Gullo S, et al., J Obes Weight Loss 2021, 4: 010
DOI: 10.24966/OWL-7372/100010

HSOA Journal of Obesity & Weight Loss

Review Article

Behavioral Nutrition: A New Multifactorial Paradigm for Sustainable Weight Loss

Stephen Gullo[1*] and Errol J Philip[2]

[1]*Center For Health Sciences, New York, NY 10075 United States*

[2]*Notre Dame Laboratory for Psycho-oncology Research, University of Notre Dame, Notre Dame, IN, USA*

Abstract

Excess body weight is the greatest global health-care challenge of the 21st century. Despite the meteoritic rise in obesity rates, population-based interventions continue to rely upon three key factors to promote weight-loss: (1) moderating consumption, (2) individual willpower and (3) the belief that eating behavior is a cognizant and rational process. This review outlines the substantial evidence that suggests that the role of such factors is tenuous at best, runs counter to real-world eating behavior, and fails to promote sustainable weight-loss among the vast majority of individuals. Indeed, in focusing on the most obvious variable, calories, we have overlooked the most critical, the role of an individual's history and behavior in the food environment. Behavioral Nutrition represents an approach to sustainable weight-loss that emphasizes individual differences in food behavior and the implementation of specific strategies to effectively navigate the modern food environment. This approach seeks to incorporate evidence from diverse disciplines, including behavioral economics, habit psychology and neuroscience, and provide individuals with weight-control advice that is sustainable and effective. Reliance is placed upon strategy rather than willpower, advises against the moderate consumption of problematic foods, and introduces effective strategies to combat persistent food-based advertising and destructive attitudes and beliefs surrounding consumption.

Keywords: Behavioral nutrition; Diet; Obesity; Weight-loss

***Corresponding author:** Stephen Gullo, Center For Health Sciences, New York, NY 10075 United States, Email: drg@drgullo.com

Citation: Gullo S, Philip EJ (2021) Behavioral Nutrition: A New Multifactorial Paradigm for Sustainable Weight Loss. J Obes Weight Loss 4: 010.

Received: Mar 28, 2021; **Accepted:** April 2, 2021; **Published:** April 10, 2021

Background

Excess body weight [obesity/overweight]is the greatest global health-care challenge of the 21st century. Weight gain has increased dramatically over the past three decades in the US, with over 40% of the adult population now obese [1]. This trend has been mirrored globally and has shown no signs of abating [2]. Obesity exerts a tremendous burden on individuals and society alike, and now accounts for more preventable deaths and life-years-lost than smoking [3]. It is a recognized risk factor for cardiovascular disease, diabetes, hypertensions and many common forms of cancer [2], is associated with an average of 6-8 years of life lost and incurs billions of dollars of health care spending annually [4,5]. In addition, obese and overweight status has been consistently associated with impairments in quality of life and psychological well-being, as well as weight-related stigma and discrimination [6,7]. Since 1960, the adult obesity rate alone has increased rapidly from 13 to 34 percent since 1960 [8], with a number of theories put forward to explain this unparalleled increase. For example, this brief period has witnessed dramatic changes in the modern food environment, with calories from refined carbohydrates becoming abundant, widely available and economical to consume compared to fresh fruits and vegetables [9]. This increased availability has been coupled with documented increases in portion size and the caloric density of many common foods, contributing to an increase of360 calories in daily adult food intake over the past 30 years and consequent increase in the weight of the US population [10,11]. Further explanations have focused on reductions in physical activity, including reduced emphasis of exercise in schools, more sedentary professional lives, and increased reliance on transport and modern conveniences.

The field of nutrition science has played a critical role over the past thirty years in educating the public concerning calorie control, macro and micronutrients, and raising awareness regarding the relationship between diet and health. This growing awareness was further emphasized by the ongoing publication of government sanctioned guidelines concerning appropriate caloric consumption for human health [12]. Despite relative consensus on the broad constituents of a healthful diet[e.g. a diet high in vegetables, fruits, whole grains and limited intake of sugars [13, 14], few among the population adhere to such guidelines [15]. Growing recognition of the risks associated with obesity and excess weight have spurred empirical and clinical endeavors across multiple disciplines to address this public health issue, while commercially, a vast weight-loss industry has developed to cater to the public's interest in topics concerning diet, weight and health. Despite this intensive interest and awareness, and billions of dollars dedicated to public health interventions and campaigns, the rate of obese and overweight adults in the US and globally has continued to rise, even with polls suggesting that the majority of the US adult population has tried to lose weight, with an average of four to five weight-loss attempts annually [16,17].

The most notable and consistent population-based intervention to address this unprecedented rise in obesity and overweight has

been to enhance public awareness and provide education concerning appropriate nutrition for health. Education has been complimented by an ongoing focus among modern day weight-loss approaches on calorie control and increased physical activity; a focus that exists across the government sanctioned 'food plate', long-standing programs such as Weight Watchers, and popular industry diets. As such, the restriction of calories, through limiting portion size and-or minimizing/excluding entire macronutrient classes, constitutes a prominent goal within the majority of weight-loss approaches. Critically however, an approach that focuses primarily on education and caloric restriction is reliant upon the persistent and ongoing exertion of willpower to limit consumption and assumes that food selection and intake is a rational, conscious and knowledge-based decision-making process. Indeed, growing evidence suggests that it is the removal or limiting of certain foods that may hold the key to control and sustainable weight-loss [18].

Whereas empirical data supports the effectiveness of weight-loss programs focused on education and calorie control in promoting short-term weight reductions(usually 5-7% of initial body weight), sustainable weight-loss remains elusive, even within the most intensive programs, and for some, messages of moderation can reactivate poor lifelong eating habit s [19]. Most individuals will regain some or all their lost weight over the course of two to five years [20]. Modern weight-loss approaches are therefore relatively effective in achieving their stated goal; many individuals who follow one diet or another will indeed lose weight. It is the application of this approach to long-term weight-control that has signaled its failure, as it may become both ineffective and potentially harmful to the millions seeking long-lasting effects and improved health. Indeed, an emphasis on calorie control, rather than human behavior, overconsumption, and the power of food cravings, may have led many to the assumption that long-term failure in weight-control is the result of a character, personality deficit or psychological impediment, rather than environmental, cultural, biological, genetic, and epigenetic influences and an inadequate dietary model.

Modern weight-loss approaches thus constitute an incomplete approach to long-term weight-control and one that must be complimented by a much more comprehensive appreciation of dietary habits, thought patterns and behaviors, and individual differences in consumption, food preferences, and control, as outlined below in a new approach to weight-loss [21]. Indeed, the selection and consumption of food in the modern era of abundance may have little to with nutritional analysis, appropriate macronutrient levels, or sustenance, as educational programs over the past decades have ensured that most the population is aware of what constitutes a healthy diet. Instead it could be argued that food consumption (and thus long-term weight control) is driven by a host of forces including personality, cognitive processes, food history, personal habits, ingrained behaviors, genetics, responses to environmental cues, neurochemistry and biological drivers, and mood states. In such circumstances, the current model of weight loss, with its emphasis on education, caloric restriction, moderation (moderate food intake) and will power, is ill equipped to promote sustainable weight-control and instead may have resulted in high rates of failure. One must question where the scientific evidence for this longstanding and continued approach to weight management lies, or perhaps by focusing on the most obvious factor, calories, and the field has overlooked the most critical, the person consuming those calories. The current paper will argue that mainstream dietary advice rests upon three broad and interwoven assumptions, each of which possess a questionable evidence base and are incongruent with human behavior, habit psychology and patterns of consumption. These include the prominent roles assigned to moderation, will-power and rational decision-making and nutritional analysis in food consumption [21-23]. Despite the rise and fall of various approaches and emphasis upon various macromolecular classes, these three assumptions have remained steadfast in their influence upon mainstream dietary advice. As noted earlier, the majority of weight-loss approaches rely heavily on an individual's willpower to curb calorie consumption, as well as the provision of nutritional information to enhance decision-making in the food environment. In addition to these two primary role-players, the widely held maxim that all food should be consumed in moderation remains a central tenant of food-based messaging among dieters and the food industry alike. These broad assumptions, in concert with a rapidly changing food environment and societal emphasis on personal willpower, may have contributed to millions of failed weight-loss attempts, suffering, and an ongoing obesity epidemic. A new approach, one that builds upon the successes and insights of the fields of nutrition and dietetic science, but more fully acknowledges the influence of human behavior, is needed to address this healthcare emergency. As emphasized in the National Weight Control Registry studies [24], sustainable weight loss requires a commitment to ongoing behavioral change, as well as greater recognition of the myriad of factors that exert influence on our eating patterns. Indeed, recent clinical guidelines recommend that patients with obesity be referred to intensive, behavior-focused interventions to address weight-control [25]. The senior author, former Chair of the National Obesity and Weight Control Education Institute of the American Institute at the Columbia University Medical Center and recipient of the UN Schoenberg Award, calls this broadened approach Behavioral Nutrition; a comprehensive approach that considers the many variables that effect human eating behavior. These include the importance of assessing a patient's food history, contributions from the diverse fields of habit psychology and behavioral economics, and the critical roles assigned to personality style, neurochemistry [response and effect of food], biological variability, food strategy, and cultural conditioning. Thus critically, food and dieting are not just considered from a nutritional point of view, but from its effects on the person's individual consumption patterns and long-term habits.

Critique of the Assumptions that underlie our Current Approach to Weight-Control

Assumption 1: To moderate consumption

The premise that all food can be consumed in moderation has long been a foundation for weight-control efforts; and yet may be the single greatest myth promoted by those within the mainstream dietary industry. There exists scant scientific evidence that suggests that this approach is suitable for the majority of individuals seeking weight control, and instead, emerging evidence suggests that such advice may, in fact, be detrimental to long-term efforts to maintain a healthy weight. The challenge of moderating consumption has historical roots in the Greek *Meden Agan* ["nothing in excess"] inscribed at the temple of Apollo at Delphi, suggesting that humans have long possessed tendencies towards excess. In the current era, few Americans adhere to such advice and follow published nutritional guidelines, tending to over-consume calories from added sugars, fats and refined grains, while under-consuming calories from fruits, vegetables, whole grains and

fiber [10, 26]. The recommendation to moderate consumption through calorie and portion control has formed the cornerstone for weight-loss advice for more than three decades, however an increasing number of health experts are questioning the effectiveness of such an approach. Whereas a small number of individuals may be able to successfully consume foods in moderation and maintain a healthy weight, and thus have no need for the weight-control field, evidence suggests that this is sufficiently rare that it should not constitute the primary emphasis of nutritional advice for the population at large[20]. Predating more recent calls to reevaluate the modern approach to weight-control, the senior author questioned the wisdom of preaching moderation during his keynote address at the 1994 National Obesity and Weight Control Symposium at Columbia University. In an important text he co-author edsoon after [21], Gulloin stead insisted that an addictive model was a far more effective explanatory framework for why so many fail at weight-control [27].

Indeed, arecent study exploring the myriad of ways in which moderation is defined in the context of food, found that individuals possessed fluid and subjective definitions of moderation. For example, participants often redefined moderation to constitute more food than they were currently consuming, thus enabling them to adhere to the belief that they were following this dietary dictum [28].Indeed, interviews with those who have been successful in maintaining weight-loss have found that the majority avoid certain foods, rather than seeking to consume them in moderation, often stating that 'if they don't begin, then they don't have a problem'[18]. In subsequent books [21-23] and based on extensive clinical experience, Gullo has noted that a primary emphasis on portion control and moderation alone is an unsustainable approach to long-term weight-control, asserting that human behavior tends towards gratification and excess, especially in an environment that promotes such excess. This idea is reflected in many domains of psychology, including perhaps most famously, Freud's theories on the human mind and the desire to seek pleasure and gratification, and avoid pain. Thus, nutritional advice should reflect the interaction between human behavior and food consumption [e.g. the tendency for individuals to finish whatever portion size is provided and overconsume],rather than solely the constituents of the food itself. Validating the senior author's message from two decades earlier [22] has been prominent researcher Nora Volkow, Director of the National Institute on Drug Abuse at the National Institutes of Health [NIH], who has asserted that human beings are "programmed to overconsume" and that conceptualizing weight-control within an addictive model is more consistent with current scientific evidence [29,30]. Adding further support to this reconceptualization is Mozaffarian from the Harvard School of Public Health. He has noted that "the notion that it is ok to eat everything in moderation is just an excuse to eat whatever you want" [31], emphasizing the danger of such a message as part of a national approach to population weight-control. We maintain that long-term weight-loss success rates are so low because only a minority of individuals can successfully consume foods in moderation. The majority of individuals, especially those with a history of weight-cycling, have failed to benefit from prevailing weight-loss models and their focus on moderation. The small percentage, perhaps 5% at most, of individuals who are able to sustain weight-loss may be a correlarly of the number of individuals who are able to effectively utilize approaches focused on moderation, and in turn, have no use for the weight-control field.

Emerging evidence suggests that current food products combine fat, sugar and salt in such concentrated and texture demounts that the human body is unable to exert its evolutionary ability to maintain metabolic homeostasis and regulate weight. These products are engineered to be highly palatable and provide the greatest level of enjoyment ["bliss point"], and when packaging, labeling and in-store placement are guided by focus groups, promote further consumption [32]. Multiple lines of evidence suggest that such combinations of sugar, fat and salt, such as is easily accessible in the modern day food environment, activate areas of the brain heavily associated with reward and pleasure, overcoming attempts at moderation and promoting excess [33]. Thus, physiological and genetic drivers [e.g. evolutionary role of seeking sweet foods]can be manipulated to circumvent decision making and appetite control, instead enhancing a food's ability to not only satisfy, but stimulate consumption [34]. Indeed, Volkow and colleagues have examined the many potential overlapping neural systems that may drive both food consumption and substance abuse [35-39], noting the human tendency towards immediate gratification, whether in the form of drugs or highly palatable food , and the overlapping and redundant neural reward mechanisms [e.g. dopaminergic] that both drive and reinforce such pleasure-driven behavior. A host of biological and behavioral similarities between overconsumption and substance abuse have been identified and thus further suggest a revised approach to weight-control [38,40-44]. It has been two decades since the senior author first proposed the utility of an addiction framework to better understand the high rates of failure at weight-control. The validity of this approach is now finally being widely recognized and investigated, with the concept of food addiction receiving increasing attention from the research community [45-48], and recently, in the inclusion of criteria for Binge Eating Disorder in the Diagnostic and Statistical Manual of Mental Disorders [Fifth Edition] of the American Psychiatric Association [49]. Researchers acknowledge that further work is needed regarding the ability of macronutrients such as sugar and fat to prompt the hallmark signs of addiction; but they argue that when these foods are combined with accessibility and persistent food triggers [e.g. advertising], psychological addiction and consequent overconsumption are a likely consequence [50,51]. Thus, strategic restriction, or in some cases abstinence, of problematic foods may be necessary for many individuals with a history of weight-control issues. For many, guidance to consume all foods in moderation may represent a dictum that promotes further destructive cycling through short-term successes and long-term failure. The health risks associated with excess weight are as serious as those associated with tobacco and alcohol use; thus, if the inability to exert control in the context of certain foods can be analogous to the inability to exert control over tobacco or alcohol consumption, then it is perhaps time to consider the utility of a message that has centered on moderation.

Assumption 2: The importance of willpower

Evidence suggests that willpower represents an excellent skill for implementing short-term behavior change but is of little use in the long-term. In the context of weight-management this aligns with consistent short-term success in dieting efforts, but failure in maintaining such weight-loss [20]. Willpower provides a fragile foundation for weight control; it is easily compromised by fatigue, mood, lifestyle, environmental triggers, physical health, anxiety and other forms of psychological distress. Further, given the abundance and availability of inexpensive processed food products, along with

broad-based food advertising, willpower is required on an ever-increasing number of occasions throughout the day to deny temptation and overconsumption. Importantly, the emotional and physical pain and discomfort associated with excess weight, as well as the weight-based discrimination that is ever-present in modern day society, can be a powerful motivator in initial weight-loss efforts. However, initial success in losing weight can reduce this pain and discomfort, and in turn reduce its potency as a driver of motivation and willpower. Thus, weight-loss strategies that do not rely predominantly on willpower are so critical in promoting effective long-term weight-loss and maintenance efforts.

Research efforts have suggested that willpower may be best thought of as analogous to a muscle, one that can become fatigued if used in excess, thus leading to eventual failure in exerting control [52]. In their seminal study, Baumeister and colleagues reported that individuals who had resisted the temptation to consume cookies and candy, thus exerting willpower, were more likely to concede in a follow-up puzzle task than those who had not exerted prior willpower [53]. The authors claimed that the prior exertion of self-control had taxed resources and thus rendered them less able to persevere on an unrelated task. This situation can be readily considered in the context of the current food environment, in which there is almost constant exposure to highly palatable food, and thus requires frequent exertion of willpower and self-control. Willpower is also heavily relied upon in the context of portion control, a critical area of consideration given the increasing size of common food products and the excessive portions served at most restaurants and food outlets. Once again, reliance upon willpower in this context is not compatible with typical human food behavior, as biological, psychological and environmental cues all converge to increase the likelihood of an individual consuming the entirety of what is placed in front of them, even if this is exceeds their nutritional or hunger needs. This is supported by a host of experimental evidence suggesting that consumption is driven by a variety of cues, including amongst other things, the size of the plate on which food is served [54], and that appetite expands in line with the amount of food available. Thus, whereas portion control should remain an important factor in maintaining a healthy diet, it must be considered through the lenses of human behavior and environmental cues, and thus utilized in concert with behavioral strategies. For example, the senior author emphasized the importance of 'volumizing' nearly two decades ago [22], counseling patients to select foods that were less calorie dense to ensure that they consume an appropriate volume of food in order to feel satisfied and thus limiting the impact of portion restriction [22]. This approach was further validated and popularized years later by Barbara Rolls in her work on 'volumetrics' [55].

A further domain of investigation that suggests that willpower may not represent the ideal target for weight-control efforts has explored biological mechanisms related to energy regulation. Numerous and redundant biological and evolutionary mechanisms exist to promote food consumption, especially in the context of dieting and an intentional reduction in caloric intake. Many argue that, in the context of reduced caloric intake, the orchestrated hormonal and metabolic shifts that underlie these biological mechanisms create such an intense desire and craving for food that efforts based primarily on willpower are easily overcome [56]. For example, evidence suggests that neuropeptide-Y can promote over-consumption in the context of a calorie-restricted diet [33], thus increasing the difficulty of maintaining a dietary approach that centers on restriction or removal of entire macronutrient classes in the long-term. There is also increasing interest in the role of insulin in regulating appetite and retarding weight-loss. Evidence suggests that the excessive consumption of simple carbohydrates or sugars, and resultant increase in insulin to regulate blood sugar, can paradoxically increase appetite and promote fat storage [57]. In addition, research has emerged from an Australian group suggesting long-term dysregulation of hormones associated with appetite among those maintaining initial weight-loss [58]. In their study, weight-loss was associated with expected changes in a host of hormones associated with appetite regulation, including leptin, insulin, peptide YY, and ghrelin, each of which perform synergistic effects to increase hunger and food drive. Importantly however, the authors reported that this appetite-promoting pattern of dysregulation continued to persist one year after initial weight-loss and had not reverted to pre-weight-loss levels. Finally, food manufacturers are critical contributors to the state of our current food environment and, as business entities, rely on our continued consumption of their products to maintain profitability. It is therefore important to remain cognizant of the ways in which such consumption is promoted, and how such efforts may undermine the weight-loss efforts of even those with the strongest willpower. Much has been written regarding practices employed by the food industry to increase consumption of their products, including manipulation of taste, packaging, messaging, portion size and restaurant design [32]. Such efforts are specifically designed to erode willpower and promote consumption, creating further challenges for those seeking to control their weight.

As noted by Gullo [22], perhaps the clearest example of industry-driven consumption was in the 1980's when Lay's Potato Chips released an advertising campaign that featured the tagline "Bet you can't eat just one". This line resonated with consumer audiences because of its truth: it is virtually impossible for most consumers to eat just one chip. The crunchy, salty characteristics of chips are known appetite triggers and stimulants and the consumption of such snack food in the absence of hunger represents hedonic hyperphagia, a term coined by Hoch and colleagues to describe excessive consumption driven by pleasure rather than hunger [59]. More optimistically, researchers and clinicians may be able to draw on some of the elements that underlie the prominent role of advertising in driving overconsumption and eating behavior and use them to promote weight-control efforts instead. As documented in his early work [22], the lead author frequently incorporates lessons from advertising psychology in the promotion of weight-loss, creating recordings and statements that can be recited by patients and used to combat the frequent stream of advertisements pertaining to food in the modern-day environment. Finally, it is important to question why so many individuals who struggle with weight management can successfully navigate other personal and professional roles, many requiring dedication, perseverance and self-control. This suggests that there is something else at play in our complex relationship with food and day-to-day consumption patterns, and a need to adopt a broader and more behavioral perspective in addressing the epidemic of obesity that currently plagues the US.

Assumption 3: Nutritional analysis and rational consumption

Our consumption of food and behavior in the food environment are primarily viewed as rational cognizant processes. This focus compliments the emphasis on willpower and self-control and underpins the importance placed on nutrition-based education

campaigns and knowledge concerning calories and constituents of food in promoting health [60-62]. Whereas such knowledge is important in helping individuals navigate existing food offerings and craft healthful diets, it is possible that in the context of obesity and long-term difficulties controlling weight, insufficient consideration has been given to the prominent role of life-long habitual practices, impulsive consumption, and methods by which such ingrained habits can be effectively changed in the long-term. The emerging field of behavioral economics, pioneered by Daniel Kahneman [63], Richard Thaler and Daniel Ariely [64], has provided insight into the dynamics and habitual processes that may underlie behavior in the food environment, suggesting that individual's food choices are driven by predictable departures from rational decision making [65-67]. This departure may be especially pertinent in the context of widely available calorie dense products and thus drive the lack of success in promoting sustainable weight-loss. Many individuals report that repetitive weight-regain and cyclic dieting is often the result of life-long habits that foster over-consumption of a specific type of food or in specific circumstances. Learnt behaviors, whether in the context of food consumption or driving a motorcar, function similarly. Higher order cognitive processes in the pre-frontal cortex are activated to initially learn a behavioral sequence, most easily in the context of a salient reward. Once this behavioral pattern is practiced and rewarded frequently enough it will become learnt and possible to activate in the context of appropriate triggers. Once triggered, the basal ganglia plays an important role in carrying out the behavioral sequence, enabling it to become more automatic and requiring less awareness, thus returning resources to the prefrontal cortex [68]. If indeed this is the case in the realm of food behavior, then we need to consider strategies to circumvent such habits.

A recent government report examined the importance of behavioral economics in guiding dietary consumption in the context of food assistance programs, outlining a number of important elements in the promotion of healthy food choices [69]. The authors reiterated the inadequacy of self-control and willpower in guiding long-term dietary choices, noting instead the driving forces of emotion and impulsive behavior. The influence of the environment, external cues that trigger behavioral patterns, and 'default' dietary options are emphasized in the context of dietary consumption. These factors, if modified to promote healthier options, could make a significant contribution to curbing the weight of the US population.

In line with this conclusion, Liu and colleagues argued in a recent paper that the provision of nutritional information through food labeling and calorie counts has only a modest impact on the food choices and behavior of individuals [70]. They note instead the importance of moving beyond information-based interventions and to considering the food environment as the primary driver of eating behavior. Studies suggest that food choices can be shifted by the implementation of behavioral strategies or minor changes to the environment, for example, the increased consumption of vegetables by placement at the start of a lunch line, or decreased consumption of candy when it is offered in opaque containers [71-73]. Liu also notes the critical influence of behavioral biases; including the human tendency to place greater emphasis on immediate gratification relative to delayed gratification [74], the ability of emotions to drive food choices that are deleterious to long-term health [75], and the tendency to for individuals to gravitate towards the default choice irrespective of alternatives [76]. These behavioral biases, among others, challenge the premise that food choices represent the culmination of rational information-based decision-making, and emphasizes the need for consideration of broader influences on weight-control in society.

In sum, weight-loss programs that maintain a focus on moderate consumption, willpower and the belief that eating behavior is a cognizant and rational process, run contrary to human behavior and may not best serve those seeking to make long-term weight-changes. As emphasized by the lead author, in focusing on the most obvious variable, we have overlooked the most critical: the role of an individual's food history and their behavior in the food environment. Growing empirical and clinical evidence, has shown that an individual's commitment to losing weight and maintaining this weight-loss can be too easily overcome by the multitude of complex and interconnected forces, including powerful biological mechanisms, life-long eating habits and highly effective food chemistry and targeted advertising. Through questioning the three interwoven assumptions explored in the current paper, we can move forward with an intervention framework that better matches human behavior and can thus promote long-term, sustainable success in weight-control. Behavioral nutrition, as pioneered by the lead author, represents such an approach and is outlined below.

Behavioral Nutrition: A comprehensive Model of Weight-Control

An 'odyssean' approach to weight-control

Behavioral Nutrition represents an approach to weight-loss and maintenance that emphasizes individual differences in habitual food behavior and the consequent implementation of specific strategies to effectively navigate the modern food environment. This approach seeks to incorporate evidence from diverse disciplines, including behavioral economics, habit psychology and neuroscience, and provide individuals with weight-control advice that is sustainable and effective. Reliance is placed upon strategy rather than willpower, advises against the moderate consumption of problematic foods, and introduces effective strategies to combat persistent food-based advertising and destructive attitudes and beliefs surrounding consumption. This approach has led to successful outcomes that are more than ten times those published in the field of weight-control and led to the senior author's practice being rated one of the top two weight-related practices in the country. In contrast to the modern dietetic approach, Behavioral Nutrition seeks to recognize that it is not simply the nutritional content of problematic foods that leads to weight-gain, but that long-term weight-control is governed by how one behaves in the presence of certain foods. This focus on individual patterns of behavior is complimented by a primary emphasis on strategy rather than willpower in guiding calorie control, thus representing what the senior author characterizes as an 'Odyssean' approach to sustainable weight-control. Odysseus possessed penetrating insight into his own vulnerability in the face of the Siren's song and devised an effective strategy to avoid destruction and navigate temptation. Similarly, one must acknowledge that certain foods or situations may be associated with temptation and over-consumption, and thus proactively devise strategies to manage them. Success therefore comes from a recognition of one's vulnerabilities, rather than in spite of them. Indeed, the potential for high levels of sugar, fat and salt, as presently found in many processed food items, to act as an addictive 'siren song" is becoming widely recognized

and will be examined in further depth below. Sustainable weight-loss interventions thus require a much more comprehensive approach to weight-control in the modern-day food environment, with an increased emphasis on *behavior in the presence of food rather than the food itself.* Behavioral nutrition incorporates effective elements of existing approaches to weight-loss, including cognitive behavioral therapy [77] and behavioral weight management [78]. However, it is the recognition and incorporation of a patients' food history, and habit psychology, strategy and genetic differences in food choices that underpin this novel and highly effective approach to successful long-term weight-control. All the elements of Behavioral Nutrition act in tandem to promote success, recognizing that food consumption is multifaceted and yet the prevailing diet model continues to focus almost solely on nutritional information.

Cornerstones of Behavioral Nutrition

Assessment of individual food history

The accurate diagnosis and effective treatment of any mental or physical health condition begins with a focused patient history and recognition of an individual's unique characteristics and circumstances. For a variety of reasons, including reliance on uniform dietary guidelines, the modern dietetic approach has largely ignored the importance of considering an individual's history of weight-control efforts and unique pattern of food consumption. Such ignorance has led to the separation of food consumption from food habits and behavior and led many to fail in their endeavors to sustain weight-loss. This reliance upon standardized dietary advice has reinforced the mantra that all foods can be consumed in moderation, an assumption that has resulted in millions of dieters repeatedly regaining lost weight through engagement in the same harmful food behaviors and habits, over and over again. It is therefore crucial that the central emphasis on moderate consumption be critically examined, and that patients be guided to think *historically not just calorically* and begin to recognize the important role their own patterns of consumption play in sustainable weight-loss. As noted, weight-management is the only area of healthcare that routinely ignores a patient's history, biological variability, culture and environment. Whereas information regarding past dieting may be collected, rarely do assessments explore fully an individual's food preferences, habitual practices around food, maladaptive/flawed thinking, historical triggers for weight regain, or destructive patterns of behavior. A detailed history concerning such information provides a basis for individualized treatment that addresses past failures and, with the implementation of strategies reflective of this history, creates long-term potential for sustainable weight-loss.

Individuals with a history of weight difficulties likely possess a relationship with food that is based on a series of destructive behavioral patterns and predictable over-consumption of certain foods in certain contexts. Through the exertion of willpower, these patterns can be curbed in the service of dieting in the short-term but are easily re-established once restrictions are removed. The weight-regain that is so often reported is typically the result of predictable returns to life-long habits of consumption. The majority of individuals with weight-control issues will report a history of predictable trigger foods and situations that have consistently led to weight regain. These patterns of overconsumption form part of an individual's Eating Print, or food history, and is critical to elucidate and fully understand in order to develop a sustainable approach to weight-loss. For example, triggers of overconsumption can include certain food types, situations (e.g. buffets), behaviors (e.g. arriving home), or times of the day. Despite initial efforts to restrict exposure to these triggers, the F-Q Principle dictates that as frequency begins to once again increase, so will quantity, and thus the resulting weight regain. Indeed, for most individuals, eating in moderation does not work, does not provide control, and does not lead to sustained success.

The first step, therefore, in pursing sustainable weight-control is to implement an eating plan that honors lifestyle, history, biological variability, and the psyche (e.g., mood eating since eating sometimes isn't about food). This plan should provide rapid results to drive motivation and perseverance, and thus should utilize an individuals' food history and Eating Print to establish the most effective path forward. Whereas basic nutritional information is explored, the focus remains on behavior and implementing a plan that will provide a foundation for sustainable eating habits to be developed. It is therefore more than just calories and a nutritional breakdown of a food item; it is whether such a food satisfies or stimulates appetite. By examining food in this unique context, one is able to consider whether the habitual consumption of this food will be associated with a positive or negative impact on an individual's weight, and in turn their appearance, self-esteem, well-being and health. An individual's history with a food item, including how much is routinely consumes once he or she has begun, is a key determinant in deciphering its broader impact on weight-loss efforts beyond objective nutritional constituents. One might ask whether an individual finds a food satisfying or does it tend to stimulate overconsumption and endanger weight-loss efforts. Sampling foods within this context can help distinguish which products may be safe to consume as part of a structured eating plan, and what may be best to substitute or 'box-in' and consume only during certain time frames.

Nutritional Analysis: Necessary but not Sufficient

Nutritional analysis is necessary for dieters but insufficient. The Behavioral Nutrition eating plan does not simply recite nutritional information. Dieters know what and what not to eat. Rather, it provides a critical psychological tool: structure. The reason all diets work in the short-term, but are not able to provide sustainable results, is that they provide a temporary structure to eating behavior. However, once the structure of a diet is removed and the average dieter returns to their original eating patterns with the simple admonition to consume all foods in moderation, then lost weight is quickly regained. Diets organize information in an operationally accessible but unsustainable way. As significantly, nutritional information is of secondary importance to dieters. Few dieters want to know the number of phyto-nutrients in broccoli as opposed to cauliflower. They also know that French fries, cookies and other nutrient dense foods will not help their efforts to lose weight and sustain these results.

Personality, Lifestyle and Culture

The entire diet field talks about changing eating habits but there is a dearth of knowledge about habit psychology and no guiding principle to changing these habits. Experts fall short of their stated goal due partly to a lack of recognition of the power of habit psychology, individual preferences and their impact on weight. Indeed, much of the advice given in the field of weight control is contrary to the tenants of habit psychology [e.g. all foods in moderation or the practice of

counting points in popular programs such as Weight Watchers]. These programs ignore the fact that a breadstick, as an example only, may only be worth one point in their system, but it may reactivate the habit patterns of over consuming and thus equate to several breadsticks, an Achilles' heel for many dieters.

Neurochemistry: Genetically Driven Individual Preferences in Food Consumption

Emerging research concerning individual differences in the way food is experienced has developed over the past two decades, led by prominent scientist Artemis Simopoulos, chair of the Nutrition Coordinating Committee at the NIH and consultant to the Office of Consumer Affairs at the White House. Whereas a global preference for sweet and salty tastes has an evolutionary basis derived from a long history of food scarcity and hunger [79], evidence suggests that individual differences may exist in these preferences, including more recent evidence that food preferences may be driven by identifiable genetic markers and that certain individuals may possess a biological vulnerability to over-consume certain types of food. Further, longitudinal studies suggest that exposure in infancy to both fruits and vegetables and sugar-sweetened beverages can drive later consumption patterns [80, 81].

Simopoulos and colleagues contend that given the critical role that lifestyle plays in human health and disease, the rapid advances in understanding the contribution of genetics to disease and disease treatment must be met with similar enthusiasm in the field of nutrition [82-84]. The authors foresee a future in which the assessment of individuals' genetic makeup and individual preferences will enable not only personalized medical treatment, but targeted designer dietary advice far superior to current uniform 'one-size fits all' approach of modern dietetics and population health.

Two decades of research has examined the characteristics of 'supertasters', a term coined by Linda Bartoshuk in the 1990's to describe individuals who experience taste sensations at a far greater intensity than the average person [85]. Studies have suggested that these genetically-driven differences in taste sensation can be associated with marked differences in body habitus, with supertasters tending to be leaner than non-supertasters [86]. An expansive literature also exists documenting the various genetic influences upon taste perception and consequent food preferences [87-90]. Individual differences have been noted in each of the taste arenas, including bitter, sweet and salty, as well as the potential for these traits to drive a downstream association from taste perception to food preferences and selected consumption, and ultimately body habitus and nutritional status. Further complicating the pursuit of long-term weight-control is evidence suggesting that neural responses to food may differ among those of increased body weight. In a recent paper, Garcia-Garcia and colleagues reviewed 22 studies and noted consistent evidence supporting the hypothesis that obese individuals possess enhanced neural activity in areas associated with salience and reward in response to food stimuli [91].

Importantly thus, individual genetically based preferences likely manifest in habitual overconsumption and weight-gain associated with a singular food or food group. For such individuals, attempts to consume certain food products in moderation are met with failure and weight-regain, as they often trigger long-held genetically driven patterns of consumption. Considering this emerging science, there has been insufficient consideration of the power of behavioral triggers and the danger of the modicum to consume "everything in moderation". While it is true that moderate consumption, consisting of a single cookie for example, will not result in weight gain or regain, if this exposure triggers a behavioral pattern in which a box of cookies is rapidly consumed, then such advice is destructive to the long-term goals of many individuals.

Strategy Trumps Willpower: Managing Cravings and Navigating Sustainable Weight-Loss

The lead author has sought to operationalize Behavioral Nutrition over the past two-decades and in turn propose that the axiom that all individuals can consume "all foods in moderation" has led many to weight-loss failure. Rejection of this widespread weight-management advice predates the findings of the Harvard study cited within and emphasizes the reality that advising individuals to eat all foods in moderation is a license to eat whatever they want. Gullo's pioneering work has utilized evidence from diverse empirical fields, as well as personal experience working with thousands of individuals who have successfully maintained weight-loss, in stark contrast to the relative few who succeed within standard weight-loss trials or through mainstream diets. It is important to note the impact that initial weight-loss can have on motivation and persistence in weight-control efforts. The emotional pain and discomfort associated with one's appearance is most often a critical driver of the willingness to commit to changes in behavior and consumption. However, as initial success is achieved and confidence and self-esteem are enhanced, this distress will lessen and therefore motivation will also decrease. It is therefore critical that strategies be established that do not rely solely on willpower and motivation, which will naturally wane, while also ensuring the client is aware of their food history, cognitive patterns and individual neurochemical responses to trigger foods.

Critically however, willpower and self-control remain central tenants of mainstream weight-loss efforts, despite the unprecedented rise in obesity and overweight over the past three decades and a greater emphasis upon cognitive and behavioral weight-loss treatments within the empirical domain [19, 78, 92].As noted earlier, an expansive literature now exists concerning the role of willpower in behavior change and many findings bring into question its central role in promoting sustainable behavior change and weight-control. In addition, an ongoing focus on willpower as a primary driver in weight-control serves to ignore the complexity of weight gain and loss and propagate the notion that an inability to sustain weight-loss stems from weakness and personal failings. Such ideas further promote the societal image of obese and overweight individuals as lazy, slothful and lacking self-control, thus in turn contributing to well-documented levels of weight-bias and weight-based discrimination [93].

Behavioral patterns driven by food triggers underlie why general advice to maintain a balanced diet and consume food in moderation after weight-loss frequently lead to weight regain. Without restrictions imposed by calorie counting or the removal of entire food groups, individuals will revert to habitual behavioral patterns. Short-term weight-loss does not eliminate these long-held patterns of consumption. Consequently, if individuals don't possess awareness of these patterns and develop alternative strategies, then history is too often left to repeat itself. Indeed, strategy needs to be implemented in the context of one's lifestyle and be congruent with

one's personality. The current model of weight-loss focuses much more how individuals should behave rather than how individuals do behave in their relationship with food. Indeed, most are aware of how they should behave and what they **s**hould eat, however, this may be irrelevant given the tendency of human beings towards excess and the strength of historical patterns of consumption [64].

Substitution of trigger food items can play a critical role in sustaining weight-loss efforts. Whereas modern food industry has created many barriers to weight-loss, it has also produced a multitude of low-calorie options that can satisfy individuals without sacrificing long-term weight and health goals. The importance of adopting foods and behaviors that don't contribute to feelings of deprivation is critical and requires that one asks whether a selected food provides satisfaction and satiety or stimulates overconsumption. As explored in depth in the first section of the paper, willpower does not represent a reliable foundation on which to develop sustainable weight-control efforts. The implementation of rules around trigger foods or situations can relieve the anxiety and tension that is associated with exerting willpower on a routine basis. This strategy, termed 'boxing in', requires the client to adopt self-imposed rules regarding when a problem food can be consumed, for example, only on special occasions or certain holidays. This strategic approach provides all-important feelings of control in the context of trigger foods and promotes a more sustainable approach than moderate consumption. The emerging realm of habit psychology suggests that behavioral patterns are easily learnt and reinforced in the existing food environment, and for many will begin in childhood or adolescence [94].For example, our cultural treatment of food can guide ideas around food and consumption, with comfort foods and sweets often used in affectionate contexts, as we refer to others as 'honey' or 'cookie', while certain food stuffs possess negative connotations, a 'bad apple'. As noted earlier, once patters are learnt they are often relegated from conscious awareness and easily triggered by a variety of sensory and environmental cues. Once identified through examination of an individual's food history, research has suggested that such behavioral patterns can be difficult to erase, and instead can be replaced with an alternative or competing behavior. This strategic adoption or substitution of competing thoughts and behaviors once again stems from the fields of habit psychology, with such texts as the Power of Habit [95], and the advertising world.

The ability of advertising to influence behavior is widely recognized, with companies exerting tremendous resources to guide consumer desire. Strategies that employ brief messages or slogans create an internal dialogue and help guide a belief system around the referenced item. These messages have created a culture that promotes excess and indulgence, with no recognition of the consequences of such behavior. This almost child-like approach to food consumption is easily seen through our internal dialogue around food, with a sense that we 'should be allowed to eat it', or that we are being deprived by an invisible hand, or that we can indulge without mind to the consequences. This approach to food must be placed within an adult framework, whereby we recognize our agency in decision making, and the need to consider the consequences of our chosen behavior on our long-term weight and health. Cognitive switching is an approach by which one's internal dialogue can be rewritten and brought to serve weight-loss goals. This approach involves talking to oneself in a new way. All of us carry on a continuing internal dialogue about other people or events or about ourselves. How we talk to ourselves about food either encourages overeating or empowers us to limit or avoid overeating entirely. The winners at weight control permanently change their thinking as well as their weight. Changing your thinking is necessary to change your behavior. Cognitive switching enables a person to actually switch his/her thinking about how he/she eats with a new self-talk, and then reinforcing it. The successful dieter's cognitive switch replaces the old, defeatist way of thinking about food that only tempts him to overeat with a new way that matches his goals.

Conclusions

It is becoming increasingly clear that a broad and far-reaching societal response will be needed to curb the global pandemic of obesity. In promoting sustainable weight-loss for the millions who are overweight and obese, we must take aim at the heart of the problem, our history and relationship with food, rather than the overt symptom that is excess weight. To be effective, our interventions must recognize the ever-changing food environment, its interaction with human behavior, and the dominant role that our individual food history, guided by years of family and cultural influences, play in our pursuit of health. Behavioral Nutrition represents a renewed focus on behavioral strategies that honor an individual's food history; an approach that recognizes that excess weight itself is not the problem, but a symptom of a destructive relationship with food and eating, and that one can indeed lose weight but does not lose their history with food. Behavioral Nutrition represents a novel approach to promoting sustainable weight-loss and one that seeks to restore the word 'diet' to its original meaning; '*diaita'* – a way of life.

Acknowledgement

This manuscript is dedicated to the late Jimmie Holland M.D. who provided ongoing support for this collaboration and work, and to Artemis P. Simopoulos M.D, who recognized early the importance of this approach to weight-loss and wrote the forward to the senior authors' first book.

This work has evolved from four decades of clinical and academic studies by Gullo and its key ideas were first presented as a keynote address for the National Obesity & Weight Control Symposium at Columbia University Medical Center in 1993. The authors would like to thank all those who have contributed to this work.

Conflicts of Interest: None

References

1. Hales CM, Carroll MD, Fryar CD, Ogden CL (2020) Prevalence of obesity and severe obesity among adults: United States, 2017–2018. NCHS Data Brief 360 : 1-8.

2. WHO (2011) Global status report on noncommunicable diseases 2010. Geneva.

3. Taksler G (2017) Obesity larger factor than diabetes, tobacco use, hypertension or high cholesterol. Society of General Internal Medicine 2017, Annual Meeting, Washington D.C.

4. Fontaine KR, Redden DT, Wang C, Westfall AO, Allison DB, et al. (2003) Years of life lost due to obesity. JAMA 289: 187-193.

5. Cawley J, Meyerhoefer C (2012) The medical care costs of obesity: an instrumental variables approach. J Health Econ 31: 219-230.

6. Fontaine KR, Barofsky I (2001) Obesity and health-related quality of life. Obes Rev 2: 173-182.

7. Puhl RM, Heuer CA (2010) Obesity stigma: important considerations for public health. Am J Public Health 100: 1019-1028.

8. Flegal KM, Carroll MD, Kit BK, Ogden CL (2012) Prevalence of obesity and trends in the distribution of body mass index among US adults, 1999-2010. JAMA 30: 491-497.

9. Drewnowski A (2004) Obesity and the food environment: dietary energy density and diet costs. Am J Prev Med 27: 154-162.

10. Food Availability (Per Capita) Data System (2014) USDA Economic Research Service ,USDA.

11. Ledikwe JH, Ello-Martin JA, Rolls BJ (2005) Portion sizes and the obesity epidemic. J Nutr 135: 905-909.

12. Dietary goals for the United States (1977) Select Committee on Nutrition and Human Needs. Washington D.C.

13. Harvard Health Publications & The Nutrition Source (2014) Healthy Eating Plate.

14. Rock CL, Doyle C, Demark-Wahnefried W, Meyerhardt J, Courneya KS, et al. (20121) Nutrition and physical activity guidelines for cancer survivors. CA Cancer J Clin 62: 243-274.

15. Briefel RR, Johnson CL (2004) Secular trends in dietary intake in the United States. Annu Rev Nutr 24: 401-431.

16. Annual Survey of Consumption Habits(2005) : Gallup.

17. Weight-loss Market Facts (2012) Marketdata Enterprises.

18. Fletcher AM (2003) Thin for Life: 10 Keys to Success from People Who Have Lost Weight and Kept It Off. Rux Martin/Houghton Mifflin Harcourt.

19. Sarwer DB, Green AvS, Vetter ML, Wadden TA (2009) Behavior therapy for obesity: where are we now? Curr Opin Endocrinol Diabetes Obes 16: 347-352.

20. Kraschnewski JL, Boan J, Esposito J, Sherwood NE, Lehman EB, et al. (2010) Long-term weight loss maintenance in the United States. Int J Obes 34: 1644-1654.

21. Gullo SP (1995) Food Control Training as a Successor to Dieting: A New Model for Weight Management. Obesity: new directions in assessment and management, Philadelphia Charles Press.

22. Gullo SP (1998) Thin Tastes Better: Control Your Food Triggers and Lose Weight Without Feeling Deprived. Random House publishing Group, New York.

23. Gullo SP (2004) The Thin Commandments: The Ten No-Fail Strategies for Permanent Weight Loss. Rodale Books, USA.

24. Thomas JG, Bond DS, Phelan S, Hill JO, Wing RR, et al. (2014) Weight-loss maintenance for 10 years in the National Weight Control Registry. Am J Prev Med 46: 17-23.

25. Curry SJ, Krist AH, Owens DK, Barry MJ, Caughey AB, et al. (2018) Behavioral Weight Loss Interventions to Prevent Obesity-Related Morbidity and Mortality in Adults: US Preventive Services Task Force Recommendation Statement. JAMA 320: 1163-1171.

26. Nutrient Intakes from Food: Mean Amounts Consumed per Individual, by Gender and Age in U.S. in 2011-2012. Department of Agriculture ARS Washington D.C.: U.S. Department of Agriculture, Agricultural Research Service.

27. Gullo SP (1994) National Obesity and Weight Control Symposium. Columbia University.

28. vanDellen MR, Isherwood JC, Delose JE (2016) How do people define moderation? Appetite 101: 156-162.

29. Volkow ND, Wise RA (2005) How can drug addiction help us understand obesity? Nat Neurosci 8: 555-560.

30. Wang GJ, Volkow ND, Fowler JS (2002) The role of dopamine in motivation for food in humans: implications for obesity. Expert Opin Ther Targets 6: 601-609.

31. Brody J (2011) Still Counting Calories? Your Weight-Loss Plan May Be Outdated. New York Times.

32. Moss M (2013) Salt Sugar Fat: How the Food Giants Hooked Us. Random House Trade Paperbacks, New York.

33. Morganstern I, Barson JR, Leibowitz SF (2011) Regulation of drug and palatable food overconsumption by similar peptide systems. Curr Drug Abuse Rev 4: 163-173.

34. Schatzker M (2016) The Dorito Effect: The Surprising New Truth About Food and Flavor: Simon & Schuster.

35. Volkow ND, Wang GJ, Baler RD (2011) Reward, dopamine and the control of food intake: implications for obesity. Trends Cogn Sci 15: 37-46.

36. Volkow ND, Wang GJ, Fowler JS, Telang F (2008) Overlapping neuronal circuits in addiction and obesity: evidence of systems pathology. Philos Trans R Soc Lond B Biol Sci 363: 3191-3200.

37. Volkow ND, Wang GJ, Fowler JS, Tomasi D, Baler R, et al. (2012) Food and drug reward: overlapping circuits in human obesity and addiction. Curr Top Behav Neurosci 11: 1-24.

38. Volkow ND, Wang GJ, Tomasi D, Baler RD (2013) The addictive dimensionality of obesity. Biol Psychiatry 73: 811-828.

39. Volkow ND, Wang GJ, Tomasi D, Baler RD (2013) Obesity and addiction: neurobiological overlaps. Obes Rev 14: 2-18.

40. DiLeone RJ, Taylor JR, Picciotto MR (2012) The drive to eat: comparisons and distinctions between mechanisms of food reward and drug addiction. Nat Neurosci 15: 1330-1335.

41. Drewnowski A, Krahn DD, Demitrack MA, Nairn K, Gosnell BA,et al. (1995) Naloxone, an opiate blocker, reduces the consumption of sweet high-fat foods in obese and lean female binge eaters. Am J Clin Nutr 61: 1206-1212.

42. Fantino M, Hosotte J, Apfelbaum M (1986) An opioid antagonist, naltrexone, reduces preference for sucrose in humans. Am J Physiol 251: 91-96.

43. Yeomans MR, Gray RW (2002) Opioid peptides and the control of human ingestive behaviour. Neurosci Biobehav Rev 26: 713-728.

44. Wise RA (2013) Dual roles of dopamine in food and drug seeking: the drive-reward paradox. Biol Psychiatry 73: 819-826.

45. Avena NM, Rada P, Hoebel BG (2008) Evidence for sugar addiction: behavioral and neurochemical effects of intermittent, excessive sugar intake. Neurosci Biobehav Rev 32: 20-39.

46. Dagher A (2009) The neurobiology of appetite: hunger as addiction. Int J Obes (Lond) 33: 30-33.

47. Ifland JR, Preuss HG, Marcus MT, Rourke KM, Taylor WC, et al. (2009) Refined food addiction: a classic substance use disorder. Med Hypotheses 72: 518-526.

48. Pelchat ML (2009) Food addiction in humans. J Nutr 139: 620-622.

49. American Psychiatric Association (2013) Diagnostic and Statistical Manual of Mental Disorders,5th Edition: DSM-5. American Psychiatric Publishing.

50. Garber AK, Lustig RH (2011) Is fast food addictive? Curr Drug Abuse Rev 4: 146-162.

51. Berridge KC, Ho CY, Richard JM, DiFeliceantonio AG (2010) The tempted brain eats: pleasure and desire circuits in obesity and eating disorders. Brain Res 1350: 43-64.

52. Muraven M, Baumeister RF (2000) Self-regulation and depletion of limited resources: does self-control resemble a muscle? Psychol Bull 126: 247-259.

53. Baumeister RF, Bratslavsky E, Muraven M, Tice DM (1998) Ego depletion: is the active self a limited resource? J Pers Soc Psychol 74: 1252-1265.

54. Lieberman LS (2006) Evolutionary and anthropological perspectives on optimal foraging in obesogenic environments. Appetite 47: 3-9.

55. Rolls B, Barnett RA (2005) The Volumetrics Weight-Control Plan. HarperTorch.

56. Leibel R, Rosenbaum M (2010) Metabolic Responses to Weight Perturbation. Novel Insights into Adipose Cell Functions: 121-33.

57. Lustig RH, Schmidt LA, Brindis CD (2012) Public health: The toxic truth about sugar. Nature 482: 27-29.

58. Sumithran P, Prendergast LA, Delbridge E, Purcell K, Shulkes A, et al. (2011) Long-term persistence of hormonal adaptations to weight loss. N Engl J Med 365: 1597-604.

59. Hoch T (2013) Everyday desire: Influence of snack food on whole brain activity patterns. 245th ACS National Meeting & Exposition, New Orleans, Louisiana.

60. Downs JS, Loewenstein G, Wisdom J (2009) Strategies for Promoting Healthier Food Choices. Am Econ Rev 99: 159-164.

61. Cawley J (2004) An economic framework for understanding physical activity and eating behaviors. Am J Prev Med 27: 117-25.

62. Stigler GJ (1961) The Economics of Information. Journal of Political Economy 69: 213-225.

63. Kahneman D (2011) Thinking, Fast and Slow. APA PsycInfo.

64. Ariely D (2008) Predictably Irrational: The hidden forces that shape our decisions. Harper Collins Publishers.

65. Kahneman D (2003) A Psychological Perspective on Economics. Am Econ Rev 93: 162-168.

66. Simon H (1986) Rationality in Psychology and Economics. Journal of Business 59: 209-224.

67. Simon H (1955) A Behavioral Model of Rational Choice. Quarterly Journal of Economics 69: 99-118.

68. Seger C (2006) The basal ganglia in human learning. Neuroscientist 12: 285-90.

69. Just DR, Mancino L, Wansink B (2007) Could Behavioral Economics Help Improve Diet Quality for Nutrition Assistance Program Participants. SSRN Electronic Journal 43.

70. Liu PJ, Wisdom J, Roberto CA, Liu LJ, Ubel PA, et al. (2013) Using Behavioral Economics to Design More Effective Food Policies to Address Obesity. Applied Economic Perspectives and Policy.

71. Wansink B, Just D (2011) Healthy Foods First: Students Take the First Lunchroom Food 11% More Often Than the Third. J Nutr Educ Behav 43: 1-8.

72. Wansink B, Painter JE, Lee YK (2006) The office candy dish: proximity's influence on estimated and actual consumption. Int J Obes 30: 871-875.

73. Just DR, Wansink B (2009) Smarter Lunchrooms: Using Behavioral Economics to Improve Meal Selection. Choices 24: 1-7.

74. O'Donoghue T, Rabin M (2001) The economics of immediate gratification. Journal of Behavioral Decision Making 13: 233-250.

75. Loewenstein G (1996) Out of control: Visceral influences on behavior. Organ Behav Hum Decis Process 65: 272-292.

76. Kahneman D (2003) Maps of bounded rationality: Psychology for behavioral economics. Am Econ Rev. 93: 1449-1475.

77. Beck J (2007) The Beck Diet Solution: Train Your Brain to Think Like a Thin Person: Oxmoor House.

78. Wadden TA, Foster GD (2000) Behavioral treatment of obesity. Med Clin North Am 84: 441-461.

79. Barrett D (2007) Waistland: The R/evolutionary Science Behind Our Weight and Fitness Crisis. USA: W. Norton & Company, U.S.A.

80. Park S, Pan L, Sherry B, Li R (2014) The association of sugar-sweetened beverage intake during infancy with sugar-sweetened beverage intake at 6 years of age. Pediatrics 134: 56-62.

81. Grimm KA, Kim SA, Yaroch AL, Scanlon KS (2014) Fruit and vegetable intake during infancy and early childhood. Pediatrics 134: 63-69.

82. Simopoulos AP (2003) Genetics: Implications for nutrition. Forum of nutrition 56: 226-229.

83. Simopoulos AP (2004) Genetic variation: nutritional implications. World Rev Nutr Diet 93: 1-28.

84. Simopoulos AP (2010) Nutrigenetics/Nutrigenomics. Annu Rev Public Health 31: 53-68.

85. Hayes JE, Keast RS (2011) Two decades of supertasting: where do we stand? Physiol Behav 104: 1072-1074.

86. Tepper BJ, Koelliker Y, Zhao L, Ullrich NV, Lanzara C, et al. (2008) Variation in the bitter-taste receptor gene TAS2R38, and adiposity in a genetically isolated population in Southern Italy. Obesity (Silver Spring) 16:2289-2295.

87. Duffy VB, Bartoshuk LM (2000) Food acceptance and genetic variation in taste. J Am Diet Assoc 100: 647-655.

88. El-Sohemy A, Stewart L, Khataan N, Fontaine-Bisson B, Kwong P, et al.(2007) Nutrigenomics of taste - impact on food preferences and food production. Forum of nutrition 60: 176-182.

89. Garcia-Bailo B, Toguri C, Eny KM, El-Sohemy A (2009) Genetic variation in taste and its influence on food selection. Omics : a journal of integrative biology 13: 69-80.

90. Hayes JE, Sullivan BS, Duffy VB (2010) Explaining variability in sodium intake through oral sensory phenotype, salt sensation and liking. Physiol Behav 100: 369-380.

91. Garcia-Garcia I, Narberhaus A, Marques-Iturria I, Garolera M, Radoi A, et al. (2013) Neural responses to visual food cues: insights from functional magnetic resonance imaging. European eating disorders review : the journal of the Eating Disorders Association 21: 89-98.

92. Van Dorsten B, Lindley EM (2011) Cognitive and behavioral approaches in the treatment of obesity. Med Clin North Am 95: 971-988.

93. Puhl RM, Heuer CA (2009) The stigma of obesity: a review and update. Obesity (Silver Spring) 17: 941-964.

94. Loth KA, MacLehose R, Bucchianeri M, Crow S, Neumark-Sztainer D, et al. (2014) Predictors of dieting and disordered eating behaviors from adolescence to young adulthood. J Adolesc Health 55: 705-712.

95. Duhigg C (2014) The Power of Habit: Why We Do What We Do in Life and Business. Random House Trade Paperbacks.

HERALD

Advances In Industrial Biotechnology | ISSN: 2639-5665

Advances In Microbiology Research | ISSN: 2689-694X

Archives Of Surgery And Surgical Education | ISSN: 2689-3126

Archives Of Urology

Archives Of Zoological Studies | ISSN: 2640-7779

Current Trends Medical And Biological Engineering

International Journal Of Case Reports And Therapeutic Studies | ISSN: 2689-310X

Journal Of Addiction & Addictive Disorders | ISSN: 2578-7276

Journal Of Agronomy & Agricultural Science | ISSN: 2689-8292

Journal Of AIDS Clinical Research & STDs | ISSN: 2572-7370

Journal Of Alcoholism Drug Abuse & Substance Dependence | ISSN: 2572-9594

Journal Of Allergy Disorders & Therapy | ISSN: 2470-749X

Journal Of Alternative Complementary & Integrative Medicine | ISSN: 2470-7562

Journal Of Alzheimers & Neurodegenerative Diseases | ISSN: 2572-9608

Journal Of Anesthesia & Clinical Care | ISSN: 2378-8879

Journal Of Angiology & Vascular Surgery | ISSN: 2572-7397

Journal Of Animal Research & Veterinary Science | ISSN: 2639-3751

Journal Of Aquaculture & Fisheries | ISSN: 2576-5523

Journal Of Atmospheric & Earth Sciences | ISSN: 2689-8780

Journal Of Biotech Research & Biochemistry

Journal Of Brain & Neuroscience Research

Journal Of Cancer Biology & Treatment | ISSN: 2470-7546

Journal Of Cardiology Study & Research | ISSN: 2640-768X

Journal Of Cell Biology & Cell Metabolism | ISSN: 2381-1943

Journal Of Clinical Dermatology & Therapy | ISSN: 2378-8771

Journal Of Clinical Immunology & Immunotherapy | ISSN: 2378-8844

Journal Of Clinical Studies & Medical Case Reports | ISSN: 2378-8801

Journal Of Community Medicine & Public Health Care | ISSN: 2381-1978

Journal Of Cytology & Tissue Biology | ISSN: 2378-9107

Journal Of Dairy Research & Technology | ISSN: 2688-9315

Journal Of Dentistry Oral Health & Cosmesis | ISSN: 2473-6783

Journal Of Diabetes & Metabolic Disorders | ISSN: 2381-201X

Journal Of Emergency Medicine Trauma & Surgical Care | ISSN: 2378-8798

Journal Of Environmental Science Current Research | ISSN: 2643-5020

Journal Of Food Science & Nutrition | ISSN: 2470-1076

Journal Of Forensic Legal & Investigative Sciences | ISSN: 2473-733X

Journal Of Gastroenterology & Hepatology Research | ISSN: 2574-2566

Journal Of Genetics & Genomic Sciences | ISSN: 2574-2485

Journal Of Gerontology & Geriatric Medicine | ISSN: 2381-8662

Journal Of Hematology Blood Transfusion & Disorders | ISSN: 2572-2999

Journal Of Hospice & Palliative Medical Care

Journal Of Human Endocrinology | ISSN: 2572-9640

Journal Of Infectious & Non Infectious Diseases | ISSN: 2381-8654

Journal Of Internal Medicine & Primary Healthcare | ISSN: 2574-2493

Journal Of Light & Laser Current Trends

Journal Of Medicine Study & Research | ISSN: 2639-5657

Journal Of Modern Chemical Sciences

Journal Of Nanotechnology Nanomedicine & Nanobiotechnology | ISSN: 2381-2044

Journal Of Neonatology & Clinical Pediatrics | ISSN: 2378-878X

Journal Of Nephrology & Renal Therapy | ISSN: 2473-7313

Journal Of Non Invasive Vascular Investigation | ISSN: 2572-7400

Journal Of Nuclear Medicine Radiology & Radiation Therapy | ISSN: 2572-7419

Journal Of Obesity & Weight Loss | ISSN: 2473-7372

Journal Of Ophthalmology & Clinical Research | ISSN: 2378-8887

Journal Of Orthopedic Research & Physiotherapy | ISSN: 2381-2052

Journal Of Otolaryngology Head & Neck Surgery | ISSN: 2573-010X

Journal Of Pathology Clinical & Medical Research

Journal Of Pharmacology Pharmaceutics & Pharmacovigilance | ISSN: 2639-5649

Journal Of Physical Medicine Rehabilitation & Disabilities | ISSN: 2381-8670

Journal Of Plant Science Current Research | ISSN: 2639-3743

Journal Of Practical & Professional Nursing | ISSN: 2639-5681

Journal Of Protein Research & Bioinformatics

Journal Of Psychiatry Depression & Anxiety | ISSN: 2573-0150

Journal Of Pulmonary Medicine & Respiratory Research | ISSN: 2573-0177

Journal Of Reproductive Medicine Gynaecology & Obstetrics | ISSN: 2574-2574

Journal Of Stem Cells Research Development & Therapy | ISSN: 2381-2060

Journal Of Surgery Current Trends & Innovations | ISSN: 2578-7284

Journal Of Toxicology Current Research | ISSN: 2639-3735

Journal Of Translational Science And Research

Journal Of Vaccines Research & Vaccination | ISSN: 2573-0193

Journal Of Virology & Antivirals

Sports Medicine And Injury Care Journal | ISSN: 2689-8829

Trends In Anatomy & Physiology | ISSN: 2640-7752