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Going Green: A Systematic Review of Proenvironmental Empirical Research in Behavior Analysis

Brett W. Gelino[1] · Tyler G. Erath[1] · Derek D. Reed[1]

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Abstract

The world is now believed to be operating in a no-analogue state, exceeding the norms of any point in documented history. Substantial disturbance of our natural environmental systems threatens life on Earth. Innovation and change are critical. Social science has historically played a vital role in amassing a body of knowledge implicating potential avenues for change. As a field, behavior analysis must keep pace with this ongoing sustainability agenda. The goal of the present review is to provide a summary of empirical works published by behavior analytic outlets to date focused on target variables of interest regarding environmental sustainability. We examined 50 experiments in their historical context and with respect to various methodological qualities. Results reveal a renewed interest in this area by behavior analysis within the most recent 5 years. We then address gaps in the literature and the means by which new efforts might be maximally contributive toward the advancement of global sustainability.

Keywords Behavior analysis · Sustainability · Climate change · Systematic literature review

Scientists have long foreseen the possible dangers of the reckless treatment of our natural environment (Zalasiewicz, Williams, Steffen, & Crutzen, 2010). Many believe we have crossed a threshold into the Anthropocene, a period of geologic history dictated by human activity (Crutzen, 2002; Crutzen & Stoermer, 2000; Steffen, Crutzen, & McNeill, 2007; see also Crutzen & Steffen, 2003; cf. Malm & Hornborg, 2014). Our species has reached a pivotal point of inaction: Even with immediate intervention on a global scale, life on Earth will be forced to adapt or perish in the

✉ Brett W. Gelino
gelinob@gmail.com

[1] Department of Applied Behavioral Science, University of Kansas, 4036 Dole Human Development Center, 1000 Sunnyside Ave, Lawrence, KS 66045-7555, USA

face of heavily perturbed planetary systems and an anthropogenically modulated climate (Thompson, 2010; see also Rockström et al., 2009a, 2009b). Water resources are dwindling, landscapes are scarred and abused, and we face one of the greatest mass-extinction events in planetary history (a biological annihilation; Ceballos, Ehrlich, & Dirzo, 2017). Although no single human behavior can be isolated as the cause of such a complex and cascading outcome, many behaviors can be faulted with either contributing to greenhouse gas emission, altering systems by which greenhouse gases are controlled (i.e., deforestation), or polluting and abusing existing systems, all thereby exacerbating the extant environmental degradation. Long-standing practices have collectively disturbed our environment, but not to a point of total catastrophe.

Social science has—at some length—met the call for action as it comes to sustainability research. There exists a body of cross-disciplinary literature examining the factors that predict environmental or ecological concern (e.g., Leiserowitz, 2006; Lorenzoni, Nicholson-Cole, & Whitmarsh, 2007; Semenza et al., 2008; Spence, Poortinga, & Pidgeon, 2011; see also Koger & Winter, 2011; Lorenzoni & Pidgeon, 2006). Many have examined cultural predictors such as religion (e.g., Wardekker, Petersen, & van der Sluijs, 2009), political affiliation (e.g., McCright & Dunlap, 2016), or aspects of the immediate environment that facilitate compliance with recommended best practice for environmentally conservative living. In this regard, science has compiled a fairly robust profile for the everyday stakeholder concerned with human–environment relations. But we need to turn our attention now toward the proportion of the population not yet invested in behavior change—those on the cusp of change or, perhaps more importantly, those who outright deny the need to adapt (whether that be one person or an entire conglomerate).

In synthesis with this growing need for pertinent research, sustainability researchers also need to prioritize the options highlighted by current leading environmental science research agendas (i.e., Intergovernmental Panel on Climate Change [IPCC]; see IPCC, 1992, 1995, 2001, 2007, 2014). Environmental solutions should take two forms: mitigation of ongoing contributors, in which efforts are aimed toward reducing harmful environmental practices and curbing further climatic change, and adaptation to ongoing effects, in which efforts are funneled into programs that seek to understand life on an Earth plagued by chaotic change. This latter area will likely include—broadly—concerns of environmental justice not limited to water insecurity, air and water pollution, soil erosion and food scarcity, waste management, forced relocation and refugeeism of at-risk populations (e.g., coastal communities), and increased frequency and severity of extreme weather events (see Schlosberg, 2004). These are targets that inevitably must draw focus, but in light of recent shifts in global–political agreements toward addressing the possibility of catastrophic outcome (e.g., Paris Agreement to the United Nations Framework Convention on Climate Change, 2015; see also the Green New Deal; H.R. 109, 2019), the bulk of work by the social sciences may be better directed toward understanding mitigation efforts, or the outright halting and reversal of change contributors.

To achieve what seems a lofty outcome, work must move beyond the attitudes best aligned with ecological responsibility. Investigation needs to begin to probe the means by which we can produce tangible changes in choice and living. A rigorously empirical body of knowledge needs to be assembled and transferred to the hands of those who can enact widespread change (e.g., policy makers). Behavior analysis and its

underlying principles, methods, and concepts provide a cutting-edge approach to evaluating such broad interventions aimed at reducing wasteful living or promoting sustainable practice (see Cone & Hayes, 1980). Historic analysis of field contributions indeed confirms the applicability of the science: Fifty years of sustainability research has been amassed by behavior analytic researchers, adjusting single-subject intervention for rollout at the community scale.

More recent experimental efforts have not been published with the same consistency as was seen in early behavior analytic ecology work; only in the past decade has work in sustainable living reflected the vested interest of early applied researchers. Given this unique applicability of a science of behavior to advancing the *behavioral* efforts of a sustainable movement, our field would be remiss to fall behind. This recent trend must continue. We turn now toward efforts to provide a sweeping overview of behavior analytic contributions to global sustainability—those published in primarily behavior analytic outlets and that present empirical results—to examine trends and directions in existing lines of research in the area of ecological interest. We aim to highlight historic practices with regard to intervention type and focus. Finally, we offer some guiding points for the future of behavior analytic work in environmental justice, resource preservation, sustainable living, and global climate change mitigation.

Method

We conducted a systematic search of behavior analytic publications focused on sustainability following the preferred reporting items for systematic reviews and meta-analyses (PRISMA) approach. Search queries, raw and cleaned generated output, and greater information pertaining to this search are documented by Gelino, Erath, and Reed (2020).

Sustainability Definition

Before an effective examination of behavior analytic contributions could be conducted, we strove to establish a standing definition for the term "sustainable" behavior—one to which all instances of research could be compared. In their reflection on policy-directed academy, Marshall and Toffel (2005) offered a hierarchy with respect to the implications of sustainable practice, including in their definition any behavior directly threatening planetary sustainability. Behaviors of interest for the current review, therefore, are those that transgenerationally threaten human livelihood, reduce life expectancy or cause other health detriments, cause the extinction of species or violate human rights, or otherwise reduce quality of life (Marshall & Toffel, 2005, p. 675).[1]

Literature Search Methods

From this definition, we sought to refine our search to target behaviors within the purview of behavior analytic study. Our initial brainstorm yielded key operant classes

[1] Interested readers might refer to the 1987 report of the World Commission on Environment and Development (known also as the "Brundtland Report" or *Our Common Future*) for a more detailed origin and overview of long-standing definitions for sustainable development.

of interest—transportation, diet management, education, political activism, waste management, conservation efforts, consumerism, and energy use. An initial cast of search terms included many broad keywords or phrases intended to capture interventions that *could* relate to sustainability in some fashion (i.e., those articles that pertain to an identified operant class of relevance without a direct intention to impact sustainable footprints; e.g., "transport," "commute," "diet," "education"). We found this approach to be too inclusive and ineffective. Although we desired to capture all efforts from the field that might serve to advance the sustainability agenda, the decision to further reduce our search efforts to exclude unintentional or loosely related research was deemed necessary to retain accessibility while simultaneously promoting the initial project intention.

We thusly conducted a more restrictive literature review, targeting specifically articles that express some *intentional* relevance to issues of environmental concern. We designated search terms by comparing commonly employed phrases in Earth science literature with key terms from the initially flagged batch of self-identified sustainability articles and reemploying those that co-occurred most often; other keywords were included based on their relevance to the sustainability conversation (e.g., "Anthropocene," "ecology"), thought likely to flag articles not targeted by one of our starting operant classes. Table 1 contains a full list of key search terms.

We conducted electronic searches using three scholarly databases—PubMed, Web of Science, and Google Scholar. Literature published through May 2020 was considered. We additionally limited our search to journals traditionally viewed as behavior analytic in nature so as to ensure our coverage best describes the field's advancement of the sustainability agenda (see Table 2 for a full list of searched outlets). An exemplar employed Boolean operator can be found in the Appendix.

Article Inclusion

The first author reviewed title and abstract records for the flagged articles to determine relevance; this process was partially duplicated by the second author to ensure objective

Table 1 Search terms used to generate the initial body of literature

Search terms (n = 16)	
waste	consumption
litter	resource
recycl*	climate
energy	global
conserv*	ecology
sustainab*	oil
water*	fuel
electric*	anthropocene

Note. Search terms were derived from relevant sustainability and environmentally concerned reports. They were subsequently cross-checked using key terms aggregated across initially collected literature. No further additions were deemed necessary. Asterisks designate a placeholder or "wildcard" allowance: Any text string may follow.

Table 2 Peer-reviewed behavior analytic journals examined

Journal title	Year of inception	# of articles (n)
Journal of Applied Behavior Analysis	1968	36
Behavior Modification	1977	3
Journal of Organizational Behavior Management	1977	2
Behavior and Social Issues	1978	5
Perspectives on Behavior Science	1978	0
Behavioral Interventions	1986	2
Behavior Analysis in Practice	2008	2
Behavior Analysis: Research and Practice	2015	0

Note. These scholarly outlets were examined for contributions to the sustainability agenda. Figures indicate the quantity of sustainability-relevant articles published by each outlet.

and reliable article inclusion. To be included, works must have as a focus a behavior that meets the aforementioned definition for sustainability *and* must acknowledge a direct contribution to the sustainability agenda. Given the purpose of the current review, we chose to focus on only full-text published articles that presented experimentally derived results. Because the inclusion of theoretical work or non-peer-reviewed writing was thought likely to stray from our emphasis on procedures and understanding of treatment effects, we decidedly did not include such efforts in our review.

Article Coding

To affirm confidence in the selection of search terms post hoc, we coded keywords from all empirical articles that met the inclusionary criteria and arranged them according to frequency (see Table 3). Of the top 10 keywords, 5 matched or demonstrated congruence with our employed search terms. This process also provided some

Table 3 Most commonly occurring keywords present in collected literature

Article keyword	n
energy*	13
feedback	12
sustainability	11
environment*	9
consum*	8
behavior analysis	7
communit*	7
cultural*	7
electric*	7
recycl*	7

Note. Asterisks designate a placeholder or "wildcard" allowance: Any text string may follow.

supplemental information regarding the categorization of methods exhibited by study authors (e.g., self-reported keyword of "feedback").

The first and second author coded literature meeting the inclusionary criteria according to relevant reported demographic features (e.g., type of sample, size of sample, location/method of recruitment) and methodological features, including target behavior, type of intervention, and location of intervention. When possible, we coded articles according to self-designated study keywords. We additionally categorized articles according to roughly defined dimensions of sustainable living, discussed in greater detail in the following sections.

Reliability

We collected interrater reliability for the inclusion and coding of 38% of articles and calculated agreement on an article-by-article basis. An agreement was scored when there was an exact match between the first and second authors as to whether the article did or did not meet the inclusionary criteria (e.g., intervention focus, target behavior) described previously. A disagreement was scored when there was not an exact match between the two scorers regarding the inclusion of a study based on the criteria. Percentage agreement was calculated by dividing the number of agreements by the number of agreements plus disagreements and converting this number to a percentage. Interrater reliability was 100%.

Results

Fifty articles met the inclusionary criteria and are summarized in what follows. The initial application of search terms flagged 1,465 works, of which 85 (5.8%) were retained for further evaluation. Exclusions were made when articles were not full text or peer reviewed or did not meet our definition of sustainability. Upon further evaluation, an additional 35 studies were excluded based on a lack of empirically derived findings. Figure 1 depicts a PRISMA flowchart outlining this decision making.

Our summary will first examine the trends present in the general distribution and publication patterns. We then focus on the independent variables—the methods of interest—that were utilized in the works as they pertain to sustainability. We approximate categories here using rough similarities between intervention topography. For instance, efforts that employed incentive delivery at any capacity (e.g., lottery systems vs. guaranteed payout) are grouped as a single category. We hope that by exploring behavior in this fashion, we can shine a light on areas to which a great deal of research focus has already been allocated and, by proxy, begin to draw attention toward underresearched foci. Representative articles employing each discussed "principle" will be summarized and used as exemplars for further research efforts.

General Trends

Figure 2 depicts cumulative publication across the previous 50 years, beginning in 1968 with the inception of the *Journal of Applied Behavior Analysis* (JABA). Examining these data in this way reveals an interesting trend regarding efforts to advance the

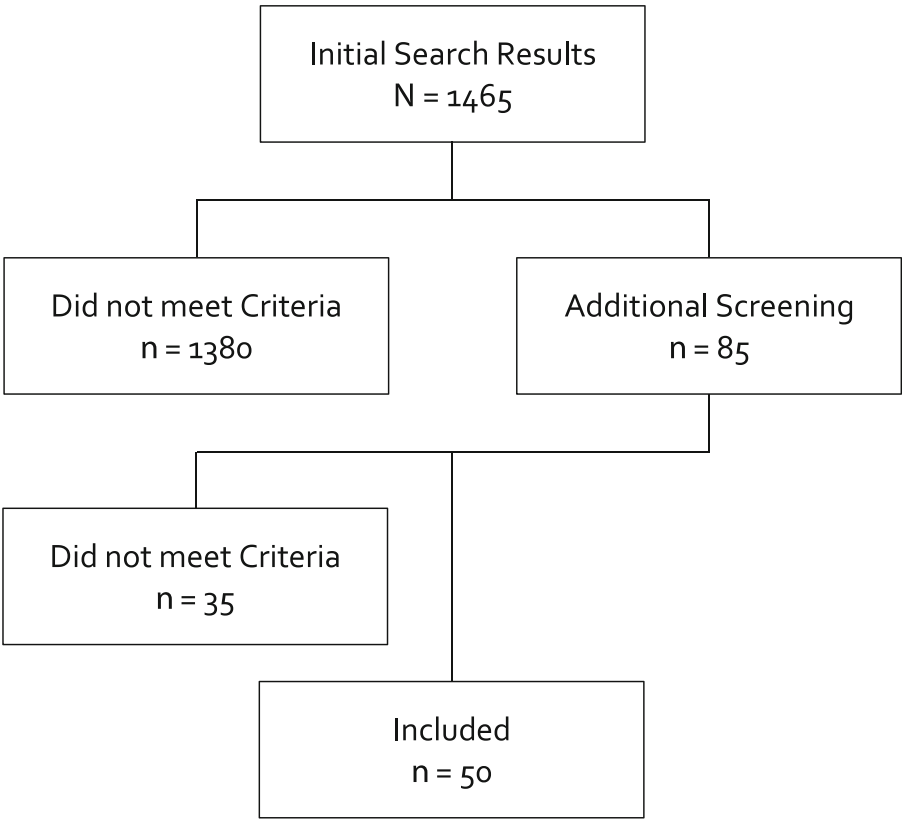

Fig. 1 PRISMA flow diagram. *Note.* PRISMA = preferred reporting items for systematic reviews and meta-analyses

sustainability agenda in that there seems to be a plateaued rate of publication spanning from the early 1980s through the early 2000s. However, this visualization also reveals what appears to be a relatively renewed interest in the topic within the previous decade. In 2017, more empirical behavior analytic contributions were added to the sustainability literature than in any single preceding year ($n = 6$), a positive note, which could suggest a second wave of sustainability work emerging from behavior analytic thought.

To better understand where these articles are being published, we overlaid our cumulative record with the date of inception of our flagged behavior analytic journals (i.e., those that hosted articles included in our review). Additionally, Table 2 presents the cumulative number of empirical studies organized by publication outlet. Far and above, JABA has hosted the vast majority of these works; pieces published in all other outlets make up only 28% of the collected body ($n = 14$). Despite this clear deviation in journal publication, the advent of subsequent outlets does not appear to have any significant impact on the rate of publication as demonstrated by our cumulative record.

Table 4 contains information with respect to target population and intervention setting. Fourteen (28%) of the studies flagged here employed a convenience sample of undergraduate students to evaluate intervention efficacy. This is encouraging, in that many more of these studies evaluated behavior change mechanisms in a more

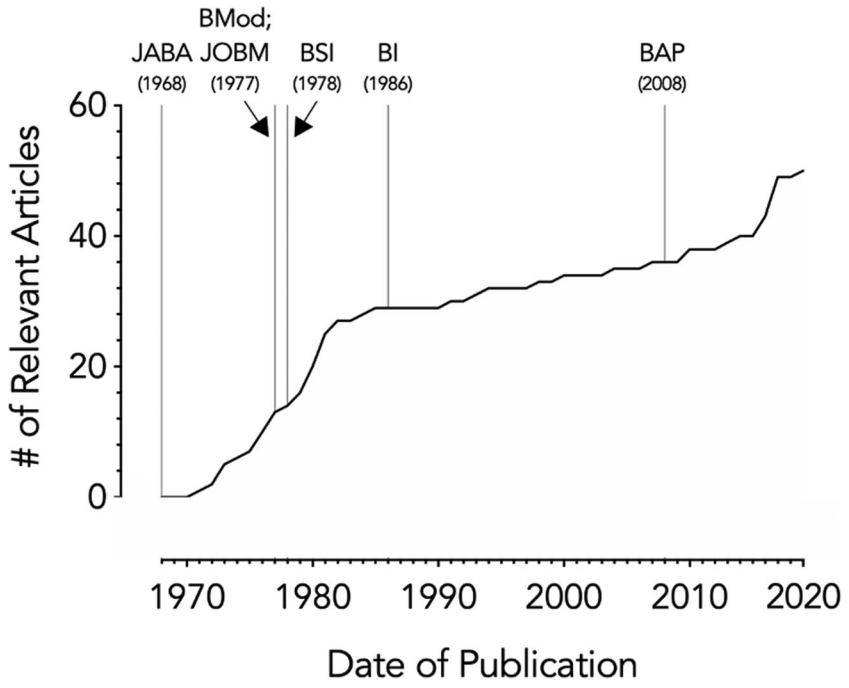

Fig. 2 Cumulative empirical publications flagged as having a focus on global sustainability published in behavior analytic journals. *Note.* JABA = *Journal of Applied Behavior Analysis*; BMod = *Behavior Modification*; JOBM = *Journal of Organizational Behavior Management*; BSI = *Behavior and Social Issues*; BI = *Behavioral Interventions*; BAP = *Behavior Analysis in Practice*

generalizable population, including households, employees of various institutions and at differing levels, and samples drawn from the general public. Of those that examined undergraduate samples, five studies specifically aimed to change driving habits, whereas two studies sought to decrease energy use—a task made more difficult by the typical disconnect between energy use and fiscal consequences. As it pertains to sample size, the majority of studies examined behavior change mechanisms among fewer than 100 participants. Some studies had incalculable sample sizes due to the public nature of their intervention, such as the stimulus control modulation of a waste receptacle presented by O'Neill, Blanck, and Joyner (1980). Others, such as the multicomponent investigation of Jacobs, Bailey, and Crews (1984) to evaluate factors motivating recycling compliance or the quasiexperimental analysis of Agras, Jacob, and Lebedeck (1980), examined behavior change on a far greater scale. These studies shifted toward the evaluation of various treatments to change behavior at the neighborhood or community level—a leading demonstration of the scalability of behavior analytic intervention.

Intervention Approaches

Turning now toward the type of interventions employed by these works, we aim to synthesize the scope of coverage demonstrated by authors in their applications of behavior analytic principles to environmentally relevant behavior. We approximate categories that we believe facilitate the exploration of this work. Note, however, that

Table 4 Descriptive characteristics of articles (n = 50) ascending by date of publication

Authors (year)	Target outcome	Target behavior	Intervention	Setting	Sample
Burgess et al. (1971)	Litter	% of litter collected	Incentives/rewards; prompting; response effort	Movie theater	Youth
Clark, Burgess, and Hendee (1972)	Litter	# of planted litter pieces collected	Incentives/rewards	Campground	Youth
Geller, Farris, and Post (1973)	Waste/recycling	Proportion of bottle purchases returnable	Prompting	Convenience store	General
Kohlenberg and Phillips (1973)	Litter	# of litter deposits	Incentives/rewards	Zoo	General
Powers, Osborne, and Anderson (1973)	Litter	# of litter pieces/bags collected	Incentives/rewards	Nature park	General
Chapman and Risley (1974)	Litter	Mean # of litter pieces per yard; weight of litter collected; # of litter collectors	Incentives/rewards; prompting	Urban community	Youth
Hayes et al. (1975)	Litter	# of litter pieces collected	Incentives/rewards	Detention center	Youth/adult resident
Kohlenberg et al. (1976)	Energy use	Cumulative "energy units" (electricity) above criterion	Education; feedback; incentives/rewards	Suburban community	Household
Seaver and Patterson (1976)	Energy use	# of gallons home heating oil used	Feedback; incentives/rewards	Suburban community	Household
Witmer and Geller (1976)	Waste/recycling	Daily lbs of paper deposited	Incentives/rewards; prompting	University dormitory	University student
Foxx and Hake (1977)	Transportation	Mean # of miles driven per day	Incentives/rewards		University student
Hayes and Cone (1977)	Energy use	Mean hourly kWh usage per day	Education; feedback; incentives/rewards	Apartment complex	University student household
Palmer et al. (1977)	Energy use	Daily kWh usage	Education; feedback; prompting	Suburban community	Household

Table 4 (continued)

Authors (year)	Target outcome	Target behavior	Intervention	Setting	Sample
Hake and Foxx (1978)	Transportation	# of miles driven	Incentives/rewards; self-monitoring		University student
Bittle et al. (1979)	Energy use	Mean daily kWh LRusage	Feedback	Rural community	Household
Winett et al. (1979)	Energy use	Daily kWh usage	Feedback; self-monitoring	Suburban community	Household
Agras et al. (1980)	Resource use	Monthly water usage (ft^3)	Education; penalties/fines; prompting		Community
Bacon-Prue et al. (1980)	Litter	# of litter pieces collected	Incentives/rewards; response effort	Mental health facility	Resident with IDD
Luyben (1980)	Energy use	% of classrooms with lights powered off	Prompting	University academic building	University staff/student
O'Neill et al. (1980)	Litter	# of litter pieces collected; weight of litter collected	Stimulus control	University sports stadium	General
Foxx and Schaeffer (1981)	Transportation	# of miles driven per day	Feedback; incentives/ rewards	Research consulting firm	Employee
Hake and Zane (1981)	Transportation	# of miles driven per day	Incentives/rewards		General
Hayes and Cone (1981)	Energy use	Monthly kWh usage; % change in kWh usage	Feedback	Suburban community	Household
Slavin et al. (1981)	Energy use	kWh usage per resident	Feedback; incentives/ rewards	Apartment complex	Household
Van Houten, Nau, & Merrigan (1981)	Energy use	kWh usage by elevator; # of elevator riders	Feedback; response effort	University administrative building	General
Jacobs, Fairbanks, Poche, and Bailey (1982)	Transportation	Proportion of parkers carpooling	Incentives/rewards	University parking	University staff/student
Winett et al. (1982)	Energy use	Mean daily kWh usage	Feedback; education; modeling	Suburban community	Household
Jacobs et al. (1984)	Waste/recycling	% of sample recycling participation	Prompting; response effort	Suburban community	Household

Table 4 (continued)

Authors (year)	Target outcome	Target behavior	Intervention	Setting	Sample
Winett et al. (1985)	Energy use	Mean daily kWh usage per household	Education; modeling	Suburban community	Household
Keller (1991)	Waste/recycling	% of sample recycling participation	Feedback; incentives/ rewards	Suburban community	Household
Austin, Hatfield, Grindle, and Bailey (1993)	Waste/recycling	# of recyclable pieces in trash bin; # of recyclable pieces in recycle bin	Prompting	University administrative building	University staff/student
Brothers et al. (1994)	Waste/recycling	# of recyclable pieces in trash bin; # of recyclable pieces in recycle bin	Response effort	Research institute	Employee
Ludwig, Gray, and Rowell (1998)	Waste/recycling	# of recyclable pieces in trash bin; # of recyclable pieces in recycle bin	Response effort	University academic building	University staff/student
H. Staats et al. (2000)	Energy use	% of offices with uncovered heating grates; % of offices with identical thermostat settings	Feedback; prompting	University building	Office space occupant
Schroeder et al. (2004)	Political action	# of participants reporting contact with environmental organization/political representative	Education; modeling	Coastal community	Business owner/manager
Manuel et al. (2007)	Reusables	Mean % of sample choosing reusable dining ware	Education; prompting; response effort	University cafeteria	General
Bekker et al. (2010)	Energy use	Daily kWh usage	Feedback; incentives/ rewards; prompting	University dormitory	University student

Table 4 (continued)

Authors (year)	Target outcome	Target behavior	Intervention	Setting	Sample
O'Connor et al. (2010)	Waste/recycling	# of recyclable pieces in trash bin; # of recyclable pieces in recycle bin	Response effort; stimulus control	University academic building	General
Hirst, Miller, Kaplan, and Reed (2013)	Energy use	Consistency of measurement; sensitivity to changes in power use	Product review		
Frazer and Leslie (2014)	Energy use	kWh usage	Feedback; goal setting	Community	Household
Camargo and Haydu (2016)	Resource use	# of resources used by each group per round; # of resources available to group; accuracy of instructions regarding sustainable practice provided by "experienced" participant	Education; feedback; information	Laboratory	University student
Miller et al. (2016)	Waste/recycling	# of recyclable pieces in trash bin; # of recyclable pieces in recycle bin	Prompting; response effort	University academic building	General
Pandey et al. (2016)	Energy use	kWh consumption of each building	Feedback; prompting	University administrative building	University staff
Clayton and Nesnidol (2017)	Energy use	% of rooms with lights turned off	Feedback; goal setting; prompting	University academic building	University staff/student
Desrochers and Mosher (2017)	Energy use	Average time target devices powered off	Education; feedback; goal setting; information		University student
Fritz et al. (2017)	Waste/recycling	# of recyclable pieces in trash bin; # of recyclable pieces in recycle bin; # of refuse items left in classroom	Prompting; response effort	University academic building	General
Jadro (2017)	Transportation	Average miles per gallon	Feedback		

Table 4 (continued)

Authors (year)	Target outcome	Target behavior	Intervention	Setting	Sample
Schultz et al. (2017)	Energy use	Daily kWh usage	Feedback; incentives/ rewards; prompting	Sorority house	University student
Venditti and Wine (2017)	Transportation	Tire pressure relative to efficiency ideal	Response effort	Human services organization	Employee
Szczucinski et al. (2020)	Waste/recycling	# of compostable pieces in compost bin; # of noncompostable pieces in compost bin	Prompting; response effort; stimulus control	University cafeteria	General

Note. Some studies were either not limited to or did not conform to a single community or sample (e.g., Agras et al., 1980); these columns were intentionally left blank. IDD = intellectual and developmental disability.

given the nature of these interventions, most employ at least two primary independent variables at some capacity. We also note here that these categorizations represent our best attempt to group these articles. This was a necessarily difficult task given that many of these interventions can overlap in their influence on behavior (e.g., prompting and feedback may both operate similarly in the environment), and thus some readers may take issue with this categorization. We reiterate again the desire to explore these methods rather than concretely label the studies therein. As such and to better understand these methods, we have chosen to explore only a handful of representative articles or approaches from each category that convey the method or a unique aspect of the broader intervention class. Additional information regarding methodological components for each study can be found in Table 4.

Incentives Of the collected works, 20 studies (40%) utilized some form of incentive delivery as a mechanism for behavior change, making incentivization the most common consequent strategy. These incentive systems focused on the selection of rewards that were sufficient to maintain interest in the behavior change while also yielding a treatment that was sustainable with respect to cost and resources. Authors varied greatly in the means by which they approached incentive delivery. Some, such as Burgess, Clark, and Hendee (1971) and Kohlenberg and Phillips (1973), employed small-cost rewards acquired through a partnership with accompanying groups—in these cases tickets to the movie theater in which litter collection was hosted or a free soda pop from the concession stand at the intervention site, respectively. Others employed a probabilistic-type approach. Hayes, Johnson, and Cone (1975) introduced a system of incentive payout to encourage litter collection, referred to in their work as the *marked-item technique*: From among the total deposit of litter in the target location, a small sample of items were marked in a way identifiable only to the researchers. Participants who collected litter were eligible for payment based on the number of marked items they returned. Similarly, Hake and Foxx (1978) and Foxx and Hake (1977) employed small monetary payouts for compliance with reduced driving goals, coupled with a probabilistic chance of winning a grand prize should they fully complete the study.

Feedback The provision of information related to participant performance was among the leading approaches (n = 17; 34%) to change behavior highlighted in the literature review. These approaches are particularly well suited for interventions seeking to promote long-term behavior suppression, as in home-heating or electricity conservation. Feedback was presented in the form of feedback cards or slips (e.g., Bittle, Valesano, & Thaler, 1979; Palmer, Lloyd, & Lloyd, 1977; Seaver & Patterson, 1976), posters or similar visualizations (e.g., Clayton & Nesnidol, 2017; Schultz, Kohn, & Musto, 2017), direct contact via letters or email (e.g., Pandey, Diller, & Miller, 2016; Slavin, Wodarski, & Blackburn, 1981), or direct face-to-face meetings (e.g., Winett et al., 1982). Alternatively, as a means of providing more immediate feedback, Kohlenberg, Phillips, and Proctor (1976) arranged the intervention environments such that, when home energy use exceeded a certain predefined threshold, a 40-W lightbulb would glow in the participants' home to signal a need for electricity-use reconfiguration. In a similar fashion, Jadro (2017) reported the preliminary effects of a real-time feedback delivery system, stationed in the automobile, for fuel economy and the encouragement of environmentally friendly driving.

Punishment The last of the consequent approaches and the only published study of its kind, Agras et al. (1980) examined the effects of enacted policies in the San Francisco Bay Area aimed at reducing water consumption. This quasiexperimental analysis focused on the reduction in water use achieved through the assignment of monetary fines for exceeding allocated water-use thresholds. In this particular case, fines scaled to the severity of the water-use violation, thereby providing an opportune circumstance to evaluate the effects of potential punishers on environmentally conservative behavior (i.e., if effective, higher fines should be followed with lower or zero-fine periods).

Prompting and Education A simple prompting mechanism was present in 18 (36%) of the examined works. Most commonly, this came in the form of posters or flyers clearly visible in the intervention site (e.g., Miller, Meindl, & Caradine, 2016; Schultz et al., 2017; H. Staats, van Leeuwen, & Wit, 2000; Witmer & Geller, 1976). Other prompts were delivered in a more direct manner (as opposed to posting in a common location), such as Jacobs et al.'s (1984) brochures or Pandey et al.'s (2016) email prompts. Some of these, such as those employed by Luyben (1980), were constructed as *informational* prompts, not only serving as novel discriminative stimuli but also providing some useful information to further facilitate the behavior change (e.g., highlighting key electricity-consuming devices in the household). In most cases, prompts were used as a secondary behavior change mechanism, paired frequently with consequent strategies like incentive delivery or feedback.

An additional 10 works (20%) featured prompting-type educational information campaigns—potentially establishing operations—as a formal behavior change mechanism. Many of these included tips to maximize behavior change or information (e.g., expected energy savings, implications of behavior change for environmental benefit) intended to motivate greater compliance. Others used information as a more formalized behavior change mechanism. Manuel, Sunseri, Olson, and Scolari (2007) used informational posters to alter the value of dinnerware such that individuals were less likely to choose disposable cups and plates in favor of reusables. Camargo and Haydu (2016) invited participants to complete a virtual task wherein collected "resources" were exchangeable for real-world money but were drawn from a pool shared by all other participants. Those who received informational prompts regarding the state of the resource pool were more likely to behave in a sustainable manner.

Response Effort In the realm of antecedent strategies, 11 studies (22%) examined the use of response effort manipulation to promote or discourage various environmentally profound behaviors. These most frequently materialized as the introduction or rearrangement of trash receptacles to manipulate the effort required to properly dispose of refuse (e.g., decrease effort for recycling; Bacon-Prue, Blount, Pickering, & Drabman, 1980; Brothers, Krantz, & McClannahan, 1994; Burgess et al., 1971; Miller et al., 2016; O'Connor, Lerman, Fritz, & Hodde, 2010). A 2017 study by Venditti and Wine examined the introduction of a tire fill station at participants' work site as a means of reducing response effort for maintaining proper tire pressure (i.e., maintain fuel economy). Szczucinski, Gelino, Cintron, Becirevic, and Reed (2020) employed a response effort manipulation on an experimental compost waste receptacle to increase the probability of participant interface with instructional prompts and to promote more appropriate composting behavior.

Stimulus Control Seven (14%) of the originally identified works included, in the primary intervention, some form of stimulus control salience modulation, wherein the primary goal was to increase the efficacy of an existing discriminative stimulus in producing desired responding (as opposed to the proliferation of novel discriminative stimuli, as observed in studies categorized as primarily prompting interventions). Of these, four included a manipulated trash or waste receptacle that was intentionally designed to stand out and draw greater attending from within the decision-making environment (e.g., O'Neill et al., 1980; Szczucinski et al., 2020). Additional measures focused on the manipulation of other aspects of the environment (e.g., moving key aspects of the decision-making process to increase attending) to yield behavior change.

Self-Monitoring In a different display of feedback delivery, five studies (10%) examined the role that self-sustained monitoring can have in modulating environmentally relevant behavior. Because these sorts of interventions require greater involvement by the participant, self-monitoring procedures in all cases involved some form of informational session to instruct proper measurement technique and ensure participants were aware of the purpose of their study involvement. Generally, these methods instructed participants to keep a running record of their behavior as it pertained to the intervention goal; established contingencies for continued involvement aided in offsetting the upfront resource demand placed on participants (e.g., Hake & Foxx, 1978). Other studies instructed participants to generate a personal goal for behavior change and monitor their progress over time (e.g., Desrochers & Mosher, 2017; Winett, Neale, & Grier, 1979)

Modeling Three of the studies (6%) flagged in the literature search used some form of modeling as a primary intervention. Two studies—Winett et al. (1982) and Winett, Leckliter, Chinn, Stahl, and Love (1985)—used a form of video modeling in which participants watched actors demonstrate appropriate behavioral strategies to achieve the behavior reduction targeted in the intervention (e.g., the appropriate means of coping with discomfort when setting the thermostat at more eco-friendly temperatures). A third investigation by Schroeder, Hovell, Kolody, and Elder (2004) pursued the interface with newsletters containing modeled political activism (e.g., mock letters to local political representatives) as a means of encouraging greater outreach by coastal business owners. Although these were the only articles employing modeling as a primary intervention parameter, the nature of proenvironmental behavior makes it inevitable that those exposed to methods of any study summarized here—within the recruited sample or not—were the beneficiaries of modeling as an intervention, as with a bystander watching recycling in action (who is thereby more inclined to recycle as a result).

Commitment and Goal Setting Alternatively, four studies (8%) employed commitment responses and goal setting to encourage sustainable choices. Desrochers and Mosher (2017) provided an instructional session covering the importance of energy reduction and asked individuals to sign a contract committing to keep certain energy-demanding devices powered off on a more frequent basis. Frazer and Leslie (2014) recruited households to participate in an energy reduction effort, a leading component of which involved a signed commitment to reduce electricity consumption to 80% of baseline use.

Discussion

Behavior analysis presents a uniquely advantageous approach to understanding behavior change mechanisms that motivate sustainable living. A steadfast emphasis on experimental control and social validity results in research that has direct implications for the sustainability movement. As suggested by our literature review, the field has in many senses begun to hint at this vast capability to advance the agenda. The work conducted to date has covered a variety of behaviors of ecological relevance and employed a full gamut of behavior analytic methods. Our rate of publication in this area may not demonstrate consistency over the 50-year span for which applied behavior analysis has been formalized, but the cumulative body has undeniably covered the bases.

Although this body of sustainability literature is widely encompassing, there remain countless other impactful target behaviors that have not yet been examined. If we are to scale interventions in the years to come—a seemingly necessary step to continue advancing our role in the sustainability conversation—we also need to expand our understanding of principles to know which interventions are most productive as they pertain to varying outcomes. Researchers should place emphasis on those behaviors most impactful for change by referring to materials made public by other fields, such as that presented by Hawken (2017). By targeting behaviors with meaningful repercussions, we may well be ensuring the invaluable nature of our work rather than simply continuing to demonstrate the efficacy of long-standing field principles. The work of others might now be a guide to ensure the impact of our own work remains resolute.

We need also give more structured consideration to the overall methodological approach taken to changing behavior in the context of sustainable living. For instance, one point to emphasize might be the application of methods that promote long-term maintenance of behavior change effects. Such approaches are likely to be those that require the *least* amount of input from the participant and no direct upkeep by the implementing body. As a leading example, we refer readers to the growing collection of literature supporting the use of nudges and choice architecture (e.g., Tagliabue & Sandaker, 2019; see also Thaler & Sunstein, 2008) as environmental factors for change. These interventions emphasize the modulation of the decision-making setting such that particular choices are more likely, but in no way forced (e.g., placing sustainably sourced food options at eye level). We should not shy away from a more formal evaluation of these sorts of environmental adjustments in their ability to promote a greater variety of change when combined with more prototypical behavioral principles (e.g., the possible advantages of placing sustainably sourced food options at eye level *and* establishing a token economy surrounding purchases of sustainably sourced foods).

There remain countless other leading procedural applications that have thus far been relatively unexplored by behavior analysis. Gamification—the assignment of points and scores for completing everyday tasks—has proven to be an effective means by which to bring about behavior change in other settings (e.g., healthy food choices; Jones, Madden, & Wengreen, 2014a; Jones, Madden, Wengreen, Aguilar, & Desjardins, 2014b; see also Morford, Witts, Killingsworth, & Alavosius, 2014). Extension of this work to sustainability could prove fruitful. The implementation of alternative research designs might also be a strong next step for behavior analytic work in sustainability (e.g., Biglan, Ary, & Wagenaar, 2000).

As a field, we might begin to lend greater focus to the underlying influence of the problematic behavior we seek to curb. The vast majority of interventions here discussed serve as an effective means of reducing carbon footprints or conserving natural resources but do little to altogether eliminate the causes of problematic cultural practices. For behavior analysts, the historical scope of the field's efforts is a leading limitation—intervention must place greater emphasis on shifting or disrupting the metacontingencies under which everyday consumers operate (see Todorov, 2006, 2013; see also Glenn, 1988; Houmanfar & Rodrigues, 2006; Mattaini, 2004). Behavior change tactics might begin to focus on policy makers, urban planners, conglomerate executives, and special interest group leaders, as well as examine the means by which harmful practices originate and are conserved. We dream that someday, behavior analysis could help leverage field insights to better promote a behavioral approach to environmental policies, as well as an unraveling of harmful societal practices that embody poor ecological practice (we would draw attention to the unending pursuit of economic growth and the ensuing environmental exploitation; see Biglan, 2020). It is critical now that emerging lines of work continue to focus on the means by which existing interventions—those outlined here—can be reworked to address issues of cultural practice.

New and existing frameworks and conceptual lenses are hugely influential for shaping the next wave of research efforts. There exist a number of historical approaches to understanding behavior problematic in the realm of sustainability from a field perspective that have frequently gone unrecognized in this domain of work. Classical conditioning has been demonstrated as a fundamental principle present in techniques employed by marketing firms and advertisers (see A. W. Staats & Staats, 1958); further examination may present new conceptual approaches for understanding excessive consumption driven by the overvaluation of material goods (e.g., examining the effectiveness of conditioned reinforcers; see Fantino, 1977; Shahan & Cunningham, 2015; Williams, 1994; see also Rescorla, 1988). Value framing may well be a prime target to be better understood by those specializing in ecologically relevant behavior change.

We may also find inspiration and structure in discoveries from basic laboratories as a starting place for a deeper understanding of problematic ecological behavior. Nevin (2005) offered a translation of schedule-induced differences in responding observed in basic laboratory experimentation, extended to concerns pertaining to sustainability. Organisms contacting reinforcement on richer schedules, specifically those with weak contingencies through which behavior is maintained, frequently exhibit greater relative resistance to change in response output. This may principally underlie persistent consumerism and explain the apprehension toward taking more sustainable lifestyle measures (e.g., continuing to fuel personal vehicles for solitary travel despite escalating monetary and environmental costs). Indeed, viewing behavior through this lens suggests some advantage may be had when approaching behavior change at the local level (i.e., with relatively less momentum and thus more sensitivity to disruptors as compared to national policy change), focusing on the interface with underconsumed nonmaterial and low-footprint reinforcers, and/or planning interventions that capitalize on existing theories of momentum (see also Nevin & Shahan, 2011).

Behavioral economic interventions are among the most potent potential methods by which we can understand policy implications. Such methods—operant demand and delay discounting procedures, in particular—present unique advantages for the

evaluation of behavior at the community and cultural levels. In particular, the hypothetical decision-making task (e.g., hypothetical purchase task; see Roma, Hursh, & Hudja, 2016; see also Kaplan, Gelino, & Reed, 2018; Reed, Partington, Kaplan, Roma, & Hursh, 2013) has amassed a body of evaluative literature implicating its use for informing policy in a number of domains, sustainable living being one (see Roma, Reed, DiGennaro Reed, & Hursh, 2017). Discounting methods—means by which we can better understand the degradation of reinforcer value when imposed at some delay or with less-than-guaranteed delivery—similarly present a conceptually relevant mechanism for understanding decision making as it might pertain to environmentally relevant choice (e.g., Berry et al., 2017a; Berry, Nickerson, & Odum, 2017b; Hardisty & Weber, 2009; Hirsh, Costello, & Fuqua, 2015; Kaplan, Reed, & McKerchar, 2014; McKerchar et al., 2019; see also Gifford, 2011). Investigation might seek to better understand discounting as it relates to sustainability and develop interventions that modulate and reduce this discounting, thereby increasing the salience of long-delayed outcomes of irresponsible decision making in the present (or of proenvironmental decisions that may not produce immediately demonstrable benefits).

The body of research presented here does not represent all of the behavior analytic work in sustainability. We reiterate again our intention to provide an overview of what has been accomplished by the field specifically; inclusion of a greater body of publication outlets would undoubtedly uncover more works than were here reviewed. Further refinement of our sustainability definition may also yield a wider body of work. In particular, we believe a broadened search query including considerable emphasis placed on the economic ideals and forward thinking seen as essential by scholars in ecological economics to be a valuable next step (see Common & Perrings, 1992; Costanza, 1992; Hezri & Dovers, 2006; Sneddon, 2000). A quantitative analysis of the works here summarized is similarly crucial to better understand the relative value of the interventions being tested. We turn the reader toward the work of Osbaldiston and Schott (2012) as a representative existing meta-analysis; continuous updates on these efforts should be revisited.

All things considered, the field has thus far exhibited a strong effort to document the effects of various interventions to promote sustainable living. Our next steps must move beyond what we have presented to date. If we can begin to scale our work for community effect, and perhaps reframe interventions to unravel the cultural practices most contributive to harmful ecological interface, then we can truly take our seat at the table with those working to advance sustainability at large. Leading scientific organizations have called upon social scientists for contributions. Behavior analysis as a field must continue to answer the call. Together as scientists and as members of the global community, it is high time we, as behavior analysts, meet our full capability in preserving our place on Earth.

Data Availability Data and materials pertaining to the described review are publicly available via the Open Science Framework (see Gelino et al., 2020).

Code Availability Not applicable.

Declarations

Conflict of Interest The authors declare they have no conflict of interest.

Appendix

Sample Boolean Operator Search Entry

(waste[Text Word] OR litter[Text Word] OR recycl*[Text Word] OR energy[Text Word] OR conserv*[Text Word] OR sustainab*[Text Word] OR water*[Text Word] OR electric*[Text Word] OR consumption[Text Word] OR resource[Text Word] OR climate[Text Word] OR global[Text Word] OR ecology[Text Word] OR oil[Text Word] OR fuel[Text Word] OR anthropocene[Text Word]) AND ("journal of applied behavior analysis"[Journal] OR "journal of organizational behavior management"[Journal] OR "the behavior analyst"[Journal] OR "behavior modification"[Journal] OR "behavioral interventions"[Journal] OR "behavior and social issues"[Journal] OR "behavior analysis in practice"[Journal] OR "behavior analysis: research and practice"[Journal] OR "perspectives on behavior science"[Journal])

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