

Doctoral Thesis



UNIVERSITY OF TRENTO

Doctoral School of Social Sciences

BEHAVIORAL ECONOMICS AND HEALTH

Nudging for our own good

A dissertation submitted to the Doctoral School of Social Sciences in partial fulfillment of the requirements of the DOCTOR OF PHILOSOPHY (Ph.D.) degree in Economics and Management

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October 2018

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ABSTRACT

Each of us is made up of the decisions that we make. The rich tapestry of our lives is constructed from the hundreds of thousands of decisions that have led us to this very moment. If each of us were endowed with perfect rationality, our optimal decision-making qualities might lead us down similar paths. But here we are, instead each of us on unique and sometime bumpy rides accentuated by our perfectly irrational choices.

The goal of my research is to make sense of our faulty decision making in areas related to personal health by applying insights from the field of behavioral economics. I am not the only one searching for answers. It's an exciting time to be a behavioral economist in light of the relatively recent birth of the subfield, as a splinter off of the traditional economics cutting block. It is a moment of prolific research in a thriving field of economists seeking to understand how exactly we err in the decision-making process, and what precisely can be done to help us err less.

The timing could not be better for addressing poor decision-making in the health field. Behavioral factors play a starring role in today's burgeoning health crises, considering that smoking and tobacco use, lack of physical activity, poor eating habits, excessive alcohol use, and medical treatment noncompliance contribute to many of today's most prevalent health problems.

In this doctoral thesis, I consider first and foremost the foundations of behavioral economics and its arrival from notions of bounded rationality and Prospect Theory, and what tools it offers to address pressing health issues. In the first chapter, I also consider the innovations in applications of behavioral economics to the most persistent health issues. In the following chapters, I offer new research (performed in collaboration with my coauthors) that applies concepts of behavioral economics to enhance decision making in two contexts. The role of information provision and quality is considered in light of parental decision making in the setting of childhood vaccines. Then I present the results of HealthyMe, an intensive collaborative effort involving experimental testing of an intervention to encourage active travel by foot and on bicycle using participants' cellphone to both record active travel and deliver nudge and feedback messages through a specially developed cellphone app.

Keywords: Behavioral Economics; Active Travel; Nudge; Physical Activity; Vaccination; Anti-Vaxxer; Vaccination Hesitancy;

DEDICATION

To Mom and Dad, who have given me unconditional love and support for as long as I can remember, and

To Gino and Giorgio, who are really truly the coolest kids I know and my luck charms in this life

ACKNOWLEDGEMENTS

Just to show you that I come by all this honestly, I should start by mentioning that my father, having already been bestowed by three universities the initials of B.S., J.D., and M.B.A. to place after his name, began a Ph.D. program in his mid-thirties. I am not sure why he chose to pursue another degree while working full-time as an associate dean at the University of Wisconsin, or why my mom agreed that Dad start the long and arduous doctoral process at a time when they were in parenting overdrive, with five children between the ages of 5 and 12 years old. As she did for my dad, Mom has given me tremendous support and encouragement throughout this and every other pursuit in my life. Strongly encouraged by my mom to complete the darn thing before the clock ran down, Dad finished his thesis—examining university tuition rates as they relate to state residency status—albeit long after others in his starting bunch who likely had less complicated lives. This summer, he told me about how he was only able to finish by taking a week off and heading up to our family cabin alone. There on Sunday Lake, he wrote the final chapter of his PhD thesis by hand on our pier.

Gino was eight and Giorgi six when we moved from Madison to Trento about a month before I started this doctoral program. I guess then that I followed in my father's footsteps. I was easily old enough to be the mother of my classmates in the 29th cycle of the doctoral program in the Department of Economics & Management, and I will graduate a good bit after most of them (although quicker than my father's seven years!). Although I envy Dad's week at the cabin alone writing that final chapter on Sunday Lake, I too managed to complete a doctoral thesis while juggling parenting and working.

The reason why I was able to conduct three research missions that I am proud to present as the chapters of this doctorate is that I was not alone. I have endless gratitude for many individuals who helped make it possible. Luigi Mittone, Matteo Ploner, and Dominique Cappelletti have essentially taught me all that I know about behavioral economics and how to conceive of, design, run, and analyze experiments that might best provide meaningful contributions to the field. I thank each of them from the bottom of my heart and feel lucky for having such a highly qualified and competent set of mentors that consistently challenged me to hypothesize and resolve research questions in better, more creative, and more innovative ways. My colleagues and officemates were all generous and supportive in taking time to help me at many different points—so thank you all. Marco Tecilla was a great help in the CEEL office. Prof. Enrico Zaninotto was always available to help things go smoothly. I am thankful for the comments of many in the department who attended my research presentations and offered suggestions that improved my research ideas and this end product.

Because my life was always quite full beyond CEEL and the University, I really owe great thanks to many who helped me balance the doctorate with teaching at the *liceo* and with raising the boys. My husband Fabio had no choice but to pick up the slack so many times and I thank him heartily for that. Our friends Lorenza and Giancarlo were the first phone call if I needed help with the boys, and over and over for years, they answered 'yes'. Mothers tend to have each other's backs, and my friends Emanuela and Alessandra were quick to offer playdates, carpooling, hot meals, and kind words

throughout the final push. Among many others, I owe these friends much appreciation, thanks and gratitude.

My siblings PJ, David, Ann, and Molly have been my best friends since childhood and were ever-present supporting me in so many ways throughout this journey. I am thankful for the multitude of help I have received from my in-laws Elda, Samuela and Marco, Guido and Paola, Dario, Vasco and Antonella. My Aunt Mary died about a week before I turned in this thesis. Being my godmother, she treated me like I was the smartest one on the planet; I feel the flutter of her angel wings celebrating with me. I am thankful for that and the encouragement of all my extended family members. I owe enormous thanks to my parents for their unwavering encouragement: I had to pull this off for my dad, the truest academic and best advisor I know. A common refrain in our home is “Let’s ask Grampy”—he acts as my kids’ best encyclopedia. My mom convinced us all that we could achieve any goal—no matter how far-fetched—and I believed her. I am thankful that her message has given me the confidence and gumption to take on some big and crazy dreams.

Finally, and foremost, I am grateful to Gino and Giorgi. They really did have to share their mom with the doctoral program, and they did not have a choice about that. Countless times, life was tougher for them because I had to work on my doctorate, and countless times, they quieted down when I shouted from the other room, “I’m *trying* to *work*!” During these years, they ate fewer homemade cookies, played few board games with me, and often had to scream to get my attention away from some behavioral economics issue I was working out in my head. And they didn’t really complain much about this lost attention. They took it in stride and that has been quite lucky for me. After they learned Grammy and Grampy would come visit for the PhD graduation, they asked “when will you be done?” in continuation for a while, but eventually gave that question up as the months rolled by...maybe they figured the day would never come! While I recognize that they may have learned something about dedication during this long process, I am happy for them that the long journey is over—and they get their Mom back.

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INTRODUCTION

If you look at economics textbooks, you will learn that homo economicus can think like Albert Einstein, store as much memory as IBM's Big Blue, and exercise the willpower of Mahatma Gandhi. Really. But the folks that we know are not like that. Real people have trouble with long division if they don't have a calculator, sometimes forget their spouse's birthday, and have a hangover on New Year's Day. They are not homo economicus; they are homo sapiens.

Richard Thaler & Cass Sunstein, (2008)
Nudge: Improving Decisions for our Health, Wealth and Happiness

Each of us is made up of the decisions that we make. The rich tapestry of our lives is constructed from the hundreds of thousands of decisions that have led us to this very moment. If each of us were endowed with perfect rationality, our optimal decision-making qualities might lead us down similar paths. But here we are, instead each of us on unique and sometime bumpy rides accentuated by our perfectly irrational choices. In my doctoral work, I have sought make sense of our faulty decision making in areas related to personal health by applying insights from the field of behavioral economics. I am not the only one searching for answers. It's an exciting time to be a behavioral economist in light of the relatively recent birth of the subfield, as a splinter off of the traditional economics cutting block. It is a moment of prolific research in a thriving field of economists seeking to understand how exactly we err in the decision-making process, and what precisely can be done to help us err less.

The timing could not be better for addressing poor decision-making in the health field. Behavioral factors play a starring role in today's burgeoning health crises, considering that smoking and tobacco use, lack of physical activity, poor eating habits, excessive alcohol use, and medical treatment noncompliance contribute to many of today's most prevalent health problems. Given the heavy individual and societal costs of disease and illness and the seeming inadequacy of current policy measures to guide meaningful change, behavioral economists, governmental and policy 'choice architects', and health care professionals have been hard at work testing innovative potential solutions to try

and curb individual's health-defeating behaviors. The number of studies is encouraging despite the frequent mixed results. Random control trials are constantly testing the efficacy of applying behavior economics to improve decision making in numerous health areas, an important step if we are to devise strategies worthy of guiding policies toward better health outcomes.

In this doctoral thesis, I consider first and foremost the foundations of behavioral economics and its arrival from notions of bounded rationality and Prospect Theory, and what tools it offers to address pressing health issues. In the first chapter, I also consider the innovations in applications of behavioral economics to the most persistent health issues. In the following chapters, I offer new research (performed in collaboration with my coauthors) that applies concepts of behavioral economics to enhance decision making in two contexts. The role of information provision and quality is considered in light of recent controversy surrounding parental hesitancy and uncertainty regarding childhood vaccines. In an online survey performed on Amazon MTurk, we tested the efficacy of several different informational messages for their ability to influence attitudes toward vaccination. Finally, I present the results of HealthyMe, an intensive collaborative experiment involving an intervention to encourage active travel by foot and on bicycle using participants' cellphone to both recorded active travel and delivered nudge and feedback messages through a specially developed cellphone app. In both experiments, we offer considerations to be taken into account in the pertinent health settings.

Chapter 1.

Behavioral Economics and Health: An Overview of Concepts and Applications for understanding and encouraging positive health outcomes

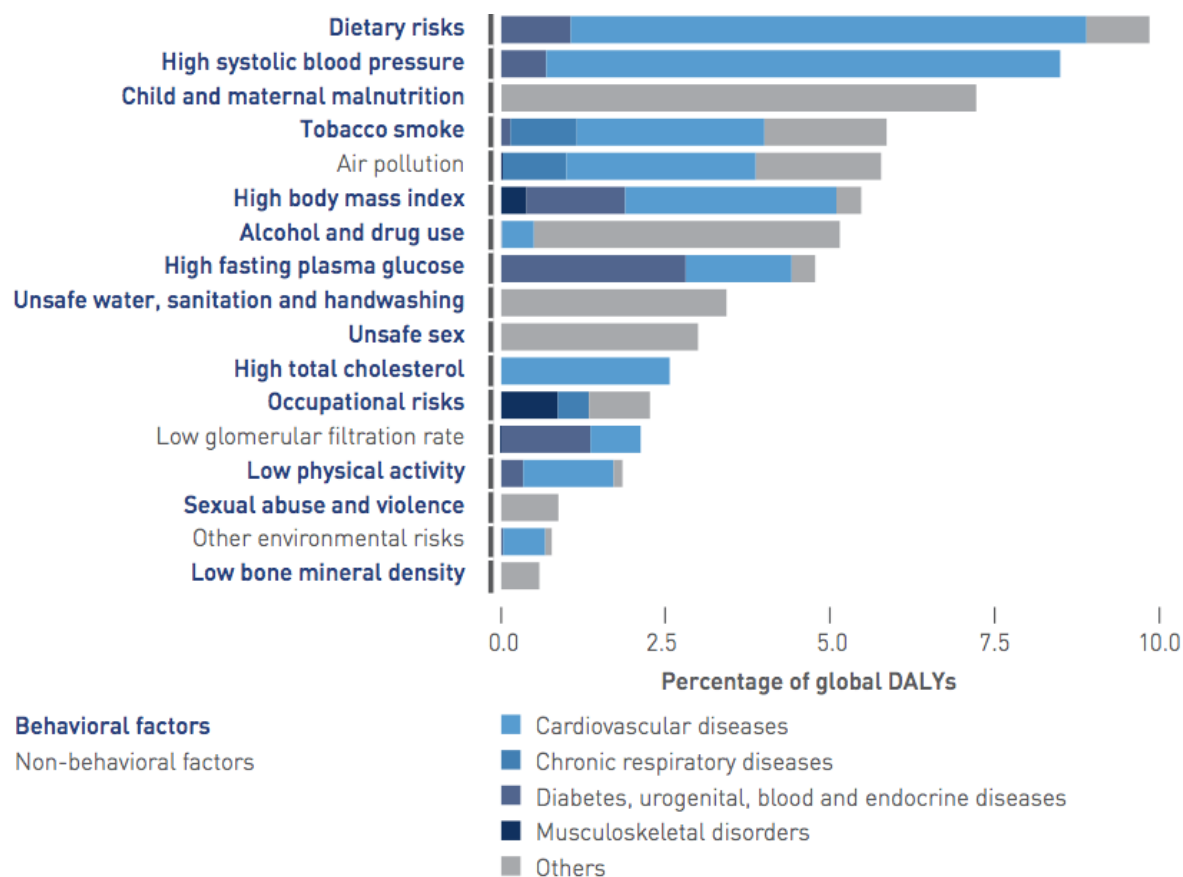
Abstract

The alarming increases in diseases and deaths related to lifestyle and behavioral factors have proven largely resilient to traditional policy measures. Choice architects including governments, policy makers, health care providers, and public health professionals, as well as individuals themselves need new improved methods for dealing with the burgeoning health issues faced on individual and societal levels. Traditional economics is limited by its assumptions that people act in rational ways to pursue their own best interest. By leveraging insights from the field of psychology, behavioral economics attempts to provide a better understanding of how people behave and approach decisions by mapping patterns of irrationality due to cognitive biases and heuristics. The evolution of the field of study is considered in this paper, as are the fundamental concepts that relate to individual decision making in health areas. I consider the application of insights and tools deriving from behavioral economics to several health contexts. The adequacy of such tools is illuminated by examples from experimental settings, and discussions regarding the role of the choice architect as policymaker.

1.1 Introduction

Individual behavior plays a key role in the collective health of our society. Tobacco use, physical inactivity, unhealthy diet, alcohol overuse and other individual behaviors are estimated to underlie a staggering 40% of premature mortality in the United States (Volpp & Asch 2017). A large share of the most problematic and deadly diseases in our society, particularly in developed countries, are the direct result of, or can be significantly exacerbated by, unhealthy behaviors. Smoking, unhealthy food choices, overeating, medication non-adherence, and lack of physical activity are examples of modifiable behaviors that greatly affect health status and rates of disease and mortality. In addition to causing personal costs of illness and lowered life expectancy, these behaviors also cost society billions of dollars in terms of health care costs and lost wages and productivity. Behavioral factors play a contributing role in the development of long-term conditions such as diabetes, cardiovascular diseases, chronic respiratory diseases, and musculoskeletal disorders. Hallsworth et al. (2016) estimate the total from lost output and treatment costs related to these long-term conditions with significant at \$30.4 trillion over the next 20 years. In Figure 1, they depict the degree to which behavioral risk factors contribute to, and are intertwined with, the overall disease burden. Staggering statistics such as these provide the “why” for my exploration in this paper of how we can improve health behavior and outcomes by using insights from the field of behavioral economics.

Figure 1.1 Global disability-adjusted life years (DALYs) attributed to risk factors in 2013
 Source: Hallsworth et al. (2016)



Of great importance in addressing these problems is a solid understanding of when and why people (choose to) engage in behaviors that may be harmful to their health. Traditionally we turn to social sciences and particularly economics to provide solutions to large-scale problems, such as the growing burden of healthcare attributable to modifiable behavioral patterns. However, the very presence and high levels of individuals' engagement in self-harming behaviors reveals some degree of inadequacy of neoclassical economics to offer satisfactory policy solutions in health areas. As of 2015, the projected *increase* of the global economic burden caused by cardiovascular diseases alone was expected to be 16 percent, increasing from \$906 million in 2015 to more than \$1 trillion by 2030, and total output losses (expected to occur at *every* income level) are projected to increase sharply over time (US Board on Global Health 2017, emphasis added). The impending crisis in health care costs owing even in part to modifiable health behaviors begs the question of whether methodology exists that can help improve behavior and choices in the area of personal health.

Let us start with a look at the problem from the perspective of traditional economics. The great number of individuals in modern society who engage in behaviors that they know to be self-harming would not be accounted for in traditional economic models that assume individuals will make optimal decisions given the information and resources available. The rational choice perspective indicates that we could greatly diminish or even essentially eradicate numerous modern diseases and health problems simply by providing information. While informational campaigns are an important tool for those designing health policies, they only partially address major societal health issues, and entirely ignore the biases and pitfalls in the human decision-making process. For example, individuals often struggle to make optimal choices even when they do have adequate information available, due to limited attention or limited self-control. In recent years, due to mounting evidence regarding its capacity to positively influence outcomes, the applications of behavioral economics have assisted policy makers in different countries and sectors to integrate behavioral insights into policy design and implementation in more systematic manner.

The traditional approach to understanding health problems and developing strategies to address them has relied on employing policies grounded in the social sciences, particularly conventional economics. Based on its inherent assumptions that individuals have full access to and comprehension of all pertinent knowledge relevant to the available choice alternatives, that they are able to compute which choice is in their own best interest and have unlimited self-control and thus that they will make rational decisions, classical economics foresees limited motives for intervention in personal decision-making processes.

Consider an example that illustrates the limitations of assuming individuals are rational. If a rational individual fails to take prescribed heart disease medication, the decision is likely optimal, since by assumption this individual has thought through all the costs and benefits and decided that the costs (e.g. the cost of medication purchase, and unpleasant side effects it may cause) outweigh the potential benefits (e.g. lower risk of a heart attack). Traditional economics restricts intervention to two cases. The first entails the situation where the preferred choice of the rational decision maker is

prevented by a constraint such as inadequate amount of money to afford the cost of medication. In such a case, classical economist may suggest a policy that involves loosening the constraint by loaning him money for the medication or policies that lower the cost of the medication. A second motivation for policy intervention would be the case where *externalities* result from the decision, such as the cost to society (health system's cost to government and/or tax-payers) for indirect effect on others for the individual's choice not to take his medication (Kessler & Zhang 2014). In the case of medication noncompliance, policy makers cannot benefit from classical economics if there are not constraints (such as inability to pay based on economic situations) or externalities (costs that others incur as a result of an individual's behavior) as described. If the individual has health insurance that covers both the costs of medication and subsequent treatment caused by noncompliance, yet that individual simply chooses not to take the medication, there is no policy reason to intervene under rational choice theory. Because evidence indicates both that medication non-adherence is a problem even among those who can get their medication for free and that non-adherence causes up to half of all medication-related hospital admissions in the U.S. (Kessler & Zhang 2014), the non-compliance problem should clearly be addressed in some way to improve our individual and collective health. Clearly then, the resolution of health issues arising from complex issues such as medication non-compliance requires a more realistic view of how human decision making truly takes place. As the field of behavioral economics has improved upon traditional economic theories to incorporate an understanding of suboptimal decision processing, it provides the framework and potential to offer solutions when individuals act counter to their own best interest.

Herein I not only discuss the inadequacy of conventional economics methods in addressing health care problems caused by flawed or suboptimal individual decision-making, but also present the numerous tools offered by the relatively new field of behavioral economics. Moreover, I explore examples of the current and potential applications of behavioral economics within the health field.

1.2 Developing a new approach: Bounded Rationality, Prospect Theory, and Dual process theory

The field of behavioral economics arose from the observation and acknowledgement by economists that individual behavior was not always in line with the expectations of classical economics due to demonstrated limitations in human cognitive capacities and behavioral biases. Based on the standard expected utility theory, neoclassical economics holds that individuals in any given decision-making situation consider potential benefits and costs of the alternative choices, calculate the present net value of each decision based on probable outcomes, and make the decision that maximizes their expected utility. Of course, behaving in such a way makes the most sense and is the most rational because individuals act in their own self-interest. However, there is vast evidence from the medical community that when faced with health-related decisions, often individuals in fact do not act in their own best interest. They make errors on a pervasive scale regarding health care decisions. Common tendencies include failures of self-control, putting far too much value in present enjoyments versus future well-being, attaching excessive value to the status quo even when new information makes it inadvisable, and overstating the risk of certain contingencies and understating it for others (Rice 2013). Developing policies to help improve health care decision making requires a true and realistic understanding of *why* individuals act in suboptimal ways, a question that behavioral economics has been seeking to answer since its inception.

Take the example of chronic smokers. These individuals demonstrate limited human rationality because they choose, over and over every time they light a cigarette, to continue smoking despite their knowledge that smoking has serious long-term health consequences. In the case of smokers, we can assume that they do have knowledge of the harm they choose to incur because of the dominant placement of information detailing health risks on cigarette packaging. Do they weigh costs and benefits of smoking? The habitual smoker may display *present bias*, in that he overweighs the nearly-immediate benefit—the gratification of the cigarette’s nicotine hit, a brief chemically-induced euphoria—and underweights the future cost—the far greater but less tangible result of smoking-related health problems. We might also characterize the

choice by noticing that the smoker prefers a smaller-but-sooner reward to a larger-but-later reward, and thus as the time of the receipt of the rewards approaches, a preference reversal occurs wherein the smoker prefers the smaller sooner reward (gratification from smoking) to the larger later reward (health benefits from not smoking). Indeed, present bias and individual differences in undervaluing future rewards are associated with numerous negative health behaviors, and associated conditions including almost every form of drug dependence, overweight and obesity, problem gambling, risky sexual practices (Rice 2016). Excessive discounting of future rewards is a core characteristic of the pathology and disease process underpinning clinical states like addiction and obesity, and the associated increases in risk for chronic disease and premature death (Rice 2016). The present bias represents an error in decision-making due to time inconsistency in weighing costs and benefits, and individuals who commit this error demonstrate flawed reasoning that is inconsistent with assumption from classical economics that individuals act rationally and in their own best interest.

The fact that individuals have difficulty assessing the net present value of the costs and benefits associated with smoking (or not), exercising (or not), eating healthfully (or not), and other health-related behaviors means that any approach based on treating them as perfectly rational economic agents is ill-equipped to provide effective models and satisfactory policy solutions. The susceptibility to *present bias* leads to an underweighting of future health benefits, and thus it overrides individuals' rationality and optimal decision making and contributes to outcomes like procrastination. In other words, because traditional economic theory contains at its core the assumption that human beings act rationally, it is greatly limited in explaining the non-rational human behavior patterns that mark many health issues facing society today.

In areas pertaining to health, taking actions that preserve and improve one's own state of current and future wellness represents the most rational behavior, whether we measure utility as physical health level or ability to work and earn money (thus earning capacity). However, particularly in developing countries, a significant percentage of today's population living with compromised personal health problems consistently make choices that are self-harming. Policy makers turn increasingly to solutions deriving

from the field of behavioral economics and the burgeoning knowledge it offers regarding the motivations for individual behavior and decision making. But what are the origins of behavioral economics, the relative newcomer that has emerged in response to academic exploration of the reasons why individuals behaved in ways not only counter to their own good but often even quite harmful to their well-being?

The roots of behavioral economics derive from social scientist Herbert Simon's theory of bounded rationality (1955) wherein he suggests that classical economic models do not comport with reality because they fail to acknowledge most individuals have limited or 'bounded' capacities for rationality (Simon 1955). Simon's works were seminal in proposing that individuals are limited in their ability to process information and compute the expected utility of alternative choices, particularly when facing complex decisions. According to Simon, the often-severe limitations of the individual decision maker with respect to both knowledge and computational ability require us to distinguish between the real world and that individual's perception of it and reasoning about it. Particularly in cases where the actor is facing a complex decision or a new problem that they have never faced before, the principle of bounded rationality recognizes that the capacity of the human mind for formulating and solving such problems is very small. Simon argued that the global rationality of economic man must be revised to account for the type of rational behavior truly compatible with and reflective of actual human measures regarding availability of information, effects of time constraints in decision-making, and capacity for computation of which alternative is optimal (Simon 1955).

Simon and those who later expanded and elaborated on his theory of bounded rationality to create the field of behavioral economics focused on *how* individuals reached decisions or judgments, rather than the final decisions themselves. For them, one unrealistic implication of the traditional economic model of decision making was that it proposed an all-inclusive context of knowledge and information wherein the decision-making agent was aware of not only all relevant details in the present moment but also cognizant of expectations and future implications. Alternatively, a more realistic view would assume that individuals had limited information available and

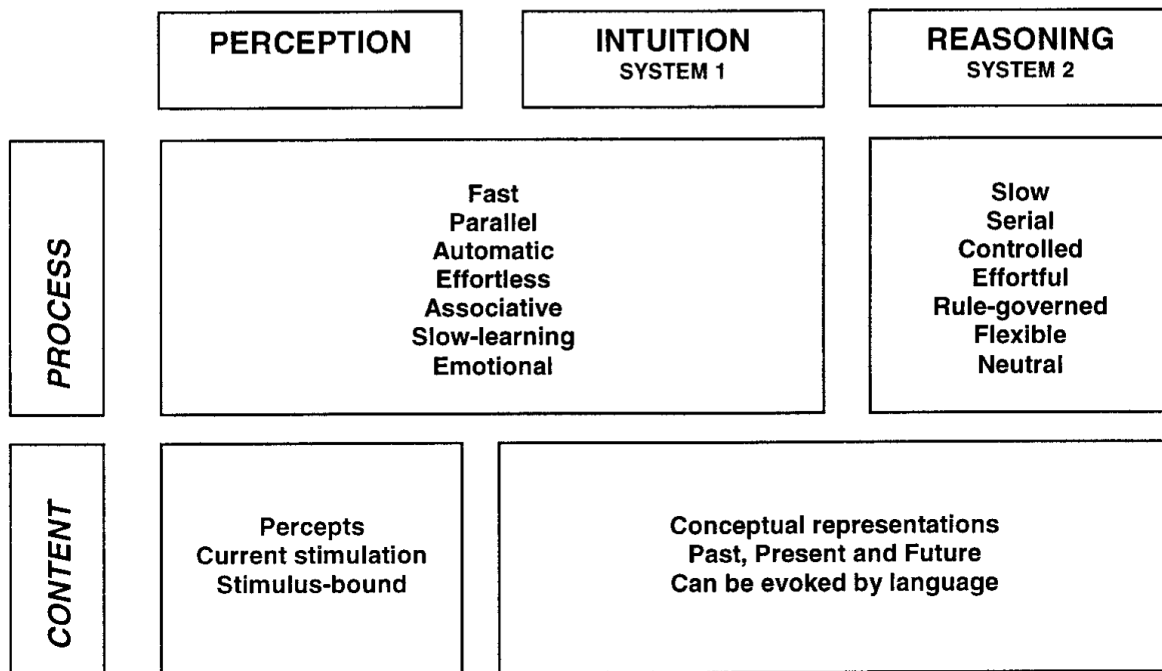
models would account for how individuals often processed information in the absence of full knowledge of, and capacity for processing, comprehensive decisional factors: by using heuristics.

While quite useful, the natural human tendency to simplify the processing of information by using heuristics often involves ignoring certain aspects of a complex decision, and thus committing errors and suboptimal decision making. *Heuristics* are mental shortcuts or rules of thumb that simplify the decision-making process by reducing the complex task of assessing probabilities and predicting values to a simpler judgmental operation (Tversky & Kahneman 1974). Heuristics are generally applied to intuitive decisions made during the so-called System 1 cognitive processes, the thoughts and preferences that come to mind rapidly and without significant reflection, in contrast to the much slower and more deliberate thought process associated with the System 2 cognitive judgment process known as reasoning (Kahneman 2003).

Adopting the notion from psychology that two separate but interacting cognitive systems control our judgments and choices has enabled behavioral economists to better distinguish the type of thought processes most susceptible to decision-making errors. Intuition, or the System 1 thought process, is characterized by decision making that is fast, automatic, and often charged with emotion while the System 2 process tends to require more time, effort, concentration, computation, and deliberation. Psychologist Daniel Kahneman's schematic chart in Figure 1 summarizes well the basic characteristics defining the two systems. System 1 functions similarly to the perceptual processing of current stimulation, and being governed by habit, may be difficult to control or modify. Recall the earlier discussion of smoking and the challenge it presents, that of modifying a habitual pattern of making a health-defeating (thus suboptimal) choice. Research suggests that System 1 governs the bulk of our thoughts and actions, with some degree of monitoring by System 2. In part this may lie in our limited overall capacity for the cognitive effort that System 2 processes require, in contrast to effortless, automatic processes of System 1 that allow for performing multiple System 1 tasks concurrently (Kahneman, 2003). System 2 processing requires time and focused concentration in order to deliberate over prospective choices, and thus System 2

decisions are made one at a time. Similarly lack of time or increased stress levels may cause us to defer decisions to System 1. Behavioral economics develops strategies and tools for addressing flaws in System 1 decision making, and given two systems' interaction, also holds promise for improving System 2 processing.

Figure 1.2: Kahneman's schematic portrayal of *Process and Content in Two Cognitive Systems*
Source: Kahneman (2003)



Expanding upon Simon's notion of bounded rationality, Kahneman and fellow psychologist Amos Tversky defined a number of heuristics and noted that systematic reliance on heuristics, while sometimes useful, potentially caused errors of judgment or led to heuristic-induced *cognitive biases* in human decision making (Tversky & Kahneman 1974). In 1979, Tversky and Kahneman published *Prospect Theory: An analysis of Decision under Risk* in which they presented an alternative to expected utility theory that sought to capture human behavior more accurately, based on the evidence from their own and others' studies demonstrating its inadequacy to account for heuristics and cognitive biases (Kahneman & Tversky 1979). Simply put, Prospect Theory describes how people make choices when they are uncertain about the probabilities related to alternating choices and outcomes.

In short, the authors evaluated two phases in making choices, the first phase of ‘editing’ during which individuals consider between offered ‘prospects’, and the subsequent phase in which individuals evaluate the (edited) prospects and choose that with the highest value. In the editing phase, individuals perform several operations that help them organize and reformulate the prospects in order to simplify the choice. According to the 1974 review, because they lack the knowledge, time, and capacity to perform optimal processing of information, individuals rely on three heuristics of judgment that the authors label as *representativeness* (judging the likelihood of an event based on overestimation of its similarity to other events/objects), *availability* (estimating the frequency of an event based on the ease with an idea can be brought to mind), and *anchoring* (relying too much on an initial piece of information). Although using these mental shortcuts in and of itself may be a rational way of dealing with limited time available for thinking through a decision, the actual resulting decision may be erroneous. For example, people using the availability heuristic may overestimate the likelihood of a plane accident if one has occurred recently.

After detailing the anomalies of preference that result from the individual decision maker’s process of editing the prospects, Tversky and Kahneman demonstrate that decision outcomes are perceived as gains or losses from the initial ‘reference’ point rather than as absolute evaluations of the final result, and that losses from this starting point cause greater emotional impact than gains of an equivalent amount so thus losses are perceived as larger than gains. From their analysis, the authors laid out a novel framework that incorporated the presence of preferences and cognitive biases into a descriptive analysis of decision making when weighing risky options or prospects (Kahneman & Tversky 1979). In later works largely based on subsequent empirical findings, Tversky and Kahneman refined and expanded upon Prospect Theory, adding, for example, their finding that people are averse to risk in facing the prospect of gains but seek risk in the face of large losses. A key concept is that individuals’ reliance upon and repetitive use of mental shortcuts and their related development of cognitive biases is in itself predictable, and people’s systematic use of heuristics allows for the identification of patterns of irrationality in decision making. An understanding of these

errors in the decision-making process is the first step toward developing strategies or policy measures to address them in a manner that improves behavior and outcomes.

The key underpinnings of Prospect Theory launched a new sub-branch of economics. While Prospect Theory was derived from examples involving monetary outcomes, the authors claimed that it could be applied more generally to situations of choices made under uncertainty, in a similar manner that expected utility theory extends to typical decision-making situations. Indeed, the novelty that Prospect Theory presented was immediately seized upon by numerous others who elaborated on its principal holdings to develop the burgeoning field now known of as behavioral economics. Traditional economic theory had not addressed the decision-making process because the theory assumed that people will choose the best option available by simply matching their preferences with cost and benefit data. There was no interest in the decision-making process per se, because the outcome was the all-important characteristic (Rice 2013).

The evolution of this study into how people make real world choices has provided valuable insight into decision making when facing health-related choices. The contributions of Tversky, Kahneman, and numerous subsequent economists including 2018 Nobel prize winning economist Richard Thaler have provided us with conceptual explanations and a resulting toolbox of applications grounded in behavioral economics. Applying these tools allows us not only to understand why individuals act in irrational ways, but also to shape policy solutions that stimulate individuals who are facing decisions and uncertain about the alternate prospective outcomes to act in their own best interests.

1.3 Concepts from Behavioral Economics relevant to health-related decisions

Because it provides theoretical explanations for individuals' suboptimal choice patterns, behavioral economics offers a promising conceptual framework for examining choice situations wherein individuals repeatedly choose health-defeating options over health-promoting alternatives. The research identifying areas in which individuals' deviation

from perfect rationality is highly systematic and predictable has enabled behavioral economists to create specific strategies to address these errors. In this section, I review the some of the suboptimal patterns of behavior that have been identified in the field of behavioral economics, with a focus on concepts that are particularly apt for understanding health-related behavior.

1.3.1 Temporal Inconsistency

One important principle is that individuals tend to be inconsistent in weighing the value of costs and benefits over time. It seems that individuals have difficulty with interpreting future prospects, and specifically that they undervalue future benefits and costs relative to present costs and benefits. This natural human tendency to discount future events explains *present bias*, described in the earlier example of smokers choosing immediate gratification at the expense of their own long-term health. In neoclassical economics, models describing the discounting of future rewards relative to immediate ones are based on the assumption that people discount a future reward by a fixed percentage for each unit of time delay. Thus, neoclassical economics offered an exponential discounting function, holding that the amount that individuals discount a future benefit depended only on the length of time that they must wait for it and a fixed and constant discount rate.

However, research by psychologists and behavioral economists has documented that the exponential discounting proposed by the neoclassical model does not adequately describe the way in which individuals discount future events (Frederick et al. 2002). The oft-cited example is that subjects consistently prefer \$100 today over \$110 tomorrow but simultaneously prefer \$110 in 31 days over \$100 in 30 days. While in both choices the larger reward requires the wait of one day, subjects evaluate the choice differently. Thus subjects' preferences are not time-consistent because later preferences (it is worth waiting one more day for \$10 more) do not confirm earlier preferences (it is *not* worth waiting one more day for an extra \$10). Individuals profess that in one month they will favor waiting a day for the extra \$10 but that is a full reversal of their decision today. This phenomenon is referred to as *preference reversal*. In this example and other

empirical observations of hyperbolic discounting, discount rates decline rather than remain constant over time.

In other words, these examples demonstrate that discounting is more accurately portrayed with a hyperbolic curve function that accommodates for time-inconsistent decision making such as preference reversal. In addition to chronic smoking, other health-defeating behaviors based on time inconsistent preferences include making unhealthy food choices and failing to adhere to minimum physical exercise routines. In instances when presented numerous fat- or sugar-laden options, even the most health-conscious individuals likely experience conflict regarding the choice between a healthy food (or simply abstaining) with its promise of long-term benefits or the short-term pleasure of a better tasting yet less nutritious choice. Similarly, individuals may overweight the immediate perceived costs of adhering to an exercise or weight-loss program—the time and physical effort required for engaging in exercise—and simultaneously underweight long-term benefits. A related concept is *salience*, the notion that the more relevant an individual perceives an event or object to be, the larger it looms in that person's mind and fosters an expectation that it is important or will happen. The temporal immediacy of events in terms of how recently they occurred or our expectation that they are impending affects makes them appear more salient or prominent to the decision maker that can easily recall them during a decision-making process. For example, prominently displaying or positioning healthy food options in restaurant and cafeteria settings might

The idea that individuals value what is immediately available more than what may come in a distant future, leads to novel approaches to health problems. This is particularly true when individuals fail to appreciate how small behavioral actions contribute importantly, albeit via incremental effects, in avoiding long-term costly consequences. Focusing on smaller, short-term goals—i.e., losing small amounts of weight per month, or gradually reducing the number of cigarettes smoked per day or week—may be more effective than pushing long-term ambitious achievements—i.e., greater weight loss over six months or one year, quitting the smoking habit entirely. In fact, the understanding of intertemporal choice provided by behavioral economics

provides strategies for addressing health problems related to limited willpower or self-control in the face of immediate gratification. One strategy for improving healthy behavior would be to create rewards that are frequent and/or immediate for those behaviors. Another method of intervention that holds promise in countering time inconsistent behavior such as present bias is that of commitment contracts, in which individuals pre-commit to future healthy behavior.

1.3.2 Bounded Willpower and Decision Fatigue

Standard economic models of behavior describe human beings as having unbounded rationality and unbounded willpower. In contrast, behavioral economics holds that individuals demonstrate limited rationality when making decisions due to a lack of information, a limited capacity for cognitive and computational analysis of available information, and limited time in which to make such decisions. Likewise, behavioral economics accepts that individuals also demonstrate limited willpower, meaning that they act in ways that *they know* to conflict with their own best interest or alternatively for less sophisticated individuals, with what they perceive as their own best interest (*for further discussion of degrees to which decision makers vary from 'naïf' to partially naïve to 'sophisticate', depending on knowing or understanding their own future preferences, see O'Donoghue & Rabin 1999*).

Understanding bounded willpower is important in seeking to improve individual decision making related to personal health, given that self-control issues are particularly evident in, and often markers of, chronic diseases. In fact, both preventative health behaviors (such as brushing and flossing teeth) and consumption of sinful goods (such as cigarettes or fatty foods) tend to involve situations of intertemporal choice in which future costs and benefits are discounted (Thorgeirsson & Kawachi 2013). While all humans struggle to varying degrees with succumbing to health-defeating behaviors, health problems are compounded for those who experience frequent lapses in self-control in the face of daily decisions such as smoking less or not at all, making healthy food choices, adhering to prescribed medication schemes, and maintaining physical exercise regimes.

In addition, individuals may demonstrate lapses in both willpower and rationality when they experience *mental depletion* or *decision fatigue*—mental depletion caused by the effort of making multiple decisions. This is evidenced by inconsistency of choice when facing the same decision in alternate moments. The amount of information that people are exposed each day has greatly increased with the modern era. Consider that twenty-five years ago, it was claimed that an edition of the *New York Times* contained more information than the average person in 17th century England would have been exposed to in their entire lifetime (Hallsworth et al. 2016). Given our *limited attention* and limited capacity for focusing on and processing information, we cannot possibly input and process the incredible amounts of information we encounter each day. Unfortunately, those with heavy cognitive loads—such as people living in poverty or with a medical condition who have many pressing issues to think about—are even more likely to have limited attention and thus commit errors in decision-making (Hallsworth et al. 2016). Mental depletion refers to the fact that people tend to grow tired from the mental energy expended to make decisions—including the gathering of information, comparison and weighing of complex options, and calculation of which option is best—and to exert self-control, and to expend emotional and mental energy of other forms. As their mental energy is depleted, it becomes increasingly more difficult to act how they intend, to resist temptation, and to undertake the mental effort to make informed decisions; consequently, individuals experiencing mental depletion in the face of pressing needs shorten their horizons, limit their perspectives, and demonstrate less will-power (Pinto et al. 2014). For example, mental depletion is at work when tired individuals feel overwhelmed by the task of comparing products’ nutritional information at the grocery store or resist unhealthy desserts.

The classic example of decision fatigue derives from a study in legal realism by Danziger et al. (2011), who offer evidence of decision fatigue from over 1,100 judicial decisions involving eight judges making prisoner parole determinations. Specifically, they found that, as judges advanced through their docket of cases, with each repeated ruling, they were increasingly likely to favor the default, status quo outcome (denial of parole). As the judges’ mental depletion increased, they had an increased tendency to simplify decisions by accepting the status quo. Anecdotally I can confirm a similar phenomenon

from my own legal practice: my colleagues (fellow attorneys) and I were well-aware of our increased likelihood of obtaining favorable rulings in administrative law cases when the judges were running behind significantly with their scheduled caseload that day. It seems that if the judges, unable to reschedule cases except in extreme circumstances, were experiencing fatigue due to lengthier-than-scheduled hearings (generally due to the presentation of excessive amounts of evidence to be considered) and stress due to work overloads and these scheduling backups that would likely require them to work longer hours, this fatigue rendered them more likely to accept our proposals for immediate favorable rulings.

While we might generally consider that judges are involved with System 2 cognitive processes while rendering judicial decisions, they like all individuals have a limited overall capacity for mental effort and the pressures caused by time constraints, stress, and the taxing deliberation process. The evidence demonstrates that this decision fatigue may implore them to employ the use of System 1-type processing, resulting in use of heuristic simplification.

In a health context, the conceptualization of intertemporal choice allows behavioral economics to directly address and provide solutions to related problems such as bounded willpower and decision fatigue. Limited attention, mental depletion, and decision fatigue lead people to overvalue events and information that appear salient at the time that the decision is made, so that subtle influences can affect how people act (Pinto et al. 2014). Most can relate to an increased susceptibility to make unhealthy food selections, such as grabbing a candy bar located near the supermarket checkout counter or giving in to temptation by ordering an indulgent dessert, when experiencing a state of mental depletion or decision fatigue. Behavioral economics offers strategies to combat the susceptibility to making poor choices due to mental fatigue, such as prominently positioning or vividly emphasizing healthy food options in cafeteria settings or on restaurant menus.

1.3.3 Status Quo Bias, Anchoring, and Default Options

Related to the tendency that the cognitively-fatigued judges demonstrated toward simplifying decision making by adopting rulings favoring status quo situations, *status quo bias* is another concept from behavioral economics that describes an irrational behavior pattern. It essentially holds that people tend to have a preference for the current state of affairs whether or not that state is in their own best interests. Choices inevitably include an option that represents the status quo, represented by non-action or maintaining the current or most recent decision, and empirical evidence indicates that decision makers prefer this option to alternatives more than rationality would suggest. This cognitive preference is supported by ample empirical evidence on decision making in which people demonstrate a disproportionate preference for the status quo over modifying routine behavior. While adherence to the status quo may be seen as rational behavior when the effort involved in changing from the status quo negates the benefits of the switch, evidence shows that individuals exhibit inertia and maintain the status quo even when the benefits of doing so exceed the costs of the switch (Samuelson and Zeckhauser 1988). Deferring to the status quo in such cases is clearly suboptimal decision making, as it does not comport with unbounded rationality.

Samuelson and Zeckhauser (1988) note that status quo bias may be seen as a variant of anchoring, the above-mentioned concept in which people overemphasize the relevance of a given or implicit initial value by using it as a starting point from which to adjust the final decision value. Because individuals usually have a thorough understanding of their previous choice, as it may determine their current status quo regarding that subject of the decision, their present comparative analysis will both include that earlier choice in the subset of choice alternatives (whereas other prospects may be ignored), and likely use the salient characteristics of that earlier choice as an “anchor” from which to compare other options. Thus, the status quo alternative has an advantage over other options by virtue of the asymmetric position it holds in the process of considering alternate choices. In fact, preference for the status quo is demonstrated in numerous empirical settings in which rational decision making would call for selecting alternative choices yet individuals stick to the status quo, exhibiting inertia and a tendency not to reverse their earlier decisions.

It turns out that opting for the status quo provides a convenient method of simplification in other settings as well, notably when decisions involve numerous prospective choices. Not only an excessive number of decisions then, but also an excessive number of available choices cause paralysis in the decision-making process. Iyengar & Lepper (2000) demonstrated, in one of three experiments studying the effect of having limited versus ample choices available, that people who had stopped to sample jams at a grocery store tasting were more likely to purchase them when there were 6 flavors to sample (30% made jam purchase) than when there were 24 flavors (3% purchased) (Iyengar & Lepper 2000). Contrary to the idea that more choice is attractive, it seems people presented with a multitude of choice options experience become overwhelmed by the complexity and experience *choice overload*, which, similar to decision fatigue, renders them more likely to revert to heuristics such as sticking with the status quo, represented by the default option or choice deferral, the avoidance of making the choice altogether.

Strategies deriving from an understanding of this cognitive bias involve restructuring the *default* options surrounding a particular choice. The classic example illustrating the strength of deference to the default option involves the organ donation provision on driver's licenses. Johnson and Goldstein (2004) considered the effect of opt-in versus opt-out default options in various European countries where the option to donate organs in case of a fatal car accident is presented (Johnson & Goldstein 2004). In places where individuals were explicitly required to opt-in by choosing to be a donor when failure to opt-in passively resulted in the default option of not being a donor, the proportion of those who opted to be potential donors (giving explicit consent) ranged between 4 and 28%, drastically lower than the 98% or higher rate of potential donors found in opt-out countries. where individuals by passive default were automatically considered to be potential donors unless they explicitly opted out by choosing not to be potential donors. Even after difference in organ donation preferences Whether owing to deference to or blind acceptance of the wisdom of policymakers or the state offering them this choice, avoidance of making an active decision about a subject that may be unpleasant to consider (one's own post-death bodily dismemberment), or inertia or simple lack of energy to invest in altering the status quo, those opting (in or out) to potentially donate

organs are affected profoundly by the schematic framing of the default option. Obviously then defaults have an incredible potential for influencing individual choice, even if such influence owes to the format of the default options in itself allowing the avoidance of making choice.

To reduce decision-making errors or optimize treatment and costs based on choices made by physicians, changing the default option can be an effective strategy to overcome status quo decisions, and can be achieved quite easily within the electronic health record systems used nearly universally in developed countries. For example, to encourage the prescription of generic drugs, changes to make the generic the automatic default option within electronic prescription system is likely to effectively bring about the change for medical doctors who cling to the status quo, formerly that of prescribing higher cost name-brand prescription drugs. Likewise, if specialist physicians such as oncologists or dermatologists agree that a specific path of care is preferred, that treatment regimen and laboratory testing should be the default offered by the electronic system.

In the realm of health care decision making, potentially harmful anchoring has been shown to exist and compromise optimal choice in numerous settings. For example, purchasing and using smaller package sizing—e.g., the 16-ounce rather than 32-ounce bottle of oil—has been shown to reduce consumption amounts, as has it been shown that the quantity of food served and consumed is anchored significantly to external cues such as the size of plates and bowls, which can increase consumption by 15-45% (Hanoch, Barnes, & Rice 2017; Thorgeirsson & Kawachi 2013). The implicit lesson from this finding is that to alter the status quo (eating portions that are too large), one must change the anchor or default. To encourage healthy eating choices and help individuals confront the path of least resistance toward nutritious eating, behavioral economics suggests intentionally designing default options that reduce plate and portion sizes and replacing nutritionally-deficit sides like French fries with healthy ones such as carrot slices (Wansink 2004).

1.3.4 Loss Aversion and the Effects of Framing

In Prospect Theory and their subsequent work, Tversky and Kahneman (1979, 1984) demonstrated that losses loom larger than gains, a concept known as *loss aversion*, and that decision makers typically will pay more to avoid losing a given amount than they will pay for the chance to receive a gain of that same amount. In a variety of experimental settings, they have shown that individuals making decisions weigh losses from an initial reference point more heavily than gains from that same point, and moreover, that the pain of losing is about two times the pleasure of gaining the same amount. When presented with a policy choice about saving lives in the face of a disease outbreak that is expected to kill 600 people, subjects responded differently if the wording of the policy options focused on lives saved (people living, representing gain) or lives lost (people dying, representing loss). Specifically, they preferred taking risks in choosing policy options when those options were framed in terms of lives lost, but they preferred to go with other option that represented the non-risky safe option when the same exact options were framed in terms of lives saved (Kahneman 2011). This example illuminated the principle that individuals' preference is for the sure safe option when considering gains, but they are more willing to take risks in the face of losses.

The consumer marketing notion that “presentation is everything” apparently holds true for individuals' interpretation of the options in decision making contexts: how choices are presented or worded changes their appeal. Presenting choices in a manner that highlights positive or negative aspects of the same decision will produce different results. The insight that loss aversion offers is that carefully crafting the way that health decisions are presented or “framed”, in terms of emphasizing health gains versus losses, is likely to have an effect on how individuals respond to them. Loss aversion tells us that, as a rule, decision makers are likely to evaluate the loss owing to the change to be greater than the gain, and furthermore, that people may be more motivated to undertake a particular behavior when the consequences involve penalties (losses) rather than rewards (gains).

Various types of framing approaches exist, including risky choice framing similar to the type tested by Tversky and Kahneman (e.g. the risk of losing 10 out of 100 lives vs the opportunity to save 90 out of 100 lives), attribute framing (e.g. beef that is 95% lean vs

5% fat), and goal framing (e.g. motivating people by offering a \$5 reward vs imposing a \$5 penalty) (Levin et al. 1998). Levin et al. (1998) reviewed studies using all three types. In their review of evidence provided by numerous studies, consistency existed: positive frames enhanced risk averse responses more than negative framing in risky choice framing, attributes labeled in positive terms were seen more favorably than those labeled in negative terms, and negatively framed messages were more impactful on behavior than positively framed messages.

Of particular relevance to our discussion in promoting rational health-related decisions is the use of goal framing, as it is typically employed to encourage individuals to undertake preventative health measures, such as cancer screenings (PAP tests, mammography screenings, skin cancer detection). Even if they portray the same statistical evidence or core information, messages that focus on obtaining the positive consequence (gain) of performing the specific health-related act are perceived differently than messages focusing on avoiding the negative consequence or loss associated with performing the same exact action. For example, loss framing occurs in messages stressing negative consequences of breast screening (“women who *do not* perform breast self-examinations have a *decreased* chance of finding tumors in the early more treatable stages of the disease”) while gain framing emphasizes positive consequences (“women who perform breast self-examinations have an *increased* chance of finding tumors in the early more treatable stages of the disease”). Levin et al. (1998)’s examination indicates that negative (loss) framing generally has a stronger impact on responses than positive (gain) framing (Levin et al. 1998). The authors showed that for the 19 types of goal framing studies they examined, the greatest persuasive impact was generally achieved by using negative framing.

As research increasingly focuses on framing and other concepts from behavioral economics, new evidence provides a more refined understanding regarding precisely which types of framing work best in which health messaging areas. For example, in a more recent review of 94 studies using framing methods, Gallagher & Updegraff (2012) compared the persuasive impact of gain-framed versus loss-framed messages on various outcomes used in framing studies (attitudes, intentions, and behavior). Following the

format of an earlier study by Rothman and Salovey (1997),¹ the authors' review differentiated between behaviors that serve an illness *prevention* function, such as skin cancer prevention, smoking cessation, safe sex, and physical activity behavior, and illness *detection* function, such as mammography, cholesterol screening, and HIV testing. With respect to *prevention*, Gallagher and Updegraff found that gain-framed messages were significantly more likely than loss-framed messages to promote prevention *behavior*, despite only a marginally persuasive effect on prevention *attitudes* and *intentions*. With respect to *detection*, loss-framed messages had a minor, but not statistically significant, advantage over gain-framed messages in the promoting attitudes, intentions, and the actual detection behavior.

Other factors such as personal beliefs about susceptibility or motivational orientation may interact with framing. As an example, one study demonstrated that naturally occurring beliefs about susceptibility to illness or health problems shaped people's responses to framed messages in promoting healthy behavior (dental flossing). Gain-framed messages, emphasizing the benefits of adherence to the healthy behavior, resulted in increased flossing behavior for those with low perceived susceptibility than high perceived susceptibility, whereas loss-framed messages were more effective for those perceiving high susceptibility than those perceiving low susceptibility (Updegraff et al. 2015).

Understanding loss aversion and the effects of framing allows for policy makers to use framing techniques that foster the optimization of health care decisions. As the above discussion relates, distinguishing between framing effects may require paying close attention to the choice setting and accounting for individual beliefs and attitudes. Moreover, failing to consider these factors and effects in developing policies may compromise their effectiveness.

¹ The authors proposed that underlying function of a health behavior should serve as a useful heuristic for the perceived riskiness of a health behavior and should moderate people's responses to framed messages. Specifically, they proposed that gain-framed messages should be more persuasive for illness prevention behaviors, and loss-framed messages should be more persuasive for illness detection behaviors.

1.3.5 Social Information and Feedback

Since humans are social beings, we tend to be strongly influenced by the behavior, or patterns of behavior, exhibited by our peers. People tend to feel pressure to comply with *social norms*, acting in a socially acceptable way when interacting with others. In moments of uncertainty, individuals may look to the behavior of their peers and take social cues from others. Thus, individuals may ignore their own common sense in making a decision and follow what others do. Receiving *social proof* (information about how others behave) can lead people to conform with others' behavior rather than using available information to make independent decisions. The perception of what others choose or do in a particular situation gives individuals the same convenience that defaults offer, a ready guide for their own behavior.

While messages about health risks or benefits have been the traditional focus of efforts to improve health, it turns out social norms can be more powerful. When following social norms occurs among entire social groups or networks, a larger affect may occur, referred to as herd behavior. Social norms are credited with achieving successful behavioral health interventions such as the self-enforcement of seat belt laws or laws prohibiting smoking in public places. These laws created social conventions which then became self-sustaining. Many if not most decisions are made in a social context within social networks. Particularly when making decisions under conditions of uncertainty, imitating others and referring to what others are doing comes naturally and nearly automatically for many people. Looking to others is efficient and effective because it offers a shortcut for processing information and making decisions when choosing how to act.

Because we all identify with particular social groups, social norms are an even more salient influence if they contain descriptive norms of others in our social network. Norms may be descriptive—simply describing the behavior of others—or injunctive—describing the conduct that others approve or disapprove of. Messages simply revealing social norms (descriptive) can be more effective in changing behavior than messages shaming individuals for their own inadequate past behavior (injunctive). In a study testing methods to reduce missed appointments among patients, when patients were exposed to information regarding the number of patients who turned up for their

appointments, as opposed to past reference to missed appointments, the result was in a 32% reduction of non-compliance (Martin & Dunbar-Rees 2012).

Within the realm of health-related choices, it has been found that highlighting healthy descriptive norms is an effective strategy to promote healthy behaviors. For example, in an experiment that highlighted healthy descriptive norms in signs placed at the entrance to a campus food court ('every day more than 150 [fellow university] students have a tossed salad for lunch here'), Mollen *et al.* (2013) and demonstrated that healthy eating behaviors increased by making them salient as a social norm in a social setting. In another study, where grocery cart placards informed shoppers that the average shopper purchased five or more produce items at particular stores, the descriptive norm message resulted in a significant increase in average produce spending, with no change in total spending (Payne et al. 2015). The study underscores individuals' reliance on both social and 'provincial' norms. These cases show that simply informing people that others perform a particular healthy behavior, that it is in fact the social norm, allows improvements to their own health behavior.

To complicate matters, while people want to conform to social norms, they often misperceive the norms and behavior of others (Payne et al. 2015). They may overestimate, or underestimate, the degree to which peers engage in unhealthy behaviors. One classic example is that college students tend to overestimate how much alcohol their peers consume, and thus they may rely on their perception of a social norm rather than the social norm itself to engage in more drinking themselves. Simply becoming aware that a behavior is more or less prevalent than people thought can lead them to gravitate toward that norm in their own behavior. The cautionary tale here is that care must be taken when conveying messages that risky or unhealthy behaviors are the social norm, as the message may induce others to adopt the same behavior. Furthermore, for those already outperforming the social norm, it is particularly important to offer positive reinforcement (an injunctive norm such as a smiley face icon to encourage continuation of the above-the-norm behavior) with the descriptive norm message to prevent a 'boomerang effect', where those who become aware that they have

underestimated the prevalence of the undesired behavior may then increase that undesired behavior (gravitate toward the norm) (Frederiks et al. 2015).

A finding from social psychology is that the more that the social norm information is connected to people's social self and identity, the stronger the impact on behavior (Reynolds et al. 2015). Men and women have been shown to have five times higher odds of becoming physically active if their spouse also became active (Patel et al. 2016). This increased impact is also demonstrated by studies of *peer effects*. In particular, peer effects have been demonstrated to be particularly influential in the behavior of teenagers. In a study involving over 6,000 students, researchers found that when a teenager's perception of the share of classmates who use a substance such as alcohol, marijuana, or tobacco products increased by 10 percentage points, that student's probability of using the substance also increased (Kawaguchi 2004). Likewise a study of over 11,000 tenth grade students found that a student with a 7% chance of using drugs was moved from a school setting where no classmates used drugs to a similar school setting where half of the classmates used drugs, that student's probability of using drugs jumped to 20%; similar if slightly less marked results occurred with smoking and alcohol use (Gavaria & Raphael 2001). Peer groups have been shown to have a significant influence on college student's own body mass index, grade point average (GPA), and propensity to cheat academically. Given this demonstrated tendency to conform with others, the value in providing peer group and social norm information, especially to groups susceptible to the peer effect such as teenagers, is limited to situations where that norm demonstrates optimal or desirable conduct. Thus, an important strategy for using this concept is the avoidance of messages that a majority of a such groups' population partake in a risky or unhealthy behavior.

In adults, numerous studies have identified that neighbors, coworkers, and others in one's social environment exert a significant influence on behavior. An example from the health setting involves a project by the UK Behavioural Insight Team to combat the overuse of antibiotics. In a letter from the Chief Medical Officer, highest prescribing doctors were informed that they were prescribing antibiotics at a higher rate than 80 percent of their peers. The subsequent reduction in prescriptions over the next three

months amounted to 75,000 fewer doses, proving the efficacy of social norm feedback in one's peer group (Hallsworth et al. 2015). Similarly, peer support from those who suffer from the same chronic condition has been shown to improve self-management behaviors. In patients with diabetes, peer support has been shown to improve medication adherence, diet, exercise, blood glucose monitoring, and glucose control. One study showed that diabetes patients engaged with peer mentorship coupled with a modest financial incentive achieved a statistically significant decrease their hemoglobin HbA_{1c} levels, whereas those having only a much greater financial incentive (with no peer mentoring) did not (Long et al. 2012).

A related social *consensus* heuristic is that of giving weight to an important social norm within an expert community. People's beliefs and judgments on certain medical issues are often guided by what they see as a norm or consensus within in the medical community. Individuals need not invest in learning complex information because they rely on a simple normative fact (e.g., 90 % of medical experts agree that vaccines are safe) (van der Linden et al. 2015). Highlighting consensus among doctors and other medical professionals can be a valuable tool for improving and encouraging informed decision making. For example, one study found that highlighting the degree of medical consensus about childhood vaccine safety increases perceived scientific agreement, which in turn acts as a "gateway" belief because it both promotes favorable public attitudes toward vaccination and reduces perceived risk and belief in the discredited autism-vaccine link (van der Linden et al. 2015).

Finally, *feedback* is an important tool to improve behavior by increasing awareness about one's own behavior relative to social norms, peer activity, or simply one's own intentions or beliefs. Providing people with feedback about how they are progressing toward health treatment goals, possibly compared to a peer group (of the same age and sex, or those with similar health issues), can motivate them to improve or stay committed to target behaviors. In its simplest form, individuals gain valuable perspective on their own behavior when they perform self-monitoring by keeping track of calories or grams of fat consumed, daily measures of body weight, or steps walked, for example. Self-monitoring alone has proven effective in changing behavior; reviews

have found “consistent relationships between dietary self-monitoring and weight loss, between the use of pedometers and increased physical activity (one review found that the physical activity was increased by 27% on average, albeit noting long-term effectiveness is largely unknown), and between the use of blood glucose monitoring and blood sugar control among patients with diabetes” (Thorgeirsson & Kawachi 2013).

Feedback can be structured to focus on different aspects of the choice or utilizing various principles from behavioral economics. Feedback can be purely information, goal-oriented—informing how well individuals are progressing toward health goals either set by them personally or standard goals for particular health issues, normative—expressing how well they are performing relative to social norms, or peer-oriented—detailing how individuals are performing in real-time relative to others. Given the present bias preference in which people respond more strongly to immediate incentives than to delayed incentives, one strategy for encouraging physical fitness activity might be giving feedback on, for instance, gym use daily rather than monthly or annually (Pinto et al. 2014).

Visual feedback has been shown to be a particularly useful tool in encouraging behavioral change in the health arena. For example, in one study, students shown a photograph that highlighted facial UV damage were more likely to report reduced tanning booth use at follow-up than students offered no photograph, though both groups of students received verbal and written information concerning risks (Watkinson et al. 2010). Similarly, showing smokers an ultrasound image of atherosclerotic plaque build-up in their carotid artery, together with an image of a disease-free artery, increased perceptions of risk and intentions to stop smoking compared to those who received routine verbal feedback (Watkinson et al. 2010).

Many new vehicles for providing feedback have emerged in recent years due to the role that cellphones, smartwatches, and mobile technology have played in offering options for quantifying personal physical activity. The latest generation of mobile phones often offer applications that provide detailed feedback information as a standard and pre-installed application. In telling me that she had a day full of activity, a friend who may

have described her day to me a few years ago as simply “constant action” or “on the go” might now tell me exactly how many steps her smartwatch logged. In light of new technology, studies have started to explore and employ novel approaches to capturing, analyzing, and providing feedback (Andersson et al. 2018, Sunio & Schmöcker 2017). The accuracy of feedback is greatly enhanced with the precision advantage that these technological devices offer, allowing for objective measures over self-reporting. For further discussion, see chapter 3 of this thesis, in which I present the findings of a field experiment that was conducted in collaboration with Luigi Mittone, Dominique Cappelletti, and Matteo Ploner and employed mobile phone tracking technology to both capture subject movement and provide feedback to the participants.

In addition to providing informational feedback or analysis about an individual’s own performance, descriptive normative feedback that includes measures of performance relative to others—especially in one’s peer group—can trigger a desire to improve behavior to meet or exceed the peer group average in a similar manner to the strategy of illuminating social norms (as discussed above). For example, consumers receiving descriptive normative messages comparing their household energy usage to that of neighbors used significantly less energy in the short-term compared to households receiving only energy saving tips (Frederiks et al. 2015). Peer comparisons act on the notion of relative social ranking, the principle that individuals care about how they compare with others generally and even more so when compared to others in their social group and in close geographic proximity (thus the term ‘provincial norms’). Given the success of peer comparison feedback in reducing the prescription of antibiotics, the use of peer normative comparison feedback is seen as a powerful tool to help physicians reduce unnecessary and unjustified variations in care and increase use of highly valued methods of “best practice” (Navathe & Emanuel 2016). Furthermore, the increasing capability to produce real-time performance data makes generating peer comparisons easier in a host of different settings.

1.4 Behavioral Economics in Policy-Making: the Choice Architect and Nudges

With increasing research into non-rational patterns of human conduct by Kahneman, Tversky, and numerous others following Simon’s theory of bounded rationality, the field

of behavioral economics has evolved throughout the past half-century and currently serves an important role in guiding policy. The concepts detailed above seek to understand and provide explanations for a wide array of human behaviors displaying irrationality in a systematic manner. As described in the examples offered above, the concepts detailed herein illuminate not only the existence of suboptimal patterns of conduct but also shed light on reasons for these patterns. Thus, they allow those seeking to alter or improve individual decisions a set of theories upon which to develop strategies or “tools” for enhancing the decision-making setting in a way that encourages optimal choices. If we look at the advertising methods, it seems that private firms have long understood similar concepts deriving from psychology that encourage consumers to choose their products at the point of sale. For decisions related to health outcomes, it behooves those shouldering the costs of health-related illness—governments, the public as citizens paying taxes to sustain public health care costs, and insurance companies—to counter unhealthy behaviors using the tools gleaned from behavioral economics.

The intentional construction or alteration of the decision-making environment has been the subject of much discourse in recent years due to the development of behavioral economics and the use of its principles by policy makers. As numerous economists have presented their findings in popular science books, the concepts of behavioral economics have captivated the general public. One of the best-selling books about behavioral economics geared to the public is *Nudge: Improving decisions about Health, Wealth and Happiness*, written by economists 2017 Nobel prize-winning Richard Thaler and Cass Sunstein (whose early death occurred before the awarding of 2017 Nobel prize in Economics). In *Nudge*, they present *choice architecture*, a term they coin in reference to the practice of influencing individuals’ choices by designing or altering the manner in which information and choice options are presented to people. Choice architects recognize that individuals have cognitive biases, use heuristics, and have bounded rationality, as we have discussed throughout. In their words, Thaler and Sunstein describe these irrational individuals as Humans whom they contrast with Econs, the perfectly informed, utility-maximizing agents with stable non-changing preferences who match the rational economic man of traditional economic theory. Given their knowledge about Humans, choice architects use their understanding of the concepts of

behavioral economics to encourage better decision making in a number of ways, including by setting defaults carefully, by simplifying excessive information to highlight certain aspects or facilitate choice comparisons, and by framing the information or alternate choices in a certain way.

However, performing choice architecture can be controversial because it may amount to, or be viewed as, paternalistic because of the assumption that the choice architect knows what is best for the Human, even more than the Human himself—and thus is protecting that Human from his own poor decision making. In fact, Thaler and Sunstein propose the theory of *libertarian paternalism*, that includes the libertarian notion that people be given choices but also the paternalistic idea that experts or policymakers guide them through the decision. The most important feature in their vision of libertarian paternalism is the *nudge*, which they define as any aspect of the choice architecture that alters (or seeks to alter) people’s behavior in a predictable way without forbidding or significantly incentivizing any options. In addition, note Thaler and Sunstein, nudges should also be easy to implement and “cheap to avoid”. (Since the writing of their book, the term ‘nudge’ has come to represent a whole host of interventions including most of those discussed herein.)

Because people who have been ‘nudged’ are encouraged to act in ways the choice architect wants them to rather than how they themselves want to, and the potential danger that nudges present is a paternalistic abuse of power—where the policymaking choice architect encourages behavior she wants rather than that in the Human’s best interest. Major objections to manipulations of the choice architecture include the lack of transparency (in contrast to achieving policy goals by legal instruments or fiscal instruments) and susceptibility to the public officials’ own behavioral biases and use of heuristics (Reisch et al. 2016). Despite these criticisms, policy makers increasingly nudge people toward making better choices in health behavior and beyond.

In the health area, where poor health choices on an individual level have significant costs financially on personal and societal levels, and in terms of personal well-being, the promise of behavioral economics is new insight to supplement existing public policy

approaches. But its power would be greatly diluted if people are suspicious of policies involving choice architecture. However, in a recent study exploring whether individuals in six European countries approved of nudging healthy eating behavior, Reisch *et al.* (2016) found that strong majorities in all countries generally did approve of the health nudges. The study participants considered nine government interventions—such as public education messages mandated in movie theaters discouraging smoking and overeating, mandatory subliminal advertising of same type in movie theaters, mandatory information nudges requiring calorie labels and high salt content warnings, and mandatory choice architecture for retailers like candy-free cashier zones. Possibly owing to their recognition of individuals’ lack the self-control and discipline in maintaining healthy eating habits, the participants viewed soft nudges as “benign assistance rather than malicious tricks” (Reisch et al. 2016).

Whether related to nudge concepts and theory of libertarian paternalism espoused in the 2008 book by Thaler and Sunstein or not, the idea that policymakers at government and private levels might best help people facing critical decisions by nudging them toward better choices caught fire. In 2010, the government of the United Kingdom, a coalition led by David Cameron including the usually disparate Conservative party and Liberal Democrats, established the Behavioral Insight Team (BIT) to investigate ways of “harnessing the insights from behavioral economics and social psychology” to meet the coalition’s commitment to “help people to make better decisions form themselves” (Sanders & Hallsworth 2015).² The team went to work on testing and implementing nudge interventions to address a broad spectrum of issues from increasing levels of tax compliance and electoral participation to encouraging organ donation and charitable giving. Despite the support of Cameron and the coalition-at-large, the establishment of BIT was met with skepticism by many public officials; in response, the small organization was given probationary status based on demonstrating results, an important factor leading to BIT’s consistent use of randomized controlled trials with evaluation of causal effect (Hallsworth 2016). BIT has undertaken numerous projects

² This so-called ‘Nudge Unit’ operated for some years in probationary role of the UK Cabinet office, but in 2014 became a partially private social purpose entity, with owners (in equal shares) including the government but also its employees and Nesta, a charity organization. Sanders & Hallsworth (2015).

to improve the British National Health Service. In one example from 2016-17, they achieved a 38% reduction in the number of patients referred to over-booked hospitals by engineering a pop-up prompt in the online referral system used by general practitioners.

Other countries followed suit in incorporating behavioral insights, and Table 1 represents only a partial list. For example, in 2014, the United States followed suit by establishing the Social and Behavioral Sciences Team (SBST) and in 2015, President Obama ordered government agencies to use behavioral insights to improve the efficiency and effectiveness of their work. Following Thaler and Sunstein’s general recommendation that nudges be cheap and easy to implement, the SBST’s application of behavioral insights were generally low-cost and involved simple re-framing of information, (re-)adjusting of defaults, or sending (sometimes personalized) reminder letters or text messages employing the basic techniques discussed above. Among other results, SBST was successful within its first year in increasing government revenue from small businesses and increasing rates of (a) health insurance enrollment, (b) enrollment of veterans in government-provided employment services and government-provided pension plans, (c) college enrollment by high school graduates, and (d) student loan repayment compliance for those who had missed a payment (Social and Behavioral Sciences Team 2015 Annual Report). Reisch et al. (2016) report that over 150 governments enlist behavioral insights to guide policy. In addition, both the World Bank and the European Commission have launched major new initiatives to apply behavioral insights to policy (Hallsworth et al. 2016).

Table 1.1 Examples of Government Policy Initiatives or Partnerships Incorporating Behavioral Science, Source: adapted from UN Environment Programme (2017)

COUNTRY	BEHAVIOURAL SCIENCE POLICY INITIATIVES
United Kingdom	The UK was the first country to create a central high-level policy unit in 2010 to incorporate behavioral insights into policymaking. The Behavioural Insights Team (BIT) was originally set up to improve public services based on behavioral science principles. BIT also works with other countries to achieve effective public policy design.
Denmark	The Danish Nudging Network, founded by behavioral scientist Pelle Guldborg Hansen in 2010, partners with governments and companies to design and test interventions through the application of behavioral science theories.
Australia	Australia’s New South Wales Government, in partnership with UK’s Behavioural Insights Team, created a Behavioural Insights Unit housed under the Department of Premier and Cabinet in 2012. The unit incorporates insights from behavioral science literature to effectively deliver government services.

United States	The White House Social and Behavioral Sciences Team (SBST) was established in 2014 by the Obama Administration. SBST uses insights from social and behavioral science to improve the U.S.'s federal policies and programs. City governments, such as New York City, are also beginning to incorporate specialized behavioral policy teams to develop and implement initiatives. Defunct from January 2017 with entrance of Trump Administration.
Singapore	The Behavioural Insights and Design Unit was established by Singapore's Ministry of Manpower in 2014 to improve the government's policies and programs as well as better understand how individuals behave with regard to these government services.
Canada	The government of Ontario created a Behavioural Insights Unit (BIU) in 2015, which launched the Centre of Excellence for Evidence-Based Decision Making Support that aims to use behavioral science research to improve services offered by government agencies, and design and test interventions that are cost-effective and yield better outcomes.

1.5 Applications of Behavioral Economics to Specific Health Settings

Within the above discussion of the concepts of behavioral economics that are most pertinent for health decisions, numerous examples have been used to illustrate the application of these concepts in health settings. In this section, the application of behavioral economics concepts is considered at greater length and by health area, including applications to encourage healthy eating patterns, physical activity, vaccine uptake, smoking cessation, illness-detection behavior, and sanitary behaviors such as hand-washing.

1.5.1 Encouraging Healthy Eating Patterns and Weight Loss

Among the most worrisome patterns of unhealthy behavior is the persistent struggle with making healthy food choices, as poor food choices can result in obesity, diabetes, and a number of other health problems. People face seemingly ever-increasing options for unhealthy and nutrient-deficient processed food choices when grocery shopping or eating out, a factor that renders more challenging the favoring of unprocessed foods with rewarding nutritional properties. Despite retaining control over their diet, individuals must navigate carefully in a food environment that in recent times has introduced an influx of hyper-palatable foods high in sugar, fat, and salt (Gorski & Roberto 2015). Based on assumptions that people act rationally when making food choices, government policy has tended toward addressing problems such as obesity and obesity-related diseases by providing better information about nutrition (Liu et al. 2013).

However, policies guided by the rational view of human behavior have been relatively ineffective in impacting individuals' food choices, due to difficulty in understanding (or lack of motivation to consider) nutritional information, and limited self-control (Schwartz et al. 2012). In 1994, the U.S. implemented the Nutrition Labeling and Education Act (NLEA) requiring accurate nutritional information to be provided in a uniform manner on food packages. However, most empirical investigations of information disclosure policies have found that simply providing information is not effective in changing the behavior of those who receive it, or even that, in certain situations, information disclosure backfires, producing the opposite of its intended effects (Downs et al. 2015). For example, little to no impact was noted in terms of diners' choices or total number of calories purchased after the introduction of calorie posting requirements in restaurant chains, according to multiple studies conducted in New York and Seattle (Downs et al. 2015). Despite the provision useful information, it seems that the labeling and calorie posting solutions have not resulted in improving eating choices. In fact, obesity rates (measured as those with a body mass index greater than 30) have doubled in most OECD countries over the past thirty years (Rice 2013). In this section, I consider simple cost-effective interventions based in behavioral economics that hold promise for improving healthy eating patterns.

Several notions from behavioral economics help us understand unhealthy eating habits. Eating habits are generally considered to take place within System 1 system, and thus governed by intuitive, non-deliberative, impulsive thought processes. At the core, present bias, status quo bias, and preference for default options each play a role in the tendency toward poor eating choices (Liu et al. 2013). Present bias, a tendency to overweigh immediate benefits relative to delayed benefits, explains the overvaluation of both the immediate benefit, the instant gratification provided by high-calorie desserts or fried foods and the immediate costs associated with dieting and the simultaneous underweighting of the future costs, the elevated risk potential for health problems in the long-term. Related to the overweighing of present benefits, individuals often make food decisions based on convenience. The convenience of food that is quick and easy to access, combined with the salience of the candy bar at the sales counter or tempting

dessert tray, increase the juxtaposition between present options and faraway future health implications, especially in light of limited self-control. People often try to eliminate the convenience of the unhealthy food item themselves, by removing or failing to refill appetizer bowls, or by failing to purchase (or purchasing a small container size of) an item that they know may test their self-control. The strong influence of convenience has been demonstrated by cafeteria studies showing that people ate more ice cream when the lid of an ice cream cooler was left open than closed, drank more milk when the dispenser was placed close to the eating area, and drank more water when a pitcher was on their table than further away (Wansink 2004). Secretaries who had Hershey Kisses located on their desk ate 5.6 more per day than those who had to walk two meters away from their desk to get them (Wansink 2004).

Status quo and defaults play similar roles in affecting (un)healthy eating behavior. Individuals are prone to stick closely to the current or default option even when better options are available (Liu et al. 2013). Status quo bias shapes food choice in that individuals may have difficulty with changing their patterns of eating, not only the foods themselves but also the portion size they are accustomed to eating. Weight loss generally involves overcoming inertia and preference for the status quo as one must not only substitute unhealthy choices for healthy ones, but also re-set the status quo regarding portion sizes and food choices. The roles of status quo, anchoring, and default options in determining food choices were discussed to some degree above in section 3.3 above. Anchoring, the tendency to attribute relevance or significance to initial information provided, occurs when people eat more when served larger portions or for example, in the study where participants used 30% more pasta when given a 2-pound box compared to a 1-pound box (Roberto & Kawachi 2014). Sticking to the status quo implies relying on food defaults, the vast majority of which encourage unhealthy choices (Roberto & Kawachi 2014) especially in light of increasingly large portion sizes (Liu et al. 2013). Consumption norms can provide an easy rule of thumb for consumption behavior, as package size, variety, plate size, or eating in the presence of others suggest norms for acceptable consumption quantity (Wansink 2004).

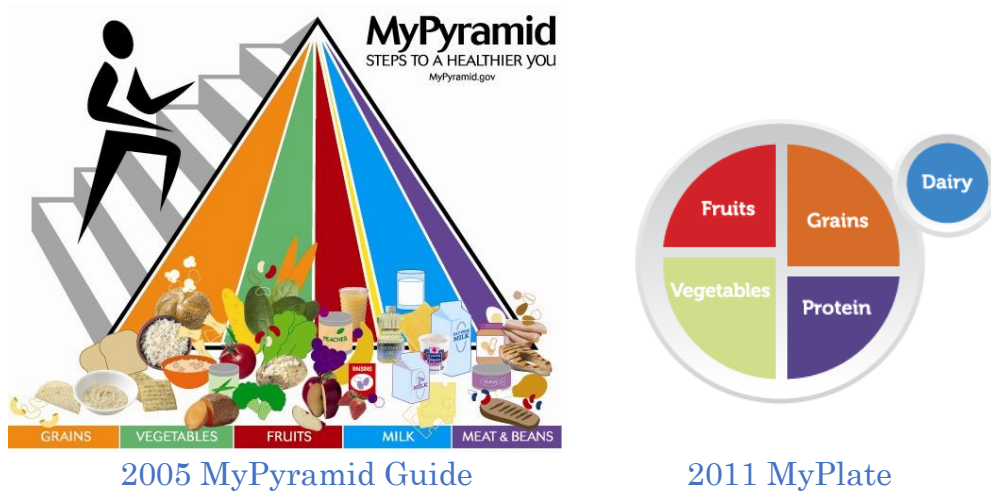
Changing defaults in the entire realm of food experiences can help reduce the amount of food consumed. Studies have shown that decreasing portion size of meals, sandwiches, and snacks all significantly decreased the total food consumption amount (Liu et al. 2013). Studies have also demonstrated that the sizes of serving bowls, individual portion dishes, and packages provide norms on how much to serve and to consume; even nutrition experts served themselves 31% more ice cream when given a larger personal bowl, without being aware that they had done so (Liu et al. 2013). An important suggestion is to enhance healthy eating by altering the default side dishes and drinks—for example, from French fries to salads, and from soda pop to water—served automatically with restaurant, cafeteria, and fast food meals. One study recommended explicitly asking customers to “right-size” rather than “downsize” portion sizes as they found that doing so suggested optimal (versus negative, with use of “downsize”) social consumption norms and triggered self-control in customers at Chinese restaurants (Schwartz et al. 2012). These examples underscore the potential importance of adjusting the default portion sizes to shift expectations, so that status quo and anchoring shift accordingly toward consumption norms that are more representative of a truly healthy portion sizes. Interventions altering the default serving size can create new anchors to guide portion control, as demonstrated by a Canadian study in which obese diabetes patients given portion control plates lost more weight and needed less diabetes medication than those in the control group given standard dietary teaching (Pinto et al. 2014).

Small, often barely discernible, changes to the eating setting or grocery store environment are appealing interventions in part because they do not rely on people making effortful changes or comprehending complex health information (Marteau et al. 2012). They encourage healthy behavior by acting on System 1 intuitive style cues, and thus circumventing the need for individuals to engage in energy-consuming System 2 deliberate thought processes to comprehend complex health information. For example, prominently displaying or positioning healthy food options in restaurant and cafeteria settings increases the salience of those choices while decreasing the salience and perceived convenience of unhealthy choices. Interventions such as putting fruit rather than fatty snacks near the cashier, putting salad bars in the middle of the food-

purchasing area, offering choice of vegetables, and requiring that sweets and soft drinks be paid for by cash rather than lunch cards have been shown to increase selection of healthy food options in school cafeterias (Rice 2013). In short, choice architects can encourage healthy and nutritious choices by making them more convenient in the physical environment and more representative of truly healthy portion sizes in default situations.

The human limitation for processing complex information has also been a factor in deciphering healthy choices. Behavioral economics can offer tools for presenting information in ways that are easier for individuals to digest and understand. In 2005, the USDA introduced MyPyramid (depicted below in Figure 3), a chart depicting food guidelines using rainbow graphics to indicate serving amounts across different food categories and guidelines provided information such as daily consumption recommendations such as 6.5 ounces of meat and 9 ounces of grains. Although designed to foster healthy food decisions by provision of nutritional information, MyPyramid was criticized because the complexity of the pyramid information rendered it difficult for people to process, particularly in light of its numeric information—for example, people are not easily able to picture the true size of a 6.5-ounce steak serving (Robert & Kawachi 2014). Given that humans have limited attention and limited capacities for numeracy and complex processing, it is unsurprising that individuals had significantly greater difficulty recalling the MyPyramid guidelines as compared to a far simpler half-plate green graphic with message to “fill half of your plate at every meal with fruits and vegetables”. Immediately following exposure, only 19% recalled the MyPyramid guidelines, versus 85% recalling the half-plate message; one month after exposure, the recall rates were 0.7% for MyPyramid and 62% for the half-plate graphic (Roberto & Kawachi 2014, Riis & Ratner 2011). In effect, the half-plate graphic reflects application of concepts from behavioral economics by providing a visual rule of thumb that is memorable because it provides visual simplification, easy, and inexpensive to implement. In fact, the U.S.D.A. updated its guidelines in 2011 and replaced the pyramid shape with a much simpler MyPlate graphic (depicted below), somewhat similar to graphic half-plate graphic used by Riis and Ratner.

Figure 1.3. Towards Simplification: 2005 and 2011 USDA Food Recommendations
Source: USDA (<https://www.choosemyplate.gov/brief-history-usda-food-guides>)



Other applications to simplify information and provide signifiers to help grocery shoppers and restaurant clients base their choices on salient information. The ‘street light system’ has been introduced in various countries to provide simplified information about nutritional value using visual cues, indicating good choices (green), neutral choices (yellow), and bad choices (red) (Oullier et al. 2010). The simplification, vividness, and salience helped consumers who were three times more likely to identify the healthier food products if they instead used the streetlight system, which ranked and color-coded levels of four nutrients (total fat, saturated fat, sugar, and sodium) as high, medium, or low (Thorgeirsson & Kawachi 2013)

Finally, another strategy that incorporates understanding of temporal inconsistency and present bias to encourage healthy behaviors is that of pre-commitment, any means through which individuals impose constraints on their own future behavior (Liu et al. 2013). For example, pre-commitment to ordering healthy food options in the present moment when one knows to be susceptible to poor choices in a future moment has been demonstrated to potentially reduce calorie consumption (Gorski & Roberto 2015). This type of commitment may prove helpful in placing online grocery shopping orders for future delivery, as well as pre-ordering school lunches or workplace meals and snacks. A related application incorporating concepts of loss aversion and present bias involves interventions requiring participants to pre-commit money toward their own healthy behavior, with the risk of losing it if they do not attain a particular goal. Commitment

devices are arrangements made to help fulfill a plan for future behavior, especially when they anticipate difficulty in sticking to such plan (Bryan, Karlan, and Nelson 2010). Commitment devices such as deposit contracts encourage people to change their behaviors based on the principle of present bias in which people are more willing to commit to performing an action, one that they prefer not to do in the present moment, in a future moment. Behavioral economists often refer to Odysseus' decision to tie himself to the mast when passing through the area of the Sirens' beautiful singing to prevent himself from jumping ship as the original example of a commitment device (Rice 2013). Furthermore, Bryan, Karlan, and Nelson (2010) point to ad hoc commitment device behavior such as only taking a fixed amount of cash out to party for the night, buying junk food in small rather than large packages, and leaving one's laptop or papers at the office to avoid working at night.

In one study (Volpp et al. 2008) involving commitment devices (deposit contracts), participants were given the goal of losing 16 pounds in 16 weeks. They could deposit between 1¢ and \$3 each day of the month, with the added incentives of employer matching and additional employer contribution of \$3 per day. Those who met their target weight at month's end received the accumulated money whereas those who did not lost their deposited money, which was contributed to a pool to be equally divided among all participants who lost 20 pounds or more over the course of the experiment's sixteen weeks. The participants who had committed to the deposit contracts lost on average three times as much weight (14 pounds) as those in the control group (4 pounds), although it is uncertain whether those individuals were able to keep the weight off after the commitment period ended. Of note is the relative cost-effectiveness of commitment devices with respect to other approaches to achieving weight loss such as behavioral interventions and pharmacotherapy tend to produce modest results at significant cost, while surgical treatment, although effective in morbidly obese individuals, has a relatively high rate of complications and significant expense (Volpp et al. 2008).

1.5.2 Encouraging Physical Activity

Like the effects of poor nutritional choices and unhealthy eating patterns, lack of physical activity is a major risk factor for non-communicable diseases, the leading cause of death worldwide. The increase in sedentary lifestyles has increased levels of physical inactivity, which along with increases in unhealthy eating patterns, has played a dominant role in the burgeoning numbers of people who are overweight or obese. As with unhealthy eating, poor exercise habits are often grounded in problems of intertemporal choice and present bias as individuals tend to overvalue present costs of undertaking physical activity and undervalue future benefits of improved health outcomes due to active lifestyle. Social information is particularly influential on individual decision making, and social norms regarding physical activity levels can serve as an anchor from which individuals gauge their own activity levels (Zimmerman 2009). Individuals consider social information to be particularly relevant, especially as it regards others in their social peer group. Identity—how individuals view themselves—can depend on social context, such as peers but also including those around an individual such as neighbors.

As with meeting weight loss goals, pre-commitment can help individuals meet goals for healthy lifestyle behaviors such as increased physical activity. Commitment devices have provided a solution for the effect of time-inconsistent preferences, in individuals who may want to adhere to healthy lifestyle but frequently succumb to temptations for immediate gratification (Matjasko et al. 2016). The website StickK.com allows individuals to input a goal such as a visiting the health club to exercise three times per week, or losing 5 pounds in two months, and to enter credit card information which will be automatically charged to make a donation to a specified donor if the goal is not met. Not only have the precommitment devices offered by StickK.com proven successful in helping people overcome limited willpower with respect to their exercise goals, researchers who manipulated the StickK.com website and nudged people to undertake longer exercise commitments completed the commitments and more weeks of exercise (Matjasko et al. 2016). The StickK.com website as of mid-March 2018 claims individuals have created 396,387 commitments, completed 963,438 workouts, resisted smoking 23,294, 685 cigarettes, and wagered over \$35,000,000 to date. Commitment contracts bring the risk of loss into the present moment and rely on loss aversion to keep

individuals motivation (Thorgeirsson and Kawachi 2013). As it requires the payment upfront to use gym facilities for the month or year, contracts for gym membership act as commitment device—wherein the individual joining in the present moment incurs an immediate cost and commits to enabling or dictates future healthy behavior by prepaying for gym visits. Prepaid exercise classes are another example of precommitment devices undertaken in everyday life.

Another valuable tool from the behavioral economist's toolbox is for encouraging exercise and counteracting limited willpower is feedback. In numerous areas of personal health, immediate and frequent feedback increases awareness of health behavior and can thus provide a crucial step to changing behavior and counteracting bounded willpower (Godino et al. 2013). Self-monitoring, the most basic form of feedback and a key element of behavioral self-regulation, has been correlated with weight loss and increased physical activity (Thorgeirsson & Kawachi, 2013). In a review of 26 studies with a total 2767 participants, Bravata et al. (2007) found that pedometer use was associated with significant increases in physical activity (an average of 27% over baseline) and significant decreases in body mass index (BMI) and blood pressure. Furthermore, peer feedback based on social comparison has been effective in increasing levels of physical activity, as discussed more extensively in section 3.5 of this chapter and in Chapter 3.

Some argue that physical activity will increase if it becomes the default option in a given environment, such as new building designs that make stairs comparatively easier to access than elevators (Luoto & Carman 2014). (Das et al. 2016) explore ways to shift the status quo of inactivity as the default in the workplace, and suggest encouraging active alternatives to sitting by both short-term, less expensive interventions—such as automated screen saver reminders to prompt brief activity breaks, balance balls replacing chairs, active or standing meetings, support for active commuters such as preferred parking, annual workplace events such as 5K runs or golf outings, and movement friendly dress codes—as well as long-term more costly options—such as standing or treadmill desks (opt-out instead of opt-in), building design that makes stairs prominent in placement, accessible, convenient, and visually appealing and promotes

walkability on work grounds, on-site showers and accessibility to active transport routes for commuters. Many of the low-cost suggestions use the principles of behavioral economics to induce a potential shift in social norms, making active options the default in the workplace. In encouraging physical activity in the workplace, employers have the opportunity to increase levels of healthy, productivity, and wellness for all employees—a benefit to both the employer and employee (Das et al. 2016).

Finally, the power of framing is important when encouraging physical activity. Zimmerman (2009) suggests promotion of increased physical activity by framing it as something fun to do rather than presenting exercise as an obligation as doctors and policies currently do by using the jargon of minimum recommendations (e.g., of “30 minutes per day, 3 days per week”). Recent works have researched models to increase physical activity in children and adults by considering theoretical frameworks focused on fun (Visek et al. 2015).

1.5.3 Encouraging Vaccine uptake

Concepts from behavioral economics offer potential for increasing immunization rates for mandated childhood vaccinations and voluntary immunizations such as tetanus vaccines or annual flu shots. Chapter 2 offers an in-depth discussion of existing methods and use of behavioral economics to inform and improve rates of childhood vaccination, within the research study exploring one such method. Without reiterating the later discussion, I simply mention pertinent factors herein. The first is that social norms are an important factor in vaccination decisions. Parents may give great weight to the decisions that other parents have made regarding vaccination. Thus social information is important, including social parenting norms in general but particularly social identity with others in parents’ perceived peer group. Moreover, underlining the norms of experts provides a guideline for parents facing decisions regarding childhood vaccination. Simply highlighting consensus among the medical community, by stating for example that 90% of doctors agree vaccines are safe, has been shown to reduce concern about childhood vaccination and increase intentions to vaccinate (Matjasko et al. 2016).

Defaults clearly play an important role in vaccination. Whether or not childhood vaccinations are required by law determines one important default, but generally even where it is, there is an opportunity to retain parental control over the vaccination decision by an opt-out choice. The language used by pediatricians when speaking about vaccination compliance may be particularly important, as they convey the default and status quo options to parents in many cases. Thorgeirsson & Kawachi (2013) note that the use of defaults has been suggested for mandating healthcare workers to receive annual influenza vaccinations, with opt-out possible only if they decline in writing.

Simple prompts have been effective in encouraging health behaviors by providing stimuli that is new and highly visible, and several studies have demonstrated the prompting people to make a plan effectively promotes vaccination (Matjasko et al. 2016). One study sent college students messages about the benefits of a tetanus vaccine and found that despite being effective in shifting the students' beliefs and attitudes about the vaccine, students did not vaccinate in significant numbers. However, when the information sent also included a card prompting students to write down a date and time that they intended to get vaccinated, the percentage of students who followed through and vaccinated increased by an order of magnitude (Thorgeirsson & Kawachi 2013). Another study confirmed that emailed appointment times and locations for their next influenza vaccination increased vaccination rates by 36% (Matjasko et al. 2016). These studies demonstrate simplistic, low-cost, and yet quite effective interventions that guide individuals toward vaccination compliance behavior.

1.5.4 Encouraging Smoking Cessation

Throughout the earlier sections herein, multiple concepts have been illuminated using the example of smoking cessation. The chronic use of tobacco presents significant health risks for individuals and is particularly dangerous when combined with other health-defeating behaviors such as poor eating habits and physical inactivity and conditions such as obesity. Explanations of whether smoking and tobacco use are rational or irrational in light of addiction have focused on a the theory of rational addiction (TORA), a commonly used model from traditional economics to explain addictive behaviors, but works in behavioral economics has shifted from the question of rationality or irrationality and focused on developing interventions to try to improve behaviors with

regard to addictive substances by taking into account decision-making heuristics (Luoto & Carman 2014). One of the most common interventions to encourage smoking cessation is the use of incentives. While incentives are typically a tool of traditional economics, the way that they are designed or structured may be improved using insights from behavioral economics. The effectiveness of incentives offered to those who abstain from the addictive good (cigarettes) has been improved by taking into account the effects of present bias and time-inconsistent behaviors, by for example offering immediate rewards for compliance (Luoto & Carman 2014). In addition, commitment contracts have been used successfully to promote smoking cessation, as people post deposits in a present moment of willpower that can help them overcome future moments of depleted willpower to get their deposited money back rather than forfeit. The StickK.com website boasts that its deposit contracts have prevented the smoking of over 23 million cigarettes as of mid-March 2018. One program in the Philippines involving deposit contracts had greater results seen one year later than during the program duration itself and another study found that deposit contracts resulted in greater behavioral change than reward programs (Matjasko et al. 2016). Both studies showed however that getting individuals to participate can pose a challenge.

Peer effects have been shown to have a significant influence on alcohol and tobacco use, as discussed in section 3 above. Self-help peer groups such as Alcoholics Anonymous and Weight Watchers take advantage of the social peer group as support for overcoming self-control problems related to bounded willpower (Luoto & Carman 2014). Given the effect of peers on smoking and drinking, one randomized control trial undertaken in 59 Welsh school to address teen smoking included peer mentors, students trained to discourage smoking in informal conversations with peers, in treated schools (Kessler & Zhang 2014). Students in the treated schools showed a decreased likelihood for smoking one year later.

1.6 Conclusion

The documented increases in diseases and deaths related to lifestyle and behavioral factors are alarming and have proven largely resilient to tradition policy measures. Choice architects including governments, policy makers, health care providers, and public health professionals, as well as individuals themselves need new improved

methods for dealing with the burgeoning health issues faced on individual and societal levels. Traditional economics is limited by its assumptions that people act in rational ways to pursue their own best interest. Behavioral economics has developed through attempts to better understand and explain how people actually behave in real world by leveraging insights from the field of psychology. From Herbert Simon's curiosity into bounded rationality to the models developed by Kahneman and Tversky in Prospect Theory, the field of economics has expanded to incorporate an entire subfield that recognizes the necessity of studying the systematic patterns of irrationality present in actual human behavior. The mapping of cognitive biases and heuristics has provided enormous explanatory capabilities for understanding human behavior, as have the understanding of how social norms, limited attention, and states of depletion affect decision making. We are only able to improve behavior and outcomes in health and other realms if armed with a clear understanding of how human beings act.

From understanding true human behavior to addressing how to make improvements to it is a significant leap. In the studies that I have cited throughout, behavioral economists have tested both the depths of their understanding of human behavior and their ability to design interventions to help guide better behavior. The frequent inadequacy of interventions to produce the hypothesized or intended effects in these studies indicates the complexity of the work, and the necessity to develop applications that have been well-tested in random control trials of solid construction. In the health area, given the many troubling tendencies toward health-defeating behaviors, the promise of behavioral economics for choice architects and policy makers is that of devising strategies and tools for improving methods of encouraging healthy behaviors without unwarranted encroachment on the freedom of human choice. These tools—and above we have discussed some, including framing, setting defaults, and making healthy choices more vivid, visible or salient—can be added to the policy maker's toolkit and used in combination with the traditional strategies employed in health settings, such as education, taxation and incentives, and regulation. Policy makers might also consider the way that companies use insights from behavioral economics to influence health behaviors and attitudes toward products that they sell and consider whether companies unfairly manipulate individuals by encouraging unhealthy choices or health-defeating

behaviors. Protection for consumers may necessitate policy responses if companies unfairly use the principles of human decision-making that underlie behavioral economics to increase their profits.

Chapter 2.

Parents who (don't) vaccinate children: Do scope and source of available vaccination information matter?

With Matteo Ploner, University of Trento

Abstract

Objective: The study explores whether the source and the scope of vaccine-related information affects individual intent to administer childhood vaccinations, and whether demographics or general attitudes toward medical sources affect the decision to vaccinate. **Methods:** In an online survey performed in July 2016, individuals in four treatments were presented with general information about the MMR vaccine with differing assessments of associated risks. They were asked whether they would advise friends to administer the MMR vaccine, whether they would vaccinate their own child, and their frequency of medical consultation, level of trust in doctors, and demographic information. **Results:** Individuals were more likely to choose vaccination when risk information was grounded in scientific evidence and emphasized collective societal risks. Trusting doctors and medical information had a statistically positive effect on opting and advising for vaccination. Females and young individuals viewed vaccines more favorably. **Conclusions:** Campaigns encouraging vaccination should present accurate science-based information, bolster doctor images as credible scientific sources, and tailor specific messages to males and older parents as both view vaccination less favorably.

2.1 Introduction

In 2014, roughly fifteen years after documenting of the elimination of measles, the United States witnessed a record 667 measles cases, up from 55 cases in 2012 and 187 cases in 2013. Although the source of measles infection generally derives from those who live or have travelled outside of the US (where they have become infectious), the outbreak and spreading of the disease is facilitated by the existence of unvaccinated individuals.³ Given the 2014 and other recent outbreaks, considerable media attention has been focused on the “Anti-Vaxxers”, an outspoken group of parents who chose not to vaccinate their children based on their view that the potential side-effects of vaccine ingredients are more harmful than the diseases themselves, those being measles, mumps, and rubella in the case of the MMR vaccination.

Despite a general consensus within the scientific community regarding the fact that the benefits outweigh the risks of childhood vaccinations, concerns about vaccine safety and the anti-vaccination movement have managed to gain a stronghold of support, even amongst celebrities. Several sources of doubt regarding vaccine safety exist, one being a 1998 article in *The Lancet* by Andrew Wakefield et al. which claimed a potential link between the MMR vaccination and autism (Opel et al 2011). Despite the later retraction of the article and media campaigns to dispel reliance on the faulty information, one study evidenced that 20% of the American population remains convinced of a link between autism and the MMR vaccine (Jolley & Douglas 2014) while another research poll found that only 80% of American parents consider vaccines safe (*Washington Post*, 2015). Other doubts about vaccine safety relate to theories that pharmaceutical companies inflate vaccine efficacy, fail to accurately evidence harmful side effects of vaccines, and bribe scientists and government to do the same (Jolley & Douglas 2014). In the US, a recent study

³ Source: National Center for Immunization and Respiratory Diseases, Division of Viral Diseases. <http://www.cdc.gov/measles/cases-outbreaks.html>

revealed concerning increases in vaccine refusal. Specifically, the percentage of US pediatricians reporting parental vaccine refusals increased from 74.5% in 2006 to 87.0% in 2013, with the reported reasoning for vaccine- refusing parents being that immunizations are unnecessary (up to 73% by 2013) (Hough-Telford et al. 2016). Studies examining vaccination decision-making reveal that vaccination acceptance behaviors among parents are not dichotomous but rather exist on a continuum between pro- and anti-vaccination extremes: while less than 5% of parents have strong enough convictions to refuse all vaccination outright, a larger portion—around one-third in the US studies—are ‘vaccine hesitant’, agreeing to some vaccines while refusing others, and/or delaying vaccines so that coverage does not meet recommended schedules (Dubè et al 2015).

Because under the concept of *herd immunity*, a population is protected from diseases only if >93-95% of the population is immunized,⁴ the failure of even small percentage of the population to undergo immunization can lead to disease outbreaks. The current immunization levels worldwide for measles, as measured at the end of 2015, hover between 61% (child receiving recommended two doses of measles vaccination) and 85% (children receiving at least one dose), while the percentage of children in the United States vaccinated against measles by the end of 2014 was 91%.⁵ The UK provides the example of a decline from 92% to 82% of uptake from 1996 to 2003, which decline has been attributed to media coverage following the publication of Wakefield et al.’s (subsequently discredited and retracted) study highlighting serious side effects of the MMR vaccine (Abhyankar et al. 2008). Eliciting greater concern, un- and under-vaccinated individuals tend to cluster together, leading to potential and

⁴ Source: Measles Vaccines: WHO position paper, Weekly epidemiological record (2009), No. 35, 84 (357), <http://www.who.int/wer/2009/wer8435.pdf>.

⁵ Source: <http://www.who.int/mediacentre/factsheets/fs378/en/>, <http://www.cdc.gov/nchs/fastats/measles.htm>

actual increased transmission of vaccine preventable diseases (Dubé et al. 2015). Perceived risks of vaccination have been identified by numerous studies as a reason for non-immunization.

Given the prominence of the internet in the current era, studies have examined vaccine-related content on websites and social media platforms and found them to contain a substantial degree of inaccurate information (Dubé et al. 2015). The spread of information through the internet has allegedly contributed to the increase of vaccine hesitancy and refusal among parents (Betsch et al. 2010, Brown et al. 2010). The internet and recent forms of social media allow for rapid and ubiquitous sharing of (mis)information and have allowed new methods of organization and empowerment in online communities arguing for or against vaccinations (Larson et al. 2011). In a study regarding vaccine information sources used by parents, Jones et al. (2012) found that compared to parents who did not use the Internet for vaccine information, those who sought vaccine information on the Internet were more likely to have lower perceptions of vaccine safety, vaccine effectiveness, and disease susceptibility, and were more likely to have a child with a nonmedical exemption (Jones et al. 2012). The aforementioned authors note that attempts by the media to offer balanced coverage to all viewpoints exacerbates the challenges to public confidence in vaccines by granting equal media space to outlier views and small extremist opinions as views validated through a rigorous process of peer review by the scientific community (Larson et al 2011).

Given the serious potential health implications to populations at large by a decline in the uptake rate for the MMR vaccination, we are motivated by the potential ill effects of the current anti-vaccination movement to explore how public health campaigns can best develop strategies to provide evidence-based information to parents. Due to the propagation of doubts and media-sensationalized mistruths regarding vaccine safety, the reality of the true

benefits and risks of the MMR vaccination may be difficult to discern for parents searching for reliable information. Our study considers whether presenting vaccine safety information in scientifically accurate evidence-based formats versus experience-based sensationalized manners affects individuals differently, as measured by their propensity to vaccinate, a clear reflection of their views on vaccine safety. Furthermore, we explore whether stressing individual benefits of vaccination rather than collective benefits (herd immunity) impacts parental decision making.

2.2 Theoretical Background and Current Literature

The parental decision regarding childhood vaccination has been extensively studied. Brunson (2013) researched the roots of parental attitudes toward vaccination decision-making, and to identify best intervention strategies. She found that parents assessed the decision according to whether they were ‘acceptors’ (generally relying on social norms), ‘reliers’ (relying on others for information, direction, and advice), or ‘searchers’ (actively researching public information on their own), and that interventions must address differently each of these assessment method types (Brunson 2013). In fact, since the prevailing social norm is to vaccinate, acceptors will select to administer vaccines unless their social peer group predominantly selects not to vaccinate. Betsch et al. (2015) suggest that vaccine refusal is determined by 4 “Cs”, complacency, (in)convenience, rational calculation of pros and cons, and lack of confidence, but postulate that only those refusing vaccination due to lack of confidence (the latter group) is obstinate and infected with mistrust due to anti-vaccinations movements. In their review of determinants of parental decision-making regarding vaccination, Dubé et al. (2015) trace the history of vaccination opposition and resistance dating back to origins when the first vaccines were introduced in the 1790s through to the modern-day anti-vaccination movements, and the authors identify contextual determinants such as communication/media, religious values, social norms, and health

policies, organizational determinants related to accessibility and quality of vaccination services, and individual determinants such as parents' knowledge, attitudes and beliefs or sociodemographic characteristics.

As current scientific evidence is unwaveringly in support of the promulgated vaccination recommendations, we might ask how and why vaccination hesitant parents involved in the decision-making process are led astray from the rational evidence-based choice to vaccinate their children according to established national and international health protocols. Behavioral economics offers the concept that individuals may rely on cognitive biases and heuristics to simplify complex decisions by implying judgements about risks. For example, exposure to anti-vaccination information may cause parents to perceive vaccines as presenting greater risk than in fact indicated by scientific evidence because of the *availability bias*, the tendency to judge events as frequent if they are easily recalled. Likewise, due to the *omission bias*, individuals have been shown to be more averse to risks associated with an action—such as receiving an ‘unsafe’ vaccine—than to risks associated with inaction—the chance of contracting a vaccine preventable disease (Dube et al. 2015). While the media coverage followed by the decision maker and other elements of the societal context are important and difficult to control, drafters of vaccine information might best factor in the effects of these biases within a balanced evidence-based discussion of the risks and benefits of vaccination.

Much of the current research tends to be focused on improving the content and presentation of vaccine safety information. In an experiment testing the attractiveness of first-person narrative accounts detailing vaccine side effects in social media postings versus clear statistics regarding the occurrence of vaccine-adverse side effects, Betsch et al. (2011) found that for those reading the narratives, bias resulted both in judging the riskiness of the vaccination and (less so) the subjective probability of side effects. Jolley & Douglas (2014)

investigated the impact of anti-vaccine conspiracy theories and beliefs on vaccine intentions and demonstrated that exposure to anti-vaccine conspiracy theories was associated with lower intention to vaccinate. Their findings suggested that successful interventions against anti-vaccine conspiracy theories should be investigated in future studies, including the manipulation of the source of information presenting counter-conspiracy allegations due to their related finding that belief in conspiracy theories is associated with mistrust in scientific claims.

Indeed vaccination decisions involve trust on behalf of individual decision makers due to information asymmetry between these individuals and the various players in the health care system. Individuals' reliance on various sources helps them to correctly assess and weigh the risks and benefits of vaccination as they have incomplete information. Trust guides the decision on multiple levels: trust in the product (the vaccine itself) and those who produce it (pharmaceutical companies), trust in the doctors and healthcare professionals that recommend and administer the vaccine, and trust in the policy-makers (healthcare system, government, and public health research bodies that approve and recommend or even require the vaccine) (Larson et al. 2018). Likewise, individuals place their trust in information in exchange for simplification of the decision complexity, and such trust inherently hinges upon their assessment of the trustworthiness of the source. Freed et al. (2011) queried 1552 parents by online survey about the credibility and trust levels that they held in certain varied sources (AAP website, government websites, pharmaceutical company websites, television programs reporting child harmed by vaccine, news/magazine articles reporting child harmed by vaccine, anti-vaccination group websites) and people (child's doctor, other health providers, government vaccine officials/experts, family and friends, parents who believe children were harmed by vaccines, celebrities). They found that the perceived credibility of the source of vaccine-safety information had a

marked impact on the acceptance of and the degrees to which the information was trusted and on which it was acted. Similar to Brunson (2013), the authors concluded that since different groups of parents seek and trust information from different sources, diverse strategies must be employed by public health pro-vaccination efforts to reach parents using innovative methods of promulgation to reach as many parent groups as possible.

In their systematic review of vaccine research literature explicitly involving the concept of trust, Larson et al. (2018) identified as a common theme the interaction between trust, information and conflicts of interest due to financial incentives, and particularly the perceived trust violation when health care professionals, the government, or the health system at large were seen to financially benefit from vaccination—leading to a perception of bias in the information provided by these individuals or institutions. In the recent years, the existence of and promotion of evidence-based information about the benefit-risk ratios and vaccine safety has proven insufficient to quell vaccine safety concerns. After examining cases wherein diminished levels of confidence in vaccine safety reached a ‘tipping point’ at which vaccination rates declined due to the creation of a ‘social amplification of risk’, Larson et al. (2011) suggest that the vaccine community has been negligent in failing to demand that research of psychological, sociocultural, and political factors driving individual vaccine decisions match the rigorous scientific evidence supporting vaccination. Our exploration of individuals’ reactions to differing information and sources of such information responds to the calls by these authors for experimental studies investigating how various sources of information act as levers of trust (or mistrust) in relation to vaccination decision making.

Adding to the complex relationship between trust of the information source and skepticism reflected in the information processing and decision making, behavioral economics tells us that the framing of vaccine information plays a

potentially crucial role in the vaccine decision. In some countries, law mandates that vaccine-specific information be provided before administration of the vaccine. For example, under the National Childhood Vaccine Injury Act of 1986 (42 USC §§ 300aa-1 to 300aa-34), United States law requires that information based on available data and information be presented in ‘understandable terms’ and including a concise description of both the benefits and risks of the vaccine, information regarding the availability of the National Vaccine Injury Compensation Program, and ‘other relevant information’. This information, periodically updated, is referred to as the Center for Disease Control (CDC) Vaccine Information Statement (VIS). (As discussed further below, our study in fact presents the exact information and wording from the VIS to one of the experiment treatment groups.) Multiple studies have considered how altering facets, such as the visual appeal, format of presentation or ease of understanding, of the VIS might improve parental confidence or immunization rates (i.e, Klein et al. 2009), or how the timing of VIS distribution may affect the same (Vannice et al. 2011; Frew et al. 2016).

Framing plays a key role in presenting information for public digestion as demonstrated by Grant et al. (2015) in their examination of both pro-vaccine and anti-vaccine websites. They found that whereas the pro-vaccine websites studied focused on the accurate transmission of evidence-based scientific research about vaccines and government-endorsed vaccine practices, the vaccine-skeptical websites studied concentrated on creating communities of people affected by vaccines and used this more personal framework to challenge vaccine-related scientific literature and government practices. The authors consider whether the rhetorical features of framing information via personal narrative are more persuasive to people seeking information about vaccine-related practices. Tangherlini et al. (2016) examined parent forums about health care using an automated analytic approach and found widespread narrative frameworks restructured the vaccine discussion so that “it is taken

for granted that vaccines and not vaccine preventable diseases (VPDs) pose a threat to children”. They conclude that exposure to this endemic narrative framework may influence the health care decision making of parents joining the forums, and call for an examination of the role of persuasive storytelling in influencing personal behavior tied to the diminution of herd immunity in some communities. Pointing to the polio epidemic in the United States and the importance of personal narrative in uniting the country against the disease, Boom and Cunningham (2013) assert that medical experts might better attempt to turn the narrative framework to their advantage. The authors support their call for the use of narratives with evidence that many people misunderstand qualitative information and thus miscalculate true risk levels, and evidence indicating that the use of narratives in populations at risk for hepatitis B resulted in increased risk perception and intention to vaccinate.

The importance of testing vaccination messaging for effectiveness before presenting it to the public is highlighted by the results of a study by Nyhan et al. (2014). The authors conducted a study presenting five groups of parents with either written corrective information regarding the MMR vaccination link to autism, written information about the dangers of the diseases prevented by MMR, visual images of children who have the diseases, a dramatic audio narrative about a child nearly dying from measles, or no intervention. They found that none of the messages increased intent to vaccinate among parents of children aged 17 or younger, and that in fact the images and narrative about children with measles, mumps or rubella actually increased beliefs in serious vaccine side effects. This surprising finding speaks to the importance of understanding individuals’ lack of confidence in vaccination information (and their lack of trust in the sources providing such information), as well as the resulting decline in vaccination rates widely considered a health care crisis.

Given that the parental decision regarding vaccination includes the public health collective benefits and costs, parents may discern that individual interests are in conflict with collective interest: in a population with a high vaccination uptake level, the individually rational strategy of ‘free-riding’ would allow the parent to avoid any possible costs associated with vaccination and enjoy the benefits of herd immunity. In light of this potential social dilemma, Betsch (2014) concluded that strategies to increase vaccine uptake should be directed at correcting skewed risk perceptions and activating pro-social motivation. In an online experiment, Betsch et al. (2013) varied messages among treatments with regard to whether herd immunity made individual benefit, social benefit, or both salient in the vaccination decision context. They found that vaccination intentions decreased when individual benefits were emphasized, and that communication of social benefit both reduced free-riding and increased vaccination intentions. The authors concluded that communicating social benefits of vaccination may prevent free-riding and thus should be explicitly communicated if the individual decisions are meant to consider public health benefits. Although our study offers messages that are more closely aligned with conveying risks of vaccines than benefits, we too explore the effects of framing individual versus collective perspectives in vaccine safety information. Our second research question explores the validity of the indication from Betsch (2013) that emphasis of collective benefits of vaccination are most effective in stimulating intention to vaccinate. Framing our vaccination information literature in terms of vaccine risks rather than benefits, we offer further evidence to the Betsch (2013) study. Our contribution also contributes to the multiple themes in vaccination research illuminated above by its focus on isolating the appeal of scientific versus non-scientific language framed in terms of both individual risk and collective risks of vaccination. Furthermore, we test responses to the vaccine information literature both in terms of attitudes and beliefs, and indicated propensity to vaccinate.

2.3 Objectives and Research Questions

The goal of the current study is to explore how individuals' decisions regarding vaccination of their children is influenced by framing the source of vaccination information as scientific versus non-scientific, and by focusing its scope on private versus collective benefits of vaccination. We also research whether demographics or people's level of trust in doctors affected their own intentions and/or advice given to others regarding administering childhood vaccinations. On the basis of the literature, we sought to explore the following research questions:

Q1: Is the decision to vaccinate influenced by whether the source of vaccine-related information is highly scientific (evidence-based) versus narrative and of questionable scientific accuracy (experience-based)?

Q2: Is the decision to vaccinate affected by whether the source of information is focused on individual benefits/risks of vaccination or collective benefits/risks of vaccination?

In our study, we measured intent to vaccinate based on asking two queries after presenting the varying vaccine-related information—would you advise a friend to vaccinate, and would you vaccinate your own child—so our results reflect a hypothetical decision to vaccinate rather than actual decision followed by administration (or not) of the vaccine.

2.4 Method

2.4.1 *Data Collection*

In our initial survey batches, three hundred and fifteen participants were recruited online in July 2016 via Amazon Mechanical Turk (MTurk), a crowdsourcing tool allowing researchers to conduct online behavioral research

in a high-quality inexpensive experimental setting. MTurk offers online “workers” the opportunity to complete surveys in exchange for compensation, and research indicates that MTurk workers are representative of the U.S. population (Mason & Suri 2012). Our study required that participants were residents of USA over the age of 18 and had achieved on prior MTurk surveys—also called “human intelligence tasks” or HITs—a >90% approval rating, a measure indicating the reliability of their work in other surveys. Participants received 25 cents in exchange for their participation in the study, which was estimated to require of them just five to ten minutes. Using the same parameters, we recruited a second group of 330 subjects in December 2016.

MTurk workers who met the qualifications and opted to participate in the survey were redirected to one of four survey treatments hosted on SurveyMonkey (a platform for creating online surveys). The four surveys represented our four research treatments and each survey contained identical information on the first several screens: participants were informed that our survey involved how people make decisions, that it required 5-10 minutes, and that we accepted as valid only those whose focus on reading and comprehending the survey was evident. Participants were asked to turn off distractions such as televisions and loud music in order to concentrate on the survey. Participants could only partake in only one of four treatments, each of which was presented in precisely the same manner on the MTurk website’s list of available HITs, and duplicity was prevented by employing their MTurk worker number as payment code.

On each survey, four questions were designed to identify subjects who had rushed through the questionnaire without taking time to read the content of the vaccine-related information well, and participants who failed this screening—i.e., were not able to correctly answer the four comprehension questions—were removed from the analyses. The July 2016 experiment took

place in two survey batches, the first occurring on July 21, 2016, and the second on July 28, 2016. The first publications of the MTurk HIT worker request for each survey was made on July 21, 2016, on which date 64 individuals completed the BS-I survey, 61 individuals the BS-C survey, 65 individuals the S-I survey, and 67 individuals the S-C survey on SurveyMonkey. After “cleaning” these results by rejecting the results of any subject who answered incorrectly to any of the four reading comprehension test questions, a second batch of MTurk workers was solicited by a HIT publication on July 28, 2016. On that date, 19 individuals completed BS-I, 14 individuals completed BS-C, 13 individuals completed S-I, and 12 individuals completed S-C. After the cleaning of both July batches and subsequent removal of survey results from those who failed to correctly answer the reading comprehension questions, our final clean sample of 259 total subjects included 65 in BS-I, 60 in BS-C, 67 in S-I, and 67 in S-I . The time required to complete the surveys varied little between the different treatments, ranging from average response time of 5:15 for survey S-C to 6:33 for survey S-I.

The December 2016 experiment was undertaken in the identical manner as that of July 2016 and using the same questions with the exact wording and formatting as the July surveys, except for the addition of one query in all surveys.⁶ The original December 2016 publications of the MTurk HIT worker request for each survey (BS-I, BS-C, S-I, and S-C) was made on December 14, 2016. As with the July surveys, we rejected the results of any subject who answered incorrectly to any of the four reading comprehension test questions to “clean” our results. In this process, we resubmitted the survey HITs several times over the ensuing week and had complete results for all four surveys by

⁶ The new query took the form of two questions added at the end of the other questions for each survey: “Do you have any children?” and if answered yes, “Did you choose to have the MMR vaccination administered to your child(ren)?” We added this question for its potential in capturing validity and measuring discrepancies between expressed intent and actual behavior.

December 22, 2016. The clean sample for the December 2016 survey resulted in an additional 71 subjects in survey BS-I, 72 in BS-C, 69 in S-I, and 68 in S-C. The time required to complete the different treatments vary slightly with average response times ranging from 4:46 for survey S-I to 6:19 for survey BS-I. Thus the clean sample from which we derive our findings consists of 539 total subjects, including 136 participants in survey BS-I, 132 in survey BS-C, 136 in survey S-I, and 135 in S-C.

2.4.2 Design and Material

After being referred to the brief introductory page on SurveyMonkey, the participants of all treatments continued on to a page with information about vaccines in general and the specific recommendation by the US Department of Health and Human Services' Center for Disease Control (CDC) regarding the administration of the two doses of the measles/mumps/rubella vaccine (MMR) at 12-15 months of age and 4-6 years of age respectively. As indicated above, for each survey two questions tested that the participants read and understood the information. Responses to all questions throughout all treatments were required before participants were allowed to continue to the next online page.⁷

Following this general information page with comprehension questions, the surveys diverged for the next page of treatment-specific information followed by two comprehension questions. The experiment was structured with four treatments that explored our research questions by presenting differing

⁷ At any point that the subject attempted to advance to the next page of the survey without answering a question, they were redirected to the unanswered question with the following message highlighted in red: "This question requires an answer. Remember that your survey will only be accepted for payment on Amazon Mechanical Turk if your answers demonstrate that you have read the text throughout the survey." The only exception is the last question in the December 2016 batch of surveys where we specified that only individuals who had children should answer the question.

vaccine-related information according to the between-subject design indicated below:

Table 2.1 - Experimental treatments (labels)

		<i>Benefit/risk</i>	
		<i>Individual</i>	<i>Collective</i>
<i>Source</i>	<i>Barely Scientific</i>	BS-I	BS-C
	<i>Scientific</i>	S-I	S-C

Having presented the general benefits of vaccination on the earlier page, all of the treatments offered vaccine-related information at this point that was focused on the inherent risks of vaccination—with variance in the tone and scientific accuracy of the risks according to treatment.

The BS-I treatment asked subjects to carefully read vaccine-related information from a (fictional) *Parents for Safe Vaccination* website. An excerpt (full scripts of all treatments are available in appendices) of that article was:

...Many of the parents of recovered children I know, myself included, blame vaccines for their child’s regression into autism and use vaccine injury as the roadmap to treat their child. With so many kids with autism, the environment has to be to blame, and vaccines are an obvious culprit. Almost all kids get vaccines — injected toxins — very early in life, and our own government clearly acknowledges that vaccines cause brain damage in vulnerable kids. Time magazine’s article on the autism debate reports that the experts are certain “vaccines don’t cause autism; they don’t injure children; they are the pillar of modern public health.” I say, “that’s a lie and we’re sick of it.”

The BS-I information presented to subjects was styled based on actual anti-vaccination websites.

For the S-I treatment, we exhibited the risk information provided on the CDC's *Vaccine Information Statement*⁸, designed as a scientifically based fact sheet for parents. An extract of the information—drawn verbatim from CDC's material—follows:

A vaccine, like any medicine, is capable of causing serious problems, such as severe allergic reactions. There is an extremely small risk of MMR vaccine causing serious harm or death. Most people who get MMR vaccine do not have any serious problems with it.

Mild problems

- *Fever (up to 1 person out of 6) ...*

Moderate problems

- *Seizure (jerking or staring) caused by fever (about 1 out of 3,000 doses)*
- ...

Severe problems (very rare)

- *Serious allergic reaction (less than 1 out of a million doses) ...*

The S-I treatment is a reflection of the type of information that may be contained in informational leaflets distributed by doctors' offices, but also reflects the factual information found online in medical sites or government health program sites.

In the BS-C treatment, we again drew upon the literature of the anti-vaccination movement concerning vaccine safety. An excerpt of the information given was:

People are so scared they are going to get some horrible disease they risk their precious immune system and opt to pump tons of known neurotoxins and animal cells into their body without blinking!

If we could start exposing the Big Pharma lie – they aren't an industry trying to improve our health, they are trying to weaken us and make us

⁸ <http://www.cdc.gov/vaccines/hcp/vis/vis-statements/mmr.html>

sicker so we are slaves to their expensive drugs, we could end this madness.

The treatment is focused on doubt that the government, politicians, and pharmaceutical companies are truly concerned with the collective good of the population. The implication is that the pharmaceutical companies push vaccination in spite of risks that are significant.

The S-C treatment contrasts by focusing on similar concerns as the BS-C treatment but using a less inflammatory discourse about legitimate concerns regarding potential conflicts of interest that may exist between government and pharmaceutical companies, and the potential weakness of having a passive reporting system for vaccine side effects. An example from the text follows:

William Posey, Congressman (R-FL), stated..., "...[T]oo many top CDC personnel go to work for the vaccine makers when they leave. That's a revolving door that creates a serious conflict of interest and perverts incentives that compromise integrity." ...

The same federal health agencies responsible for developing, regulating and making vaccine policy are also in charge of monitoring vaccine safety. Vaccine safety is monitored by the Vaccine Adverse Events Reporting System (VAERS)... ([that] relies on voluntary reports from consumers and healthcare practitioners) and CDC states: "Limitations of passive surveillance systems include variability in reporting standards, reporter bias and significant under-reporting of events."

The four treatments differed with respect to one another only on each survey's online page presenting the vaccine-safety information and accompanying comprehension test questions.

Following the treatment-specific text with test questions, the participants of all treatments then proceeded directly to the two questions that represent our outcome measures of the vaccine-safety information. Subsequently, each

treatment proceeded to pose six questions measuring frequency and type of medical consultation, and levels of trust in doctors, internet and other sources for medical and health information. Finally, subjects were asked their sex, age, and employment status before receiving instructions for obtaining payment via MTurk.

2.4.3 Outcome Measures

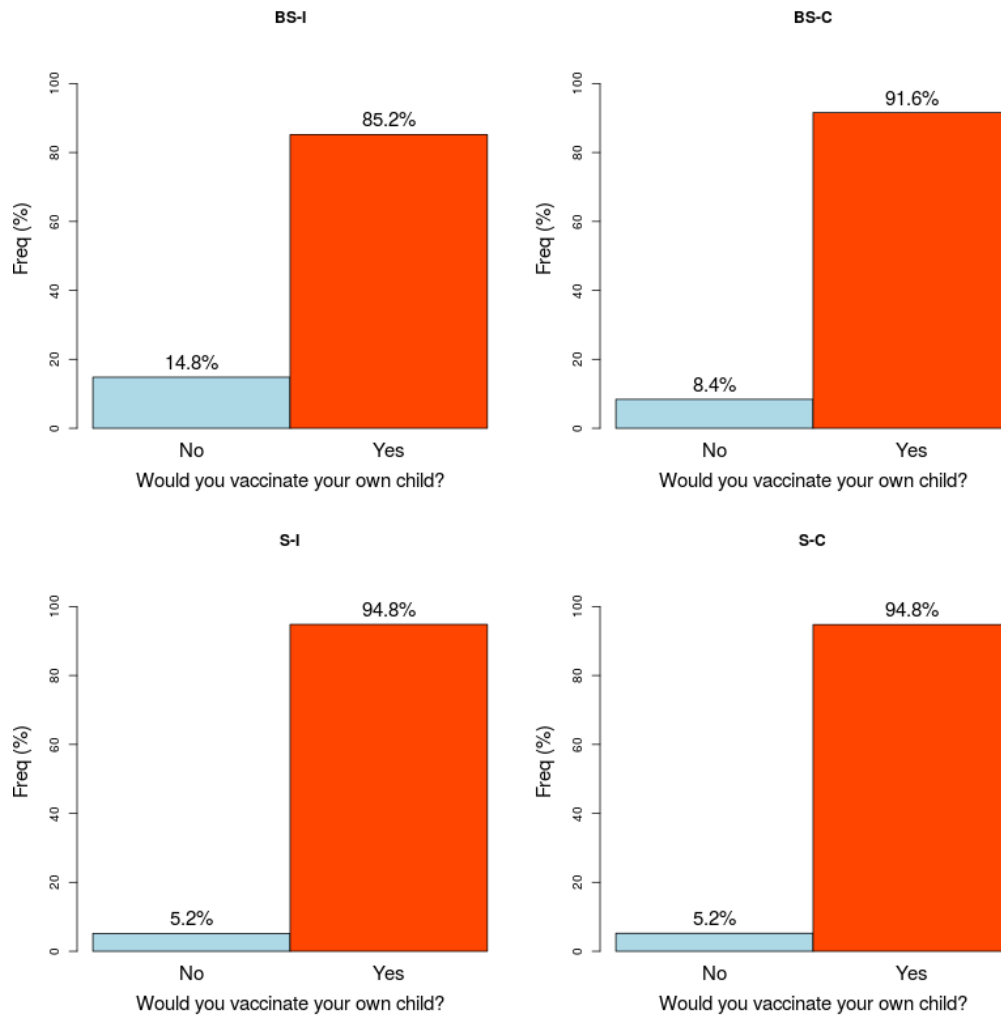
Directly following the reading of the information and completing the respective reading comprehension test questions, the effect of the vaccine-safety information was measured in two ways. First, we assessed general attitudes toward vaccination by asking about whether subjects would advise a friend to obtain the MMR vaccination for his/her child (“advise friend to vaccinate”). Subsequently we assessed vaccination intention by asking whether subjects would give their own child the MMR vaccination (“vaccinate own child”). For both questions, we opted to measure response by yes/no answers rather than a Likert-type scale.

2.5 Results

2.5.1 Descriptive Analysis

Figure 1 shows the percentage of Yes/No answer to the question: “*Would you give your own child the MMR vaccination?*”

Figure 2.1 - Attitudes towards vaccination

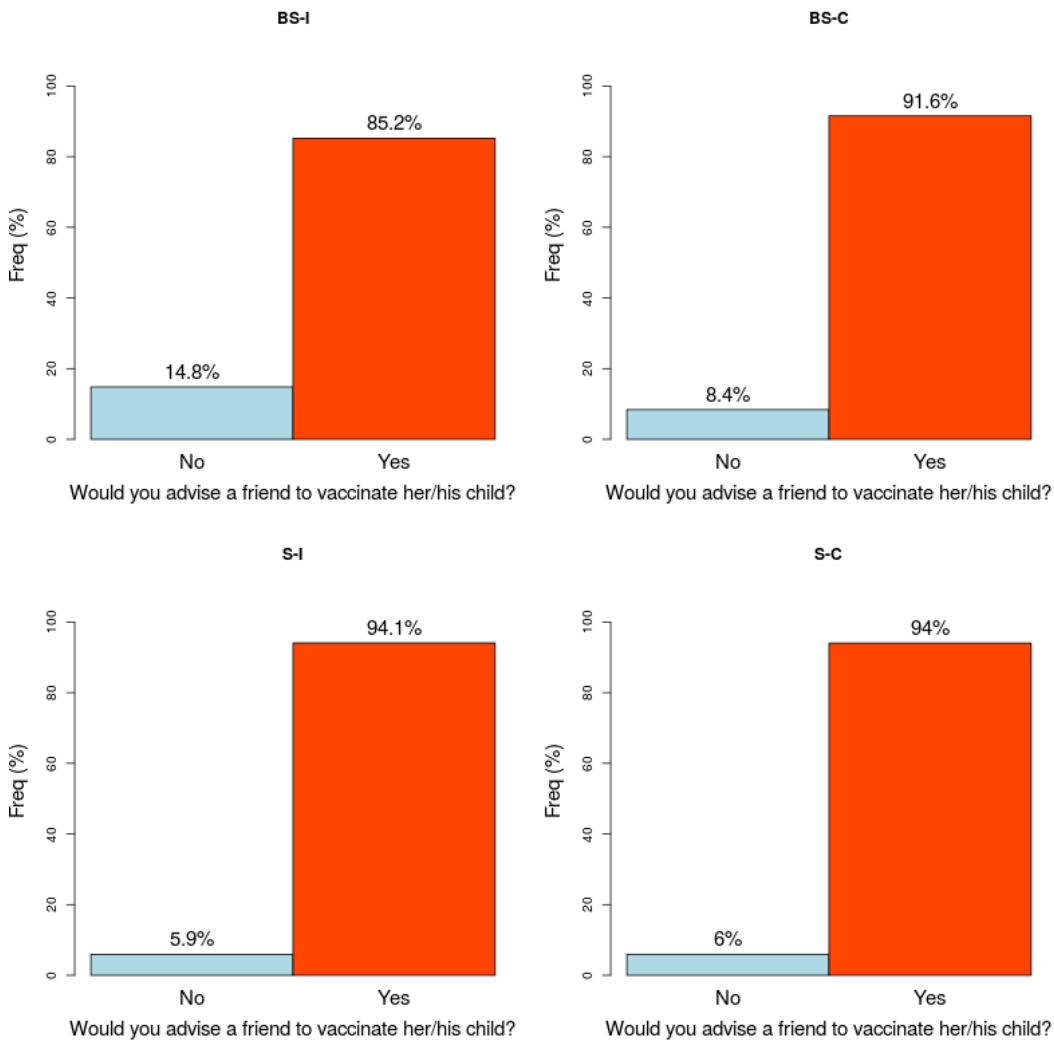


As the figure shows, the large majority of participants in the survey report to be in favor of vaccination for their own child, in all treatments. The largest share of individuals opposing vaccination is observed in condition BS-I (14.8%), while the lowest is observed in conditions S-I and S-C (5.2%). A series of Chi-squares tests shows that the share of those opposing vaccines is significantly higher in condition BS-I than in conditions S-I and S-C (p -value=0.015 and p -

value=0.016, respectively). For all other comparisons, no significant differences are detected (all p-values>0.150).

Figure 2 shows the percentage of Yes/No answers to the question “If you had to advise a friend about whether to obtain a vaccination for his/her child, how would you advise your friend regarding the MMR (Measles, Mumps, Rubella) vaccine?”

Figure 2.2-Attitudes towards giving advice to vaccinate



Similar to what observed for the question about vaccination of one’s own child, the large majority of participants are in favor of vaccination. Again, the largest share of individuals opposing vaccination is registered in condition BS-I

(14.8%) and the lowest in conditions S-I and S-C (5.9% and 6%, respectively). A series of Chi-squares tests shows that the share of those opposing vaccines when advising friends facing the decision for their children is significantly higher in condition BS-I than in conditions S-I and S-C (p -value=0.028 and p -value=0.030, respectively). For all other comparisons, no significant differences are detected (all p -values>0.150).

2.5.2 Regression Analysis

In Table 2.2, we report the outcomes of a regression estimates about potential determinants of the decision to vaccinate, when the choice affects one's own child (column 1) or a friend's child (column 2). The dependent variable is equal to 1 when a positive attitude towards vaccination is reported and equal to 0 when the attitude is negative. The explanatory variables are given by the treatment dummies, with treatment BS-I serving as a baseline. A set of dummy variables captures how often each subject visits her/his doctor (*Doctor_Visit*) and consults her/his doctor (*Doctor_Consult*). We also control for the trust in the doctor (*Trust_Doctor*) and whether the doctor's advice is followed by the subjects. The variable *Source_info* controls for the main source of information regarding medical issues and finally we control for gender (*Male*) and age class (*Age*).⁹

⁹ The dummy variable *Doctor_Visit*\Never is equal to 1 when the subject interviewed states to never visit her/his doctor, the dummy variable *Doctor_Visit*\Seldom is equal to 1 when the frequency of visits equal 5 times or less per year, and the dummy variable *Doctor_Visit*\Often is equal to 1 when the frequency of visit is greater than 5 times per year. The dummy variable *Doctor_Consult*\Never is equal to 1 when the interviewed states to never visit her/his doctor, the dummy variable *Doctor_Consult*\Seldom is equal to 1 when the frequency of visits is once or twice per year, and the dummy variable *Doctor_Visit*\Often is equal to 1 if the frequency of visit is higher than once or twice per year. The dummy variable *Trust_Doctor*\Nothing is equal to 1 when the interviewed reports no trust at all in the doctor, *Trust_Doctor*\Little is equal to 1 when a moderate or little trust is reported, and *Trust_Doctor*\Alot is equal to 1 when maximum level of trust is reported. The dummy variable *Age*\Young is equal to 1 when individuals are less than 40 years old, *Age*\Middle is equal to 1 when older than 39 and younger than 60, and *Age*\Elderly is equal to 1 when older than 59.

Table 2.2 Regression analysis (Logit, Odds ratio reported)

	(1)	(2)
	Own Child	Other's child
<i>Intercept</i>	0.182	0.271
<i>BS-C</i>	3.291**	3.511**
<i>S-C</i>	3.723***	3.367**
<i>S-I</i>	3.632**	3.172**
<i>Doctor_Visit\Never</i>	1.952	1.926
<i>Doctor_Visit\Seldom</i>	3.373*	2.812
<i>Doctor_Consult\Never</i>	2.121	2.449
<i>Doctor_Consult\Seldom</i>	1.788	1.895
<i>Trust_Doctor\Little</i>	0.204***	0.194***
<i>Trust_Doctor\Nothing</i>	0.190	0.097**
<i>Follow_Doctor\Yes</i>	2.428	3.180**
<i>Source_Info\Internet</i>	2.975	1.865
<i>Source_Info\Medical</i>	5.013**	2.387
<i>Source_Info\Pharmacies</i>	0.790	0.236
<i>Source_Info\Print</i>	0.964	0.553
<i>Male</i>	0.390**	0.389**
<i>Age\Middle</i>	2.658	3.151
<i>Age\Young</i>	3.835*	3.571*
Num. obs.	535	535

*** p<0.01, ** p < 0.05, * p<0.10

As the regression outcome shows, all conditions positively impact on the odds to vaccinate, relative to the baseline condition BS-I, both when the choice affects one's own child and a friend's child (more than twice as likely). A series

of linear hypotheses tests show that there is not a significant difference among treatments.

The regression analysis shows that those with little trust in doctors tend to be less likely to approve vaccination than those trusting doctors a lot, both when asked about their own child and a friend's child. Furthermore, when asked to advise a friend regarding his/her child, distrust in doctors statistically dampens the likelihood to recommend vaccination. The positive impact of reliance upon medicine in terms of disposition towards vaccination on the odds to vaccinate is also captured by the coefficients of *Source_Info \ Medical*, for own child's decision and, *Follow_Doctor \ Yes*, for other's child decision.

Concerning the impact of socio-demographic variables, males are less likely to support vaccination than females and, for choices affecting one's own child, younger individuals tend to favor vaccinations more than older individuals, even though the effect is only marginally significant.

2.6 Discussion

Our results highlight an important interaction between source and scope of information about vaccines. Specifically, an attitude of resistance to vaccination is fostered by the joint presentation of information not supported by scientific findings (BS), and focused on potential negative consequences for individuals, rather than for the society as a whole (I)Anti-vaccination movements gain strength by disseminating information to parents that is often not scientifically accurate. Given the potentially catastrophic result if an increasing number of parents facing childhood vaccination decisions choose not to vaccinate their children, it is important to understand the dynamics of how individuals digest and assess the information regarding benefits and risks of childhood vaccinations. Our results indicate that even when presented with an accurate assessment of the *benefits* of vaccination, individuals exposed to information presenting the individual *risks* of childhood vaccination

inaccurately—in non-precise scientific terms using generalizations based on non-truths or half-truths—are less likely to favor vaccination, both of their own and of others' child(ren). Given the diffusion of mistruths regarding vaccination, our findings indicate the importance of countering the “barely scientific” claims of vaccination risk by making available via ample media channels accurate and scientifically grounded truths regarding these risks. Given the significantly higher percentages of individuals in our study who viewed vaccination favorably after exposure to accurate information, the hope for dispelling vaccination “myths” is wide dispersion of scientific truths regarding vaccination benefits and risks.

The result should be squared with other research showing parents' strong reliance on the internet in seeking both information and advice on vaccination safety (that is, both the risks and benefits). While research regarding parental consultation of online vaccination information and its scope of influence on parental decision-making is limited (Dube et al. 2015), Betsch et al. (2010) demonstrated that viewing anti-vaccination websites increased negative beliefs regarding immunization and was linked to significantly lower vaccination rates of children in the experimental group five months later. The authors did not observe a corollary effect by exposing parents to online pro-vaccination information. We referred earlier to the heuristics affecting decision-making in this realm, as well as the established finding that individuals are affected to a greater degree by risks than by benefits. Heeding the advice suggested by this heuristic—that is, presenting information focused upon the risks of contracting disease for the unvaccinated versus benefits of vaccination, pro-vaccination literature might prove more convincing if it focuses on risks of not vaccinating (not the benefits of vaccination), just as anti-vaccination literature focuses on the risks of vaccination (rather than the benefits of not vaccinating).

Our results should be read in conjunction with the caveat presented by MacDonald and Picard (2009), who caution that the availability of academic articles via the internet is problematic due to the inability of nonacademics to correctly interpret the careful precise scientific language. Using the example of the relation between the MMR vaccine and autism, the authors demonstrate that precisely crafted scientific language can easily be interpreted incorrectly by non-scientists. Academics involved in vaccine research and thus familiar with the scientific principle that the null hypothesis cannot be proven would conclude that a particular report does not find evidence that the vaccine causes autism, yet individuals unfamiliar with the scientific process—such as parents, politicians, journalists and even health care worker—could reasonably interpret the same scientific result summary as support for the vaccine causing autism. Words such as “probable”, “possible”, and “unlikely” hold certain meanings within scientific language but be interpreted problematically by the general public. Given the potential severe harm if non-scientists unschooled in the formal scientific process misinterpret language related to causal association, the authors advocate that academic jargon that obscures meaning should be replaced by crisp, clear conclusions. Our S treatments presented subjects with language that is scientifically accurate but also clear and difficult to misinterpret. Our findings reinforce the former study, and provide evidence that scientific language—when it is carefully crafted to convey clear and straightforward messages—is an important aspect to consider in drafting public health information regarding vaccine safety.

A second finding is that, within the BS treatments, participants were more likely to opt for vaccination when the information provided to them focused on collective risks of non-vaccination than on individual risks. The BS-I treatment resulted in the least favorable views toward vaccination even when compared to BS-C. In short then, our study indicates that diffusion of anti-vaccine

information focused on side effects or risks for individual children is more harmful to vaccination compliance attitudes than information exaggerating collective risks to the community at large. Knowledge of this effect assists public health agencies in properly assessing and countering current and future claims posed by anti-vaccination proponents, especially given the potential importance of disseminating effective responses in a timely manner. Interestingly, viewed in light of our results, forged scientific studies may be particularly effective in dissuading vaccination both because they are presented as scientific and because they focus on individual risks.

Furthermore, the present paper confirms the importance of trust in doctors as a key and determinative factor linked to individuals' attitudes toward vaccination. We conclude that the effect of individuals' level of trust in doctors trumps in importance a number of other factors such as frequencies of doctor visits, doctor telephone consultations and internet medical searches.

Our demographic findings can help guide public policy decisions. The finding that males are less likely than females to be favorable towards vaccination can be construed as a positive finding in light of the fact that anecdotally women are often the parent making decisions for their children's care. Doctors and informational materials should accordingly be cognizant of including presentation styles appealing to both mothers and fathers. Furthermore, the finding that younger individuals tend to favor vaccines for their own children may indicate that medical professionals should initiate dialogues with older parents that present the unbiased facts regarding vaccine risks and benefits and allow opportunities for addressing doubts. In addition public health officials and doctors might focus on attracting the attention of older parents by customizing vaccination information in both content and dissemination outlets to older readers.

Furthermore, our study suggests that rather than concentrating the bulk of its efforts on disseminating vaccine safety information of one particular type or another, public policy can be more effective if it also focuses on bolstering the levels of trust in doctors. The goal of a public health campaign encouraging vaccination would ostensibly be to facilitate individuals in making unbiased decisions. Like the present treatments, scores of previous studies have focused on understanding how individuals presented with myths, misconceptions, and halftruths about vaccination safety are influenced by such information. However, one flaw with this approach is that subjects are fed information by the researchers rather than seeking information of their own choosing. In reality, individuals contemplating the vaccine safety issue are capable of directing their own web-based or other research, and may be likely to search for information that matches their own preconceived beliefs. In fact, data has shown that participation in social media simply reinforces one's belief about vaccination (Edwards et al. 2016). Clearly no campaign is capable of redirecting parents' personal internet searches. Thus efforts to bolster vaccination rates must focus not only on presenting accurate information, but also capitalize on the one constant factor that families have in common—the contact with a medical professional. Given that the medical expert having greatest contact with respect to the child's health is the pediatrician, an open discourse regarding vaccination benefits, risks and parental concerns should be encouraged with early and regular discussions regarding childhood vaccination. In short, the focus on communication accuracy must be augmented by another salient factor in the vaccination decision, trust in medical professionals. This finding is in line with, and augments with our evidence, the previously discussed vaccine literature focused on the importance of trust in the vaccine decision making process.

Given the scientific evidence, rational decision makers should choose to administer the MMR vaccine. What our study indicates is that individuals who

trust their doctor's advice are more likely to favor vaccination. We expect that the overwhelming majority of doctors—understanding well both the scientific evidence that children's benefits from vaccination are greater than the risks posed to them by vaccination side effects, and the importance of herd immunity—encourage their patients to administer the MMR vaccine as recommended by the CDC and WHO. Thus it is not surprising that those who hold greater trust in doctors view vaccination more favorably; in fact, trust in doctors by individual decision makers may indicate a general trust in scientific evidence or, alternatively, an increased numeracy (i.e., ability to reason with numbers or probabilities) involved in weighing the benefits and risks of vaccination. Exploration of these correlations could be included in further studies.

Moreover, our findings would indicate that Brunson's 'reliers' are a prevalent portion of decision makers, and that the source they 'rely' upon is their child's doctor. Many of the current studies focused on improving information communicated by public health campaigns mistakenly assume that parents tend to be 'searchers' who rely predominantly on their own research of public information. Obviously one avenue is providing ample and easy-to-locate scientific information both in written and online formats. However, future study and public policy should incorporate the finding that doctor trust levels are an key factor in encouraging vaccination compliance, and focus instead on understanding the 'reliers' and on devising ways to encourage trust in doctors. In any case, the public policy message provided by our study is that MMR vaccination may best be encouraged by concerted efforts to present doctors as credible, well-informed, and reliable sources of scientific information. These efforts could focus on educating pediatric doctors regarding how best to present information to parents or foster healthy exchange of communication with parents throughout the history of doctor visits to encourage doctor trust. Our results thus have important implications for improving doctor training and

education that should be considered both by medical schools preparing future pediatric doctors and agencies such as the American Academy of Pediatrics (AAP) who organize ongoing training and education programs for current medical practitioners.

Recently the AAP changed its long-held stance and acknowledged that an individual pediatrician's decision to terminate their relationship as care-giver for families that consistently refuse to vaccinate their children was an "acceptable option. While the AAP had long endorsed a policy of avoiding patient dismissal and did reiterate the importance of building trust with parents, the September 2016 report acknowledged that patient dismissal may be a worthwhile "last resort" in some cases. Meanwhile doctors in increasing numbers have implemented new strict dismissal policies, due to their own fears about exposing their patients still too young to receive their shots to unvaccinated children. Our evidence supports earlier findings that one of the most important factors in getting parents to accept vaccines is the influence of a concerned pediatrician. We posit that trust is developed over the course of numerous visits and contacts, and that physicians should be focused from the first contact with parents upon not only providing scientific, evidence-based information regarding the gamut of health-based medical issues, but also developing a caring rapport with parents that includes responding to their concerns.

2.6.1 Limitations:

Several possible limitations may exist in our study. One stems from the fact that the data was obtained from a self-administered survey. In our description offering the HIT on MTurk, we sought to minimize response bias and social-desirability bias among subjects by indicating only that we were conducting a survey about how people make decisions, and by assuring that respondents

knew that their anonymity was guaranteed. No mention was made to the potential subjects regarding the vaccination subject.

Inherently our research questions regarding vaccination of one's own child and advice to a friend about vaccinating his/her child limit our findings to self-reported intent as opposed to actual vaccination administration, and thus limit the external validity accordingly. The usual caveat is thus in order regarding intention versus actual behavior, and we cannot claim that our subjects' self-reported intent directly relates to vaccination uptake. Given that our research occurred outside of a medical setting in which to observe individuals' response to the treatments in terms of actual administration of the vaccination, the outcome measures of our study are limited as are numerous studies on similar questions by measure of intent rather than actual behavior. In this respect, the inherent difficulty of measuring childhood vaccination behavior is obvious. However it is well established that intent is a strong indicator of actual behavior. Future studies could coordinate with doctor's offices to better discern the effects of information's scope and source on actual vaccination administration.

2.7 Implications

The present research suggests that the most important public policy measures available for encouraging vaccination compliance are strategies to disseminate accurate scientific information regarding vaccination risks, and to strengthen trust levels in doctors and/or conversely to combat parental lack of trust in physicians. Future research should focus on (1) understanding how individuals who are exposed to *both* scientifically accurate information and imprecise inflammatory information decipher the interplay between the two sources and (2) the best strategies to foster the development of trusting relationships between parents and pediatricians. To devise effective strategies, future studies must be designed to explore sources of doubt in and mistrust of doctors. Focusing on the sources and wording of literature and/or press campaigns to promote diffusion of scientifically accurate information is most likely to result in a change in parental attitudes toward vaccines when combined with efforts to bolster trust levels in doctors.

Appendix 1. Analysis of effects of information sources (Barely Scientific versus Scientific) and scope (individual benefits/risks of vaccination versus collective benefits/risks of vaccination) by chi square and Fisher’s tests of 2x2 contingency tables

Structure:

	Individual benefit/risk	Community benefit/risk
Source= BS	Survey 1 (BS-I)	Survey 2 (BS-C)
Source= Scientific	Survey 3 (S-I)	Survey 4 (S-C)

Relevant Questions for Comparison:

Q5: If you had to advise a friend about whether to obtain a vaccination for his/her child, how would you advise your friend regarding the MMR (Measles, Mumps, Rubella) vaccine?

Q6: Would you give your own child the MMR vaccination?

1) Surveys 1 and 2

1.a) Analyzing Results of **Q5** on **Surveys 1 and 2** in a 2x2 contingency table

	“Yes” on Q5 (advise Vacc)	“No” on Q5	Total (clean sample)
Survey 1	116	20	136
Survey 2	121	11	132
Total	237	31	268

Fisher’s Exact test: The two-tailed P value equals 0.1269

Chi squared test with Yates correction equals 2.0173 with 1 degree of freedom.

The two-tailed P value equals 0.1499

The association is considered to be not statistically significant.

1.b) Analyzing Results of **Q6** on **Surveys 1 and 2** in a 2x2 contingency table

	“Yes” on Q6 (advise Vacc)	“No” on Q6	Total (clean sample)
Survey 1	116	20	136
Survey 2	121	11	132
Total	237	31	268

Fisher’s Exact test: The two-tailed P value equals 0.1269

Chi squared test with Yates correction equals 2.073 with 1 degree of freedom.

The two-tailed P value equals 0.1499

Both tests yield a finding that the association is considered to be not statistically significant.

2) Surveys 1 and 3

2.a) Analyzing Results of **Q5** on **Surveys 1 and 3** in a 2x2 contingency table

	“Yes” on Q5 (advise Vacc)	“No” on Q5	Total (clean sample)
Survey 1	116	20	136
Survey 3	128	8	136
Total	244	28	272

Fisher’s Exact test: The two-tailed P value equals 0.0267

Chi squared test with Yates correction equals 4.817 with 1 degree of freedom.

The two-tailed P value equals 0.0282.

For both, the association is considered to be statistically significant.

2.b) Analyzing Results of **Q6** on **Surveys 1 and 3** in a 2x2 contingency table

	“Yes” on Q6 (advise Vacc)	“No” on Q6	Total (clean sample)
Survey 1	116	20	136
Survey 3	129	7	136
Total	245	27	272

Fisher’s Exact test: The two-tailed P value equals 0.0137

Chi squared test with Yates correction equals 5.921 with 1 degree of freedom.

The two-tailed P value equals 0.0150

For both tests, the association between rows (groups) and columns (outcomes) is considered to be statistically significant.

3) Surveys 2 and 4

3.a) Analyzing Results of **Q5** on **Surveys 2 and 4** in a 2x2 contingency table

	“Yes” on Q5 (advise Vacc)	“No” on Q5	Total (clean sample)
Survey 2	121	11	132
Survey 4	127	8	135
Total	248	19	267

Fisher’s Exact test: The two-tailed P value equals 0.4835

Chi squared test with Yates correction equals 0.0278 with 1 degree of freedom. The two-tailed P value equals 0.5982.

For both, the association is considered to be not statistically significant.

3.b) Analyzing Results of **Q6** on **Surveys 2 and 4** in a 2x2 contingency table

	“Yes” on Q6 (advise Vacc)	“No” on Q6	Total (clean sample)
Survey 2	121	11	132
Survey 4	128	7	135
Total	249	18	267

Fisher’s Exact test: The two-tailed P value equals 0.3380

Chi squared test with Yates correction equals 0.611 with 1 degree of freedom.

The two-tailed P value equals 0.4344.

For both tests, the association is considered to be not statistically significant.

4) Surveys 3 and 4

4.a) Analyzing Results of **Q5** on **Surveys 3 and 4** in a 2x2 contingency table

	“Yes” on Q5 (advise Vacc)	“No” on Q5	Total (clean sample)
Survey 3	128	8	136
Survey 4	127	8	135
Total	255	16	271

Fisher’s Exact test: The two-tailed P value equals 1.0000

Chi squared test with Yates correction equals 0.000 with 1 degree of freedom.

The two-tailed P value equals 0.9879

For both, the association is considered to be not statistically significant.

4.b) Analyzing Results of **Q6** on **Surveys 3 and 4** in a 2x2 contingency table

	“Yes” on Q6 (advise Vacc)	“No” on Q6	Total (clean sample)
Survey 3	129	7	136
Survey 4	128	7	135
Total	257	14	271

Fisher’s Exact test: The two-tailed P value equals 1.0000

Chi squared test with Yates correction equals 0.000 with 1 degree of freedom.

The two-tailed P value equals 0.9887

For both tests, the association is considered to be not statistically significant.

Appendix 2. Full text of differing survey treatments

General Information provide to all:

“Please read the following passage and answer the questions:

Every year, 2.5 million unvaccinated children worldwide die of diseases that vaccines could have prevented, and vaccines prevent the deaths of an additional 2 million children, according to the World Health Organization. The diseases that vaccines prevent can be dangerous, or even deadly. Vaccines reduce the risk of infection by working with the body's natural defenses to help it safely develop immunity to disease.

The Center for Disease Control (CDC) recommends two doses of the measles, mumps, and rubella vaccine (MMR) for children because it protects them against dangerous, even deadly, diseases.

The routinely recommended age for the first MMR dose is 12 months through 15 months. The routinely recommended age for the second MMR dose is 4 years through 6 years.”

[Followed by: Two comprehension check questions:]

- How many doses of the MMR are administered? 0/2/4/5
- Do vaccines still prevent deaths? Y/N

[End. Followed by one of Four Messages—depending on treatment group:]

BS Individual (based on individual vaccination benefit/risk):

“Please read the following from *Parents for Safe Vaccination* website:

The idea that vaccines are a primary cause of autism is not as crackpot as some might wish. Autism’s 60-fold rise in 30 years matches a tripling of the US vaccine schedule. Many of the parents of recovered children I know, myself included, blame vaccines for their child’s regression into autism and use vaccine injury as the roadmap to treat their child. With so many kids with autism, the environment has to be to blame, and vaccines are an obvious culprit. Almost all kids get vaccines — injected toxins — very early in life, and our own government clearly acknowledges that vaccines cause brain damage in vulnerable kids.

Time magazine’s article on the autism debate reports that the experts are

certain “vaccines don’t cause autism; they don’t injure children; they are the pillar of modern public health.” I say, “that’s a lie and we’re sick of it.”

There’s something wrong with this generation of kids. They aren’t healthy. Shouldn’t we ask ourselves if one culprit may be the chemicals in our environment.

Is it possible all these things are related? Could we afford to give fewer shots slightly later and possibly reduce these chronic conditions? How do you go on a hunt for toxins and not consider vaccines?

The parents of children with autism aren’t crazy. We’re recovering our kids. We’re trying to help other parents do the same, and we hope new parents can avoid our fate. One in 75 now have autism and that is a tremendously large number, especially considering that 250,000 Amish have zero cases of autism and they don’t vaccinate. That being a coincidence is a statistical improbability.”

[or]

BS Collective (based on population-wide disease control):

“Please read the following information carefully:

Unfortunately, most people still listen to the ‘threats and scare tactics’ our government uses to convince them they need vaccines – common sense is a long lost trait. People are so scared they are going to get some horrible disease they risk their precious immune system and opt to pump tons of known neurotoxins and animal cells into their body without blinking!

If we could start exposing the Big Pharma lie – they aren’t an industry trying to improve our health, they are trying to weaken us and make us sicker so we are slaves to their expensive drugs, we could end this madness. Even doctors are often clueless to this fact! I find it insulting that we have a worsening state of health in this country despite all the medications and advances in technology...diabetes, obesity, heart disease, stroke and cancers rise daily to epidemic proportions. How can people continue to trust the systems in place causing this to happen?

All we can do is continue to expose the lies and reintroduce people to healthy organic lifestyles thru common sense and education. People are waking up with the recent political scandals going on in this country and starting to realize who is and isn’t looking out for their interests. Keep up your healthy lifestyle and talk about this to everyone you meet and you’ll teach others thru your good example and common sense!”

[or]

Scientific Individual (based on individual vaccination benefit):

“Please read the following information carefully:

A vaccine, like any medicine, is capable of causing serious problems, such as severe allergic reactions. There is an extremely small risk of MMR vaccine causing serious harm or death. Most people who get MMR vaccine do not have any serious problems with it.

Mild problems

- Fever (up to 1 person out of 6)
 - Mild rash (about 1 person out of 20)
 - Swelling of glands in the cheeks or neck (about 1 person out of 75)

If these problems occur, it is usually within 6-14 days after the shot. They occur less often after the second dose.

Moderate problems

- Seizure (jerking or staring) caused by fever (about 1 out of 3,000 doses)
 - Temporary pain and stiffness in the joints, mostly in teenage or adult women (up to 1 out of 4)
 - Temporary low platelet count, which can cause a bleeding disorder (about 1 out of 30,000 doses)

Severe problems (very rare)

- Serious allergic reaction (less than 1 out of a million doses) Signs of a severe allergic reaction can include hives, swelling of the face and throat, difficulty breathing, a fast heartbeat, dizziness, and weakness. These would start a few minutes to a few hours after the vaccination.
- Several other severe problems have been reported after a child gets MMR vaccine, including:

- Deafness
- Long-term seizures, coma, or lowered consciousness - Permanent brain damage

These are so rare that it is hard to tell whether they are caused by the vaccine.”

[or]

Scientific Collective (based on population-wide disease control):

“Please read the following information:

There is some concern about conflict of interest by large pharmaceutical companies, the US Food and Drug Administration (FDA), and the US Center for Disease Control (CDC) in their respective roles of producing, approving, and regulating safe vaccines. The primary goal of pharmaceutical companies is to sell drugs and make a profit whereas the US government agencies are charged with the responsibility of approving and regulating their safety. William Posey, Congressman (R-FL), stated in an Apr. 8, 2014 interview, "The incestuous relationship between the public health community and the vaccine makers and government officials should not be allowed to continue. I mean, you know, too many top CDC personnel go to work for the vaccine makers when they leave. That's a revolving door that creates a serious conflict of interest and perverts incentives that compromise integrity." After serving from 2002-2009 as the director of the CDC, Julie Gerberding became president of Merck Vaccines in 2009 and was named its executive vice president in 2014, responsible for Merck's global public policy, corporate responsibility and communications functions, as well as the Merck Foundation and the Merck for Mothers program. In May 2015, she sold personal shares of Merck stock on the open market for over \$2M.

The safety of the current childhood vaccine schedule has never been proven in large, long-term clinical trials.

The same federal health agencies responsible for developing, regulating and making vaccine policy are also in charge of monitoring vaccine safety. Vaccine safety is monitored by the Vaccine Adverse Events Reporting System (VAERS). VAERS is a passive reporting system (it relies on voluntary reports from consumers and healthcare practitioners) and CDC states: 'Limitations of passive surveillance systems include variability in reporting standards, reporter bias and significant under-reporting of events.'

Chapter 3.

HealthyMe: Experimentation in Behavioral Economics to Encourage Walking and Cycling as modes of transportation

With Luigi Mittone, Dominique Cappelletti, and Matteo Ploner

Abstract

The many environmental and public health benefits associated with increased physical activity levels and decreased personal vehicle use have spurred a substantial number of public policy measures designed to increase active travel, that is, everyday transport by foot and bicycle. Using insights from behavioral economics, we investigate a low-cost intervention to promote active travel. Novelties include the use of a specially designed cell phone application to deliver messages and track participant movement. We tested whether individuals increased active travel after receiving ‘nudge’ messages providing information about the benefits of active travel, nudges plus their ‘own’ transport feedback, or a combination of ‘nudge’, ‘own’ and peer ‘social’ comparison feedback. The messages produced little effect in active travel. We suggest that our findings are in line with Arad and Rubinstein (2017) who found opposition to soft interventions in a series of online experiments due to concerns about manipulation and *reactance* to government interventions that restrict choice. Our findings indicate reactance to what may be perceived as manipulative or paternalistic nudges and messages providing benefit-only information to promote active travel behavior. Our results are similar to earlier studies indicating the difficulty in creating successful nudge interventions to increase active travel behavior. As such, they reinforce the specific parameters suggested by Andersson et al. (2018) and Sunio and Schmöcker (2017), including the importance of incorporating implementation intention, which those authors refer to as ‘planning’ and ‘commitment’, as a necessary component when designing behavior change support systems (BCSSs) such as the HealthyMe app installed on participants’ cell phones.

3.1 Introduction

With its underpinnings in understanding the influences that affect human decision-making, behavioral economics is a valuable tool for designing effective policies that optimize individual choices particularly when individuals are known to act contrary to their own best interest. The evolution of modern society has facilitated the relative increase in individuals who are sedentary and unaccustomed to engaging in physical activity, particularly in developed countries (Yancey 2009). The relative lack of physical activity has in turn contributed to an increase in—and likely upcoming crisis related to—society’s most problematic and deadly long-term conditions such as diabetes, cardiovascular diseases, chronic respiratory diseases, and musculoskeletal disorders. These conditions are the direct result of, or can be significantly exacerbated by, *modifiable* unhealthy behaviors such as smoking, unhealthy food choices, overeating, medication nonadherence, and lack of physical activity. Our research focus is developing methods to address the latter by encouraging increases to frequent walking and cycling activity through use of various message types. We apply the concepts and tools offered by the field of behavioral economics to devise and test the effectiveness of message *content* (purely informational, individual feedback, or peer comparison feedback) using experiment-specific technology in the form of a cellular phone application offering novel methodology.

The present study responds, albeit on a small scale, to concerns about both individual internalities, the costs associated with physical inactivity, and the externalities related to years of continually increasing personal automobile use and simultaneously decreasing levels of physical activity. The combined list of related external costs associated with the two includes: air pollution costs attributed to the emission of harmful gases like carbon monoxide, ozone, carbon dioxide and particulate matter that damages both living beings and the environment; health-related costs due to increased risk for respiratory diseases, cardiovascular disease, anxiety, depression, diabetes, osteoporosis, high blood pressure, and certain cancers; traffic congestion costs (opportunity costs of motorists wasting time,

being delayed, wasted fuel, increasing air pollution emissions due to increased idling, headaches, and hearing disabilities); accident costs; climate change costs; and costs to nature and land. A list of such magnitude calls for policies to address the related dual problems of decreased physical inactivity and increased personal vehicle use.

Increasing rates of active travel is seen as a potential solution that hits both birds with one stone. In the relevant literature and throughout the present paper, the term ‘active travel’, refers to physical activity undertaken as a means to meet every day transportation needs, and the term generally refers to travel by foot and bicycle. In December 2014, citing a finding of the World Health Organization that lack of physical activity contributes to nearly 1-in-10 deaths—or a total of one million deaths per year—in the European Region (WHO 2009), the EU released a position paper regarding the benefits of active travel and called on European institutions and actors to take action to ensure that the multiple benefits of active travel were made central to all relevant European policies and programs. Given that insufficient physical activity is the fourth greatest risk factor for death worldwide and 1 in 4 adults is not active enough, with high-income countries having greater levels of insufficient physical activity, new strategies are urgently needed to increase levels of physical activity.

Our study was designed to contribute toward understanding human preferences regarding the individual decision to engage in walking and bicycling as a mode of transport for typical daily activities—such as commuting to work, grocery shopping, and getting to appointments—and toward devising effective methods to encourage individuals to choose these methods of active travel over other transportation modes. An ambitious review of interventions to increase walking by Ogilvie et al. (2007) found that despite a large volume of studies, the sizeable number that failed to yield significant results illustrate an ‘inverse evidence’ law whereby we know the *least* about the effects of interventions *most likely* to influence the health of the largest number of people. The importance of such contributions is particularly evidenced by the recognized difficulty in identifying effective interventions to affect active travel behavior. We designed a field experiment to test the effectiveness of

various nudge¹⁰ messages delivered via a specially-developed cellular phone app to encourage them to bicycle or walk more frequently during their daily routines and ran the experiment in November and December 2016. Several unique aspects of the study make it a novel contribution to the existing literature: first, it provides data regarding the factors influencing the population of an Italian city,¹¹ and second, it utilizes smartphone technology for data collection and diffusion of intervention messages. The remainder of this paper will discuss the research study in greater detail, including presentation of pertinent literature, experiment design, and evaluation of results.

3.2 Relevant Literature

Given the timely advantages that increases in active travel offer in response to burgeoning crises in health, air quality, and environmental degradation, there is a plethora of literature discussing interventions to encourage active travel in related fields including health, psychology, and transport and urban planning. The majority of the literature contains cross-sectional studies based on assessing comprehensive public policy programs that combine multiple interventions. As behavioral economists (our field merges principles of economics and psychology), we recognize the value of a multidisciplinary approach and thus considered active travel research from various fields including behavioral, social, and medical sciences, environmental and urban transport sectors, and economics. While there is significant literature on increasing physical activity in general, there has been relatively little direct research on low-cost interventions to encourage active travel using easy-to-implement applications from behavioral economics, much less using cellphone tracking.

In a small-scale experiment (n=35), Zhao and Baird (2013) tested a commercially available

¹⁰ By the term “nudge”, we mean “any aspect of the choice architecture that alters people’s behavior in a predictable way without forbidding any options or significantly changing their economic incentives. To count as a mere nudge, the intervention must be easy and cheap to avoid.” Thaler & Sunstein (2008): 6.

¹¹ The value of this aspect is confirmed by Ogilvie et al. (2008) who note that even in the case of interventions shown to be effective in selected groups or in the short term, it is not clear whether these can be sustained and generalized, particularly to populations outside the United States and Australia where a bulk of research has taken place.

cell phone application (Moves) for feasibility in promoting active travel in two pilot studies and identified the appeal for both experimenters and subjects for collecting detailed travel data and testing behavioral influences on travel decisions. We considered the suggested improvements to their app in creating our own. Another small sample (n=135), Jariyasunant et al. (2013) tested Quantified Traveler (QT), a computational travel feedback system devised using a cellphone app that collects travel data, processes it in a cloud-based server into personalized travel diaries containing carbon, calories, time, and cost footprints. The intervention increased participants' intentions to change travel behavior towards using more sustainable transportation modes, increased certain beliefs regarding the connection between health benefits and sustainable travel, and led decreased automobile use from first to last week in the three-week study. However, results did not yield any significant increase in walking, bicycling, or use of public transit. Aside from offering technical lessons regarding their common reported difficulty with interruptions in data collection and battery life consumption of the phones involved due to the requirements of the GPS and/or accelerometers, the studies offer little in the way of useful findings.

Quite recently—and long after we designed and ran the experiment in this study—an ambitious research paper reviewed 32 studies focused on how information and communication technology (ICT) in general, and smartphone applications in particular, has been used to influence behavior change toward a modality shift from car use to walking, cycling or public transport. The authors then created and tested a behavior change support system (BCSS) model for smartphone applications (Andersson et al. 2018). The results suggested the important aspects in instigating behavior change through smartphone applications were personalization to user, relevant and contextualized information and feedback, commitment, and appealing design. The authors concluded that each of these components was essential and that studies combining all of them had the best chances to affect sustainable travel behavior.

There are a number of literature reviews that assess interventions based on different criteria in the attempt to identify the characteristics of successful measures, and each offers instructive advice for structuring experimental studies. In an international review

of interventions to increase bicycling, Pucher et al. (2010) concluded that the effect of individual interventions did often yield mild increases when used in isolation, but that the coordinated introduction of multifaceted measures, policies, and programs to encourage active travel were far more effective due to synergies with complementary measures (such as infrastructure changes, education and promotion campaigns, and bicycle access programs). Due to this synergetic effect, the difficulty in disentangling effects of individual policies, and the success of comprehensive measures, the authors recommend a meta-level approach to evaluation that examines the impacts of different sets of strategies across a large number of cases rather than focus on the impacts of specific interventions in isolation.

One crucial limitation noted by the Pucher et al. (2010) and other reviews is that most studies assessing active travel have not been adequately designed to control for causality by including before-and-after measures of a treatment and control group (Ogilvie et al. 2007, Ogilvie et al. 2004, Martin et al. 2012, Yang et al. 2010). Based on our review of a substantial number of studies, the main reason observed for this deficiency is that many of the research articles elaborate data from government and public agency initiatives, often complex and multi-faceted, that result not from experiments but rather from long-term policy programs that promote active travel by a set of comprehensive interventions. This fact is particularly true of the literature from the UK where the government has identified and heavily subsidized the promotion of active travel as a viable solution to degeneration in population health due to declines in physical activity and concern for environmental effects of air pollution and greenhouse gas emissions (Creating Growth, Cutting Carbon 2011).

In review of financial incentives, Martin et al. (2012) developed a hierarchy of possible policy interventions to promote active travel using the Nuffeld intervention ladder, a tool for instructing the use of the least intrusive intervention when devising public health policy. Nudging in ways suggested in this experiment—by providing accurate yet salient information or persuasive messages to sway people to use active travel—occupies the post of least intrusive intervention, and thus the preferred solution if it functions. A 2011 assessment of nudging in health areas found that, at that time, despite the excitement by

policymakers surrounding the great potential for stimulating behavioral change through nudging, few nudging interventions had in fact been evaluated for their effectiveness in changing behavior in general populations and none had been evaluated for “its ability to achieve sustained change of the kind needed to improve health in the long term” (Marteau et al. 2011). A systematic review of articles involving interventions to increase cycling concluded that while infrastructure changes designed to make cycling a more feasible transport choice do appear to increase cycling, existing data is insufficient to indicate whether less costly interventions based on changing perceptions and decision-making regarding walking and cycling as transport choices are able to increase those modes of travel (Yang et al. 2010). Our experiment sought to respond to this lack of evidentiary support for nudging by offering evidence that simple nudging messages could be effective in promoting active travel.

We assume that the individual choosing whether to engage in active travel faces a similar decision to those choosing whether to partake in other forms of physical activity, but that the decision regarding active travel involves the weighing of more information and is thus far more complex. Aside from the usual motivational factors affecting decisions relating to physical exercise in one’s free time, there are numerous other factors in active travel decisions such as actual and perceived notions of safety, weather, traffic, air pollution, and parking. Based on research performed in four English towns, Pooley et al. (2014) suggest that the challenge to behavioral change toward more active travel is focused on three factors: perceptions of risk, constraints created by family and household responsibilities, and perceptions of how walking or cycling might be perceived by others. Based on the notion of shifting societal perceptions of physical activity, Yancey (2009) proposed a motivational model to increase physical activity based on making the default point of reference that of active choice and render the inactive choice more difficult as the opt-out to address some of these factors. His model seeks to reset the default for physical activity by incorporating brief, structurally integrated activity bouts in typical daily activities.

Concepts from behavioral economics serve as a guide for understanding active travel attitudes and behaviors, because the decisions not to use active travel may not be entirely rational. Unlike standard economic theory that assumes individuals make rational choices maximizing long-term values like health, behavioral economics incorporates principles from psychology to help explain why individuals often make decision that do not optimize their future economic and physical well-being. Psychologists Amos Tversky and Daniel Kahneman laid much of the foundation for behavioral economics by showing that individuals perform in this suboptimal decision-making manner in a predictable pattern, based on following a common set of decision errors. Particularly when they lack information about a decision, individuals rely on certain rules that simplify information processing and analysis or calculation of costs and benefits related to choice alternatives. Tversky and Kahneman (1979) identified the anchoring-and-adjustment heuristic that affects individuals when uncertain about a decision. Judgment is affected by the knowledge of what, from an individual's personal experience, are salient factors to the decision at hand. These so-called *anchor* points can be social norms, habits acquired in childhood, or a cultural frame. Individual anchor points are particularly pertinent as they are likely to determine beliefs, such as whether physical activity such as walking or cycling is seen as fun or as drudgery, and whether commuting to work is considered virtuous or strange. Anchor points can be quite difficult to shift, and behavioral economics accordingly suggests that physical activity promotion should incorporate attempts at a cultural shift to support individual health-promotion efforts (Zimmerman 2009).

Related to anchoring, individuals attribute weight to social information such as who conveys a message. People tend to more easily disregard information from those whom they dislike, and to attribute greater weight to information received from those whom they view as peers (Dolan et al. 2012). For example, individual physical activity levels were shown in a field experiment to converge to the lowest-performing members of their groups (John & Norton 2013). Health behaviors are affected by social influences. A finding from social psychology is that the more that the social norm information is connected to people's social self and identity, the stronger the impact on behavior (Reynold et al. 2015). Men and

women have been shown to have five times higher odds of becoming physically active if their spouse also becomes active (Patel et al. 2016). Normative influences can be leveraged to increase the likelihood that a person will adopt a target behavior. Furthermore, a system can motivate users to adopt a target behavior by leveraging the natural human drive to compete (Sunio et al. 2017). In one study, subjects having social peer comparison feedback (with respect to median performance level) combined with a modest financial incentive were shown to be more likely to increase physical activity (number of steps per day measured on a smartphone application) toward a performance goal than other groups that had social peer comparison to the 75th percentile performance and the same incentive as well as subject groups with no incentive (Patel et al. 2016). Anchoring peer comparison to the higher level of the top quartile was less effective, possibly because subjects were demotivated. In general, however, the use of peer comparison feedback has not been well examined in either interventions to increase physical activity or in active travel cases.

3.3 Motivations and Uniqueness

3.3.1 Motivations

While increases in active travel would benefit both the public sector and private sector, policymakers lack clear evidence regarding the effect of “soft” interventions. Encouraging active lifestyles that improve physical and mental wellbeing could offer enormous savings to national health systems shouldering the medical cost of illness. Employers and society at large benefit from a healthier and more active workforce through reduced absenteeism and increased productivity.¹² Society benefits if we mitigate environmental damage caused by air pollutants, safeguarding our world for future generations. On an individual level,

¹² Studies in the UK and Copenhagen, Denmark have performed cycling assessments. The UK found that a 20% increase in cycling between 2011 and 2015 would result in decreased mortality valued at £107 million, potential savings to the UK NHS estimated at £52 million due to reduced illness, and savings to employers of a further £87 million through reduced absences from work. The City of Copenhagen found that the benefit to society when a person chooses to cycle is 1.22 Danish Kroner per kilometer cycled, that society suffers a net loss of .69 Danish Kroner per kilometer driven by car, and that the health and life expectancy benefits of cycling are seven times greater in cost-benefit terms than cost of accidents. Merseyside Transport Partnership, *Merseyside Active Travel Strategy*, March 2011.

the benefits of increased physical activity are numerous and well documented with respect to health and wellbeing. Notably, traditional economic models have quantified an individual's health as a component of the stock of human capital, and health-related happiness as a function of a health stock that an individual builds over time with appropriate health investments.¹³ Health translates to utility, because the healthier an individual, the less time she loses to sickness, and the more time she can dedicate to productive, consumption-creating activities.

For all of these reasons, numerous cities throughout the world are in the process of instituting complex and multifaceted programs, including substantial and costly "hard" measures such as changes to urban infrastructure (i.e. more bicycle paths), in the effort to foster increased walking and cycling. In addition to "hard" measures, multifaceted plans include "soft" policy measures to increase active travel behavior.

The effort to increase active travel has often been based on sparse evidence of what methods truly correlate with increases in cycling and walking as a frequent means of transport. Multiple systematic reviews have noted that evaluations of active travel interventions with robust study designs are needed to provide stronger evidence, as the small number of studies that exist are at high risk of bias (i.e., Petrunoff et al. 2016). Our study provides empirical evidence regarding active travel interventions that, in contrast to costly changes to the built environment and politically charged legal avenues requiring years to put in place (such as lowering speed limits to 30 kilometers per hour to facilitate cycling and walking safely), are relatively low cost, easy, and quick to implement. To enhance research quality and provide increased study reliability with data driven approaches, one study pointed to the need for collaboration between physical activity researchers and transport planners to increase the relevance of academic research in applied settings such as active travel promotion (Crist et al. 2018). We suggest further

¹³ Richman (2005), employing the health economics model developed by Michael Grossman. On both individual and public levels, exercise such as active travel represents investment in personal health.

expansion of this concept to include information technologists and behavioral economists to address active travel policy and promotion in optimal fashion. Our research motivation was devising a robust experiment to test soft interventions that increase the frequency of active travel in trips made for regular daily activities.

3.3.2 Uniqueness of Study Attributes and Challenges

Trento provides a unique experiment location. It has been evidenced that cross-cultural differences make effective strategies unique within a culture or country. Given that the factors affecting active travel by bicycle and foot may differ due to cultural factors unique to Italy (or even unique to Trento within Italy), our study is among the first to identify effective motivating factors for Italians/Trento citizens in choosing active travel by bike or by foot. The three studies involving Italian cities profiled in Sunio & Schmöcker (2017) were essentially focused on open source, sustainable transit platforms and thus complement our study nicely, as we are more concerned with identified behavioral motivations for active travel. In consort with those studies, ours can offer a small start toward understanding unique factors and best practice in encourage Italians (and for ours, more specifically Trento residents) to opt more frequently for the bike or walk over the car.

Despite the significant and numerous benefits to active travel, research has indicated that cross-cultural barriers exist related to many different factors including perceptions of cyclists (more so than walkers), family obligations that discourage bicycling and walking (need to drop off or pick up young children, fear of bicycling children being in or near car traffic, complaints of small children regarding being tired, etc.), and the desire to maintain hair or clothing in pristine conditions based on social norms regarding physical appearance.

Challenges specific to active travel by bike or foot in the Trento area include the topography. The fact that the city center is located in a valley, with many residential areas located in the mountainous terrain rising on both sides, provides a landscape barrier that may make riding or walking to work infeasible unless shower facilities are available at the workplace, or public buses provide bicycle racks to make the trip home doable. In fact, the

use of electric bicycles (whereby the cyclist has electrically-charged motorized assistance for steep terrain) is significant in the city. We found it most reasonable to focus not only on increasing cycling and walking on the way to and from the workplace, but rather on increasing the frequency of total bicycling and walking for general transport purposes (commuting, shopping, errands). Within the relevant literature, studies often focus on increasing the transport modes in trips under a distance of five miles. We hoped to increase active travel in any mode where it replaces use of personal vehicle or public transportation.

A challenge in Italy is the particular importance of presenting oneself well with regard to physical appearance, a factor that may deter cycling or walking due to detrimental effects on hairstyle and clothing appearance that due to the Italian cultural norms, may be relatively higher than in other countries. However, given the finding that at least in commuting to the workplace, people place the greatest value on the time necessary for transport, active travel is particularly attractive due to both the significant commuter traffic congestion and the sizeable pedestrian-only area of the downtown center in Trento.

3.4. Research Design

3.4.1 Overview

To achieve our research objective of identifying the most effective methods of encouraging individuals' active travel, we designed a field experiment comparing the true effects on daily movement of groups receiving conditional, unconditional, and/or 'nudge' messages focusing on health, economic, or environmental benefits. Given the dearth of active travel studies involving robust and controlled experiential data, we sought to create a solid reliable design for our experimental intervention. As detailed below, a preliminary survey determined the messages most likely to elicit positive responses toward active travel. Subsequent to the identification of such messages, we ran an experiment that both sent and measured the effectiveness of such messages by using participants' cellular phones with a specifically designed app. The experiment format and use of human subjects was approved by the Telecom Research Division.

3.4.2 Data Collection: Development of HealthyMe Cellphone Application

To improve the accuracy of our results, we opted against self-reporting to measure the effectiveness of the proposed incentives due to the evidence that self-reported measurements of behavior change are prone to significant measurement error and thus questionable reliability and validity (Kahn et al. 2002). We tracked subjects' movement through a mobile phone application that we developed to meet our experiment needs. Installed on each subjects' cellular phone, the Android app used the phone's GPS and accelerometer to collect data from which we could deduce the mode of transport and the amount of time in motion. A similar sort of tracking methodology has been employed in a limited number of other studies (some reviewed above), but it is certainly not diffuse despite the increasing number of cellphone applications available for tracking movement.

Based on the suitability of application tracking for this genre of research, we expect to be among the first wave of researchers to effectively use technology greatly enhancing data reliability. The obvious advantage over self-reporting is the degree of precision in tracking movement mode. Self-reporting may suffer from inaccuracy due to both under-counting when individuals incidentally omit smaller trips (seemingly insignificant for the individual), and overestimation due to the 'halo effect', in which individuals who view walking and cycling as virtuous behaviors feel they should be doing more and thus inadvertently inflate the degree to which they engage in the activities (Krizek et al. 2009). For these reasons, data collected using automated means are generally considered superior to that obtained by self-reported means.

The app was composed of two main components. The first, developed by the team at Telecom Italia's research division, Strategy and Innovation Joint Open Lab (SKIL), used the mobile device sensors and Google APIs to track the user, deduce the mode of transport, and provide data regarding time spent in such transport mode. To meet the needs of our experiment design, the app installed on participant's personal mobile smartphones allowed coordination with the smartphones' own accelerometer and global positioning systems

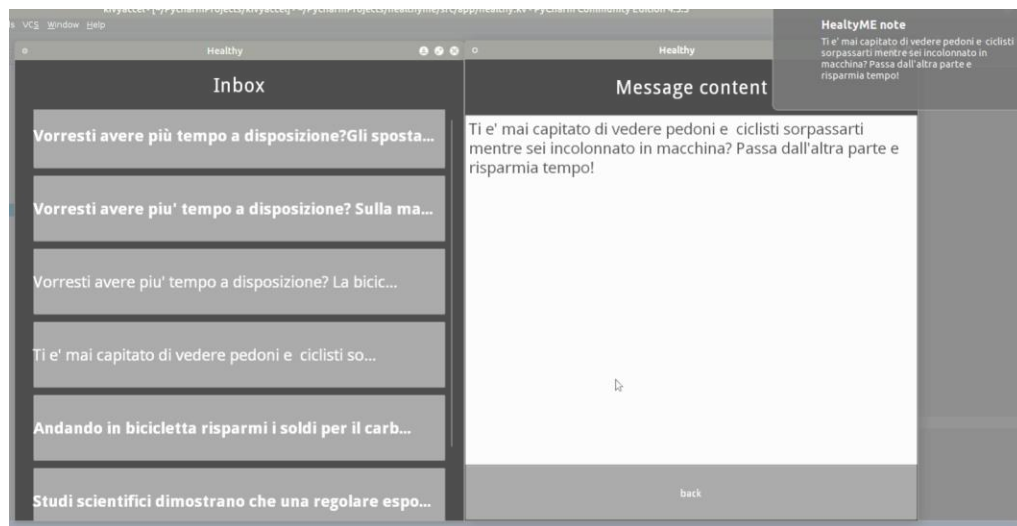
(GPS) for the recording of data capable of revealing the amount of time spent in active travel, and the specific mode of transport (as the accelerometer can decipher the different modalities of movement by foot, by bicycle, by car, and by public transport).

The second component of the app, developed in collaboration with the Behavioural Economics-Nudge unit (BEN) of the Bruno Kessler Foundation and our CEEL team of the University of Trento, computed statistics on the collected data and relayed the treatment messages to the participants. Thus, in addition to collecting data, the app was specifically designed with an internal messaging system to deliver the intervention messages directly to the users. This component of the app created a read-only messaging facility within the app itself. As modern cellphone use has evolved to the point that smartphone users are flooded with large quantities of information (e.g., emails, text, IM, app notifications), a key point of our study was to minimize the risk that the treatment messages were missed, ignored, disregarded, or deleted without reading by the user.

When a message was delivered to the mobile, the app generated a notification which was visible on the participants' mobile phones from the standby screen and from the notification window. Clicking the notification widget brought up the app interface which displayed all messages received in a list.¹⁴ Non-read messages appeared in bold font format. By clicking on a message item, the entire message became available to read in a dedicated screen page. We implemented a heuristic that required the user to stay on the reading page for a configurable amount of time t before considering the message as 'read'. The following figure taken with the app running on Linux during app development depicts the display of the messaging app. The incoming list of messages is shown on the left, and the message display during reading is shown on the right. On the top right corner, a notification pop-up message is visible.

¹⁴ See Figure 1 below. As with an email account, just the initial portion of the message appears.

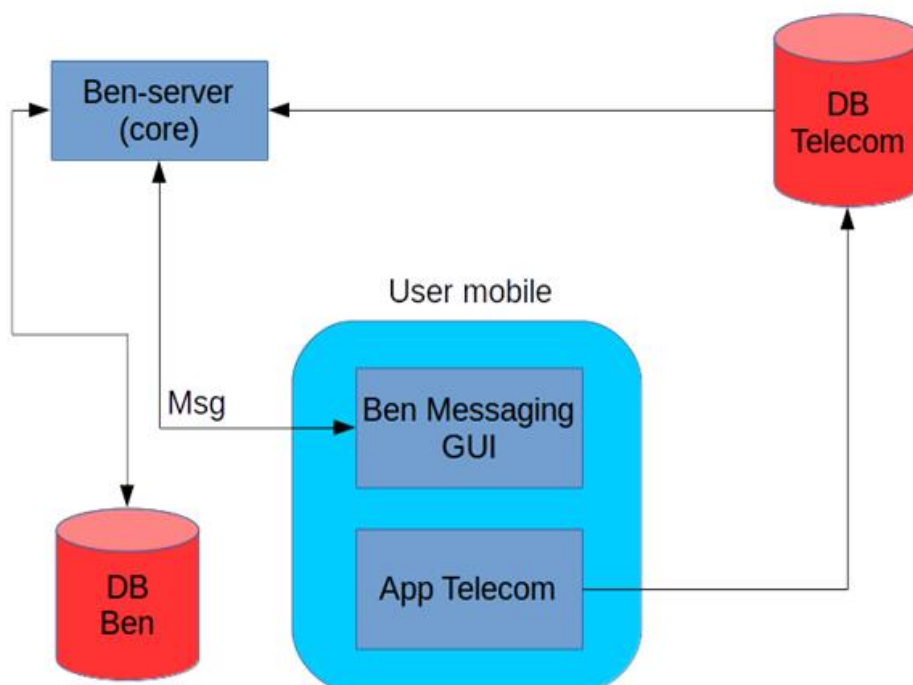
Figure 3.1. HealthyMe App's visual messaging platform



User data had to be collected and then stored in a safe place where it could be analyzed as it represented the source of information over which our study was grounded. Data collection was enabled by the use of the Telecom server in addition to the aforementioned monitoring equipment installed throughout the community, and by the Bruno Kessler Foundation's server accessed by BEN. The figure below demonstrates that the two components of the app detailed above did not actually communicate with one another. The essentials for data collection consisting of the movement-tracking application on the individual mobile phones, the server housed at Telecom research division that received the incoming location data and made it available in raw form, and the software that analyzed the raw data into the meaningful statistics and information (modality of travel, number of seconds in each modality, etc.). Figure 3.2 demonstrates our interactive solution for gathering information garnered via the mobile phones of participant app users and collecting such on the partner databases for further analysis¹⁵.

¹⁵ Further information on system configuration is detailed in the appendix.

Figure 3.2. HealthyMe Software Design and Component Integration



3.4.3 Creation of Intervention Messages to Encourage Active Travel by Bike and Foot

We focused on studying the effects of several “nudging” interventions, both the *unconditional* sort wherein message content was not related to the participants’ actual active travel performance, and *conditional* messages where content was based on performance and/or level of achievement represented by performance. Furthermore, we sought to understand whether framing the social nature of the unconditional messages as private versus public made them more (or less) effective, and similarly whether framing conditional messages as personal results (‘own’ performance) versus comparisons relative to others in one’s peer group (‘social’) had an impact on how effective they were in encouraging the active travel activity.

3.4.3.1 Preliminary Survey: Devising Unconditional Treatment Messages

A critical element to the design of unconditional messages was to create messages that were both instructional and encouraging to participants. The messages generally educated participants about the benefits of active travel by noting relevance to several salient factors. To devise the content of the unconditional messages, we thoroughly reviewed research from diverse origins in public health, transport, and behavioral economic literature for studies revealing the primary benefits of active travel and the factors previously identified as influential in affecting individual decisions to (or not to) use active travel. After organizing lists of the most important factors, we created messages specific to the three main categories of effects that emerged—physical and mental health messages, environmental messages, and what we label “opportunity cost” messages, based on motivations to undertake active travel for convenience of time, money (in parking and fuel costs), and hassle in traffic.¹⁶ For illustrative purposes, we provide an example of the messages specific to each category in the table below.

¹⁶ For illustrative purposes, we share the most and least effective messages derived from the survey sessions as they are indicative of our inquiry and development of study messages. The most effective message (translated from Italian into English) was: “Cardiovascular diseases are the leading cause of death. The risk of coronary heart disease for a person who takes no regular physical exercise is equal to that of a smoker smoking 20 cigarettes a day! Make our society healthier by walking and cycling more!” The least effective message was: “For direct and indirect costs related to poor lifestyle choices, Italy spends about 60 billion Euro per year. Make a positive contribution to reducing this cost by maintaining an active lifestyle. Free up economic resources for other uses.”

Table 3.1. Samples of ‘Nudge’ Unconditional Message Content by Type (translated to English)

Message Type	Sample Message
Health Benefit	“Cardiovascular diseases are the leading cause of death. The risk of coronary heart disease for a person who does no regular physical exercise is equal to that of a smoker who smokes 20 cigarettes per day. Make our society healthier by choosing to go on foot and by bicycle!”
Environmental Benefit	“Surprising news: the air pollution levels that you breathe inside your car are up to 15 times greater than the pollutant levels breathed by those walking and bicycling the same route at the same time. Help the environment and your health: walk or ride your bike when you can!”
“Opportunity Cost” Benefits (saving time, hassle, money)	“Tired of wasting time looking for a parking spot? Going on foot or by bike creates less traffic in our city and saves time!”

To gain a better understanding of which messages would be most powerful, we performed a survey. After considering an online survey (offered via Google survey or Mechanical Turk), we opted instead for a smaller-scale locally based survey as we deemed it a better method for ascertaining the factors most salient to Italians and the local community. We translated the sample unconditional messages into Italian, and held four sessions (n=85), two each on September 24, 2015 and October 21, 2015 respectively, to gather responses to 20 unconditional messages in an incentivized survey. Participants, mainly university students, were recruited from the database of potential participants of the University of Trento Cognitive and Experimental Economics Laboratory (CEEL).

3.4.3.1.1 Preliminary Survey: Method

Before viewing the survey questions on the computer screen, each student was given a pen and a sheet of paper with two fill-in-the-blank boxes that instructed them to imagine that in their work for the local community government, they had to devise two messages that would be effective in promoting active travel in the community. This activity allowed us to filter for general themes and ascertain that we have not overlooked a significant influence on behavior. After completing the written responses, the subjects proceeded to the online portion of the survey that asked them first to rate the importance to them of the following benefits of active travel, on a scale of 1 (not at all important) to 7 (very important): Health, Physical Fitness, Mental Health, Environmental, Time-saving, Money-saving, Flexibility, Enjoyment, Convenience. Following these initial questions, the subjects were given two tasks to complete.

Task 1: Participants were asked to read, one at a time, the 20 unconditional messages, and to rate on the same scale of 1 to 7 the degree to which they find the message to be *a) Clear*, *b) Convincing*, *c) Effective*, and *d) Powerful* in encouraging individuals to pursue goals of walking or bicycling. Further, they were asked to rate, on the same ranking scale (1 to 7), how much the message would encourage *e) them* and *f) others* to pursue the active travel goals.

Task 2: Participants were presented the same 20 messages, but instead of expressing their own opinion they were asked to guess how others were evaluating the messages. Specifically, they were asked to guess how effective others in the experiment judged the message to be in encouraging individuals to walk or bike, on a scale from 1(not at all) to 7 (very much).

One of the 20 answers in Task 2 was randomly drawn and if the answer given matched the answer given by the majority of other participants, 2 Euro were added to the show-up fee of 5 Euro. Each session took about 50 minutes and individuals were paid in cash at the end

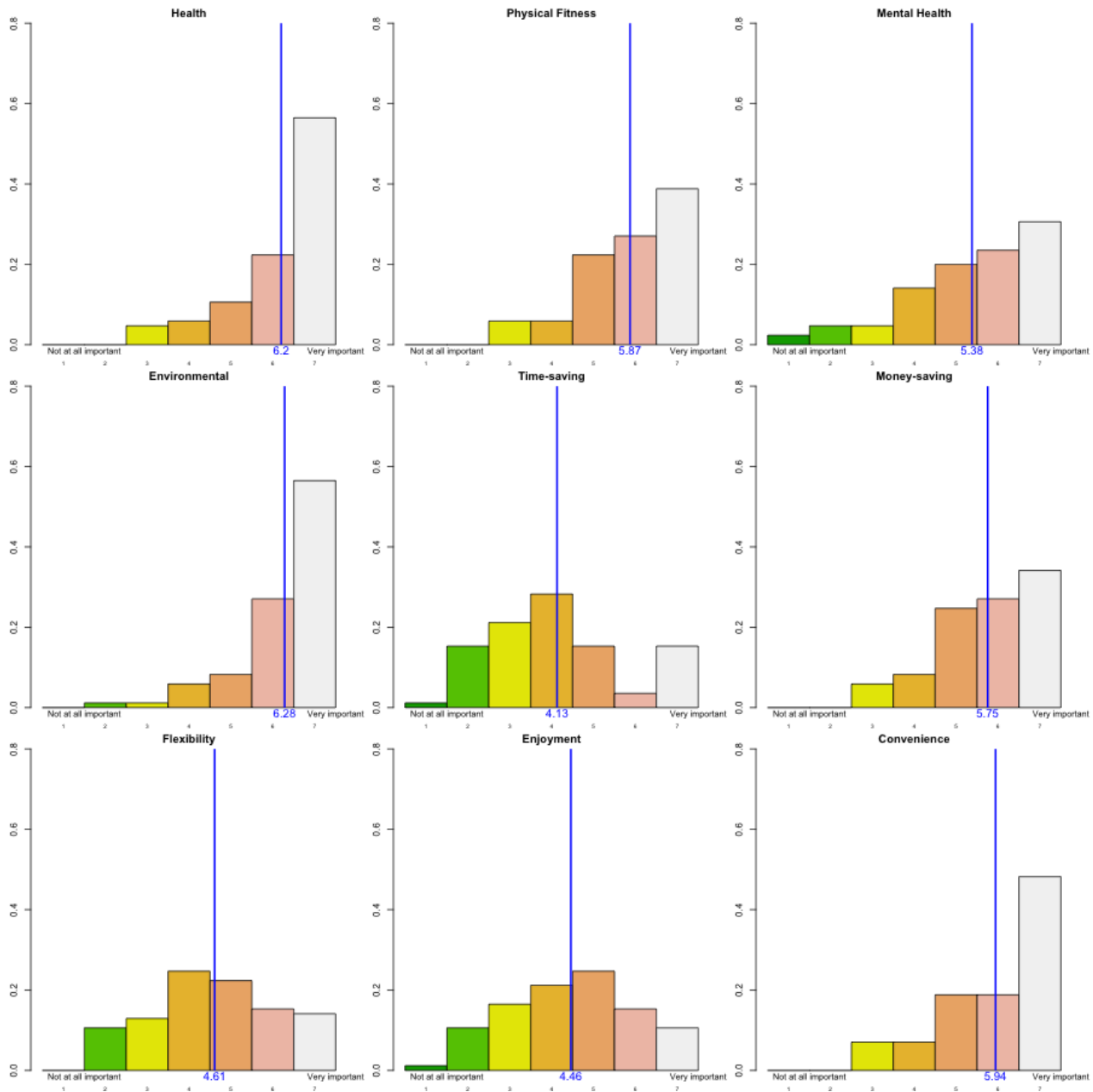
of the session. To control for potential order effects, we reversed both the order of the 20 questions and the order of the tasks, across experimental sessions.

3.4.3.1.2 Preliminary Survey: Results

Figure 3.3 provides a representation of the answer to the first question checking about the perceived importance of the benefits of active travel (Health, Physical Fitness, Mental Health, Environmental, Time-saving, Money-saving, Flexibility, Enjoyment, Convenience). As highlighted in Figure 3.3, health-related and environmental benefits scored very high in terms of importance, while results indicate much less importance was accorded to lifestyle benefits such as flexibility and saving time (labeled herein as benefits to ‘Opportunity Cost’).

The importance of health benefits is further confirmed by outcomes of the incentivized task (Task 2). The questions receiving the highest scores when guessing evaluations by others are all health related and point to benefits in terms of cardiovascular diseases, aging, and weight loss. The importance of health benefits is further confirmed by outcomes of the incentivized task (Task 2). The questions receiving the highest scores when guessing evaluations by others are all health related and point to benefits in terms of cardiovascular diseases, aging, and weight loss.

Figure 3.3. Subjects' Perceived Importance of Active Travel Benefit



The regression analysis reported in Table 3.3 provides an assessment of the drivers of evaluations in Task 2. As dependent variable, we take the effectiveness reported value (1-

7). As explanatory variables, we consider the nature of the benefit (Health, Environment, and Opportunity Cost) and the social nature of the benefit (Private vs. Public).

Table 3.2 Regression analysis (LMM)

Effectiveness	Coeff (SE)
(Intercept)	4.592 (0.098)***
Private	0.198 (0.061)**
Environment	0.003 (0.080)
Health	0.228 (0.067)***

N= 1700 (85x20)

***p<0.001, **p<0.01, *p<0.05

As outcomes of the estimate show, private benefits are perceived as much more powerful than public benefits and health benefits are more important than environmental and economic ones.

By analyzing the results of the survey including the messages written by the subjects, we not only selected the most effective messages but also refined the treatment design. Based on the preliminary survey, we altered the original idea of offering three types of unconditional messages (based on type of benefit offered by active travel, such as health or environmental) to three separate treatment groups, furnishing for each type of benefit messages to motivate increased active travel for both public “community-minded” reasons and private “self-interested” reasons. Based on the subjects’ indications that health benefits provided the most convincing arguments for encouraging walking and cycling, we prioritized these benefits in refining and selecting the nudge messages.

3.4.3.2 Developing Conditional Messages

A form of social consequence, performance feedback has also been shown to promote a variety of behaviors (Meredith et al 2014). Conditional messages furnished participants with information of two types: those in the ‘own’ treatment group received simple feedback

detailing their own activity levels as measured by length of time, and those in the ‘social’ treatment group received the same information plus details comparing their activity levels to their peers, defined as other subjects of the same sex and age category. The messages used the data amassed by users on the previous day (t-1). Specifically, these conditional messages read as follows (translated from Italian to English): “Yesterday you walked for ___ minutes and rode your bicycle for ____ minutes” plus, only for those in the ‘social’ treatment, the additional message “On average, other [men/women] of your age who are participating in this experiment walked for _____ minutes [more/less] than you and rode their bicycles for ____ minutes [more/less] than you.”

3.4.3.3 Developing Placebo Messages

In our control group, we also sent messages with the same frequency as the conditional and unconditional messages sent to the participants in those parallel treatment groups. The content of these placebo messages was designed to have a neutral effect and thus was entirely unrelated to the topic of active travel and/or specific movement of the participants. Available in the Appendix, the placebo messages included quotations, math riddles, nonsensical statements, and information tidbits regarding local events, generally followed by “Good Morning!”

3.4.4 Treatments

To ascertain the effectiveness of the conditional and unconditional messages, we divided the participants into four treatment groups with the following structure:

Table 3.3. Message Structure

Treatment Group ↓	Control	Unconditional	Conditional	
	Placebo Messages	Nudge Messages	Personal Feedback Messages	Peer Comparison Feedback Messages
Placebo	✓			
Nudge		✓		
Nudge+Own		✓	✓	
Social		✓	✓	✓

The subjects in each treatment group received messages sent directly to them via cellphone app at the same time each morning, with subjects in the ‘Own’ and ‘Social’ groups receiving multiple messages including both conditional and unconditional content.

3.4.5 Experiment Design

The experiment took place in the months of October, November, and December of 2016. Because the initial “Observation” period was of variable lengths depending on the date that each subject installed the HealthyMe app on their phone, the total period of data collection varied among subjects. However, the first date that observations were possible was October 18th, 2016 (based on those installing on the release date of the app, October 17, 2016). The observation period ended on November 17, 2016, and was immediately followed by the treatment period, spanning November 18 to December 4, 2016, the final date of data collection.

In a pre-experiment period, the subjects were recruited through the databases of potential participants of both Smart Crowds, a territorial virtual laboratory conducting R&D and innovation projects through participants’ Android-compatible smartphones, and the University of Trento CEEL. Potential participants were referred to the Smart Crowds

website and were able to register their participation starting on October 17, 2016. Based on the minimum requirements for installation of the app, one requisite for participation was the ownership or daily use of a personal mobile phone that used Android service.

Participation was encouraged by offering a number of Amazon gift certificates to randomly-selected subjects who met the substantial requisites of participation including: (1) downloading and installing the app on their personal mobile phone, (2) keeping the app installed and data connection active for the entire period of experiment duration, and (3) completing two online surveys, one at the start and another at the conclusion of the experiment. Subjects who met these requirements were entered into a drawing for 33 Amazon gift certificates in the amounts of €250 (1), €150 (1), €100 (1), and €50 (30). Smart Crowds managed the process of registration and required potential participants to consent to experiment terms and conditions, to download the HealthyMe app to personal mobile phones, and to complete a pre-experiment survey¹⁷. To achieve anonymity, subjects were identified by their mobile phone's unique IMEI number and were divided randomly into the four treatment/control groups.

All participants were monitored for their activity level throughout the experiment as the objective was to measure whether and to what degree the participants' active travel varied based on their treatment. Their participation required them to maintain an active data connection on their personal cellular phones—through Wi-Fi, 3G, or 4G networks—during the daytime hours from 7:00 a.m. to 9:00 p.m. throughout at least seventy-five percent of the experiment duration to facilitate data collection. Using the design and component integration detailed above (in section 4.2), we were able to measure, to the second, the amount of time each participant spent in each transportation mode.

¹⁷ Participants were directed from Smart Crowds to Survey Monkey for completion of the questionnaire. Discussed further below, the pre-experiment survey collected basic subject data, actual active travel frequency, and perceptions and attitudes toward active travel.

The experiment duration included two periods, a “Baseline” during which no messages were sent and we simply measured baseline activity levels (cycling and walking) for each participant, and a “Observation” period in which messages are sent daily, with the content varied according to treatment group. The Baseline period spanned variable amounts of time, as it started for each participant on the date when the app was installed on that participant’s cellular phone. The period was thus potentially over four weeks for those who installed on October 17 (the first possible day for registration and app download), and those who installed the app on the last day of registration, October 28, had a three-week baseline measurement. The baseline activity levels for each subject, as measured in the pre-Observation period, could thus be compared to the subsequent activity levels during the treated Observation period to ascertain the effects of the messages.

The Baseline period ended on November 17 and the Observation period spanned from November 18 through December 4, 2016. For the Observation phase, subjects were divided randomly into the three treatment groups—‘nudge’, ‘own+nudge’, and ‘social’—and one control ‘placebo’ group. The treatments were differentiated by the content of messages they received during the treatment phase of the experiment. All participants were sent daily messages each morning with content varying dependent on their treatment group. The subjects in the ‘nudge’ treatment group received the unconditional nudge messages detailing benefits of active travel based on the environmental, health, and the economics of time and money; we provide a detailed explanation of how we created and selected these and the other messages in section 4.3 above.

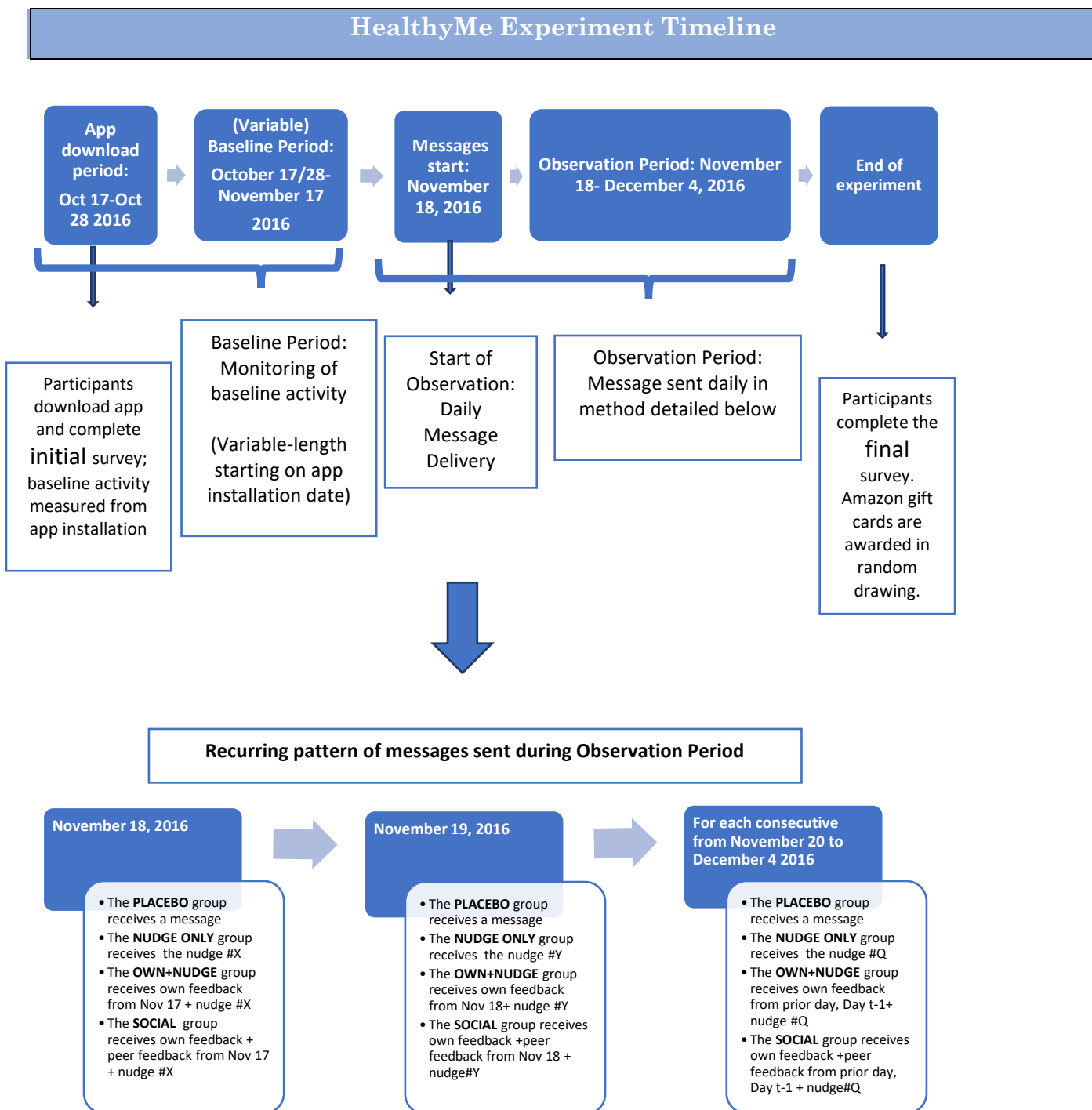
The members of the ‘own’ treatment received an unconditional nudge message plus a conditional message containing specific feedback detailing their own personal cycling and walking activity levels for the previous day. The members of the ‘social’ treatment received an unconditional nudge message, the same conditional feedback message detailing the previous day’s activities, and another conditional message comparing their personal activity level with others of the same sex and age. In lieu of no message, the control group

received placebo messages in an effort to match most closely the participant experience in the treated groups.

The experiment terminated on December 4, 2016 and participants were informed that they could disinstall the app from their cellular phones. At the experiment's conclusion, the subjects were asked to complete a post-survey questionnaire aimed at capturing subjective and objective information regarding the activity elicited by the experiment format. The questionnaire reiterated the questions regarding attitude and perception toward cycling and walking to capture whether the experiment changed perceptions or attitudes. After sufficient time was given for participants to complete the questionnaire, the Amazon gift certificates were awarded in a random drawing from all eligible participants who met the minimum requirements.

The following timeline provides the details and specifications of the experiment.

Figure 3.4. Timeline



3.5 Evaluation

3.5.1 Sample Attrition and Refinements for Reliability

At the experiment's start, subjects were directed to complete a questionnaire collecting demographic information and surveying their attitudes, habits, and perceived behavioral control beliefs toward bicycling and walking. While 428 participants completed the pre-experiment survey, we suffered attrition in the number of participants for a variety of reasons, including technical difficulties with app installation or abandonment, possibly motivated by technical reasons such as cell phone battery depletion. At the experiment's end, all participants were again required to complete an online survey, aimed at collecting the same attitudinal measures and habits, their perceptions regarding whether the experiment changed their awareness of active travel benefits, and feedback regarding app-related technical issues. By this time a reduced number (333) participants completed the final exit questionnaire. Moreover, their survey responses revealed a number of factors that forced us to further reduce the sample size in order to maintain the highest possible reliability and validity in our results.

Of the 333 participants who responded to the exit questionnaire at the experiment's termination, the following factors called for us to eliminate a significant number from the experiment. First, in answering our question, "did you experience any app crashes?", 73.57% of the respondents indicated that they had not, 19.82% indicated that had experienced crashes of the app that were later resolved, while the remaining 6.31% of respondents said that they experienced app crashes that did not resolve.¹⁸ Thus we reduced the sample by eliminating the 21 (representing the 6.31% of) participants with unresolved crashes, and thus our subject pool was reduced to 312 participants.

¹⁸ NB: Noted also above in various points, here and elsewhere we have translated to English, but in the experiment itself, all contact with our participants—whether in treatment-specific messages sent within the app, emails from Smart Crowd indicating the experiment start/end, entry and exit questionnaires, or any other form of contact—was conducted in the Italian language. For example, in the present case our survey question read as follows: *Hai sperimentato dei crash da parte della app?* Responses: (1) *No, mai*, (2) *Si ma poi sono stati risolti*, and (3) *Si e il problema non si è risolto*.

Our next refinement was based upon an unanticipated programming glitch with the app that the participants had installed at the experiment's start. During the course of the experiment's observation period, we discovered a problem with the app that would affect some cellular phone's capability to accept and/or correctly display our treatment messages. We prepared a corrected version of the app, and detailed instructions were sent out to participants indicating that the experiment now required them to download and install a new app and that once the new app was installed, they could proceed to dis-install the original app. The notification was sent with such wording that the participants in fact would be unaware that this was not a planned event in the course of the experiment. The new and updated version of the app that was released to participants mid-experiment on November 14th through Smart Crowds, the virtual lab platform used to coordinate registration, downloads, and contact for the experiment. We were able to see through the download counter on Smart Crowds that participants were prompt in downloading the new app. When asked in the final questionnaire whether they had installed the new app, in fact all but 7 of the remaining 312 participants indicated that they had done so. Due to the crucial role that the new app played in message delivery, we excluded those participants from the experiment, except to consider, where indicated, their answers to the surveys.

The most troubling response on the exit questionnaire was in answer to whether or not at a certain point in the experiment participants had received messages from the app. Over one-third, 33.93% of participants, indicated that they had never received messages from the app. Obviously these 113 participants were also eliminated from our analysis and findings regarding the effectiveness of treatment messages. However, some were the same participants whose elimination had been signaled by the refinements discussed above. A final refinement also relates to a question from the exit survey, based on reports that some received empty messages. Respondents were asked whether, if they did receive messages, those messages were (a) always legible, (b) sometimes lacking text (empty), or (c) always lacking text (empty). While most (63.54% or 176 participants) responded that the messages were always legible, and we decided to consider the results of those whose messages

sometimes lacked text, those whose messages were always empty were eliminated from our results.

While the number of participants was significantly decreased by the above refinements, the responses to the survey questions did serve the important purpose of limiting our analysis and results to the participants who experienced the study according to its design. As such, the refinements guarantee an increased degree of reliability and authenticity regarding the study results. In analysis of some questionnaire responses, we were able to include the responses of some participants that we have referred to ‘eliminated’ in this section. However, they were not included in our regression analysis regarding the effectiveness of the messages in the placebo, ‘nudge’, ‘own’, and ‘social’ treatment groups. The results eliminated in the refinements are only included in the analysis and results where feasible, specifically those regarding attitudes and perceptions, based on the data from the pre- and post-experiment questionnaires.

After the above-described refinements, the number of participants was reduced to a total of 191 for the purpose of experiment treatment analysis. One final refinement took the sample size from 191 to 176. When we analyzed the massive amount of active travel record data, we found that 15 of the 191 participants remaining after the earlier refinements had no logged travel segments. We are uncertain what technical difficulty was encountered, but seemingly their phones interacted insufficiently with the app or monitoring equipment. These participants were removed leaving the total number of participants at 176. The subjects were divided into the four treatment groups at random. However, as subjects had been randomly divided into treatment groups based on equal numbers at the experiment’s onset, the significant depletion of participants due to experiment attrition and the necessary refinements described herein had an effect on the sizes of our treatment groups, leading to slightly disproportionate groups.

Of the 176 participants, the participant pool included 40 in the Placebo group (receiving placebo messages), 53 in the Nudge group (receiving ‘nudge’ messages), 40 in the Own

group (receiving ‘nudge’ message and message reporting own personal feedback), and 43 in the Social group (receiving ‘nudge’ messages and messages reporting own personal feedback, and messages giving comparison feedback with respect to others of same age group and gender).

3.5.2 Sample Description & Perceived barriers to active travel

Of the 176 subjects that comprised the total participant pool after refinements, 31% (54) were female and 69% (122) were male, and 50% were students and 32% worked full-time. They were disproportionately young, with 82.4% (145) between the ages of 18 and 35. The age distribution was as follows: 48.6% (86) aged 18-25, 33.5% (59) aged 26-35, 12% (21) aged 36-45, 2.2% (4) aged 46-55, 1.7% (3) aged 56-64, and 1.7% (3) aged 65 or older. Most, 16%, had no children, and were either high school graduates (39%) or college graduates (49.4%); only 2 had not completed high school, and 10% had higher than college degrees. Body mass index (BMI) measures varied, equating to 4% obese, 22% overweight, 71% normal, and 2% underweight. Their self-reported health status at the experiment outset was nearly entirely rated as acceptable (19%), good (48%) or very good (23%).

Based on their own self report in the pre-experiment survey, we obtained self-perceived pre-experiment measures of their transport and active travel statistics indicate. Sixty-eight percent owned or had access to a car, 75% a bike, and 6% an electric bike. Fifty-three percent lived at an altitude of over 50 meters higher or lower than they place they worked or studied. Seventy-three percent had easy access to car parking, 87% to secure bicycle parking, at their place of work or study. The mean maximum distance required to arrive at work or perform daily activities was 7 km. The means of transportation used most frequently was personal vehicle for performing everyday activities such as travel from home to work or place of study (27%), grocery shopping (38%), visiting friends and family (51%), going to movies, restaurants, etc. (43%), cycling accounted for 9-10% of each of the same activities, walking was much more frequent—22% , 55%, 23%, and 35% respectively,

and public transport was used frequently only as transport to work or place of study (37.5%).

Finally, participants indicated whether and to what degree certain factors represented barriers to bicycling for their daily active transport needs. The factors included weather, significant elevation change (study location city , Trento, is in a valley surrounded by mountains), lack of bike paths, lengthy distances, not feeling safe on the road, absence of secure bicycle parking area, need to transport family members, personal physical fitness levels, the need to arrive at destination appearing physically presentable (hairstyle, clothing), and the need to wear formal dress upon arrival, on a Likert-type scale of 1 (the factor has no effect) to 5 (the factor strongly impedes active travel). Because the study was run from mid-October through December, among the coldest months annually in Trento, it is no surprise that the factor seen as the greatest impediment was the weather conditions (3.82/5 on Likert), followed by significant elevation change (3.48/5), the necessity to be presentable upon arrival (3.15/5) and significant travel distance (3.15/5).

3.5.3 Measured Active Travel Behavior

In addition to gauging behavioral attitudes through the pre- and post-experiment surveys, the smartphone app allowed the measurement of any realized shifts in active travel behavior from the observation period to the treatment period. This measurement provided the data crucial to our assessment of whether the messages received by participants affected their engagement in active travel during the duration of the experiment.

3.5.3.1 Overall Activity

In Figure 3.5, the graphs present a description of the time spent in movement activities (on foot, in vehicle, on bicycle) across the 4 treatments conditions (Nudge, Own+Nudge, Placebo and Social) in the time interval Oct 15 – Dec 15. For each activity, the total number of seconds that participants engaged in that activity in each day in the time interval is

reported in the graph. The time interval between the two vertical segments is the Treatment period (Nov 18–Dec 4). The time interval preceding the Treatment period is taken as a measure of the baseline activity of participants for our *difference-in-difference* analysis.

Figure 3.5. Overall activity per transportation mode, in each treatment condition



The graphs show that across all conditions the largest activity time is that associated with “in vehicle”, followed by “on foot”, and finally the very low activity level associated with “on bicycle”. Figure 3.5 reports the share of active users rather than total users. A user is classified as *active* if in a specific day he/she submitted at least one activity signal. The rationale behind including only *active* participants is that individuals who did log any segments of activity may have passed an entire day at their residence, but likely had left their phone (and thus tracking capacity) off, disabled the app (whether voluntarily or

involuntarily), or had malfunction of the HealthyMe app tracking. In any case, these individuals did not provide data regarding the decision to engage in vehicle versus active travel modes.

Figure 3.6. Share of Active Records

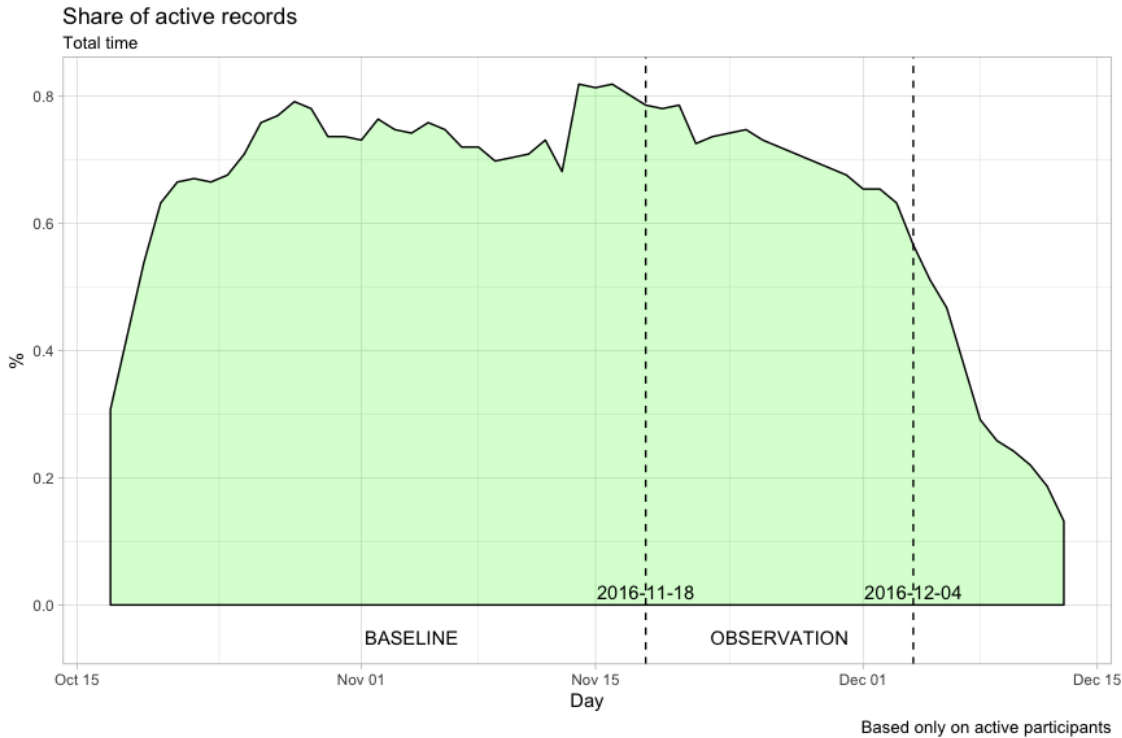
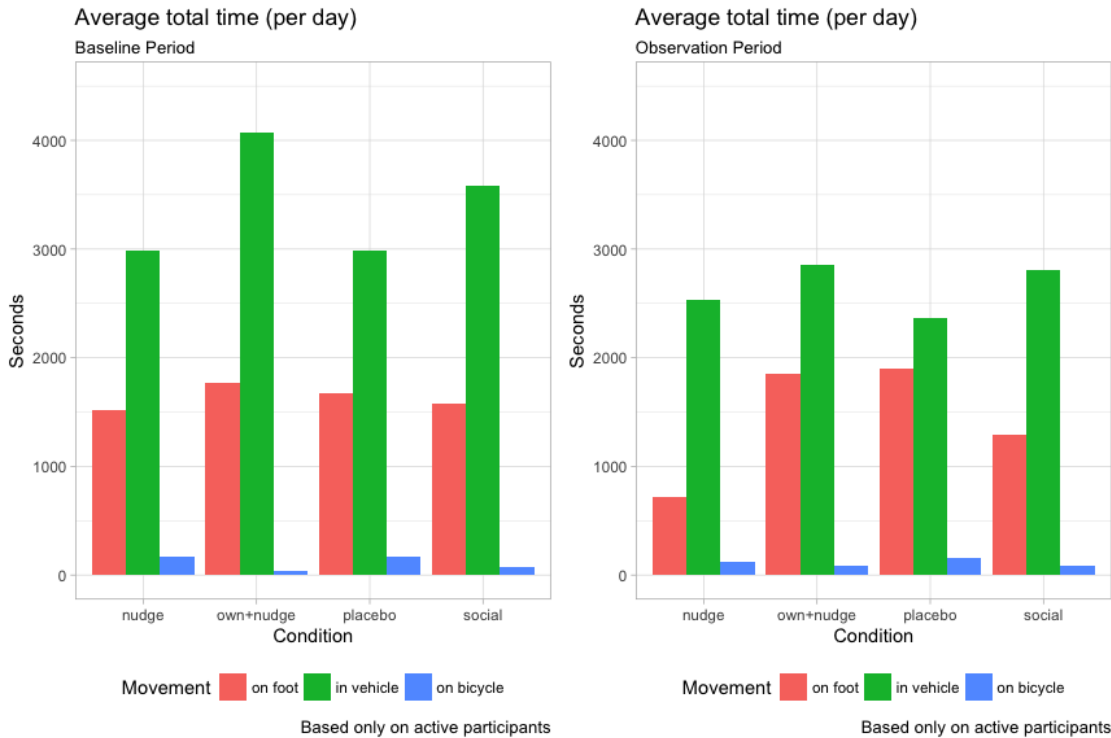


Figure 3.6 depicts the share of active records and demonstrates strong adherence in that the share of active records is high and remains solid throughout the experiment. It is particularly stable during the observation period. As expected, the number of active users decreases sharply after the communication of the end of the tracking activity.

3.5.3.2 Individual Activity

The results of interest for our research questions are found in the measurements of individual activity as measured on foot, in vehicle, and on bicycle. Figure 3.7 shows the average amount of time that users spent per day engaged in each activity across the four experimental treatment conditions.

Figure 3.7. Average total user time spent daily in transportation/ active travel mode during the 2 experiment phases, in seconds



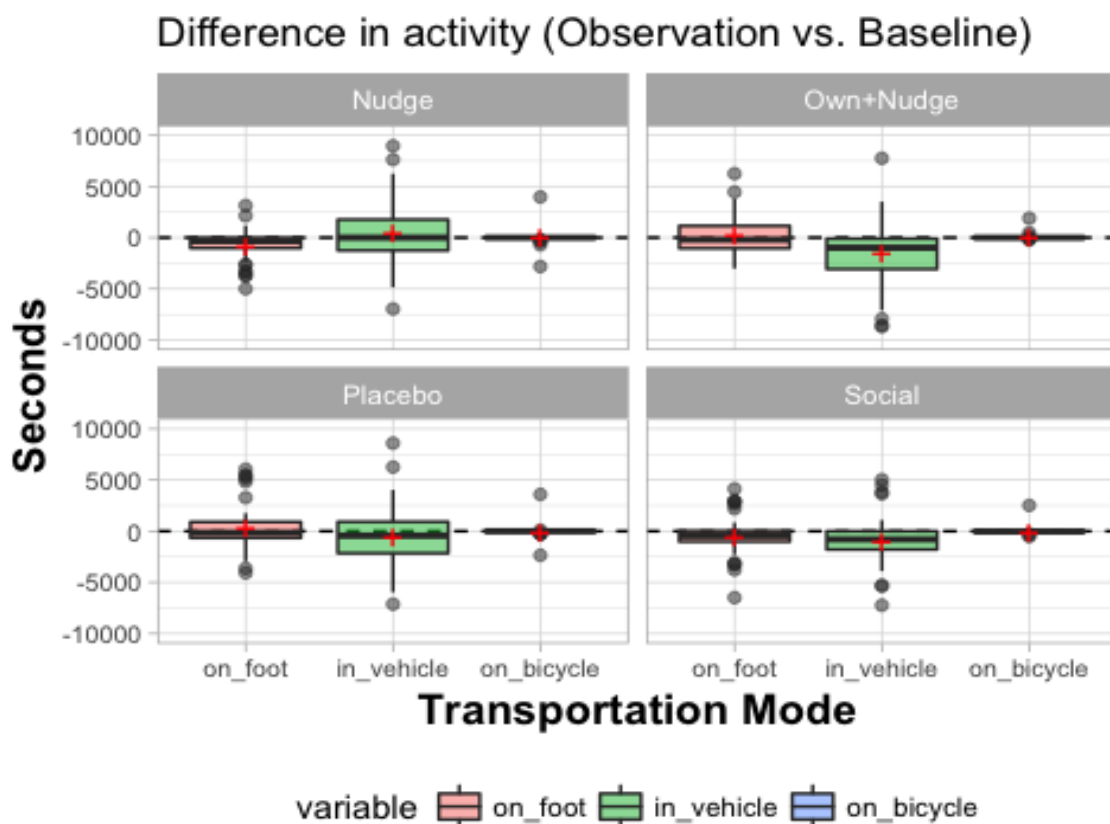
As shown by the graph, the transportation activity in which users spend more time is the *in vehicle* mode, across all conditions in the Observation period. Specifically, daily seconds spent *in vehicle* go from 2980.6 in Placebo to 3586.9 in Social. Daily seconds spent *on foot* go from 1512.6 in Nudge to 1772.2 in Own+Nudge. Time spent *on bicycle* is

quite marginal across all treatment conditions, with the maximum time equal to 168 seconds in Placebo during the Observation period.

3.5.3.3 Difference in activity

The figure below reports the difference in average individual activity for each transportation mode in the Observation and Treatment periods. An outlier observation equal to 71499.89 collected in the Own+Nudge condition for *in vehicle* has been removed from the graph for the sake of representation. The symbol “+” denotes average values.

Figure 3.8. *Difference in Activity*



As the graph shows, in the Nudge condition, the *in vehicle* activity tends to increase in the Treatment period, while activity *on foot* tends to decrease. Thus, as a whole, those receiving the Nudge messages alone (with no additional feedback about their personal or comparative amount of cycling and walking) increased the amount of time engaged in transport by vehicle and decreased the amount of time engaged in walking. In contrast,

in condition Own+Nudge and Placebo the *on foot* activity tends to increase while the *in vehicle* activity tends to decrease. Finally, in condition Social both *on foot* and *in vehicle* tend to decrease. In all conditions changes in *on bicycle* are small in magnitude.

The table reports on a linear regression in which the dependent variable is given by the difference in average individual activity. As explanatory variables we consider the treatment conditions, gender and age.

Table 3.5. Linear regression, using difference in average individual activity as dependent as dependent variable

	In vehicle	On bicycle	On foot
(Intercept)	35.613 (1904.110)	73.039 (167.390)	80.933 (642.806)
Nudge	525.697 (1439.577)	21.489 (126.553)	-1226.213 * (485.985)
Own+Nudge	888.827 (1516.796)	24.314 (133.341)	-51.295 (512.053)
Social	-257.462 (1496.519)	-13.621 (131.559)	-682.358 (505.208)
Gender	1142.638 (1135.500)	-204.648 * (99.822)	-4.125 (383.332)
Age	-31.775 (52.689)	-0.452 (4.632)	6.415 (17.787)
R ²	0.013	0.028	0.054
Adj. R ²	-0.018	-0.002	0.024
Num. obs.	166	166	166
RMSE	6523.744	573.502	2202.341
*** p < 0.001, ** p < 0.01, * p < 0.05, p < 0.1			
mode		Test	p-value

As the regressions shows, the Nudge condition causes a significant decrease in *on foot* activity, relative to the Placebo condition. A series of linear restriction hypotheses shows that Nudge also significantly differs from Social. No other significant differences among treatment are detected. Concerning demographic variables, females show a drop in the use of bicycle relative to males. The results of the estimation are confirmed also when considering additional explanatory variables like *Education*, *Presence of underage children*, *Type of job*, *Hours at work*, *BMI*, *Self-reported physical activity*.

3.5.4 Self-perceived measures of motivation, knowledge and belief

In an exit questionnaire, we queried individuals on whether and to what degree their participation in the experiment motivated them to engage in movement, and approximately 70% denied that it had influenced them much. In response to a question asking whether and to what degree the experiment increased their knowledge of the benefits of physical activity, approximately 65% of participants denied that their knowledge had increased appreciably. Finally, we asked whether and to what degree their participation in the experiment had increased subjects' belief that bicycling and walking more was doable, and approximately 60% denied that the experiment had considerably affected that belief.

3.5.5 Technology Functionality and Adequacy

A crucial element of our experiment was the use of the specially-designed HealthyMe app to deliver messages to participants, and the collection, storage, and analysis of travel data using interface between the cellphone, monitoring equipment, and databases (as described above in section 4.2). With regard to the app and data collection systems, our experiment relied upon efficiency and accuracy for conveying messages, capturing travel data measurements with precision, and satisfaction in users' app experience. Any study requiring use of technology is subject to some measure of attrition based on user-side lack of technological sophistication. Potential participants were not able to participate in our

experiment unless their cellphones utilized the Android system (to the exclusion of those with I-Phones for example). To some degree, the issues arising from the app that affected attrition in study participation numbers have been addressed above in the discussion of subject pool refinements (in section 5.1). According to responses on the exit questionnaire, 74% of participants did not experience crashes of the app, and the problem resolved for most of those who did (20% of total participants). The most troubling responses garnered in the exit survey informed us that approximately one-third of all those who completed the exit survey never received messages or received messages that were empty, with no text. Obviously, those who received empty or no messages were not subject to the treatment conditions and thus were excluded from our analysis. Unfortunately, this refinement called for the removal of 113 participants. Most did not judge the app to consume the smartphone's battery or data usage to an excessive degree.

Aside from issues related to messaging, the data capture system using Telecom's monitoring system. The monitoring system produced some inaccuracies in data collection. The combined effect of these inaccuracies and the flaws in the messaging system created large variances in the data.

3.6 Discussion

Participants in all treatment conditions decreased their vehicle use, a finding that reflects a fitting response to the conditional and unconditional messages regarding active travel (note, though, that even those in the Placebo condition decreased *in vehicle* travel). However, we might have expected an increase in participants' active travel, and our results do not indicate that the subjects did not supplement the decrease in vehicle use with an increase in active travel, except for slight increases in *on foot* in the Own+Nudge and Placebo conditions. The fact that the Placebo condition shared similar results to Own+Nudge dilutes any significance we might assign to these results. Moreover, in the Nudge condition, we experienced decreases in all three travel modes during the treatment period. Given that the Nudge condition resulted in a significant decrease in *on foot* activity

with respect to the Placebo control group, it appears that the participants in Nudge group were affected negatively by the messages that they received. The finding represents a contrary result relative to our expectations, albeit a relatively small one in terms of incremental transport changes.

The negative response in the Nudge group may be attributable to people's response of *reactance* to the manipulative nature of soft interventions. In social psychology theory, reactance explains an individual's unpleasant feeling when she feels her freedom to engage in a specific behavior is threatened or limited, and the accompanying increased motivation to engage in that behavior that has been threatened or limited. She displays reactance by engaging in the restricted behavior out of protest that her freedom to choose that behavior has been limited. Arad and Rubinstein (2017) demonstrated that participants in an online experiment making decisions in a hypothetical setting displayed reactance when they chose behaviors that had been threatened by government policy, in spite of their perception that another choice was preferable or in their best interest. The authors explain the resistance of a significant portion of their subjects to engage in behavior that the vast majority prefer or consider desirable as reactance to the government's restriction of their choice.

Governments or others who use choice architecture to increase public welfare may indeed elicit an unexpected reaction, the reactance response wherein people are attracted toward the restricted choice. The motivation toward the restricted choice is related to people's hostility toward the 'meddling' with individual free choice and occurs even despite their knowledge or perception that the reactive decision is not in their best interest (Arad and Rubinstein 2017). These authors demonstrate that in their own and the recent work of four other studies, a significant portion of participants acted as if in protest to the interventions by contrarily not making the choice being encouraged by the government. Their studies confirmed that a large number of individuals have concerns about the manipulative nature of soft interventions, wherein the libertarian paternalist government acts as choice architect that "knows what's good for its citizens". The authors found that a significant

number of participants preferred informational interventions over soft interventions that affected a participant's choice without him being aware. The studies caution that people prefer government to take the role of information provider rather than choice, and that many experience reactance and are attracted to make the choice that the choice architect has chosen to restrict when they perceive that their choices have been limited. Account should be taken by choice architects for *reactance* in which people opposing the choice restriction oppose a policy even when they support the intervention's goals (Arad & Rubinstein 2017).

Our study differs from the hypothetical questions posed by Arad and Rubinstein because government roles were not discussed, nor did we act as choice architects encouraging certain behaviors by designing or restricting the choice situation. However, we believe that we elicited a similar response from participants. In all groups except the Placebo condition, we sent unconditional messages that would likely be perceived by participants as nudges designed to increase the participants' active travel levels. We touted the advantages and benefits of active travel, from health benefits to environmental benefits to economic savings to reduction of 'hassle factors'. Our participants knew that we were tracking their activity and thus they easily would have perceived the unconditional Nudge messages as an attempt to encourage active travel behaviors. Their response of decreased active travel may be in reaction to their perception that we were prodding them toward more active travel, similar to the reactance seen in Arad and Rubinstein (2017) in their hypothetical decisions regarding government and employer interventions to curb unhealthy eating in the workplace. Our Nudge participants' reaction indicates that they may be resisting our attempts to persuade them in a reactance response to what they perceive as our attempt to manipulate them or act in a (libertarian) paternalistic manner, knowing what is best for them and seeking through lightly veiled statements of benefits to impose our will that they engage in active travel. Just as the subjects in Arad and Rubinstein (2017) indicated that government should not play a paternalistic role in seeking to affect people's nutritional or unhealthy eating habits, the contrarian behavior of reducing active travel—or even the neutral response of not increasing active travel—may represent a refutation to accept our

paternalistic meddling, albeit by a soft intervention that does not limit or restructure their choices. Thus, the result of the Nudge condition demonstrates an extension and elaboration of the same reactance response seen by Arad and Rubinstein (2017). It extends the reactance response to a real-world situation in that ours was an experiment carried out over considerably longer time in real life situations versus an online experiment involving hypothetical scenarios. Our experiment expands upon other aspects. Arad and Rubinstein (2017) saw reactance among subjects when proposing *government-initiated choice-restricting* hypothetical situations, whereas our participants demonstrate reactance toward *experimenter-imposed informational non-choice restricting* messages, albeit skewed toward presenting *only the benefits* of active travel modes. We argue that although the differences are significant, the same dynamic of reactance is at work in both studies.

Given that the bulk of all active travel modality shifts in our study were relatively small, we also argue that another important result is actually the lack of any strong result itself, that is, there was no *marked* increase in active travel as a result of receiving our treatment messages. Our results essentially demonstrated that people's active travel behavior did not change appreciably as a result of receiving the Nudge, Own+Nudge, or Social treatment messages that we sent to them. We recall the words of Marteau and colleagues (2011):

Evidence to support the effectiveness of nudging as a means to improve population health and reduce health inequalities is, however, weak. This reflects *absence of evidence* as well as *evidence of little or no effect*.

It seems that our study contributes to the latter; by failing to have the effect that we had hypothesized, that of increasing active travel through the conditional and/or unconditional messages, our study adds to the hefty number of studies that demonstrate the ineffectiveness of both conditional and unconditional messages. In their review of nine technology-based systems or apps to encourage sustainable travel modes, Sunio & Schmöcker (2017) found, similarly to Marteau et al. (2011), that the interventions to promote sustainable behavior change had generally yielded small effects and thus that no

definitive conclusions could be derived yet. Offering a caveat related to the utilization of smartphones and devices as platforms for changing behavior, Sunio & Schmöcker (2017) pointed to evidence that usage of such devices had generated negative attitudes toward sustainable behavior and cautioned that the design of technology such as HealthyMe apps should include particular features to maximize persuasive potential. These features include: tunneling (guiding users through the process or experience), tailoring (to meet personal needs, interests, personality, or usage context), rehearsal, simulation, social facilitation, and cooperation.

Research has established well that individuals who do not formulate both a goal or target behavior (e.g., to increase active travel) and a plan for implementing that target behavior (e.g., to begin commuting on foot to work) are less likely to experience behavior change (Sunio & Schmöcker, 2017). Planning for when, where, and how to implement the target behavior appears to be a key factor for changing active travel behaviors. Nonetheless, Sunio & Schmöcker (2017)'s review of nine technology-based systems (most cellphone-based) designed to encourage active travel and sustainable mobility found that, unlike health-based behavior-change-support-systems (BCSS)¹⁹, mobility-focused BCSSs often fail to incorporate the *planning* or *simulation* features that facilitate user's implementation intention. Because habit plays an important role in determining transport choices, apps or technology-based methods of changing travel behavior such as the HealthyMe app may be more likely to increase active travel choices only when they incorporate strategies involving the user in breaking the habit, by developing plans (how, when, where) for active travel and by simulating putting that active travel behavior into use (gamification has been suggested).

Similarly, the recent work by Andersson et al. (2018) reviewed previous research and theory on BCSSs and identified essential aspects in the creation and development of

¹⁹ Sunio & Schmöcker (2017) adopt an earlier study's definition of BCSS as "an information system designed to form, alter, or reinforce attitudes, behaviors or an act of complying without using deception, coercion, or inducements"

persuasive smartphone applications, including customization to the user, contextualized information and feedback, commitment, and appealing design. While we incorporate the other features, our study did not include features of the commitment aspect. The authors of Andersson et al. (2018) assert that based on their review of previous research on ICT use to influence behavior, failure to incorporate each of the essential aspects has produced mixed results. The essential ingredient that Andersson et al. (2018) refers to as ‘commitment’ seems to be the same component that Sunio and Schmöcker called ‘planning’ or simulation, and notably this feature is lacking in our design. Although we intentionally left the component of intention implementation out of our design because we wanted participants to test our nudges on an audience that was ‘blind’ to our intent, it would seem from these two reviews of BCSSs that the lack of influence on participants’ active travel behavior may be owing to this missing component of participant buy-in or explicit commitment or planning.

There are several limitations of this research that should be noted and addressed in future work. There were some technical difficulties: the first relates to data detection and/or capture and our indications that the data collection may have missed some participant activity; the second relates to errors in the delivery of our treatment-specific messages through our cell phone app. These technology gaps create some large variances in the data. Also, there was considerable attrition in this study, as is typical of studies that are long-term. Technological difficulties such as battery consumption likely played a role in the uneven adherence and/or abandonment of some participants. Although there was not a large difference in attrition between the conditions, there was more attrition in the Nudge+Own condition and the resulting treatment groups are not balanced in terms of numbers.

3.8 Implications for Future research

We answer, but also reiterate, the calls of Andersson et al. (2018) and many of the authors they reviewed, for further exploration into and development of a successful tool for

collecting active travel data and measuring active travel behavior change with the use of smartphone technology. While we cannot be sure whether our results would have been somewhat different with better data capture, the considerable ‘noise’ created by the large variances indicates a ‘technology gap’ between what we set out to do and what the technology was able to do. We set out to create a system that both send messages with an in-app pop-up delivery style (thus enhancing their accessibility and salience for users), and to measure results to these messages by collecting travel data. Our app, in the cases of most participants, performed well. However, we reiterate the indications from Andersson et al. (2018) and Sunio & Schmöcker (2017) that findings have been sometimes been imprecise from these studies and that future research should continue with robust designs considering the specific advice offered herein and by these authors to structure research capable of testing the ways to increase active travel using the latest technological advances.

Appendix 3.1 PROJECT HealthyMe – List of Nudges (translated from Italian to English)

#	Message
1	Remember that you stay young and live longer if walking and bicycle. Add years to your life and life to your years!
2	Did you know that physical activity alleviates feelings of depression, stress, loneliness, and anxiety, stress, increases self-confidence, and helps you have a positive self-image? Getting yourself moving on foot or bike is a great way to get exercise and have fun!
3	Did you know that you breathe in up to 15 times more carbon monoxide traveling the same route at the same time in your car than you do on foot or bicycle? Help the environment and your health, go by foot or bike when you can!
4	Did you know that a regular exposure to traffic has been shown to decrease work productivity and life satisfaction? Go by foot or bike when you can!
5	The World Health Organization suggests 150 minutes of physical activity per week for a healthy lifestyle. Does that seem like a lot? Remember that each week has 10080 minutes!
6	Did you know that to burn off a slice of cake you must stand for 336 minutes or do ironing for 95 minutes? But it takes only 33 minutes of bicycling at a moderate speed!
7	You don't need to become a great athlete to reap the benefits of physical activity, just start going by bike and foot!
8	Did you know that to burn off a ham sandwich require 227 minutes of standing or 64 minutes of ironing? But you can burn the same amount in only 23 minutes of bicycling!
9	Did you know that, with respect to sedentary persons, those who are active are more productive at work? For a more productive society, let's go by foot and bike more!
10	Did you know that the risk of obesity among children is constantly increasing? For a healthier future, let's teach the younger generations about active living. Be a role model!
11	Remember that those who walk and bicycle contribute to a cleaner and more beautiful city. The whole community owes them our thanks!
12	Did you know that cardiovascular disease is the leading cause of death? The risk of developing a cardiovascular disease for a sedentary person is the same as for smoker who smokes 20 cigarettes per day. Make our world a healthier one by going by bike and foot.
13	Did you know that in Europe, 1 in 3 car uses is for distances less than 3 kilometers? Contribute to cleaner air. Let's go by foot and bike when we can.
14	You have 1440 minutes in each day. Spend 30 of them in action, even split in 2 or 3 sessions.
15	Remember that walking and bicycling is a positive message and an encouraging example for other citizens. For a cleaner and healthier environment, be a role model, go by foot and bike when you can!
16	Did you know that cities with many bike paths top the list of cities with high quality of life? Take a break from your driving habit and discover why.
17	Remember that getting around in the city is generally faster, easier, and more efficient if you use your bike. Save yourself more time!

18	Did you know that the direct and indirect costs of poor lifestyle choices among citizens cost the State of Italy spends around 600 million Euros per year? Help reduce these costs by being active!
19	Even with our busy lives, we can welcome opportunities to be physically active: take the stairs, go to work and school by foot or bike, enjoy a quick walk in the fresh air!
20	Tired of wasting time searching for parking? Going on foot or bike reduces traffic in our city and helps you save time!
21	Remember that for persons aged 18 to 50 years old, drivers have a higher risk of accident than those who travel by bike. And if you travel by foot, it's even lower than on bike!
22	Remember those who are physically active have lower direct medical costs than those who are sedentary.
23	Did you know that, with respect to sedentary individuals, those who walk or ride a bike for 20 minutes per day are four times more likely to state that they are happy or very happy?
24	Physical activity is even good for your social life: communities that report diffuse physical activity also report higher levels of physical recreation and social participation.
25	The widespread benefits of physical activity are even economic: lower costs of public health, increase productivity and lower number of work absences are only a few examples. Let's get more active!
26	Walking and taking the bike are the easiest and cheapest ways to stay fit!
27	Did you know that in Europe 1-in-2 car trips are for distances under 5 kilometers? For a more livable city, let's walk and go by bike when we can!
28	Taking part in physical activity, particularly for the young, gives an important outlet for energy, helps with managing daily responsibilities, and improves socialization.
29	Moderate daily physical activity reduces bad cholesterol, improves good cholesterol, and reinforces the immune system. Getting moving on your bike or walk when you can!
30	Physical activity improves your well-being and your balance, and contributes, especially for youth, in diminishing risks related to substance abuse and violent behavior.
31	Physical activity has positive effects on psychological well-being, reduces anxiety, and promotes healthy sleep patterns.
32	Physical activity contributes to prevention of disability, slows the atrophy of muscle mass and strengthens bones, improves balance and coordination reducing, especially in older individuals, the risk of accidental falls and related broken bones.
33	Physical exercise slows the aging process. If regularly performed as an adult, physical activity can add up to 5 years to your life!
34	Scientific studies show that the lack of exercise is as dangerous as smoking. To enjoy the benefits of physical activity, it's not necessary to become an Olympic champion. Just move a bit more every day, even two or three 10-minute sessions.
35	It's a fact that traffic causes nervousness, depression, and insomnia. For a more relaxed society, let's all walk or get there by bike!
36	Physical activity improves psychological well-being. Clinical tests demonstrate that exercise can be helpful even in the treatment of depression.
37	Even if you have little time, try to seek out every occasion to get a little exercise: take the stairs, go by bike or foot when commuting, take a quick walk in the fresh air!

38	A recent study demonstrated that everyday physical activity can help your brain to develop new cells that contribute to improved learning and memory capacities.
39	Remember that walking and going by bike are free and fun!
40	Physical exercise alters body composition: you form muscle mass, reduce fat stores, and speed up your metabolism and consumption of calories even as rest, an important factor for losing weight!
41	Numerous studies demonstrate that physical activity improves psychological well-being, methods of stress management, and mental functions, like our planning and decision making capacities, and short-term memory.
42	Remember: a daily dose of physical activity helps improve both your physical and psychological states. Two or three 10 minute sessions of physical activity are nearly equal to exercising the same time in one session, and are easy to add to your everyday activities.

Appendix 3.2 PROJECT HealthyMe – List of placebo messages (translated from Italian)

#	Message
1	“To start the day right, choose a coffee, and to continue it well, choose a smile.” (Stephen Littleword, <i>The Small Stuff</i>). Have a nice day!
2	There are three mothers and each has two daughters. They decide to go to a movie. There are only 8 seats left in the theater but they are all able to sit anyway. How is that possible? Have a nice day!
3	From the 18th to 20th of November 2016, the first home expo dedicated to Design, Style, and Green Building takes place at the Riva del Garda fairgrounds. Have a nice day!
4	Good Morning! The world does not belong to those who rise early, but to those who are happy to wake up. Have a nice day!
5	From November 12th to 3rd December 2016, the Arco Auditorium will host the showing of <i>SU e ZO dal PALCO 2016 - 4 sabi en dialet</i> , a play using local dialect! Have a nice day!
6	Did you know...the planet Mars has two small natural satellites: Fobos and Deimos. It is the only rocky planet in our solar system that has a system of satellites. Have a nice day!
7	“You’ve got to get up every morning with determination if you’re going to go to bed with satisfaction.” Have a nice day!
8	Mantua is Italy’s Capital of Culture in 2016, a great reason to visit this beautiful city. Have a nice day!
9	Did you know...Durendal is the name of the sword that according to legend was used by Roland, the legendary paladin in the battle of Roncevaux Pass to defend against the entire army of Charlemagne. Have a nice day!
10	Starting in November 2016 MART museum presents “Umberto Boccioni”, an exhibition to celebrate the 100th anniversary of the great artist’s birth. Have a nice day!
11	The morning is the father of taking action and the evening is the mother of thinking. Have a nice day!
12	In Arco through January 8th, the exhibit “Segantini and Arco” explores the relationship between the artist and his city. Have a nice day!
13	A positive first thought of the day upon waking can change your whole day. Good Morning!
14	Sunday December 4th, 2016 Marco Mengoni will be in concert at Bolzano’s Sporting Arena. Have a nice day!
15	In a small lake, there is a water lilly which doubles its size every day. If the plant is able to cover the whole lake in 48 days, how many days would it take to cover half the lake’s surface? Have a nice day!
16	Do you like Italian music? Tuesday December 13, 2016 Raphael Gaulazzi will be in concert at the Santa Chiara theater in Trento. Have a nice day!
17	If you think you are facing a tough day, consider the day that Ronald Wayner sold his 10% share of Apple for \$800. Today it would be worth roughly 600 billion. Have a nice day!
18	“The sunrise is one of the biggest mysteries made up of both dreams and thought. “ (Victor Hugo) Have a nice day!

19	Saturday the 10th and Sunday the 11th of December 2016 the Festival of <i>Canderlo</i> (a local dumpling) will take place in Borgo Valsugana, including tasty food, children's activities, and special shopping hours in the town's historic center. Have a nice day!
20	If 5 machines take 5 minutes to produce 5 hammers, how much time would it take 100 machines to produce 100 hammers? Have a nice day!
21	Renata's father has 5 daughters. The first 5 are named Babbana, Bebbena, Bibbina, and Bobbona. What is the fifth daughter's name? Have a nice day!
22	Did you know... a moon rainbow is a rare sighting just like a rainbow yet produced by light reflected on the surface of the Moon instead of by the direct light of the sun. Have a nice day!
23	Good Morning! Trento is a candidate for Italian City of Culture 2018. Do you know the opportunities that the city offers? Have a nice day!
24	In 2009 UNESCO named the Dolomite mountains a World Heritage Site. Visit this spectacle of nature just outside your front door! Have a nice day!
25	The world does not belong to those who rise early, but to those who are happy to wake up. Have a nice day!
26	A motto of the American army is: "We do more before 9 in the morning than most people do all day". Are you ready to take action? Have a nice day!
27	Did you know....50.62% of the Trento greater area is covered in forests? Have a nice day!
28	Every day can't be a great one, but there is something great in every day. Have a nice day!
29	Did you know... in 1642, mathematician and philosopher Pascal invented an instrument for making calculations that predates the modern calculator?
30	"It's common that a difficult problem at night is resolved in the morning, after the dream committee has worked on it." (John Steinbeck). Have a nice day!
31	A legend tells that <i>Piazza Pasi</i> in Trento still holds the buried treasure of <i>Brenno</i> . Good luck on your treasure hunt!
32	A notebook and a pen cost €1.10. The notebook costs 1 euro more than the pen. How much does the pen cost? Have a nice day!
33	Did you know that Torre Verde street held the oldest port of commerce in Trento? Have a nice day?
34	Do you know the sweet proverb of Trentino folk in love "Quando l'amor 'l gh'è la gamba la tira el pè"? Have a nice day!
35	Did you know... the green ray is an optic phenomenon at the moment the sun rises and sets when the sun creates a subtle green ray of light for a few seconds. Have a nice day!
36	"If we were created to jump out of bed the moment we wake, we would sleep in a toaster." (Garfield). Have a nice day!
37	Thursday the 15th of December 2016 – at 20.45 the theatrical show "Il malato immaginario" will play at the Cultural Association Number 11, Theater of Pergine Valsugana. Have a nice day!
38	The 13th of January 1985 in just one snowfall 150 cm of snow covered Trento. How will the next winter be?

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