichment. It is hoped that this review also provides a source of inspiration for more research on the use of training as a form of enrichment, with multiple areas requiring more detailed investigation. For instance, there is needed research to evaluate training animals to engage with potential enrichment devices in meaningful ways, to assess public feedings or similar HAIs as enrichment procedures, and to determine the effects of animal shows on the welfare of those animals. Likewise, there is greater interest in assessing the welfare of animals through positive rather than negative indices, as one of the main goals of animal welfare research is to optimise overall welfare, rather than simply provide adequate outcomes (Mellor 2016; Lawrence *et al* 2019; Mellor &

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Beausoleil 2019; Mellor *et al* 2020). As such, three additional areas of emphasis are considered below, with a focus on how they could expand our current knowledge of the training as enrichment effect.

Behavioural diversity and enclosure use variability

As noted above, there is greater interest in positive welfare metrics to assess the well-being of animals. The use of behavioural diversity and enclosure use variability indices are examples of such methods (for reviews, see Brereton 2020; Miller *et al* 2020). Identifying variability in both the frequency of behaviours and areas of an enclosure used by an animal are directly relevant to whether training functions as enrichment, since training could be hypothesised to have a positive or negative effect on both measures. For instance, does training only a select number of behaviours result in an increase or decrease in the variability of those behaviours? Does training in limited areas increase or decrease overall enclosure use? It is possible that, for training to function as enrichment, we need to take into consideration both the frequency and type of behaviours we train, as well as the regularity or variability in the places where we train.

The learning effect

Training procedures offer a source of learning/enrichment opportunities not just for the trainee(s), but for the trainer(s) and those observing training sessions as well (Lukas *et al* 1998; Fernandez & Timberlake 2008; Hazel *et al* 2015). Students, volunteers, and visitors have the potential to function as a source of training enrichment themselves, provided they are somehow involved with training interactions. Similarly, the type and regularity of such training interactions could be the source of independent variables within any training as enrichment study. With the increased interest in HAI research and the desire for many visitors at various animal facilities to interact with the animals, there is a near unlimited source of possibilities to consider for future research.

Within-subject methodology

The field of behaviour analysis has been integral in developing the use of husbandry training procedures and environmental enrichment for animal welfare research and practice (see both *Brief history* sections). Behaviour analysis has also focused on within-subject methodology to implement both basic and applied research, which has resulted in many training and enrichment studies using similar designs (Fernandez & Timberlake 2008; Maple & Segura 2015; Alligood *et al* 2017). Some of the many benefits of within-subject methodology include: (i) a focus on many data-points from a few individuals (as opposed to few data-points from many individuals); (ii) an emphasis on inductive data collection that modifies procedures based on real-time results (as opposed to *a priori* hypothesis testing); and (iii) the ability to assess an individual's learning repeatedly and over time (as opposed to pre- versus post-test analyses) (Johnston & Pennypacker 2010; Bailey & Burch 2017). To properly study the training as enrichment effect, within-subject methodological designs appear best suited to address many of the possible research questions. Put simply, training is a learning-related phenomenon, and learning is often best understood by frequently measuring the performance of individuals.

Conclusion

The concept of training as enrichment has played an important role in promoting the use of training procedures as a common behavioural welfare practice. While this concept is critical for animal training practitioners, it has remained a source of speculation for those interested in its scientific validity. This review attempts to address this concept empirically by treating training as an independent variable manipulation and the enriched outcome as a dependent variable result. Evidence from existing published research supports the ability of training to facilitate enrichment usage, modify interactions, and expand behavioural repertoires in ways that enrich the welfare of those animals. Future research is necessary to expand our understanding of the conditions under which training might function as enrichment, as well as provide more extensive support for the notion that training procedures can be a desired, enriching activity for the lives of animals under human care.

Declaration of interest

None.

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