HHS Public Access

Author manuscript

Pediatr Clin North Am. Author manuscript; available in PMC 2017 June 01.

Published in final edited form as:

Pediatr Clin North Am. 2016 June ; 63(3): 425–446. doi:10.1016/j.pcl.2016.02.001.

Behavioral Economic Factors Related to Pediatric Obesity

Angela J. Jacques-Tiura, Ph.D. and

Department of Family Medicine and Public Health Sciences, School of Medicine, Wayne State University, iBio – Behavioral Health, 6135 Woodward, H206, Detroit, MI 48202

Mark K. Greenwald, Ph.D.

Department of Psychiatry and Behavioral Neurosciences, School of Medicine; Department of Pharmacy Practice, Eugene Applebaum College of Pharmacy & Health Sciences; and iBio – Behavioral Health, Wayne State University, Tolan Park Medical Building, 3901 Chrysler Service Drive, Suite 2A, Detroit, MI 48201

Angela J. Jacques-Tiura: atiura@med.wayne.edu

Summary

The field of behavioral economics suggests that food and activity choices are governed by costs, available alternatives, and reinforcement. Here, we review basic and translational research using a behavioral economic (BE) framework with overweight or obese children up to age 18. We address BE concepts and methods, discuss developmental issues, the continuum of BE intervention approaches, findings of studies focused on increasing the cost of unwanted behaviors (i.e., energy-dense food intake and sedentary behavior) and decreasing the cost of desired behaviors (i.e., healthy food intake and PA), and our team's recent basic behavioral studies using BE approaches with minority adolescents.

Keywords

Obesity; pediatric; behavioral economics; incentives; food reinforcement; demand; energy intake; physical activity

Introduction

Pediatric overweight and obesity are highly prevalent: about 32% of American children and adolescents are overweight (sex- and age-specific BMI 85th to 95th percentile) or obese (BMI ≥ 95th percentile).[1] Although treatments have produced some improvements,[2] innovative non-medication approaches are needed to curb this trend. The field of behavioral economics offers pathways for interventions to increase physical activity (PA) and healthier food intake and decrease sedentary behavior and unhealthy food consumption. Behavioral economics suggests that food and activity choices are governed by costs, available

Correspondence to: Angela J. Jacques-Tiura, atiura@med.wayne.edu.

alternatives, and reinforcement. Here, we review basic and translational research using a behavioral economic (BE) framework with overweight or obese children up to age 18. We address BE concepts and methods, discuss developmental issues, the continuum of BE approaches, findings of studies focused on increasing the cost of unwanted behaviors (i.e., energy-dense food intake and sedentary behavior) and decreasing the cost of desired behaviors (i.e., healthy food intake and PA), and our team's recent work using BE approaches with adolescents.

What is a behavioral economic approach?

Behavioral economics posits that reinforcers, available alternatives, and costs govern choices.[3] Holding other factors constant, individuals engage in behaviors that are highly reinforcing, or have minimal suitable alternatives and lower costs (in money, time, or effort). Box 1 includes key terms. For example, using a BE approach, interventionists may try to *increase* healthy eating by:

- increasing the reinforcing properties of healthful foods (e.g., touting the full flavors),
- changing food environments to stock more healthful options than unhealthy options
- lowering the cost of more healthful foods.

How may a behavioral economic approach complement other treatment approaches?

Because the BE approach focuses on changing environmental factors or reinforcers to change food- and PA-related behaviors, the BE approach is compatible with most currently available behavioral treatment approaches (e.g., family-based lifestyle behavioral interventions), and could complement medication-assisted treatments once those come to fruition for pediatric obesity treatment. We emphasize that BE approaches should not be implemented in isolation but, rather, integrated with other viable strategies as part of multimodal, multilevel interventions.[4]

On the other hand, the BE approach – which relies on environmental sources of reinforcement to promote healthier outcomes (e.g., weight loss) – could potentially conflict with those cognitive-behavioral interventions that emphasize the importance of patients' *internal* motivation for behavior change (self-determination). Notably, there has been debate regarding this issue of exogenous vs. endogenous locus of motivation elsewhere; namely, it has been hypothesized that external incentives could undermine a patient's internal motivation for behavior change. However, data supporting this conclusion are mixed;[6–8] rather than opposite ends of the motivation spectrum, intrinsic and extrinsic motivation appear to exist more independently than earlier thought.[9–11] A recent review of treatments for cannabis dependence demonstrated that long-term follow-up results from interventions combining contingency management (i.e., giving vouchers for abstinence) and cognitive-behavioral therapy were better than for those using just one form of treatment,[12] suggesting

that interventions targeting both intrinsic and extrinsic forms of motivation to change can be efficacious.

Compatibility of BE-based interventions with other treatment approaches partly depends on which outcomes are being targeted. Key questions in BE studies involve which behavior(s) will be reinforced, whether the behavior will be price-sensitive (elastic), and how other available reinforcers will compete for control of behavior. The specific approach depends on the proposed mechanism of action in relation to the desired outcome, e.g., increased healthy (or decreased unhealthy) food intake, increased PA (or decreased sedentary activities), increased energy expenditure (or decreased energy intake), or perhaps weight loss that is more distally mediated by the aforementioned factors.

In the case of increasing healthy nutrient intake, the BE approach presumes that greater availability and price-lowering manipulations will drive demand higher and, indirectly, could increase demand elasticity for unhealthy food. Conversely, if decreasing unhealthy nutrient intake is the focus, this presumes that demand for punished nutrient intake will become more price-elastic and, indirectly, could result in more inelastic demand for healthy food. Similar BE substitutive relationships can be illustrated with regard to targeting behaviors associated with energy expenditure. Thus, when reinforcing PA one may observe a collateral reduction in sedentary activity, or when punishing sedentary activity one may observe an increase in PA. Both types of effects have been experimentally demonstrated in obese children.[13]

As noted above, targeting more than one behavioral outcome (multimodal intervention) may be advantageous, but involves more complex mechanisms. A classic example is targeting both increased healthy nutrient intake and PA, which presumes these behaviors are compatible or, in BE terms, complementary. Increased PA might (aside from its acute anorectic effect) increase overall food consumption without regard to type of nutrient intake, thus, an intervention that seeks to increase desirable macronutrient consumption would be needed to narrow post-exercise food intake. Consequently, a significant challenge of multimodal interventions will involve determining which reinforcers can serve as economic complements, so that desired outcomes are synergistically enhanced and undesired outcomes synergistically suppressed. Failure to consider these issues could result in two interventions that, while mildly effective in isolation, cancel each other's effects.

At the individual level, BE interventions can be used to reduce undesirable activities such as sedentary behavior (see Tables 1-3). At the interpersonal level, BE approaches can be used to promote immersion of the individual in peer social networks that engage in PA and meaningfully interpersonal interactions, and/or discouraging sedentary behavior and unhealthy food intake.[14] It noteworthy that PA and sedentary behaviors, or eating healthy foods and avoiding unhealthy foods, are not necessarily substitute activities; rather, an inverse behavioral relationship must be demonstrated empirically in specific contexts when one manipulates one but not the other.[15,16]

Likewise, BE interventions can be targeted at the family level, e.g., reinforcing behaviors of the caregiver (e.g., purchasing predominantly healthy foods at the grocery store, restricting electronic media until after the child has exercised for 15 min) and the child (e.g., eating

enough fruits and vegetables, exercising 3× weekly for 30 min each time). At the community level, BE approaches may be implemented within schools, after school centers, work place cafeterias, or other centers in which food and activity choices are presented. Although many organizations may try an education approach, evidence suggests education alone may not improve behavior; on the other hand, pairing education with a reinforcer can increase healthier food choices.[17] Many of these are seen as "nudge" approaches,[18] in which consumers' choices are limited or restricted in some way to increase selection of healthier options.

Continuum of BE approaches

Public policy stance

The IOM's obesity-prevention report[19] proposed a broad set of interventions to address obesity including child-focused measures such as positioning schools to function, in effect, as health centers (e.g., promoting PA, banning high-sugar drinks). However, Marlow and Abdukadirov[20] have questioned this approach, noting some regulatory interventions (e.g., labeling/disclosure of nutrient content, taxing junk food) do not have reliable supporting data. They observe from the alcohol and tobacco literature that taxation approaches are not "one size fits all", rather they tend to be more effective for individuals with less-severe consumption problems (whose intake is price-elastic) than those with greater problems (whose intake is price-inelastic). These authors contend taxation will not be particularly effective for modifying unhealthy food intake among the real population of interest, obese individuals. They also argue that top-down regulatory policies, which are rational in their design, may not shift individual's food intake behaviors that are habit-based (i.e., irrational). Consistent with this hypothesis, Best et al.[21] found that children observed to have greater food RRV and who steeply discounted future food rewards at treatment baseline were less sensitive to an intervention that increased healthier food options in their natural environments.

Third-party payers

Organizations that shoulder the economic burden from the consequences of unhealthy eating (e.g., employers, insurers) have been paying attention to BE insights. From an actuarial perspective, health benefits of interventions more readily accrue to individuals with less-severe problems. Nonetheless, evidence from health incentive plans indicates it is possible to "nudge" employees' behavior through small, frequent payments – delivered outside of paychecks to increase their salience – for low-threshold, repeated healthy behaviors.[18]

Increasing availability of healthy foods

Particularly in urban and low-income settings, there is a critical need to re-engineer the food environment to enable consumers (caregivers and children) to purchase and consume healthier foods. Many urban contexts suffer from being "food deserts", i.e., lack of ready access to healthy options and dominated by unhealthy options. To remediate this problem, locally coordinated action is needed to *re-set the default options of the food economy, i.e., make healthy foods, rather than unhealthy foods, the salient market feature*.[22] Community representatives (e.g., legislators, philanthropists, business owners, religious organizations,

educational institutions, families) must work together to determine the best native solutions for investing in building and operating food markets. But, ideally, healthy food options should be located proximal to population centers and at the epicenter of community activities, thereby providing the opportunity to bring more people into greater contact with healthier food options. At the same time, we recognize that re-setting default marketplace options is difficult and, even when this condition is met, this will not be sufficient for individuals' behavior change. For instance, it is equally necessary to increase the availability and salience of these healthy foods within the home environment. After purchasing foods, caregivers must monitor eating behaviors in the home environment. Taking a cue from the substance abuse literature again, parental monitoring is an effective preventive strategy for unwanted behaviors.

Behavioral commitment

At an organizational level, considerable evidence has accrued to indicate that health behaviors can be promoted through default opt-out plans than default opt-in plans. This observation could be due to the ‘endowment effect’ (over-attachment to existing reinforcers or lifestyle) and/or to the effort required to switch (representing a cost or price).

At the individual level, having people make written plans can motivate behavior change. The mechanism of this behavioral effect could stem from delay discounting: If the person can envision the temporal horizon for completing a concrete behavior (which is being examined by use of “episodic future thinking” interventions),[23-27] it becomes more salient than alternatives. Another possible explanation is that the written plan may – particularly in a social context – solidify personal intention (a promissory note, of sorts) by decreasing temptation to escape the commitment to avoid shame.

Developmental considerations

BE-based research, specifically assessing RRV (of food, activity, or other commodities), has been conducted with infants as young as 9 months,[28] and with toddlers, preschoolers, young school-age children, and adolescents. Children across ages demonstrate individual differences in their level of reinforcement from food; one key factor to consider is how to assess RRV. Infants can learn to press buttons to get what they want, and older children can learn a variety of computer-based games or understand questionnaires. Younger children may be more amenable to increasing PA by decreasing sedentary activity.[15,29] Gender differences are not often found, but mixed results have been reported (girls biked more than boys in a video game experiment,[30] boys were more likely to substitute physical for sedentary activity,[15,31] boys indicated stronger reinforcement from food).[28,32] Brain substrates underlying impulsivity and self-control mechanisms – mediated by frontal-cortical regions -- are less well developed in children and adolescents relative to adults, as evidenced in larger delay discounting for children.[33]

Current state of the basic, translational, and intervention literature on BE-related factors in pediatric obesity

Increasing consumption of healthy foods

Table 1 describes six intervention studies focused on food intake, including both those studies that aim to increase consumption of healthy foods and studies that aim to decrease consumption of unhealthy foods. BE suggests that when the price (in money, time or other costs) of healthy foods is lowered, children may increase consumption. Easing access in a high school cafeteria increased intake of healthier options and decreased consumption of less healthy options.[34] Incentives paired with healthy options can increase consumption in both preschoolers[35] and older children.[17] Healthy and unhealthy foods are not necessarily substitutes for one another, however. For example, among children randomized to decreasing their snack food consumption; increasing their fruit, vegetable, and low-fat dairy intake; or increased growth monitoring, fruit and vegetable intake increased during treatment but intake was unrelated to decreases in snack food intake or total energy intake.[36] Although snack food consumption did not significantly decrease, reductions were significantly associated with energy intake reductions. Further, reinforcing engagement in alternative activities to eating may increase such engagement overall, but such changes may not be enough to meaningfully affect weight.[37]

Taken together, research focused on increasing consumption of healthier foods suggests:

- using incentives paired with healthy options
- altering default choices to healthier options
- decreasing energy dense food consumption rather than increasing healthier foods consumption to decrease energy consumption.

Increasing physical activity

Table 2 describes 13 basic research and intervention studies focused on increasing PA, including those studies reinforcing increased PA itself and those reinforcing not engaging in sedentary activities. The goal of providing incentives for exercise and social activity are based on the BE idea that these activities can compete with energy-dense food consumption and, thus, can function as economic substitutes. It has been noted that the RRV of PA may be greater when such activity occurs in multiple, short bouts rather than fewer, extended bouts.[29] This is tantamount to lowering the short-term unit price of PA and, from the perspective of delay discounting, making it more feasible in the present time. Several studies found that PA can substitute for sedentary activity among nonoboese[16,31,38–40] and sometimes among obese[13,40] children. Not surprisingly, substitution of PA for sedentary activity is more likely when the child is less reinforced by the sedentary activity.[41] Using time for sedentary activity as a reinforcer for engaging in PA may also encourage some obese children to increase their PA level[42] and improve health outcomes.[43] An early study demonstrated that reinforcing reducing time spent in sedentary activity may produce better weight outcomes among obese children than reinforcing increased time spent in PA, perhaps because the children had more autonomy with their time not spent sedentary. Overweight

children may benefit from engaging in PA with other children, as the presence of another child can increase reinforcement from PA.

Taken together, research focused on increasing PA suggests that:

- decreasing sedentary time may increase physically active time
- treating sedentary time as a reinforcer for physically active time may increase physically active time
- engaging in PA with another child may increase reinforcement for overweight children.

Nudging

Health behaviors are difficult to initiate. The baseline conditions of a person's environment set a default behavior mode (*status quo*) that is hard to overcome. Thus, it may be necessary to breach that gap by resetting the baseline conditions (e.g., where the caregiver shops for food, stocking a lunch line with tasty healthier options[34]). Likewise, health behaviors are also notoriously difficult to maintain, and the incentives used to sustain behavior changes may necessitate increasing the frequency of monitoring and reinforcement. In this regard, technology is a useful handmaiden of behavior change in the obesity prevention/treatment field because electronic messaging (e.g., well-timed reminders to exercise or eat certain foods) can overcome limitations of traditional office-based interventions. More research is needed in the area of nudging.

Individual differences as mediators/moderators of BE-inspired interventions

Table 3 describes 17 basic and translational research studies of factors that may moderate, mediate, or otherwise influence BE-guided intervention effects. As noted above, incentive approaches may work better for individuals whose demand is less intense and/or price-elastic.[21] Overweight and obese children typically find foods and sedentary activity more reinforcing, and PA less reinforcing, than lean children,[28,32,44,45] and increasing weight is associated with higher reinforcement from snack foods.[46,47] Ostracized adolescents (those excluded from the group) may find energy-dense food more reinforcing,[48] suggesting that more engagement with other children may be beneficial for reinforcement from food and PA. Impulsivity (i.e., failure of self-control), mediated by frontal-cortical brain regions, is correlated with greater energy-dense food intake, and needs to be considered as a constraint on behavior change.[21] Thus, interventions must weigh incentive value (positive reinforcement of healthy, or punishment of unhealthy, food intake) against underlying impulsive tendencies of the individual (potentially associated with younger age of the child) that will tend to undermine these efforts.

Another individual-difference characteristic that closely relates to BE-inspired tactics is income level, which can moderate the food purchasing/consumption. Specifically, increases in income may ameliorate substitution of lower cost healthier options for more favored and more expensive less healthy options.[49] When income is constrained, substitution may occur if healthy choices have lower costs than unhealthy choices.[49] Children's healthy and unhealthy choices can be elastic.[49]

An additional factor to consider when evaluating the reinforcing value of food and activity is what exact commodities are being measured and compared. For example, lean children find an active video game (boxing) more reinforcing than the sedentary version, but overweight children found them equally reinforcing (although the lean and overweight children differed in how reinforcing each type was),[30] and dancing and bicycling riding are both physical activities but motivation to engage in each vary, as did how to engage in them as video games.[44] Among lean children, RRV of sweet foods was highest but RRV of sweet, salty, and savory foods were all correlated and their combination was associated with energy intake.[50]

Taken together, other BE-guided research suggests that:

- weight status, impulsivity, income, feelings of inclusion, and type of commodity may serve as moderators or mediators of intervention effects.

Current and future directions

Tables 1-3 demonstrate that the majority of BE-guided research is conducted with primarily White, upper middle class samples (with notable exceptions[17,21,46,49]). Our team is investigating the role of RRV in basic research and as a moderator of intervention treatment effects in African American adolescents. In our sequential multiple assignment randomized trial (SMART),[54] African American adolescents (12-16 y/o) with obesity (BMI≥95th percentile) completed 3 months of motivational interviewing plus skills building with their caregivers in their home or clinic (first randomization). Adolescents who did not lose at least 3% of their baseline body weight were re-randomized to complete three months of contingency management (reinforcement for weight loss) or additional skill building in their home. At baseline, we measured adolescents' RRV of a favorite snack food using a food purchase task questionnaire. Preliminary analyses indicate that adolescents' RRV interacted with treatment sequence to influence weight loss and reduction of metabolic syndrome symptoms. These findings highlight the need to assess individual differences in RRV at the start of treatment.[21]

In an ongoing laboratory study with a sample of African American adolescents and caregivers, we are determining whether caregiver food purchasing is related to their child's (12-17 y/o) BMI. Each caregiver completes a typical shopping trip for their household in a ‘virtual grocery store’ where each item is displayed with its picture, nutritional information, package size, and local price. Participants place items in their grocery cart and amount spent is displayed during shopping. We will compare caregivers’ virtual shopping behavior with their recent real-world grocery receipts as a validation test of the experimental model. That this is a low-SES urban sample with relatively low access to traditional large grocery stores and frequent use of convenience and “corner stores” is a novel experience that could provide revealing information regarding food purchasing behaviors. This virtual grocery store model is expected to provide data relevant to food price-elasticity that may be useful in intervention studies and policy planning.

In this same project, we are determining whether adolescent BMI is related to food demand, particularly in relationship to a stressor. In two separate experimental sessions (stress

[listening to crying babies] and neutral [listening to nature sounds] in randomized order), each adolescent can work for unit amounts of two foods on 11 independent choice trials: his/her preferred high-palatable food (1 Oreo or 5 Doritos per trial; determined at screening) or 1 baby carrot. In each 30-min session, we vary food UP by increasing the response requirement (# mouse-clicks) for each successive same-food choice on a PR schedule as in our recent work.[55] The adolescent can consume his/her earned food after each session, and we measure amount and rate of consumption. We measure heart rate and saliva cortisol as a manipulation check on stress reactivity. Preliminary findings indicate that teens with higher (questionnaire-based) levels of food disinhibition and automaticity consume more snack food following the experimental stressor. Our future work will build on this project by expanding the menu ("mini-buffet" model) in the food-choice task, and examining how engaging in PA of varying intensities prior to the food-choice task affects biomarker, neurocognitive and food-reinforced responding among African American adolescents with obesity.

Summary/Discussion

With regard to improving children's eating and activity behaviors, behavioral economics posits that reinforcers, available alternatives, and costs govern choices. The research reviewed here demonstrates that:

- environmental factors powerfully affect choice and nudges may improve personal and population health
- food and activity reinforcement value varies across children (e.g., due to trait or other historical factors), age and possibly gender
- higher pre-treatment food and lower activity reinforcement may decrease the success of weight loss interventions for youth
- children may substitute PA for sedentary activity if reinforced
- more ethnically and financially diverse samples are needed.

Although the American Academy of Pediatrics has made recommendations to pediatric health providers to promote family diets that are rich in fruits and vegetables, low in energy-dense products, balanced with greater engagement in PA and less engagement in sedentary activities,[56] there are feasibility challenges in how to communicate and achieve these goals. The BE framework suggests that pediatric clinicians should take careful behavioral histories (perhaps aided by staff with specialized behavioral training), focused on the child's "marketplace" of food and activity options (influenced at the person-, caregiver/family-, and school/community-levels), to identify barriers (i.e., opportunity costs of foregoing currently-preferred activities for new ones) and incentives (e.g., changing the default options, and milestone rewards) to "nudge" behavior change.[5] Clinicians and families must agree on the specific behaviors and time frame to be targeted for change, with recognition that smaller, sustainable steps are more likely to be completed (less delay discounting, lower price) than more ambitious goals.

Acknowledgments

Disclosures: This work was funded by Wayne State University Office of the Vice President for Research (Wayne State University Diabetes and Obesity Team Science), National Institutes of Health grants 2R01DA015462 and U01HL097889, Helene Lyckaki/Joe Young, Sr. Funds (State of Michigan), Detroit Wayne Mental Health Authority.

References

1. Ogden CL, Carroll MD, Kit BK, et al. Prevalence of childhood and adult obesity in the United States, 2011-2012. JAMA. 2014; 311(8):806–814. DOI: 10.1001/jama.2014.732 [PubMed: 24570244]
2. Altman M, Wilfley DE. Evidence update on the treatment of overweight and obesity in children and adolescents. J Clin Child Adolesc Psychol. 2015; 44(4):521–537. DOI: 10.1080/15374416.2014.963854 [PubMed: 25496471]
3. Bickel, WK.; Vuchinich, RE., editors. Reframing health behavior change with behavioral economics. Psychology Press; 2000.
4. Huang TT, Drewnowski A, Kumanyika SK, et al. A systems-oriented multilevel framework for addressing obesity in the 21st century. Prev Chronic Dis. 2009; 6(3):A82. [PubMed: 19527584]
5. Wilfley DE, Kass AE, Kolko RP. Counseling and behavior change in pediatric obesity. Pediatr Clin N Am. 2011; :1403–1424. DOI: 10.1016/j.pcl.2011.09.014
6*. Deci EL, Koestner R, Ryan RM. A meta-analytic review of experiments examining the effects of extrinsic rewards on intrinsic motivation. Psychol Bull. 1999; 125:626–668.
7. Ledgerwood DM, Petry NM. Does contingency management affect motivation to change substance use? Drug Alcohol Depend. 2006; 83:65–72. [PubMed: 16310974]
8*. Ng JYY, Ntoumanis N, Thørgersen-Ntoumani C, et al. Self-determination theory applied to health contexts: a meta-analysis. Perspect Psychol Sci. 2012; 7:325–340. DOI: 10.1177/1745691612447309 [PubMed: 26168470]
9. Gerhart B, Fang M. Pay, intrinsic motivation, extrinsic motivation, performance, and creativity in the workplace: revisiting long-held beliefs. Annu Rev Organ Psychol Organ Behav. 2015; 2:489–521. DOI: 10.1146/annurev-orgpsych-032414-111418
10. Lepper MR, Corpus JH, Iyengar SS. Intrinsic and extrinsic motivational orientations in the classroom: age differences and academic correlates. J Educ Psychol. 2005; 97:184–196. DOI: 10.1037/0022-0663.97.2.184
11. Naar-King, S.; Suarez, M. Integrating motivational interviewing into your practice. In: Naar-King, S.; Suarez, M., editors. Motivational interviewing with adolescents and young adults. Guilford; 2011. p. 75-84.
12. Cooper K, Chatters R, Kaltenthaler E, et al. Psychological and psychosocial interventions for cannabis cessation in adults: a systematic review short report. Health Technol Assess. 2015 Jul; 19(56):1–130. DOI: 10.3310/hta19560
13. Epstein LH, Saelens BE, O'Brien JG. Effects of reinforcing increases in active behavior versus decreases in sedentary behavior for obese children. Int J Behav Med. 1995; 2(1):41–50. [PubMed: 16250788]
14. Epstein LH, Wrotniak BH. Future directions for pediatric obesity treatment. Obesity. 2010; 18:S8–S12. DOI: 10.1038/oby.2009.425 [PubMed: 20107466]
15. Epstein LH, Raja S, Gold SS, et al. Reducing sedentary behavior: the relationship between park area and the physical activity of youth. Psychol Sci. 2006; 17:654–659. [PubMed: 16913945]
16. Epstein LH, Roemmich JN, Paluch RA, et al. Physical activity as a substitute for sedentary behavior in youth. Ann Behav Med. 2005; 29(3):200–209. [PubMed: 15946114]
17. List JA, Samek AS. The behavioralist as nutritionist: leveraging behavioral economics to improve child food choice and consumption. J Health Econ. 2015; 39:135–146. DOI: 10.1016/j.jhealeco.2014.11.002 [PubMed: 25530206]
18. Loewenstein G, Asch DA, Volpp KG. Behavioral economics holds potential to deliver better results for patients, insurers, and employers. Health Affairs. 2013; 32(7):1244–1250. DOI: 10.1377/hlthaff.2012.1163 [PubMed: 23836740]

19. IOM (Institute of Medicine). Accelerating progress in obesity prevention: solving the weight of the nation. Washington, DC: The National Academies Press; 2012.
20. Marlow ML, Abdukadirov S. Can behavioral economics combat obesity? Regulation. 2012; 35(2): 14–18.
21. Best JR, Theim KR, Gredysa DM. Behavioral economic predictors of overweight children's weight loss. J Consult Clin Psychol. 2012; 80(6):1086–1096. DOI: 10.1037/a0029827 [PubMed: 22924332]
22. Gittelsohn J, Lee K. Integrating educational, environmental, and behavioral economic strategies may improve the effectiveness of obesity interventions. Appl Econ Perspect Policy. 2013; 35(1): 52–68. DOI: 10.1093/aepp/pps044
23. O'Neill J, Daniel TO, Epstein LH. Episodic future thinking reduces eating in a food court. Eat Behav. 2015; 20:9–13. DOI: 10.1016/j.eatbeh.2015.10.002 [PubMed: 26562686]
24. Dassen FC, Jansen A, Nederkoorn C, et al. Focus on the future: episodic future thinking reduces discount rate and snacking. Appetite. 2015; 96:327–332. DOI: 10.1016/j.appet.2015.09.032 [PubMed: 26431684]
25. Daniel TO, Said M, Stanton CM, et al. Episodic future thinking reduces delay discounting and energy intake in children. Eat Behav. 2015; 18:20–24. DOI: 10.1016/j.eatbeh.2015.03.006 [PubMed: 25863227]
26. Daniel TO, Stanton CM, Epstein LH. The future is now: reducing impulsivity and energy intake using episodic future thinking. Psychol Sci. 2013; 24(11):2339–2342. DOI: 10.1177/0956797613488780 [PubMed: 24022653]
27. Daniel TO, Stanton CM, Epstein LH. The future is now: comparing the effect of episodic future thinking on impulsivity in lean and obese individuals. Appetite. 2013; 71:120–125. DOI: 10.1016/j.appet.2013.07.010 [PubMed: 23917063]
28. Kong KL, Feda D, Eiden R, et al. Origins of food reinforcement in infants. Am J Clin Nutr. 2015; 101(3):515–522. DOI: 10.3945/ajcn.114.093237 [PubMed: 25733636]
29. Epstein LH, Kilanowski CK, Consalvi AR, et al. Reinforcing value of physical activity as a determinant of child activity level. Health Psychol. 1999; 18:599–603. [PubMed: 10619533]
30. Epstein LH, Beecher MD, Graf JL, et al. Choice of interactive dance and bicycle games in overweight and non-overweight youth. Ann Behav Med. 2007; 33(2):124–131. [PubMed: 17447864]
31. Epstein LH, Paluch RA, Kilanowski CK, et al. The effect of reinforcement or stimulus control to reduce sedentary behavior in the treatment of pediatric obesity. Health Psy. 2004; 23:371–380. DOI: 10.1037/0278-6133.23.4.371
32. Rollins BY, Loken E, Savage JS, et al. Measurement of food reinforcement in preschool children: Associations with food intake, BMI, and reward sensitivity. Appetite. 2014; 72:21–27. DOI: 10.1016/j.appet.2013.09.018 [PubMed: 24090537]
33. Epstein LH, Dearing KK, Temple JL, et al. Food reinforcement and impulsivity in overweight children and their parents. Eat Behav. 2008; 9:319–327. DOI: 10.1016/j.eatbeh.2007.10.00 [PubMed: 18549991]
34. Hanks AS, Just DR, Smith LE, et al. Healthy convenience: nudging students toward healthier choices in the lunchroom. J Public Health (Oxf). 2012; 34(3):370–6. DOI: 10.1093/pubmed/fds003 [PubMed: 22294661]
35. Cravener TL, Schlechter H, Loeb KL, et al. Feeding Strategies Derived from Behavioral Economics and Psychology Can Increase Vegetable Intake in Children as Part of a Home-Based Intervention: Results of a Pilot Study. J Acad Nutr Diet. 2015; 115:1798–1807. [PubMed: 26014476]
36. Looney SM, Raynor HA. Are changes in consumption of “healthy” foods related to changes in consumption of “unhealthy” foods during pediatric obesity treatment? Int J Environ Res Public Health. 2012; 9(4):1368–1378. DOI: 10.3390/ijerph9041368 [PubMed: 22690199]
37. Epstein LH, Roemmich JN, Stein RI, et al. The Challenge of Identifying Behavioral Alternatives to Food: Clinic and Field Studies. Ann Behav Med. 2005; 30(3):201–209. [PubMed: 16336071]
38. Epstein LH, Paluch RA, Consalvi A, et al. Effects of manipulating sedentary behavior on physical activity and food intake. J Pediatrics. 2002; 140:334–9. DOI: 10.1067/mpd.2002.122395

39. Epstein LH, Roemmich JN, Paluch RA, et al. Influence of changes in sedentary behavior on energy and macronutrient intake in youth. Am J Clin Nutr. 2005; 81:361–6. [PubMed: 15699222]
40. Epstein LH, Smith JA, Vara LS, et al. Behavioral economic analysis of activity choice in obese children. Health Psy. 1991; 10:311–316.
41. Epstein LH, Roemmich JN, Saad FG, et al. The value of sedentary alternatives influences child physical activity choice. Int J Behav Med. 2004; 11:236–242. [PubMed: 15657024]
42. Goldfield GS, Kalakanis LE, Ernst MM, et al. Open-loop feedback to increase physical activity in obese children. Int J Obes Relat Metab Disord. 2000; 24(7):888–92. [PubMed: 10918536]
43. Goldfield GS, Mallory R, Parker T, et al. Effects of Open-Loop Feedback on Physical Activity and television viewing in overweight and obese children: a randomized, controlled trial. Pediatrics. 2006; 118(1):e157–166. DOI: 10.1542/peds.2005-3052 [PubMed: 16818530]
44. Penko AL, Barkley JE. Motivation and physiologic responses of playing a physically interactive video game relative to a sedentary alternative in children. Ann Behav Med. 2010; 39(2):162–169. DOI: 10.1007/s12160-010-9164-x [PubMed: 20169428]
45. Temple JL, Legierski CM, Giacomelli AM, et al. Overweight children find food more reinforcing and consume more energy than do nonoverweight children. Am J Clin Nutr. 2008; 87(5):1121–1127. [PubMed: 18469229]
46. Hill C, Saxton J, Webber L, et al. The relative reinforcing value of food predicts weight gain in a longitudinal study of 7-10-y-old children. Amer J Clin Nutr. 2009; 90(2):276–281. DOI: 10.3945/ajcn.2009.27479 [PubMed: 19535428]
47. Epstein LH, Yokum S, Feda DM, et al. Food reinforcement and parental obesity predict future weight gain in non-obese adolescents. Appetite. 2014; 82:138–142. DOI: 10.1016/j.appet.2014.07.018 [PubMed: 25045864]
48. Salvy SJ, Bowker JC, Nitecki LA, et al. Effects of ostracism and social connection-related activities on adolescents' motivation to eat and energy intake. J Pediatr Psychol. 2012; 37(1):23–32. DOI: 10.1093/jpepsy/jsr066 [PubMed: 21880695]
49. Epstein LH, Handley KA, Dearing KK, et al. Purchases of food in youth: influence of price and income. Psychol Sci. 2006; 17:82–89. [PubMed: 16371148]
50. Epstein LH, Carr KA, Scheid JL, et al. Taste and food reinforcement in non-overweight youth. Appetite. 2015; 91:226–232. DOI: 10.1016/j.appet.2015.04.050 [PubMed: 25891040]
51. Epstein LH, Valoski AM, Vara LS, et al. Effects of decreasing sedentary behavior and increasing activity on weight change in obese children. Health Psychol. 1995; 14:109–115. [PubMed: 7789345]
52. Salvy SJ, Roemmich JN, Bowker JC, Romero ND, Stadler PJ, Epstein LH. Effect of peers and friends on youth physical activity and motivation to be physically active. J Pediatr Psychol. 2009; 34(2):217–225. DOI: 10.1093/jpepsy/jsn071 [PubMed: 18617572]
53. Epstein LH, Dearing KK, Handley EA. Relationship of mother and child food purchases as a function of price: a pilot study. Appetite. 2006; 47:115–118. [PubMed: 16682097]
54. Naar-King S, Ellis D, Idalski Carcone A, et al. Sequential multiple assignment randomized trial (SMART) to construct weight loss interventions for African American adolescents. J Clin Child Adolesc Psychol. 2015 Feb 10.:1–14. Epub ahead of print. [PubMed: 25668386]
55. Reslan S, Saules KK, Greenwald MK. Validating a behavioral economic approach to assess food demand: effects of body mass index, dietary restraint, and impulsivity. Appetite. 2012; 59:364–371. DOI: 10.1016/j.appet.2012.05.025 [PubMed: 22659562]
56. Daniels SR, Hassink SG. Committee on Nutrition. The role of the pediatrician in primary prevention of obesity. Pediatrics. 2015; 136:e275–e292. DOI: 10.1542/peds.2015-1558 [PubMed: 26122812]

Box 1

Definitions of Key Behavioral Economic Terms

Term	Definition
Behavioral economics (BE)	Interdisciplinary field at the intersection of economics and psychology, involving the analysis of purchasing/consumption of goods (e.g., energy-dense food) in relation to constraints such as availability and price of a good and of competing goods (e.g., nutritious foods) or activities (e.g., physical activity). This field espouses that individuals do not always make rational decisions (unlike assumptions of classical economic theory that rely on "cold" calculation of utilities), potentially improving the predictive validity (translational value) of empirical studies.
Cross-price elasticity	Refers to how distinct reinforcers (e.g., two different foods, or food vs. nonfood item) interact in relation to their purchasing/consumption. The rate of change in consumption of a second good (at a constant unit price, UP) relative to change in UP of a first good. When UP increases in the first good result in less consumption, demand for the second good can increase (*substitute*), decrease (*complement*) or not change (*independent*). Thought experiment: consider situations in which these activities could serve as substitutes or complements: socializing, exercising, watching television, listening to music, eating an apple, eating pie a la mode.
Delay discounting (DD, also inter-temporal discounting)	The DD procedure involves choices between an immediately consumable reinforcer of smaller value (e.g., 1 candy bar now) and a deferred reinforcer of larger value (e.g., 10 candy bars one week later), or choices between an consumable reinforcer now (e.g., high-fat food) and a delayed punisher that could be mildly averse and briefly delayed (e.g., gastrointestinal upset) or more delayed and more negative (e.g., obesity, hypertension). When a subject prefers the smaller sooner option to the larger later option, s/he engages in steeper discounting of the delayed reward (exhibits less self-control).
Demand intensity	Amount of a good purchased/consumed at a very low (or free) unit price, i.e., without significant constraint. This amount corresponds to the Y-intercept of the demand function.
Nudge	Implemented when evidence suggests individuals are making poor health (or other) decisions, a nudge is a programmed change in the person's environment to promote behavior that favors the individual's best interest. Example: Using a default 'opt-out' vs. 'opt-in' for healthier choices.
Own-price elasticity	Measured in a specific context, the rate of change in consumption of a good relative to changes in its UP. Elasticity is not a fixed characteristic of a good (e.g., physical activity or living in an environment with greater availability of healthy foods may increase price-elasticity of some unhealthy foods). A good has *inelastic* demand when increases in its UP result in less-than-proportional decreases in consumption (i.e., demand is relatively price-insensitive). A good has *elastic* demand when increases in its UP result in greater-than-proportional decreases in consumption (i.e., demand is highly price-sensitive).
Relative reinforcing value (RRV)	Goods are often available and can be purchased/consumed in competition with one another (i.e., market conditions). RRV reflects the degree to which one good (e.g., pizza slices) is purchased/consumed more than other concurrently available goods (e.g., low-fat, low-calorie salad). RRV is not a fixed parameter of any good, and progressive increases in food RRV characterize obesigenic behavior.
Unit price (UP)	A ratio score that reflects the "cost" of a good (numerator) relative to the "benefit" or unit amount (e.g., caloric, fat, sugar, or salt content of a single serving) of the good (denominator). "Cost" can include (but is not limited to) money price, or time/amount of responding (effort), required to purchase or consume a specified unit amount of a good.

Key Points

- Behavioral economics offers pathways for interventions to increase physical activity and healthier food intake and decrease sedentary behavior and unhealthy food consumption.
- The BE framework suggests that pediatric clinicians should take careful behavioral histories, focused on the child's “marketplace” of food and activity options, to identify barriers and incentives to “nudge” behavior change.
- Clinicians and families must agree on the specific behaviors and time frame to be targeted for change, with recognition that smaller, sustainable steps are more likely to be completed than more ambitious goals.

Table 1

Research Studies Aiming to Increase Healthy Food (or Decrease Unhealthy Food) Choices and Consumption

Authors	Population	Type of Study	Manipul ation	Conclusion
Cravener et al.[35]	24 3-5 y/o who consume <2 servings of vegetables/day and at least one parent with BMI≥25; 8% minorities	Experimental, 4 week RCT with 2 week intervention period	Random assignment to treatment (families provided vegetables with favorite cartoon character and stickers as default choice for meals and snacks, granola bar available after 5-min wait) or control (generic packages of vegetables and granola bars)	Pre-kindergarten children's vegetable intake may be increased if vegetables are presented as default choice and paired with cartoon reinforcers.
Epstein et al.[37] study 1	35 8-12 y/o with BMI ≥85th percentile enrolled in family-based weight loss treatment (FBT); average SES is upper middle class	Experimental and longitudinal	Random assignment to traditional FBT for weight loss or FBT+ reinforcement for engaging in behavioral alternatives to eating	OW/obese pre-adolescents reinforced for weight loss engaged more in non-eating activities than children in traditional FBT, but the increase was not related to weight changes.
Epstein et al.[37] study 2	13 8-12 y/o with BMI ≥85th percentile, average consumption of 2 snacks/day; 30% minorities	Experimental, within subjects	6 weeks -- 2 weeks baseline, 2 weeks enriched (kids given alternative activities to complete), 2 weeks second baseline (enriched and second baseline counterbalanced)	OW/obese pre-adolescents spent more time in alternatives to screen and eating time, but that time didn't translate to health outcomes.
Hanks et al.[34]	Public high school students	Field study within high school; means from 2 days before and after manipulation compared	1 of 2 convenience lunch lines stocked only with healthier options for 8 weeks following control “normal” 8 weeks	If adolescents are given easy healthier options, they'll take them (nudge effect).
List and Samek[17]	1614 children 7-18 y/o attending one of 24 “Kids Cafes” after-school programs in low-income areas of Chicago (most kids eligible for Free or Reduced Price Lunch Program)	Experimental field study -- sites randomized to dessert treatment condition with food choices recorded during extended baseline and treatment periods	Sites randomly assigned to no treatment, gain (child gets a prize if choose and eat fruit) short condition, loss (child given prize before dessert choice, if choose cookie or do not eat fruit choice, forfeit prize) long and short conditions, education long and short conditions, or education + loss long and short conditions	Incentives, and educational messages paired with incentives, can increase choice and consumption of fruit over cookies whereas educational messages alone do not increase fruit consumption or choice.
Looney and Raynor[36]	80 4-9 y/o with BMI ≥85th-<95th percentile (OW) or ≥95th percentile (obese) and not meeting at least dietary or PA recommendation; <32% minority	Experimental, 6 month family-based weight loss RCT	Random assignment to growth (increased growth monitoring to families), decrease (decrease snack food [SF] and sugar sweetened beverage consumption), or increase (increase fruit and vegetable [FV] and low-fat dairy intake)	Changes in FV and SF were unrelated in these OW/obese children. FV changes were unrelated to energy intake changes; reducing SF led to reduction in energy intake.

Table 2

Research Studies Aiming to Increase Physical Activity (or Decrease Sedentary Activity) Choices and Consumption

Authors	Population	Type of Study	Manipulation	Conclusion
Epstein et al. [38] (subset of Epstein et al.[16])	13 8-12 y/o children; BMI<95th percentile; 15-25h/week sedentary activities; no systematic changes in factors related to energy intake/ expenditure; average SES is upper middle class	Experimental within-subject crossover: baseline, increase, and decrease sedentary activity periods of 3 weeks each	Increase and decrease sedentary behaviors as assigned; monetary incentives for appropriately changing sedentary activity levels	Among non-obese pre-adolescents, increasing sedentary behavior is related to greater kcal intake and less PA, leading to positive energy balance.
Epstein et al.[31]	63 8-12 y/o BMI>85th percentile; 10% minorities	Experimental 6 month RCT to improve diet and PA, follow-up data collected at 6 and 12 months	Random assignment to sedentary group (reinforced for time NOT spent sedentary activities) or stimulus control (reinforced for recording sedentary behaviors but not behavior change, instructed to change environment regarding sedentary activities)	Substituting PA for sedentary activity and complementing reduced snack foods with reduced sedentary activity can both produce weight loss, increased PA, and decreased sedentary activity time in these OW/obese pre-adolescents.
Epstein et al.[15] (further analysis of Epstein et al.[16])	58 8-16 y/o who report 15-25h/week of screen time; average SES is upper middle class	Experimental within-subject crossover: baseline, increase, and decrease sedentary activity periods of 3 weeks each. Related behavior to GIS coding.	Increase and decrease targeted sedentary behaviors (TV, video games, recreational computer use) as assigned; monetary incentives for changing sedentary activity levels.	Built environment matters -- having a large park nearby led to increased PA and time in MVPA while sedentary behaviors were reduced.
Epstein et al.[16]	58 8-16 y/o who report 15-25h/week of screen time; 12% minorities	Experimental within-subject crossover: baseline, increase, and decrease sedentary activity periods of 3 weeks each	Increase and decrease targeted sedentary behaviors (TV, video games, recreational computer use) as assigned; monetary incentives for appropriately changing sedentary activity levels	Sedentary and PA behaviors are largely substitutive; higher BMI kids more likely to decrease PA when sedentary behaviors increased; whereas children with lower general levels of PA were more likely to show larger increases in PA when sedentary activity decreased.
Epstein et al.[39] (subset of Epstein et al.[16])	16 12-16 y/o with BMI<95th percentile and report 15-25h/week of screen time; average SES is upper middle class	Experimental within-subject crossover: baseline, increase, and decrease sedentary activity periods of 3 weeks each	Increase and decrease targeted sedentary behaviors (TV, video games, recreational computer use) as assigned; monetary incentives for appropriately changing sedentary activity levels	Among non-obese adolescents, when targeted sedentary behaviors decrease, PA can increase and energy intake can decrease.
Epstein et al.[41]	30 non-obese 8-12 y/o; 23% minorities	Experimental in lab random assignment of 1) access to all 4 PA and sedentary activities; 2) all 4 PA and least favorite sedentary activity; or 3) all 4 PA and favorite sedentary activity	RRV-PA vs. sedentary assessed by computer task and questionnaire. In computer task, PA schedule remained at VR2; sedentary schedule increased from VR2 to VR32 over trials. Subjects asked whether willing to perform 20 button presses for 10 min of PA or 10 min of sedentary; then increasing number of button presses for sedentary	When constraining sedentary activity options to one less preferred, children engage less in sedentary option and more in PA; but challenging to substitute PA for sedentary activity when sedentary is highly valued and sedentary options are available.
Epstein et al.[13]	27 obese 8-12 y/o	In lab experimental: group × type of activity × day	Random assignment to activity group (reinforced for time spent in active options), sedentary group (reinforced for time NOT spent in 2 preferred sedentary activities), or control. Over 5 daily sessions, given access to 4	Reducing access (either via reinforcing activity or non-engagement) can increase time spent in active activities among obese children.

Authors	Population	Type of Study	Manipulation	Conclusion
			active and 4 sedentary for 45 min	
Epstein et al.[40] exp 1	18 kids, M age=10.5 y/o, lean (<20% average weight), moderately obese (20%-80% over average weight), very obese (>80% over average weight). Some obese kids starting FBT for weight loss	In lab	Computer game with unchanging variable ratio reinforcement of vigorous-activity (bike riding) and ascending or descending variable ratio reinforcement for sedentary activity (watching videos)	When sedentary activities have high costs, lean and some obese children will choose PA; some more obese children will work for sedentary regardless of cost.
Epstein et al.[40] exp 2	23 obese kids, M age=10.1 y/o (20-100% OW)	In lab	Computer game with unchanging VR reinforcement of highly liked or disliked vigorous activity and ascending or descending VR reinforcement for sedentary activity (watching videos)	When costs are the same, obese children choose sedentary activities; but when costs increase, children may switch to vigorous activity.
Epstein et al.[51]	61 obese 8-12 y/o, between 20% and 100% OW but neither parent >100% OW; 4% minorities	Experimental 4 month RCT to improve diet and PA	Randomly assigned to reinforcing decreased sedentary activity, reinforcing increased PA, or reinforcing both	Reinforcement for reducing sedentary activity produce better weight outcomes than reinforcing increased PA in these obese pre-adolescents.
Goldfield et al.[42]	34 8-12 y/o children with BMI ≥85th percentile, enrolled in family-based pediatric obesity treatment study; average SES is upper middle class	Experimental in lab, random assignment to 1 of 3 groups	Requirement of accumulating 1500 (or 750) pedometer counts of PA in 20min to earn 10min of TV activity vs. control (access to PA and TV activity for 30min)	OW/obese children engage in more PA if reinforced with preferred sedentary activities.
Goldfield et al.[43]	30 8-12 y/o with BMI ≥85th percentile who watch ≥15h TV/week and engage in <30min MVPA/day and have parent willing to enforce study contingencies	8 week RCT	Kids randomly assigned to open-loop feedback + reinforcement (accumulating 400 PA counts earns the kid 1 hr of TV viewing) or just open-loop feedback (wear accelerometer but no activity restrictions)	OW/obese children exhibit health improvements (e.g., decrease weight, BMI, fat intake, calories from snacks, and snack patterns) and increase PA time if reinforced.
Salvy et al.[52]	88 12-14 y/o; 19% minorities	Experimental: 2 (weight: ≥ or < 85th percentile) × 2 (gender) × 2 (social context: alone vs. friend or peer) mixed design	2 sessions: 1) RRV of biking alone vs. playing video games alone, 2) RRV of biking with a friend or with a peer (randomly assigned)	Presence of a friend or unfamiliar peer can increase motivation (RRV) to engage in PA (bike riding) and to bike longer, especially for OW children.

Table 3
Other Research Studies Related to Weight Loss, Intake, or Activity Using a BE Approach

Authors	Population	Type of Study	Manipulation	Conclusion
Best et al.[21]	241 OW (BMI≥ 85th percentile) 7-12 y/o with ≥1 parent with BMI≥25, enrolled in family-based weight loss treatment; 35% minorities	Prospective, with BE factors treated as baseline predictors of weight loss	Assessed RRV-food (HED), RRV-money, DD-food, DD-money, environmental enrichment (availability of alternatives)	Pretreatment individual differences matter. Weight loss less for children who were more impulsive with money reward, and for food-impulsive children highly reinforced by food. Having better alternatives in home environment helped children less reinforced by food lose more weight.
Epstein et al.[30]	35 8-12 y/o (17 non-OW with BMI<85th percentile; 18 OW with BMI>95th percentile); 26% minority	In lab	Computer choice task (RRV) for active and sedentary alternatives for dancing and bike riding, reinforcement schedule increased from VR8 to VR128	Children were more motivated to play an interactive dance video game but not for an interactive (vs. other form) bike video game.
Epstein et al.[50]	198 8-12 y/o; BMI percentile between 50th and 85th OR <50th with parent BMI ≥25; 31% minority	In lab	Questionnaire version of RRV of favorite sweet, savory, and salty foods vs. access to magazines and word games	Sweet foods most reinforcing among non-OW children, but may be overall RRV-food related to higher energy intake.
Epstein et al.[53] (subset of Epstein et al.[16])	10 10-12 y/o and their mothers; 20% African American	In lab	Food choice task in which subjects were given $5 in $0.25 tokens to spend on snack or fruit/vegetable. Across trials, one food remained $1 while other varied from $0.50 to $2.50	Mothers' purchasing of healthy and unhealthy foods related to their child's purchasing; for both food types as cost increased, purchasing decreased.
Epstein et al.[33]	50 8-12 y/o with BMI≥85th percentile and parents; 30% minorities	In lab	Paper questionnaire assessing RRV-food and money (vs. other) and computer-based delay discounting (DD) task	RRV-food is related in kids and their parents. DD depends on magnitude of immediate reward but kids were more impulsive than parents. Parents' and kids' DD not related.
Epstein et al.[49] study 1	32 10-12 y/o; 35% minority	In lab	Food choice task in which subjects were given $5 in $0.25 tokens to spend on snack or fruit/vegetable. Across trials, one food remained $1 while other varied from $0.50 to $2.50	Youths' food purchasing depended on its price and price of alternative, but substitution did not occur.
Epstein et al.[49] study 2	20 10-14 y/o; 25% minorities	In lab	Food choice task in which subjects given $1, $3, or $5 in imitation coins to spend on snack or fruit/ vegetable. Across trials, one food set remained at market value; one set varied from 50% below to 50% above market value	Findings support own-price elasticity. Substitution of alternatives depended on amount of money available to spend (income). Substitution only occurred with low income.
Epstein et al.[29]	32 6-11 y/o, recruited for studies 1) to prevent childhood obesity in non-obese kids with obese	In lab, relating computer-assessed RRV of PA and sedentary activities with 4 days of naturalistic activity data	Computer game to assess RRV of concurrently available sedentary activities (Nintendo game, videos,	The more reinforcing children find PA, the more physically active they are. Multiple shorter PA sessions may be more

Authors	Population	Type of Study	Manipulation	Conclusion
	parents, or 2) to modify food intake in obese kids; 6% minority		reading, coloring) or PA (bicycle ergometer or stepper). PA reinforced on variable ratio (VR)2 schedule, while sedentary schedule increased from VR2 to VR16 across games	reinforcing than fewer longer sessions.
Epstein et al.[47]	130 non-obese (BMI<95th percentile) adolescents (M age=15.2yrs); 21% minorities	In lab, relating computer-assessed RRV of money and favorite snack food with BMI change over 2 years	Computer choice task (RRV) for money and favorite snack food	Higher zBMI associated with finding snack foods more reinforcing (and having more obese parents).
Hill et al.[46]	316 7-9 y/o (baseline) enrolled in 1 of 5 schools in London, UK; 54% non-White	Observational, longitudinal design	Questionnaire version of RRV of cookies vs. stickers on progressive ratio (PR) schedule	Children who find food more reinforcing than stickers gain more weight over 1 year
Kong et al. [28] study 1	27 9.0-18.6 month olds; weight-for-length z scores ranged from -1.50 to 2.55; 22% minority; 64% family income > $50k	In lab	Computer mouse to work for favorite food or Baby Einstein video clips on sequential, independent PR schedule	Infants and toddlers at risk for obesity demonstrated greater food than video reinforcement, and low reinforcement levels for the video.
Kong et al.[28] study 2	30 8.9-17.8 month olds; weight-for-length z scores ranged from -1.03 to 2.65; 11% minority; 53% family income > $50k	In lab	Computer mouse to work for favorite food or bubbles play time on sequential, independent PR schedule	Infants and toddlers at risk for obesity demonstrated greater food than video reinforcement, and low reinforcement levels for the bubbles activity.
Penko & Barkley[44]	24 8-12 y/o; 11 lean (BMI<85th percentile) and 13 OW/obese (BMI≥85th percentile)	In lab	Computer mouse to work for Wii vs. sedentary video boxing game access on independent PR schedule	Lean children find active games more reinforcing than sedentary games (and more so than OW children) but OW children found them equally reinforcing (and sedentary game more reinforcing than for lean children).
Rollins et al.[32]	33 3-5 y/o; BMI percentiles ranged from 3.2 to 95.7; 24% not White; 64% of families' income > $80k	Conducted at preschools	Computer station to work for Scooby Doo and Sponge Bob graham crackers on independent, concurrent PR schedule	Preschoolers are willing to work for snacks. Children with higher BMI and reward sensitivity levels worked faster to access the snacks, and faster (and more) responding corresponded to snack consumption in a separate task
Salvy et al.[48]	103 adolescents (M age= 13.6yrs); 21% minorities	In lab, relating RRV-food and social interaction with ostracism manipulation, sedentary activity tasks, eating, conversing with peer	Computer choice task (RRV) for social interaction time and favorite snack food	Ostracized adolescents may have higher motivation for obtaining favorite snack foods.
Temple et al.[45] Exp 1	45 8-12 y/o (20 with BMI≥90th percentile; 25 with BMI<75th percentile); 27% minorities	In lab	Computer station to work for pizza or non-food alternative on VR schedule	OW children find food (pizza) more reinforcing (willing to work harder to get it), and consume more of it than non-OW children
Temple et al.[45]Exp 2	45 8-12 y/o (20 with BMI≥85th percentile; 25 with BMI<85th percentile); 23% minorities	In lab	Computer station to work for liked snack food (chips, Skittles, M&M's) or non-food	OW children find food (snacks) more reinforcing/ are willing to work harder to get it than to get sedentary activities, and

Authors	Population	Type of Study	Manipulation	Conclusion
			alternative on VR schedule	consume more of it than non-OW children