Chapter 11
Global Sustainability: A Behavior Analytic Approach

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Sustainability: A Behavior Analytic Approach

We enter now the *Anthropocene*, an epoch defined by human activity. To live in this time bears a connotation: an era of human dominance over nature; a nod to the awesome potential of *Homo sapiens* for collectively yielding systemic change (Crutzen, 2002; Crutzen & Stoermer, 2000). Thus far, our contributions to planetary cycles have been cumulatively destructive. Interdependent systems regulating planetary extremes are showing signs of degradation. Thousands of years of ecological carelessness have culminated in far-reaching threats to Earth's biotic livelihood. Humans have thus far feigned helpless to rewrite a still unwritten fate, but life in the Anthropocene remains unscripted—to package existence as defined by environmental catastrophe is but a choice, a tragedy of the commons that can yet be avoided.

In 1990, the Intergovernmental Panel on Climate Change (IPCC) recapped nearly five decades of environmental study with its first official report released for public scrutiny (see IPCC, 1992). Broad interest in environmental health has long waxed and waned, corresponding in large part to the happenings of global—usually political—affairs. The Gingrich-championed *Contract with America* of 1994, for instance, resulted in the rolling-back of many standing environmental protection

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policies (see Gingrich & Armey, 1994; see also Lynch, 2001), while the events of September 11, 2001 forced much of the public spotlight toward the combatting of global terrorism. Yet the potential of *and* for environmental perturbation—a function of accelerated change—has continuously grown, underscoring the need for action to curb pollution and reduce greenhouse gas emission. This first report by the IPCC expanded upon previous documents of similar nature, chiefly describing ongoing concerns, probable long-term threats, and options to address the effects of a changing global climate. The agency has since released four additional assessment reports, maintaining a broad focus and historic emphasis on advancing technologies and scientific practices (see IPCC, 1995, 2001, 2007, 2014).

Notably, these IPCC reports present two distinct avenues for climatic change solution: (a) mitigate the effects of a changing climate, and/or (b) promote adaptation to the outcomes too far gone for realistic or probabilistic preventative measures. More inevitabilities than options, solutions of either type present challenges of global scale. Efforts of this magnitude will be *necessarily* technological and behavioral in nature, as neither solution is alone adequate to generate sufficient change. Consider, for example, the market release of new technology: mass production of environmentally friendly "green" options will have little impact unless a sufficient proportion of the population embraces these choices *and* does so in the intended manner (e.g., reusable water bottles are of little benefit if thrown away after only a few uses). Technologies for social reformation need now keep pace with emerging development from long-standing advances of the global sustainability agenda. Across the many reports by and for environmental science—to and from government officials—social scientists have been called upon for a better understanding of behavior contributing to wasteful living, adherence to newly established sustainable practices, and the potential effects of long-term exposure to environmental pollutants. To this call, social scientists *must be willing to rise*.

As they stand, the contributions of the social sciences are reasonably robust and far-reaching. A rich literature exists examining the correlates of attitudes toward environmental preservation (e.g., O'Connor, Bord, & Fisher, 1999). Many investigators strive to catalogue the variables predicting sustainable living practices—the means by which better choices can be embraced by the general public. These are important and meaningful contributions; we cannot begin to produce broad change unless we understand the thoughts and attitudes that facilitate reformation. Yet these contributions alone will not suffice. Investigation must continue to move beyond attitudes and opinions, correlates and predictors, embracing instead an experimental approach to evaluating human behavior. It is high time our science of behavior, one grounded in empirical methodology and with an outlook conducive to widespread behavioral change, joins the global sustainability conversation.

The purpose of this chapter will be multifold. First, our discussion will work to unpack the concept of sustainability. Next, we seek to outline the unique advantages of a behavior analytic approach to understanding activity at the population level, targeting specifically contributions already made by behavioral researchers toward advancing our understanding of sustainability and/or achieving a more sustainable lifestyle. Finally, we hope to highlight some gaps in the literature and provide direction for those seeking greater involvement in ecologically focused research.

On the Concept(s) of Sustainability

Producing a concise and accurate definition of sustainability has historically proven difficult (see Toman, 1992). Literature spanning several decades and involving scientific figureheads of varying expertise has sparked debate with respect to a number of questions, namely: *what exactly are we sustaining?* For instance, a foremost discussion must focus upon the type of *scarcity* which might result from careless use of resources. Stemming from differing domains of thinking, ecological researchers disagree as to whether the population may be faced with Malthusian scarcity—a finite end to the supply of natural resources—or Ricardian scarcity—a gradual degradation of natural resources, at the end of which no viable provision can be obtained (Hall & Hall, 1984; see also Barnett & Morse, 2011). Further still, these concepts may be divided based on the nature of the commodity under interest (e.g., coal vs. oil). Synthesizing all meanings in a broadly satisfactory fashion (a complex task made more difficult given the vast array of sciences involved in sustainability research) is beyond the scope of the current chapter. Instead, a solitary understanding of the *goals* of sustainability may be a more palpable discussion.

In 1987, the report of the World Commission on Environment and Development (WCED)—known informally as the "Brundtland Report" or *Our Common Future*—outlined the tasks and goals necessary to achieve worthwhile sustainable development (WCED, 1987). From this report, we can distinguish several primary (i.e., of utmost necessity) and secondary dimensions of sustainability. Table 11.1 displays these dimensions, as summarized in part by Holden, Linnerud, and Banister (2014) and Høyer (1999). In many senses, these dimensions create a foundation upon which a working definition of sustainability might be built. The 2005 initiative of Marshall and Toffel to define sustainability synthesized these goals into a far more concise approach to defining sustainable behavior. Accordingly, behaviors of concern in ecological research are those that (a) threaten human livelihood, (b) reduce life expectancy or cause other health detriments, (c) result in the extinction of species or violation of human rights, or (d) otherwise reduce quality of life (Marshall & Toffel, 2005). Expansion of these categorizations with the assumption that these targets might impact organisms at *any time* (i.e., future generations) is a sufficient base from which discussion may proceed.

Table 11.1 Dimensions of sustainable development as outlined by the 1987 WCED report

Dimension placement	
Primary	Preserve long-term ecological viability
Primary	Satisfy baseline human need
Primary	Promote generational fairness and equity
Secondary	Maintain non-fiscal value of natural landscape
Secondary	Increase perceived value of natural preservation
Secondary	Invite public involvement
Secondary	Pursue improved quality of life

Enter Behavior Analysis: A Science of Behavior

The potency of an effective science of behavior is such that any organism can learn via behavior analytic instruction, as is the understanding shared by *behavior analysts*. The question thus stands—in combatting the behavioral components of a global sustainability crisis, to what extent has behavior analysis lent its expertise? B. F. Skinner was often quoted for his belief that we can "save the world with behavior analysis." Work emerged from the field which strived to do just that; gradually, behavioral scientists have conducted research with an aim toward unpacking problems of broad societal concern, as is the stated mission of those practicing applied behavior analysis (Baer, Wolf, & Risley, 1968). Yet the scope of this work has been insufficient. As the curtains on his career began to close, Skinner published a paper recording his dissatisfaction with the field as it stood, noting the lack of worthwhile progress in combatting the many grand problems plaguing the globe (Skinner, 1987). Small-scale investigation—while impactful in its own right—was no longer alone adequate, not when the potential for more was so strongly evident and so desperately needed.

In the years following Skinner's (1987) sentiments, a growing number of behavior analytic studies have been published that overtly evaluate methods to advance global sustainability. Recent years have seen a wide range of methods and topics evaluated and addressed via behavior analytic research. Such is one aim of the current chapter—to shine light on the vast potential of behavior analysis to advance global sustainability. Literature from within the field will be examined in its historical context and for trends; review will focus on both self-identified contributions and those methods which, despite a lack of demonstrated application, may hold potential to help redefine the Anthropocene as an age of human *conservation*.

Foundations of Environmental (In)Action

Concern over human activity as it relates to environmental longevity is by no means a recent development. As early as 1763, Benjamin Franklin expressed concern over changing weather patterns in a letter to American academic Ezra Stiles (B. Franklin, personal communication, May 29, 1763 as cited in Labaree, 1959), and still others expressed concern over environmental practices centuries earlier (e.g., tenth and eleventh century efforts to conserve forest cover; Young, 1978). The turn of the twentieth century marked increased awareness of general environmental issues, including the raging debate of "conservation" versus "preservation" fueled by Gifford Pinchot and John Muir (e.g., the battle over Hetch Hetchy, which continues today). Both conservation and preservation have implications for current conceptualizations of sustainability and remain at the heart of natural resource use and theory within government entities such as the United States Forest Service and the National Park Service.

By the mid-twentieth century, the first meaningful evidence of broad-scale environmental perturbation had been observed. Work conducted at laboratories like Mauna Loa Observatory (MLO) in Hawaii during the late-1950s provided initial detection of increasing concentrations of select atmospheric gasses, chiefly carbon dioxide (CO_2; Keeling, 1978; Mook, Koopmans, Carter, & Keeling, 1983). Stark contrasts between measurements taken before the start of the industrial revolution and those at MLO provided strong evidence for the burning of fossil fuels as responsible for the dramatic change, and early modeling suggested a likely relation between elevated CO_2 levels and mean global temperature. At the time, however, too little was known about the natural fluxes of the planetary carbon cycle to draw definitive conclusions regarding the long-term trends of these gasses (Keeling, 1978).

While the public lent increasing attention to the possible influence of human activity on the *observable* environment (Rachel Carson's *Silent Spring* was released in 1962, helping to fuel a zeitgeist for early environmental concern; see also Aldo Leopold's *A Sand County Almanac,* published in 1949 and largely considered a critical milestone in the American conservation and land ethics movement), Washington focused its attention on the now-obvious health-threat posed by a polluted atmosphere. A series of amendments to the 1955 Air Pollution Control Act led to the passing of the 1963 Clean Air Act—the first move by federal legislation to actively influence air pollution in the U.S. (see Clean Air Act of 1963, 1963). The first report of the Environmental Pollution Panel (EPP) via the President's Science Advisory Committee was generated in November 1965, highlighting the growing concern over environmental pollution and its possible health and environmental effects (EPP, 1965). Within a year, the Task Force on Environmental Health and Related Problems had been assembled to generate—in greater detail than the preceding report—immediate and effective interventions to mitigate environmental detriment (Task Force on Environmental Health and Related Problems, 1967).

In 1968, only a few years after the Task Force report, Baer and colleagues published their seminal article in the newly founded *Journal of Applied Behavior Analysis*, an outlet intended as the self-titled flagship for the newly christened science of social focus. During the years to follow, events that would help to fuel a spirit of environmental concern among the greater population also provided fodder for work in this new branch of behavioral science. Ehrlich's best-selling 1968 novel *The Population Bomb* drew attention to the fantastic strain placed on the planet by our swelling populace. The 1969 publicity surrounding the fouling of the Cuyahoga River in Cleveland served as recognition of human influence, highlighting primarily the issue of irresponsible waste handling practices. By 1970, enough interest backed the movement for the declaration of the nation's first Earth Day, an expansion of the previously passed Clean Air Act, and the founding of the Environmental Protection Agency (EPA). In response to the growing concern over pollution, early behavior analytic contributions emerged, the first of which worked to create cleaner, more livable environments. Burgess, Clark, and Hendee (1971) were the foremost to formally apply behavior analytic principles to issues of ecological relevance: researchers offered inexpensive rewards in exchange for full bags of collected litter. The results, although modest in effect, inspired a wave of environmentally focused

studies from behavior analysts, all of which sought to translate easily sustained procedures for ecological study.

Through the remainder of the decade, independent reports on the interplay between human behavior and the climate were generated in still greater abundance (e.g., the principle report by *The Club of Rome*; Meadows, Meadows, Randers, & Behrens III, 1972; see also SCEP, 1970; SMIC, 1971). Behavior analytic endeavors in global sustainability expanded from litter to home energy-use reduction (e.g., Seaver & Patterson, 1976), recycling (e.g., Witmer & Geller, 1976), and eco-friendly driving practices (e.g., Hake & Foxx, 1978). International interest in global sustainability was strong by the end of the 1970s, culminating in the first World Climate Conference (WCC) in 1979. Behavior analytic research into sustainable living produced the bulk of its early work through the late 1970s and early 1980s, during which time experimentation extended to issues of more complex origin. The quasi-experimental analysis of behavior change tactics in the drought-stricken western United States by Agras, Jacob, and Lebedeck (1980) served as a first attempt to evaluate contingencies scaled for community-level change. Methods by which household and university electricity consumption could be curbed (e.g., Hayes & Cone, 1981) proved promising for widespread rollout. As things stood, the field seemed poised to carve a legitimate place for future development in the sustainability movement.

In 1985, scientists of international origin reached an agreement regarding the probable and impactful elevation of mean global temperature and a changing global climate as the result of elevated atmospheric gas levels (Agrawala, 1998). Climatologist James Hansen delivered his historic testimony before the U.S. Senate Committee on Energy and Natural Resources regarding the danger of elevated greenhouse gas emissions in 1988 and, in the same year, actions were taken that led to the founding of the IPCC. Yet by the turn of the 1990s, ecologically grounded contributions by behavior analysts were in short supply. As compared to the 13 novel studies released in the preceding decade, the field published only four experimental papers examining sustainable practices between 1990 and 1999. The focus of these few had shifted entirely to low-cost environmental manipulations intended to promote recycling—an important line of work, but one that cannot alone progress the sustainability movement.

In the years since, rates of behavior analytic contributions have been in flux. The first decade of the new millennium saw only three articles published in behavioral journals, although these hinted at the diversity of the work to follow. Manuel, Sunseri, Olson, and Scolari (2007) examined inexpensive and easily maintained methods by which cafeteria patrons could be encouraged to choose reusable utensils. A 2013 behavioral economic analysis of fuel by Reed and colleagues represented the first analysis of its kind by a behavior analyst: authors used field-standard approaches to model North American operant demand for fossil fuels (i.e., oil), in turn demonstrating a rate of consumption that parallels patterns seen in drug addiction (e.g., *inelastic* demand at high prices). From 2010 to present, 16 studies have been published focusing on a range of topics and employing cheap and easily implemented treatments—an encouraging sign for behavior analytic development.

The trend is certainly moving in the desired direction, but to truly make an impact these methods must continue to evolve. What follows is a closer examination of these studies, categorized according to target behavior and discussed with respect to intervention focus. Using our established behavioral definition for *un*-sustainable practice, we collected *empirical* literature published in peer-reviewed journals of primarily behavior analytic content (data hosted by Gelino, Erath, & Reed, 2020; see Table 11.2). Articles were coded according to target behavior and—in order to assess the scope of scientific contribution—representative works are here summarized.

An Empirical Approach to Global Sustainability

Transportation

From the bulk of behavior analytic work, we identified seven studies as having a primary aim of promoting more eco-friendly transportation; all focused explicitly on reducing fuel use via less frequent driving or through the promotion of more economical driving habits. Four of these studies—Foxx and Hake (1977), Hake and Foxx (1978), Foxx and Schaeffer (1981), and Hake and Zane (1981)—employed basic odometer monitoring as a primary dependent variable. The earliest, Foxx and Hake, demonstrated a meaningful reduction in miles driven by delivering inexpensive rewards for meeting driving reduction goals; 21 university students achieved a reduction of over 2500 miles in a four-week period, corresponding to an estimated 170 gallons of gasoline. Using similar reward deliveries, Jacobs, Fairbanks, Poche, and Bailey (1982) promoted carpool transportation in a university setting, yielding a cumulative 868 additional carpool trips and an estimated fuel savings of 620 gallons. To provide greater context for the results of these driving reduction mechanisms, authors in all articles state the economic relevance of the reward costs and generated savings—a focus on low-cost or free rewards (e.g., tour of a local mental health facility) yielded in each case results that far outweighed the cost of implementation.

Behavior analytic work in transportation was absent for several decades following, and only recently has the work resurfaced as an emphasis of behavior analytic experimentation. Venditti and Wine (2017) focused on the promotion of regular maintenance to ensure personal vehicles were running at top possible efficiency. Participants were informed of the importance of maintaining proper tire pressure and provided access to a free-for-use air pump at their place of employment. Those who received the informational briefing demonstrated significantly greater adherence to proper tire pressure. Beyond demonstrating the utility of prompting and effort manipulation to yield greater compliance with vehicle efficiency standards, the study underscored the potential for ecologically conscious business practices to generate more responsible action by employees through the implementation of relatively simple, low-cost modifications.

Table 11.2 Empirical studies related to environmental sustainability published in behavior analytic journals through 2019 (sorted by publication date)

Citation	Target behavior	Intervention[a]
Burgess, R. L., Clark, R. N., & Hendee, J. C. (1971). An experimental analysis of anti-litter procedures	Litter	Incentive/ reward Prompting Response effort
Clark, R. N., Burgess, R. L., & Hendee, J. C. (1972). The development of anti-litter behavior in a forest campground	Litter	Incentive/ reward
Geller, E. S., Farris, J. C., & Post, D. S. (1973). Prompting a consumer behavior for pollution control	Waste/recycling	Prompting
Kohlenberg, R., & Phillips, T. (1973). Reinforcement and rate of litter depositing	Litter	Incentive/ reward
Powers, R. B., Osborne, J. G., & Anderson, E. G. (1973). Positive reinforcement of litter removal in the natural environment	Litter	Incentive/ reward
Chapman, C., & Risley, T. R. (1974). Anti-litter procedures in an urban high-density area	Litter	Incentive/ reward Prompting
Hayes, S. C., Johnson, V. S., & Cone, J. D. (1975). The marked item technique: A practical procedure for litter control	Litter	Incentive/ reward
Kohlenberg, R., Phillips, T., & Proctor, W. (1976). A behavioral analysis of peaking in residential electrical-energy consumers	Energy use	Feedback Incentive/ reward Information
Seaver, W. B., & Patterson, A. H. (1976). Decreasing fuel-oil consumption through feedback and social commendation	Energy use	Feedback Incentive/ reward
Witmer, J. F., & Geller, E. S. (1976). Facilitating paper recycling: Effects of prompts, raffles, and contests	Waste/recycling	Incentive/ reward Prompting
Foxx, R. M., & Hake, D. F. (1977). Gasoline conservation: A procedure for measuring and reducing the driving of college students	Transportation	Incentive/ reward
Hayes, S. C., & Cone, J. D. (1977). Reducing residential electrical energy use: Payments, information, and feedback	Energy use	Feedback Incentive/ reward Information
Palmer, M. H., Lloyd, M. E., & Lloyd, K. E. (1977). An experimental analysis of electricity conservation procedures	Energy use	Feedback Information Prompting
Hake, D. F., & Foxx, R. M. (1978). Promoting gasoline conservation: The effects of reinforcement schedule, a leader, and self-recording	Transportation	Incentive/ reward Self-monitoring
Bittle, R. G., Valesano, R., & Thaler, G. (1979). The effects of daily cost feedback on residential electricity consumption	Energy use	Feedback

(continued)

Table 11.2 (continued)

Citation	Target behavior	Intervention[a]
Winett, R. A., Neale, M. S., & Grier, H. C. (1979). Effects of self-monitoring and feedback on residential electricity consumption	Energy use	Feedback Self-monitoring
Agras, W. S., Jacob, R. G., & Lebedeck, M. (1980). The California drought: A quasi-experimental analysis of social policy	Resource use	Information Penalties/fines Prompting
Bacon-Prue, A., Blount, R., Pickering, D., & Drabman, R. (1980). An evaluation of three litter control procedures—trash receptacles, paid workers, and the marked item technique	Litter	Incentive/reward Response effort
Luyben, P. D. (1980). Effects of informational prompts on energy conservation in college classrooms	Energy use	Prompting
O'Neill, G. W., Blanck, L. S., & Joyner, M. A. (1980). The use of stimulus control over littering in a natural setting	Litter	Stimulus control
Foxx, R. M., & Schaeffer, M. H. (1981). A company-based lottery to reduce the personal driving of employees	Transportation	Feedback Incentive/reward
Hake, D. F., & Zane, T. (1981). A community-based gasoline conservation project: Practical and methodological considerations	Transportation	Incentive/reward
Hayes, S. C., & Cone, J. D. (1981). Reduction of residential consumption of electricity through simple monthly feedback	Energy use	Feedback
Slavin, R. E., Wodarski, J. S., & Blackburn, B. L. (1981). A group contingency for electricity conservation in master-metered apartments	Energy use	Feedback Incentive/reward
Van Houten, R., Nau, P. A., & Merrigan, M. (1981). Reducing elevator energy use: A comparison of posted feedback and reduced elevator convenience	Energy use	Feedback Response effort
Jacobs, H. E., Fairbanks, D., Poche, C. E., & Bailey, J. S. (1982). Multiple incentives in encouraging car pool formation on a university campus	Transportation	Incentive/reward
Winett, R. A., et al. (1982). The effects of videotape modeling and daily feedback on residential electricity conservation, home temperature and humidity, perceived comfort, and clothing worn: Winter and summer	Energy use	Feedback Information Modeling
Jacobs, H. E., Bailey, J. S., & Crews, J. I. (1984). Development and analysis of a community-based resource recovery program	Waste/recycling	Prompting Response effort
Winett, R. A., Leckliter, I. N., Chinn, D. E., Stahl, B., & Love, S. Q. (1985). Effects of television modeling on residential energy conservation	Energy use	Information Modeling
Keller J. J. (1991). The recycling solution: How I increased recycling on Dilworth road	Waste/recycling	Feedback Incentive/reward
Austin, J., Hatfield, D. B., Grindle, A. C., & Bailey, J. S. (1993). Increasing recycling in office environments: The effects of specific, informative cues	Waste/recycling	Prompting

(continued)

Table 11.2 (continued)

Citation	Target behavior	Intervention[a]
Brothers, K. J., Krantz, P. J., & McClannahan, L. E. (1994). Office paper recycling: A function of container proximity	Waste/recycling	Response effort
Ludwig, T. D., Gray, T. W., & Rowell, A. (1998). Increasing recycling in academic buildings: A systematic replication	Waste/recycling	Response effort
Staats, H., van Leeuwen, E., & Wit, A. (2000). A longitudinal study of informational interventions to save energy in an office building	Energy use	Feedback Prompting
Schroeder, S. T., Hovell, M. F., Kolody, B., & Elder, J. P. (2004). Use of newsletters to promote environmental political action: An experimental analysis	Other practices	Information Modeling
Manuel, J. C., Sunseri, M. A., Olson, R., & Scolari, M. (2007). A diagnostic approach to increase reusable dinnerware selection in a cafeteria	Other practices	Information Prompting Response effort
Bekker, M. J., Cumming, T. D., Osborne, N. K. P., Bruining, A. M., McClean, J. I., & Leland, Jr., L. S. (2010). Encouraging electricity savings in a university residential hall through a combination of feedback, visual prompts, and incentives	Energy use	Feedback Incentive/ reward Prompting
O'Connor, R. T., Lerman, D. C., Fritz, J. N., & Hodde, H. B. (2010). Effects of number and location of bins on plastic recycling at a university	Waste/recycling	Response effort Stimulus control
Hirst, J. M., Miller, J. R., Kaplan, B. A., & Reed, D. D. (2013). Watts up? Pro AC power meter for automated energy recording: A product review	Energy use	Product review
Reed, D. D., Partington, S. W., Kaplan, B. A., Roma, P. G., & Hursh, S. R. (2013). Behavioral economic analysis of demand for fuel in North America	Other practices	Behavioral economic
Frazer, P., & Leslie, J. (2014). Feedback and goal-setting interventions to reduce electricity use in the real world	Energy use	Feedback Goal setting
Camargo, J., & Haydu, V. B. (2016). Fostering the sustainable use of common-pool resources through behavioral interventions: An experimental approach	Resource conservation	Feedback Information
Miller, N. D., Meindl, J. N., & Caradine, M. (2016). The effects of bin proximity and visual prompts on recycling in a university building	Waste/recycling	Prompting Response effort
Pandey, N., Diller, J. W., & Miller, L. S. (2016). E-mailed prompts and feedback messages to reduce energy consumption: Testing mechanisms for behavior change by employees at a green university	Energy use	Feedback Prompting
Clayton, M., & Nesnidol, S. 2017). Reducing electricity use on campus: The use of prompts, feedback, and goal setting to decrease excessive classroom lighting	Energy use	Feedback Goal setting Prompting
Desrochers, M. N., & Mosher, H. (2017). Evaluation of an informational and behavior change program to increase students' self-reported energy conservation	Energy use	Feedback Goal setting Information

(continued)

Table 11.2 (continued)

Citation	Target behavior	Intervention[a]
Fritz, J. N., Dupuis, D. L., Wu, W. L., Neal, A. E., Rettig, L. A., & Lastrapes, R. E. (2017). Evaluating increased effort for item disposal to improve recycling at a university	Waste/recycling	Prompting Response effort
Jadro, B. V. (2017). The use of an onboard diagnostic device to provide feedback on driving behaviors related to fuel economy	Transportation	Feedback Goal setting
Schultz, N. R., Kohn, C. S., & Musto, A. (2017). Examination of a multi-element intervention on college students' electricity consumption in on-campus housing	Energy use	Feedback Incentive/ reward Prompting
Venditti, G. A., & Wine, B. (2017). Effects of decreased response effort and task clarification on proper tire pressure	Transportation	Response effort
Kaplan, B. A., Gelino, B. W., & Reed, D. D. (2018). A behavioral economic approach to green consumerism: Demand for reusable shopping bags	Other practices	Behavioral economic
Szczucinski, D., Gelino, B. W., Cintron, C. J., Becirevic, A., & Reed, D. D. (2019). Increasing appropriate composting in high-traffic university settings	Waste/recycling	Information Prompting Response effort Stimulus control

[a]Primary intervention presented coding difficulties in that, often, treatments were broadly classifiable according to multiple categories (e.g., stimulus control vs. prompting). We attempted to simplify the coding process by using direct wording of authors wherever possible

Waste Disposal

The choices we make with respect to how we handle our waste will have lasting impacts. We flagged 11 articles from among the greater body of literature as focusing on sustainable waste management, all of which evaluated the ability of simple *nudges* (see Thaler & Sunstein, 2008) toward more active consumer recycling. Interventions targeting a wide range of demographics were conducted in office settings (e.g., Austin, Hatfield, Grindle, & Bailey, 1993; Brothers, Krantz, & McClannahan, 1994), neighborhoods (e.g., Jacobs, Bailey, & Crews, 1984; Keller, 1991), university buildings (e.g., Ludwig, Gray, & Rowell, 1998; Miller, Meindl, & Caradine, 2016; O'Connor, Lerman, Fritz, & Hodde, 2010), university dorm halls (e.g., Witmer & Geller, 1976), and storefronts (e.g., Geller, Farris, & Post, 1973).

Of the methods employed, none required any notable cost for continued upkeep. For instance, four articles evaluated the effects of recycle bin relocation, thereby assessing the role of effort to disposal and proximity to other waste receptacles in promoting adherence to responsible waste management. Six articles used prompts or informational signage to encourage more frequent and compliant recycling by study participants, and only two studies involved the delivery of direct monetary compensation. Witmer and Geller (1976) used flyers and small, inexpensive raffle and competition rewards to promote recycling on a college campus. Similarly,

Keller (1991) offered the purchase and delivery of a grocery store gift card of modest value to a local homeless shelter if two local neighborhoods were able to meet recycling goals. All studies thereby demonstrated sustained, marked increases in recycling via simple and cost-effective procedures.

Energy

The curbing of energy use has been thus far the most fruitful area of sustainability-focused research in behavior analytic experimentation. We identified 21 articles as having a focus on eco-friendly energy practices, all of which were working toward a meaningful reduction of electricity or fuel-oil consumption. Studies proposing potential interventions evaluated efficacy in university residence halls (e.g., Bekker et al., 2010), residential locations (e.g., Kohlenberg, Phillips, & Proctor, 1976), office settings or university administrative buildings (e.g., Staats, van Leeuwen, & Wit, 2000), and classrooms (e.g., Clayton & Nesnidol, 2017); one additional study assessed an intervention to reduce cumulative everyday energy use (i.e., pledges to keep certain devices powered off more frequently; Desrochers & Mosher, 2017). The majority of these works were published prior to the year 2000, with only nine original studies published in the last 20 years having a focus in energy-use reduction.

Research in this area embodies a wide range of behavior analytic methods and principles. Seaver and Patterson (1976) achieved modest reductions in household heating oil consumption by mailing feedback slips containing information on past and present fuel consumption and the difference in monetary terms to customers following oil deliveries. Reductions in oil use resulting from feedback delivery averaged 31 gallons per household, with some participants saving over 50 gallons—a figure indicative of substantial savings if generalized to the greater community. Similarly, Kohlenberg and colleagues (1976) used feedback and incentives to reduce household electricity use during times of peak energy demand. Participants' living spaces were fashioned with a lightbulb that would shine to signal periods of electricity consumption exceeding 90% of the preceding 2 weeks' average. Paired with a rebate scaled to the degree of electricity use reduction achieved, feedback delivery consistently curbed energy use during times of peak consumption. More recently, work in this area has shifted toward examination of modern assets as change agents for sustainable behavior. Pandey, Diller, and Miller (2016) used e-mail as a medium for prompts and feedback to reduce electricity consumption by occupants of administrative buildings on a college campus.

From this bulk of energy-concerned works, several studies demonstrate relatively unique applications of behavior analytic technologies. Van Houten, Nau, and Merrigan (1981) examined the use of feedback—the amount of energy used in the preceding week—and modulated response effort in the form of delayed door opening to discourage wasteful elevator rides. Door opening times ranging from 16 to

34 s resulted in significantly fewer elevator trips and a subsequent savings of 32.9 kWh/day in the target setting. Such extensions of the literature that produce easily implemented procedures are instrumental to curbing energy use on a global scale, particularly if human reliance upon nonrenewable and pollutive sources of energy is to continue.

Resource Conservation

Whether through overuse or pollution, human activity poses a threat to natural resources. In the area of resource conservation, the literature review revealed ten investigations self-labeled as having interest in ecological responsibility. Among these, two—Agras et al. (1980) and Camargo and Haydu (2016) —were focused on reducing irresponsible resource consumption via simple prompts and variations on information delivery. For example, the latter of these employed a virtual fishery game in which respondents could catch fish to be exchanged for real-world money. Periodically, players were prompted with messages concerning the rate of fish reproduction and the dwindling resources remaining; those that received informational messages demonstrated more sustainable practice (Camargo & Haydu, 2016).

The remaining works in this category attempted to address refuse litter via a mix of behavior analytic methods. These studies primarily worked to incentivize the *cleaning* of already-deposited litter, often capitalizing upon inexpensive incentive delivery systems to generate the greatest rate of cooperation. For instance, Hayes, Johnson, and Cone (1975) used a probability-based payout system (e.g., *marked item*) to incentivize litter collection. Practices such as these can be readily administered on a large scale to generate meaningful improvements to ecosystems for which habitability is threatened by human influence.

Education & Other Sustainable Living Decisions

Sustainable decision making faced by the everyday consumer inevitably extends well beyond the easily categorized behavior thus far discussed. The pervasive nature of ecological responsibility is one that demands a more informed populace—one that can recognize the potential detriments of poor choice and skeptically evaluate the benefits of supposed eco-friendly practices (or misinformation campaigns). In politics especially, a voting body more aware of the probable outcomes of various propositions can establish momentum for a comprehensive environmental protection plan. The full scope of the applications of effective education on environmental responsibility is far too broad for effective summary, but here we take this as an umbrella category for the less obvious, day-to-day decisions that separate the average consumer from the everyday sustainability warrior.

Of the literature reviewed, we recognized three studies as having some emphasis on the promotion of sustainable decision making in everyday contexts. Flagged works focused primarily on generating more interest in reusable products—cafeteria dinnerware (Manuel et al., 2007) and shopping bags (Kaplan, Gelino, & Reed, 2018) —to prevent excessive waste. Alternatively, Schroeder, Hovell, Kolody, and Elder (2004) examined the use of newsletter prompts to increase environmentally driven political action by business leaders for whom the local natural environment was essential for business operation. Six weeks of newsletter delivery containing models for political outreach resulted in a significant proportion of sampled individuals contacting political or organizational leaders (46% of the experimental group). Extension of these techniques could have far-reaching implications should they continue to show efficacy in generating pro-environmental political action.

The View from the Bottom: Recapitulation, Reevaluation, and Redirection

In considering the literature highlighted in this review, there are notable trends present. For instance, as has been indicated, these procedures mostly embody low-cost, low-effort approaches to generating behavior change. Much like the *nudges* discussed by Thaler and Sunstein (2008; see also Simon & Tagliabue, 2018; Tagliabue & Sandaker, 2019), the interventions discussed here are socially valid—a foremost priority of applied behavior analysis—and easily maintained environmental modulations. Such is a critical basis from which to develop a global package for sustainable living, particularly when considering the general societal preference for pull motivation, or encouraged compliance that does not feel forced (as opposed to the more easily recognized push motivation; e.g., bans, fines).

To produce meaningful change without resorting to aversive tactics—as, again, embodied by the *nudge*—is to seamlessly integrate sustainable and renewable practices into the lives of those who might otherwise fight to preserve their familiar comforts. However, greater attention is needed in a number of areas to fully address change in favor of a more conducive environment for sustainable living. We shift now toward discussion of viable next steps for producing greater contribution to global sustainability.

Systems Level Analysis

Although there are clearly behavior analytic interventions that have shown to be effective at increasing sustainable practices at the individual level, these interventions alone will not be enough to affect climate change and other anthropogenically influenced environmental detriments (e.g., species extinction) in a meaningful way.

Thus, behavior analysts need to be thinking about broad-scale changes including targeting behavior of corporations and yielding change at the cultural level. Encouragingly, there is a growing literature in behavior analysis on cultural phenomena (e.g., see Seniuk, Cihon, Benson, & Luke, 2019). Although a full discussion of these concepts is beyond the scope of this chapter, we highlight two concepts that could be beneficial for impacting sustainable practices in cultural systems.

Macrocontingencies Macrocontingencies are "operant behavior governed by individual contingencies [resulting in] … a cumulative effect of social significance" (Glenn et al., 2016, p. 19). In other words, the cumulative effect of many people's behaviors can have a positive (or negative) effect on socially significant outcomes. For instance, if "50% of the world's population restrict their diet to a healthy 2500 calories per day and reduce meat consumption overall [it is estimated that] at least 26.7 gigatons of emissions could be avoided from dietary change alone" (with those emissions being the product of permanent behavior change and an accumulation over 30 years from 2020 to 2050[1]; Project Drawdown: Solutions, 2019). Thus, if many people ate fewer calories and less meat, the cumulative effect could result in a significant decrease in carbon emission. One means for this type of change is by taking evidence-based units shown to be effective for changing individual contingencies, known as evidence-based kernels (e.g., Embry & Biglan, 2008; Luke & Alavosius, 2012), and disseminating them to a larger population. This might be done, for instance, by requiring that federal policies mandate school cafeteria environmental arrangements or visual feedback to students (i.e., evidence-base kernels) that promote plant-based food choices during lunch.

Metacontingencies The metacontingency describes a "contingent relation between (1) recurring interlocking behavioral contingencies having an aggregate product and (2) selecting environmental events and conditions" (Glenn et al., 2016, p. 13). This concept highlights situations wherein behavior of one or more individuals is interdependent on—and thus, directly connected to—another individual's behavior in order to create a product or intended effect, which is then selected by the actions of an external environment.

As it relates to sustainability, the overfishing of sharks—a direct outcome of shark finning—may serve as an example. In order to create the aggregate product (i.e., shark fins), there are recurring interlocking behavioral contingencies operating on, for example, individuals employed in the shark fishing industry. Each employee, with their varying roles and responsibilities, plays an integral role in providing the given product, which is then purchased by consumers in the external environment (i.e., a cultural consequence). Thus, in order to impact such a metacontingency, the behavior of policymakers and other regulatory bodies may be of keen interest as a target. To have a more widespread effect on the use of sustainable fishing practices,

[1] For reference, the United States was responsible for the release of approximately 6.5 gigatons of CO_2 in 2017 (EPA, 2019).

such an intervention should not focus on the fishers or a singular fishing company; rather, it should focus on the antecedents and consequences for the policymakers and regulatory bodies who could write the policies and regulations that are needed for effective behavior change at the systems level.

With these considerations in mind, those who want to target sustainable practices should consider who is best to target in the system (e.g., policy makers) and the contingencies in place for those people (e.g., elections, funding, regulations) that will promote or hinder sustainable practices or kernels. Large conglomerate organizations are among the greatest threats to global sustainability—changing the patterns and demands of their consumers may well be the most viable option for forcing adaptive outcomes (e.g., the servicing of power grid infrastructure to support widespread "green" energy use; greater availability of meat-alternative or vegan-friendly food choices). This approach does present barriers. Namely, it is more difficult to impact the environment of the people who can make the biggest change in the system. However, other chapters in this book, including Chaps. 8, 16, and 17, provide additional guidance for that work.

Targeted Behavior Change

Further, our efforts should be guided by those more versed in the environmental impacts of behavior. Referring to our historical analysis, empirical work has in large part followed the general buzz of sustainability discussion. Behavioral researchers should accept a leading limitation in our foray into environmental studies—we typically have no training in environmental studies. "Recycling" has long been a hot topic of environmentally conscientious observers, yet the extent to which an improved recycling cooperative is likely to yield a meaningful difference in carbon emissions is all but unknown to the prototypical behavior analyst. Of perhaps greater concern—are recycling efforts yielding *any* meaningful change? Might we be better off allocating our efforts toward, say, promotion of more efficient driving practices? Moreover, are there sufficient systems in place to ensure efforts are met with comparable outcomes? If 90% of Americans took the time to sort their plastics from their papers, this might be wasted effort if only a small fraction of those materials avoids a landfill. An ever-resolute focus on everyday behavior is the cog upon which all other research in the system depends, but our literature review suggests efforts by behavioral scientists might be more impactful if informed by the extant literature of other physical and social sciences.

We must now rely upon those who have laid the groundwork and allow the efforts of others to inform and guide our own unique expertise. As behavior analysts continue considering novel approaches to promoting sustainability, we implore them to give time toward prioritization of sustainable development. Many such hierarchies of sustainable development—lists outlining the most impactful habits with respect to carbon footprint—are available for use when planning interventions. As a starting point, we offer reference to the work of Hawken and colleagues in their 2017 novel

Drawdown. Together with a body of environmental scientists, Hawken outlines a plan for curbing carbon emissions and increasing sustainable development on a community scale. Often unconsidered infrastructural deficits, for instance inefficient tactics for refrigerant (e.g., chlorofluorocarbons, or CFCs) disposal, receive their due spotlight for a continuing role in planetary system change. Let us collectively stick with what we know best and consult with others when solutions move beyond our plane of expertise.

Along these lines, behavior analysts should be making efforts to delve into interdisciplinary, collaborative efforts. We need to now leverage partnerships with others to produce more meaningful, more impactful studies that cut to the core of a targeted issue. This may require reinterpretation of research methods: alternative designs are suited for alternative circumstances (e.g., Biglan, Ary, & Wagenaar, 2000; see also Flay et al., 2005). Combining the expertise of those grounded in public policy, Earth sciences, renewable energies, ecology, conservation sciences, or a similar domain with the principles and concepts of behavioral science is likely to yield far more impactful research than what has been observed to date.

Necessarily interwoven with improved selection criteria and a fruitful systems analysis, behavioral empiricists should consider the efforts required by everyday individuals to produce lasting change. Maintenance of intervention effects is a leading concern, but what we propose here focuses greater attention on the role of the previously discussed "nudge." Behaviors of interest—within the domains highlighted by groups like Hawken and colleagues—should be those that require the *least* effort from the organisms upon which change is hinged. For example, a common target for sustainable development is energy consumption by the everyday household—how might we curb unsatisfactory electricity use? Historically, efforts have pursued reduced energy habits as a means of reducing carbon footprints. Yet with systems adapting to support the gradually increasing demand for renewable energies, efforts might instead promote transfer from nonrenewables to clean, albeit potentially more expensive sources of energy. Such a change would be a summative low-effort response by the household, one which would require little ongoing effort to maintain, but would decrease said household's carbon footprint.

Of course, not all behaviors are well-suited for such a frame. Water consumption, for instance, is a domain that requires immediate intervention without room for shortcut; selecting a detergent-free dishwashing soap—a choice that could lead to significantly lower effort public water treatment—might serve as a viable target for intervention. Too, infrastructure must catch up to social development before many at-present complexities can be resolved with straightforward methods. Purchase of zero-emission electric vehicles is practical primarily for those who commute short distances—a limitation of battery capacity—and for those with access to a readily available charging source within range of their typical vehicle stationing location. (We also note that battery assembly presents its own complication given the dependence on externally sourced precious metals.) Ultimately, understanding and promoting practices such as these could serve as a vital step toward systems level development, in that greater societal demand often yields more progressive effort

(see Lin, Tan, & Geng, 2013; see also Cohen, Lobel, & Perakis, 2015; Coombs, Green, Richards, & Walsh, 2001).

Conclusions

Behavior analysis has—at present—a respectable body of literature documenting the efficacy of long-standing principles to bring about more sustainable living. These interventions span a relatively wide berth of targetable behaviors, not limited to energy conservation, waste handling, and resource conservation. As a next step, future research might seek to address areas of sustainability that have thus far remained understudied. Dietary change and political action are critical behaviors to understand but are largely absent from behavior analytic sustainability literature, and thus may embody meaningful targets for future work (the former having an already robust body of research in other areas of ABA; see Rafacz, 2019; see also Bachmeyer, 2009).

Additionally, research should continue to evaluate the ability of novel behavioral procedures—those that have not yet been applied to behaviors of environmental relevance *or* applied on a community scale—to bring about meaningful change (e.g., establishing more eco-friendly driving practices via implementation of procedures described by works like Van Houten, Nau, & Marini, 1980 and Van Houten & Nau, 1983). Further, new work should be ever focused on the "bigger picture:" that research must be capable of informing policy, or should itself be an evaluation of potential policy-driven effects. Our most important work may well be that which yields results directly scalable for policy use or community intervention. Such a shift in research focus may necessarily involve, in some cases, sacrificing hallmark features of behavior analytic intervention. Direct observation of behavior becomes far more difficult when studies are scaled to community levels, and so behavior analysts must be making use of the various methodological tools at their disposal (e.g., interrupted time-series experiments; Biglan et al., 2000). Behavioral economic measures, particularly those suited for use in traditionally difficult-to-measure circumstances (e.g., hypothetical purchase task; see Roma, Reed, DiGennaro Reed, & Hursh, 2017) may also be looked to as means of exploring possible policy effects.

More broadly, future research should also seek to address the limitations of the current literature review. The suggestions offered here embody only those informed by works published by behavior analytic journals, but this by no means encompasses all behavior analytic scholarship (i.e., that published outside flagship journals; e.g., DeLeon & Fuqua, 1995; Geller, Erickson, & Buttram, 1983). Truer still, the methods of generating said literature can certainly be improved upon; alternate keywords and a more expansive database list would likely yield a greater body of work. The list presented here is thus a demonstration—a representation of the field as members of other sciences are likely to observe. Readers might also turn to existing quantitative analyses of the literature, such as that presented by Osbaldiston and Schott (2012).

To revisit the concerns expressed by Skinner (1987), the field indeed seems to have *begun* to meet the call to action, but much work remains. Behavior analysis embodies the practices and rigor required to produce truly impactful methods for promoting sustainable change on a global scale, but the broad translation and assessment of these methods with behaviors of environmental concern is a necessary first step. To this end, behavior analysis has only begun to generate a meaningful body of literature, and so the task falls to the newest generation of behavior analysts. As the climate continues to warm and planetary systems change, the need for behavior change will grow ever more dire. Solutions must be capable of addressing issues on two fronts: climatic change will force adaptation, while mitigation efforts proceed in preventing a fall to ruin. Rising to the call and meeting the challenges ahead is the only approach we can take should we hope to avert catastrophic outcome. As a species we may have entered the Anthropocene, but the dice have not yet been cast. With equal contribution from all sciences—physical and social—we can yet rewrite expectations for the generations to come.

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