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BEHAVIOR ANALYSIS AND ENVIRONMENTAL PROTECTION: ACCOMPLISHMENTS AND POTENTIAL FOR MORE

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Abstract: The contributions and merits of an applied behavior analysis approach to encouraging pro-environment behavior are reviewed, along with a discussion of ways behavioral science can play a greater role in protecting the environment. After presenting the most serious threats to the earth's environment, the targets, settings and techniques of the behavioral intervention literature are reviewed. It is argued that behavior analysis can play a greater role in solving environmental problems through (a) reexamination and expansion of intervention targets, (b) increased focus on long-term maintenance of pro-environment behavior, and (c) more effective dissemination of intervention strategies and research findings.
Key words: environment, environmental protection, conservation, pro-environment behavior, recycling

In 1970 the first Earth Day served as an activator for behavior analysts to embark on a new challenge. We were reminded that human behavior causes serious damage to the earth's environment and threatens the future of humans and other species. If human behavior is the problem, behavior analysis can offer the technological solutions for turning things around. Behavioral scientists answered the call, and applications of behavior analysis to protect the environment blossomed during the 1970s. During that decade, numerous studies demonstrated the effectiveness of behavioral technology in decreasing environmentally destructive behaviors such as littering, excessive vehicle use, and wasteful consumption of home energy and water. Other field studies focused on increasing pro-environmental behaviors such as carpooling, recycling, litter pick-up, and increasing the use of mass transit (see reviews by Cone & Hayes 1980 and Geller, Winett, & Everett, 1982).

Unfortunately, the field that seemed so fruitful and full of promise for crucial social change peaked during the late 1970s and early 1980s. A review of behavioral interventions to preserve the environment during the 1980s revealed 54 published studies of behavior-based interventions to preserve the environment, with an almost linear decline in the number of articles published by year through 1990 (Dwyer, Leeming, Cobern, Porter, & Jackson, 1993). In a 1990 *Journal of Applied Behavior Analysis* editorial, Geller mourned the decline of the field, reported on the opinions of prominent environmental researchers on why the decline occurred, and optimistically declared the 1990s as "ripe for environmental protection research" (Geller, 1990, p. 273).

However, behavioral environmental protection is far from reaching its potential. Although research evaluating *behavioral interventions* to preserve the

environment continues to be published (a literature search revealed 32 published studies since 1990), publications in leading behavioral journals have declined substantially (e.g., only five articles in the *Journal of Applied Behavior Analysis* since 1990 compared to 15 in the 1970s). In contrast, the publication of research concerning environmental *attitudes* has flourished. Although *Environment and Behavior* published more research concerning behavioral interventions to preserve the environment than any other journal since 1990 (i.e., nine articles), research reports focusing on environmental attitudes and demographic characteristics of those involved in environmentally-relevant behavior outnumbered intervention articles at a rate of seven to one. In addition, there is little evidence the effective behavioral interventions that are documented in research journals have escaped their pages to make significant contributions toward solving real-world environmental problems. In other words, the external validity of this research is weak or nonexistent.

The purpose of this paper is to review the contributions of behavioral scientists in promoting pro-environmental behavior and explore reasons for the limited impact. After an overview of the environmental crisis, the behaviors targeted by interventions are reviewed, as well as the components of the most successful interventions. We conclude with a discussion of ways to increase the impact of applied behavior analysis for protecting the environment.

THE IMPACT OF HUMAN BEHAVIOR ON THE ENVIRONMENT

Over the past 100 years the earth's human population has increased from approximately 1.5 billion in 1900 to 6.3 billion in 2003 (Brown & Flavin, 1999; Cohen, 2003). At the same time, technology has changed the lives of many, making us more mobile, more comfortable and more efficient consumers. The United Nations has projected that the global population will reach 8.9 billion by 2050 (United Nations, 2002). This projected increase of 2.6 billion people is more than the entire population of the world in 1950 (2.5 billion) (Cohen, 2003). The limits of the earth's carrying capacity are relatively unknown, and it is possible that it will be overwhelmed (Oskamp, 2000; Winter, 1996).

Even at today's population level, many of our current practices are not sustainable, meaning the consequences of our actions and limitations of resources will make it impossible to conduct business as usual for future generations. The bottom line is that all human inhabitants of the earth require its resources to meet their basic needs of water, food and shelter. And many of us require substantially more to meet our perceived needs of comfort, convenience and transportation.

There are consequences to meeting each of these needs that extend beyond resource depletion. Most of what we do and consume requires energy, which we generate by burning fossil fuels. Extracting, processing, transporting and burning fossil fuels produces pollution and negatively impacts natural environments. Many of the products we produce by burning fossil fuels are used briefly, and then discarded, which leads to additional problems of waste and pollution. Although a

thorough review of the environmental crisis is beyond the scope of this paper, some of the most serious threats are outlined below.

Air Pollution

Ninety percent of the energy used in industrialized countries comes from the burning of fossil fuels (Flavin & Dunn, 1999). When fossil fuels such as oil or coal are burned they produce a variety of byproducts, including carbon dioxide, carbon monoxide, nitrogen, sulfur oxides and particulate matter. These air pollutants have been linked to respiratory problems and lung cancer in humans and are the cause of acid rain, ozone depletion and other environmental problems (Flavin & Dunn, 1999). Although stricter emissions laws have improved air quality in the U.S. and in many other countries, air pollution presents a serious health hazard worldwide. The World Health Organization estimates that disease resulting from ambient air pollution is responsible for 800,000 deaths worldwide each year (World Health Organization, 2002).

Climate Change

Perhaps the most dramatic threat to the earth's environment is global warming. Carbon dioxide and other gas byproducts of burning fossil fuels have formed a blanket around the earth that allows light to penetrate without allowing heat to escape. The result is a greenhouse effect and a slowly warming planet. Scientists estimate the average global temperature has increased by approximately .6 degrees Celsius over the past 150 years, and project increases between 1.4 and 5.8 degrees Celsius by 2100 if greenhouse gasses are not significantly reduced (Intergovernmental Panel on Climate Change, 2001). Although this seems like a modest increase, very small changes in global temperature can lead to dramatic consequences. A worst-case scenario includes a warming of the oceans that leads to melting polar icecaps and then to the flooding of coastal areas, followed by extreme changes in weather patterns causing droughts and desertification in some areas and floods in others. Consequently, even slight global warming can threaten the earth's ability to sustain life as we know it.

Although there is significant uncertainty about the rate and course of global warming, the relatively small changes we have already experienced may pose significant threats to human health. The World Health Organization estimates that global warming is responsible for 154,000 deaths worldwide by creating conditions more favorable for the spread of diseases such as malaria, dengue fever and diarrhea (World Health Organization, 2002).

Water Pollution and Depletion

Pesticides, fertilizers, industrial chemicals and wastes, fossil fuel emissions, and residential runoff have polluted much of our fresh water supply. Thirty-three percent of the lake acreage and 15 percent of the total river miles within the U.S. are so contaminated with mercury, PCBs and other chemicals that the U.S.

Environmental Protection Agency (EPA) has issued fish advisories warning that some or all species are unsafe to eat (U.S. Environmental Protection Agency, 2003b). Since many waters have not yet been tested, the EPA recommends that pregnant women and young children limit their intake of fish caught from *any* U.S. freshwaters to six and two ounces per week respectively. Mercury contamination is a significant problem in the oceans as well. The EPA recommends that pregnant women and children avoid eating large ocean species such as shark and swordfish, and limit overall consumption to 12 ounces or less per week (U.S. Environmental Protection Agency, 2002).

Solid Waste

The EPA estimates that Americans generate an average of 4.6 pounds of garbage per person every day, which is an increase of almost two pounds daily per person since 1960 (U.S. Environmental Protection Agency, 2003a). Although recycling has been successful in diverting 28% of solid waste from landfills, the remaining 72% is either burned or buried in landfills, practices that lead to further environmental problems such as soil and water contamination and increased greenhouse gas emissions.

Soil Erosion and Contamination

Erosion associated with mining, intensified farming techniques, and overgrazing has led to extensive loss of topsoil. Increased use of chemical pesticides in agriculture has further contributed to the contamination of our land and water (Oskamp, 2000; United Nations Environment Programme, 2002). In addition to disrupting ecosystems and producing billions of tons of solid waste a year, many mines rely on chemicals such as cyanide in their operations, causing further contamination to land and water (Sampat, 2003).

Loss of Green Space and Species Diversity

Only about 50% of the earth's original forest cover remains. This means loss of habitat for species, loss of protection for watersheds, and increased erosion and flooding (Abramovitz & Mattoon, 1999). Due to a combination of habitat destruction, introduction of exotic species and overharvesting, the number of plant and animal species inhabiting the earth is shrinking at an alarming rate. Worldwide, 14% of all plant species, 11% of bird and mammal species and 33% percent of fish species are threatened with extinction (Brown & Flavin, 1999). Some scientists estimate the current extinction rate for plants and animals is at least 1,000 per year, which is 100 times greater than the extinction rate of previous centuries (Tuxill, 1999).

Recent research suggests that in the future global warming may pose an even greater threat to species diversity than habitat loss. A recent study published in *Nature* sampled diverse ecosystems comprising 20% of the earth's terrestrial surface. Using relatively conservative estimates of global warming, the study

estimates that by the year 2050 twenty-four percent of the plant and animal species in those regions may become extinct as a consequence of climate change alone (Thomas et al., 2004).

Despite the overwhelming scope of environmental problems, the suitability of a behavior analytic approach to solving environmental problems is clear. Global warming, overpopulation, overflowing landfills, ozone depletion, acid rain, loss of green space, water pollution and species extinction are all problems that are primarily, if not exclusively, caused by human behavior. Unfortunately, the distant and sometimes invisible negative consequences of environmentally damaging behaviors seem to be overpowered by the relatively immediate and certain reinforcers of comfort and convenience.

INTERVENTION TARGETS AND SETTINGS

Behavioral scientists have successfully applied the principles of behavior analysis to increase a variety of pro-environment behaviors and decrease a variety of behaviors that damage the environment. We begin by reviewing the environmentally relevant behaviors targeted for intervention, and follow with a more detailed description of intervention techniques.

Perhaps in part due to the popular Keep America Beautiful campaign, litter control was a prime target for pioneers in the field. Some early examples include litter control applications at movie theaters (Burgess, Clark, & Hendee, 1971), grocery stores (Geller, Witmer, & Tuso, 1977; Geller, Witmer, & Orebaugh, 1976), shopping centers (Geller, Brasted, & Mann, 1980), football stadiums (O'Neill, Blanck, & Joyner, 1980), camping areas (Crump, Nunes, & Crossman, 1977; Powers, Osborne, & Anderson, 1973), and even prisons (Hayes, Johnson, & Cone, 1975).

Increasing the rate and efficiency of recycling has also been a popular target. This protects the environment by decreasing the amount of waste directed toward overflowing landfills, and reducing the amount of energy required to produce new products. Twenty of the 32 studies published since 1990 targeted recycling in a variety of settings, including research centers (Needleman & Geller, 1992), universities (Austin, Hatfield, Grindle, & Bailey, 1993; Ludwig, Gray, & Rowell, 1998), and neighborhoods (DeLeon & Fuqua, 1995; De Young et al., 1995; Werner et al., 1995).

Decreasing the energy used in buildings for the purposes of heating, cooling and lighting has also drawn considerable attention from environmental behaviorists. This is an important area for intervention, since burning fossil fuels accounts for nearly 70% of all electricity generation (Energy Information Administration, 2003a). These interventions have mainly been conducted in private homes (Brandon & Lewis, 1999; McMakin, Malone, & Lundgren, 2002; Winett, Leckliter, Chinn, Stahl, & Love, 1985), with smaller numbers of studies tackling energy use in institutional, corporate or industrial settings (Siero, Bakker, Dekker, & van den Burg, 1996; Staats, van Leeuwen, & Wit, 2000).

Behavioral interventions have also attempted to reduce energy consumption and pollution by altering transportation-related behavior. Changing transportation behaviors is a crucial area for intervention, not only for conservation of resources, but also because the use of motor vehicles is a major cause of greenhouse gasses. Behaviors targeted for change include reducing the miles traveled in personal vehicles (Foxx & Hake, 1977), increasing miles per gallon through changes in the driving behaviors of professional drivers (Runnion, Watson, & McWhorter, 1978), and increasing the use of carpools (Jacobs, Fairbanks, Poche, & Bailey, 1982), public transportation (Bamberg, 2002), and bicycles (Mayer & Geller, 1982-1983).

Another category of environment-relevant interventions targets consumers' purchasing behavior, attempting to persuade them to buy products that are more environmentally friendly. Although very few of these studies have been published, they hold promise. If successfully implemented on a large scale they could reduce the amount of solid waste and toxic chemicals introduced into the environment, and influence companies to produce more environmentally friendly products. Examples of this type of intervention focus include Geller, Farris, and Post's (1973) attempts to increase the purchase of returnable bottles (an option no longer available to most Americans), and De Young et al.'s (1993) attempt to encourage consumers to buy products with less packaging and harmful chemicals.

INTERVENTION STRATEGIES

The intervention strategies used by environmental behaviorists can be conceptualized with the basic three-term contingency or ABC (antecedent-behavior-consequence) model of behavior change. Behaviors are directed by the antecedent stimuli that preceded them and announce the availability of a positive or negative consequence. Further occurrences of the behavior are determined by the consequences that follow. Most behavioral interventions to protect the environment can be classified as either antecedent or consequence strategies for behavior change.

Antecedent Strategies

A wide variety of antecedent strategies have been effective at influencing environment-relevant behaviors, including: (a) information/education, (b) verbal or written prompts, (c) modeling and demonstrations, (d) commitment, and (e) environmental alterations.

Information and education. Although providing information and promoting awareness of a problem are often important components of an intervention, information alone is seldom sufficient to change behavior (Geller, 1992). However, provision of information and a strong rationale for an intervention program may increase the probability that participants will continue desired behaviors after the intervention has been withdrawn (Geller, 1989). Education and information have often been combined with other intervention components, and they have generally focused on the positive environmental impacts or personal savings achievable by increasing pro-environment behaviors.

In an intervention that combined educational information with commitment, Thompson and Stoutmeyer (1991) found that a message focusing on the long-term environmental consequences of water conservation was more effective in decreasing household water consumption than a message that focused solely on the personal economic benefits that could be gained from conservation. Similarly, Staats et al. (2000) found that office workers improved their energy-conserving behaviors (keeping thermostat settings consistent and removing objects from heating grates) immediately after an informational brochure was delivered. Later, other intervention components (poster prompts and feedback) were added to maintain these energy-conserving practices.

There is some evidence that information-based interventions tailored to fit specific situations may be more effective than general information. By using a pre-intervention survey to assess the procedures and behaviors leading to oil pollution in individual garages, Daamen, Staats, Wilke, and Engelen (2001) delivered tailored messages that specified how pollution could be minimized. They demonstrated that this approach was more effective than general messages about preventing oil pollution, which they sent to a group of comparable garages.

Prompting. Prompting strategies are verbal or written antecedent messages that designate desirable target behaviors. Geller et al. (1982) identified several conditions under which prompting strategies are most effective. Specifically, prompts work best when the target behavior is relatively easy to perform, clearly defined, and when the message is displayed in close proximity to the place where the target behavior can be performed. In addition, the message should be stated politely to avoid eliciting reactance (Brehm, 1972) or countercontrol (Skinner, 1971).

Prompts are an attractive intervention, since they can be relatively low cost, and can have considerable impact if used properly. By increasing the size, improving placement and clarifying instructions on signs, Werner, Rhodes, and Partain (1998) dramatically increased the rate of polystyrene recycling and decreased levels of contamination in a university cafeteria. Similarly, Austin et al. (1993) increased the rate of paper recycling by 54% over baseline by placing signs describing items appropriate for recycling and disposal over recycling bins and garbage cans. Simple prompting strategies have also been effective at increasing energy-conserving behaviors (Winett, 1978) and the proper disposal of litter (Durdan, Reeder, & Hecht, 1985).

Modeling. Modeling strategies involve demonstrating a desired pro-environment behavior to a target population. The outcome is observational learning (Bandura, 1967). Modeling can involve in vivo demonstrations, but reaches a broader audience through videotape or television. Although few pro-environment interventions have used modeling, Winett and colleagues demonstrated its utility in two studies designed to increase home energy conservation. Participants who viewed a 20-minute videotaped presentation of conservation behaviors significantly decreased their residential energy use over a nine-week period compared to controls (Winett, Leckliter, Chinn, & Stahl, 1984; Winett et al., 1985). More recently, McMakin et al. (2002) used videotaped

modeling as part of a multicomponent campaign to reduce the home energy use of residents at military bases.

Commitment. Commitment strategies involve asking participants to make a verbal or written commitment to perform a desired behavior. Once people have made a commitment, they are more likely to perform the target behavior, especially when the commitment is active, public, and perceived as voluntary (Cialdini, 2001). From a behaviorist perspective, honoring the commitment may be seen as a case of rule-governed behavior in which fulfilling a promise leads to positive internal consequences whereas breaking the rule leads to aversive consequences (Geller, 1995, 2001). Social psychologists would explain this phenomenon with the powerful social norm of consistency, which creates pressure to be internally and externally consistent (Cialdini, 2001).

Obtaining a behavioral commitment has been a component of many behavior-based interventions (e.g., Bachman & Katzev, 1982; Burn & Oskamp, 1986; Geller & Lehman, 1991). Pardini and Katzev (1983-1984) demonstrated that groups asked to make verbal or written commitments showed significantly higher rates of newspaper recycling than controls. Although written and verbal commitments led to similar results during the intervention period; during a two-week follow-up period, the written commitment was longer lasting, producing significantly higher recycling rates than the verbal commitment.

DeLeon and Fuqua (1995) demonstrated that combining a public commitment to recycle paper (participants' names were published in a local newspaper) with feedback resulted in a 40% increase in the weight of recycled paper for residents of an apartment complex. Werner et al. (1995) found that a written commitment to participate in a curbside recycling program resulted in greater rates of participation than informational brochures or face-to-face contact without a written commitment.

Environmental design. Another antecedent strategy for increasing pro-environmental behavior is the introduction of devices or objects into the environment that make opportunities for pro-environmental behavior more salient or convenient. Geller et al. (1980) decreased littering behavior and increased litter pick-up by creating trash receptacles that were aesthetically pleasing and placing them in convenient locations.

To increase the frequency of office paper recycling, Brothers, Krantz and McClannahan (1994) first placed a recycling container in a central location, which led to a 28% recycling rate. When recycling trays were subsequently placed on the desktops of employees, recycling increased to a rate of 85-94%, and was maintained for a seven-month period. Similarly, Ludwig et al. (1998) showed that moving recycling receptacles for aluminum cans from hallways into the classrooms where most of the drinks were consumed led to substantial increases in the collection of recyclable drink containers.

Consequence Strategies

According to Skinner (1987), consequences are the primary determinant of behavior. In fact, the antecedent strategies reviewed above are presumed to work by announcing the availability of consequences associated with pro-environment behavior. Researchers have primarily employed two consequence strategies for changing environmentally relevant behavior: rewards and feedback.

Rewards. Although behavior can be controlled through positive or negative consequences, environmental behaviorists have favored rewards over punishment because of the negative attitudes and countercontrol measures that can result from punishing consequences (Brehm, 1972; Skinner, 1971). During the 1970s, reward strategies were a popular component of environmental interventions. Fifty-five percent of the interventions reviewed by Geller et al. (1982) involved the use of tangible rewards, including monetary rewards and rebates, raffle coupons, toys, movie tickets and coupons for free beverages. In contrast, only 27% of the studies (15 of 54) from the 1980s reviewed by Dwyer et al. (1993) used rewards, and only 13% (4 of 32) environment-related studies published since 1990 used rewards.

Interestingly, the use of rewards has consistently led to notable behavior change, but the desired behaviors frequently dropped to baseline levels when the reward contingency was removed (Dwyer et al., 1993; Geller et al., 1982). Since most of the interventions that used rewards were relatively short in duration, it is possible the rewards were not in place long enough for other positive consequences intrinsic to pro-environmental behavior to take effect (Geller, 2002). In addition, intrinsic consequences that support pro-environmental behavior are not always available.

Feedback. A feedback strategy involves providing information to participants about their environment-relevant behaviors. Such data make the consequences of behavior (e.g., money spent, environmental degradation or protection) more salient, and increase the likelihood of behavior change corresponding with the consequences. Much of the early environment protection research employing feedback targeted home energy consumption and most interventions showed modest but consistent energy savings (Geller et al., 1982; Dwyer et al., 1993). The frequency with which feedback was provided varied from continuous feedback provided by special monitoring devices (Winett et al., 1982) to monthly feedback comparing the current month's use to previous years (Hayes & Cone, 1981).

In an innovative study that combined handwritten feedback to residents of his neighborhood about recycling rates and the promise of food donations to a homeless shelter when target recycling rates were met, (Keller, 1991) demonstrated a 19% increase in the rate of recycling in his intervention area, while rates in a control area remained relatively constant. Interestingly, Keller was only 10 years old when he conducted the study, demonstrating that research promoting actively caring for the environment and others need not be restricted to those who have or are pursuing a Ph.D.

Feedback has continued to be a popular intervention technique in more recent studies. On a university campus, Larson, Houlihan, and Goernert (1995) posted the

number of aluminum cans deposited in a recycling container over the previous week. Without any other persuasive environmental message, this intervention led to a 65% increase over baseline in the number of cans recycled.

Shultz (1998) found that group or individual feedback about curbside recycling amounts increased the recycling rates, while interventions using pleas and information-based strategies did not. In a study by DeLeon and Fuqua (1995), apartment residents given group feedback about their paper recycling behavior showed a 25% increase in the weight of recyclable paper collected relative to controls. Siero et al. (1996) found that providing workers with feedback about energy-wasting behaviors at their own and a comparison manufacturing plant led to greater decreases in energy-wasting behaviors than providing feedback about only their plant.

The studies described above indicate that behavior-based interventions can effectively improve environment-relevant behaviors. Although the impact of the interventions varied, the large-scale adoption and application of behavior analytic principles could ameliorate the negative impact human behavior has on the environment. Still, there is much more that could be done. The paragraphs that follow outline some ways to expand the positive impact of a behavior analytic approach to environmental protection.

CHOOSING BEHAVIORAL TARGETS

Gardner and Stern (1996) raised the question of whether environmental behaviorists have targeted the most important environmental problems. Or, have they focused their pro-environment interventions on behaviors that are most convenient to target? Considering the diverse threats to the earth's environment, the targets of behavioral interventions have been rather limited in scope. Published reviews of behavioral interventions to protect the environment (Dwyer et al., 1993; Geller et al., 1982) and the authors' informal review of studies published since reveal three primary targets for behavioral intervention: (a) increasing recycling-related behavior, (b) decreasing residential energy use, and (c) reducing environmental litter.

All of these are certainly worthy targets. Increasing recycling means less garbage in landfills, fewer natural resources are depleted since materials are being reused, and less greenhouse gas is produced (since it takes less energy to recycle old materials than to create new ones). Decreasing home energy use is also important, as 36% of all electricity is used in residences, and most electricity consumed in the United States is generated by burning fossil fuels (Energy Information Administration, 2003b). Finally, littering is a significant problem that is unsightly and poses a potential threat to the health of humans and wildlife.

In addition to being worthy targets, recycling, decreasing home energy use and reducing litter are relatively convenient to measure objectively and to target for change. Litter and recyclables can be measured and weighed, and home energy use can be read from a meter. However, other target behaviors could yield greater environmental benefits, but may be more challenging to influence.

Consider recycling, for example, and the mantra: "Reduce, Reuse, Recycle." Most of us have probably heard this enough to consider it a cliché, but it is a valuable heuristic for what can be done to preserve the environment. The order is important, as it suggests three levels of intervention impact. Reduce is listed first, because reducing consumptive behavior has the greatest environmental impact. Second, when we do consume, it is best to purchase products that can be used more than once, or to find creative ways to reuse one-time-use commodities. Finally, we should recycle what we cannot reuse.

Gardner and Stern (1996) point out that by focusing on litter and recycling, we are focusing on the end of the waste stream instead of reducing consumption, which would lead to the greatest benefits. Very few studies have attempted to intervene at the consumption and reuse levels. Some examples are Geller et al.'s (1973) intervention to encourage shoppers to choose returnable bottles, and DeYoung et al.'s (1993) intervention to encourage consumers to purchase products with minimal packaging, and cleaning products without harmful chemicals. DeYoung et al. did note the methodological challenges inherent in research aimed at reduction. For example, their attempt to quantify source reduction based on shopping receipts failed, requiring them to rely on self-reports.

More research on source reduction is needed, as there are opportunities for creativity and positive environmental impact. If patterns of purchasing could be altered on a large scale to favor products with minimal packaging and less harmful chemicals, companies would likely respond by producing products that are more environmentally friendly. After all, the behavior of decision makers within companies is also controlled by the three-term contingency, and increased profits should be reinforcing for them.

Stern (2000) and others explain that corporations are responsible for more environmental degradation than are individuals, and that changing individual behaviors addresses only a mere fraction of the environmental crisis. By promoting source reduction through purchasing behaviors, psychologists would support a form of consumer activism that begins to address this problem. Although it would be a radical departure from past targets, perhaps a broader form of social activism should be a target for future interventions. For example, implemented on a large scale, interventions that encourage citizens to limit their stock investments to green companies, vote for pro-environment candidates, and boycott the most serious polluters could contribute to making corporate behavior more environmentally friendly.

MAINTAINING PRO-ENVIRONMENT BEHAVIOR

Long-term behavior maintenance has been a thorny problem for behaviorists attacking environmental problems, and may be one of the reasons why behavioral interventions have not attracted wider appeal and application. Most of the studies reviewed by Geller et al. (1982) and Dwyer et al. (1993) used relatively short intervention periods and after the intervention was withdrawn, the target behavior usually returned to baseline levels. This research suggests three potential solutions

to the challenge of long-term maintenance: (a) focus on behaviors that do not need to be maintained, (b) implement intervention evaluations of appropriate length and design so factors which increase response maintenance can be discovered, and (c) design interventions that can continue indefinitely.

Curtailment vs. Efficiency Behaviors

Not all pro-environment behaviors need to be maintained for long periods of time in order to have beneficial effects. Gardner and Stern (1996) distinguished between curtailment and efficiency behaviors. Curtailment behaviors involve reducing consumption, and require repeated action and response cost in order to be effective (e.g., reducing vehicle use through increased use of public transportation or carpooling). In contrast, efficiency behaviors are one-time behaviors involving the adoption of efficient technologies that reap repeated benefits with continued use (e.g., purchasing a fuel efficient vehicle). To date, most environmental behaviorists have targeted behaviors that require repeated action. Large-scale interventions that focus on increasing one-time efficiency behaviors could have powerfully beneficial effects on the environment while obviating the need for maintenance.

Currently, technology exists that could dramatically reduce the amount of energy we consume. For example, the EPA sponsors a program called "Energy Star," which identifies the most energy efficient products on the market. According to the Energy Star website, the average household could save about 30% of energy costs (approximately $400) by switching to more efficient appliances for heating and lighting (Energy Star, 2003). The savings to the environment would be dramatic. The EPA estimates that if every American home would convert the lighting of just one room to efficient compact fluorescent lighting, 800 billion kWh of energy would be saved and the release of a trillion pounds of greenhouse gasses would be prevented.

Despite their great potential, compact fluorescent lights (CFLs) have not yet been adopted on a wide scale. Barriers impeding large-scale adoption may include the fact that CFLs cost ten times more than incandescent bulbs (an immediate consequence), while the monetary savings over the five-year life of the bulb ($30-$50) and the environmental benefits are remote and relatively invisible.

Applying a behavior analytic approach to increase the purchase of CFLs and other more efficient technologies could result in dramatic savings for both consumers and the environment. For a dramatic example of the savings possible through CFL adoption, the reader is referred to Howard, Delgado, Miller, and Gubbins (1993). Their article provides details of a successful campaign to convince the University of Notre Dame to use CFLs in university dormitories.

Research Response-Maintenance

Not all environmental problems can be solved through the adoption of more efficient technology. Behaviors such as recycling need to be sustained over long periods of time, and the curtailment of environmentally harmful actions is also

important. Another way to address the problem of maintenance is to make response maintenance the focus of programmatic research. It seems especially crucial to find ways to improve response maintenance with reward-based interventions, which have been shown to have powerful effects on the initiation of desired behavior, but not on its duration.

Based on a comprehensive review of behavior-change strategies to improve industrial safety, Boyce and Geller (2001) identified three key factors related to behavioral maintenance, and in need of systematic research: (a) Reward schedules should be large enough to get a behavior started, but not so large as to serve as complete justification for performing a behavior; (b) Representations of the kind of behavior required to earn a reward should be more general than specific; and (c) When a behavioral commitment is requested, it should be accompanied by information that provides a sound rationale for the behavior.

Although the studies reviewed by Boyce and Geller were in the domain of organizational safety, the findings are relevant for environmental protection. Each of the three principles could serve to facilitate a transition from behavior controlled by extrinsic consequences to control by intrinsic and internal consequences (Geller, 2001) or rule-governed behavior (Malott, 1992). Although these recommendations are a useful starting point, the need for follow-up research is obvious. A systematic study of response maintenance requires that intervention periods be extended beyond the short demonstration period typifying previous research.

Permanent Interventions

The challenge of maintenance can also be addressed by implementing interventions that do not need to be discontinued. One way to do this is through environmental design as discussed above. Another approach is institutionalization, which Boyce and Geller (2001) defined as the "continuation of program-related contingencies by on-site workers after the outside intervention agents or researchers have left the setting" (p. 33). If reward, feedback or prompting strategies are cost-effective, there is no reason why they cannot be continued indefinitely. Bottle bills, which provide incentives for returning plastic and aluminum beverage containers, are an example of an incentive/reward program that is institutionalized in 10 states. Empirical studies have shown that bottle bills have led to increased recycling and decreased littering (Levitt & Leventhal, 1986).

In order to make a large-scale contribution toward environmental preservation, researchers must first design efficient and cost-effective interventions, demonstrate their utility through research and then "pitch" them to the proper authorities. This final step is an element of effective dissemination, a process meriting further discussion.

THE CHALLENGE OF DISSEMINATION

In his 1990 editorial titled "Where Have All the Flowers Gone?" Geller identified the failure of effective dissemination of behavior-change technology as a

primary reason for the limited impact of applied behavior analysis in solving environmental problems. "Controlled by local contingencies for tenure and promotion…we published our strategies for environmental protection in journals and textbooks read only by other behavioral scientists or their students, and we presented our research only at psychology conferences" (p. 272). Unfortunately, this quote from over a decade ago rings true today.

The publication of interventions in scholarly journals seems to be the most powerful reinforcer controlling the behavior of most academics and a marker for closure and completion of a study. If behavioral strategies for environmental preservation are ever to make a substantial contribution, this must be only the beginning. Concerted efforts are needed to communicate the practical implications of research findings to policy makers and community leaders, and encourage their application. Of course, we could also work to change the contingencies controlling our behavior. Qualitative accounts of efforts to get programs adopted may not be standard fare for journals, but perhaps they should be (cf. Finney, 1991).

Geller (1989) has advocated integrating applied behavior analysis and social marketing in order to maximize dissemination and adoption. In the same paper, he outlines important aspects of dissemination, including: (a) developing an interdisciplinary support network of researchers, practitioners, corporate leaders, community volunteers and government personnel who are concerned with the target behavior; (b) exchanging jargon free, practical information with policymakers and grassroots organizations; (c) documenting research findings in publications (including periodicals and newsletters) that reach people who are concerned with the target problem; (d) using the news media to sell cost-effective interventions; and (e) gaining support from the private sector.

Through personal experience, we have found that the media can be extremely open to stories about pro-environment behavior. For example, in order to combine research with service, our Center for Applied Behavior Systems "adopted" a section of the New River for litter pick up. In order to determine the content of the litter, we constructed a trash histogram with three-foot wide bars constructed of different kinds of litter. A quick email with digital image attachments led to a telephone interview with a reporter and a two-page spread in the local newspaper a few days later (Hoffman, 2002).

McKenzie-Mohr (2000) devised a pragmatic approach to implementing and promoting programs to encourage pro-environmental action that he has labeled "community-based social marketing." After selecting a target behavior, his approach involves a careful analysis of the barriers that prevent the desired behavior, piloting a community-wide intervention plan with a small segment of the community, and finally, implementing and evaluating a community-wide application. Noting that it is unrealistic to expect program planners to read psychological literature, McKenzie-Mohr calls upon psychologists to make the information accessible to community leaders. McKenzie-Mohr has answered his own call for dissemination by collaborating with colleague Jay Kassirer to create a website that (a) outlines behavior change techniques based on behavioral and social psychological principles, (b) provides case studies of successful

interventions, and (c) offers a planning guide with organizational tools for creating a successful intervention. We encourage readers to view the website at www.toolsofchange.com and take advantage of this synthesis of behavioral interventions to protect the environment.

Finally, a strategy that could address both the need for dissemination and the problem of maintenance is to imbed research interventions within environmental organizations from the outset. It is likely that positive environmental outcomes are a significant reinforcer for the behavior of members of environmental groups. This should increase the chances that successful interventions will continue after researchers move on to new ideas and problems. This is also a proactive way of addressing the problem of dissemination. Rather than focusing on producing effective interventions in a vacuum and then "selling" the results to the proper groups, group members will have first-hand knowledge of the effectiveness of interventions and how to implement and maintain them.

IN CONCLUSION

Given that environmental degradation threatens the well-being of all inhabitants of our planet, environmental preservation may be one of the most important social issues of our time. This paper has reviewed behavioral interventions that attempted to increase pro-environment behaviors and decrease environment-destructive and/or wasteful behavior. The review has shown that behavioral technology can help significantly to protect our environment for future generations.

Despite the demonstrated power of behavioral technology, the publication of behavioral interventions to preserve the environment has declined over the past decade, while environmental attitude research has flourished. Just as the first Earth Day served as an activator for behavior analysts to apply their craft to the problem of environmental degradation, the current "decade of behavior" (Carpenter, 2000) should serve as an activator for renewed efforts to find behavioral solutions to environmental problems. Although attitude research is important, it is critical to address the behavior that is so often the root of the problem and the best target for a solution.

By expanding the scope of behavioral targets, addressing the problem of long-term maintenance, and broadly disseminating what we have learned, a revitalized behavior analytic approach may reach its potential to help preserve the environment.

REFERENCES

Abramovitz, J. N., & Mattoon, A. T. (1999). Reorienting the forest products economy. In L. R. Brown, C. Flavin, H. French, J. Abramovitz, S. Dunn, G. Gardner, et al. (Eds.), *State of the world 1999* (pp. 60-77). New York: Norton.

Austin, J., Hatfield, D. B., Grindle, A. C., & Bailey, J. S. (1993). Recycling in office environments: The effects of specific, informative cues. *Journal of Applied Behavior Analysis, 26*, 247-253.

Bachman, W., & Katzev, R. (1982). The effect of non-contingent free bus tickets and personal commitment on urban bus ridership. *Transportation Research*, 16A, 103-108.

Bamberg, S. (2002). Effects of implementation intentions on the actual performance of new environmentally friendly behaviours – Results of two field experiments. *Journal of Environmental Psychology, 22,* 399-411.

Bandura, A. (1967). *Social learning theory.* Englewood Cliffs, New Jersey: Prentice-Hall.

Boyce, T. E., & Geller, E. S. (2001). Applied behavior analysis and occupational safety: The challenge of response maintenance. *Journal of Organizational Behavior Management, 21*, 31-60.

Brandon, G., & Lewis, A. (1999). Reducing household energy consumption: A qualitative and quantitative field study. *Journal of Environmental Psychology, 19,* 75-85.

Brehm, J. (1972). *Responses to loss of freedom: A theory of psychological reactance.* New York: General Learning Press.

Brothers, K. J., Krantz, P. J., & McClannahan, L. E. (1994). Office paper recycling: A function of container proximity. *Journal of Applied Behavior Analysis, 27,* 153-160.

Brown, L. R., & Flavin, C. (1999). A new economy for a new century. In L. R. Brown, C. Flavin, H. French, J. Abramovitz, S. Dunn, G. Gardner, et al. (Eds.), *State of the world 1999* (pp. 3-21). New York: Norton.

Burgess, R. L., Clark, R. N., & Hendee, J. C. (1971). An experimental analysis of anti-littering procedures. *Journal of Applied Behavior Analysis, 4*, 71-75.

Burn, S. M., & Oskamp, S. (1986). Increasing community recycling with persuasive communication and public commitment. *Journal of Applied Social Psychology, 16*, 29-41.

Carpenter, S. (2000). Behavioral science claims the decade. *APA Monitor on Psychology, 31*, 22-26.

Cialdini, R. B. (2001). *Influence science and practice.* Boston: Allyn and Bacon.

Cohen, J. E. (2003). Human population: The next half century. *Science, 302,* 1172-1175.

Cone, J. D., & Hayes, S. C. (1980). *Environmental problems: Behavioral solutions.* Monterey, California: Brooks/Cole Publishing Company.

Crump, S. L., Nunes, D. L., & Crossman, E. K. (1977). The effects of litter on littering behavior in a forest environment. *Environment and Behavior, 9,* 137-146.

Daamen, D. D. L., Staats, H., Wilke, H. A. M., & Engelen, M. (2001). Improving environmental behavior in companies: The effectiveness of tailored versus nontailored interventions. *Environment and Behavior, 33*, 229-248.

DeLeon, I. G., & Fuqua, R. W. (1995). The effects of public commitment and group feedback on curbside recycling. *Environment and Behavior, 27,* 233-250.

De Young, R., Boerschig, S., Carney, S., Dillenbeck, A., Elster, M., Horst, S., Kleiner, B., & Thompson, B. (1995). Recycling in multi-family dwellings: Increasing participation and decreasing contamination. *Population and Environment: A Journal of Interdisciplinary Studies, 16,* 253-267.

De Young, R., Duncan, A., Frank, J., Gil, N., Rothman, S., Shenot, J., Shotkin, A., & Zweizig, M. (1993). Promoting source reduction behavior: The role of motivational information. *Environment and Behavior, 25*, 70-85.

Durdan, C. A., Reeder, G. K., & Hecht, P. R. (1985). Litter in a university cafeteria: Demographic data and the use of prompts as an intervention strategy. *Environment and Behavior, 17,* 387-404.

Dwyer, W. O., Leeming, F.C., Cobern, M.K., Porter, B.E., & Jackson, J. M. (1993). Critical review of behavioral interventions to preserve the environment: Research since 1980. *Environment and Behavior, 25,* 485-505.

Energy Information Administration, (2003a). *Electricity Generation and Environmental Externalities: Case Studies.* Retrieved July 18 from http://www.eia.doe.gov/cneaf/electricity/external/external_sum.html

Energy Information Administration, (2003b). *Estimated U.S. electric utility retail sales of electricity to ultimate consumers by sector, census division, and state, year to date (December) 2002 and 2001.* Retrieved July 18, 2003 from http://www.eia.doe.gov/cneaf/electricity/epm/epmt47p1.html

Energy Star, (2003). *Buy products that make a difference.* Retrieved June 17, 2003 from http://www.energystar.gov/index.cfm?c=products.pr_index

Finney, J. W. (1991). On further development of the concept of social validity. *Journal of Applied Behavior Analysis, 24*, 245-249.

Flavin, C., & Dunn, S. (1999). Reinventing the energy system. In L. R. Brown, C. Flavin, H. French, J. Abramovitz, S. Dunn, G. Gardner, et al. (Eds.), *State of the world 1999* (pp. 22-40). New York: Norton.

Foxx, R. M., & Hake, D. F. (1977). Gasoline conservation: A procedure for measuring and reducing the driving of college students. *Journal of Applied Behavior Analysis, 10,* 61-74.

Gardner, G. T., & Stern, P. C. (1996). *Environmental problems and human behavior.* Boston: Allyn & Bacon.

Geller, E. S. (1989). Applied behavior analysis and social marketing: An integration to preserve the environment. *Journal of Social Issues, 45,* 17-36.

Geller, E. S. (1990). Behavior analysis and environmental protection: Where have all the flowers gone? *Journal of Applied Behavior Analysis, 23*, 269-273.

Geller, E. S. (1992). It takes more than information to save energy. *American Psychologist, 47*, 814-815.

Geller, E. S. (1995). Integrating behaviorism and humanism for environmental protection. *Journal of Social Issues, 51,* 179-195.

Geller, E. S. (2001). *The psychology of safety handbook*. Boca Raton, FL: CRC Press.

Geller, E. S. (2002). The challenge of increasing proenvironmental behavior. In R. B. Betchel, & A. Churchman (Eds.), *Handbook of environmental psychology* (pp. 525-540). New York: John Wiley & Sons.

Geller, E. S., Brasted, W., & Mann, M. (1980). Waste receptacle designs as interventions for litter control. *Journal of Environmental Systems, 9,* 145-160.

Geller, E. S., Farris, J. C., & Post, D. S. (1973). Promoting a consumer behavior for pollution control. *Journal of Applied Behavior Analysis, 6,* 367-376.

Geller, E. S., & Lehman, G. R., (1991). The buckle-up promise card: A versatile intervention for large-scale behavior change. *Journal of Applied Behavior Analysis, 24*, 91-94.

Geller, E. S., Winett, R. A., & Everett, P. B. (1982). *Environmental preservation: New strategies for behavior change.* New York: Pergamon Press.

Geller, E. S., Witmer, J. F., & Orebaugh, A. L. (1976). Instructions as a determinant of paper-disposal behaviors. *Environment and Behavior, 8*, 417-438.

Geller, E. S., Witmer, J. F., & Tuso, M. E. (1977). Environmental interventions for litter control. *Journal of Applied Psychology, 62*, 344-351.

Hayes, S. C., & Cone, J. D. (1981). Reduction of residential consumption of electricity through simple monthly feedback. *Journal of Applied Analysis of Behavior, 14*, 81-88.

Hayes, S. C., Johnson, V. S., & Cone, J. D. (1975). The marked item technique: A practical procedure for litter control. *Journal of Applied Behavior Analysis, 8,* 381-386.

Hoffman, J. (2002, November 15). Beer cans, used diapers and underwear. What's in that trash? *The Roanoke Times, New River Valley Current*, pp. 1, 11.

Howard, G. S., Delgado, E., Miller, D., & Gubbins, S. (1993). Transforming values into actions: Ecological preservation through energy conservation. *The Counseling Psychologist*, 21, 582-596.

Intergovernmental Panel on Climate Change (2001). *Climate change 2001. Vol. 4: Synthesis report.* Cambridge: Cambridge University Press.

Jacobs, H. E., Fairbanks, D., Poche, C. E., & Bailey, J. S. (1982). Multiple incentives in encouraging car pool formation on a university campus. *Journal of Applied Behavior Analysis, 15,* 141-149.

Keller, J. J. (1991). The recycling solution: How I increased recycling on Dilworth Road. *Journal of Applied Behavior Analysis, 24*, 617-619.

Larson, M. E., Houlihan, D., & Goernert, P. N. (1995). Effects of informational feedback on aluminum can recycling. *Behavioral Interventions, 10*, 111-117.

Levitt, L., & Leventhal, G. (1986). Litter reduction: How effective is the New York State bottle bill? *Environment and Behavior, 18,* 467-479.

Ludwig, T. D., Gray, T. W., & Rowell, A. (1998). Increasing recycling in academic buildings: A systematic replication. *Journal of Applied Behavior Analysis, 31,* 683-686.

Malott, R. W. (1992). A theory of rule-governed behavior and organizational behavior management. *Journal of Organizational Behavior Management, 12*, 45-65.

Mayer, J., & Geller, E. S. (1982-1983). Motivating energy efficient travel: A community-based intervention for encouraging biking. *Journal of Environmental Systems, 12,* 99-112.

McKenzie-Mohr, D. (2000). Fostering sustainable behavior through community-based social marketing. *American Psychologist, 55,* 531-537.

McMakin, A. H., Malone, E. L., & Lundgren, R. E., (2002). Motivating residents to conserve energy without financial incentives. *Environment and Behavior, 34*, 848-836.

Needleman, L. D., & Geller, E. S. (1992). Comparing interventions to motivate work-site collection of home-generated recyclables. *Journal of Community Psychology, 20*, 775-785.

O'Neill, G. W., Blanck, L. S., & Joyner, M. A. (1980). The use of stimulus control over littering in a natural setting. *Journal of Applied Behavior Analysis, 13,* 379-381.

Oskamp, S. (2000). A sustainable future for humanity? How can psychology help? *American Psychologist, 55*, 496-508.

Pardini, A. U., & Katzev, R. D. (1983-1984). The effect of strength of commitment on newspaper recycling. *Journal of Environmental Systems, 13,* 245-254.

Powers, R. B., Osborne, J. G., & Anderson, E. G. (1973). Positive reinforcement of litter removal in the natural environment. *Journal of Applied Behavior Analysis, 6,* 579-586.

Runnion, A., Watson, J. D., & McWhorter, J. (1978). Energy savings in interstate transportation through feedback and reinforcement. *Journal of Organizational Behavior Management, 1,* 180-191.

Sampat, P. (2003). Scrapping mining dependence. In L. Starke (Ed.) *State of the World 2003* (pp. 60-77). New York: Norton.

Schultz, P. W. (1998). Changing behavior with normative feedback interventions: A field experiment on curbside recycling. *Basic and Applied Social Psychology, 21,* 25-36.

Siero, F. W., Bakker, A. B., Dekker, G. B., & van den Burg, M. T. C. (1996). Changing organizational energy consumption behaviour through comparative feedback. *Journal of Environmental Psychology, 16,* 235-246.

Skinner, B. F. (1971). *Beyond freedom and dignity.* New York: Knopf.

Skinner, B. F. (1987). *Upon further reflection.* Englewood Cliffs, NJ: Prentice-Hall.

Staats, H., van Leeuwen, E., & Wit, A. (2000). A longitudinal study of informational interventions to save energy in an office building. *Journal of Applied Behavior Analysis, 33,* 101-104.

Stern, P. C. (2000). Psychology, sustainability, and the science of human-environment interactions. *American Psychologist, 55,* 523-530.

Thomas, C. D., Cameron, A., Green, R. E., Bakkenes, M., Beaumont, L. J., Collingham, Y. C. et al. (2004). Extinction risk from climate range. *Nature, 427,* 145-148.

Thompson, S. C., & Stoutemyer, K. (1991). Water as a commons dilemma. The effects of education that focuses on long-term consequences and individual action. *Environment and Behavior, 23,* 314-333.

Tuxill, J. (1999). Appreciating the benefits of plant biodiversity. In L. R. Brown, C. Flavin, H. French, J. Abramovitz, S. Dunn, G. Gardner, et al. (Eds.), *State of the world 1999* (pp. 96-114). New York: Norton.

United Nations Environment Programme (2002). *Fact Sheet, North America. Global Environment Outlook-3.* Retrieved July 18, 2003 from http://www.unep.org/geo/pdfs/GEO-3%20Fact%20sheet%20N%20America.pdf

United Nations Population Division (2002). *World population projections: The 2002 revision.* Retrieved January 9, 2003 from http://esa.un.org/unpp/

U. S. Environmental Protection Agency (2002). *Should I eat the fish I catch? A guide to healthy eating for women and children.* Retrieved January, 2004 from http://www.epa.gov/ost/fish/fishwomenchildren.pdf

U. S. Environmental Protection Agency (2003a). *Basic facts: Municipal solid waste.* Retrieved June 17, 2003 from http://www.epa.gov/epaoswer/non-hw/muncpl/facts.htm

U. S. Environmental Protection Agency (2003b). *Update: National listing of fish and wildlife advisories.* Retrieved January 6, 2004 from http://www.epa.gov/waterscience/fish/advisories/factsheet

Werner, C. M., Turner, J., Shipman, K., Twitchel, F. S., Dickson, B. R., Bruschke, G. V., & von Bismark, W. B. (1995). Commitment, behavior and attitude change: An analysis of voluntary recycling. *Journal of Environmental Psychology, 15,* 197-208.

Werner, C. M., Rhodes, M. U., & Partain, K. K. (1998). Designing effective instructional signs with schema theory: Case studies of polystyrene recycling. *Environment and Behavior, 30,* 709-735.

Winett, R. A. (1978). Prompting turning-out lights in unoccupied rooms. *Journal of Environmental Systems, 6,* 237-241.

Winett, R. A., Hatcher, J. W., Fort, T. R., Lecklitter, I. N., Love, S. Q., Riley, A. W., & Fishback, J. A. (1982). The effects of videotape modeling and daily feedback on residential electricity conservation, home temperature and humidity, perceived comfort, and clothing worn: Summer and Winter. *Journal of Applied Behavior Analysis, 15*, 381-402.

Winett, R. A., Leckliter, I. N., Chinn, D. E., & Stahl, B. (1984). Reducing energy consumption: The long-term effects of a single TV program. *Journal of Communication, 34,* 37-51.

Winett, R. A., Leckliter, I. N., Chinn, D. E., Stahl, B., & Love, S. Q. (1985). Effects of television modeling on residential energy conservation. *Journal of Applied Behavior Analysis, 18,* 33-44.

Winter, D. D. (1996). *Ecological psychology: Healing the split between planet and self.* New York: Harper Collins.

World Health Organization (2002). *The world health report 2002.* Geneva: World Health Organization.