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# Some Current Dimensions of the Behavioral Economics of Health-Related Behavior Change

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## Abstract

Health-related behaviors such as tobacco, alcohol and other substance use, poor diet and physical inactivity, and risky sexual practices are important targets for research and intervention. Health-related behaviors are especially pertinent targets in the United States, which lags behind most other developed nations on common markers of population health. In this essay we examine the application of behavioral economics, a scientific discipline that represents the intersection of economics and psychology, to the study and promotion of health-related behavior change. More specifically, we review what we consider to be some core dimensions of this discipline when applied to the study health-related behavior change. Behavioral economics (1) provides novel *conceptual systems* to inform scientific understanding of health behaviors, (2) *translates* scientific understanding into practical and effective behavior-change interventions, (3) leverages varied aspects of behavior *change* beyond increases or decreases in frequency, (4) recognizes and exploits *trans-disease* processes and interventions, and (5) leverages *technology* in efforts to maximize efficacy, cost effectiveness, and reach. These dimensions are overviewed and their implications for the future of the field discussed.

### Keywords

behavioral economics; health behaviors; trans disease processes

## Introduction

Efforts to understand and improve health-related behavior change is of increasing importance as the United States (US) continues to underachieve on important markers of population health (Henningfield, 2014; Higgins, 2014; Kaplan, 2014; Schroeder, 2007;

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Schroeder, this issue). Behavioral economics, a field at the intersection of economics and psychology, has been studying health-related behavior change for more than 20 years (Bickel & Vuchinich, 2000; Kessler et al. 2014). However, behavioral economics is not a singular field but rather is composed of overlapping fields derived from constitutive disciplines; that is, some behavioral economic perspectives are more closely aligned with economics, while other are more closely aligned with psychology. The latter brings a greater emphasis on decision science. The form of behavioral economics that we address in this essay comes with an emphasis from a specific area of psychology, namely, behavior analysis (Hursh et al. 1988). Despite these various forms, we believe there may be utility in delineating some core aspects or dimensions of behavioral economics in the study of health-related behavior change. Establishing similar dimensions as a framework to advance study has previously been effective in other areas of behavior change research and application including behavior analysis (e.g., Baer et al., 1968).

The field of behavioral economics and health-related behavior change can be described through at least five dimensions; that is, behavioral economics of health-related behavior changhe (1) provides novel conceptual systems to inform scientific understanding of health behaviors, (2) translates scientific understanding into practical and effective behavior-change interventions, (3) *leverages varied aspects of behavior change* beyond increases or decreases in frequency, (4) recognizes and exploits trans-disease processes and interventions, and (5) leverages technology in efforts to maximize efficacy, cost effectiveness, and reach. Note that we are not suggesting these dimensions are unique to the behavioral economics of health-related behavior change. Indeed, an emerging discipline that is derived from other disciplines would be expected to share some dimensions with them. Each of these dimensions is discussed in further detail below.

## Rationale for Studying Health-Related Behavior Change

Health-related behavior change is a fundamentally important area for research and intervention because despite spending more on healthcare than any other nation, US population health lags far behind most other developed nations on important health indicators such as infant and maternal mortality rates, life expectancy, and rates of illness and injury (Schroeder, 2007; Higgins, 2014). Indeed, the U.S. National Research Council's Institute of Medicine undertook a study comparing US population health to other developed countries and uncovered an overarching pattern that became the subtitle of their report, “poorer health and shorter lives” (Woolf & Aron, 2013). That report examined the individual behavior patterns contributing to excess morbidity and mortality, including tobacco use and abuse of alcohol and other substances, poor diet and inadequate physical activity, risky sexual practices, and high injury and accident rates. Poor adherence with medication and preventive medical regimens is another major contributor to the relatively poor health status of the US (World Health Organization, 2009).

Consider some additional specific details associated with US population health. Tobacco use in the US serves as a great exemplar that substantial changes in health behaviors are achievable having moved from being the country with the highest prevalence rates among developed countries in the 1960s to presently having the lowest rates other than Sweden

(Higgins, 2014). Unfortunately, prevalence of daily smoking in the US still exceeds 16% of the population over 15 years old (OECD, 2009). That continuation of cigarette smoking in combination with the time-lagged adverse impacts of earlier smoking practices leaves the US among the highest in annual rates of tobacco-related disease and premature death (Jemal et al., 2011), a trend that many predict will turn for the better in the near future (Schroeder, this issue).

Alcohol and other substance abuse, of course, are important contributors to global rates of violence, traffic accidents, poisonings, drownings, and self-inflicted injuries (World Health Organization, 2011). While the US does not consume as much alcohol or drugs as other comparable countries, Americans lose more years of life as a result of alcohol and substance use (Woolf & Aron, 2013). This observation of lower consumption associated with worse health outcomes may be explained by the unhealthy patterns of consumption in the form of binge drinking and other drug misuse. Causal data, however, are lacking on the reason for worsened health outcomes related to alcohol and drug use (Woolf & Aron, 2013).

Poor diet and excessive caloric intake are major contributors to obesity and obesity-related disease (cardiovascular disease, type-2 diabetes, colon and other site-specific cancers). The US leads the world in per capita number of daily calories consumed (OECD, 2009). In addition to poor diet, inadequate physical activity contributes to obesity-risk and these same chronic diseases. Rates of physical activity are consistently lower in countries with higher income (Hallal et al., 2012). In the US, rates of moderate to vigorous physical activity are generally similar to other high-income countries; however, average time spent engaging in sedentary activities In the US such as watching TV far exceeds patterns in other countries (Brunello et al., 2008).

Finally, risky sexual behaviors are associated with the spread of infectious disease including HIV and AIDS. Indeed, the US has the second highest rate of HIV infection when compared to 17 comparable developed countries and the single highest incidence of AIDS (Woolf & Aron, 2013).

Overall, a broad scientific consensus considers the above patterns of unhealthy behaviors as among the leading, although certainly not the only, contributors to the unsettling disparities in health when comparing the US to other developed countries (Woolf & Aron, 2013) and when comparing health indicators across differing socioeconomic levels within the US. (Higgins, 2014; Higgins, 2015a; Higgins, 2015b; Schroeder, 2007; Schroeder, this issue).

## Novel Conceptual Systems

Behavioral economics underscores how the various unhealthy behavior patterns outlined above can all be conceptualized in terms of behavioral choice wherein relatively health-defeating options are repeatedly chosen over health-promoting alternatives. Two decision-making processes that behavioral economics research has demonstrated are integral to understanding these suboptimal choice patterns are delay discounting and elasticity of demand.

## Novel Models and Applications of Delay Discounting and Consumer Demand Theory

Delay discounting refers to the reduction in the value of a reinforcer as a function of delays to its delivery. Classical economics stipulated that delay discounting should be a rational process characterized by an exponential function, but that conceptualization of discounting can not easily accommodate the common phenomenon of preference reversals (Samuelson 1937). Preference reversal refers to a change in preference from a larger later reward to a smaller sooner reward as the time to the receipt of both rewards decreases (Green et al. 1994) In contrast to the classical model of discounting, behavioral economics demonstrates that discounting curves are best described by a hyperbolic function that can readily accommodate preference reversals (Rachlin et al. 1991). To date, the hyperbolic function has been shown to be the most universally applicable characterization of discounting, underscoring the value of this behavioral economic perspective in accommodating irrational choice. Importantly, the rate by which a commodity is discounted can be quantified and compared between and within individuals. Indeed, individual differences in rates of discounting future rewards is associated with numerous negative health behaviors, and associated conditions including almost every form of drug dependence (Bickel et al., 1999; Bickel et al., 2014b; Yi, Mitchell, & Bickel, 2010), overweight and obesity (Bickel et al., 2014c; Epstein et al., 2010; Privitera et al., 2015; Weller et al., 2008), problem gambling (Alessi & Petry, 2003; Andrade & Petry, 2012; Reynolds, 2006), risky sexual practices (Chesson, 2012; Meade et al., 2011), and health disparities (Bickel & Marsch, 2001; Bickel et al., 2014a). Indeed, the broad generality of excessive delay discounting across health behaviors and associated conditions is the basis for its designation as a trans-disease process (Bickel et al., 2012a) and proposals that excessive discounting may represent an endophenotype of negative health behaviors (e.g., Bickel, 2015). Other studies have shown that pretreatment discounting rates can be predictive of therapeutic outcomes (Sheffer et al., 2014; Sheffer et al., 2012). Moreover, several efforts are ongoing to examine whether producing greater valuation of delayed outcomes would, in turn, result in therapeutic changes in corresponding health behaviors, such as reduction or cessation of substance use. Delay discounting also may exert nuanced influence in the developmental course of health-related behavior patterns. With regard to cigarette smoking among women, for example, a clear and robust association exists between discounting rates of monetary rewards and the likelihood of being a smoker (Chivers et al., this issue), a modest but significant association between discounting and the likelihood of quitting smoking without formal treatment upon learning of a pregnancy (White et al., 2015), but no discernible association with the likelihood of responding to formal treatment among the subset of women who continue smoking after learning they are pregnant (Lopez et al., 2015).

Demand refers to the relationship between price and consumption of a commodity and can be used as a measure of value of the commodity in question (Bickel et al., 1993). Relatively high valuation of specific reinforcers, such as drugs or food, is associated with negative health behaviors (Bickel et al., 2014d). Converging studies show that among those with addictions and obesity, for example, the health-defeating commodities (i.e., drugs and food, respectively) are excessively valued and inflexible to change relative to individuals without those problems. Stated differently, addicted and obese individuals will pay (e.g., with time, money, or effort) disproportionately for these commodities, indicating inelastic demand characteristics (Epstein & Saelens, 2000; Epstein et al., 2010; Jacobs & Bickel, 1999; Murphy et al., 2014). Quantitative markers of inelastic demand for these commodities may indicate clinically relevant differences in the severity of such health-related pathologies and may be useful in individualizing treatments as well as indicators of successful treatment response (MacKillop & Murphy, 2007).

Taken together, delay discounting and demand provide two powerful conceptual tools for assessing and potentially intervening on health-related behavioral pathologies. Excessive delay discounting and persistently inelastic demand, together, can be theoretically characterized as core parts of what is discussed below as reinforcement pathology, a trans-disease process that underpins clinical states like addiction and obesity, and their associated increases in risk for chronic disease and premature death (Bickel et al., 2012b; Bickel et al., 2014d; Carr et al., 2011).

## Other Conceptual Systems

Behavioral economics employs a variety of conceptual systems that can guide development of behavior-change methods. These conceptual systems take into account behavior analysis principles such as reinforcement, cognitive psychology principles such as heuristics and biases in decision-making, and weave them into models that elucidate patterns of interrelatedness and are sufficiently dynamic and change-oriented so as to be practically useful in supporting development of behavior-change strategies. Below we briefly review some additional conceptual models employed in the behavioral economics of health-related behavior change.

One conceptual framework that has considerable influence in this area is dual-system models. Numerous dual-system models exist (see Hofmann et al., 2009 for a review); however, only two closely aligned models have specifically addressed addiction and other health-related behaviors (i.e., Bickel et al., 2007; Noël et al., 2013). Here, we focus on the Competing Neurobehavioral Decision Systems model of health-related behaviors (Bickel et al., 2007; Bickel & Yi, 2007).

The Competing Neurobehavioral Decision Systems view suggests that choices include two neurobiological decision systems. One is the impulsive decision system that is embodied in the evolutionarily old limbic and paralimbic brain regions and functions to obtain biologically important reinforcers and to engender emotions and motivation. The other is the executive decision system that is embodied in the evolutionarily younger prefrontal cortices and is fundamental to considering the future, remembering important goals, and planning. When in a healthy state, these two decision systems function in regulatory balance such that they are responsive to circumstance and can adapt to situations that require immediate focus, deferred consideration, or anywhere in between. However, with disease states these systems are dysregulated; for example, behavior can be biased towards the short term if the executive system is relatively hypoactive and the impulsive system relatively hyperactive. This model can serve to elucidate behavioral and neural systems that need to be targeted to reestablish some form of regulatory balance and improve health (Bickel et al., 2014e).

Building on dual-decision models, Codagnone and colleagues' (Codagnone et al., 2014) incorporate 'nudging' techniques (Thaler & Sunstein, 2008) and a multi-axis model for behavior change. The resulting nudging taxonomy provides guidance on how to influence choice architecture across two axes which span automatic versus reflective and hot versus cold affect dimensions of choice. This model is instructive and consistent with the Competing Neurobehavioral Decision System in its ability to point to counterbalances, such as activating more rational and analytical processes when individuals, groups, or communities tend towards impulsive and unhealthy choices. Nudges can be applied to choices made across many different domains and levels from individual health to the practices of healthcare systems, product marketing, and public policy (e.g., Thaler & Sunstein, 2008; Sunstein, 2014). For example, in health care settings, the use of defaults (one form of nudging), specifically for endof-life plans, changed choice behavior and may be used to improve important outcomes such as receipt of wanted and unwanted end-of-life care (Halpern et al., 2013). So too, nudges have been shown to increase childhood health food choices (Cravener et al., 2015; Anzman-Frasca et al., 2015; Radnitz et al., 2013), optimize physician medical orders (Olson et al., 2015), and increase organ donations (Ugur, 2015). Together, these diverse conceptual systems that build on dual systems with multi-axis models of behavior change may serve as the foundation for experimental designs and the development of behavior change interventions.

## Translates Knowledge into Effective Behavior-Change Interventions

Behavioral economics is an inherently translational discipline considering that it is a hybrid of economics, psychology, as well as behavioral pharmacology, cognitive neuroscience and neuroeconomics. It is not alone in this regard as much of contemporary science is focused on translational approaches that cross the divide between more basic or fundamental and applied science. Translational science brings knowledge gained in controlled laboratory studies to the clinical treatment of pathologies, but, importantly, is also bidirectional with observations made under less-controlled clinical conditions also informing and setting the occasion for more basic investigation.

### Financial Incentives

Here we use incentive programs as an exemplar of translation of basic knowledge into effective interventions. Systematic use of financial incentives (referred to as contingency management in the area of addictions, and conditional cash transfers in global anti-poverty efforts) is clearly a translational intervention (e.g., Higgins et al., 2012). These incentive programs entail the systematic delivery of reinforcers contingent (or conditional) upon achieving some predetermined behavioral target or goal. Use of incentives was initially explored across a wide-range of different types of behavioral disorders as part of the development of behavior modification, but was most thoroughly and systematically researched in the area of drug dependence (e.g., Higgins et al., 2008). More specifically, the field of behavioral pharmacology had long established that drugs of dependence function as reinforcers; that is, drug naive laboratory animals readily self-administer drugs of dependence. Extensions of that work in both the non-human and human laboratory demonstrated that arranging contingent availability of alternative drug reinforcers could decrease the frequency of drug consumption (Higgins 1997). To the extent that availability of these alternative non-drug reinforcers was mutually incompatible with drug use, it functionally represented an increase in the price of continued drug use. More specifically, the intervention changes the opportunity cost of using the substance and forces an interchange between the drug and the incentive (e.g., Higgins, 1996; Higgins 1997; Higgins et al., 2004).

Financial incentives in the form of vouchers exchangeable for retail items garnered considerable attention when they were demonstrated in controlled trials to significantly reduce cocaine use in dependent outpatients when virtually everything else that was investigated with this population failed miserably (Higgins et al., 1994; Silverman et al., 1996). Thereafter that incentives model was extended to a wide range of different types of substance use disorders and different populations, with a striking level of efficacy. Indeed, a programmatic series of literature reviews on the use of this model with substance abusers identified 177 controlled studies published between 1991 and 2014, with 155 (88%) of them supporting efficacy (Davis et al.,this issue; Higgins et al., 2011; Lussier et al., 2006). Examples of substance abusing populations to which the contingent incentives approach has been applied include smoking cessation in the general adult population (Halpern et al., 2015) as well as pregnant (Higgins & Solomon, in press) and adolescent (Krishnan-Sarin, 2013) smokers, but also to a wide range of other health problems including weight loss (Jeffery, 2012) and medication adherence (DeFulio & Silverman, 2012).

Behavioral economic interventions have become increasingly well known and accepted because of their track record for effectiveness. The incentives and choice architecture interventions discussed above are currently widely used strategies for changing health behaviors. In addition, interventions to reduce delay discounting such as episodic future thought and working memory training are being studied as additional candidate approaches to enact change.

## Other Translations and Applications

Psychology lends many principles to behavioral economics to leverage in developing efficacious behavior-change interventions. The psychological foundations underpinning incentives, as discussed above in the section on translation, was first observed by early behavioral psychologists such as B.F. Skinner and Edward Thorndike (Skinner, 1953; Thorndike, 1911) and then applied to health behaviors such as drug abuse (e.g., Higgins et al., 2008) and overeating (e.g., Jeffery et al., 2012). Choice architecture and defaults, as mentioned above in the section on conceptual models, are lower intensity strategies for influencing choice. These behavior change strategies, stemming from cognitive psychology and the study of decision-making heuristics and biases (Tversky & Kahneman, 1974; Tversky & Kahneman, 1981; Kahneman & Tversky, 1982), may be leveraged to influence health behaviors. Nudges include: a) *setting defaults*, such as opt out programs for organ donations, b) *leveraging social norms*, such as emphasizing what choice the majority of people make, c) *making healthy choices more convenient*, such as placing healthy foods in more visible and accessible places, d) *providing warnings*, such as labels and graphic images on cigarette packages, and *e) encouraging pre-commitments*, such as making a commitment to treatment in the future (Thaler & Sunstein, 2008; Sunstein, 2014). While the degree of influence of these lower-intensity manipulations of choice may have on population health are still debated (Loewenstein et al., 2012), their conceptual value for understanding irrationalities in health-related choice patterns and relatively low costs are generating considerable interest.

Emerging areas for behavioral economic interventions include efforts to change value over time to influence individual choices towards more health-promoting behaviors as opposed to choices that are easy or pleasurable in the moment (Murphy et al., 2006; Murphy et al., 2007). Two candidate interventions show promise at changing delay-discounting values. One intervention to change delay discounting is the use of episodic future thought. Episodic future thinking requires individuals to pre-experience future events by vividly imagining realistic events that may happen. Initial evidence for this potential change-oriented intervention showed promise in reducing discounting of future rewards (Peters & Büchel, 2010). Episodic future thinking interventions have been successful in reducing discounting of the future among the obese (Daniel et al., 2013a, 2013b), nicotine-dependent (Stein et al., under review) and alcohol-dependent (Snider et al., in press), as well as reducing consumption of food (Daniel et al., 2013a) and cigarettes (Stein et al., under review) in obese and nicotine-dependent samples, respectively. These findings suggest that it may be a successful intervention for pathologies characterized by self-control failures.

Another candidate treatment is working memory training. In this intervention participants are exposed to sequential working memory sessions with tasks increasing in difficulty from session to session. Working memory training has been studied in a variety of disorders ranging from children with attention deficit hyperactivity disorder (Klingberg et al., 2005) to adults with traumatic brain injuries (Björkdahl et al., 2013). Of specific interest to health behavior change, several studies have investigated working memory training as an intervention to reduce delay discounting, increase self control, and subsequently aid in health behavior change. Decreases in delay discounting following working memory training have been observed in treatment-seeking stimulant users (Bickel et al., 2011) as well as decreases in alcohol consumption in problem drinkers (Houben et al., 2011) and a longer duration of treatment effects among obese children (Verbeken et al., 2013). However, we note that some studies have failed to find a working memory training effect (e.g., Rass et al., 2015).

Taken together, the field of behavioral economics has already contributed well-validated, highly efficacious interventions, such as incentives for the treatment of negative health behaviors. Others strategies such as defaults and choice architecture are earlier in the stages of development and validation, but, as discussed above, have shown efficacy in controlled studies and are growing in popularity. More recently developed or emerging interventions such as episodic future thinking and working memory-training interventions show promise in laboratory experiments and await further translational applications to the clinic.

## Leveraging Varied Aspects of Behavior Change

Of course, change is the goal of behavior economic interventions, but what kind of change is being targeted or promoted should be clearly elucidated or specified. The two most familiar aspects of change are increases and decreases in the frequency of particular health behaviors as discussed above. Behavioral economics also addresses other important aspects of behavior change discussed below in this emerging area of study.

One aspect of change is referred to as rate or baseline dependent change (Bickel et al., 2016), which was first observed in behavioral pharmacology research (Dews, 1977). Although rate dependence can take several forms, the most typical is an inverse relationship between baseline rate of responding and the proportion of change. With this typical form of rate dependence, the same intervention may increase, decrease, and have no effect on the target behavior depending on the baseline frequency of the behavior. For example, the impact of multiple interventions, including working memory training and substance dependence treatments, on degree of delay discounting have been shown to be rate dependent, with individuals exhibiting relatively high discounting rates at baseline showing the greatest reductions in the rate of discounting (Bickel et al., 2014f). Also important to note about this pattern of results is that the trials with the largest treatment effects also showed the greatest rate-dependent relationships. Moreover, a recent review and reanalysis of the rate-dependent effects of medications, such as modafinal could account for 67% of the variance in the results examined (Bickel et al., 2016). Together these findings suggest that rate dependence may operate across diverse behavior-change interventions. Rate dependence may also permit understanding individual differences in treatment, but also could be used to personalize treatment; that is, for conditions where rate dependence has been shown to operate, careful assessment at baseline could identify individuals who are more or less likely to benefit from an intervention.

Another aspect of behavior change is stability of *change*. When the changed behavior meets a challenging circumstance, that behavior could be fragile and fall apart or become less frequent, it could be robust and be insensitive to the effects of the challenge, or it could be anti-fragile where the challenge actually strengthens the behavior (Taleb, 2012). This approach to health-related behavior change has been less frequently explored but should be an important area of future investigation considering that it has the potential to elucidate not only if we can change a health behavior but also the likihood that change will be sustained over time.

One example of a study modeling the importance of an initial period of sustained abstinence to longer-term success in quitting smoking is the work by Higgins and colleagues where cigarette smokers were incentivized to be abstinent for one day, one week, or two weeks. Following these differing duration abstinence periods, participants were given a relapse test; that is a choice to receive either money ($0.25/choice) or opportunities to smoke (two puffs/cigarette). The results showed a systematic decrease in preference for the smoking option (i.e., less relapse) as a function of increasing duration of abstinence indicating that an initial period of sustained abstinence decreases the relative reinforcing effects of cigarette smoking compared to a common non-drug alternative reinforce (Bradstreet et al., 2014; Lussier et al., 2005; Yoon et al., 2009). Such knowledge has been used in designing treatment interventions to promote longer-term behavior change in such challenging populations as cocaine-dependent outpatients (Higgins et al., 2007) and is part of the general rationale underpinning the widely used escalating schedules of reinforcement with reset contingencies in incentives-based interventions (Roll & Higgins, 2000; Higgins et al., 2007; Romanowich & Lamb, 2015). Of course, despite these instructive studies on how to promote more lasting behavior change following discontinuation of incentive-based interventions, relapse remains a challenge with this treatment approach (e.g., John et al., 2012; Volpp et al., 2008) as it is with other behavior change strategies underscoring the need for continued study and a more complete understanding of how to sustain behavior change (e.g., Leahey et al., this issue).

Behavioral economics underscores the importance of recognizing that there are important aspects of behavior change beyond producing increases and decreases in the frequency of behavior. We have illustrated this point with observations on rate dependence and stability of change. Recognizing the contributions of these and other processes that can render behavior change fragile or sturdy in the face of experimental or real world challenge has the potential to extend basic understanding as well as technological aspects of process and mechanisms of change.

## Trans-Disease Processes and Therapeutics

Behavioral economics brings what might be considered a contrary view to the current scientific approaches to health behaviors and associated diseases (See Bickel & Mueller, 2009, for a more in depth discussion of this topic). Most contemporary approaches assume that each disease is unique. This is evidenced by the organizational structure of the National Institutes of Health, disease specific journals, and disease specific professional societies. Consider the consequences when we add to this assumption two other aspects of contemporary science. The first aspect is the highly successful reductionist approach that remains highly evident in contemporary science; that is, the assumption that the solution to a disease process resides in some smaller, underlying, part of the process. The second aspect is the growth in the size of the scientific literature about which scientists are expected to keep apprised. Collectively, scientists may learn more and more about a smaller aspect of the disease process and, this, in turn, may lead to the problem of intellectual silos that risk obscuring recognition of commonalities across diverse diseases and disorders.

In contrast, behavioral economics of health-related behavior change is exploring and underscoring processes and interventions that have generality across multiple diseases. Delay discounting as we noted above has been recognized as a decision process that is operating in a wide variety of diseases and disorders. Indeed, the pattern of excessive discounting across these health-defeating behaviors provides evidence that the process of delay discounting is a trans-disease process (Bickel et al., 2012a). More recent evidence suggests that it is a behavioral marker of pathology (Bickel et al., 2014b) and may also be an endophenotype of addiction (Bickel, 2015) and other health-compromising behaviors.

Interventions may also be efficacious across multiple disorders. For example, as we noted above, the efficacy of financial incentives has broad generality across weight loss, tobacco and other substance abuse, and adherence with medications and other medical regimens. The emerging evidence on the intervention of episodic future thinking also supports generality across multiple disorders and can engender greater valuation of the future rewards and decrease valuation and consumption of brief intense reinforcers such as drugs or food.

Collectively, a conceptual framework that includes trans-disease processes and interventions distinguishes behavioral economics from many contemporary scientific approaches. The scope of trans-disease processes and of interventions remains an open question that will require additional research in order to understand the scope and breadth of trans disease processes.

## Leveraging Technology

According to Baer et al. (1968) when defining dimensions of behavior analysis, technological refers to the "techniques making up a particular behavioral application [being] completely identified and described" (p. 95). While we agree with this distinction, especially as it applies to a treatment being both effective and generalizable, we wish to extend this dimension to also encapsulate technological advancements that increase the reach of interventions or increase treatment efficiency or cost effectiveness (Kurti et al., in press). Technological advancements such as computerized-delivery of assessments and interventions allow for highly sensitive measurement of change and near identical replication of experimental manipulations oftentimes without the burden of traveling to a laboratory or clinic. Note that technological advancements are not unique to behavioral economics or to health-related behavior change, but rather the domain of technological advancements is furthering this field amongst others. Importantly, technological advances can be key to reducing the burden and cost of participating in research and/or receiving treatment and hence a boon to cost-effectiveness.

One promising behavioral economic intervention uses advancement in voice recognition software, Interactive Voice Response, to provide regular assessment of drinking patterns (Tucker et al., 2012; Tucker et al., 2009). Through regular remote assessment of drinking, the experimenters can use the collected data in a money allocation algorithm called the Alcohol-Savings Discretionary Expenditure index to compare previous years' savings compared to alcohol expenditures. The Alcohol-Savings Discretionary Expenditure index can then be used to prospectively predict drinking outcomes following natural resolutions to stop or moderate drinking (Tucker et al., 2008; Tucker et al., 2009; Tucker et al., 2012).

Another application of technology in behavioral economic interventions is the use of remote behavior-monitoring systems in incentives-based interventions (Kurti et al., in press). For example, having participants use a web camera to submit time-stamped videos of breath carbon monoxide (CO) testing to verify smoking status in to reduce cigarette smoking, allows for convenient sampling of smoking status obviating any need for smokers to visit the clinic for that purpose (Stoops et al., 2009; Dallery & Raiff, 2011). So too, breath-alcohol sampling for alcohol drinkers is currently undergoing feasibility studies for remotely monitored incentives-based interventions. Using these remote technologies, incentives studies are able to have a greater reach, more frequent objective verification of treatment targets, and greater cost-effectiveness.

Another intervention, based on the community reinforcement approach (Higgins et al., 2003), is the Therapeutic Education System, an adjunctive computer-delivered intervention developed to help with opioid dependence. The goal of the community reinforcement approach is to bring the patients in contact with pro-social reinforcer that may effectively compete with drug use. A novel extension employed in the Therapeutic Education System is the use of fluency training, where accuracy and speed of responding is required to move onto the next module. Fluency training helps to ensure optimization for mastery of the cognitive-behavioral skills and information presented during computerized modules. Randomized clinical trials have assessed the efficacy of computer-delivered compared to therapist-delivered modules, finding that the Therapeutic Education System was associated with significantly greater rates of abstinence as well as significantly lower dropout rates (Bickel et al., 2008; Campbell et al., 2014; Christensen et al., 2014). Leveraging state-of-the-art technologies in the further development of behavioral economic interventions will allow for more frequent and accurate assessment as well expanding the reach for behavioral economic interventions.

## Conclusion

Over the past 20 years, the behavioral economics of health-related behavior change has developed into a growing and robust field that is continuing to develop new and refine existing interventions to promote change over an ever-expanding range of health behaviors. As we have outlined above, this field is informed by novel conceptual systems, is inherently translational, focuses on developing efficacious trans-disease interventions, researches a variety of different aspects of change in health behaviors, promotes recognition of trans-disease processes, and leverages technology to extend reach and cost-effectiveness. Without question the magnitude and adverse impacts of highly prevalent and unhealthy behavior patterns remain large and challenging. The ways that behavioral economics may change and evolve to assist in meeting those challenges over the next 20 years will define the future of the field and may contribute to improved population health in the U.S. and globally. We look forward to seeing the field's evolution and to assisting in meeting emerging challenges.

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## Highlights

- The United States lags behind other countries on markers of health-related behaviors
- Behavioral economics targets health-related behaviors
- Five dimensions of behavioral economics are presented
- Future directions for the field of behavioral economics are discussed