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ANALYSIS OF DELAY DISCOUNTING AS A PSYCHOLOGICAL MEASURE OF SUSTAINABLE BEHAVIOR

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ABSTRACT: As concerns regarding the current and future state of the planet continue to grow, the need to understand the behavioral mechanisms that underlie behaviors linked to large-scale delayed outcomes becomes more critical. Delay discounting refers to decline in the subjective value of stimuli as the delay-interval to access those stimuli increases. In this article, the relevance of delay discounting to issues of sustainability is explored, in addition to other relevant behavioral explanations of the issue. The research on delay discounting and related processes is summarized, specifically research that relates discounting and sustainability issues. Implications for behavior change and future research are discussed.
KEYWORDS: delay discounting, sustainability, choice, decision-making, behavior analysis

Sustainability has been generally defined as behavior "…that meets the needs of the present without compromising the ability of future generations to meet their own needs" (World Commission on Environment and Development, 1987). There is a pressing challenge to increase sustainable development across realms of the environment, economy, and social/political landscape, as people all over the globe struggle with poor water quality, threat of natural disasters, extreme poverty, lack of access to quality food, education, and healthcare, and an ever-expanding population affecting the earth's natural resources (The Earth Institute, 2014). Underlying these sustainability issues is the impact of human behavior, including actions, inactions, communication, and decisions that have a direct effect on sustainability issues. These human behaviors include, but are not limited to, policy decisions by political leaders, production and resource allocation policies by businesses, and consumption patterns by consumers. Delay discounting, a measure of an individual's endorsement of long-term consequences as opposed to

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short-term consequences, represents a crucial choice process that underlies behavioral sustainability issues across the above examples. Delay discounting, thus, provides a conceptual framework for understanding and taking action on the human behavioral components at the core of sustainability issues. This is an area in need of more research, as sustainability-related global problems continue to grow, and behavior change toward sustainable outcomes is not occurring fast enough to counteract what could be the permanently devastating effects of unsustainable behavior.

Behavior Analytic Conceptualizations of Sustainability Issues

While the application of empirically-derived behavioral principles and interventions to sustainability issues has increased in the past several years, much of this recent literature is conceptual and theoretical, explaining how behavior analytic concepts and principles might be used to solve sustainability problems (see Heward & Chance, 2010); many of these same arguments were made by Skinner (1987) almost 30 years ago, and have been revisited in the literature (Rumph, Ninness, McCuller, & Ninness, 2005; Chance, 2007), but without a dramatic outcome in terms of tangible, meaningful change. A possible reason for this is that the theoretical framework, while powerful, may still be incomplete or difficult to translate into practice.

However, there have been many studies conducted over the years, across disciplines, which have implemented interventions aimed at changing behavior related to sustainability goals (see Lehman & Geller, 2004; Osbaldiston & Schott, 2012, for reviews); a large portion of the research is confounded by the use of unsystematically-evaluated, multi-intervention packages which obfuscate the underlying mechanisms implicated in behavior change. Furthermore, much of this research pertains to specific, small-scale interventions rather than large-scale, sustained interventions that could have a meaningful impact on sustainability issues. Another related issue is the failure of interventions to include plans for maintenance, or long-term follow-up probes that assess the extent to which the programmed behavior change maintains over time. It is important to note, however, that small-scale interventions and research on the related behavioral processes lay the necessary foundation for large-scale applications of those interventions and processes (see Luke & Alavosius, 2012). Thus, further research on the relevant behavioral processes that evoke or mitigate sustainable behavior should lead to function-based interventions or tools that can be applied on larger scales.

Comprehensive behavioral models are necessarily complex; sustainable behavior encompasses several multi-layered levels of analysis, and, by nature, involves large delays and net consequences (Glenn, 2004; Heward & Kimball, 2013; Malott & Glenn, 2006; c.f., Malott, 1988). Although behavioral models are often simplified to discussions of consequences, even that most basic process (e.g., reinforcement) is more complex than diagrams depict (although diagrams are helpful for some basic understanding that can be further put in context). Simplifying the models for the sake of conciseness likely involves omitting or ignoring information that may be functional and necessary, unless pragmatic analyses of data show otherwise. The challenge toward implementation is two-fold: 1) simplified versions are insufficient to address complex, interwoven sustainability problems, and 2) behavioral models are not the norm.

Within the field of psychology, analysis of, and intervention for, sustainability problems are being attempted through conceptually varied and often incompatible multidisciplinary approaches; much of the psychological literature is based on models from more mainstream

cognitively-oriented psychology (see Stern, 2000), which emphasize the role of thoughts, feelings, and attitudes, and how those constructs are correlated with future pro- or un-sustainable behavior (Heward & Kimball, 2013; Newsome & Alavosius, 2011). Within these models, it is assumed that thoughts, feelings, and attitudes are the cause of behavior (e.g., "I think about how I should be a better steward for the environment, and thus, I do not drive").

Within behavioral models, however, behaviors such as thoughts are shaped in tandem with overt behavior in complex ways. The processes of operant learning are at the source of thoughts and overt behavior, although relations among behaviors can short-circuit the process, so classes of behaviors are able to appear from minimal explicit reinforcement. For the sake of example, environmentally relevant behavior (ERB; Newsome & Alavosius, 2011) could occur overtly and with correlate thoughts, which then serve as precursors to any similar subsequent thoughts, feelings, and/or attitudes, which, in turn, would serve as an antecedent for future evoked sustainable behavior. That is, cleaning up litter in the woods might contact approval from others (social reinforcement) and evoke the complimentary thought, "I am doing good things for the environment," which would likely be reinforced by feelings of happiness (automatic reinforcement, perhaps elicited, as the thoughts could also function as respondent conditioned stimuli). In the future such related thoughts (e.g., "I really enjoyed helping out in the woods") might serve as an antecedent for, or occur alongside, sustainable behavior, and act as a discriminative stimulus or other context cue for self- or automatic reinforcement for environmentally relevant behavior; these patterns would, therefore, represent a cycle of overt behaviors and covert thoughts/feelings that propel future sustainable thoughts/behavior. In these examples, we have discussed environmentally relevant behavior as an operant class for the sake of clarity; in reality, the processes may be the result of relations made in the course of the behaver's history, though not specifically related to sustainability (e.g., social reinforcement for drawing a picture may bring some ERB to strength, due to relations between drawing and being outside in nature, or between the source of the reinforcement and being outside, and so on).

With respect to the processes that might evoke or mitigate sustainable behavior, there are many other relevant issues that may be necessary for a functional model (see Chance, 2007; Grant, 2010, for a synthesis of factors related to sustainability supported by behavior analytic literature). One issue is that knowledge about future aversive consequences (e.g., predictions about dire environmental outcomes associated with global warming) does not necessarily lead to adaptive behavior, especially if a person has no past reinforcing experience with that behavior, the behavior is effortful, or competes with established behavior (including rules and preferences) or a combination of these factors. As a result, warnings and predictions sometimes produce the unintended consequence of encouraging people to simply escape or avoid the dire predictions (Skinner, 1987). Thus, awareness alone is not sufficient to alter sustainable behaviors and, in some instances, can actually contribute to the problem if people avoid discussions about, and planning for, a sustainable future. Todorov (2010) suggested that behavior analysts should be directing the people in their environments to more immediate consequences, such as those associated with pollution of the near environment. Todorov argued that the focal point of motivating sustainable behavior should be on what affects indifferent communities (e.g., recycling, public transportation, etc.) as opposed to the long-term, dire "end of the world" outcomes that global warming threatens.

Additionally, the promotion of sustainable behavior poses a unique challenge, as sustainability is an outcome that is difficult to quantify and that depends on the pro-active behavior of many. A critical issue involves that the "normal" behavior of many is unsustainable.

When humans are asked to change current behaviors of which the most detrimental consequences are likely to occur sometime in the temporally distant and uncertain future, the change is unlikely. The large delay between a person's unsustainable behavior and any direct negative (environmental or otherwise) critical consequences (e.g., running out of clean water or air) is likely to have little effect on behavior when more immediate consequences control incompatible behavior; see Figure 1 for an illustrative example. Furthermore, the consequences would also likely affect the lives of people that are socially and temporally distant from the "behaver" (e.g., behaver's grandchildren) and people who might be unknown and theoretically unimportant to the behaver (e.g., people who share the biosphere but never interact with the behaver) (a more detailed account of this issue is addressed in the following section of the paper discussing discounting).

On the other side of the spectrum, many instances of relevant pro-sustainable behavior may contact immediate aversive consequences (e.g., rationing water, the increasing price of gasoline); this may produce an immediate reduction in comfort and/or reinforcement and an increase in response effort. This can offset the delayed and probabilistic environmental consequences that are critically important for long-term survival and well-being of organisms on the planet.

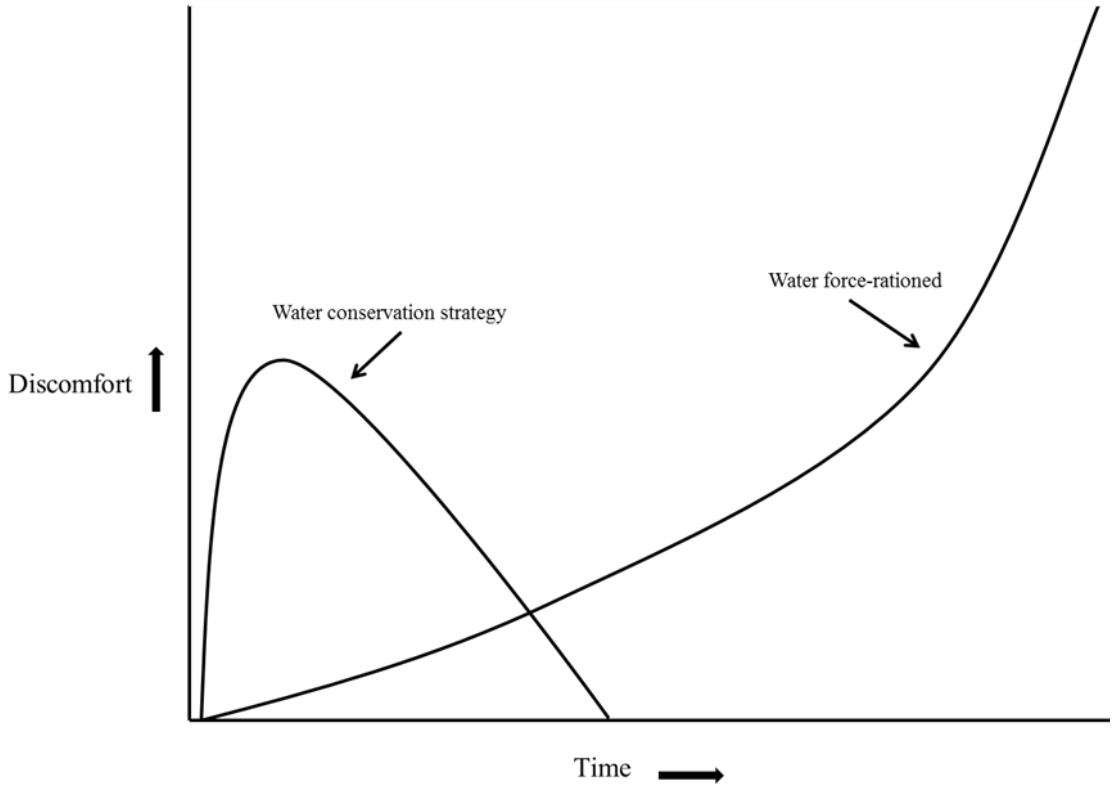

Figure 1. Hypothetical diagram of subjective discomfort from a sustainable water conservation strategy versus long-term inaction resulting in water shortage and forced rationing. The conservation strategy is initially uncomfortable, but with water still available, a behaver's comfort level adjusts back to baseline. Whereas when water is force-rationed, discomfort only continues to rise as lack of water leads to foraging and varied behavior.

Engaging in pro-sustainable behavior has very delayed, though positive, consequences in the absence of directly engineered contingencies of reinforcement (see Figure 2). Thus, the amount of immediate reinforcement available for engaging in sustainable behavior is likely to be less than the amount of reinforcement for engaging in less sustainable activities. This becomes even more apparent to a behaver when faced with a choice between the two; the less sustainable choice is rewarding simply due to lower response effort and achieving short-term outcomes. The availability of large magnitude but delayed reinforcement for sustainable behavior does not consistently tip the choice in its favor. Appropriately, Grant (2010) argued that what is necessary for a consumer culture that supports a sustainable society is a balancing act in which the use of resource-intensive reinforcers is minimized and resource-light stimuli are increased and/or made to be more potent reinforcers for behaviors (via verbal transformation of stimulus function, for example). A pragmatic examination of choice, including precise, quantifiable measures, and an analysis of the verbal and environmental stimuli that mediate the behavior, may assist in changing these contingencies.

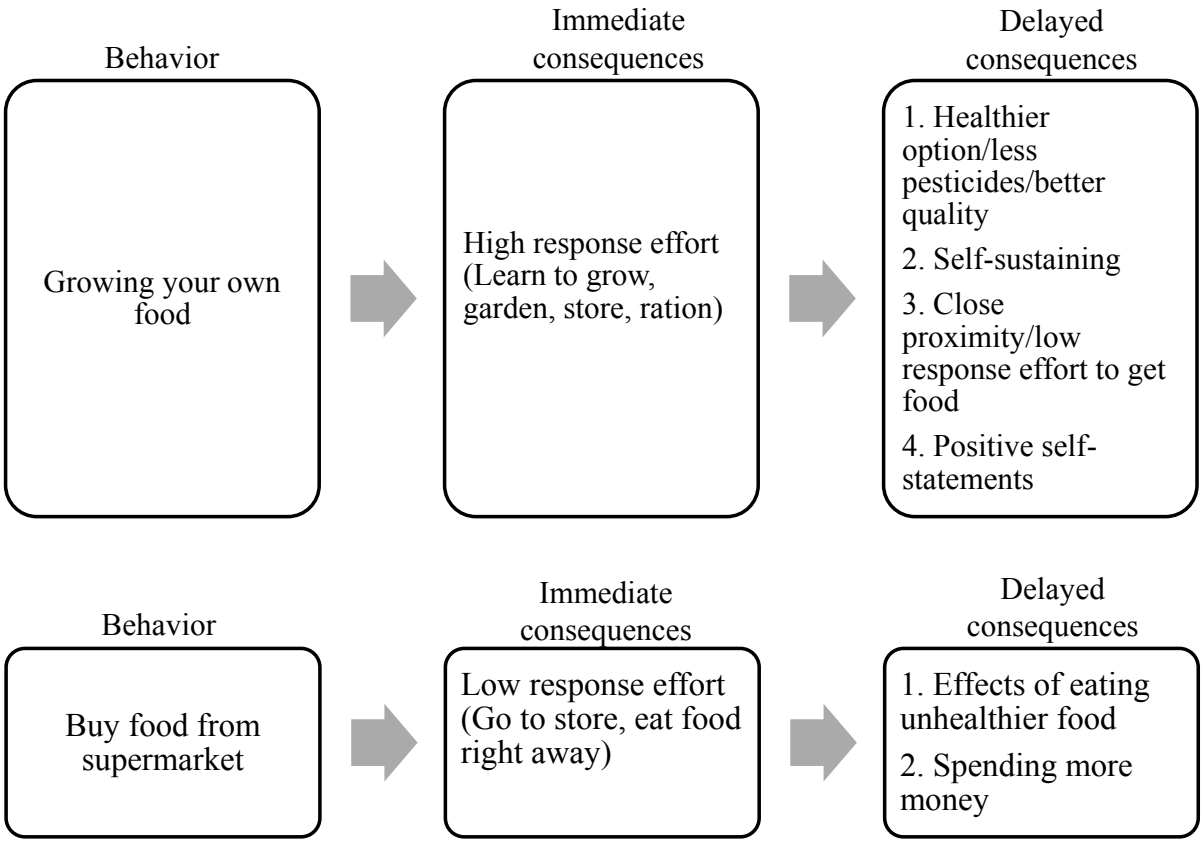

Figure 2. Immediate and delayed consequences for sustainable (top panel) and unsustainable (bottom panel) behavior.

Further Examining Choice: Discounting

Further assessment of the behavioral processes underlying pro- versus un-sustainable behavior points to an examination of choice. From a behavior analytic perspective, the sustainable behavior of an individual involves a choice between response options that have differing short- versus long-term consequences, as indicated above. In a simplified binary choice model, one behavior produces immediate positive consequences for the behaver but deferred negative consequences for future versions of the behaver and future generations, whereas the other response option produces more positive deferred outcomes for future generations but possibly at the cost of more immediate response effort or lowered immediate reinforcement for the behaver. The analysis of variables that influence choice in such concurrent response situations has been an active research area under the rubric of "temporal" or "delay discounting" (see Green & Myerson, 2004; Madden & Bickel, 2010; Odum, 2011a for reviews). Delay discounting is a phenomenon in which individuals choose a response option that produces a lesser amount of a resource (reinforcer) sooner, rather than a response option that produces more of that resource at a later time (see Madden & Bickel, 2010). Delay discounting functions are, thus, a measure of decreases in the subjective value of a stimulus as a function of time to its delivery. Delay discounting may be viewed within a framework of behavioral economics, in which one observes allocation of behavior with respect to conditions influencing the value and consumption of various commodities (Bickel & Marsch, 2001).

Typical research in delay discounting measures a person's endorsement (via selection) of response options that produce long-term consequences as opposed to short-term consequences (i.e., events that are not immediate or in which their likelihood of occurrence is uncertain)—a clear analogue measure of someone's likelihood to engage in sustainable behavior. Within behavioral psychology, discounting has been used as a measure of impulsivity and self-control (Ainslie, 1975; Madden & Bickel, 2010; Rachlin, 2000), although impulsivity is descriptive of a smaller category of behaviors than all of those implicated in choice. Additionally, impulsivity and discounting are not causal variables in a functional sense, but are descriptive. The functions of unsustainable and impulsive behaviors are not hidden within discounting curves or models, and are privy to their own analysis.

Researchers have argued that delay discounting is among the most useful choice models (see Rachlin, Green, & Tormey, 1988). Delay discounting captures critical aspects of choice by examining differential delays to resources, implicating the effects of both time and probability. Delay discounting is also an explicit measure, without the baggage of less precise hypothetical constructs. Ways of precisely assessing a human's discounting function vary, and include: a binary choice method, which poses a series of questions in evaluating whether an individual prefers one hypothetical reward now versus another hypothetical reward later; a multiple choice (MC) method, in which a time delay is posed, and the individual chooses a corresponding stimulus value based on the given multiple choices; and a fill-in-the-blank (FITB) method, in which the individual designates a stimulus value on their own, given varying delays. The hypothetical rewards in these discounting scenarios have been shown to function as if they were "real" rewards (Johnson & Bickel, 2002; Madden, Begotka, Raiff, & Kastern, 2003). The use of differing measures have been shown to potentially influence one's rate of discounting (Smith & Hantula, 2008; Weatherly & Derenne, 2011, 2013b). A rule of thumb for researchers is to use the

method of assessing discounting that is most analogous to the real-world topography of choice behavior (i.e., do people have to make one of two choices [binary], pick from many options [MC], or generate their own response [FITB] in situations of choice with respect to whatever commodity is being discounted? [See Weatherly, 2014 for an examination of persisting issues in discounting research.])

A related function is probability discounting, which measures decreases in value of a stimulus in relation to *chance* of its delivery. While some have speculated that discounting produced by decreased probability and discounting produced by delay are the same processes (Green & Myerson, 1996; Rachlin, Raineri, & Cross, 1991), others have suggested that the processes are distinctly different (Weatherly, Petros, Jónsdóttir, Derenne, & Miller, 2015). The processes could be related, as delay to an outcome can decrease probability of its occurrence, and the uncertainty of an outcome that comes with an extended delay could decrease its value. While the scientific community is consistent in their projections about continued rising temperatures, ocean acidification, and numerous other events with serious health consequences to many if not all species, there are still unforeseen impacts that even scientists cannot easily predict due to the vast complexity of the global ecosystem. This uncertainty, while it is a necessary part of a natural science, can affect perception about the probability of future events, particularly when they are delayed, much like the long-term effects of unsustainable behavior; this can be seen in the political discourse and can be inferred by the inaction of many people around the world. Probability discounting can, therefore, be implicated in sustainable or unsustainable behavior, though not as clearly as delay discounting.

Another behavior captured within a discounting function that is likely relevant to sustainable behavior is social discounting, which examines the influence of behavior on the individual versus the group; in colloquial terms, social discounting measures a spectrum of cooperation and competition. This is especially relevant to the theory behind the "tragedy of the commons" (Hardin, 1968), in which people's short-term interests are at odds with the group's long-term interests with respect to a common resource (e.g., parks, oceans, atmosphere), and implicated in environmental problems such as overfishing, habitat destruction, and a water crisis due to over-irrigation.

Discounting reward value relative to others has been shown to be a function of social distance, such that the "further" a person is judged to be from the behaver, the less the behaver will value resources for that person (e.g., a behaver's friend is closer in social distance than an acquaintance, and the behaver would value rewards for the friend more than the acquaintance; Jones & Rachlin, 2006). Social distance is a relatively broad concept that may involve both temporal distance (making choices with reference to people in the future, such as the behaver's grandchildren and/or future versions of the behaver) and geographic distance (engaging in behavior that supports the local community, but failing to behave in ways that would benefit individuals in nations on the other side of the globe). Studies examining social discounting have likened the process to delay discounting (Rachlin, 2000; 2002).

Social discounting is almost certainly a research area with great potential in its application to analysis of sustainability issues, especially with respect to community collaboration and cooperation toward common sustainability-oriented goals. However, social discounting is a concept that is much more complex than delay discounting, as its aspects are much harder to quantify in a reliable way. By expanding the analysis of both model- and function-based social discounting research, there is great potential to provide a concise model (similar to what has been

achieved in delay discounting and research on delayed reinforcers), that can encompass some of the more difficult parts of a behavioral model discussed below (e.g., intentions, verbal behavior).

Discounting research in psychology has followed an empirical line of fitting formulas and models to the observed behavioral phenomena. Mathematical models for the analysis of behavior have been popularized within the field of behavioral economics (see Doyle, 2013 for a review of mathematical models used in psychology and behavioral economics). Behavioral economics involves the application of microeconomics principles and techniques to describe and understand behavior, specifically how deviations in rational behavior can maximize value (Hursh, 1980; 1984). In earlier research in behavioral economics, discounting functions were conceptualized as exponential, implying that costs and benefits of equal size always have equal value at the same point in time. In psychological research, discounting models have been found to be hyperbolic, or a variation on a hyperbolic model. In his research with pigeons, Mazur (1987) found evidence that delay discounting functions are hyperbolic, not exponential. In a series of studies conducted on delay and probability discounting functions with undergraduate students, Rachlin et al. (1991) found that the form of the delay discounting function for humans was the same as that of pigeons (hyperbolic), and that the hyperbolic discounting function accounted for preference reversals between delayed rewards. Myerson and Green (1995) compared the hyperbolic discounting function to an exponential decay function and found that delay discounting behavior of young adults was better explained with the hyperbolic function. Hyperbolic discounting models imply that impulsive choices occur less often when organisms choose between *a series of* smaller sooner rewards and larger delayed rewards than when organisms choose between a *single* smaller sooner reward and larger delayed reward pairs.

In psychology, discounting data are typically analyzed by fitting the responses across different delays to a hyperbolic function (e.g., Mazur, 1987; Rachlin et al., 1991), a hyperbolic-like function (e.g. Green, Myerson, & Ostaszewski, 1999; Green & Myerson, 2004; Rachlin, 2006), or by calculating the Area Under the Curve (AUC) through summing the areas of successive trapezoids created by the responses across the delays (Myerson, Green, & Warusawitharana, 2001). AUC differs from hyperbolic functions (and other models) primarily because the data are not fit to a model, but the curve is calculated from the data. AUC allows researchers to place emphasis on conditions delivered to participants and the functional, "final" causes of their behavior, as opposed to emphasizing the topographical, formal causes of models and their fit with data (Aristotle, 350 BCE; see Killeen, 2001).

The formulas for discounting models are powerfully predictive, but of course, are models and therefore represent a formal cause, so they do not account for all individual differences. The behavioral processes underlying discounting are not as clear as the formulas. Reinforcement is most effective when immediately delivered, and loses effectiveness as it is delivered more temporally distant from the behavior (Chung, 1965; Chung & Herrnstein, 1967; Ferster, 1953; Skinner, 1938, p. 139; Watson, 1917). This clear finding may account for why discounting occurs across species.

Despite these clear patterns, studies have shown that discounting is malleable (Koffarnus, Jarmolowicz, Mueller, & Bickel, 2013); some interventions to promote self-control appear to be "skills-training" shaped through differential reinforcement (e.g., Dixon & Tibbetts, 2009; Ragotzy, Blakely, & Poling, 1988). If reinforcement is a key part of the discounting paradigm, then either schedule discrimination, rule-governance, or both may be necessarily involved in order to bridge the temporal gap from behavior to reinforcer. Rule-governance refers to behavior under the control of a verbal stimulus. With rule-governed behavior, the relevant contingency

does not have to be temporally contiguous, as the delayed reinforcer can be "understood" to be related to behavior. The definition of a verbal stimulus, and of verbal behavior is not agreed upon, and has been considered a contingency-specifying stimulus (Blakely & Schlinger, 1987; Schlinger & Blakely, 1987; Skinner, 1957; Skinner, 1966), a naming relation (Horne & Lowe, 1996), and a relational frame (Hayes, Barnes-Holmes, & Roche, 2001). Generally, though, a verbal stimulus is behavior that involves contingencies not necessarily directly learned through reinforcement, but could be learned through relations with other events. Verbal behavior is often observed and suggested to be a trait of humans (Horne & Lowe, 1996), although, conceptually, non-humans could have many of the necessary behaviors that we consider to be specific to humans (Barnes, 1996; Sidman, 2000). Discounting is malleable across species, as well, indicating that rule-governance may have more of an effect on humans than other animals. For example, in humans, reinforcement magnitude and delay discounting vary inversely; that is, larger, delayed rewards decrease in value as a function of delay more slowly than a smaller reward. This magnitude effect in non-human animals is elusive and perhaps non-existent (see Grace, 1999; Green, Myerson, Holt, Slevin, & Estle, 2004). It is possible that the magnitude effect in humans is mediated through rule-governed behavior, as are many other aspects of complex choice in humans. The framing of the contingency, the description of outcomes (i.e., as gains or losses), and other formulations of choice presentation have all been reliably shown to affect responding for humans along delayed and probabilistic choices (Kaplan, Reed, & McKerchar, 2014; Tversky & Kahneman, 1981; Weatherly & Derenne, 2013a), indicating the powerful effects of language. Metaphors, for example, have been shown to influence conceptualization of social issues (Thibodeau & Boroditsky, 2011), and are hypothesized to be higher cognitions (relating relations) within behavior analytic theories of language (Stewart, Barnes-Holmes, Hayes, & Lipkens, 2001) and have been prominent in the application of such theories (e.g., Hayes, Levin, Plumb-Vilardaga, Villatte, & Pistorello, 2013).

A functional analysis of a choice situation may not necessarily have to involve verbal behavior. Many accounts have found that behavior thought to be controlled by heuristics is explained with behavioral selectionist principles (Donahoe & Palmer, 2004). Intervention, however, is likely to occur at both a verbal and environmental level, allowing the incorporation of verbal behavior into a functional analysis of choice to be pragmatic.

Intersections of Discounting and Sustainability in the Existing Literature

While there has been a significant amount of research within the field of economics exploring the relationship between delay and probabilistic discounting and sustainable behavior (see Norgaard & Howarth, 1991 for a seminal examination of the issue), a limited number of studies within psychology, especially limited within behavior analysis, have addressed the relationship between delay discounting and sustainability issues. Strictly economic studies have been traditionally more concerned with the implications for monetary and business outcomes as climate change progresses, and have addressed discounting often from a rational standpoint relating to these issues. Psychological research has been empirically focused on discounting as a behavioral phenomenon, examining behavior and clear correlates such as self-control; such a framework is in opposition to discounting as a rationalist explanation for other issues, such as sustainability (though there have been more recent studies applying behavioral economics to more socially relevant issues such as medical treatment adherence [see Stevens, 2014]).

Discounting is a model of choice, and therefore can be useful in measuring behavior that should predict, or correlate with, sustainability. Within domains of psychology and economics research, this concept is not always specifically phrased as "delay discounting," though the underlying process is an examination of the value of immediate versus delayed consequences. Time perspective, for example, is conceptually similar to delay discounting; both relate to an individual's decision making between the present and future. Studies examining the relationship between time perspective and endorsement of sustainable behavior have indicated that endorsement of sustainable behavior and future time perspective is reduced by immediate concerns (Arnocky, Milfont, & Nicol, 2014), similar to what has been found in behavioral psychology. The general results indicate that preferring larger, later rewards to smaller, more immediate rewards, in addition to considering future consequences, predict sustainable behavior for the planet and its inhabitants. Research has indicated the measures are indeed similar, but not completely redundant (see Daugherty & Brase, 2010).

With respect to the intersection of the literature, Arbuthnott (2010) conducted a review of published research, drawing from the social psychology literature on delay of gratification as well as behavior analytic research on delay discounting. Following this review, the author concluded that behavior change within the realm of sustainability is dependent on the salience of future potential outcomes and the response effort needed to reach immediate versus delayed goals. Other researchers have examined the discounting of environmental outcomes with respect to specific environmental challenges, such as the storage of radioactive waste (Svenson & Karlsson, 1989), the health effects associated with greenhouse gas emissions (Hendrickx, Van den Berg, & Vlek, 1993), and ocean water quality (Guyse, Keller, & Eppel, 2002). These authors typically used preference scales to evaluate responses to different scenarios as opposed to the more explicit discounting methods and functions. These studies collectively found that participants discounted monetary outcomes differently than environmental or health outcomes (i.e., often that environmental outcomes were valued more), and that participants' perceptions about their "willingness to engage" in sustainable behavior did not change as a function of delay of the environmental consequences. However, "willingness to engage" in behavior is often a poor representation of people's actual behavior and may not accurately represent human behavior in the presence of experienced contingencies of reinforcement. Some researchers have suggested that this discrepancy (that what one thinks or states he/she/others should do is quite different from what one actually does) is a major factor underlying unsustainable behavior (Chance, 2007; Malott, 2010). When researchers have used the more explicit, precise discounting methods and analyses (such as those described earlier in the present article) rather than "willingness to engage," the discrepancy between reported willingness and discounting appears to correct itself. For example, Hardisty and Weber (2009) examined the discounting of monetary versus environmental gains and losses with the binary choice method. Discounting rates were much higher for gain scenarios than loss scenarios, though the commodities (money vs. environmental outcomes) were discounted similarly. The authors posited that the difference between their results and the results of others was methodological or model-related, implying that the various studies accounted for valence of the outcomes, or preferences, for participants with differing efficacy.

The methodological shortcomings in the few previously-mentioned studies were addressed by Kaplan et al. (2014), who utilized a visual analogue scale to assess concern for environmental outcomes with respect to delay, social, and probability discounting. Across each of these

domains, respondents were presented with environmental scenarios and then asked to assess concern as well as the extent to which they would take action with respect to the problem posed in the scenario. For all three domains, ratings of concern were ranked higher than ratings indicating the probability or extent to which the individual was likely to take action. These findings further depict the common finding that verbal statements, ideals, attitudes, and intentions regarding environmental issues rarely match up to planned or actual behavior. This lends additional support to utilizing explicit self-report measures that are reliable along a relevant dimension, such as discounting along choice. Affecting a discounting curve, of course, still requires an intervention on choice behavior relevant to the sustainability issue at hand.

Choice, with regards to sustainable actions, can be captured with explicit delay discounting analyses. Despite the differences in capturing one's discounting function, the research supports that value of sustainability-related stimuli decays over time. However, the extent of discounting in reference to sustainable outcomes will vary across individuals and groups. There may be some groups of people who have established patterns of behavior that seem to mitigate this problematic delay to reinforcement; understanding the decision-making processes of such individuals, their history, and current contextual variables that influence behavioral sensitivity to delayed consequences could lead to more functional interventions.

An examination of the verbal behavior of individuals who behave unsustainably might indicate that some motivation for sustainability is present, but some condition may be preventing the overt response; environmental stimuli that can mediate the behavior may not be present, and/or verbal behavior must be transformed to affect overt behavior.

Moving Forward

With respect to better understanding individual differences, some studies have shown that a person's delay discounting rates remain consistent across time and with respect to different commodities (see Odum, 2011b, for a review), indicating the possibility of delay discounting having characteristics of a "personality" trait. However, other studies have demonstrated that discounting rates differ with respect to different commodities (Estle, Green, Myerson, & Holt, 2007; Weatherly, Terrell, & Derenne, 2010), suggesting against this as being a trait variable. Regardless of whether delay discounting is a trait or is context specific, we must acknowledge that delay discounting is a learned behavior that can be intervened upon, and should be treated as such (Bickel, MacKillop, Madden, Odum, & Yi, 2015). Sustainable behavior, like discounting, can be operationalized and intervened upon as well. Both discounting and sustainable behavior are the results of a learning history that has shaped and reinforced behavior that can be described as "responsible," "future-oriented," "non-impulsive," "sustainable," and so on.

In considering potential interventions to promote future-oriented choices and pro-sustainable behavior, prior research has shown that behavioral interventions can be implemented to change discounting curves, mainly for psychological disorders with impulsivity components (see Koffarnus, Jarmolowicz, Mueller, & Bickel, 2013 for a review of interventions that have been shown to impact discounting curves). Thus, there is potential to implement interventions for increasing sustainable behavior in conjunction with discounting as a metric, as it is easy to attain and is a precise (quantifiable) measure of choice that captures a dimension (a rule-governed sensitivity to delayed rewards) critical to almost any behavioral solution to a sustainability issue. Discounting is, of course, not a final measure of success, just as it is not a final cause.

As has been pointed out, prior research in this area has indicated that humans often do not behave in accordance with their "intentions" or their willingness to engage in sustainable behavior. This signifies a need to bring intent in line with behavior, either via some guided purposeful presentation in order to take advantage of modifiers of verbal behavior and transformation of function, or via modification of the stimuli in one's environment by potentially increasing the salience of immediate versus delayed outcomes, or a combination. As people often choose the lower effort, more immediate, unsustainable choice that will more quickly contact reinforcement, rather than the more delayed, likely more effortful, sustainable response, it would be productive to consider ways in which one can reduce response effort or bring attention to properties that may allow for a perception of reduced effort associated with the immediate and delayed outcomes of sustainable behavior. Additionally, examining skill-building interventions that aim to change one's discounting curves and increase the value of delayed reinforcers and sustainability-related stimuli could be fruitful in providing effective methods of incentivizing sustainable behavior. While these exist in limited form related to impulsivity, many behavior analysis and therapy techniques, such as stimulus control (Poling & Gaynor, 2008), are purported to bring rules in line with environmental contingencies, and allow for people to recognize what is maintaining their behavior. For those individuals who steeply discount the future, it may be beneficial to begin with a more "selfish" goal (e.g., a person planning for their own future with reference to long-term sustainable outcomes that directly benefit him/her). This self-interested behavior, in turn, can begin to evoke the behavior necessary to differentially reinforce the eventual sustainable behavior patterns that benefit both themselves *and others*.

In conclusion, the use of discounting measures can enhance behavior change research by employing a measure that captures choice in a manner that is critically relevant to the far-delayed consequences of sustainable behavior. Of course, the ultimate goal of behavioral research is prediction and influence (Watson, 1913). Research should lead to a functional technology for identifying what behavioral process should be targeted in a person (e.g., impulse control) or what resource or environmental stimulus is most likely to engender controlling consequences; discounting is a relevant measure of this, not the functional solution. The more functional relations between the environment and behavior are discovered and understood, the more that behavioral interventions have the potential to be successful.

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