NCCOR
National Collaborative on Childhood Obesity Research

MARCH 2017

Health, Behavioral Design, and the Built Environment White Paper

EXECUTIVE SUMMARY

Purpose of the Health, Behavioral Design, and the Built Environment Project

The National Collaborative on Childhood Obesity Research (NCCOR) brings together four of the leading health research funders in the United States—the Centers for Disease Control and Prevention (CDC), the National Institutes of Health (NIH), the Robert Wood Johnson Foundation (RWJF), and the U.S. Department of Agriculture (USDA)—to address the problem of childhood obesity in America. In 2014, NCCOR initiated the Health, Behavioral Design, and Built Environment Project in recognition of an important knowledge gap, namely, how do specific aspects of the built environment influence healthy living? A series of meetings in 2015–2016 brought together a multidisciplinary group of experts to discuss methods and evidence on applying behavioral design principles to foster active living and healthy eating, and to inform the development of this white paper. This Project seeks to enhance the ability to understand, translate, and operationalize strategies that alter the human experience with the natural and built environment for the advancement of public health. The purpose of this paper is to *provide an overview of behavioral design, describe and consider the conceptual domains and their relevance to behavioral design, guide research and practice to develop applications that enable and promote healthier behaviors among children, and stimulate further discourse on the application of behavioral design through dissemination.*

The Project took a domain-level approach, inclusive of art, philosophy, political science, science, and spirituality, to draw core principles and theories from diverse disciplines to develop a framework for considering and applying behavioral design strategies to promote healthy eating and active living. Specifically, the principles and theories of design and human propensities and behavior guided the framework development. With respect to the design arena, this white paper draws from fields of study and practice that construct, organize, and present the physical and informational world, such as art, architecture, and community design fields. With respect to the human behavior and psychology arena, the paper considers the theories of human behavior and cognition, such as conscious, reasoned behavior, automatic thinking, and social thinking. While the existence of the agent (i.e., individuals or groups of people) within the environmental sphere of influence is generally acknowledged in public health efforts, the ability to effectively create and apply strategies to enhance health promotion requires an increased consideration of the agent and environment interface. Considering behavioral design principles from theoretical concepts to practice application may facilitate a more comprehensive understanding and ability to influence how the agency-exposure interaction produces experiences. It also considers the exposure aspects that influence the agent and the inherent reciprocity and conditioning perpetuated by that interaction. Given that few such interactions are health-neutral, advancement in behavioral design can incentivize the design and building process to maintain health as a proximate performance outcome.

Key Aspects to Consider for Behavioral Design Relevant to Active Living and Healthy Eating

The built world, whether intentional or not, influences the human experience. The lack of behavioral focus may be due to competing requirements (i.e., time, cost, safety, esthetics), but also may be due, in part, to a lack of awareness or interest in how the designed and constructed environments influence people. If behavioral outcomes are desired and attempted, limitations exist

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in knowledge and understanding of how design affects behavior, and in the standards and skills of designers, architects, and others on how to most effectively apply these theories to practice. Regardless of the quality and extent of the environment's design aspects, individual or group responses to it may vary based on inherent individual factors (such as developmental stage, gender, or mindset) and competing influences. Design considerations are relevant to health behaviors in most if not all settings, such as homes, buildings in general, schools, playground and parks, community layout and content, transportation, and worksites. Many aspects of these settings are designed and have the ability to influence a range of issues—from seemingly small matters, such as the shapes of rooms, types of furniture, or paint color in buildings, to the broader scale issues of connectivity of streets and access to public transportation.

Within food settings, behavioral design strategies can support healthier food and beverage choices by informing, encouraging, enabling, and generally making the healthier choices easier, default, normative, and less expensive. Behavioral design may also be able to increase transparency in food choices and could potentially bring more awareness to one's actions. In doing so, behavioral design seeks to not only make the healthier choice the easier choice, but to create a culture of healthier food behaviors. The relationship of behavioral design to the physical activity environment has similarities to that of its relationship to the food and beverage environment, but the interfaces may be more direct and immediate. Modern built environments are shaped in ways that impede or reduce activity, such as through labor-saving devices or efforts to improve safety. However, it has the potential to be shaped in ways that not only encourage but require physical activity. As with food, physical activity is a continuous and cumulative habit, and thus small repetitive changes over long periods of time are sufficient to create notable outcomes (positive or negative). Incorporating behavioral design to facilitate physical activity efforts can systemize synthetic approaches to the whole environment.

As opportunities for children to spend time outdoors have declined and research has expanded on the potential beneficial effects of exposure to the natural environment, more attention has become focused on how to increase exposure to "natural environments."

In terms of human behavior, much research has shown that sensory stimulation regarding food can later influence behaviors. In addition to thinking automatically, people also think socially. In a similar way that thinking automatically results in people being influenced by the effects of defaults, salience, priming, and affect, thinking socially results in people being influenced by the effects of norms and ego. In the past two decades, the recognition of the limitations of education-only intervention strategies aimed at individuals has led to a focus on multi-level, systems-based interventions that employ environment and/or policy to promote healthy behaviors. With this paradigm shift has come a greater connection between public health and environmental psychology, and an opportunity to leverage environmental psychology concepts and theories to promote healthy eating and active living.

Application of Design Strategies

While several sectors of society affect a child's eating and exercise behaviors, and health outcomes, research indicates that well-designed, well-implemented, school programs can effectively promote physical activity, healthy eating, and reductions in screen time. To improve the schools' ability to promote healthy eating using design principles, an NCCOR-sponsored tool was recently developed—the Healthy Eating Design Guidelines for School Architecture.

Over the past decade, the application of design strategies to the retail food environment has been considered at the local, state, tribal, and national levels, particularly to address disparities in access to healthy foods and with special attention on promoting healthy eating among participants in federal food and nutrition assistance programs.

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Recognizing that more Americans are eating food prepared away from the home, restaurants have used behavioral design strategies to promote healthy eating. Much work remains to understand the full potential of menus, along with other facets of restaurants including playgrounds and on promoting the selection and consumption of healthier foods and beverages. Besides healthy eating, researchers and practitioners are increasingly exploring the application of behavioral design principles in the school physical environment to foster active living and reduce sedentary behaviors. Outside of the school setting, the application of behavioral design principles to foster active living has primarily focused on promoting walking and walkable communities including improvements to public transit, especially considering disparities in access and opportunities for improvement among low-income, racial/ethnic minorities, and rural communities.

Conclusions

Research and evaluation will play an instrumental role in determining which combination of strategies has the greatest potential to positively impact active living and healthy eating among youth. Case studies will be an invaluable learning tool, particularly ones detailing multidisciplinary approaches. Equally important, periodic reviews and meta-analyses may help identify the most promising strategies, relevant rigorous methodologic designs for addressing different types of questions, and future research needs and opportunities.

An exhaustive summary of the many behavioral design approaches and strategies is beyond the scope of this current effort. However, we have outlined a formative list of aspects to consider, along with examples, when evaluating or intervening in the behavioral design process:

- **Individual—agent-level; includes consideration of the developmental stage, conditioning, experiential load, and privacy needs**
- **Social—group-level; includes consideration of interaction mechanics (i.e., cohesion versus separation), social heterogeneity (leadership, staff), and social norms**
- **Economics—includes consideration of affordability, transparency, and incentives**
- **Space—includes consideration of flow paths, density, scale, and zoning**
- **Time—includes consideration of history, priming, sequence, and routine**
- **Atmosphere—includes consideration of ambience (i.e., general "feel"), materials, and landscape**
- **Information—includes consideration of policy, availability, and meaning.**

NCCOR provides information on current tools and resources on its website and is engaging with many disciplinary fields and experts to understand how these issues are being addressed in their fields and to consider the application of these approaches to public health.

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PURPOSE OF THE HEALTH, BEHAVIORAL DESIGN, AND BUILT ENVIRONMENT PROJECT

Research has demonstrated that individual-level interventions to change behaviors related to the prevention of obesity, such as promotion of healthy eating and active living, can be effective in the short term but are unsuccessful in supporting weight loss maintenance.[1] Lessons learned from the fields of tobacco control, seat belt use, and vaccination, to name a few, illustrate how changing culture (i.e., norms, values, customs, and traditions), societal characteristics (e.g., informational and physical built environment), and the natural environment support greater and more sustained adoption of the targeted behavior changes.[2] Over the past decade, there have been numerous innovative efforts to change the food and physical activity environments to reduce overweight and obesity in children.[3,4,5] These efforts have taken place across the globe at the local, state, tribal, or federal levels in childcare centers, schools, food service and retail settings, hospitals, worksites, and faith-based organizations.[6,7,8,9,10,11] Evidence suggests some of these efforts were less successful than anticipated.[5,12,13] The mixed results may be explained, in part, because the applications of specific isolated interventions did not sufficiently encompass the complex and multimodal systems that influence adoption and maintenance of healthy eating and active living.[13,14,15]

The National Collaborative of Childhood Obesity Research (NCCOR) initiated the Health, Behavioral Design, and Built Environment Project to explore how behavioral design can support healthy actions by enhancing our understanding and ability to communicate and operationalize strategies that alter the experience with the built and natural environment.

Because our lives and actions are guided by the complex human experience, this project took a domain-level approach that is inclusive of science, art, philosophy, political science, and spirituality. This approach guided the breadth of expert input and allowed us to draw core principles and theories from diverse disciplinary areas to develop a behavioral design model. This multidisciplinary framework will help us advance the development of more effective and sustainable applications of behavioral design to promote healthy eating and active living. Specifically, the principles and theories of design and human propensities and behavior will guide the framework development. The design arena will draw from fields of study and practice that construct, organize, and present the physical and informational world, such as art, architecture, community design, and design fields. The human behavior arena will draw on the theories of human behavior and cognition, such as conscious, reasoned behavior, automatic thinking, and social thinking.

The Health, Behavioral Design, and Built Environment Project goal is to identify and draw from the theories of behavior and design, and relevant fields of application (e.g., nutrition, physical activity) to develop methods for applying and guiding design efforts that promote or enable well-being and performance. There is a specific focus on enabling the development of behavioral design applications to the built and natural environments. Many factors influence the use and effectiveness of behavioral design to alter feelings, perceptions, choices, actions, and behaviors relative to lifestyle factors that, in turn, influence health outcomes. This effort focuses on applying these concepts to the areas of healthy eating and active living for children and their families in the context of the built environment and community *(See Figure 1)*. This white paper is informed by 2015–2016 NCCOR meetings related to deriving and applying behavioral design principles to foster active living and healthy eating. The meeting participants are listed in the Acknowledgments section.

This white paper has several purposes, namely to:

1. **Define and provide an overview of behavioral design and develop a shared language across disciplines to facilitate this transdisciplinary work**
2. **Describe and consider the conceptual domains to determine their relevance to developing behavioral design, including the scientific basis, current fields of active research, relevant professional trades, and other areas that consider how behavioral design interacts with aspects of human culture**
3. **Guide research and practice in developing easy-to-use, effective, and sustainable behavioral design methods to enable and promote healthy eating and active living among children and families in the communities where we live, learn, work, and play**
4. **Stimulate further discourse on the application of behavioral design to this field through workshops, peer-reviewed publications, and other actions**

FIGURE 1: EXAMPLES OF DISCIPLINES CONTRIBUTING TO BEHAVIORAL DESIGN

This multidisciplinary effort is fostered within NCCOR, which brings together four of the nation's leading health research funders—the Centers for Disease Control and Prevention (CDC), the National Institutes of Health (NIH), the Robert Wood Johnson Foundation (RWJF), and the U.S. Department of Agriculture (USDA)—to address the problem of childhood obesity in America. These leading national organizations work in tandem to manage projects and reach common goals; combine funding to make the most of available resources; and share insights and expertise to strengthen research. NCCOR focuses on efforts that have the potential to benefit children, teens, and their families, and the communities where they live, learn, work, and play. NCCOR places a special emphasis on the populations and communities where obesity rates are highest and rising the fastest, namely: African-Americans, Hispanics, Native Americans, Asian/Pacific Islanders, and children living in low-income communities.

History of Other Relevant NCCOR Activities

One of NCCOR's long-term activities has been to examine how integrating innovations in the design of building and the community built and social environments can facilitate active living and healthy eating for children and their families. As part of that effort, in 2010, NCCOR initiated a strategic partnership with innovators in the architecture and green building industry to: (1) help establish the evidence for what factors are important in developing healthy and environmentally sustainable buildings and communities; and (2) promote transdisciplinary research in this arena.

A key secondary goal of this continuing partnership is to increase the availability, quality, and rigorous evaluation of built-environment projects designed to promote health.

To facilitate this partnership, NCCOR and the National Academy of Environmental Design (NAED) co-sponsored a two-day workshop in 2011, in partnership with the U.S. Green Building Council (USGBC) Center for Green Schools. The workshop included government researchers as well as academic, nonprofit, private sector researchers, and practitioners from the urban planning, architecture, landscape architecture, interior design, and law fields. Participants examined how environmental design strategies can be used to promote active living and healthy eating in school environments. The workshop enabled professionals from a broad range of design, public health, and environmental sustainability disciplines to learn about each other's priorities and how they could be integrated to design healthier spaces. This workshop also laid the groundwork for an article,[16] which put forth recommended strategies for green health and environmental design research and practice. Since this workshop, NCCOR has continued to work with its partners to promote the development of cross-disciplinary training programs in architecture, green building, and public health, including the development of green health resources for researchers and practitioners. NCCOR member organizations have also continued to fund related research.

FRAMING THE ISSUES

This section provides an overview of how the interaction between humans and their environments is influenced by behavioral design and the resulting potential for impacting public health. Human actions, behavior, and decision making are intricately connected with the full range of human exposures or environments and conditioning. Herein the primary focus is on the physical environment, specifically those designed related to food and physical activity. In addition, we briefly address the role of the natural and informational environments. In this paper, "agent" is used to generally represent the idea of individuals or groups, and "exposure" is inclusive of both the *internal* physical and psychological experience and the *external* social, natural, and built environment.

A. The Behavioral Design Interface

"The taste of the apple…lies in the contact of the fruit with the palate, not in the fruit itself; in a similar way… poetry lies in the meeting of poem and reader, not in the lines of symbols printed on the pages of a book. What is essential is the aesthetic act, the thrill, the almost physical emotion that comes with each reading." – JL Borges

What humans "do" is a complex interplay of our intrapersonal and external experience. This interplay of relationships changes over time as we move through our individual stages of development, but also as human society and culture evolve. Group norms and behaviors (culture), as well as the physical and informational world (society), exist in reciprocity with the intrapersonal (physical and psychological) to form, adapt, and condition human experience.

Recognizing these complexly interwoven ideas at varying levels, such as through socio-ecologic, behavioral change, and systems models, public health efforts to improve healthy eating and active living attempt to include individual and environmental approaches via multilevel—intrapersonal, interpersonal, organizational, community, and policy—interventions.[17,18,19,20,21,22,23,24,25,26,27,28]

It is challenging to design and implement multilevel approaches, and, in turn, such approaches are uncommon and may be less robust in impact than anticipated.[12,13,15] Although the containment of the individual (agent) within the environmental spheres of influence is acknowledged in these public health efforts, the ability to effectively construct and apply strategies to create health-promoting efforts requires increased considerations of the behavioral implications of the design of the agent and environment interface (*See Figure 2*).

The ability to construct and the efficiency used to apply these approaches may be facilitated by an increasing understanding and consideration of how individual (agent) and environmental (exposure) qualities create our experience. Recognizing the necessary complexity, it needs to be noted that agent and exposure are also plural, as in group agency or a multifaceted exposure. Behavioral design as a "science to practice" framework facilitates our understanding and the ability to influence how the agency-exposure interaction produces experiences. Given that few such interactions are health-neutral, advancement in behavioral design can incentivize the design and building process to maintain health as a proximate performance outcome. Behavioral design, therefore, considers the exposure aspects that influence the agent and the inherent reciprocity and conditioning perpetuated by that interaction.

The past few decades have seen increasing work in science, philosophy, and other domains of human experience to refine and resolve the intricate connectivity that we call experience that results from the agent-exposure interface. Efforts include increasingly realistic behavioral and cognitive models that focus on what humans actually do and are able to do in lieu of a history of cultural expectation and idealism.[29] Behavioral economics, choice architecture, and numerous commercial endeavors (e.g., marketing, architecture, and design), often working in conjunction with emerging technologies, have examined and applied these concepts to influence individuals and groups toward particular physical actions or psychological mind states.[30,31] The overall success of these efforts is highly variable but appears less effective in some areas than anticipated,[12,15,32] a situation that can be potentially remedied by more systemic and systematic approaches and by more realistic expectations.[31] Regardless, the conceptual, theoretical, and evidence base of methods and strategies used to apply behavioral design continues to increase in scope and resolution.

Gathering these concepts under a single rubric of behavioral design can facilitate systemic and systematic considerations and approaches for developing and applying strategies. Beginning with the most basic relationship that defines experience, agent and exposure, behavioral design provides needed context and resolution (details on specific issues) to guide and inform the development and application of public health strategies (*See Figure 2*).

FIGURE 2: OUR EXPERIENCE AS AN INTEGRAL PART OF BEING AN AGENT WITHIN A FIELD OF EXPOSURE.

Behavioral design's maturation requires drawing from the base domains of human experience to explore, contextualize, and guide our understanding of the relationship between our actions and the natural and built environment.[33,34] The importance of a domain-level approach should not be underestimated. Because this approach goes beyond systems or even ecologic approaches and, if done with care, enforces considerations from the different ways we think and act. Moreover, a domain-level approach tempers and guides behavioral design to respect and protect freedom, rights, autonomy, and, in general, sovereignty. Developing a methodological approach to behavioral design assists our ability to be effectively inclusive of the complex nature of humans and the potential to modify our world toward particular ends. Ideally such an approach is guided and informed by an overarching conceptual framework containing principles representing the fundamental domains and a methodology containing the basic aspects to be considered in the application of behavioral design. This initial cursory attempt does not fully achieve such an approach but attempts to remain true to the ideal.

Behavioral design is not a new endeavor, though the past century has greatly enriched our empirical understanding of human behavior and cognition and the application of this understanding to community and commercial design and layout. The technology, trade, and tricks of behavioral design extend to prehistory; the way we organize and layout communities, design structures or buildings, use information posturing to sell material goods or ideas, and entertain are all richly poignant aspects of archaeological record.[35,36] Infiltrating the primary historic currency of artistic intuition, advances in empirical evidence of environmental design's influence on behavior has led to design and designers being major actors in industry and architecture. The increased recognition of the role of design in influencing human action builds on previous efforts to organize and design tools, buildings, and communities with intent or an artistic inclination. As the scope of design increases and its impact becomes increasingly robust via scientific research, this trend may accelerate. Current common uses of design are numerous, some examples include: using layout, placement, lighting, color, and signage to influence purchasing decisions of food and other consumer goods; the interface and physical design of electronic goods; laying out forms or websites for enrollment programs (e.g., insurance, retirement, job applications); and designing buildings, parks, playgrounds, and communities.[36]

Businesses, architecture firms, community planners, and governments have taken note, applying these strategies to increase sales, improve the human experience, save money, increase safety, and benefit public health and well-being. For example, governments that have behavioral insight teams include the United States, Canada, United Kingdom, the Netherlands, Germany, France, Denmark, Singapore, and Australia.[37,38,39,40,41] General public sector approaches tend to focus on organizing the decision environment such that the easy and default options maximize the public good.

B. Human Responses to Exposure: Physical and Informational Environments

"There are significant challenges and no doubt inherent error in any attempt to dissect experience into agent-exposure, observer-observed, subject-object, or human-environment." – William James

As William James and others have pointed out, we do not experience separate conditions of agent and exposure but rather a singular synthetic experience. Nevertheless, our experience is not passive in its emergence. Indeed, our experiences are an artificial reciprocity informed, molded, and driven by behavioral (agent) and the design (exposure) aspects. Behavioral design represents an experiential control locus, achieved by altering and aligning aspects of agent and exposure.

Experience, agent-exposure immediacy, is of course also mediated, reinforced, moderated, and guided by numerous informational aspects, which are critical aspects of behavioral design. However, other than a brief recognition of the importance of the informational environment we only address the use of information as a medium for factual education. Internal exposure is discussed in the psychology section (i.e., mindsets, mental models, and developmental stages), while external exposure is discussed in the section on the physical (natural and built) and informational environments.

Recognizing the reciprocal nature of "agent and exposure" is foundational to developing an understanding of behavioral design. At a low resolution this might be referred to as feedback loops, but more specifically it includes those items left as time passes, such as conditioning, resilience, expectation, repeated behaviors, and normality. Regardless of our desires, these effects are decisive in our relationship with the world. This conceptual perspective recognizes "experience" as the central and iterative influence on the momentum of our lives; this momentum contains and modifies our whole being including our biologically dictated but changing propensities such as our developmental stage and our physical or psychological assets or limitations.

With this momentum, our actions lie on a continuum from the planned, informed, or highly intentional (aware) to the unaware, reactive, or default (sometimes referred to as mindless, fast thinking, or automatic).[29] Decision-making, suggestive of intent, tends toward the "aware" side of this continuum (i.e., slow thinking). At least semantically, it might be argued that a choice made without awareness is still a decision, but in general what is referred to as a decision trends on the aware side.

This does not imply that decisions are well informed and balanced or effectively consider alternatives (so called "rational" decisions), instead that decision-making advances are based on available information and overall context (so called "bounded rationality").[29]

Physical and informational exposure enables, guides, encourages, requires, informs (or the reverse of these), while the agent reacts in accordance with their abilities and desires (physical attributes, information processing, goals, ambitions, routines, etc.). Contributing to this reciprocity are the parts of experience that are less-aware, such as our experiential load that is conditioned, reactive, instinctual, and subliminal. Further, cognitive load, ego depletion, tiredness, and other trying or will power-depleting experiences may influence the balance of experience between agent and exposure.[42,43] Thus, both actions and decisions are closely intertwined with exposure and can support or detract from health behaviors (i.e., our actions or decisions related to eating or physical activity).

Providing specifics in a few areas can be illustrative, but as in many areas of human behavior, isolated single behavioral design activities within the larger context may negate or complement their effects. This caution is warranted as popular descriptions of this work may overstate possible outcomes. Therefore, the potential impacts of single exposure issues may be small; however, the cumulative aspect of the total behavioral design environment and the cumulative effect over time can be significant.

On the physical side, the environment can affect how much effort is required for any specific action. In the case of eating behaviors, for example, environmental factors may be the distance to a grocery store, the placement of items in a store, or the layout of items in a cafeteria or on a restaurant menu. The easy and default option environment, presented as related to physical distance, time needed, distance from the present, or overall required effort, creates gravitational centers of likelihood for particular outcomes. A person's previous exposure compounds these effects as time layers experience and creates routines, habits, and norms that may manifest themselves as ingrained eating practices or a certain level of physical activity. These personal routines can come from or become group routines, norms, or cultural practices.[44]

The cognitive states and conative/affective states are closely bound (in our relationship) to exposure. Our limited mental energy and bandwidth to engage in conscious decision-making for frequent and repetitive behaviors, such as eating and moving, are taxed by emotional implications and our ability to process information.[45,46,47,48] Exposure may complement, enable, or retard cognitive capacity, affecting functionality, energy expenditure (for the same task), or awareness (of actions) and ultimately the quality of decisions when viewed retrospectively.

The integration and maintenance of prior exposure influences emotions and is instrumental in how we manage time and predictive of our actions (and the level of intention we give them). For example, our response to living with adversity and insecurity—such as threats, poverty, or social class—can be the development of a scarcity mindset, which leads to effects such as short-term decision making that overvalues the present over the future.[46,47,48,49]

Physical exposure influences affective states such as emotions, feeling, and moods, as well as cognitive abilities such as focus.[50,51] For example, the soundscape can trigger post-traumatic stress disorder (PTSD) responses or alleviate them, increase aggressiveness in children or reduce it, and influence our ability to think clearly or focus.[51,52]

Cognitive, affective, and physical responses to sensory perception also affect higher brain functions of learning, memory, and creativity. As one example, exposure to background noise and/or color (e.g., computer screen and wall paint) can cause stress or calming responses.[50,51,53,54] Another example is how enhancing the spaciousness of a room with a high ceiling may improve our ability to focus our efforts, thoughts, or actions.[55] These effects occur largely on a continuum, though effects are often threshold dependent, with adverse sensual experiences leading to difficulties in decision making, default option choice, and negative stress responses.[56]

To iterate, the effects of many specific exposures on health and behavior have been demonstrated empirically but largely with a focus on a limited number of variables, i.e., how sound influences concentration. The entirety of the "whole" exposure is less well studied, although commercial environments are specifically designed to modify sensory experiences to produce often unconscious actions, such as what foods to choose and how long to spend eating. This "whole" exposure is not simply about a single event as in going to a restaurant, but a day, month, or years of events that modify or enforce single or recurrent actions.

C. Ethics of Modifying Exposure

Influencing actions through design is generally seen as less ethically controversial than influencing action by limiting people's choices or by constraining their actions (for example, bans on the use of *trans* fat or portion-control policies). Influencing actions through design is also generally seen as less ethically controversial than influencing action by financially disincentivizing certain actions—such as taxing sugar-sweetened beverages—which some view as regressive and thus strikes some people as unfair.[57] However, influencing actions through design is seen as more ethically controversial than influencing action by just providing information and education. A primary ethical concern is that using behavioral design to influence action is manipulative and is an ethically inappropriate way to exert control over people. As design expert Dan Lockton puts it: "All design influences our behaviour, but as designers we don't always consciously consider the power this gives us to help people (and, sometimes, to manipulate them)."[58] Multiple ethicists have articulated the concern that nudges (one kind of behavioral design) can be manipulative.[59,60,61,62]

As a first response to these concerns about manipulation, it is important to note that design—through sounds, colors, smells, signs, and the physical layout of spaces—can slow people down, prompt them to engage in reflection, and put them into more reflective mind states. Thus behavioral design is not always used to make our experience less reflective and deliberative. Another important response to concerns about manipulation is that the intention behind behavioral design can be made transparent, through the use of signs or design features that are overt.

But what about behavioral design that does not enhance reflection and reflective mind states, but instead influences behavior without prompting reflection about this behavior (for example, prompting people to take the stairs rather than the elevator, but without prompting any reflection about that matter)? What about behavioral design that is not fully transparent to people who encounter it—or design that is transparent to us but nonetheless influences us emotionally and psychologically in ways that we cannot control? Should we worry that this behavioral design could be manipulative?

Whether behavioral design is manipulative and is ethically problematic for that reason are complex ethical questions. The case that behavioral design is manipulative might go roughly as follows: it is manipulation whenever someone's action is influenced by means other than rational persuasion or by means other than engaging her in reflection and deliberation. Behavioral design does not influence action by rationally persuading people to act in a certain way, nor does it influence action by engaging people in reflection and deliberation, but instead bypasses reflection and deliberation. Thus behavioral design is manipulative. But this argument is based on an understanding of manipulation and rationality that many scholars would reject. There are countless examples of influence that do not engage people in reflection and deliberation, and are not rational persuasion, yet are not manipulative. Rather than understanding manipulation as influence that does not engage people in rational deliberation, a better understanding is this: manipulation is influence that intentionally makes people fall short of various rational ideals and behavioral ideals. With this way of defining manipulation, designers' and policymakers' use of behavioral design is not inherently manipulative, but only manipulates us when it intentionally makes us fall short of rational ideals and behavioral ideals.[63,64]

Thus, one could argue that using behavioral design to promote health is not manipulative because it aims to influence people to act in healthier ways, which better aligns people's behavior with their goals and values. Continuing this line of thought, one might argue that the use of behavioral design by many in the private sector is different. That is, many in the private sector are not using behavioral design with the aim of making consumers' behavior better align with consumers' goals and values, but rather most in the private sector are primarily aiming to produce behavior that is profitable for commercial interests.

Also relevant to the ethics of behavioral design is work on "bounded rationality." Behavior is not consistently produced by informed deliberation that culminates in a "rational" choice; this is a lesson of work on "bounded rationality."[65,66] And at baseline, many people are not behaving in ways that are "rational" or align with their goals and values.[65,67] Thus the ethical standard by which we assess whether influence is manipulative should not be whether that influence encourages rational deliberation, but instead whether that influence encourages behavior that better aligns with people's goals and values. Furthermore, as Cass Sunstein has argued, reducing the number of choices that people make can enhance their autonomy: "If we had to make far more decisions, our autonomy would be compromised, because we would be unable to focus on what concerns us."[67]

Therefore, arguments can be made that behavioral design is not inherently manipulative—it can prompt reflective engagement with the world, and even when it doesn't, it can help align people's behavior with their goals and values. A further argument in favor of behavioral design is that it can enhance our ability to make good choices when it counts by reducing the number of choices we have to actively make. While these ethical defenses of behavioral design have merit, a note of caution is needed. It is not defensible to assume that healthier behavior *always* aligns with people's goals and values, so it is not defensible to assume that behavioral design for health *always* helps people align their behavior with their goals and values. Nor is it ethically defensible to assume that it always makes people better off. A theme in the ethics literature is that unhealthy behavior has benefits and healthy behavior has costs—for example, when people drink less soda, they might experience less pleasure or lose out on valuable social experiences.[68,69,70] Thus the most ethically preferable behavioral design efforts are those that not only produce healthier behavior, but which also make healthier behavior less costly and more rewarding for individuals and groups. In this context, it may be useful to draw a distinction between uses of behavioral design that provide people with new opportunities or experiences, or make existing options better—for example, making walking paths and parks safer or more beautiful—and uses of behavioral design that do not. An example of the latter would be setting an option as the default to take advantage of the psychological propensity to stick with the default, but without making that option any better. While the latter strategies may be ethically defensible in many cases, the former are generally ethically preferable, all other things equal.

Another way to defend behavioral design for health against the charge of manipulation is to concede that it may be manipulative. Nonetheless, the argument would go, this manipulation may be ethically acceptable when it makes enough individuals better off or provides sufficient benefit to the public.[62] This defense also allows us to distinguish behavioral design for health from much behavioral design in the private sector, which arguably does not primarily aim to make individuals better off or to benefit the public.

It is also important to distinguish behavioral design that has paternalistic aims—it aims to change individuals' behavior to improve *their own* health and well-being—and behavioral design that is not just paternalistic, but also aims to change individuals' behavior to protect or benefit others. Ethicists generally agree that it is harder to justify paternalism, especially if a society's shared political values include valuing extensive personal liberty and individual freedom, but easier to justify measures that benefit third parties or protect them from harm.[71,72,73,74] For example, tobacco control measures have been justified as protecting bystanders from the harms of secondhand smoke, not just as protecting smokers themselves.[72] That government has a responsibility to protect citizens' health from others' harmful behavior is an idea that has resonance even with those who think individuals should be free to harm themselves.[71,72,73,74] Similarly, the view that government and civil society have a responsibility to protect children's health and well-being may be accepted even by those who think that adults should be free to adopt unhealthy lifestyles.

KEY ASPECTS TO CONSIDER FOR BEHAVIORAL DESIGN RELEVANT TO ACTIVE LIVING AND HEALTHY EATING

A. The Built and Designed Environment

In the modern world, our exposure and thus experience are heavily influenced by the built world, which may or may not be intentionally designed to have specific behavioral outcomes. This lack of behavioral focus is, in part, the compromise in managing competing requirements but is also frequently simply a lack of awareness or interest in how the environments we construct actually affect people. Construction and design are driven by factors, such as cost, time, tradition, or priorities, while also addressing the functional necessities, such as structural soundness, safety, durability, and esthetics—based on a given price, timeframe, and preferences. If behavioral outcomes are desired and attempted, limitations exist in knowledge and understanding of how design affects behavior, and in the standards and skills of designers, architects, and others on how to most effectively apply these theories to practice. Regardless of the quality and extent of the environment's design aspects, agentic response (that is, that of agents) may vary as it is influenced or even dictated by inherent individual factors (such as development stage, gender, mindset, or difficulty of influencing a specific behavior) and competing and holistic influences.

Design considerations are relevant to health behaviors in most if not all settings, such as homes, buildings in general, schools, playground and parks, community layout and content, transportation, and worksites. Many aspects of these setting are designed and have the ability to influence from seemingly small issues, such as the shapes of rooms, types of furniture, or paint color in buildings, to the broader scale issues of connectivity of streets and access to public transportation.[35,36]

Commercial, business, economic, and political influences all play a role in the built environment's design. Differing opportunities and costs are presented by whether an effort encompasses development/build or redevelopment/rebuild. The former represents expensive and long-term impacts; in such efforts it is critical to include behavioral design consideration early in the process, although time may be limited for such considerations. Regarding the latter, which is more common and can be done at many levels from full renovations to minor updates, behavioral design components can be added based on available funds. In both cases, an important parameter to consider are operational policies such as tobacco cessation or food service policies and contracts that do not require overt changes to physical structures. Such approaches may be particularly useful when funds are limited to enact physical changes.

Strategies to facilitate the integration of behavioral design into practice include legislative (e.g., zoning and land use regulations), business approaches (e.g., rating and certification systems), and their amalgam (e.g., community planning and requirement for certification).

The Food and Beverage Environment

Enabling effective thinking about the potential impact of behavioral design on food and eating patterns requires moving past basic assumptions that taste, price, and convenience are the sole or even primary drivers of dietary choice. For simplicity's sake, we will only use food in this section but we are generally referring to foods and beverages. Our relationship to food is intertwined with much of what it means to be human and stands as a starkly unique quality in the animal world. Food as nourishment and pleasure is physically and viscerally desired and needed. Fluid is essential to hydration. Collectively, food is the social and culture currency where traditions pass, stories are told, deals are made, and relationships are formed and bonded.

Food is a primary activity of our species, in one way or another we spend much of our time, use most of our land, and a good deal of planetary resources to produce, process, prepare, transport, sell, buy, eat, and dispose of food. Food is omnipresent—everywhere and at all times—and thus our personal and commercial environments are rich in designed materials and structures that influence and often facilitate food and our relationship with food.

At the individual and family levels, food selection, preparation, and consumption are influenced by numerous aspects. These factors include how food is made available in communities and how it is prepared, served, presented, priced, and marketed, as well as the myriad of personal, social, and cultural issues alluded to above. Overlaying virtually all aspects that connect us to food is the potential to influence our actions through physical and informational design. Probably because food is intricately and intimately related to the human psyche, connecting as physical necessity and visceral identity, using behavioral design to influence our actions related to food is common and traditional though increasing in sophistication in the commercial sector.

Commercial and academic research have explored and demonstrated—in structured experiments and real-life marketplace implementation—the ability to influence food choices with a myriad of approaches such as: packaging, portion sizes, salience, health claims, labeling, design in general, visceral stimulants (e.g., sounds, smells), and cultural/social/normative approaches. Not surprisingly, people generally lack insight about the influence of these strategies on their personal dietary choices.[56]

Behavioral design strategies can support better food and beverage choices by informing, encouraging, enabling, and generally making the healthier choices easier, default, normative, and less expensive. Behavioral design may also be able to increase the transparency of how food environment may be driving choice, enabling people to recognize persuasive intention even if near awareness thresholds. As a result, behavioral design could potentially bring more awareness to one's actions. Evidence-based behavioral design strategies include numerous approaches that can be roughly classified as ambience, functional design, labeling, presentation, sizing, pricing, priming, prompting, default, and normalization.[31] These strategies are widely employed to sell food but are not limited in their influence and play a general role in ways humans act and persuade.

Therefore, the concepts used in behavioral design traditionally have not been discrete, nor do they require intention or understanding of the concepts to be used (i.e., they are used to some degree inadvertently whenever we offer food). These and other strategies in our food environment produce a concerted exposure. The ideal combination and specifics of application are dependent on many issues, may vary by specific circumstances that may not be fully understood, thus limiting the provision of comprehensive and accessible guidance on application (See Application of Design Strategies to Food and Physical Activity Environments for further discussion).

The Physical Activity Environment

The relationship of behavioral design to the physical activity environment has similarities to that of its relationship to the food and beverage environment, but the interfaces may be more direct and immediate. Movement is inherent and feels good to many, and the built environment is largely where physical activity happens and has the potential to be shaped in ways that not only encourage but require physical activity. Unfortunately, the modern built environment has progressively made physical activity difficult, for both intentional and unintentional reasons. If environments are designed and constructed with humans in mind, it may be supposed that we might achieve sufficient exercise simply by going through our usual daily routines. It is generally presupposed that in the past the ambient level of physical activity required by the demands of daily living may have been sufficient for a healthy lifestyle. However, a variety of issues have slowly eroded our physical activity levels in response to the demands of daily living.

As with food, physical activity is a continuous and cumulative habit, and thus small repetitive changes over long periods of time are sufficient to create notable outcomes (positive or negative). For example, many labor-saving devices reduce our physical activity. A few illustrative examples in homes include dishwashers, garage door openers, and remote controls; other examples from our work or social environment include inactive transport, elevators, fewer jobs with manual labor, generally more automation and labor-saving devices, and, in general, increasing screen time from all devices. Numerous aspects of the modern built environment impede activity. For example, walking, biking, and other active transport are difficult and dangerous in a car-centric environment; wide-ranging safety issues, real or perceived, reduce free and open outdoor play for children; and car-based transportation systems generally reduce physical activity. Adding to the general trend toward sedentary behavior, where movement only happens from couch to car and car to work, is the general decline of access to esthetic and nature areas. Improving access to sidewalks may improve activity, but we also need open engagement with natural areas and clean, safe, and appealing built environments to reduce the cognitive barriers. Recent place making efforts have highlighted the need for places for these activities; one example that addresses this issue is the Project for Public Spaces, which is a nonprofit planning, design, and educational organization that is dedicated to helping people create and sustain public spaces that build stronger communities (See Application of Design Strategies to Food and Physical Activity Environments).

A relative consensus exists on recommendations for how built environments—such as schools, playgrounds/parks, communities, cities, and transport systems—can be designed to encourage and enable more active living. Reviews report a variety of successful approaches to increase activity that may potentially be facilitated and augmented by integrating behavioral design concepts. Behavioral and social approaches include social support within communities and worksites, physical education, classroom activities, after-school sports, and active transport in schools. Environmental and policy approaches include access to places for physical activity and informational activities, community and street-scale urban design, active transport policy and practices, and community-wide policies and planning.

Numerous groups have developed these strategies for recommendations; for example, the CDC recommended strategies, briefly summarized below, to create environments that encourage physical activity:

- **Improve access to outdoor recreational facilities such as parks and green spaces.**
- **Build or enhance infrastructures such as sidewalks, paths, and trails to support walking and bicycling for transportation and recreation.**
- **Support locating schools within easy walking distance of residential areas.**
- **Improve access to public transportation.**
- **Support mixed-use development where people can live, work, play, and meet everyday shopping and lifestyle needs within a single neighborhood.**
- **Enhance personal and traffic safety in areas where people are or could be physically active.**
- **Participate in community coalitions or partnerships to address obesity.**

Operationalizing these strategies from ideation and information campaigns to policies can benefit from including behavioral design. Incorporating behavioral design to facilitate physical activity efforts can systemize synthetic approaches to the whole environment.

B. Natural Environment

As opportunities for children to spend time outdoors have declined and research has expanded on the potential beneficial effects of exposure to the natural environment, more attention has become focused on how to increase exposure to "natural environments." People experience nature in many places ranging from less-structured environments, such as the wild spaces of large national parks, to more structured spaces, such as large urban parks, smaller neighborhood green spaces, or "pocket" parks, and cultivated farms and gardens, to very structured spaces, such as the inclusion of conservatories or clusters of plants and animals in the built environments of homes, schools, hospitals, and worksites. For the purposes of this report we briefly summarize some of the evidence related to the more structured environments and what is known of children's experiences, behaviors, and health outcomes.

A recent report on "Using Parks to Improve Children's Health" provides one taxonomy of the diverse means by which exposure to nature through parks may improve children's health (*See Figure 3*).

This and other reports categorize these pathways to health benefits as follows: protective vegetation (improved air quality, shade, and cooling); water or blue spaces (soothing sights and sounds, and improved water quality); reprieve from noise (enabling "attention restoration" and relaxation); opportunities for socialization and social cohesion, physical activity, and play; and improved mental, emotional, and physical health benefits (reduced stress, improved cognition, vision, healthier weights, improved sleep quality, and improved asthma). However, recent reviews on the effects of green areas on public health in the urban context conclude that much of the evidence is derived from cross-sectional and descriptive studies that limit the ability to draw causal inferences. These reviews note the need to involve an extensive range of professionals from a wide diversity of fields, such as health, urban planning, transportation, and design, to enhance the quality of research in this field. Metrics and systems for quantifying the contribution of public parks to physical activity and health, such as the Rand System for Observing Play and Recreation in Communities (SOPARC), have recently been published.[76] Two companion programs developed by the Natural Learning Institute, NatureGrounds and Pathways for Play, have been providing guidance on creating opportunities to encourage active lifestyles for children, families, and communities. NatureGrounds published best practice guidelines on creating and retrofitting play environments for parks and school grounds that integrate manufactured play equipment and the living landscape. Similarly, Pathways for Play published guidelines on conceptualizing and planning pathway environments that focus on connecting play and physical health, primarily by creating play pockets into shared use community pathway networks that provide opportunities for physical activity.[77, 78]

Engaging children in gardening is another opportunity for enhancing their exposure to the natural environment. Children become involved in gardening in home, community, and school gardens; the preponderance of the research occurs with children and school gardens. Gardening provides opportunities for children to be involved in designing, planting, and maintaining gardens as well as harvesting, preparing, and sharing foods. Most of the work on school gardens has focused on food-based gardening. A 2009 review noted that quantitative studies on school gardening showed positive outcomes in the areas of science achievement and food behavior but did not consistently improve children's environmental attitude or social behavior.[79] Qualitative studies identified a wider scope of desirable outcomes, including positive social and environmental behaviors. This active area of research is often supported by the USDA and involves USDA Cooperative Extension educators. A recent randomized controlled trial examining the impact of a school garden intervention on children's physical activity suggests that school gardens help to promote children's physical activity and reduce sedentary activity.[80]

This growing evidence base has stimulated an interest in the development of park-prescription programs, which involve pediatricians and other health care providers who provide prescriptions for children and their families to become active in park-based, community-building activities and physical activity. Research is now exploring the effects of such programs on health behaviors and health outcomes; the first national conference on parks prescription was in April 2016, to discuss the implementation of such programs.

C. Human Behavior

Traditionally, the dominant model of human behavior is that of the deliberative, intentional, and rational actor. This human behavior model posits that decisions and behaviors are the result of a reflective process where individuals consciously analyze information and make decisions based solely on their preferences. Many health behavior theories come from this model, including the Health Belief Model,[81] the Theory of Reasoned Action,[82] and the Theory of Planned Behavior.[83] Public health researchers and practitioners have developed multiple interventions based on the rational actor model. Many interventions based on the tenants of the rational actor model use information and incentives to achieve behavior change. These interventions, however, have had limited effectiveness.[84] According to the rational actor model, actors' intentions would directly lead to their behaviors. Empirical research on the relationship between intentions and behaviors, however, shows that intentions are weakly correlated with behaviors[85] and that intentions account for little of the variance in behavior change.[86]

Much of the advancement in our understanding of human behavior comes from a shift from the rational actor model to the dual-system model of cognition.[66] The dual-system model posits human cognition as taking place via two parallel systems—a reflective system and an automatic system. The reflective system is deliberative and slow; it is associated with rational, rule-based thought and requires conscious effort and control. The automatic system, in contrast, is uncontrolled and fast; it operates at an unconscious level that requires no noticeable effort and is characterized by automatic, associated thought. The automatic system is responsive to external stimuli and, as such, is largely influenced by context and environment.

This section of the paper aims to discuss human behavior principles as they pertain to the behavioral design field. For this section we apply the criteria used in Hollands and colleagues (2013), which confines its discussion of behavioral interventions to those that take place in physical microenvironments and that operate at an unconscious—automatic system—level. The physical microenvironments concept comes from the ANGELO framework.[87] This framework states that environments can be broken down into two factors: size and type. The size factor consists of two sizes: micro, which refers to a setting "where groups of people gather for specific purposes," and macro, which refers to a sector of "a group of industries, services, supporting infrastructure."[87] The type factor consists of four different types: physical, economic, political, and sociocultural. We limit our discussion to behavior principles that can be influenced though physical microenvironments because these are the environments where eating and physical activity behaviors occur and are where behavioral design interventions can most likely be applied. Furthermore, we limit our discussion to behavioral principles that operate at an unconscious level because this is the level where behavioral design interventions are most likely to operate. In these ways, behavioral design has much in common with choice architecture.[65]

For our discussion on behavioral principles, we use the frameworks presented by the World Bank in its *2015 World Development Report* and the United Kingdom's Institute of Government.[38] In the *2015 World Development Report*, the World Bank presents three principles of human decision-making: thinking automatically, thinking socially, and thinking with mental models. In a report by the United Kingdom's Institute of Government,[38] the mnemonic "MINDSPACE" was put forth to represent what they believe to be the most robust effects on behavior via the automatic system: messenger, incentives, norms, defaults, salience, priming, affect, commitment, and ego (*See Table 1*). We will use the principles of human decision-making as our overarching framework with the MINDSPACE mnemonic to provide further context in our discussion of these principles. That said, we will not be discussing the thinking with the mental model principle or the effects of messenger, incentives, commitment, and ego because they, in our interpretation, do not readily appear to be easily manipulated through changes in physical microenvironments.

Thinking Automatically

As mentioned above, much of human behavior is influenced by automatic thought processes. If human decisions were based solely through the reflective system, humans would attend to and account for all available information and make deliberate rational decisions based on that information and their preferences. Human decisions, however, do not solely operate through the reflective system but rather are influenced by the automatic system. As such, humans have certain automatic and unconscious biases that influence their decisions and behaviors. One of the biases is known as the status quo bias, which is humans' bias to select status quo options when making a decision. This bias leads to the large effects of defaults on behaviors. Experiments show that manipulating default options leads to behavior changes including organ donation, financial decisions, and health care utilization.[65] Another bias in human decision-making is that we tend to make decisions based not on the universe of information available, but rather on what we attend to.[88]

Figure 3: USING PARKS TO IMPROVE CHILDREN'S HEALTH

Although there's still a lot to learn about the true health impact of park prescriptions, many studies suggest that spending time outdoors can offer a variety of health benefits by an equally wide variety of means.

1. PROTECTIVE VEGETATION
Vegetation can reduce the spread of air pollutants both by blocking the dispersal of pollutants and by removing pollutants from the air. Trees and vegetation also offer shade and natural cooling of surfaces and ambient air.

2. BLUE SPACES
Bodies of water—sometimes called blue spaces—provide soothing sights and sounds. Waterways, riverside vegetation, and permeable surfaces also absorb stormwater and filter pollutants from runoff.

3. REPRIEVE FROM NOISE
Parks can provide a break from the noise of urban life. Mesmerizing natural features such as bubbling water, drifting clouds, and rustling leaves enable "attention restoration," leaving people relaxed and refreshed.

4. COGNITIVE BENEFITS
Simple proximity to or views of green spaces has been associated with positive outcomes such as increased self-control, reduced behavioral problems, better school performance, and improved cognition. Enhanced cognition also goes hand in hand with healthier coping strategies.

5. VISION
Spending time outdoors may reduce the risk of myopia in children.

6. SOCIALIZATION
Socializing with family, friends, and even strangers can be a natural stress reducer. Opportunities to engage with new people in new situations also enhances children's cognitive development.

7. PHYSICAL ACTIVITY
Parks typically offer many opportunities for physical activity. Outdoor exercise, especially, can enhance emotional well-being and appears to amplify the many benefits of physical activity. Secondary health benefits result from the reduction in obesity and improved quality of sleep fostered by outdoor activity.

Source: Seltenrich N. Using parks to improve children's health. Environmental Health Perspectives. 2015 Oct;123:10:A254-59.

Human decisions then tend to be influenced by stimuli that are most salient in a given context and environment. Salient stimuli tend to be simple, novel, and accessible.[38] Previous research shows that changing the salience of healthy foods in a physical microenvironment led to positive eating behaviors.[89] A third bias is that priming, or the unconscious exposure to stimuli, influences our decisions and behaviors. In the realm of eating behavior, much of priming takes place via advertisements in physical microenvironments. These advertisements tend to be for food with low nutritional value. That said, it is possible for priming to take place via mechanisms other than advertising and to be used towards the end of promoting healthy eating. Furthermore, priming may be used in physical microenvironments to promote physical activity. Lastly, human decisions and behaviors are biased by affect. In addition to making cognitive evaluations when making a decision, individuals also make unconscious and automatic affective evaluations. These affective evaluations influence behavior in that individuals are more likely to engage in behaviors and select options that they associate with positive affect, and they are less likely to engage in behavior and select options that they associate with negative affect. Knowing this, physical microenvironments involved in eating and physical activity can be manipulated such that healthy eating and physical activity are associated with positive affect.

One key factor that influences automatic thought, particularly in the area of eating behavior, is the sensory stimuli found in a particular environment. Much research has shown that sensory stimulation regarding food can later influence behaviors. For example, both the sight[90] and smell[91] of food can affect food choice and eating behavior. This relationship, in part, is due to the fact that individuals make automatic associations between sight and smell with taste and satiating properties. Many restaurants and grocery stores manipulate their environments to take advantage of the fact that individuals think automatically through the use of visuals and smells associated with delicious foods.[92]

Thinking Socially

In addition to thinking automatically, people also think socially. In a similar way that thinking automatically results in people being influenced by the effects of defaults, salience, priming, and affect, thinking socially results in people being influenced by the effects of norms and ego. Traditional rational actor models assume that humans are selfish and inward looking. However, more recent research shows that humans are very attuned to their social environments and that these social environments influence their decisions and behaviors. Social norms are one way in which social environments influence decisions and behaviors. People are more likely to engage in behaviors and to make decisions that they perceive to be normative. As it pertains to physical microenvironments where eating behaviors and physical activity take place, interventions can take place that make healthy eating and physical activity appear normative. Ego is another aspect of thinking socially that influences behaviors and decisions. People fundamentally want to view themselves positively, and they automatically and unconsciously compare themselves with others. As a result, people are more likely to engage in behaviors that are in line with their positive self-image and that are associated with high status. Similar to how physical microenvironments can be designed to present healthy eating and physical activity as normative, they can also present these behaviors as socially desirable and positive.

Thinking with Mental Models

Beyond thinking automatically and socially, individuals also think with mental models.[93] According to the World Bank (2015), "mental models include categories, concepts, identities, prototypes, stereotypes, causal narratives, and worldviews." Mental models have a large influence on individuals' decisions and behaviors. Affect is one avenue that mental models may operate through. Individuals may have mental models about healthy eating and physical activity that directly relate to affect. For example, children may have mental models that healthy food is disgusting and that physical activity is boring. Should we be able to change these mental models to ones that associate more positive affect with healthy behaviors activity, we may increase the likelihood that children engage in these behaviors. One aspect of the power of mental models is that mental models influence how individuals perceive their environments. Mental models can change what individuals attend to in an environment. As such, mental models can affect the salience of certain aspects of an environment. It is possible, at least theoretically, that activating a healthy mental model may make certain aspects of an environment associated with healthy behaviors more salient to individuals. Mental models also operate through identities. We have already discussed how ego can influence behaviors and decisions. A key part of ego is identity, which is one of the strongest mental models that individuals have. Individuals often make decisions and engage in behaviors because they are consistent with their identity. Knowing that individuals think with mental models, and specifically through identities, we know that we can facilitate healthy behaviors through activation of certain identities.

Developmental Stages

Given that the focus of our effort is on improving children's health, we felt it important to discuss different developmental stages and how they can impact decisions and behaviors. For this section, we focus on Piaget's stages of cognitive development.[94] According to Piaget, children's cognitive capacities increase as they age through a stage processes. The first stage, sensorimotor, is from birth to two years old and is characterized by children experiencing the world through movement and the five senses.

TABLE 1: THE MINDSPACE FRAMEWORK FOR BEHAVIOR CHANGE

MESSENGER	We are heavily influenced by who communicates information
INCENTIVES	Our response to incentives are shaped by predictable mental shortcuts such as strongly avoiding losses
NORMS	We are strongly influenced by what others do
DEFAULTS	We "go with the flow" or pre-set options
SALIENCE	Our attention is drawn to what is novel and seems relevant to us
PRIMING	Our acts are often influenced by sub-conscious cues
AFFECT	Our emotional associations can powerfully shape our actions
COMMITMENTS	We seek to be consistent with our public promises, and reciprocate acts
EGO	We act in ways that make us feel better about ourselves

Source: Dolan P, Hallsworth M, Halpern D, et al. Influencing behaviour: The mindspace way. J Econ Psychol. 2012 Feb;33(1): 264-77.

The second stage, preoperational, is from two to seven years old and is characterized by children being able to form stable concepts and to engage with their environment through symbols. A key aspect to these first two stages is that children in these stages are egocentric. Children are no longer egocentric when they reach the third stage, concrete operational, which takes place between ages 7-11. During this stage, children develop logic. The final stage, formal operational, is when children gain abstract reasoning and takes place at 11 years old and older. Children may be more or less responsive to certain environmental manipulations and may be more or less influenced by certain behavioral principles as a function of their stage of development. For example, children who are in the first two stages and are thus egocentric, may be less responsive to social interventions.

D. Environmental Psychology

The environmental psychology field began in the 1960s, emerging from the work of social psychologists who recognized that the physical environment played a role in social phenomenon such as cooperation and competition, and the work of cognitive scientists interested in how environment affected cognitive processes.[95] A third impetus for the formation of the environmental psychology field was concern regarding environmental degradation[96] and a desire to understand and promote ecological or "pro-environment" behavior. Thus traditionally, environmental psychologists have focused on: (1) factors that encourage people to engage in ecological behaviors such as recycling and using public transportation,[97] and (2) understanding how the environment affects function, behavior, or well-being.

For example, environmental psychologists interested in how the environment affects humans explore topics such as environmental stressors including noise and crowding.[98] In recent years, the environmental psychology empirical findings and theoretical frameworks have been increasingly leveraged to affect public health.

In the past two decades, the public health field has recognized the limitations of education-only intervention strategies aimed at individuals and rather, has embraced multi-level, broad-brush interventions that employ environment and/or policy to promote healthy behaviors.[99,100] With this paradigm shift has come greater connection between public health and environmental psychology[101] and an opportunity to leverage environmental psychology concepts and theories to promote healthy eating and active living. A few core environmental psychology concepts and theories of potential relevance to behavioral design will be highlighted here.

Lessons from Sustainable Behavior

It may be possible to leverage lessons from strategies to promote pro-environmental behavior toward the promotion of active living. These lessons may be particularly appropriate when behaviors have dual positive outcomes: good for the environment and good for human health. For example, behaviors that save energy and increase human movement include using a clothesline rather than a gas or electric clothes dryer, taking the stairs instead of using an elevator, and using public transportation rather than driving a private vehicle.

Layout

Environmental psychologists have examined various aspects of the physical layout of interior spaces. While relatively little research has examined the implications of interior layout for healthy eating and active living, these topics are rife with opportunity, individually or collectively for obesity prevention and control purposes. Environmental psychology researchers have discovered that the configuration of seating arrangements profoundly influences social interaction. Sociopetal arrangements, characterized by moveable seating that can be configured for face-to-face interaction at comfortable interpersonal distances, promote social interaction. Sociofugal arrangements, which discourage social interaction, are typically inflexible shoulder-to-shoulder seating in rows, such as in a train station or church. Space syntax theory provides tools to exam the effects of spatial configuration on human behavior.[102] Among the concepts from space syntax is architectural depth, which refers to the number of spaces one must pass through to reach a given room. Research suggests that in crowded residential settings, architectural depth allows people greater control over social interaction and thereby dampens the impact of crowding on social withdrawal and psychological distress.[103] Another aspect of layout is floorplan openness. An open floorplan is one with few walls and is visually permeable, while a closed floorplan has walls and doors. Recent empirical research suggests that due to the greater visibility and convenience of food access, an open kitchen-dining room floorplan in the home environment (compared to a closed floorplan) directly affects the number of food trips made to the kitchen and indirectly affected the amount of food consumed.[104] Focusing mainly on convenience, behavioral economists have begun to examine the impact of some aspects of layout on children's dietary intake within a school lunchroom.[105]

Affordance

One of the key concepts in the field of environmental psychology is **affordance**. An affordance is a characteristic of the environment that signals how an object or environmental feature can be used.[106] By providing the user of a space with clues, an affordance can foster certain behaviors. Flat surfaces afford sitting, while knobs afford turning, for example. Affordances can therefore nudge building occupants. The notion of affordance can be contrasted with **environmental determinism**, which suggests that environments *cause* behavior.[95]

Behavior Setting

In the 1940s, Roger Barker proposed the notion of **behavior settings** as the unit of analysis to examine small-scale social systems within their natural, ecological context. Behavior settings can be examined in terms of the number of people and the number of roles they contain. A setting that is **overstaffed** (or "overmanned") has fewer roles than people, while a setting that is "**understaffed**" has more roles than people, leading, according to staff theory, to people feeling more needed and obligated to fill a role. The ratio of roles to occupants has implications for the social dynamics of the environment and the activities completed. Understaffed environments tend to encourage people to complete harder and more diverse tasks.

III. APPLICATION OF DESIGN STRATEGIES TO FOOD AND PHYSICAL ACTIVITY ENVIRONMENTS

This section provides an overview of the research on the application of behavioral design strategies to foster active living and healthy eating among children, teenagers, and their families, along with the communities in which they live, learn, work, and play.

A. Healthy Eating

While several sectors of society affect a child's eating and exercise behaviors, and health outcomes, research indicates that well-designed, well-implemented, school programs can effectively promote physical activity, healthy eating, and reductions in television viewing time.[107] In the United States, almost all (more than 95 percent) children and adolescents are enrolled in school.[108] American students also attend school for more than 13 years of their life and spend an average of 6.7 hours a day there during the school year. Research indicates the school's physical environment influences student behavior, attitudes, and academic achievement.[109] Studies have examined the role of seating position, classroom design, density, privacy, noise, the presence or absence of windows, and open space. Several facets make up the school food environment and a variety of factors influence the foods children are offered and, ultimately, eat at school.[110] Increasingly, researchers and practitioners are exploring the application of behavioral design principles to the school food environment,[111] especially within the USDA-sponsored National School Lunch Program that more than 30 million students participate in every school day.[112] The Pew Charitable Trust Kids' Safe and Healthful Foods Project assessed school kitchen equipment and infrastructure challenges across the United States and found that 88 percent of surveyed school districts needed at least one piece of kitchen equipment and 55 percent needed kitchen infrastructure changes such as electrical upgrades.[113]

A recent systematic review identified 102 studies reporting evidence regarding the influence of the school physical environment on healthy-eating outcomes.[114] Most of these studies (n=71; 70%) were from the United States. Using a causal loop diagram, this review determined that architecture and design helped create supportive, healthy-eating school environments and positively affected healthy-eating outcomes.

A range of influential physical factors emerged from the studies reviewed; specifically, serving style, water access, vending machines, on-site food production such as school gardens, and educational signage. The school physical environment review discussed how potential synergistic influences could potentially impact the role of physical space and design. In particular, the review noted how the adoption and use of healthy-eating programming and practices were critical, yet it acknowledged major implementation barriers such as competing priorities and inadequate resources.

To improve the schools' ability to adopt healthy nutrition curriculum and promote healthy eating using design principles, a recent NCCOR-sponsored tool was developed, known as Healthy Eating Design Guidelines for School Architecture.[115] Based on a pilot of this tool in a rural school district in Virginia, the guidelines helped remove physical barriers; nonetheless, unanticipated challenges emerged and school staff varied in their awareness and comfort with using the new healthy-eating features.[116] Often, the school-based interventions used multiple modifications to improve the intake of fruits and vegetables, while others have targeted low-fat milk and water. Some interventions simultaneously used behavioral design strategies to target improvements in physical activity. Several studies also rigorously evaluated specific strategies such as using attractive names for vegetables or serving sliced fruit. In conclusion, infrastructural changes are increasingly being explored in the school food environment and generally help promote healthy eating when complemented by nutrition education and promotion, along with changes in meal preparation practices and procurement strategies.

Efforts to promote healthy eating outside of the school food environment have examined a range of design strategies and have mainly targeted the following key eating settings: home, childcare centers, worksite, retail food outlets, and restaurants.[13,108] Special attention has generally been given to improving access to healthier foods and beverages among the most high-risk, underserved populations. To illustrate, an innovative social experiment conducted from 1994 to 1998 randomly assigned 4,498 women with children living in public housing in high-poverty, urban census tracts to one of three groups, namely to: (1) receive housing vouchers, which were redeemable only if they moved to a low-poverty census tract and had counseling on moving; (2) receive unrestricted, traditional vouchers, with no special counseling on moving; and (3) offered neither of these opportunities (control group).[117] From 2008 through 2010, various health outcomes were examined among participants, and results found that the opportunity to move from a neighborhood with a high-level poverty to one with a lower level of poverty was modestly associated with reductions in extreme obesity and type 2 diabetes. In the home, a recent randomized controlled trial with children aged 3-5 years participating in a home-based intervention tested the effects of a strategy that paired positive stimuli (i.e., stickers and cartoon packaging) with vegetables and presented them as a default snack and found significant effects on vegetable intake.[118] In childcare centers, interventions have not been as extensively explored in comparison to the school food environment. Nevertheless, evidence is emerging that shows the promise of applying behavioral design principles in this developmentally important setting. For instance, a recent study found building a garden at a childcare center was positively associated with the attending preschoolers' intake of fruits and vegetables.[119] While not a key sectorfor affecting healthy eating among children and adolescents, research in institutional food service settings have furthered or laid the foundation for the evidence base to inform the use of design strategies in school or childcare center food environments; specifically studies conducted in worksite,[120] military,[121] health care,[122] and university[123] settings.

Over the past decade, the application of design strategies to the retail food environment has been considered at the local, state, tribal, and national levels, particularly to address disparities in access to healthy foods[124] and with special attention on promoting healthy eating among participants in federal food and nutrition assistance programs.[125] Strategies have ranged from product labeling to point-of-purchase prompts, to zoning provisions supporting the development of community gardens and farmers' markets, to public-private partnerships incentivizing the building or renovating of grocery stores.[13,126] An in-store example used a randomized controlled trial to evaluate the effects of in-store marketing strategies to promote the purchase of specific healthier items in five product categories and found the intervention resulted in significantly greater sales of the skim and 1% milk, water, and two of the three types of frozen meals, compared with the control store sales during the same time period.[89] On the other hand, a recent study evaluating the introduction of a government-subsidized supermarket into an underserved, urban neighborhood did not find any significant changes in household food availability or children's dietary intake.[127] Indeed, healthy food store interventions have had mixed results on positively influencing eating behaviors and health outcomes.[128] A recent commentary recognized these mixed findings and acknowledged how addressing access is a critical ingredient, and went on to emphasize how initiatives to improve diet quality and, ultimately, health outcomes need to consider innovative approaches beyond just building a retail food outlet and must aim to build the infrastructure necessary within and around a retail food outlet to promote healthy eating.[129] Moreover, multidisciplinary evaluations are needed that examine the influence of these healthy retail interventions on increasing access to healthy foods and nutrition-related behaviors and health outcomes, as well as their impact on improving community and economic development.[130]

Recognizing that more Americans are eating food prepared away from the home,[131] behavioral design strategies have been applied to promote healthy eating in restaurants. A 2013 review examining the use of choice architecture on eating behavior reported that nutrition labeling at the point-of-purchase was associated with healthier food choices.[32] This review also identified other behavioral design strategies that are being used in self-service settings, such as manipulating the plate and payment options; however, the review determined the evidence base was too limited to understand how the strategies impact the selection and consumption of healthier food and beverage choices. Notwithstanding, studies conducted at this stage indicate how minor changes, such as varying the proximity of more and less healthier items or the serving utensils, can positively affect selection.[132] The majority of behavioral design-related research in restaurants centers on menu engineering.[133] Key menu positioning strategies include shifting attention and taste expectations towards healthier items by using descriptive words, placement, or formatting. Another approach is to increase the perception of value, for example, deemphasizing attention on the price of the entrees and placing the price at the end of an item description. Even among children, a recent study found menu modifications are associated with healthier ordering patterns without removing choice or reducing revenue.[134] Much work remains to understand the full potential of menus, along with other facets of restaurants including playgrounds, on promoting the selection and consumption of healthier foods and beverages.

B. Active Living

Besides healthy eating, researchers and practitioners are increasingly exploring the application of behavioral design principles in the school physical environment to foster active living and reduce sedentary behaviors.[135,136] Evidence demonstrates how the school physical environment can affect the amount and type of physical activity offered to schoolchildren during the school day.[135] More recent efforts have looked beyond physical education and recess, and explored how the school physical environment impacts the amount and type of active living that schoolchildren engage in before and after school via active transport to and from school[137] and joint use agreements.[138] Another recent strategy being explored is standing desks.[139] In 2015, a tool emerged for designers and decision makers, known as the Physical Activity Design Guidelines for School Architecture.[140] Using a qualitative review process, this tool put forth evidence-based and theory-driven, school design guidelines that promote increased physical activity among students categorized into the following 10 design domains: school siting and community connectivity; building massing and programming; smart fitness facilities; active classrooms; outdoor learning areas; active play and leisure areas; active navigation areas; signage and wayfinding; furniture specifications; and mobile technologies and virtual designed environments. Based on the relative strength of the literature identified, the review determined that six studies had strong evidence. Five of these six studies focused on school playground interventions and the remaining study examined school gardens. Other strategies deemed to have substantial supporting evidence included locating new schools and/or renovating schools, when possible, in higher density neighborhoods where students live close to school; factoring in safe walking/cycling and public transportation access in choosing school sites; providing multiple and varied outdoor fitness facilities; including an indoor gymnasium; designing indoor and outdoor physical activity facilities to accommodate use of both fixed and movable equipment; including both hard and soft surfaces, green or “natural” areas, and variations in sun and shade; renovating and/or building playground and break areas to include fixed play equipment with age-appropriate challenge and less structured space for use of portable equipment; and including signage with point-of-decision prompts for stair use and other physical activity opportunities. While it is informative in a space where little synthesized guidance was available, the authors of the Physical Activity Design Guidelines for School Architecture recognized the limited evidence base for the application of behavioral design principles in school settings on physical activity and discussed the need for further research.[141] However, this field is evolving rapidly, and a recent publication characterizes core principles and lays out design strategies across 10 areas of spatial and equipment requirements to address within schools.[140]

Similar to work conducted on school campuses, researchers and practitioners have focused extensively on the role of playgrounds—on and off school grounds—to foster active living and reduce childhood obesity.[142,143] In particular, efforts have examined inequalities in the geographic and social distribution of physical activity facilities.[144] Nevertheless, mixed results regarding the associations between the built environment and youth physical activity, sedentary behavior, and screen time call attention to the difficulty of disentangling causation in this space.[145] Moreover, evidence suggests physical/social environmental interventions of this type often need to be complemented by efforts to overcome real or perceived perceptions of crime and road safety.[146] Weather also affects the influence of urban design and the built environment on physical activity in children.[147] Beyond the school setting and playgrounds, a 2011 paper conducted a case study analysis of the seven current projects—representing academic, health care, residential, and workplace—that implemented the Leadership in Energy and Environmental Design (LEED) Innovation Credit for Health through Physical Activity, which put forth 30 strategies.[148] This review determined that stair design strategies were the most commonly used item regardless of building type.

The following 10 strategies were applied in all seven projects: providing accessibility to all floors via unlocked stairways; locating a stairway that is at minimum 25 feet off a main lobby and is visible from a principle path of travel; posting stair prompt signage at elevator call areas; providing enhanced lightening, finishes, and thermal comfort within the main circulation stair; and locating the project within a quarter mile of a walking trail or recreational space.

Aside from building focused projects, the application of behavioral design principles to foster active living has primarily been on promoting walking and walkable communities including improvements to public transit, especially considering disparities in access and opportunities for improvement among low-income, racial/ethnic minorities, and rural communities.[149] Indeed, the U.S. Surgeon General's recent call to action—known as *Step It Up!*—drew special attention to walking as the most common activity of both teens and adults and recognized the importance of access to spaces and places that make it safe and easy for all Americans to walk or wheelchair roll.[150] Specifically, the Surgeon General's report discussed how the design of communities and streets can help increase walking and improve walkability. To make these types of infrastructural improvements, *Step It Up!* started with the roles of transportation, land use, and community design, before addressing the roles of parks and recreational and fitness facilities, schools, colleges and universities, worksites, volunteer and nonprofit organizations, health care, media, and public health. Moreover, a recent systematic review determined that physical activity-related interventions using policy and environmental changes resulted in stronger effects on physical activity or BMI when the intervention involved improvements to active transportation infrastructure.[151] As one example, studies in Salt Lake City, Utah demonstrated how public transit use directly generated new physical activity among riders and did not reduce from other physical activity.[152] New riders also lost ($P<.05$) and former riders gained ($P<.01$) weight.[50] A recent cross-sectional study conducted by the International Physical Activity and Environment Network gathered data from 6,822 adults aged 18-66 years from 14 cities in 10 countries on five continents and found net residential density, intersection density, public transport density, and number of parks were significantly, positively, and linearly related to physical activity. The similarity of findings across diverse cities illustrate the potential that engaging urban planning, transportation, and park sectors could have in efforts to increase physical activity.[153]

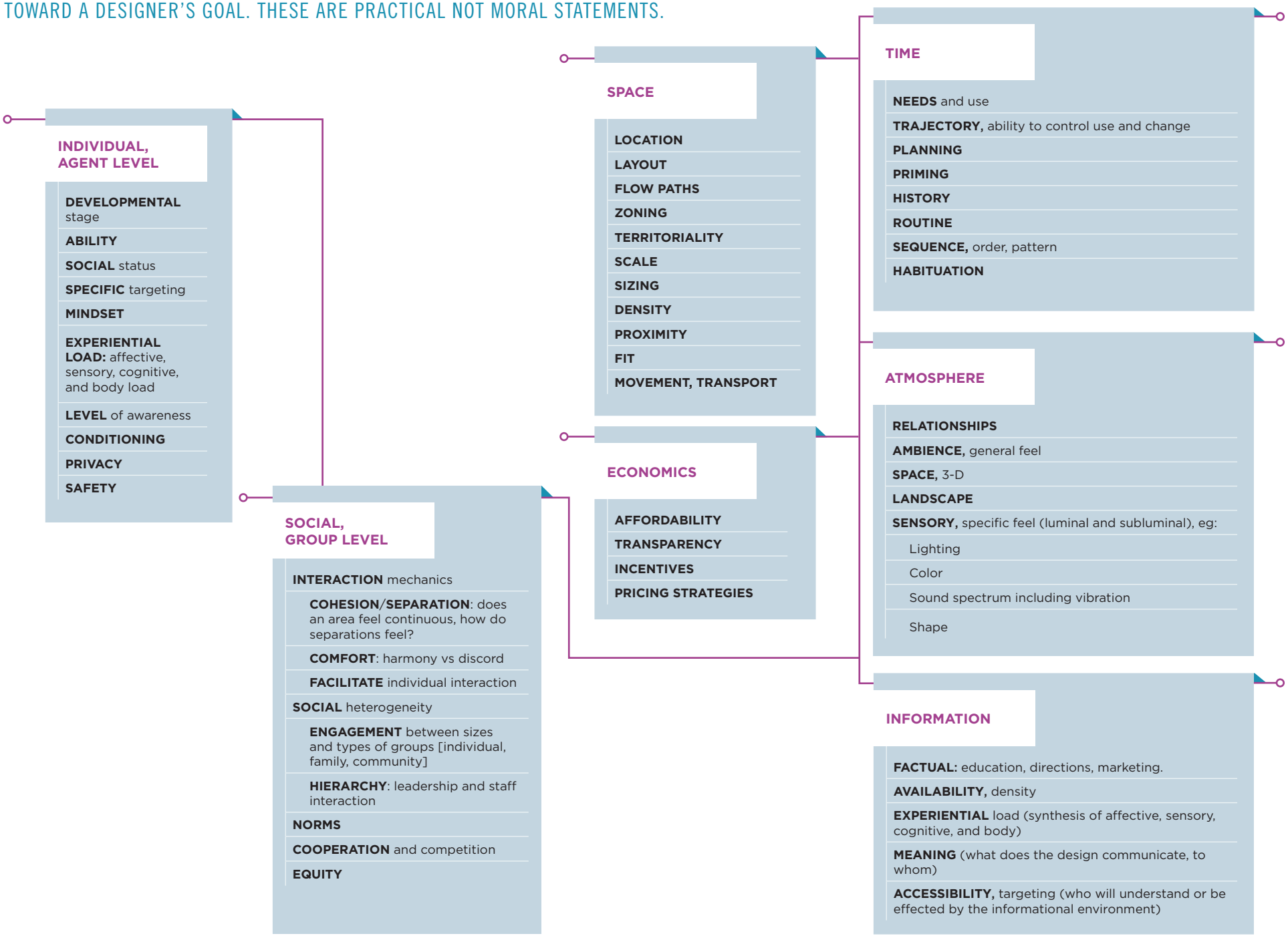
IV. CONCLUSIONS

Behavioral design strategies have been applied and evaluated in a variety of settings and have the potential to influence eating and exercise behaviors among children and adolescents. As research and practice evolves, a better sense of which strategy or, more likely, which combination of strategies, has the greatest potential to positively impact active living and healthy eating among youth. In addition, multidisciplinary approaches and evaluation could potentially facilitate a better understanding of the effectiveness of using behavioral design in targeted settings to reduce childhood obesity. The use of case studies will be instrumental to help elucidate the details from development to implementation to evaluation to translation and dissemination. Equally important, periodic reviews and meta-analyses may help identify the most promising strategies, relevant rigorous methodologic designs for addressing different types of questions, and future research needs and opportunities.

While a detailed summary of the many behavioral design approaches and strategies is beyond the scope of this current effort, we have attempted to capture aspects to consider when evaluating or intervening in the behavioral design process (*See Figure 4*).

One goal of the development of this white paper is to provide an overview of the core concepts in behavioral design and examine how they have been applied to changing the design and the built environment. We hope that this effort will allow researchers and practitioners to consider it critically in their work and use it for research and practice. In addition, NCCOR has developed a web-based listing of current tools and resources on the NCCOR website that are available to researchers and practitioners. We are also beginning a process of engaging with other disciplinary fields and taking feedback from external experts, along with NCCOR meeting participants, to understand how these issues are being addressed in their fields and to guide future directions.

FIGURE 4: ASPECT USE VARIES DEPENDING ON DESIRED OUTCOME, THESE ASPECTS ARE NOT REQUIREMENTS TOWARD AN AIM BUT CONSIDERATIONS TOWARD A DESIGNER'S GOAL. THESE ARE PRACTICAL NOT MORAL STATEMENTS.



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GLOSSARY

AFFECTIVE, COGNITIVE, AND CONATIVE STATES	The three states of the mind. **Affective state** refers to feelings and emotions. **Cognitive state** refers to one's thought process or mindset. **Conative state** refers to natural tendency, impulse, striving, or directed effort.
AGENT AND ENVIRONMENT INTERFACE	Interconnection, communication, or interaction between an agent (individual or group of people) and their environment (i.e., external stimuli).
BEHAVIORAL DESIGN	Integration of evidence and strategy from numerous academic and trade disciplines, such as architecture, behavioral psychology, community planning, economics, environmental design, and public health, to create experiences where the norms are healthier and healthier behaviors are easy or more likely. At its core, behavioral design seeks to consider not only the agent(s) and the environments in which they live, work, and play, but also the "experience" or "meaning" created by their interaction.
BUILT ENVIRONMENT	The man-made surroundings that provide the setting for human activity, ranging from buildings and parks to routes of transit and communities. A social science term, built environment has been defined as "the humanitarian-made space in which people live, work, and recreate on a day-to-day basis."
CHOICE ARCHITECTURE	The design of different ways in which choices can be presented to consumers and the impact of that presentation on consumer decision-making.
COGNITIVE LOAD	Total amount of mental effort being used in the working memory.
COMPLEX AND MULTIMODAL SYSTEMS	Nonlinear, stochastic (or randomly determined) systems with multiple potential centers depending on perspective, interest, or intervention.
DOMAIN-LEVEL APPROACH	Incorporation of the base areas of human experience into the examination or development of a concept.
EGO DEPLETION	The idea that self-control or willpower draws on a limited pool of mental resources that can be used up. When the energy for mental activity is low, self-control is typically impaired, which would be considered a state of ego depletion.
NATURAL ENVIRONMENT	All living and non-living things occurring naturally. The term is most often applied to the Earth or some part of Earth.

REFERENCES

1. Wing RR, Hill JO. Successful weight loss maintenance. Annual review of nutrition. 2001;21(1):323-41.
2. Institute of Medicine. Committee on Prevention of Obesity in Children and Youth. Preventing childhood obesity: health in the balance. Washington (DC): National Academies Press (US); 2001.
3. Feng J, Glass TA, Curriero FC, et al. The built environment and obesity: a systematic review of the epidemiologic evidence. Health Place. 2010;16(2):175-90.
4. Woodman J, Lorenc T, Harden A, et al. Social and environmental interventions to reduce childhood obesity: a systematic map of reviews. Social Science Research Unit; London (UK); 2008 EPPI-Centre report no. 1610.
5. Cauchi D, Glonti K, Petticrew M, et al. Environmental components of childhood obesity prevention interventions: an overview of systematic reviews. Obes Rev. 2016;17(11):1116-30.
6. Zhou YE, Emerson JS, Levine RS, et al. Childhood obesity prevention interventions in childcare settings: systematic review of randomized and nonrandomized controlled trials. Am J Health Promot. 2014;28(4):e92-103.
7. Goldberg S, Rabinowitz J, Gross R. School-based obesity prevention programs: a meta-analysis of randomized controlled trials. Obesity (Silver Spring). 2013;21(12):2422-8.
8. Lessard L, Breck A. Childhood obesity prevention in childcare settings: the potential of policy and environmental change interventions. Curr Obes Rep. 2015;4(2):191-7.
9. Adam A, Jensen JD. What is the effectiveness of obesity related interventions at retail grocery stores and supermarkets? -a systematic review. BMC Public Health. 2016;16(1):1247.
10. Lancaster KJ, Carter-Edwards L, Grilo S, et al. Obesity interventions in African American faith-based organizations: a systematic review. Obes Rev. 2014;15 Suppl 4:159-76.
11. Hillier-Brown FC, Summerbell CD, Moore HJ, et al. The impact of interventions to promote healthier ready-to-eat meals (to eat in, to take away or to be delivered) sold by specific food outlets open to the general public: a systematic review. Obes Rev. 2017;18(2):227-46.
12. Marteau TM, Ogilvie D, Roland M, et al. Judging nudging: can nudging improve population health? BMJ. 2011;342:d228.
13. Bowen DJ, Barrington WE, Beresford SA. Identifying the effects of environmental and policy change interventions on healthy eating. Annu Rev Public Health. 2015;36:289-306.
14. Swinburn BA, Sacks G, Hall KD, et al. The global obesity pandemic: shaped by global drivers and local environments. Lancet. 2011;378(9793):804-14.
15. Schölmerich VLN, Kawachi I. Translating the socio-ecological perspective into multilevel interventions: gaps between theory and practice. Health Education & Behavior. 2016;43(1):17-20.
16. Trowbridge MJ, Huang TT, Botchwey ND, et al. Public health and the green building industry. Am J Prev Med. 2013 May; 44(5):489-95.
17. Bronfenbrenner U. Toward an experimental ecology of human development. American Psychologist. 1977; 32: 513-31.
18. Kersell MW, Milsum JH. A systems model of health behavior change. Behavioral Science. 1985; 30(3):119-26.
19. McLeroy KR, et al. An ecological perspective on health promotion programs. Health education quarterly 1988;15(4): 351-77.
20. Cockrell Skinner A, Foster EM. Systems science and childhood obesity: a systematic review and new directions. J Obes. 2013;2013:129193.

21. Vandenbroeck IP, Goossens J, Clemens M. Foresight tackling obesities: Future choices—building the obesity system map. Government Office for Science, UK Government's Foresight Programme. 2007; retrieved on January 13, 2016 from https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/295154/07-1179-obesity-building-system-map.pdf.
22. Skinner BF. The behavior of organisms: an experimental analysis. Oxford, England: Appleton-Century; 1938.
23. Bandura A. Social foundations of thought and action. Englewood Cliffs, NJ: Prentice Hall; 1986.
24. Ajzen I. The theory of planned behavior. Organizational behavior and human decision processes. 1991;50(2): 179–211.
25. Prochaska JO, Redding CA, Evers K. The transtheoretical model and stages of change. In Glanz K, Rimer BK, Lewis FM, editors. Health behavior and health education: theory, research, and practice. 3rd edition. San Francisco, CA: Jossey-Bass, Inc.; 2002.
26. Schwarzer R. Self-efficacy in the adoption and maintenance of health behaviors: theoretical approaches and a new model. In Schwarzer R, editor. Self-efficacy: thought control of action. Washington, DC: Hemisphere; 1992. p. 217–43.
27. Sallis J, Glanz K. Physical activity and food environments: solutions to the obesity epidemic. The Milbank Quarterly. 2009;87(1):123–54.
28. Stokols D. Translating social ecological theory into guidelines for community health promotion. Am J Health Promot. 1996; 10(4):282-98.
29. Kahneman D. A perspective on judgment and choice: mapping bounded rationality. Am Psychol. 2003;58(9):697-720.
30. Arno A, Thomas S. The efficacy of nudge theory strategies in influencing adult dietary behaviour: a systematic review and meta-analysis. BMC Public Health. 2016;16:676.
31. Hollands GJ, Shemilt I, Marteau TM, et al. Altering micro-environments to change population health behaviour: towards an evidence base for choice architecture interventions. BMC Public Health. 2013;13:1218.
32. Skov LR, Lourenco S, Hansen GL, et al. Choice architecture as a means to change eating behavior in self-service settings. A systematic review. Obes Res. 2013;14:187-96.
33. Datta S, Mullainathan S. Behavioral design: a new approach to development policy. CGD Policy Paper 016. Center for Global Development. Washington, DC. Available at: http://www.cgdev.org/content/publications/detail/1426679; 2012.
34. Alexander C. The phenomenon of life: the nature of order: an essay on the art of building and the nature of the universe. Berkeley: CES Publishing; 2003.
35. Alexander C. The timeless way of building. New York: Oxford University Press; 1979.
36. Kopec D. Environmental psychology for design. 2nd edition. Canada: Fairchild Books; 2012.
37. Exec. Order No. 13707, 3 C.F.R. 56365; 2015.
38. Dolan P, Hallsworth M, Halpern D, et al. Influencing behaviour: the mindspace way. J Econ Psychol. 2012 Feb;33(1): 264-77.
39. The Behavioural Insights Team. Update Report 2015-16; 2016. Available at: http://38r8om2xjhhl25mw24492dir.wpengine.netdna-cdn.com/wp-content/uploads/2016/09/BIT_Update_Report_2015-16-.pdf.
40. Lourenço JS, Ciriolo E, Almeida SR, et al. Behavioural insights applied to policy: European Report 2016. EUR 27726 EN.
41. NSW Department of Premier and Cabinet — Behavioural Insights Unit. Understanding people, better outcomes; 2014. Available from http://bi.dpc.nsw.gov.au/library/.
42. Baumeister RF, Bratslavsky E, Muraven M, et al. Ego depletion: is the active self a limited resource? J Pers Soc Psychol. 1998;74(5):1252-65.
43. Weir, K. What you need to know about willpower: the psychological science of self-control. American Psychological Association; 2012. Available at: http://www.apa.org/helpcenter/willpower.pdf.

44. Project for Public Spaces. The case for healthy places: improving health outcomes through placemaking. Project for Public Spaces; 2016. Available at: https://www.pps.org/wp-content/uploads/2016/12/Healthy-Places-PPS.pdf.

45. Hagger MS, Wood C, Stiff C, et al. Ego depletion and the strength model of self-control: a meta-analysis. Psychol Bull. 2010;136(4):495-525.

46. Morsella E, Poehlman TA. The inevitable contrast: conscious vs. unconscious processes in action control. Front Psychol. 2013;4:590.

47. Muraven M, Baumeister RF. Self-regulation and depletion of limited resources: does self-control resemble a muscle? Psychol Bull. 2000;126(2): 247-59.

48. Baumeister RF, Masicampo EJ, Vohs KD. Do conscious thoughts cause behavior? Annu Rev Psychol. 2011; 62:331-61.

49. Shah AK, Shafir E, Mullainathan S. Scarcity frames value. Psychological Science 2015;26(4):204-12.

50. Brown B, Rutherford P, Crawford P. The role of noise in clinical environments with particular reference to mental health care: a narrative review. Int J Nurs Stud. 2015;52(9):1514-24.

51. Stansfeld SA, Matheson MP. Noise pollution: non-auditory effects on health. Br Med Bull. 2003;68:243-57.

52. Mehta R, Zhu R, Cheema A. Is noise always bad? Exploring the effects of ambient noise on creative cognition. Journal of Consumer Research. 2012;39(4):784-99.

53. Mehta R, Zhu RJ. Blue or red? Exploring the effect of color on cognitive task performances. Science. 2009;323(5918):1226-9.

54. Genschow O, Reutner L, Wänke M. The color red reduces snack food and soft drink intake. Appetite. 2012;58(2):699-702.

55. Meyers-Levy J, Zhu R. The influence of ceiling height: the effect of priming on type of processing that people use. J Consum Res. 2007;34(2):174-86.

56. Cohen DA, Babey SH. Contextual influences on eating behaviors: heuristic processing and dietary choices. Obes Rev. 2012 May;13(9):766-79.

57. Barry CL, Niederdeppe J, Gollust SE. Taxes on sugar-sweetened beverages: results from a 2011 national public opinion survey. American Journal of Preventive Medicine 2013;44 (2):158–63.

58. Lockton D. Introduction to the design with intent toolkit | design with intent. Design with Intent; 2016. Accessed November 11. http://designwithintent.co.uk/introduction-to-the-design-with-intent-toolkit/.

59. Conly S. Against autonomy: justifying coercive paternalism. Cambridge: Cambridge University Press; 2013. p. 29–32.

60. Waldron J. It's all for your own good. The New York Review of Books; 2014 Oct.

61. Sunstein CR. Making government logical. The New York Times. 2015 Sept 19. http://www.nytimes.com/2015/09/20/opinion/sunday/cass-sunstein-making-government-logicalhtml.html.

62. Eyal N. Nudging and benign manipulation for health. In Cohen IG, Fernandez Lynch H, editors. Nudging health: health law and behavioral economics. JHU Press; 2016. p. 83–96.

63. Noggle R. Manipulative actions: a conceptual and moral analysis. American Philosophical Quarterly 1996;33(1): 43–55.

64. Barnhill A. What is manipulation? In Coons C, Weber M, editors. Manipulation: theory and practice. Oxford; New York: Oxford University Press; 2014. p. 51–72.

65. Thaler RH, Sunstein CR. Nudge: improving decisions about health, wealth, and happiness. New Haven: Yale Univ. Press; 2008.

66. Kahneman D. Thinking, fast and slow. 1st edition. New York: Farrar, Straus and Giroux; 2011.

67. Sunstein CR. Why nudge?: the politics of libertarian paternalism. New Haven: Yale Univ. Press; 2014.

68. Resnik D. Trans fat bans and human freedom. The American Journal of Bioethics 2010;10(3):27–32.

69. Noe A. The value in sweet drinks. NPR.org; 2013. Accessed August 1. http://www.npr.org/blogs/13.7/2012/09/24/161277720/the-value-in-sweet-drinks.

70. Barnhill A, King KF, Kass N, Faden R. The value of unhealthy eating and the ethics of healthy eating policies. Kennedy Institute of Ethics Journal 2014;24(3):187–217.

71. Feinberg J. Harm to self. New York: Oxford University Press; 1986.

72. Bayer R. The continuing tensions between individual rights and public health. Talking point on public health versus civil liberties. EMBO Reports; 2007;8(12):1099–103.

73. Gostin LO, Gostin KG. A broader liberty: J.S. Mill, paternalism and the public's health. Public Health 2009;123(3):214–21.

74. Verweij M. Infectious disease control. In Dawson A, editor. Public health ethics. Cambridge and New York: Cambridge University Press; 2011. p. 100–17.

75. Lieberman DE. Is exercise really medicine? An evolutionary perspective. Curr Sports Med Rep. 2015;14(4):313-19.

76. Cohen DA, Sturm R, Han B, et al. Quantifying the contribution of public parks to physical activity and health: introducing SOPARC. Santa Monica, CA: RAND Corporation, 2014. http://www.rand.org/pubs/research_reports/RR774.html.

77. NatureGrounds: Creating and retrofitting play environments: best practice guidelines. PlayCore, Inc. & Natural Learning Initiative, College of Design, NC State University, 2009.

78. Pathways for play: best practice guidelines. PlayCore, Inc. & Natural Learning Initiative, College of Design, NC State University, 2010.

79. Blair D. The child in the garden: an evaluative review of the benefits of school gardening. J Environ Educ. 2009; 40(2):15-38.

80. Wells NM, Myers BM, Henderson CR. School gardens & physical activity: a randomized controlled trial of low-income elementary schools. Preventive Medicine. 2014;69S, S27-S33.

81. Becker MH. The health belief model and personal health behavior. Slack. 1974;2(4).

82. Ajzen I, Fishbein M. Understanding attitudes and predicting social behavior. Englewood Cliffs, NJ: Prentice-Hall; 1980.

83. Ajzen I, Madden TJ. Prediction of goal-directed behavior: attitudes, intentions and perceived behavioral control. J Exp Soc Psychol. 1986 Sept;22(5):453–74.

84. World Health Organization (WHO). Behaviour change strategies and health: the role of health systems. WHO: Tbilisi, Georgia; 2008.

85. Sheeran P. Intention-behaviour relations: a conceptual and empirical review. Eur Rev Soc Psychol. 2002;12:1–36.

86. Webb T, Sheeran P. Does changing behavioral intentions engender behavior change? A meta-analysis of the experimental evidence. Psychol Bull. 2006 Mar; 132(2):249–68.

87. Swinburn B, Egger G, Raza F. Dissecting obesogenic environments: the development and application of a framework for identifying and prioritizing environmental interventions for obesity. Prev Med. 1999 Dec;29(6): 563–70.

88. Kahneman D, Thaler R. Anomalies: utility maximisation and experienced utility. J Econ Perspect. 2006;20(1): 221–34.

89. Foster GD, Karypn A, Wojtanowski AC, et al. Placement and promotion of strategies to increase sales of healthier products in supermarkets in low-income, ethnically diverse neighborhoods: a randomized controlled trial. Am J Clin Nutr. 2014;99:1359-68.

90. Wansink B. Environmental factors that increase the food intake and consumption volume of unknowing consumers. Annu. Rev. Nutr. 2004;24:455-79.

91. Ferriday D, Brunstrom JM. "I just can't help myself": effects of food-cue exposure in overweight and lean individuals. Int J Obes. 2011;35(1):142-49.

92. McCrickerd K, Forde CG. Sensory influences on food intake control: moving beyond palatability. Obes Rev. 2016;17(1):18-29.

93. World Bank. World development report 2015: mind, society, and behavior. Washington, DC: World Bank; 2015.

94. Piaget J, Cook M. The origins of intelligence in children. New York, NY: W W Norton & Co.; 1952.

95. Wells NM, Evans, GW, Aldred Cheek KL. Environmental psychology. In Frumkin H, editor. Environmental health: from global to local. Hoboken (NJ): John Wiley & Sons; 2016.

96. Carson R. Silent spring. Boston: Houghton Mifflin; 1962.

97. De Young R. New ways to promote proenvironmental behavior: expanding and evaluating motives for environmentally responsible behavior. Journal of Social Issues. 2000;56(3):509–26.

98. Evans GW. Environmental stress. CUP Archive; 1984.

99. Sallis JF, Bauman A, Pratt M. Environmental and policy interventions to promote physical activity. American Journal of Public Health. 1998;15(4):379.

100. Story M, Kaphingst KM, Robinson-O'Brien R, et al. Creating healthy food and eating environments: policy and environmental approaches. Annu Rev Public Health. 2008;29:253-72.

101. Wells NM, Evans GW, Yang Y. Environments and health: planning decisions as public health decisions. Journal of Architectural and Planning Research. 2010;27(2):124–43.

102. Hillier B. Space is the machine: a configurational theory of architecture. London, UK: Space Syntax. 2007.

103. Evans GW, Lepore SJ, Schroeder A. The role of interior design elements in human responses to crowding. Journal of Personality and Social Psychology. 1996;70(1):41.

104. Rollings KR, Wells NM. Effects of residential kitchen floor plan openness on eating behaviors. Environment & Behavior; in press.

105. Hanks A S, Just DR, Smith LE, et al. Healthy convenience: nudging students toward healthier choices in the lunchroom. Journal of Public Health. 2012;fds003:1–7.

106. Gifford R. Environmental psychology: principles and practice. 5th edition. Colville (WA): Optimal Books; 2014.

107. Wechsler H, McKenna ML, Lee SM, et al. The role of schools in preventing childhood obesity. The State Education Standard. 2004. Available at: http://www.cdc.gov/healthyyouth/physicalactivity/pdf/roleofschools_obesity.pdf.

108. Story M, Kaphingst KM, French S. The role of schools in obesity prevention. The Future of Children. 2006;16(1):109-42.

109. Weinstein, CS. The physical environment of the school: a review of the research. Rev Educational Res. 1979;49(4):577-610.

110. Johnson DB, Podrabsky M, Rocha A, et al. Effect of the healthy hunger-free kids act on the nutritional quality of meals selected by students and school lunch participation rates. JAMA Pediatr. 2016;170(1):e153918.

111. Gorman N, Lackney JA, Rollings K, et al. Designer schools: the role of school space and architecture in obesity prevention. Obesity (Silver Spring). 2007;15(11):2521-30.

112. Mancino L, Guthrie J. When nudging in the lunch line might be a good thing. USDA Economic Research Service. Amber Waves. 2009;7(1). Available at: http://smarterlunchrooms.org/sites/default/files/mancino_guthrie_2009_when_nudging_in_the_lunchline_might_be_a_good_thing.pdf.

113. The Pew Charitable Trusts Kids' Safe and Healthful Foods Project. States need updated school kitchen equipment. Released March 26, 2014. Available at: http://www.pewtrusts.org/en/research-and-analysis/reports/2014/03/26/states-need-updated-school-kitchen-equipment-b.

114. Frerichs L, Brittin J, Sorensen D, et al. Influence of school architecture and design on healthy eating: a review of the literature. Am J Public Health. 2015;105(4):e46-57.

115. Huang TT, Sorensen D, Davis S, et al. Healthy eating design guidelines for school architecture. Prev Chronic Dis. 2013;10:E27.

116. Frerichs L, Brittin J, Intobubbe-Chmil L, et al. The role of school design in shaping healthy eating-related attitudes, practices, and behaviors among school staff. J Sch Health. 2016;86(1):11-22.

117. Ludwig J, Sanbonmatsu L, Gennetian L, et al. Neighborhoods, obesity, and diabetes—a randomized social experiment. N Engl J Med. 2011;365(16):1509-19.

118. Cravener TL, Schlecher 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(11):1798-1807.

119. Namenek Brouwer RJ, Neelon SE B. Watch me grow: a garden-based pilot intervention to increase vegetable and fruit intake in preschoolers. BMC Public Health. 2013;13:363.

120. Hipp JA, Reeds DN, Van Bakergem MA, et al. Review of measures of worksite environmental and policy supports for physical activity and healthy eating. Prev Chron Dis. 2015;12:140410.

121. Arsenault JE, Singleton MC, Funderburk LK. Use of the go-for-green nutrition labeling system in military dining facilities is associated with lower fat intake. J Acad Nutr Diet. 2014;114:1067-71.

122. Thorndike AN, Riis J, Sonnenberg LM, et al. Traffic-light labels and choice architecture: promoting healthy food choices. Am J Prev Med. 2014;46(2):143-49.

123. Cioffi CE, Levitsky DA, Pacanowski CR, et al. A nudge in a healthy direction. The effect of nutrition labels on food purchasing behaviors in university dining facilities. Appetite. 2015;92:7-14.

124. Larson NI, Story MT, Nelson MC. Neighborhood environments: disparities in access to healthy foods in the U.S. Am J Prev Med. 2009;36(1):74-81.

125. Just DR, Mancino L, Wansink B. Could behavioral economics help improve diet quality for nutrition assistance program participants? US Department of Agriculture Economic Research Service; 2007 June; Economic Research Report Number 43. Available at: http://www.ers.usda.gov/media/196728/err43_1_.pdf.

126. Glanz K, Bader MDM, Iyer S. Retail grocery store marketing strategies and obesity: an integrative review. Am J Prev Med. 2012;42(5):503-12.

127. Elbel B, Moran A, Dixon LB, et al. Assessment of a government-subsidized supermarket in a high-need area on household food availability and children's dietary intakes. Public Health Nutr. 2015;18(15):2881-90.

128. Williams J, Scarborough P, Matthews A, et al. A systematic review of the influence of the retail food environment around schools on obesity-related outcomes. Obes Rev. 2014;15(5):359-74.

129. Block JP, Subramanian SV. Moving beyond "food deserts": reorienting United States policies to reduce disparities in diet quality. PLoS Med. 2015;12(12):e1001914.

130. Fleischhacker SE, Flournoy R, Moore LV. Meaningful, measurable, and manageable approaches to evaluating healthy food financing initiatives: an overview of resources and approaches. J Public Health Manag Pract. 2013;19(6):541-49.

131. Yen S, Lin B, Davis C. Consumer knowledge and meat consumption at home and away from home. Food Policy. 2008;33(6):631-39.

132. Rozin P, Scott S, Dingley M, et al. Nudge to nobesity I: minor changes in accessibility decrease food intake. Judgement Decision Making. 2011;6(4):323-32.

133. Wansink B, Love K. Slim by design: menu strategies for promoting high-margin, healthy foods. Int J Hospitality Management. 2014;42:137-43.

134. Anzman-Frasca S, Mueller MP, Sliwa S, et al. Changes in children's meal orders following healthy menu modifications at a regional US restaurant chain. Obesity. 2015;23:1055-62.

135. Nettlefold L, McKay HA, Warburton DE, et al. The challenge of low physical activity during the school day: at recess, lunch and physical education. Br J Sports Med. 2011;45(10):13-19.

136. Sallis JF, McKenzie TL, Conway TL, et al. Environmental interventions for eating and physical activity: a randomized controlled trial in middle schools. Am J Prev Med. 2003;24(3):209-17.

137. Eyler AA, Brownson RC, Doescher MP, et al. Policies related to active transport to and from school: a multisite case study. Health Educ Res. 2008;23(6):963-75.

138. Everett Jones S, Wendel AM. Characteristics of joint use agreements in school districts in the United States: findings from the school health policies and practices study, 2012. Prev Chronic Dis. 2015;12:E50.

139. Minges KE, Chao AM, Irwin ML, et al. Classroom standing desks and sedentary behavior: a systematic review. Pediatrics. 2016;Jan22. pii: peds.2015-3087.

140. Brittin J, Sorensen D, Trowbridge M, et al. Physical activity design guidelines for school architecture. PLoS One. 2015;10(7):e0135297.

141. Toftager M, Christiansen LB, Ersboll AK, et al. Intervention effects on adolescent physical activity in the multicomponent SPACE study: a cluster randomized controlled trial. PLoS ONE. 2014;9(6):e99369.

142. Burdette HL, Whitaker RC. Neighborhood playgrounds, fast food restaurants, and crime: relationships to overweight in low-income preschool children. Prev Med. 2004;38(1):57-63.

143. Roemmich JN, Epstein LH, Raja S, et al. Association of access to parks and recreational facilities with the physical activity of young children. Prev Med. 2006;43(6):437-41.

144. Gordon-Larsen P, Nelson MC, Page P, et al. Inequality in the built environment underlines key health disparities in physical activity and obesity. Pediatrics. 2006;117(2):417-24.

145. McDonald K, Hearst M, Farbakhsh K, et al. Adolescent physical activity and the built environment: a latent class analysis approach. Health Place. 2012;18(2):191-98.

146. Carver A, Timperio A, Crawford D. Playing it safe: the influence of neighborhood safety on children's physical activity. A review. Health Place. 2008;14(2):217-27.

147. Katapally TR, Rainham D, Muhajarine N. Factoring in weather variation to capture the influence of urban design and built environment on globally recommended levels of moderate to vigorous physical activity in children. BMJ Open. 2015;5(11): e009045.

148. Agarwal R, Roseblum R, Riehm J, et al. Active design and LEED: Early use and analysis of the innovation credit for health. United States Green Building Council. 2011 October 3. Available at: http://www.usgbc.org/resources/active-design-and-leed-early-use-and-analysis-innovation-credit-health.

149. Sandy R, Tchernis R, Wilson J, et al. Effects of the built environment on childhood obesity: the case of urban recreational trails and crime. Econ Hum Biol. 2013;11(1):18-29.

150. U.S. Department of Health and Human Services. Step it up! The surgeon general's call to action to promote walking and walkable communities. Washington, DC: U.S. Department of Health and Human Services, Office of the Surgeon General; 2015.

151. Mayne SL, Auchincoloss AH, Michael YL. Impact of policy and built environment changes on obesity-related outcomes: a systematic review of naturally occurring experiments. Obes Rev. 2015;16(5):362-75.

152. Miller HJ, Tribby CP, Brown BB, et al. Public transit generates new physical activity: evidence from individual GPS and accelerometer data before and after light rail construction in a neighborhood of Salt Lake City, Utah, USA. Health Place. 2015;36:8-17.

153. Sallis JF, Cerin E, Conway TL, et al. Physical activity in relation to urban environments in 14 cities worldwide: a cross-sectional study. The Lancet. 2016 Jun 3;387(10034):2207-17.