



## **Duane Rumbaugh's Influence on the Science and Practice of Animal Welfare**

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Duane Rumbaugh's influence on the field of comparative psychology will be long lasting and far reaching. He is best known for his continuing influence on the field of primate cognition, but his work and that of his mentees has branched out into other domains as well. Here, we will focus specifically on his influence on the field of animal welfare and how place or location has shaped those influences. In our narrative, we will describe how different people with different perspectives have interfaced over the decades by virtue of sharing space. We will reflect on a range of physical spaces: field versus wild, different cities or geographical locations, laboratory versus zoo, and actual versus virtual. Geographic location, indirectly and/or directly, will shape the interactions among scientists and their perspectives and values. In particular, we will focus on how developments in the 20<sup>th</sup> century in San Diego and Atlanta shaped the primate research community in both laboratories and zoos. We will provide the historical context and development of perspectives that have forever altered how we think of and coexist with great apes. These interactions have yielded positive and strong connections between people that ultimately influence our understanding and treatment of animal welfare.

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Place plays an important role in any story, and this one is no different. We will briefly offer a history of how Professor Rumbaugh made his way to Atlanta and the lasting legacy that emerged from his journey and establishment of his lab there. Place can have a significant influence on a person, but, in turn, people can also influence and shape the places in which they live and work. Duane Rumbaugh's career, spanning 50 years as a professor, mentor, and academic leader, took place in a dynamic era and influenced many emerging fields. He was first and foremost a psychologist, but he also contributed ideas to the new disciplines of behavioral primatology and zoo biology. We will describe how the authors of this paper have been influenced by time working in the same geographical locations, spanning over a number of decades, in an effort to illustrate the powerful impact of Duane Rumbaugh's work. We will also consider the mutual influences between the labs and zoos that house primates in these respective regions. Arguably, many lessons have been learned from both places that have mutually altered protocols and policies to ultimately improve the care of nonhuman primates and comparative psychology more broadly.

Early in the senior author's career, comparative psychology was alive with opportunity. Scholars in the field paid close attention to the work of Hodos and Campbell (1969) who repudiated linear hierarchies in favor of the study of closely related species. Specialists in primate behavior saw the vast potential in comparative studies of monkeys and apes, but it was difficult to confine and manage populations of such complex social organisms. Primate centers, first envisioned by Robert M. Yerkes (1916), facilitated the advance of psychobiology and comparative medicine. The opportunity to conduct this research with captive populations allowed for more refined experimental control and advances in scientific inquiry with animals that served as a valuable complement to studies of wild primates. Yerkes was the first psychologist to conduct comparative studies of the closely related great ape taxa: chimpanzees, gorillas, and orangutans. Because apes were not yet abundant in captivity, he had to travel to distant sites where subjects were available. Yerkes

studied a large collection of chimpanzees at the private Quinta Palatino facility in Cuba. His book *Almost Human* (1925) was based on his early observations at this remote location. His research on gorilla mentality (Yerkes, 1928) was conducted with the subject Congo, a female mountain gorilla captured and shipped to the United States by the explorer Ben Burbridge (1928). Yerkes first observed and tested her on Burbridge's farm in Jacksonville, Florida, and continued his research when Congo was sold to the Ringling Brother's Circus. The third ape species studied by Yerkes was the young orangutan Julius, maintained in an outdoor facility in Montecito, California by Yerkes former student G. V. Hamilton (Thomas, 2006). Eventually, great apes became widely distributed in zoological parks, but only a few zoos encouraged scientists to use their facilities for research. One exception was the San Diego Zoo. Belle Benchley, who led the zoo for 26 years, expressed her curiosity about gorillas in her book, *My Life in a Man-Made Jungle* (1940). An early study of gorilla behavior was conducted on her watch when the primatologist C. Ray Carpenter (1937) studied the San Diego mountain gorillas, Ngagi and Mbongo. The early 20<sup>th</sup> century was a period of great curiosity about primates, and the settings in which research took place were widely dispersed and largely disconnected. As they were developing facilities for studying monkeys and apes, Yerkes and his collaborators also carried out important field research. Comparative psychologists H.C. Bingham, C.R. Carpenter, and Henry Nissan studied gorillas, orangutans, and chimpanzees in nature long before any anthropologists or zoologists traveled to Africa and Asia for this purpose (Maple, 1979).

### **From Coast to Coast: Research Hubs in the 20<sup>th</sup> Century**

The center that bears Robert Yerkes' name was established in Orange Park, Florida, in 1930. It was originally affiliated with Yale University. Other primate research centers in California, Oregon, Louisiana, Massachusetts, Washington, and Wisconsin were not in place until Congress allocated funding in 1959. Unique among these institutions, Emory University's Yerkes National Primate Research Center managed a large collection of great apes: chimpanzees, gorillas, orangutans, and bonobos. For students of comparative psychology, no laboratory or zoo on earth could compare to Yerkes with the world's largest collection of great apes. Yerkes National Primate Research Center is now located on the campus of Emory University in the Atlanta suburbs. Rumbaugh arrived in Atlanta in 1969, and Professor Maple in 1975, for the opportunity to study these "rational beings," as Rumbaugh called them (Rumbaugh & Washburn, 2008). We will focus on primate research conducted in San Diego and Atlanta for this manuscript, but there were critically important developments also taking place throughout other regions of the country influenced, in part, by former students who built comparable programs.

The San Diego Zoo was indeed unique for encouraging research at an early stage in its history. When Rumbaugh arrived at San Diego State College in 1954, he first studied the zoo's rodent collection, reflecting his traditional training in experimental psychology (Maple & Kuhar, 2007), but the extraordinary diversity of the zoo's collection of monkeys and apes was a compelling alternative. As he explained it (Rumbaugh, 2007), his conversion to comparative psychology was opportunistic, as his department at San Diego State needed to fill a void in their curriculum. Although the zoo opened its doors to Rumbaugh and his students, he endured more than his share of bureaucratic impediments. As one of the first psychologists to dedicate himself to the study of primates, he learned to negotiate with curators, keepers, and veterinarians to sustain the rigorous methodology required in his field. Tenacious as he was by nature, Rumbaugh persevered and took advantage of his opportunity to explore dimensions of the primate mind. His early studies of primate learning (Rumbaugh, 1970) at the San Diego Zoo set the stage for his iconic research on language acquisition that he conducted in Atlanta.

Duane Rumbaugh's leadership and scholarship helped to turn the Atlanta area into one of a few centers of excellence for primate research. Because he was continuously funded by a variety of sources, he trained many students who ultimately became colleagues and collaborators in Atlanta and beyond. At the time of his retirement, Rumbaugh protégés were employed at Emory University, Georgia State University, the University of Georgia, and many other colleges and universities throughout the nation. After he relocated to Iowa to assist with the development of the Great Ape Trust of Iowa, his successors in Atlanta continued to publish important papers. Today, the Language Research Center (LRC) at Georgia State University (GSU) is as visible as it was during Rumbaugh's lifetime. In our contribution to this collection of papers honoring Professor Rumbaugh, we will also review his influence on the development of our own lab at Georgia Tech, and the direct and indirect impact of his research on the science and practice of animal welfare. In many ways, Rumbaugh was a mentor to both of us and we owe a debt of gratitude to Professor Rumbaugh for paving the way for a scientific zoo in Atlanta.

### **Rumbaugh's Influence on TECHlab**

When Professor Maple arrived in Atlanta in 1975, he scheduled meetings with all of the local silverback investigators of primate behavior. This list of luminaries included Irwin S. Bernstein (University of Georgia), Richard K. Davenport (Georgia Institute of Technology), Richard Michael (Georgia Mental Health Institute), Ronald D. Nadler (Yerkes Primate Research Center), and Duane M. Rumbaugh (Georgia State University). Following the traditions of the primate community in Davis, California, the newly minted Ph.D. sought the advice and partnership of established scholars. The Atlanta Zoo was the setting for Professor Maple's first collaboration, as he and his students began to study a group of orangutans from Yerkes placed on loan to the zoo by Dr. Davenport. The publications generated from this research helped zoo curators throughout the world to better manage orangutans, a species that was not well studied at the time (Maple, 1980; Maple, Wilson, Zucker, & Wilson, 1978; Maple & Zucker, 1978; Maple, Zucker, & Dennon, 1979).

Professor Maple's early zoo studies established a theme evident throughout his career, as he attempted to apply basic behavioral data to improve the quality of life for captive primates. In a 1989 publication, Maple and Finlay first described their approach as "applied primatology". By this time, Professor Maple had joined the School of Psychology faculty at Georgia Tech, replacing Dr. Davenport after his unfortunate death in 1978. Primarily an engineering school, Georgia Tech is an institution where research applications are encouraged. Maple's research group became TECHlab (Georgia Tech Laboratory for Animal Behavior) until 1995, when he was appointed to an endowed chair as part of the new Center for Conservation and Behavior. The evolution of TECHlab and the Center for Conservation and Behavior contributed to the shaping of Zoo Atlanta, as it ascended to the status of an empirical zoo under Maple's 18 years of executive leadership. Both TECHlab and the Center for Conservation and Behavior operated under similar principles that motivated Professor Rumbaugh – careful experimental design, rigorous and objective documentation of behavior in order to best understand an animal's experience, and collaborative work among the group.

In the early years, graduate students in TECHlab continued the primate-centered research on social attachment that began at UC Davis under the direction of Gary D. Mitchell, a student of Harry F. Harlow at the University of Wisconsin (e.g., Erwin, Mitchell, & Maple, 1973; Maple, Erwin, & Mitchell, 1974; Maple, Wilson, Zucker, & Wilson, 1975; Maple & Westlund, 1977). At Davis, the ideas of environmental psychologist Robert Sommer were expressed in his critical evaluations of zoological parks. He encouraged Maple and his students to carry out research in local zoos (Hoff & Maple, 1982; Maple & Westlund, 1975). Sommer's own research identified many zoos in the 1970's as examples of "hard architecture" (Sommer, 1974). His findings

drew upon the work of Mitchell and other Harlow students and collaborators who discovered and documented the deleterious effects of social deprivation and social isolation on rhesus monkeys (Mason & Berkson, 1975; Mitchell, 1970; Sackett, 1968). Sommer's early suggestion to Maple, the aspiring doctoral student in his midst generated a keen and career-long interest in the publications of Heini Hediger, the iconic and scholarly Swiss zoo director who was the most productive zoo biologist who ever lived (Hediger, 1950, 1969). Sommer came to know Hediger professionally and Hediger came to know Sommer's former student from Maple's visits to Zurich in the late 1980s. Hediger's work inspired the journal *Zoo Biology* founded by Maple in 1982. *Zoo Biology* was originally formulated to serve as a peer-reviewed outlet for both basic and applied zoo and aquarium research. The very existence of this journal helped to prioritize reform in zoos and aquariums. From the earliest days of his directorship in Atlanta, Maple positioned Atlanta's zoo for change while his students and collaborators from nearby universities set out to document the change. No zoo in history has been revitalized and simultaneously evaluated by the agents of this change (for a complete history, see Desiderio, 2000). The most dramatic of these revisions was the conversion of the zoo from a barren hardscape to a verdant landscape, as the zoo was systematically softened to resemble and function as a naturalistic habitat (Coe & Maple, 1987). The revitalized zoo was also documented in a series of post-occupancy evaluations (Chang, Forthman, & Maple, 1999; Finlay, James, & Maple, 1988; Hoff et al., 1994; Hoff & Maple, 1995; Maple & Finlay, 1987; Ogden, Finlay, & Maple, 1990; Ogden, Lindburg, & Maple, 1993; Stoinski et al., 2001). Again, another important tenet of Dr. Rumbaugh's approach to science – careful and methodological collection of data – is mirrored in the development of the Professor Maple's work and approach to the empirical zoo.

Taking notice of Rumbaugh's pioneering studies at the San Diego Zoo, and his early advocacy of scientific management at the Atlanta Zoological Park (Maple & Kuhar, 2007), a creative fusion of Atlanta's municipal zoo and its local universities was clearly a possibility in 1984, but a management crisis was the catalyst for substantive reform (Desiderio, 2000). Atlanta Mayor Andrew Young hired Dr. Maple to serve as its reform director on June 15, 1984. With privatization in 1985, the re-branded Zoo Atlanta began immediately to practice evidence-based zoo management. The engineers of Zoo Atlanta's reform were comforted by the fact that there was no need to reinvent the wheel. During Rumbaugh's time in San Diego, he learned that a modern zoo could be dedicated to scientific management. Returning to the theme of its original by-laws, Zoo Atlanta, as the Atlanta Zoological Society intended, would ultimately become a small but well-integrated empirical zoo.

In 1976, the San Diego Zoo established a formal research department under the leadership of Kurt Benirschke, a highly respected pathologist affiliated with the University of California, San Diego, Medical School. However, San Diego's scientific program was organized around dedicated staff in key areas (e.g., reproductive biology, genetics, physiology, and behavior). By comparison, the Zoo Atlanta model relied on graduate students funded by endowment to carry out serious psychological research at the zoo. The director of reform in Atlanta was himself a scientist with an abundance of colleagues and collaborators available to guide and document its reformation, which tremendously helped the process. During Professor Maple's association with Atlanta's zoo, 29 doctoral students from Emory University and Georgia Tech completed their degrees based on behavioral research conducted at the zoo. Interestingly, two of these dissertations were based on research conducted at the San Diego Zoo with collaborating scientists who sponsored them (Bashaw, Bloomsmith, Maple, & Bercovitch, 2007; Ogden et al., 1993). Over the years, Zoo Atlanta and the San Diego Zoo cultivated a serious scientific partnership.

Throughout his long career, Rumbaugh also exemplified entrepreneurial leadership. He thought big as he built the LRC into a globally impacting team of scholars and educators. Much like the LRC, Zoo Atlanta built its reputation on collaboration and the recruitment of extraordinary talent. Both the LRC and Zoo Atlanta

(in partnership with Georgia Tech's School of Psychology) carried out important studies in comparative cognition. In fact, the critical mass of students and faculty conducting comparative cognition work with nonhuman primates in Atlanta – dozens over the years – is extraordinary. By building a zoo collection comprised of a large number of gorillas and orangutans, on loan from the Yerkes National Primate Research Center, the zoo functioned for two decades as a dedicated research laboratory that required no government overhead. The TECHlab/Center research program was supported by \$3.5 million of dedicated endowment generously provided by the Smithgall family of Gainesville, Georgia. The endowment continued after Professor Maple retired, but the locus of support shifted from the School of Psychology to the School of Biology. The network of university partners has dramatically expanded in recent years with faculty and students from Agnes Scott College, Dalton College, and Kennesaw State College working alongside colleagues from Emory, Georgia State, and Georgia Tech. Today, Zoo Atlanta conducts research primarily by collaboration with outsourced academics and students, but they have operated under the direction of a strong and credible scientific leader, Joe Mendelson. A recent survey revealed that among all zoos in North America publishing research, Zoo Atlanta ranked sixth in productivity (Loh et al., 2018). Comparing Zoo Atlanta with the San Diego Zoo in Rumbaugh's time there, the San Diego collection was always much larger and more diverse. Biodiversity in zoos makes them extremely important to science but, in spite of their significant size, universities often overlook zoo collections as research assets for faculty and students (Maple & Sherwen, in press). Zoos and aquariums are living laboratories with great potential to inform and inspire.

### **From Laboratory to Zoo**

Professor Rumbaugh was an experimental psychologist who conducted his comparative studies in a laboratory setting, but he also eloquently discussed the advantages of working in zoos in two publications (Rumbaugh, 1971, 1972), at a time when only a few world zoos encouraged research. His early success at the San Diego Zoo and the longevity of the behavioral research program at Zoo Atlanta (1984-present) are all the evidence needed to demonstrate the efficacy of scientific zoo biology. Programs such as these influenced the growth of zoo research, as a critical mass of graduate students were trained in San Diego and Atlanta from 1954 to the present. A forthcoming book (Kaufman, Bashaw, & Maple, in press) documents in great detail the global scientific potential of zoos and aquariums. Along with Hediger (1950, 1960) and Harlow (Harlow, Uehling, & Maslow, 1932), whose first primate lab was located at the Vilas Park Zoo in Madison, Wisconsin, Rumbaugh must be regarded as one of the true pioneers of psychological research in zoos. Although he specialized in nonhuman primates, Rumbaugh's impact extends to a universe of other species, as the technology he developed is adapted easily to a diversity of wildlife, such as carnivores, cetaceans, giant pandas, and pinnipeds (Lindemann-Biolski & Reichmuth, 2013; Perdue, Snyder, & Maple, 2013; Perdue, Snyder, Pratte, Marr, & Maple, 2009; Richards, Woltz, & Herman, 1984).

Duane Rumbaugh foresaw the application of his ideas and the potential of computer-technology to upgrade living conditions for primates and other zoo taxa. Building on these innovations, TECHlab graduates are still active locally in developing computer-animal interfaces for research and studying enrichment for a variety of species (Allard et al., 2018; Anderson et al., 2005; Anderson, Stoinski, Bloomsmith, & Maple, 2007; Mallavarapu Kuhar, Bloomsmith, & Maple, 2013; Maple, 2015; Perdue, Gaalema, Stoinski & Maple, 2011; Tarou Kuhar, Adcock, Bloomsmith, & Maple, 2004). Initially, computer technology was installed in the primary viewing blind for lowland gorillas at Zoo Atlanta. Individual animals could interact with investigators in a corner of this room in view of the public. Similar technology was available to orangutans. One of the orangutans in the zoo's collection (Chantek) was trained on American Sign Language by the anthropologist Lyn Miles. Chantek was particularly eager to operate a joy stick and communicate with his

caregivers. The Zoo Atlanta computer interface was effective at three levels: (1) It served as enrichment for gorillas and orangutans; (2) experiments to test the problem-solving abilities of these subjects were explored in many publications; and (3) the zoo utilized computer interaction to educate visitors about the advanced cognitive skills of great apes.

### **Evidence-based Animal Welfare**

In his pioneering studies of language development, Rumbaugh emphasized human-animal relationships and computer-animal interfaces to discover the cognitive capacity of his subjects. In the former, Rumbaugh's research team discovered that nonhuman primates liked to work. This propensity has been labeled "contrafreeloading" (Jensen, 1963) and "the protestant ethic effect" (Stephens, Metz, & Craig, 1975). Rewards were helpful but not necessary to keep monkeys and apes on task. In a related study, Washburn, Hopkins and Rumbaugh (1991) found that rhesus macaques preferred to choose the order of tasks to complete in a computerized test battery. The ability to choose also yielded better performance measures on some aspects of the task compared to a condition in which task order was randomly assigned. The junior author of this manuscript, Professor Perdue, worked alongside Dr. Rumbaugh during her postdoc to further address this preference for choice in nonhuman primates (Perdue, Evans, Washburn, Rumbaugh, & Beran, 2014). Given the apparent value of being in a condition in which the task order was controlled by the monkeys themselves, a step was added to assess the preference for choice. The monkeys were given an option to choose whether they were in a condition in which the order of tasks was randomly determined or in a condition in which they were in control of the order. With sufficient experience, all subjects showed a significant preference to choose the condition in which they were able to choose, suggesting a preference for choice (Perdue et al., 2014).

Rumbaugh's research contributed to a more enlightened form of animal husbandry, in which positive control replaced punitive control to encourage cooperation and elevate performance. It required an investment in the human-animal relationship (HAR) to advance psychological well-being in the laboratory and the zoo. Thus, the attentive caregiver/zoo keeper is now acknowledged as an essential component in a successful animal welfare program. The HAR also became important as experimental subjects were carefully trained to utilize computer technology and devices, such as joysticks (see Washburn et al., this issue, for more information on this topic). Initially designed to generate problem-solving and test constructs such as memory, the apparatus constructed morphed into cognitive work stations with a broader purpose (see Figure 1). These work stations provide intellectual stimulation that is clearly a form of enrichment (Maple & Perdue, 2013; Washburn, 2015). In the modern zoological garden, cognitive work stations generate data for research and encourage mental activity that reduces boredom and lethargy. Dr. Rumbaugh also showed a great awareness to how different species might best interact with cognitive apparatuses, a consideration that is equally important to considering best welfare practices. As Morimura (2006) observed, cognitive competence must be exercised for a chimpanzee to enjoy quality of life comparable to its life in the wild. We know enough about the needs of great apes to engineer such environments in the lab or the zoo. Chimpanzees and other primate subjects working to reveal their cognitive skills helped psychologists and designers create enlightened living conditions for experimental and exhibited primates (Coe & Maple, 1987; Maple & Perdue, 2013).



**Figure 1. Sun bear (photo by Bonnie Perdue) and orangutans (photo by Andrea Clay) interacting with touchscreen computer apparatus.**

Testing apparatus have evolved greatly over the last several decades and now offer increased mobility so that stations can be transported directly to whatever animal is available for testing (Perdue, Beran, & Washburn, 2017). They can also be used with a variety of interfaces, ranging from a standard personal computer to a smart tablet. These devices have already been used to make advances in our understanding of a range of nonhuman responses to tasks of metacognition, choice behavior, quantity judgments, and more (see Perdue et al., 2017, for a review).

Rumbaugh's elevation of apes in terms of their mentality contributed to the positioning of psychological well-being as a powerful component in animal welfare (Beck et al., 2001). While other projects utilized American Sign Language to examine language acquisition, Rumbaugh's approach was consistent with traditions of experimental psychology and objectified the study of language in apes. He appreciated the need for objective measures of language production and relied on technology rather than human interpretation. For example, to communicate with her caregivers, the chimpanzee Lana mastered an artificial language of arbitrary symbols known as lexigrams (Rumbaugh, 1977).

The use of technology and unusual management practices at Rumbaugh's field station in the Atlanta suburb of Panthersville led to a greater acceptance of innovation in other labs and zoos. For example, the importance of the human caregiver was elevated to an artform at the Arizona Primate Foundation, where chimpanzees were managed to achieve a state of "wellness" (Fritz & Howell, 1993). Although human health practitioners are comfortable with this construct in the context of therapy, Fritz was the first observer to apply wellness to the care of captive nonhuman primates. Wellness is essentially equivalent to "optimal animal welfare" (Maple & Bocian, 2013; Maple & Bloomsmith, 2018). In his approach to the science of animal welfare, Rumbaugh was able to shape living environments to introduce exploration as a reward and a means to examine spatial memory and wayfinding (e.g., Menzel & Menzel, 2007). Georgia Tech graduate students who studied spatial memory at Zoo Atlanta and other sites were able to extend these methods to other species such as otters (Perdue, Snyder, Zhihe, Marr, & Maple., 2011), giant pandas (Perdue et al., 2009; Tarou, Snyder & Maple, 2004), and giant anteaters (Allard, Earles, & DesFosses, 2014). The heavily wooded surroundings of the LRC enabled research on cognition in a more natural setting. In planning zoo exhibits with research in mind, a naturalistic site is suitable for work and play. The concept of a living laboratory facilitates both observational and experimental research. As primate research centers have recently de-emphasized behavioral research, zoological parks with extensive primate collections may well become the preferred venue where behavioral research is valued and encouraged. The distinction between wellness and welfare was discussed by

Maple and Perdue (2013). In this formulation, welfare is characterized by minimal standards determined by regulatory agencies. By contrast, wellness is both optimal and aspirational with essentially no limits on how well an organism should be. The key attributes of wellness are psychological in nature. Wellness requires conditions whereby animals are socially and mentally stimulated, something that was reflected in Dr. Rumbaugh's work. A framework for achieving this outcome was provided by Washburn (2015) in his four "C's" of animal welfare: comfort, companionship, challenge, and control. The category of challenge is rarely achieved in captive settings because caregivers choose to provide food and other necessary resources on a fixed and unvarying schedule. Our collective experience in managing primates suggests that it is beneficial to experience challenges, as a life without challenges does not measure up to the optimal standards associated with wellness. A well-researched example of challenge is the requirement that the animals work for food and access to other scarce resources.

### **A Place in History and in the Future**

The mark of a powerful legacy is the status of the scholar's influence long after his passing. Rumbaugh's successors have continued to publish important papers that have advanced the field of animal welfare. Given their productivity, it is evident that Professor Rumbaugh carefully planned for the continuation of his laboratory in Atlanta. Its vitality is unusual given the fate of so many other animal research labs after the retirement or death of their founders (Maple, 2016). The ability of Rumbaugh and the GSU administration to foresee the continuing impact of Rumbaugh's lab is unusual given the tumultuous shift in the academic landscape, in which so many psychological laboratories were systematically abandoned (Maple & Segura, 2014). Rumbaugh's group has effectively demonstrated that animal research can be carried out in an ethically responsible manner that advances the field of psychology while contributing to the welfare of all animals utilized in research and education. In particular, the field of applied behavior analysis, based on Skinnerian operant principles, is extremely important to enlightened animal management in laboratories and zoos. Such basic principles have been utilized to shape animals to operate joysticks and other devices.

Cross-fertilization is occurring in Atlanta now that TECHlab graduates have engaged in serious collaborations with GSU peers (e.g., Perdue et al., 2014). The far-reaching influence of Rumbaugh's lab can be recognized in the new "Think Pod" work station at the Jacksonville Zoo & Gardens, where bonobos and gorillas will soon operate computerized manipulanda imbedded in a massive artificial kapok tree within the new African Forest Exhibit. We anticipate additional research opportunities for graduate students from GSU and other institutions who want to gain experience conducting great ape research in a zoo. Today's computer technology builds on the pioneering research of Hal Markowitz who modified the behavior of elephants, mandrills, and leopards by the intervention of operant technology at the Oregon and San Francisco Zoos respectively (Markowitz, 1982). Research by psychologist Ben Beck at the National Zoo led to the exhibit known as "Think Tank," which provided joystick technology for orangutans and also introduced aerial pathways that encouraged the apes to locomote above zoo visitors and visually explore the outdoors (<http://nationalzoo.si.edu/animals/thinktank/default.cfm>). The "O-Line" system of pathways inspired Philadelphia and Jacksonville Zoos to build similar pathways so apes and big cats can leave the confines of their enclosures and explore the zoo safely. These creative measures have been engineered to contribute to autonomy and choice, two important dimensions of psychological well-being.

## **Connecting the Past to the Future**

To innovate and engage better practices and standards, zoos need to negotiate academic partnerships with nearby colleges and universities. In many cases, zoos and aquariums are located in metropolitan areas with access to college and university faculty and students who would take great interest in working with diverse collections. The story of Atlanta and its critical role as a hub of primate research highlight an exemplary case of such a geographic concentration. Of course, not all places will be so rich with opportunities and interest, but we urge the philosophy of Professor Rumbaugh— to seek out, embrace, and nurture whatever valuable opportunities might be available. Throughout his career, Rumbaugh consistently demonstrated how such partnerships can benefit scholars, students, animals, and the community. Just as important, the longevity of his program of research demonstrates the efficacy of planning for succession and sustainability. However, administrators in universities fail too often to defend iconic research programs that are misunderstood or misrepresented by extremist critics. In case after case, for the past several decades, universities have withdrawn support from traditional animal labs even when they were generating high quality publications. This shift in the zeitgeist was part ideology and part hysteria over the threats of animal rights activists and concerns over liability. Laboratories offer some forms of experimental control that cannot be matched by other settings and continue to serve a critical role. They have yielded valuable insights into animal behavior, cognition, and welfare that have guided many changes in our understanding of optimal care. Nonetheless, the face of animal research is changing, and it is our hope that the different institutions housing animals will continue to provide empirically based care. As animal research continues in laboratories, zoos, and sanctuaries, it is important for scientists to convey their findings as well as their use of evidence-based practices. In many ways, the foundation for optimal care is rooted in some of the more foundational areas of our field, such as behaviorism.

As we have argued (Maple & Segura, 2014), training through operant conditioning has never been more important in providing superior animal care and conditions that lead to optimal animal welfare, regardless of setting. Behaviorists working with animals responded to diminishing administrative support by shifting their focus to human subjects, particularly autistic and developmentally disabled individuals. In effect, this represented a complete flight from the traditional animal laboratory that once was a ubiquitous feature of most psychology departments. We firmly believe that animal learning labs need to be reinvented and upgraded to offer training experiences for students and animal managers at partnering zoos and aquariums. An examination of journals such as *The Behavior Analyst* reveals a still thriving intellectual corpus of ideas and enterprise. Because it works, behavior analysis could return in a different form to the psychology curriculum. In our opinion, there has never been a time when there was more public interest in animal behavior. Behavior analysis today is alive and well in both human and animal psychological circles. It is critically important for comparative psychology to return to its roots. Over the years, the interest in the cognitive abilities of animals has increased (Beran, Parrish, Perdue, & Washburn, 2014), but this should not come at the sacrifice of our understanding of basic learning mechanisms. Duane Rumbaugh always appreciated this idea in his writing and personal conversations. As comparative psychology develops, the lessons of Duane Rumbaugh should be carried forward. Behavior analysis is also important in the treatment of behavior disorders (e.g., Maple & Segura, 2017). We regard the “practice” of animal welfare as an approach that complements the daily work of clinical veterinarians.

## **Places of the Future: The Potential for Virtual Spaces**

As we have discussed so far in this paper, whether intentional or happenstance, the physical place in which researchers reside greatly influences ideas and collaborative opportunities. The influence of place can

manifest in several ways. As we have covered extensively, working in the same region usually means access to the same resources and regular opportunities for contact and exchange of ideas with other individuals. Ideas can also be transmitted outside of a certain place through publication and sharing findings with others at regional, national, or even international conferences. People with strong ideas may also carry these influences more permanently by changing locations within a career, as illustrated by Duane Rumbaugh's move from California to Georgia. However, improvements in virtual connectivity may lead to a new space in which collaborations can thrive. Recognizing the continuing value of his lab after retirement, Professor Maple has elected to re-establish the Center for Conservation and Behavior as a "virtual" association of scholars from many institutions. The virtual center restores the collaborative relationships among faculty affiliated with six Atlanta institutions of higher learning. With dual headquarters in Atlanta, Georgia, and Jacksonville, Florida, the virtual center will extend partnerships to colleges and universities in Alabama, north and south Florida, and programs operating in other countries (e.g., Australia and Brazil). By organizing in this way, important papers and books are already in the publication pipeline (Allard et al., 2014; Maple & Bloomsmith, in press; Maple & Sherwen, in press; Kaufman et al., in press). As the virtual center evolves, it will likely increase collaboration among GSU and Georgia Tech mentees in Atlanta and beyond.

Whatever the future holds for comparative psychology, it is indebted to the enduring achievements of prolific scientists like Duane M. Rumbaugh who discovered a new pathway and laid down a foundation of scientific inquiry as the cornerstone of animal care and our ongoing efforts to understanding animal minds. We are grateful to have overlapped in time and place with such a remarkable scholar and strive to carry his legacy into the future.

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