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Choice Is Relative: Reinforcing Value of Food and Activity in Obesity Treatment

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Abstract

Persons with obesity find high-energy-dense food and sedentary behaviors highly reinforcing. Diets and exercise programs deprive individuals of many favorite foods and activities, which can counterproductively heighten their value and lead to relapse. Since the value of reinforcers depend on the alternatives available, one approach to reducing food and sedentary activity reinforcement is to build healthy alternative reinforcers. Current behavioral treatment programs for children and adults do not attempt to build alternative reinforcers as substitutes for unhealthy behaviors to reduce the impact of food or activity deprivation on the motivation to eat or be inactive. A goal of the next generation of obesity treatment programs should focus on development of healthy behaviors as reinforcers so that people will be motivated to engage in them. This article provides an overview of relationships among reinforcers, how understanding substitutes and complements can influence eating and activity, and how enriching a person's environment and providing choice architecture can enhance weight control. Ideas for translation of these basic behavioral economic principles to obesity treatment programs are discussed.

Editor's note.

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obesity treatment; reinforcing value; choice; behavioral economics

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Common goals in obesity treatment are to reduce energy intake and increase energy expenditure. These simple goals are complicated by the fact that persons with obesity are motivated to eat palatable, high-energy-dense foods (Giesen, Havermans, Douven, Tekelenburg, & Jansen, 2010) and to be sedentary (Temple, Legierski, Giacomelli, Salvy, & Epstein, 2008). Obesity treatment potentially heightens these preferences. Diets can

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inadvertently increase wanting for food (Flack et al., 2019), and this pattern may be repeated for sedentary behaviors.

Motivation to eat or to be sedentary can be operationalized by *reinforcing value*, or how hard a person will work for access to unhealthy versus healthy food or active versus sedentary behaviors (Epstein, Leddy, Temple, & Faith, 2007). Diets involve calorie restriction and deprivation, which is the prototypical way to increase food reinforcement in basic research (Belke, Pierce, & Cathcart, 2017; Carroll & Meisch, 1984). The reinforcing value of food and sedentary behaviors are also increased when humans are deprived of food (Epstein, Truesdale, Wojcik, Paluch, & Raynor, 2003) or deprived of social reinforcers, respectively (Gewirtz & Baer, 1958). The value of any reinforcer is not fixed but depends on the context, which includes the available alternative choices (Carr & Epstein, 2018). Although one may prefer hamburgers over hot dogs, this may not be the case when steak is available; the value of a hamburger depends on the available alternatives. Similarly, most evenings, one may prefer to watch TV versus read, but given the choice between watching TV or talking with a friend, one may choose to socialize.

The goal of this article is to provide a conceptual overview of basic behavioral economic theory as applied to research on food and activity reinforcement and relationships between reinforcers. Research suggests that choice may be a critical dimension of establishing preference for a behavioral reinforcer (Thaler, Sunstein, & Balz, 2013; Vara & Epstein, 1993; Wolffgramm & Heyne, 1995). *Choice architecture* and research on environmental enrichment suggests that arrangement of one's environment can be used to encourage healthier choices (East et al., 2019; Szaszi, Palinkas, Palfi, Szollosi, & Aczel, 2018). The importance of choice, alternative reinforcers, and an enriched environment in facilitating eating and exercise behavior change are examined for use in both pediatric and adult obesity treatment programs. Previous reviews have focused on food or activity reinforcement (Epstein, Leddy, et al., 2007; Epstein, Myers, Raynor, & Saelens, 1998; Epstein & Roemmich, 2001) or environmental influences (Larson & Story, 2009) but have not emphasized substitutes, complements, or choice architecture for obesity treatment. The article discusses ways to target value of individual reinforcers, choices between reinforcers, and how environmental enrichment can be applied to health eating and activity behaviors. Implications for translation to obesity treatment are integrated into the discussions of basic principles.

The Importance of Choice

Reinforcers strengthen behaviors they follow (Epstein, Leddy, et al., 2007); in other words, they can be used to shape behaviors. For example, parents may use a favorite snack to motivate children to eat vegetables or to complete their homework. For children and adults, food, sedentary activities, and physical activities can serve as reinforcers, as people will work for access to these behaviors. The amount of work completed to obtain a reinforcer provides a quantification of the reinforcing value of food (Giesen, Haver-mans, & Jansen, 2010) or activity (Barkley, Epstein, & Roemmich, 2009). In most environments, people have choices among behaviors. Choices are not made in isolation and are influenced by the available alternatives. Cookies may have high reinforcing value when the alternative is carrots, but likely a lower reinforcing value when the alternative is ice cream. Given that there are many ways people can choose to allocate their time, studying how reinforcers motivate behavior in a choice context is important to understanding how choice architecture can influence behavior change.

Choice may be an important aspect of how preferences for reinforcers develop in both animals and humans. A classic demonstration of this phenomenon was by Wolff-gramm and Heyne (1995). Rats were randomized to one of four groups that manipulated the availability of water and alcohol in two home-cage bottles, with water in both bottles as a control, alcohol in both bottles, and continuous or intermittent alcohol in one bottle, water in the other bottle. To simplify, one group had no choice but to drink alcohol to maintain hydration, and two other groups had a choice between water and alcohol. After access to alcohol was removed for the three experimental groups, animals showed symptoms of withdrawal. In the final phase, all animals were offered alcohol. Animals in the choice groups self-administered more alcohol, and animals who had continuous choice self-administered the highest amount of alcohol. Thus, even animals who had no choice but to drink alcohol as their sole source of fluid for over 30 weeks and showed signs of alcohol withdrawal, did not self-administer alcohol differently from the control group (no alcohol experience). This pattern of behavior was replicated for alcohol (Simms et al., 2008) and opioids (Wolffgramm & Heyne, 1995) in addition to sweet, high-fat liquids (Lardeux, Kim, & Nicola, 2013). This suggests that choice may be important to establish something as a reinforcer, even drugs of abuse. Forcing someone to do something, no matter how good (or bad), may not be a formula for establishing that behavior as a preferred reinforcer.

In humans, research on variety provides the opportunity to study preference for choice between a variety of reinforcers versus single reinforcers. People eat more when they have a variety of foods available (H. A. Raynor & Epstein, 2001). Dietary variety in unhealthy food groups has been associated with obesity (H. A. Raynor & Epstein, 2001), and individuals in obesity treatment who were asked to limit energy intake decreased variety of unhealthy foods and increased variety of healthy foods (H. A. Raynor, Jeffery, Tate, & Wing, 2004). Consistent with this idea, children who were given a choice between vegetables before or during a meal ate more vegetables compared with a no-choice group (one vegetable available; Rohlfs Domínguez et al., 2013). Providing variety may offer choices and increase engagement in healthy behaviors.

The same principle applies to exercise. Providing a variety of physical activities for children, adolescents, and adults increased enjoyment of physical activities (Juvancic-Heltzel, Glickman, & Barkley, 2013). In a 30-min gym class, providing eight versus two activity choices increased bouts of physical activity in children (Sanders et al., 2016), and in a laboratory setting, seven choices versus a favorite physical activity also increased engagement in physical activity over 30 min for the seven-choice group (Barkley, Ryan, Bellar, Bliss, & Roemmich, 2011). Preference for the option with choices was observed even when the single-option alternative was the initially preferred activity (Vara & Epstein, 1993).

Given the potential for choice to establish preferred reinforcers, this principle is sadly underutilized in clinical interventions for obesity. Therapy is often considered from a topdown approach, in which an expert imparts knowledge about the best way to change a behavior. The impact of interventions may be stronger if they were developed to facilitate a client's healthy choices, with the perception of free, rather than forced, choice. An illustration translating this principle of choice can be derived from a study on promoting exercise behavior in people joining a gym (Thompson & Wankel, 1980). Women were randomly assigned to either a program based on their own activity preferences (choice) or a standardized exercise program. The group that was provided choice had higher gym attendance over 6 weeks of membership compared to adults who were given fixed exercise prescriptions. Increasing the variety of healthy foods and physical activities while also reducing the variety of less healthy foods and sedentary activities may be an approach to encourage healthier choices.

Food and Activity Reinforcement

Reinforcing Value of Food

It should not be a surprise that persons with obesity consume excess energy, as they find food to be highly reinforcing (Epstein, Temple, et al., 2007). Food is a primary reinforcer, as newborns have an inborn motivation to eat (Stunkard, Berkowitz, Schoeller, Maislin, & Stallings, 2004), and many early behaviors are shaped using food (Lu, Xiong, Arora, & Dubé, 2015). This pattern persists throughout the life span, and food and eating are an important part of the fabric of many people's lives. Research on the development of food reinforcement in humans is in its early stages, but available data suggest that the reinforcing value of palatable food can grow, or sensitize, with repeated exposures (Temple & Epstein, 2012), similar to drugs (Steketee & Kalivas, 2011).

Food reinforcement is related to greater caloric intake in (Brace & Yeomans, 2016) and outside of (Epstein, Carr, Lin, Fletcher, & Roemmich, 2012) the laboratory, and caloric intake mediates the relationship between food reinforcement and body mass index (BMI; Epstein et al., 2012). Food reinforcement is also cross-sectionally related to obesity in infants (Kong, Feda, Eiden, & Epstein, 2015), children (Temple et al., 2008), and adults (Giesen, Havermans, Douven, et al., 2010), and prospectively related to weight gain in children (C. Hill, Saxton, Webber, Blundell, & Wardle, 2009), adolescents (Epstein, Yokum, Feda, & Stice, 2014), and adults (Carr, Lin, Fletcher, & Epstein, 2014).

The reinforcing value of a food is related to characteristics of that food, such as sugar, and fat (Panek-Scarborough, Dewey, & Temple, 2012), and processed foods are especially palatable and are associated with increased brain reward (Small & DiFeliceantonio, 2019). Sight, smell, and taste may combine in interesting ways to determine a food's reinforcing value (DiFeliceantonio et al., 2018). Understanding what makes food reinforcing may help in designing future interventions to increase the value of less-reinforcing foods (e.g., vegetables) as well as how to reduce the reinforcing value of unhealthy foods.

The reinforcing value of a food is dynamic, as it can be influenced by the state of the organism. Food deprivation increases the reinforcing value of food, and food satiation can reduce its value (Epstein et al., 2003). Deprivation is a reliable and well-known way to increase the value of a reinforcer, as food deprivation is commonly used in animal learning studies to aid in operant conditioning for food (Bouton, Winterbauer, & Todd, 2012) as well as increasing the reinforcing value of other commodities, such as drugs (Carroll & Meisch, 1984). Eating can be thought to fulfill two functions—a homeostatic function and a hedonic function that is driven by eating for pleasure and not bodily need. These functions can be measured with respect to food reinforcement (Stroebe, van Koningsbruggen, Papies, & Aarts, 2013); if the goal is to assess nonhomeostatic motivation to eat, a standardized portion of food can be provided so that people are not eating just to reduce hunger. Homeo-static and hedonic differences are important to consider. Calories must be consumed to maintain homeostasis, but the intake of concern is that which occurs above and beyond this caloric need, in other words, the hedonic eating that may lead to obesity.

Reinforcing Value of Activity

A consistent body of research has shown that physical activity is a reinforcer, as both children (Roemmich et al., 2008) and adults (Flack, Johnson, & Roemmich, 2017) will work for access to physical activity. Comparable with food, people have choices of sedentary or active reinforcers, and there are individual differences influencing activity reinforcement (Epstein, Smith, Vara, & Rodefer, 1991; Temple et al., 2008). Children with obesity prefer sedentary activities to physical activities, with a dose–response relationship to the degree of obesity: the higher the degree of obesity, the greater the preference for sedentary activity (Epstein et al., 1991).

There are wide individual differences in physical activity reinforcement (Flack et al., 2017), and the reinforcing value of physical activity is related to the amount of activity in the natural environment in children (Roemmich et al., 2008) and adults (Flack et al., 2017). There are many varieties of physical activities, broadly conceptualized as resistance versus aerobic exercise. People who engage in resistance training find resistance training more reinforcing, just as people who train aerobically find aerobic exercise more reinforcing (Flack et al., 2017).

Exercise can also differ in terms of whether it is considered continuous moderate-intensity exercise or high-intensity interval training (HIIT). Research suggests that sedentary youth prefer HIIT over traditional aerobic exercise (Barkley et al., 2009). This may be advantageous because the time demand for HIIT is much less than aerobic exercise, although both provide a sufficient training stimulus to improve aerobic fitness (Wewege, van den Berg, Ward, & Keech, 2017). Just as more research is needed to determine the reinforcing characteristics of food, research is needed to assess the reinforcing characteristics of physical activity. Physical activity should be programmed to increase the reinforcing value of the physical activity as well as to improve fitness and health. Research is needed to develop programs that focus on physical activity reinforcement rather than fitness, as increasing physical activity reinforcement should also increase time spent being active (Flack et al., 2017) and improve fitness.

Relationships Among Reinforcers

Access.

If two reinforcers are equally accessible but the value of Reinforcer A is higher than Reinforcer B, people will choose Reinforcer A most of the time. If the value of Reinforcers A and B are equal, but Reinforcer A is more easily accessible, then people will generally choose Reinforcer A. One way to think about shifting a choice from an unhealthy to healthy behavior is to put constraints on access to the less healthy option. Constraints can be placed on unhealthy behaviors by either decreasing access to (or increasing effort for) the unhealthy behavior (e.g., placing food on a high shelf) or increasing access to (or decreasing effort for) healthier options (e.g., put fruit in a bowl on the table).

There are many examples of access influencing eating and physical activity. Availability and accessibility of fruits and vegetables within the home is correlated with intake of fruits and vegetables, and the opposite is also true, as stockpiling unhealthy foods is correlated with increased intake of those foods (Larson & Story, 2009). Intake of snack foods for adults was less if a person had to walk a few steps or reach over a table for snack food (less accessible) versus having the snack food on a table next to them (more accessible; Maas, de Ridder, de Vet, & de Wit, 2012). Similarly, the farther away children in a daycare center sat from the snack bowl, the less they consumed (Musher-Eizenman et al., 2010). For physical activity, a shift from sedentary to active choices can be manipulated by increasing the distance someone has to walk for access to sedentary activities, while the physical activity is immediately available (D. A. Raynor, Coleman, & Epstein, 1998). This is the opposite of the usual scenario, in which a person has easy access to a wide variety of sedentary options at home but physical activities are less accessible and require more effort to engage in. There is a hidden response cost of being active, which involves changing clothes, showering, and so forth. Research assessing the effect of having to change clothes and shower after watching a TV show on changes in sedentary behaviors would be interesting.

Individual differences in access to home physical activity was found in preschoolers, with greater access to physical activity equipment for children with normal weight versus obesity (Boles, Scharf, Filigno, Saelens, & Stark, 2013). In a meta-analytic review, decreasing access to sedentary activities had a significant effect on increasing children’s physical activity (Maitland, Stratton, Foster, Braham, & Rosenberg, 2013), suggesting that increasing effort required for sedentary behaviors can reduce sedentary behaviors and simultaneously increase physical activity. Providing an active video game to children in their homes had mixed results on increasing physical activity (Maitland et al., 2013), suggesting that just increasing access to physical activity, without changing access to a preferred sedentary activity, may not be the best choice architecture for increasing engagement in physical activity. For adults, providing physical activity equipment, including treadmills and exercise videos, increased adherence to a physical activity intervention (Kaushal & Rhodes, 2014) and helped maintain an exercise program in an obesity intervention (Jakicic, Winters, Lang, & Wing, 1999).

These studies provide clear implications for clinical interventions, as access is important for modifying both eating and activity. Within a home environment, making unhealthy foods and highly reinforcing sedentary activities less accessible, while also making healthy foods and physical activities more accessible, is an established clinical tool in pediatric and adult weight control research (Epstein, Paluch, Kilanowski, & Raynor, 2004). Clinicians should be careful to prevent restriction or intermittent access to specific foods or macronutrients, which can increase their reinforcing value in both children (Rollins, Loken, Savage, & Birch, 2014) and adults (Flack et al., 2019). Strategies that allow free choice and avoid intermittent access, combined with changes in healthy and unhealthy behavior accessibility, may shift preferences to healthier choices.

Defining substitutes and complements.

Substitutes are foods or activities that satisfy the same basic need as another food or activity. Simply, a substitute can take the place of another item. Substitutes are assessed by varying the cost of preferred Option A and determining the required increase in cost before one switches to the less preferred Option B. As an example, fresh fruit prices are influenced by the growing season. If one prefers blueberries and they are not in season, the price for blueberries is increased. When the price increases enough, one may switch to strawberries, which have a longer growing season and stable prices for longer periods. In this case, one would say that strawberries can substitute for blueberries. The point at which someone may shift buying strawberries when the price of blueberries increases will depend on how substitutable strawberries are for blueberries. If someone switches after a small price increase, then strawberries are a better substitute for blueberries than for someone who will only switch after larger price increases in blueberries.

Complements are foods or activities that are consumed or used together, and the combination of the complements may have a higher value than either alone. There are many examples of complements, including tea and biscuits, cookies and milk, or hot dogs and mustard. Complementary relationships between reinforcers can be studied by varying the cost of Option A and showing that consumption of Option B changes in the same direction as Option A, even if the price of Option B is not changed. For example, creamer consumption can be reduced by increasing the cost of coffee. However, these relationships are not always symmetrical. Increasing the cost of creamer may not reduce coffee consumption, as there may be many substitutes for creamer in coffee. Asymmetric relationships have been shown for hypothetical drug use. When increasing the price of alcohol, desire for cocaine decreased, suggesting that alcohol and cocaine are complements (Petry, 2001), but increasing the price of cocaine increased the desire for alcohol, suggesting that alcohol is a substitute for cocaine. Considering relationships between reinforcers on a continuum from substitutes to complements, with the possibility of reinforcers being partial substitutes or weak complements, may be worthwhile for understanding choice architecture.

How substitutes can influence behavior change.

Behaviors closer in value are more substitutable than behaviors different in reinforcing value. However, constraints on access to preferred reinforcers can influence substitutability of alternative reinforcers. Research has shown that healthy foods and nonfood alternatives are substitutes for snack food when access to snack food is constrained (Giesen et al., 2010; Goldfield & Epstein, 2002).

Substitution is a dynamic process, and factors that influence reinforcing value can also change substitutability between commodities. For example, food deprivation increases the reinforcing value of food while also delaying substitution for money (Lappalainen & Epstein, 1990). If food deprivation increases the reinforcing value of food, it is reasonable to assume that substitution of alternatives to food may be more challenging during a diet. For this reason, it may be worthwhile to consider building in substitutes before introducing a diet that involves caloric reduction. In addition, if the reinforcing value of food sensitizes (Temple & Epstein, 2012), research on how to sensitize substitutes would have immense clinical utility.

Because food is more reinforcing for persons with obesity (Epstein, Temple, et al., 2007; Temple et al., 2008), it may be harder to identify substitutes for food in this population. Children with obesity had both higher food reinforcement and lower value of a nonfood alternative (hand-held video games; magazines or word puzzles) than leaner peers, suggesting that substitution in children who have developed obesity might be difficult (Epstein et al., 1991). Similarly, very young children with overweight or obesity found cookies more reinforcing than fruit, and their leaner peers found fruit more reinforcing than cookies (McCullough, Guilkey, & Stark, 2017). Individual differences also moderate the substitutability of physical activity. In children, physical activities were less likely to be substitutable for preferred sedentary activities than low-preference sedentary activities in those who were overweight or obese compared with leaner children (Epstein et al., 1991). Likewise, when a high-preference sedentary activity was available, physical activity was less reinforcing and did not substitute for the sedentary alternative (Epstein, Roemmich, Saad, & Hand-ley, 2004). However, when a low-preference sedentary activity was the alternative, physical activity was relatively more reinforcing, and children substituted the physical activity for the sedentary one.

The strong reinforcing value of food makes identifying substitutes for food and sedentary activities in children and adults with obesity difficult. However, identifying reinforcers that partially substitute for food may be useful, as finding reinforcers that fully substitute for food may cause people to not eat when they should. Additionally, the strength of reinforcers can change over time, so weak substitutes can gain partial substitutability for food. People can satiate (Havermans, Janssen, Giesen, Roefs, & Jansen, 2009) or sensitize (Temple & Epstein, 2012) to repeatedly presented reinforcers. Research is needed to assess whether changes in the relative reinforcing value of food and of alternatives, or their substitution, occur over time. The first step may be identifying reinforcers that may be partial or weak substitutes for food or sedentary activity, followed by building the value of the substitute, perhaps by increasing the variety of choices for the substitute.

Translation of the principle of substitution to clinical interventions would suggest that increasing access to healthy foods that can substitute for less healthy foods and/or decreasing access to less heathy options would shift choice to the healthier alternatives. In a clinical weight-loss study, parents were asked to either decrease fat intake or increase intake of fruits and vegetables (Epstein et al., 2001), with the idea that fruits and vegetables would be substitutes for high-fat food. Both groups showed weight-loss effects. However, the increase-fruit-and-vegetable group also decreased fat intake, whereas the decrease-fat group had no change in fruit and vegetable intake. This suggests that people will not automatically substitute fruits and vegetables when they are decreasing their energy in-take. When focusing on increasing fruits and vegetables, however, people substituted fruits and vegetables for the higher fat foods and limited their intake of higher fat foods. This effect is also seen in children who were asked to increase healthy eating versus reducing unhealthy foods (Epstein, Paluch, Beecher, & Roemmich, 2008). Children in the increase-healthy-food group had better treatment outcomes and maintained weight loss over 2 years, and this effect was replicated in adults' BMI change after 6 and 12 months of treatment (Vadiveloo, Parker, & Raynor, 2018).

Reducing access to sedentary behaviors to shift choice to physically active alternatives can also facilitate substitution of physical activity for sedentary behaviors in weight-loss programs (Epstein, Paluch, et al., 2004). Sedentary youth who were randomized to earn rewards for decreasing sedentary screen time versus a group who had reduced access to preferred sedentary behaviors showed equivalent weight loss at 1-year follow-up (Epstein, Paluch, et al., 2004). However, at pretreatment, children who found physical activity more substitutable for sedentary behaviors lost more weight over 1 year than children who did not find physical activity substitutable for preferred sedentary activities.

A relevant question to ask is whether reducing access to sedentary behaviors has similar effects as increasing physical activity on substitution between physical and sedentary activities. If children have reduced access to sedentary behaviors, either through modifications to their environments or by rewarding them for being less sedentary, they have to make choices on how to allocate this newly available time. Substitution is based on the idea that they will allocate some proportion to being physically active. To test this, children were randomized to treatments that either targeted decreasing sedentary activity, increasing physical activity, or both decreasing sedentary and increasing physical activity (Epstein et al., 1995). Children in the decrease-sedentary condition had greater decreases in overweight change than children assigned to the more traditional increase-physical-activity groups. In a similar study, both decreasing sedentary behavior with the goal of substituting time spent being active and increasing physical activities decreased screen time and increased physical activity in addition to contributing to successful weight loss at 2-year follow-up (Epstein, Paluch, Gordy, & Dorn, 2000).

Alternative reinforcers to food.

Characteristics of alternative nonfood reinforcers may be an important component in identifying substitutes for food and creating choice situations to encourage substitution. Observational research has examined the relationship between alternative reinforcers to food in four categories: cognitive-enriching (e.g., reading, listening to music), social (e.g., attending a party or event), sedentary (e.g., watching TV) and physically active (e.g., running, biking), and obesity (Carr & Epstein, 2018). Adults with a higher BMI engaged in fewer cognitive-enriching, social, and physically active behaviors than leaner adults. For all adults, sedentary activities did not compete with food reinforcement (presumably because many are also complements to eating), but the other three types of alternatives did compete with food reinforcement, resulting in comparatively lower food reinforcement. Social activities had the largest effect on reducing food reinforcement. In treatment, this may be complicated by the observation that social interactions may also be complements to food.

Although diets and food restriction may inadvertently increase the reinforcing value of food (Flack et al., 2019), focusing on alternative nonfood reinforcers may limit the effects of restriction and deprivation of foods. In a family-based weight-loss study, children with lower food reinforcement lost more weight when they were exposed to a high-enriched home environment—specifically, the availability of potential alternative nonfood reinforcers (Best et al., 2012). An experimental test of building alternative reinforcers to modify food reinforcement was implemented by Kong and colleagues (Kong & Epstein, 2016; Kong et al., 2015). Initial studies showed that the relative reinforcing value of food versus an alternative reinforcer was positively correlated with infant body weight (Kong & Epstein, 2016; Kong et al., 2015). The interesting finding was that the reinforcing value of food was the same for leaner and more overweight infants. The differences were for alternatives to food, which was replicated across three different reinforcers (bubbles, music, screen time). These data suggested that alternative reinforcement, or the ratio of alternatives to food, is a driving force for developing obesity.

To test the effects of providing access to an alternative reinforcer, Kong and colleagues (2016) randomized infants high in food reinforcement to groups that attempted to strengthen music reinforcement, which was an alternative reinforcer studied in the above research. Over a 6-week period, a music appreciation program for infants and their mothers resulted in an increase in music reinforcement and a decrease in relative reinforcing value of food, even without discussing food or feeding with parents. This study provides evidence that food reinforcement can be reduced by increasing the strength of alternative reinforcers to food.

Research is needed to replicate the observation that strengthening the reinforcing value of alternatives to food can reduce the reinforcing value of eating. Research is also needed to individualize alternative reinforcers to ensure that they are the best substitutes for the targeted behavior and not complements that could inadvertently increase the problem behavior. Because there will be individual differences in the types of alternatives to food that people find reinforcing, personalizing alternative reinforcers using available methods to assess reinforcing value of alternatives to food (Buscemi, Murphy, Berlin, & Raynor, 2014; Carr & Epstein, 2018) may strengthen treatment effects and prevent relapse.

Physical activity as an alternative reinforcer.

Strategies used to increase alternatives and substitutes for food can be used for the relationship between sedentary and physical activities. One way to increase physical activity is to modify the value of physical and sedentary reinforcers. Children who earned points for limiting or decreasing their engagement in sedentary activities increased the number of minutes they engaged in physical activity and lower preference sedentary activities (Epstein, Saelens, Myers, & Vito, 1997). In the same study, children who lost points for engaging in sedentary activities also increased physical activity and lower preference sedentary activities.

When access to a preferred behavior is reduced, a person has to choose a new behavior to take its place. In a clinical weight-control trial, children earned rewards that were contingent on either decreasing sedentary activities or increasing physical activities (Epstein et al., 1995). Children in a decrease-sedentary group decreased their sedentary behavior, but they had to choose how to fill that time. They chose physical activity for about one third of the newly freed time, and their liking for physical activity increased. Children asked to increase physical activity did not increase their liking of being more active. These results support the idea that people prefer behaviors they choose rather than those same behaviors done to comply with instructions.

Complements.

Sedentary behaviors are good candidates for potential complements to food that may stimulate energy intake. In experimental studies, concurrently watching TV increased energy consumed at a meal (Bellisle, Dalix, & Slama, 2004), suggesting that energy intake and TV are complements. The current environment has exponentially greater access to, and use of, screens, with the advent of mobile devices, but research has not parsed differences between previous screen devices (TV, computers) versus mobile devices. A recent meta-analysis has shown that eating while watching TV increased the risk for obesity in children (Ghobadi et al., 2018). Epidemiological data also suggest that greater amounts of TV and other screen devices confers a higher risk for obesity (Kenney & Gort-maker, 2017) and weight gain (Mitchell, Rodriguez, Schmitz, & Audrain-Mcgovern, 2013). More accessible complements produce more engagement in complementary behaviors; having a TV in a child's bedroom is associated with an increased risk of being obese (Adachi-Mejia et al., 2007).

An experimental test of the complementary relationship between screen time and energy intake in children was accomplished by increasing or decreasing TV time from a baseline measure (Epstein, Paluch, Consalvi, Riordan, & Scholl, 2002). When screen time was increased from baseline, energy balance was increased, suggesting a complementary relationship, and physical activity was decreased, suggesting a substitution relationship. These relationships were asymmetric, however, as decreasing screen time did not increase physical activity or exhibit a significant change in energy balance over the 3-week duration of the manipulation.

Clinical research on decreasing complements to eating has focused on decreasing screen time, including TV, video games, and computers. In a randomized controlled trial, TV, videos, and video game use was reduced in 8- to 9-year-old children over 6 months in a classroom curriculum (Robinson, 1999). The intervention was associated with a lower BMI than a usual classroom control group. Although children did not substitute physical activity when TV watching was reduced, the data suggest that they consumed fewer calories in front of a screen. In another study, children were randomized to reduce screen time versus monitoring screen use over a 2-year period (Epstein, Roemmich, et al., 2008). Children randomized to the intervention group had a decrease in zBMI, which was mediated by changes in sedentary behaviors. Reducing sedentary behavior was associated with a reduction in energy intake by as much as 250 calories per day for youth who pair watching TV with eating (Epstein et al., 2002). Complements may be "stealth" components of interventions, as other unhealthy behaviors are modified along with the complementary behavior. An important aspect of the study focusing on reducing TV to prevent obesity

(Epstein, Roemmich, et al., 2008) is that families were recruited who were interested in decreasing their child's screen time for educational reasons, not to prevent obesity.

If reducing complements to eating can reduce eating behavior, then perhaps increasing complements to physical activity can help people become more active. A social context may be an important complement to being active. Salvy, Roemmich, et al. (2009) showed that exercising in a social context increased the reinforcing value of exercise compared with exercising alone. Similarly, it may be possible to identify complements for healthy foods that would increase healthy choices. For example, Huh, Vosgerau, and Morewedge (2016) suggested that real or imagined consumption activates the desire to consume complements of that food. Imagining eating 30 versus three crackers increased actual consumption of cheese, while imaging eating 30 versus three M&Ms had no effect on cheese consumption, as M&Ms are not a complement to cheese. Identifying complements to healthy behaviors and increasing access to complements may support increases in several healthy behaviors at once.

The ideal scenario for behavior change may be one in which a substitute for an unhealthy behavior is identified, and that behavior is not a complement. For example, if people are given a choice between eating and watching TV, many would choose eating. If the cost to eat is increased, people may substitute watching TV. However, a complete picture of the relationship between eating and watching TV would suggest that watching TV is not a good substitute, as it can also serve as a complement to eating. Good substitutes should not also set the occasion for the unhealthy behavior.

It may be possible to identify behaviors that increase healthy eating while also reducing other unhealthy behaviors. Exercise is a behavior that could substitute for food and sedentary activities, which would both decrease energy in-take and occasion setting for eating, as sedentary behaviors and eating are complements. Research in adults suggests that exercise reduces food reinforcement (Panek, Jones, & Temple, 2014), which could, theoretically, reduce energy intake. Exercise may also substitute for sedentary behaviors; however, they are better substitutes for people without obesity (Epstein, Roemmich, Paluch, & Raynor, 2005). The search for behaviors that can both reduce unhealthy eating and increase physical activity would be important for obesity treatment, with more research needed.

The Enriched Environment

The concept of the enriched environment is translated from basic animal research in which animals are provided increased access to social, physical, or cognitively engaging activities (Robertson & Rowland, 2005). There is a large literature on the effects of the enriched environment on obesity (van Praag, Kempermann, & Gage, 2000) as well as acquisition or maintenance of drug self-administration (Carroll, 1996) in animal models. In human studies (East et al., 2019; Strauss & Knight, 1999), investigators have shown that enriched aspects of a child's environment that include cognitively enriching materials and access to social and physical activities can impact obesity development. Examining the home environment broadens research opportunities to assess the impact of nonfood alternative reinforcers, physical activity reinforcers, and the principles of substitutes and complements on choice behaviors. Focusing on the environment to provide a multitude of choices may also provide autonomy over behavior change for the patient. As a strategy for behavior change, principles of choice architecture (Szaszi et al., 2018) can be used to make environmental changes, which may include adjusting the available choices, accessibility to choices, substitutability between reinforcers, and constraints on complements to eating or sedentary behaviors.

Two large observational studies have shown that aspects of a child's early environment can reduce the risk of obesity, using the same method for assessing characteristics of the child's home enrichment. In the first study ($n = 3{,}320$), children with reduced access to stimulating and cognitively enriching activities during Ages 0 to 8 was associated with a higher relative risk of obesity 6 years later (Strauss & Knight, 1999). These activities predicted later obesity even when accounting for household income, which is important because one could assume that families with higher income would have greater access to more cognitively enriching activities. This finding was recently replicated and extended in a study with 1,000 children who were followed from infancy to Age 21 (East et al., 2019). Results were very similar when accounting for parenting. Aspects of the child's environment that focused on cognitively enriched activity were associated with a reduction in childhood obesity at Age 21 as well as a slower rate of BMI change over the observation period. These studies provide strong observational evidence to suggest that nonfood and nonactivity aspects of the child's environment can influence the development of obesity.

Buscemi et al. (2014) considered how substitutes and complements to eating could influence weight loss in an adult weight study. To assess the role of complements, they divided nonfood pleasant behaviors into those that occurred in combination with eating or separate from eating. They showed better short- and long-term weight loss for those who engaged in more pleasant food-free alternative behaviors. This study suggests that by increasing pleasant activities, there are more sources of positive reinforcement apart from food. However, this study did not directly assess the reinforcing value of these nonfood activities or assess substitutability between these activities and eating.

The opposite of an enriched environment is one with scarce access to important reinforcers. Scarcity of both monetary and time resources influences decision making in multiple ways (Mani, Mullainathan, Shafir, & Zhao, 2013). Limiting choice options may increase the value of the limited reinforcers. For example, participants who read a hypothetical scenario that asked them to imagine losing their job, losing their savings, and moving and living with a disliked relative (income shock) increased the reinforcing efficacy of food compared with a no-income-shock group (Mellis et al., 2018).

Both low income and low education have been related to higher BMI in adults (Lin, Carr, Fletcher, & Epstein, 2013), an effect mediated by food reinforcement (Lin et al., 2013). This may be related to food scarcity and food insecurity, a type of intermittent restriction resulting from low monetary resources (Franklin et al., 2012). Scarcity and food insecurity have been theorized to increase food reinforcement through deprivation effects on reinforcing value (Epstein et al., 2003), a lack of available and reinforcing nonfood alternatives (Estabrooks, Lee, & Gyurcsik, 2003), or potential metabolic mechanisms associated with resource scarcity (Dhurandhar, 2016).

The effects of scarcity in early development on eating may persist over long time intervals. Adults exposed to a low socioeconomic environment in childhood consumed more snack calories when they were not calorie deprived than those with a high childhood socioeconomic status (S. E. Hill, Prokosch, Delpriore, Griskevicius, & Kramer, 2016). Scarcity can also modify food reinforcement in adults (Crandall & Temple, 2018) depending on their history of food insecurity. In an experiment designed as an analogue to food scarcity, adults worked for food in two sessions; in one session, they were informed midway through the experiment that there was a limited supply of food available. When limits were placed on the snack food available, individuals with a history of food insecurity increased their responding for food. One implication of these data is that people who have experienced food insecurity in the past, which include persons with low-income, may show a greater and sustained increase in food reinforcement during a diet and subsequent food deprivation than those without a history of food insecurity.

An important question when discussing access to reinforcers and enriching the environment is how can this be implemented in a low-income or resource-scarce population. Some of the most powerful reinforcers for children involve social activities, as they will work to gain access to social reinforcers (Salvy, Nitecki, & Epstein, 2009), and social reinforcers increase the reinforcing value of physical activities for children who were overweight (Salvy, Roemmich, et al., 2009). Research has found that children value positive interactions with adults (Gewirtz & Baer, 1958), and social reinforcers are more effective with increased familiarity (Mccoy & Zigler, 1965), suggesting time with parents or caregivers is a potential alternative reinforcer. Enriched environments should also increase the variety of healthy options, which then may facilitate healthy choices. An interesting aspect of enriched environments for the prevention of obesity is that some of the positive behaviors encouraged include cognitively stimulating activities, which can have effects on cognitive function (Sarsour et al., 2011) in addition to weight control.

Consideration of the larger environmental context in which people live allows for a combination of modifications to increase the relative value of healthy and unhealthy behaviors. Most of the human enrichment research is observational, so one cannot discount the possibility that an enriched environment may be correlated with reduced access to unhealthy food or a less sedentary lifestyle. An interesting study would be to evaluate whether an enriched environment can compete with an environment replete with unhealthy foods and sedentary activities, or whether access to unhealthy foods and activities would also have to be reduced.

Conclusion

Food and activity reinforcement drive eating and activity (Epstein, Leddy, et al., 2007; Epstein & Roemmich, 2001; Epstein & Saelens, 2000) and, thus, obesity. Clinicians should consider that people often have choices among reinforcers, and engaging in unhealthy eating or a sedentary lifestyle involves many choices. Based on this simple idea, this article has focused on how behavioral economic principles and choice architecture can influence eating and exercise.

Treatment of obesity has traditionally involved a diet that reduces intake of preferred foods and an exercise program that asks people to give up their preferred sedentary lifestyle and begin to engage in activities that they do not enjoy. This can be done for a limited period of time, but a diet may inadvertently increase the reinforcing value of food, and the exercise program may not be designed to foster motivation to be active, leading to high rates of relapse (Wing & Phelan, 2005). Careful arrangement of the choice context in which the diet and exercise program occurs is important. There are several basic principles that researchers and clinicians may want to consider as they design the next generation of obesity treatments. Allowing free choice by increasing access to a larger variety of healthy versus less healthy choices may increase preferences for healthy behaviors. Increasing access to substitutes and decreasing access to complements to unhealthy behaviors may include providing additional reinforcers to create an enriched environment. Alternative reinforcers may help people adapt to the loss of reinforcement when favorite foods or sedentary behaviors are withdrawn. Enriched environments with variety may reduce adaptation to any one particular alternative nonfood reinforcer. Characteristics of alternative reinforcers or physical activity may also allow for sensitization, which would increase a reinforcer’s ability to compete with unhealthy behaviors.

Healthy behaviors will not automatically develop when unhealthy behaviors are reduced. The process of establishing new healthy behaviors involves reinforcing new behaviors that can lead to a change in lifestyle. Providing alternative reinforcers in an enriched environment may be important to establishing new habits and developing a new lifestyle. Consideration of how to translate and integrate new advances in choice architecture based on behavioral economics and the enriched environment may lead to the next generation of improved treatments for obesity.

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Public Significance Statement

Current obesity treatment programs deprive individuals of many favorite foods and activities, which can counterproductively heighten their value, leading to relapse. Applying principles of behavioral economics and choice architecture, new treatments targeting health eating and activity can be designed around the idea of choice and access to healthy alternative reinforcers in one's environment.