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Animal Training, Environmental Enrichment, and Animal Welfare: A History of Behavior Analysis in Zoos

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Abstract

The modern zoo has been associated with two major behavioral welfare advances: (a) the use of training to increase voluntary husbandry care, and (b) the implementation of environmental enrichment to promote naturalistic behaviors. Both practices have their roots in behavior analysis, or the operant conditioning-centered, reward-based approach to behavioral psychology. Operant conditioning served as the foundation for the development of reinforcement-based training methods commonly used in zoos to make veterinary and husbandry procedures easier and safer for animals and their caregivers. Likewise, operant conditioning, with its focus on arranging environmental antecedents and consequences to change behavior, also provided a framework for successful environmental enrichment practices. In this paper, we outline the key individuals and events that shaped two of the cornerstones of the modern zoo: (1) the emergence of reward-based husbandry training practices, and (2) the engineering of environmental enrichment. In addition, we (3) suggest ways in which behavior analysis can continue to advance zoo welfare by (i) expanding the efficacy of environmental enrichment, (ii) using within-subject methodology, and (iii) improving animal-visitor interactions. Our goal is to provide a historical and contextual reference for future efforts to improve the well-being of zoo animals.

Keywords: animal training; animal welfare; behavior analysis; behavioral engineering; environmental enrichment; operant conditioning; zoos

1. Introduction

Due to the many advancements in zoo animal welfare and management, those familiar with modern, accredited zoos might expect to find diverse, enriched exhibits focused on the needs of each species, knowledgeable zookeepers well-versed in animal welfare and training, and visitor education experiences with an emphasis on the conservation of the zoo animals. What isn't as apparent is the important role behavior analysis, or the Skinnerian operant conditioning-focused (e.g., reward- or reinforcement-based) approach to behavioral psychology, played in the formation of the present-day zoo. The modern zoo itself can be defined by two major behavioral advances focused on improving welfare: (1) the use of animal training procedures to increase voluntary participation in husbandry or other veterinary procedures by the zoo animals (Fernandez et al., 2019; Laule & Desmond, 1998; Melfi et al., 2020), and (2) the implementation of environmental enrichment to decrease detrimental and increase species-typical behaviors (Fernandez et al., 2021a; Hoy et al., 2010; Shepherdson et al., 1998). These advances were developed through decades of research and practices that incorporated behavioral principles to identify desirable outcomes for animals and visitors alike.

For those working with or in zoos, the influence of operant conditioning on animal training may be obvious. In most cases, trainers or keepers deliver reinforcing consequences to modify an animal's behavior, often for husbandry purposes (Forthman & Ogden, 1992; Lukas et al., 1998). While the connection between behavior analysis and environmental enrichment may be less apparent, the practice of environmental enrichment also began as a set of consequence-focused operant conditioning procedures in zoos. Early enrichment practices incorporated food delivered mechanically as a reinforcer for engaging in desired responses, such as primates swinging from parts of their exhibit or felids chasing and catching artificial prey (Markowitz, 1978; Markowitz, 1982; Snyder, 1977). These procedures often incorporated visual or auditory stimuli that were meant to elicit or set the occasion for those desired responses, thus functioning as conditional (respondent) or discriminative (operant) stimuli, respectively. The advent of environmental enrichment was therefore a behavioral engineering endeavor, meant to adjust environment-behavior contingencies in the most optimal manner. From these modest beginnings, the practice grew to its current use as the major tool to increase naturalistic behaviors of all the animals we see in the zoo, as well as now extended to other settings, like shelters, homes, and farms (Bender & Strong, 2019; Markowitz, 2011; Mellen & MacPhee, 2001; Young, 2003).

The following paper examines the influence of behavior analysis on the modern zoo. We do this in three parts, with the first two parts detailing (1) the emergence of reward-based zoo husbandry training practices, and (2) the engineering of environmental enrichment in zoos. Both will sufficiently detail how behavioral principles were involved, with several photos to provide some context. For the final point, we discuss (3) the future of behavior analysis in zoos, with attention to how behavior analysis can continue to improve the lives of zoos animals by (i) expanding the efficacy of environmental enrichment, (ii) using within-subject methodology, and (iii) improving animal-visitor interactions. Our goal is to therefore detail the important role behavior analysis has had in the formation of the modern zoo, as well as how such behavioral principles can guide continued welfare progress in zoos and similar settings.

2. The Emergence of Reward-Based Zoo Husbandry Training Practices

Contemporary animal training procedures are often associated with clicker training or similar uses of conditioned reinforcers paired with positive reinforcement (Fernandez, 2001; Pryor, 1984; Ramirez, 1999). These procedures and other behavior analytic principles to train animals are tied to two major events: (1) Skinner's discovery of shaping, or the use of differentially reinforcing successive approximations to a target response (Peterson, 2004; Pierce & Cheney, 2013; Skinner, 1951), and (2) the creation of a field of Applied Animal Psychology by Keller and Marian Breland, two of Professor Skinner's graduate students at the University of Minnesota (Bailey & Gillaspay, 2005; Breland & Breland, 1951). Both events were also directly connected to Project Pelican (also known as "Project Pigeon"), a wartime effort in the early 1940s that involved training pigeons (*Columba livia*) to guide bombs (Capshew, 1993; Gillaspay & Bihm, 2002; Skinner, 1960; Skinner, 1979). The project was sponsored by government contracts and through General Mills, Inc., with much of the research conducted within the top floor of the General Mills flour mill building in downtown Minneapolis, Minnesota (Peterson, 2004; Skinner, 1960).

Figure 1. Colorized photo of Keller Breland (left) and B. F. Skinner on top of the General Mills building in Minneapolis, MN, circa 1943. (Photo courtesy of Robert E. Bailey).

Until Project Pelican, most of Skinner's research involved the use of laboratory rats (*Rattus norvegicus*), with all the research published in *The Behavior of Organisms* (1938) using rats as subjects. It was through Project Pelican that Skinner and his colleagues first began examining behavioral principles with pigeons, as well as his first experience training animals outside of an operant chamber, or "by hand" (Capshew, 1993; Skinner, 1958; for a review, see Peterson, 2004). These events resulted in the discovery of shaping, which was so profound that by 1943, Keller and Marian Breland, having worked with Dr. Skinner as

University of Minnesota Psychology graduate students on Project Pelican, left academia and began Animal Behavior Enterprises (ABE), an organization dedicated to the training of animals for a variety of applied, profit-driven purposes, including commercials and coin-operated acts (Bailey & Bailey, 1980; Breland & Breland, 1961; Breland & Breland, 1966; Timberlake, 2003; Yin, 2012).

By the 1950s, the Brelands moved their business to Hot Springs, Arkansas, where they held a tourist attraction known as “IQ Zoo”, intended as both an entertaining and educational experience (Bihm et al., 2010; Gillaspy & Bihm, 2002). The Brelands also continued to train animals for coin-operated acts and other revenue-generating ventures, as well as suggesting the use of naturalistic exhibits and visitor-focused learning opportunities within zoos and similar settings (Bailey & Bailey, 1979; Breland, 1962; 1963; Curtis, 1957).

Figure 2. Colorized photo of Keller and Marian Breland training IQ Zoo’s Professor Punch, late 1950s. (Photo from Bailey and Gillaspy, 2005).

By 1955, the Brelands also began working with marine mammal parks to establish some of the first cetacean training shows (Bailey & Gillaspy, 2005; Gillaspy et al., 2014). Originally begun with the training of bottlenose dolphins (*Tursiops truncatus*) at Marine Studios (now Marineland of Florida), the use of operant conditioning procedures to train marine mammals would soon spread to other parks, including Marineland of the Pacific, Sea Life Park, and SeaWorld (for a review, see Gillaspy et al., 2014).

Figure 3. Colorized photo of Keller Breland training a dolphin at Marine Studios/Marineland of Florida, circa 1957. (Photo from Gillaspay et al., 2014).

Eventually, the success of operant conditioning to shape the behaviors of marine mammals would be popularized by books such as Karen Pryor’s *Lads Before the Wind* (1975) and *Don’t Shoot the Dog!* (1984). At the same time, zoos began to see the benefits of using such procedures to produce voluntary participation in veterinary husbandry practices (Forthman & Ogden, 1992; Desmond & Laule, 1994). For instance, San Diego Zoo implemented a shaping protocol that allowed a diabetic drill (*Mandrillus leucophaeus*) to choose to receive insulin injections (Priest, 1991). Denver Zoo trained nyala (*Tragelaphus angasi*) and bongo (*Tragelaphus eurycerus*) to willingly enter crates to receive blood draws or other veterinary procedures (Grandin et al., 1995; Phillips et al., 1998). Bloomsmith, Stone, and Laule (1998) successfully used reward-based methods to train large groups of chimpanzees (*Pan troglodytes*) to elect to move (i.e., “shift”) from outdoor areas to an indoor portion of their enclosures. The use of reinforcement-based training procedures is now commonplace for many species within most accredited zoos, with some organizations requiring facilities to establish and use such protocols to receive accreditation (Association of Zoos and Aquariums, 2020; European Association of Zoos and Aquaria, 2019; Mackie, 2020; Savastano, 2003).

3. The Engineering of Environmental Enrichment in Zoos

The implementation of environmental enrichment in zoos can be traced to Hal Markowitz, 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 (Hediger, 1950; 1955; Morris, 1964; Yerkes, 1925), Markowitz and his colleagues were among the first to promote a systematic, functional approach to the behavior of zoo animals through behavioral engineering (Maple, 2013; Markowitz, 1978; 1979; Markowitz & Woodworth, 1978; Markowitz et al., 1975; Mellen et al., 1981). The term “behavioral engineering” itself was taken directly from the application of Skinner’s operant conditioning procedures, or the field of Applied Behavior Analysis (ABA; Capshew, 1993; Homme et al., 1968; Martin, 2017). Through the creation of contrived, reinforcement-based learning contingencies, Markowitz and his colleagues were able to produce mechanical levers that would allow 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 computerized arcade-like reaction game, and polar bears (*Ursus maritimus*) to vocalize into a voice-operated relay system that would result in a frozen fish being launched into their exhibit (Markowitz et al., 1978; Schmidt & Markowitz, 1977; Yanofsky & Markowitz, 1978). All the above was done to produce desired behaviors (e.g., foraging) or reduce undesired responses (e.g., pacing) as a form of artificial, mechanized occupational therapy for the zoo animals.

Figure 4. Colorized photo of a polar bear chasing a frozen fish catapulted into their pool at the Portland (Oregon) Zoo, circa mid-1970s. (Photo from Schmidt & Markowitz, 1977).

Among the criticisms of such applications were the artificiality of the procedures involved, as well as the arbitrary distinction of what constituted ‘desired’ responses to be

increased (Hutchins et al., 1978a; 1978b; 1979). These critics argued that, rather than engineering environments through contrived contingences, zoos should focus on creating naturalistic exhibits that increased spatial and temporal complexity, for instance, the exhibit arrangement or timing of feeding events (Hancocks, 1980; Hutchins et al., 1984). Markowitz (1982) responded to some of these criticisms by noting that, “the best interests of captive animals may not be served by making their state as ‘wild’ as possible.” (p. 12). Markowitz’s argument was that artificial and mechanical contingencies, such as those provided by enabling an elephant to pull a chain to receive part of their diet, could improve the lives of exhibited animals. “Behavioral enrichment”, a term Markowitz began using synonymously with behavioral engineering, could benefit exhibited animals by giving the animals ‘something to do’. (Markowitz, 1982; Markowitz & Spinelli, 1986).

Figure 5. Colorized photo of an Asian elephant pulling a ring to obtain fruit at the Honolulu Zoo, circa late-1970s. (Photo from Markowitz, 1982).

The term “enrichment” appeared to come directly from psychobiological and developmental neuroscience research, where comparisons were often made between animals raised in enriched versus impoverished environments (for a review, see Uphouse, 1980). Regardless, both the ideas of enriching and engineering environments were now being used interchangeably, with other authors arguing that these and the naturalistic/complexity concepts could be integrated to benefit the behavioral welfare of zoo animals (Forthman-Quick, 1984). Likewise, some of Markowitz and colleagues’ later efforts focused on naturalistic implementations of behavioral engineering endeavors, such as Asian small-clawed otters (*Aonyx cinereus*) hunting live crickets (*Acheta domesticus*) that visitors mechanically assisted in releasing into different parts of their exhibit, servals (*Leptailurus*

serval) chasing artificial prey run through clear tubes in their enclosure, and an African leopard (*Panthera pardus*) chasing bird sounds along a tree limb to receive a food reward (Foster-Turley & Markowitz, 1982; Markowitz & LaForse, 1987; Markowitz et al., 1995).

Figure 6. Colorized photo of a serval chasing artificial prey at the San Francisco Zoo, circa 1984. (Photo from Markowitz and LaForse, 1987).

The result has been the introduction of environmental enrichment as an approach that is both pragmatically focused and attends to the species-typical needs of the organisms involved. The use of enrichment is one of those rare events that requires simultaneous attention to both evolutionary and learning histories to be optimally implemented, which necessarily requires an integration between naturalistic and engineered exhibits (Mellen & MacPhee, 2001; Newberry, 1995). Equally important for the zoo is how the visitor behaves in response to enriched animals, therefore driving the need for naturalistic devices and responses for and from the animals being enriched, respectively (Fernandez et al., 2009; Learmonth, 2020). Environmental enrichment, because of its behavior analytic underpinnings, is now an animal welfare endeavor where all features of how an animal interacts with its environment are examined for their behavioral benefits (Fernandez, 2021a; Hoy et al., 2010).

4. The Future of Behavior Analysis in Zoos

Behavior analysis has had a profound influence on shaping the modern zoo; however, we have only begun to realize its full potential in animal settings. There have been many calls for the adoption of a behavior analytic framework to improve animal care (Alligood et al., 2017; Bloomsmith et al., 2007; Fernandez & Timberlake, 2008; Forthman & Ogden, 1992; Kummrow, 2021; Maple & Perdue, 2013; Maple & Segura, 2015; Martin, 2017; Tarou & Bashaw, 2007). While the science of behavior analysis grew out of basic animal studies, recent advances in applied behavior analysis have been developed and implemented primarily in human clinical settings. However, coming full circle, researchers are now successfully

adapting and using protocols developed for use with people to impact animal welfare. For example, functional analysis protocols have been used to assess and treat problem behaviors in animals (Dorey et al., 2009; Farmer-Dougan, 2014; Feuerbacher & Wynne, 2016; Franklin et al., 2021; Hall et al., 2015; Martin et al., 2011; Mehrkam et al., 2020; Morris & Slocum, 2019; Pfaller-Sadovsky et al., 2019; Salmeron et al., 2021), and empirical preference assessments have been successfully used in a variety of species (Brox et al., 2021; Cameron et al., 2013; Clay et al., 2009; Clayton & Shrock, 2020; Dorey et al., 2015; Fay & Miller, 2015; Fernandez et al., 2004; Fernandez & Timberlake, 2005; Fernandez & Timberlake, 2019; Gaalema et al., 2011; Martin et al., 2018; Mehrkam & Dorey, 2014; Slocum & Morris, 2020; Vicars et al., 2014; Woods et al., 2020). By using a behavior analytic lens, adapting existing behavioral technologies, and developing new, animal-specific, behavioral protocols and methodologies, behavior analysts could play a considerable role in guiding the next advances in modern zoos. We outline just a few of the possibilities below, including (i) expanding the efficacy of environmental enrichment, (ii) using within-subject methodology, and (iii) improving animal-visitor interactions.

Applied behavior analysts have a long history with increasing behavioral repertoires to the benefit of the participants involved, and zoo animals should be no exception to this approach. While zoos already use environmental enrichment for this purpose, behavior analysts could increase the effectiveness of these enrichment practices by drawing inspiration from human studies on factors such as schedules of reinforcement, habituation, preference, variation, and choice (e.g., Hanratty & Hanley, 2021; Mehrkam & Dorey, 2014; Learmonth et al., 2021; Ringdahl et al., 1997; Tarou & Bashaw, 2007; Woods et al., 2020). Additionally, training practices could be combined with environmental enrichment (e.g., Fernandez et al., 2019) to shape more complex behaviors that allow for increased engagement with enrichment devices. Behavior analysis can also provide guidance when enrichment protocols are used for the purpose of decreasing maladaptive behaviors. The competing stimuli framework is used in ABA to identify which items or activities effectively reduce problem behaviors by offering alternative sources of reinforcement (Haddock & Hagopian, 2020). By monitoring an individual animal's (or group's) enrichment use and problem behavior across different enrichment conditions using within-subjects designs, behavior analysts could make data-driven decisions regarding the best implementation of a variety of different types of potential enrichment items or events (Alligood et al., 2017; Bashaw et al., 2016; Carlstead et al., 1991; Fernandez & Timberlake, 2008; Markowitz et al., 1995; Sanders & Fernandez, 2020).

Within-subject, single-subject research designs such as some of the research mentioned above form the methodological foundation of behavior analysis (Bailey & Burch, 2017; DeRosa et al., 2021; Johnston & Pennypacker, 2010). These single-case designs allow researchers to experimentally determine the functional relationship between variables and effectively monitor a subject's response to interventions using as few as one subject. In ABA, the goal is to make a meaningful change in the behavior of a particular individual in a specific circumstance or setting, and single-case designs allow for this flexibility and specificity (DeRosa et al., 2021). Similarly, every attempt to provide proper behavioral welfare for any zoo animal is ultimately a study with a sample size (n) = 1. Even if it is possible to find enough similar subjects to conduct a robust group study, knowing that the average animal responds to a particular reinforcer or treatment is of limited use if the animal in question does not respond in the average way. Behavior analytic methodologies and their

focus on the overt behaviors of individuals is ideally suited for improving the lives of zoo animals (Alligood et al., 2017; Fernandez, 2021b; Fernandez & Timberlake, 2008).

Finally, zoos have become increasingly interested in understanding both direct and indirect animal-visitor interactions, with particular emphasis in minimizing adverse impacts that visitors may have on animals while also increasing visitor education and entertainment (Fernandez et al., 2009; Fernandez et al., 2021b; Sherwen & Hemsworth, 2019). A large component of understanding these interactions should come from simultaneously observing the overt behaviors of both animals and visitors, an exercise all too common for many applied behavior analysts when equally working with caregivers and clients. By focusing on learning contingencies involved for both the animals and the visitors, ABA practitioners in zoos could effectively provide win-win solutions that mutually improve the welfare of animals and the education/enjoyment of the visitor. As just one example of a way in which this could develop, more interactive elements could be incorporated into zoos. These could be in the spirit of some of Markowitz's early behavioral engineering endeavors (see 'The Engineering of Environment Enrichment in Zoos' section) but could be upgraded with modern technology (Carter et al., 2021; Clay et al., 2011; Coe & Hoy, 2020; Perdue et al., 2012) so that visitors could introduce interactive elements (e.g., movement, sound, or food) into animal exhibits and observe the behavioral responses. This would require careful arrangements and monitoring, of course, and behavior analysts have the expertise and tools to ensure its success.

5. Conclusion

Modern zoos stand on the shoulders of giants of operant conditioning such as B. F. Skinner, Keller Breland, Marian Breland Bailey, and Hal Markowitz. Behavior analytic-driven advances in animal training and environmental enrichment have improved the welfare of zoo animals and have benefited animal care workers and zoo visitors. Nonetheless, behavior analysis still has untapped potential in this setting. Further advancement of behavior analysis in animal settings necessitates true behavioral engineers who are well-trained in the fundamentals of classical and operant conditioning and can combine this theoretical background with practical knowledge of animal behavior to design habitats and arrange behavioral contingencies to optimize welfare (Martin, 2017). This will require more animal care professionals with advanced training in behavior analysis and more collaborations between zoos and academic institutions (Fernandez & Timberlake, 2008; Gray & Diller, 2017; Maple & Perdue, 2013; Maple & Segura, 2015). Integrative approaches to behavior analysis and animal behavior are rapidly increasing. We hope that this historical recognition of such work in zoos, as well as a potential guide for future research, helps foster such practices.

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References

- Alligood, C. A., Dorey, N. R., Mehrkam, L. R., & Leighty, K. A. (2017). Applying behavior-analytic methodology to the science and practice of environmental enrichment in zoos and aquariums. *Zoo Biology*, 36(3), 175-185. <https://doi.org/10.1002/zoo.21368>
- Association of Zoos and Aquariums (2020, November 20). *Animal care manuals*. <https://www.aza.org/animal-care-manuals>
- Bailey, J. S., & Burch, M. R. (2017). *Research Methods in Applied Behavior Analysis*. Routledge.
- Bailey, M. B., & Bailey, R. E. (1979, May). Animal exhibits as revenue producers. *Proceedings of the American Association of Zoological Parks and Aquariums Regional Workshop*, 367-373.
- Bailey, R. E., & Bailey, M. B. (1980). A view from outside the Skinner box. *American Psychologist*, 35(10), 942-946. <https://doi.org/10.1037/0003-066X.35.10.942>
- Bailey, R. E., & Gillaspay, J. A. (2005). Operant psychology goes to the fair: Marian and Keller Breland in the popular press, 1947–1966. *The Behavior Analyst*, 28(2), 143-159. <https://doi.org/10.1007/BF03392110>
- Bashaw, M. J., Gibson, M. D., Schowe, D. M., & Kucher, A. S. (2016). Does enrichment improve reptile welfare? Leopard geckos (*Eublepharis macularius*) respond to five types of environmental enrichment. *Applied Animal Behaviour Science*, 184, 150-160. <https://doi.org/10.1016/j.applanim.2016.08.003>
- Bender, A., & Strong, E. (2019). *Canine Enrichment for the Real World*. Dogwise Publishing.
- Bihm, E. M., Gillaspay, J. A., Lammers, W. J., & Huffman, S. P. (2010). IQ Zoo and teaching operant concepts. *The Psychological Record*, 60(3), 523-526. <https://doi.org/10.1007/BF03395725>
- Bloomsmith, M. A., Marr, M. J., & Maple, T. L. (2007). Addressing nonhuman primate behavioral problems through the application of operant conditioning: Is the human treatment approach a useful model? *Applied Animal Behaviour Science*, 102(3-4), 205-222. <https://doi.org/10.1016/j.applanim.2006.05.028>
- Bloomsmith, M. A., Stone, A. M., & Laule, G. E. (1998). Positive reinforcement training to enhance the voluntary movement of group-housed chimpanzees within their enclosures. *Zoo Biology*, 17(4), 333-341. [https://doi.org/10.1002/\(SICI\)1098-2361\(1998\)17:4%3C333::AID-ZOO6%3E3.0.CO;2-A](https://doi.org/10.1002/(SICI)1098-2361(1998)17:4%3C333::AID-ZOO6%3E3.0.CO;2-A)
- Breland, K. (1962). New strides in animal psychology bring about naturalistic behavior exhibits. *Parks and Recreation*, 45, 80.

- Breland, K. (1963). The 'Who's Teaching Whom?' Machine. *American Psychologist*, 18(5), 261. <https://doi.org/10.1037/h0039305>
- Breland, K., & Breland, M. (1951). A field of applied animal psychology. *American Psychologist*, 6(6), 202. <https://doi.org/10.1037/h0063451>
- Breland, K., & Breland, M. (1961). The misbehavior of organisms. *American Psychologist*, 16(11), 681-684. <https://doi.org/10.1037/h0040090>
- Breland, K., & Breland, M. (1966). *Animal Behavior*. New York: Macmillan.
- Brox, B. W., Edwards, K., Buist, N. A., & Macaskill, A. C. (2021). Investigating food preference in zoo-housed meerkats. *Zoo Biology*, 21640. <https://doi.org/10.1002/zoo.21640>
- Cameron, K. E., Bizo, L. A., & Starkey, N. J. (2013). Food preferences of the brushtail possum (*Trichosurus vulpecula*). *International Journal of Comparative Psychology*, 26(4), 324–336.
- Capshew, J. H. (1993). Engineering behavior: project pigeon, World War II, and the conditioning of BF Skinner. *Technology and Culture*, 34(4), 835-857. <https://doi.org/10.2307/3106417>
- Carlstead, K., Seidensticker, J., & Baldwin, R. (1991). Environmental enrichment for zoo bears. *Zoo Biology*, 10(1), 3-16. <https://doi.org/10.1002/zoo.1430100103>
- Carter, M., Sherwen, S., & Webber, S. (2021). An evaluation of interactive projections as digital enrichment for orangutans. *Zoo Biology*, 40(2), 107-114. <https://doi.org/10.1002/zoo.21587>
- Clay, A. W., Bloomsmith, M. A., Marr, M. J., & Maple, T. L. (2009). Systematic investigation of the stability of food preferences in captive orangutans: Implications for positive reinforcement training. *Journal of Applied Animal Welfare Science*, 12(4), 306–313. <https://doi.org/10.1080/10888700903163492>
- Clay, A. W., Perdue, B. M., Gaalema, D. E., Dolins, F. L., & Bloomsmith, M. A. (2011). The use of technology to enhance zoological parks. *Zoo Biology*, 30 (5), 487 – 497. <https://doi.org/10.1002/zoo.20353>
- Clayton, M., & Shrock, T. (2020). Making a tiger's day: Free-operant assessment and environmental enrichment to improve the daily lives of captive Bengal tigers (*Panthera tigris tigris*). *Behavior Analysis in Practice*, 13, 883-893. <https://doi.org/10.1007/s40617-020-00478-z>
- Coe, J., & Hoy, J. (2020). Choice, control and computers: Empowering wildlife in human care. *Multimodal Technologies and Interaction*, 4(4), 92. <https://doi.org/10.3390/mti4040092>
- Curtis, L. (1957). Coin-operated animal acts. *Parks and Recreation*, 40, 18.

- DeRosa, N. M., Sullivan, W. E., Roane, H. S., Craig, A. R., & Kadey, H. J. (2021). Single-case experimental design. In W. W. Fisher, C. C. Piazza, & H. S. Roane (Eds). *Handbook of Applied Behavior Analysis (2nd ed)* (pp. 155 – 171). Guilford Press.
- Desmond, T., & Laule, G. (1994). Use of positive reinforcement training in the management of species for reproduction. *Zoo Biology*, 13(5), 471-477. <https://doi.org/10.1002/zoo.1430130509>
- Dorey, N. R., Mehrkam, L. R., & Tacey, J. (2015). A method to assess relative preference for training and environmental enrichment in captive wolves (*Canis lupus* and *Canis lupus arctos*). *Zoo Biology*, 34(6), 513-517. <https://doi.org/10.1002/zoo.21239>
- Dorey, N. R., Rosales-Ruiz, J., Smith, R., & Lovelace, B. (2009). Functional analysis and treatment of self-injury in a captive olive baboon. *Journal of Applied Behavior Analysis*, 42(4), 785–794. <https://doi.org/10.1901/jaba.2009.42-785>
- European Association of Zoos and Aquaria (2019, April 25). *Standards for the accommodation and care of animals in zoos and aquaria*. <https://www.eaza.net/assets/Uploads/Standards-and-policies/2019-04-EAZA-Standards-for-Accommodation-and-Care.pdf>
- Farmer-Dougan, V. (2014). Functional analysis of aggression in a black-and-white ruffed lemur (*Varecia variegata variegata*). *Journal of Applied Animal Welfare Science*, 17(3), 282-293. <https://doi.org/10.1080/10888705.2014.917029>
- Fay, C., & Miller, L. J. (2015). Utilizing scents as environmental enrichment: Preference assessment and application with Rothschild giraffe. *Animal Behavior and Cognition*, 2(3), 285 – 291. <https://doi.org/10.12966/abc.08.07.2015>
- Fernandez, E. J. (2001). Click or treat: A trick or two in the zoo. *American Animal Trainer Magazine*, 2(2), 41-44.
- Fernandez, E. J. (2021a). Training as enrichment: A critical review (preprint). <https://doi.org/10.31234/osf.io/sc69u>
- Fernandez, E. J. (2021b). Appetitive search behaviors and stereotypies in polar bears (*Ursus maritimus*). *Behavioural Processes*, 182, 104299. <https://doi.org/10.1016/j.beproc.2020.104299>
- Fernandez, E. J., Dorey, N., & Rosales-Ruiz, J. (2004). A two-choice preference assessment with five cotton-top tamarins (*Saguinus oedipus*). *Journal of Applied Animal Welfare Science*, 7(3), 163-169. https://doi.org/10.1207/s15327604jaws0703_2
- Fernandez, E. J., Kinley, R. C., & Timberlake, W. (2019). Training penguins to interact with enrichment devices for lasting effects. *Zoo Biology*, 38(6), 481-489. <https://doi.org/10.1002/zoo.21510>

- Fernandez, E. J., Myers, M., & Hawkes, N. C. (2021a). The effects of live feeding on swimming activity and exhibit use in zoo Humboldt penguins (*Spheniscus humboldti*). *Journal of Zoological and Botanical Gardens*, 2(1), 88-100. <https://doi.org/10.3390/jzbg2010007>
- Fernandez, E. J., Tamborski, M. A., Pickens, S. R., & Timberlake, W. (2009). Animal–visitor interactions in the modern zoo: Conflicts and interventions. *Applied Animal Behaviour Science*, 120(1-2), 1-8. <https://doi.org/10.1016/j.applanim.2009.06.002>
- Fernandez, E.J., & Timberlake, W. (2005, May). *The Functional Value of Enrichment: Determining Environmental Enrichment Effects in Lemurs through the Use of Paired-Choice Preference Assessments*. Paper presented at the Association for Behavior Analysis Conference, Chicago, IL (USA).
- Fernandez, E. J., & Timberlake, W. (2008). Mutual benefits of research collaborations between zoos and academic institutions. *Zoo Biology*, 27(6), 470-487. <https://doi.org/10.1002/zoo.20215>
- Fernandez, E. J., & Timberlake, W. (2019). Selecting and testing environmental enrichment in lemurs. *Frontiers in Psychology*, 10, 2119. <https://doi.org/10.3389/fpsyg.2019.02119>
- Fernandez, E. J., Upchurch, B., & Hawkes, N. C. (2021b). Public feeding interactions as enrichment for three zoo-housed elephants. *Animals*, 11(6), 1689. <https://doi.org/10.3390/ani11061689>
- Feuerbacher, E. N., & Wynne, C. D. (2016). Application of functional analysis methods to assess human–dog interactions. *Journal of Applied Behavior Analysis*, 49(4), 970-974. <https://doi.org/10.1002/jaba.318>
- Forthman, D. L., & Ogden, J. J. (1992). The role of applied behavior analysis in zoo management: today and tomorrow. *Journal of Applied Behavior Analysis*, 25(3), 647 - 652. <https://dx.doi.org/10.1901%2Fjaba.1992.25-647>
- Forthman-Quick, D. L. (1984). An integrative approach to environmental engineering in zoos. *Zoo Biology*, 3(1), 65-77. <https://doi.org/10.1002/zoo.1430030107>
- Foster-Turley, P., & Markowitz, H. (1982). A captive behavioral enrichment study with Asian small-clawed river otters (*Aonyx cinerea*). *Zoo Biology*, 1(1), 29-43. <https://doi.org/10.1002/zoo.1430010104>
- Franklin, A. N., Martin, A. L., Perlman, J. E., & Bloomsmith, M. A. (2021). Functional analysis and treatment of disruptive behavior in a rhesus macaque. *Journal of Applied Animal Welfare Science*. Advance online publication. <https://doi.org/10.1080/10888705.2021.1931868>
- Gaalema, D. E., Perdue, B. M., & Kelling, A. S. (2011). Food preference, keeper ratings, and reinforcer effectiveness in exotic animals: the value of systematic testing. *Journal of Applied Animal Welfare Science*, 14(1), 33–41. <https://doi.org/10.1080/10888705.2011.527602>

- Gray, J. M., & Diller, J. W. (2017). Evaluating the work of applied animal behaviorists as applied behavior analysis. *Behavior Analysis: Research and Practice*, 17(1), 33 – 41. <http://dx.doi.org/10.1037/bar0000041>
- Gillaspy Jr, J. A., & Bihm, E. M. (2002). Marian Breland Bailey (1920-2001). *American Psychologist*, 57(4), 292-293. <https://psycnet.apa.org/doi/10.1037/0003-066X.57.4.292>
- Gillaspy Jr, J. A., Brinegar, J. L., & Bailey, R. E. (2014). Operant psychology makes a splash—in marine mammal training (1955–1965). *Journal of the History of the Behavioral Sciences*, 50(3), 231-248. <https://doi.org/10.1002/jhbs.21664>
- Grandin, T., Rooney, M. B., Phillips, M., Cambre, R. C., Irlbeck, N. A., & Graffam, W. (1995). Conditioning of nyala (*Tragelaphus angasi*) to blood sampling in a crate with positive reinforcement. *Zoo Biology*, 14(3), 261-273. <https://doi.org/10.1002/zoo.1430140307>
- Haddock, J. N., & Hagopian, L. P. (2020). Competing stimulus assessments: A systematic review. *Journal of Applied Behavior Analysis*, 53(4), 1982 – 2001. <https://doi.org/10.1002/jaba.754>
- Hall, N. J., Protopopova, A., & Wynne, C. D. (2015). The role of environmental and owner-provided consequences in canine stereotypy and compulsive behavior. *Journal of Veterinary Behavior*, 10(1), 24-35. <https://doi.org/10.1016/j.jveb.2014.10.005>
- Hancocks, D. (1980). Bringing nature into the zoo: inexpensive solutions for zoo environments. *International Journal for the Study of Animal Behavior Problems* 1, 170–177.
- Hanratty, L. A., & Hanley, G. P. (2021). A preference analysis of reinforcer variation and choice. *Journal of Applied Behavior Analysis*, 54(3), 1062 – 1074. <https://doi.org/10.1002/jaba.835>
- Hediger, H. (1950). *Wild Animals in Captivity*. Butterworths Scientific Publications.
- Hediger, H. (1955). *Studies of the Psychology and Behavior of Captive Animals in Zoos and Circuses*. Butterworths Scientific Publications.
- Homme, L., C'de Baca, P., Cottingham, L., & Homme, A. (1968). What behavioral engineering is. *The Psychological Record*, 18(3), 425-434. <https://doi.org/10.1007/BF03393790>
- Hoy, J. M., Murray, P. J., & Tribe, A. (2010). Thirty years later: Enrichment practices for captive mammals. *Zoo Biology*, 29(3), 303-316. <https://doi.org/10.1002/zoo.20254>
- Hutchins, M., Hancocks, D., & Calip, T. (1978a). Behavioral engineering in the zoo: a critique. *International Zoo News, Part I*, 25(7), 18-23.
- Hutchins, M., Hancocks, D., & Calip, T. (1978b). Behavioral engineering in the zoo: a critique. *International Zoo News, Part II*, 25(8), 18-23.

- Hutchins, M., Hancocks, D., & Calip, T. (1979). Behavioral engineering in the zoo: a critique. *International Zoo News, Part III*, 26(1), 20-27.
- Hutchins, M., Hancocks, D., & Crockett, C. (1984). Natural solutions to the behavioral problems of captive animals. *Zoologische Garten*, 54, 28-42.
- Johnston, J. M., & Pennypacker, H. S. (2010). *Strategies and Tactics of Behavioral Research*. Routledge.
- Kummrow, M. (2021). Diagnostic and therapeutic guidelines to abnormal behavior in captive nonhuman primates. *Veterinary Clinics of North America: Exotic Animal Practice*, 24(1), 253 – 266. <https://doi.org/10.1016/j.cvex.2020.09.012>
- Laule, G., & Desmond, T. (1998). Positive reinforcement training as an enrichment strategy. In D. J. Shepherdson, J. D. Mellen, & M. Hutchins (Eds). *Second Nature: Environmental Enrichment for Captive Animals* (pp. 302 – 313). Smithsonian Books.
- Learmonth, M. J. (2020). Human–animal interactions in zoos: What can compassionate conservation, conservation welfare and duty of care tell us about the ethics of interacting, and avoiding unintended consequences *Animals*, 10(11), 2037. <https://doi.org/10.3390/ani10112037>
- Learmonth, M. J., Sherwen, S., & Hemsworth, P. H. (2021). Assessing preferences of two zoo-housed Aldabran giant tortoises (*Aldabrachelys gigantea*) for three stimuli using a novel preference test. *Zoo Biology*, 40(2), 98 – 106. <https://doi.org/10.1002/zoo.21585>
- Lukas, K. E., Marr, M. J., & Maple, T. L. (1998). Teaching operant conditioning at the zoo. *Teaching of Psychology*, 25(2), 112-116. http://dx.doi.org/10.1207/s15328023top2502_7
- Mackie, J. (2020). The application of positive reinforcement training to enhance welfare of primates in zoological collections. In V. A. Melfi, N. R. Dorey, & S. J. Ward (Eds.), *Zoo animal learning and training* (pp. 211-215). John Wiley & Sons Ltd.
- Maple, T. L. (2013). Remembering Hal Markowitz. *Zoo Biology*, 32(3), 243-245. <https://doi.org/10.1002/zoo.21065>
- Maple, T. L., & Perdue, B. M. (2013). *Zoo Animal Welfare*. Springer.
- Maple, T. L., & Segura, V. D. (2015). Advancing behavior analysis in zoos and aquariums. *The Behavior Analyst*, 38(1), 77-91. <https://dx.doi.org/10.1007%2Fs40614-014-0018-x>
- Markowitz, H. (1978). Engineering environments for behavioral opportunities in the zoo. *The Behavior Analyst*, 1(1), 34 - 37. <https://dx.doi.org/10.1007%2F03392371>
- Markowitz, H. (1979). Environmental enrichment and behavioral engineering for captive primates. In J. Erwin & T. Maple (Eds.), *Captivity and Behavior: Primates in Breeding Colonies, Laboratories and Zoos* (pp. 217-238). Van Nostrand Reinhold.

- Markowitz, H. (1982). *Behavioral Enrichment in the Zoo*. Van Nostrand Reinhold.
- Markowitz, H. (2011). *Enriching Animal Lives*. Mauka Press.
- Markowitz, H., Aday, C., & Gavazzi, A. (1995). Effectiveness of acoustic “prey”: Environmental enrichment for a captive African leopard (*Panthera pardus*). *Zoo Biology*, 14(4), 371-379. <https://doi.org/10.1002/zoo.1430140408>
- Markowitz, H. & LaForse, S. (1987). Artificial prey as behavioral enrichment devices for felines. *Applied Animal Behaviour Science*, 18, 31-43. [https://doi.org/10.1016/0168-1591\(87\)90252-8](https://doi.org/10.1016/0168-1591(87)90252-8)
- Markowitz, H., Schmidt, M. J., & Moody, A. (1978). Behavioural engineering and animal health in the zoo. *International Zoo Yearbook*, 18(1), 190-194. <http://dx.doi.org/10.1111/j.1748-1090.1978.tb00256.x>
- Markowitz, H., Schmidt, M., Nadal, L., & Squier, L. (1975). Do elephants ever forget? *Journal of Applied Behavior Analysis*, 8(3), 333-335. <https://doi.org/10.1901/jaba.1975.8-333>
- Markowitz, H., & Spinelli, J. S. (1986). Environmental engineering for primates. In W. K. Benirschke (Ed.), *Primates: The Road to Self-Sustaining Populations* (pp. 489-498). Springer-Verlag.
- Markowitz, H., & Woodworth, G. (1978). Experimental analysis and control of group behavior. In H. Markowitz & V. J. Stevens (Eds.), *Behavior of Captive Wild Animals* (pp. 107-131). Nelson-Hall.
- Martin, A. L. (2017). The primatologist as a behavioral engineer. *American Journal of Primatology*, 79 (1), e22500. <https://doi.org/10.1002/ajp.22500>
- Martin, A. L., Bloomsith, M. A., Kelley, M. E., Marr, M. J., Maple, T. L. (2011). Functional analysis and treatment of human-directed undesirable behavior exhibited by a captive chimpanzee (*Pan troglodytes*). *Journal of Applied Behavior Analysis*, 44 (1), 139 – 143. <https://doi.org/10.1901/jaba.2011.44-139>
- Martin, A. L., Franklin, A. N., Perlman, J. E., & Bloomsith, M. A. (2018). Systematic assessment of food item preference and reinforcer effectiveness: Enhancements in training laboratory-housed rhesus macaques. *Behavioural Processes*, 157, 445 – 452. <https://doi.org/10.1016/j.beproc.2018.07.002>
- Mehrkam, L. R., & Dorey, N. R. (2014). Is preference a predictor of enrichment efficacy in Galapagos tortoises (*Chelonoidis nigra*)? *Zoo Biology*, 33(4), 275-284. <https://doi.org/10.1002/zoo.21151>
- Mehrkam, L. R., Perez, B. C., Self, V. N., Vollmer, T. R., & Dorey, N. R. (2020). Functional analysis and operant treatment of food guarding in a pet dog. *Journal of Applied Behavior Analysis*, 53(4), 2139 – 2150. <https://doi.org/10.1002/jaba.720>

- Melfi, V. A., Dorey, N. R., & Ward, S. J. (Eds.). (2020). *Zoo Animal Learning and Training*. Wiley Blackwell.
- Mellen, J., & MacPhee, M. S. (2001). Philosophy of environmental enrichment: past, present, and future. *Zoo Biology*, 20(3), 211-226. <https://doi.org/10.1002/zoo.1021>
- Mellen, J. D., Stevens, V. J., & Markowitz, H. (1981). Environmental enrichment for servals, Indian elephants and Canadian otters at Washington Park Zoo, Portland. *International Zoo Yearbook*, 21(1), 196-201. <https://doi.org/10.1111/j.1748-1090.1981.tb01981.x>
- Morris, D. (1964). The response of animals to a restricted environment. *Symposia of the Zoological Society of London*, 13, 99-118.
- Morris, K. L., & Slocum, S. K. (2019). Functional analysis and treatment of self-injurious feather plucking in a black vulture (*Coragyps atratus*). *Journal of Applied Behavior Analysis*, 52(4), 918-927. <https://doi.org/10.1002/jaba.639>
- Newberry, R. C. (1995). Environmental enrichment: increasing the biological relevance of captive environments. *Applied Animal Behaviour Science*, 44(2-4), 229-243. [https://doi.org/10.1016/0168-1591\(95\)00616-Z](https://doi.org/10.1016/0168-1591(95)00616-Z)
- Perdue, B. M., Clay, A. W., Gaalema, D. E., Maple, T. L., & Stoinski, T. S. (2012). Technology at the zoo: The influence of a touchscreen computer on orangutans and zoo visitors. *Zoo Biology*, 31(1), 27 – 39. <https://doi.org/10.1002/zoo.20378>
- Peterson, G. B. (2004). A day of great illumination: BF Skinner's discovery of shaping. *Journal of the Experimental Analysis of Behavior*, 82(3), 317-328. <https://doi.org/10.1901/jeab.2004.82-317>
- Pfaller-Sadovsky, N., Arnott, G., & Hurtado-Parrado, C. (2019). Using principles from applied behaviour analysis to address an undesired behaviour: Functional analysis and treatment of jumping up in companion dogs. *Animals*, 9(12), 1091. <https://doi.org/10.3390/ani9121091>
- Phillips, M., Grandin, T., Graffam, W., Irlbeck, N. A., & Cambre, R. C. (1998). Crate conditioning of bongo (*Tragelaphus eurycerus*) for veterinary and husbandry procedures at the Denver Zoological Gardens. *Zoo Biology*, 17(1), 25-32. [https://doi.org/10.1002/\(SICI\)1098-2361\(1998\)17:1%3C25::AID-ZOO3%3E3.0.CO;2-C](https://doi.org/10.1002/(SICI)1098-2361(1998)17:1%3C25::AID-ZOO3%3E3.0.CO;2-C)
- Pierce, W. D., & Cheney, C. D. (2013). *Behavior Analysis and Learning*. Psychology Press.
- Priest, G. M. (1991). Training a diabetic drill (*Mandrillus leucophaeus*) to accept insulin injections and venipuncture. *Laboratory Primate Newsletter*, 30(1), 1-4.
- Pryor, K. (1975). *Lads Before the Wind: Adventures in Porpoise Training*. Harper & Row Publishers.

- Pryor, K. (1984). *Don't Shoot the Dog!: The New Art of Teaching and Training*. Bantam Books.
- Ramirez, K. (1999). *Animal Training: Successful Animal Management through Positive Reinforcement*. Shedd Aquarium Press.
- Ringdahl, J. E., Vollmer, T. R., Marcus, B. A., & Roane, H. S. (1997). An analogue evaluation of environmental enrichment: The role of stimulus preference. *Journal of Applied Behavior Analysis*, 30(2), 203 – 216. <https://doi.org/10.1901/jaba.1997.30-203>
- Salmeron, M. C., Payne, S. W., & Hegr, A. B. (2021). Functional analysis and treatment of feline aggression in an animal shelter. *Behavior Analysis: Research and Practice*, 21(2), 128 – 139. <https://doi.org/10.1037/bar0000185>
- Sanders, K., & Fernandez, E. J. (2020). Behavioral implications of enrichment for golden lion tamarins: A tool for ex situ conservation. *Journal of Applied Animal Welfare Science*, Advance online publication, 1-10. <https://doi.org/10.1080/10888705.2020.1809413>
- Savastano, G., Hanson, A., & McCann, C. (2003). The development of an operant conditioning training program for New World primates at the Bronx Zoo. *Journal of Applied Animal Welfare Science*, 6(3), 247-261. https://doi.org/10.1207/S15327604JAWS0603_09
- Schmidt, M. J., & Markowitz, H. (1977). Behavioral engineering as an aid in the maintenance of healthy zoo animals. *Journal of the American Veterinary Medical Association*, 171(9), 966-969.
- Shepherdson D. J., Mellen, J. D., & Hutchins, M., (Eds.) (1998). *Second Nature: Environmental Enrichment for Captive Animals*. Smithsonian Institutional Press.
- Sherwen, S. L., & Hemsworth, P. H. (2019). The visitor effect on zoo animals: Implications and opportunities for zoo animal welfare. *Animals*, 9(6), 366. <https://doi.org/10.3390/ani9060366>
- Skinner, B. F. (1938). *The Behavior of Organisms: An Experimental Analysis*. Appleton-Century Press.
- Skinner, B. F. (1951). How to teach animals. *Scientific American*, 185(6), 26-29.
- Skinner, B. F. (1958). Reinforcement today. *American Psychologist*, 13, 94–99.
- Skinner, B. F. (1960). Pigeons in a pelican. *American Psychologist*, 15(1), 28.
- Skinner, B. F. (1979). *The Shaping of a Behaviorist: Part Two of an Autobiography*. New York University Press.

- Slocum, S. K., & Morris, K. L. (2020). Assessing preference in a paired-stimulus arrangement with captive vultures (*Aegypius Monachus*). *Journal of Applied Animal Welfare Science*, 1-6. <https://doi.org/10.1080/10888705.2020.1857253>
- Snyder, R. (1977). Putting the wild back into the zoo. *International Zoo News*, 24(1), 11-17.
- Tarou, L. R., & Bashaw, M. J. (2007). Maximizing the effectiveness of environmental enrichment: Suggestions from the experimental analysis of behavior. *Applied Animal Behaviour Science*, 102(3-4), 189-204. <https://doi.org/10.1016/j.applanim.2006.05.026>
- Timberlake, W. (2003). Marian Breland Bailey: many lives: (SQAB, May 25, 2002, Toronto, Canada). *Behavioural Processes*, 62(1-3), 1-4. [https://doi.org/10.1016/S0376-6357\(03\)00015-9](https://doi.org/10.1016/S0376-6357(03)00015-9)
- Uphouse, L. (1980). Reevaluation of Mechanisms That Mediate Brain Differences Between Enriched and Impoverished Animals. *Psychological bulletin*, 88(1), 215-232. <https://doi.org/10.1037/0033-2909.88.1.215>
- Vicars, S. M., Miguel, C. F., Sobie, J. L. (2014). Assessing preference and reinforcer effectiveness in dogs. *Behavioural Processes*, 103, 75–83. <https://doi.org/10.1016/j.beproc.2013.11.006>.
- Woods, J. M., Lane, E. K., & Miller, L. J. (2020). Preference assessments as a tool to evaluate environmental enrichment. *Zoo Biology*, 39(6), 382-390. <https://doi.org/10.1002/zoo.21566>
- Yanofsky, R., & Markowitz, H. (1978). Changes in general behavior of two mandrills (*Papio sphinx*) concomitant with behavioral testing in the zoo. *The Psychological Record*, 28(3), 369-373. <https://doi.org/10.1007/BF03394548>
- Yerkes, R. M. (1925). *Almost Human*. Century.
- Yin, S. (2012). Bells and whistles: When operant conditioning clicked (and clucked). *Barks Magazine*, 69, 74-78.
- Young, R. J. (2003). *Environmental Enrichment for Captive Animals*. Blackwell Science Ltd.