A FUZZY-TRACE THEORY APPROACH TO HEALTH AND MEDICAL DECISION-MAKING

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I review and test predictions of fuzzy-trace theory by bridging health and medical information with effective communications that influence decision making. First, I present an overview of the theory, describing the theory's core principles and evidence in the areas of risk perception, prevention, detection, diagnosis of disease, and decision making regarding treatment (Chapter 2). I then present findings from interventions based on fuzzy-trace theory designed to improve health and medical decision making. Fuzzy-trace theory provides guidelines for development of such interventions because it predicts reactions to health messages and explains the causal mechanisms of judgment and decision making. Second, I empirically address these predictions in a series of experiments (Chapters 3 and 4). In Chapter 3, I develop and test an intervention grounded in fuzzy-trace theory to prevent obesity (which is one of the most common risk factors for negative health outcomes). In three experiments, 864 subjects were randomly assigned to an experimental tutorial or a control tutorial with unrelated content. The experimental condition, GistFit, consisted of a static, text-based intervention (Experiment 1) or an online intervention using Sharable Knowledge Objects, a web-based tutoring system that uses artificial intelligence technology to create an Intelligent Tutoring System (ITS), $\text{GistFit}_{\text{ITS}}$ (Experiments 2 and 3). Subjects answered questions of knowledge, gist comprehension, psychosocial mediators of

behavior (e.g., attitudes, gist principles), behavioral intentions, and self-reported behavior about nutrition and fitness. The interventions improved endorsement of gist principles (or simple values). Exposure to the revised $GistFit_{ITS}$ also resulted in significantly higher scores on gist and verbatim knowledge and gist comprehension compared to control. In Chapter 4, I further explore the benefits of using the web-based tutoring system, $GistFit_{ITS}$, in a randomized, controlled experiment with 251 subjects. Engagement in tutorial dialogues revealed significant correlations with knowledge tests, gist comprehension, and endorsement of gist principles, which correlated with intentions to perform healthier behavior and self-reported behavior. Overall, results were consistent with fuzzy-trace theory, suggesting that $GistFit_{ITS}$ instills active understanding that promotes gist-based thinking, not a passive memorization of verbatim details, to assist people in making preventive health decisions.

BIOGRAPHICAL SKETCH

Priscila Goergen Brust Renck has been a Ph.D. student in Cornell University's Department of Human Development since 2011. She received her Bachelor degree in Psychology in 2007 from the Department of Psychology, Pontifical Catholic University of Rio Grande do Sul, Brazil, from where she also received a Master degree in Psychology with concentration in Human Cognition in 2010. She also earned a Master of Arts in Developmental Psychology from Cornell University in 2011. Her research interests lie in the field of cognitive and health psychology, primarily on judgment and decision-making and numerical cognition with implications for health risk communication and development.

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CHAPTER 1

INTRODUCTION

Increasing amounts of information are available to the public, and researchers and practitioners alike are concerned about how this information can be used to help improve understanding of health and medical information (Betsch et al., 2012). The communication process is particularly important in the context of healthcare, in which crucial decisions regarding prevention often hinge on understanding probabilities and health outcomes (Reyna, Nelson, Han, & Dieckmann, 2009). However, the word "communication" is often reserved for situations in which information is understood. This research has shown that limited understanding of risk, of numerical risks in particular, can be harmful in the context of health prevention, detection and diagnosis of disease, as well as treatment and disease management options (e.g., Fischhoff, Brewer, & Downs, 2011). For example, an insulin-dependent diabetic must carefully monitor blood sugar levels and manage medication accordingly because improper evaluation of blood sugar levels could translate into incorrect dosage or nonadherence to medication, which could eventually increase complications of disease.

Traditional approaches to communication of information in healthcare and medical fields emphasize telling the facts in order to facilitate informed decisions (Fischhoff, 2009). In particular, these theories suggest communicating health and medical information requires presenting detailed and precise information, which is assumed to be necessary to change someone's beliefs or behavior (Brewer, 2011; Fischhoff, 2005, 2010, 2011; see also Reyna & Farley, 2006; Stone, Yates, & Parker, 1997). According to this view, the goal of risk

communication is to "bridge gaps" between a normative ideal and descriptive reality (Fischhoff, 2009; Fischhoff & Kadvany, 2011). While the normative ideal indicates how people should make decisions, the descriptive reality is how individuals actually make those decisions (Fischhoff, 2005, 2010). A prescriptive analysis mediates the conflict between ideal and reality and makes recommendations to improve understanding. In the context of healthcare, this perspective implies that communication of health and medical information should provide accurate, detailed information that would help people reach their own conclusions. The patient is responsible for "connecting the dots" between what is communicated and making their own decisions between Treatments X and Y, Drugs A and B, or even whether to get regular screenings for cancer (e.g., Brewer & Fazekas, 2007).

The success of traditional healthcare approaches relies on the idea that pertinent information is being communicated to the patient (Brewer, 2011). However, in this model, interpretation of risk is left to the patient, which can lead to a lack of understanding and poor decisions (e.g., refusing to take worthwhile medication or vaccines). With insufficient efforts to "bridge the gap" between normative ideals and descriptive reality, patients may not always choose the best option. Most recommendations in healthcare are grounded in empirical data, but the same is not true of decisions on how to communicate risk. The basic question remains about how to best communicate those data, such as whether to communicate through words alone, numbers alone, or visual aids (e.g., Grime et al., 2007; Stone et al., 1997). More fundamentally, traditional approaches emphasize the non-directive provision of both risks and benefits of alternative courses of action, rather than directing people toward a particular meaningful resolution of the facts.

A new approach to risk communication that accounts for meaningful understanding is fuzzy-trace theory—a dual-process theory that contrasts two types of thinking: verbatim- and gist-based (Reyna & Brainerd, 1995, 2011). Analytical processing operates on verbatim representations of information—the "surface" form of information. Intuitive processing operates on gist representations of information. This type of processing is impressionistic, usually quick for familiar knowledge domains, and incorporates factors that affect the gist meaning of information, such as culture, and experience (e.g., Reyna, 2012b, 2013; Reyna & Adam, 2003). Unlike other approaches' perceptions of intuitive thought processes, gist processing is not thought to be primitive. Rather than attempting to process fewer pieces of information, gist processing takes information and extracts its essence, facilitating efficient but higher-order processing.

Fuzzy-trace theory takes the perspective that communication about risk in healthcare involves identifying the most relevant facts from messages and making their meaning comprehensible to patients, not just sharing information (Brust-Renck, Royer, & Reyna, 2013; Reyna, 2008, 2012b). The goal of health risk communication, then, is to facilitate people's understanding of the meaning of health information in context by distilling their simplest qualitative essence (Reyna, 2004, 2012b, 2013; Severtson & Vatovec, 2012). Previous research based on fuzzy-trace theory has shown that people prefer to make decisions based on the least precise gist interpretation that will allow them to make an informed decision (e.g., Reyna & Hamilton, 2001; Reyna & Brainerd, 1995; Reyna & Lloyd, 2006; Wilhelms & Reyna, 2013). Informed decisions depend on people being given accurate information and truly comprehending its meaning. This means that patients need to understand the correct gist of their situation when making an informed decision about risk.

In the following chapters, I provide a deeper and more thorough discussion of how reliance on meaningful (gist) understanding improves informed and healthier decisions (Chapter 2) and apply fuzzy-trace theory predictions to a new health domain, nutrition and fitness (Chapters 3 and 4). Specifically, in Chapter 2, I provide an overview of the implications of fuzzy-trace theory for health decision sciences, including the effect of background knowledge on health decisions, the effect of retrieval cues on risk perceptions, how retrieval of gist principles is associated with risk prevention, as well the effect of gist-based processing on probability judgments. In particular, I discuss recommendations from fuzzy-trace theory and evidence from research that information should be presented in an intuitive, user-friendly format, in which meaning is straightforward (e.g., categorical when appropriate) to help reduce risk taking behaviors and intentions, teach individuals to engage in gist-based thinking (e.g., "Even low risks happen to someone") and retrieve gist principles and relevant values from information (e.g., "It only takes once to get HIV/AIDS" and "Better to be safe than sorry").

I further discuss the design of interventions based on fuzzy-trace theory, taking into consideration how health knowledge is mentally represented, retrieved, and processed coherently in decision making, as well as how interference is inhibited (e.g., Brewer et al., 2012; Fraenkel et al., 2012). That is, I discuss how the processes of communicating risks can be effective even when information is presented in a way that allows people to mentally represent their risk without deliberative thinking. When gist values and principles are effectively communicated through meaningful representations of risk (which do not require mindless memorization), they can then be practiced sufficiently so that they can later be automatically retrieved in context to avoid (or at least reduce) risk (Reyna, 2008, 2012a).

For example, Reyna & Mills (2014) developed an intervention based on fuzzy-trace theory to teach adolescents about the risks of pregnancy and STIs from unprotected sex. The gist-based intervention was implemented as part of a randomized control trial with 734 adolescents and compared to 1) a standard multicomponent intervention ("Reducing the Risk;" Reyna, Adam, Poirier, LeCroy, & Brainerd, 2005) and 2) an unrelated control group. The intervention included the same content as the standard intervention, but risk was communicated in a gist format (e.g., "Even low risks happen to someone") and subjects were also taught to identify and automatically retrieve gist values (e.g., "Avoid risk"). Subjects were encouraged to understand the gist of information about risky behaviors, recognize risky situations rapidly, retrieve relevant values, and engage in automatic gist-based thinking. Results demonstrated that the fuzzy-trace theory curriculum produced significant improvements (relative to standard and control interventions) for 17 out of 26 outcomes, and was more effective than the others across a range of outcomes (e.g., knowledge, attitudes, and behaviors), lasting as long as 12 months after program delivery.

In this and other fuzzy-trace theory-based interventions, use of categorical gists (e.g., "No risk is better than some risk") has been associated with effective risk communication in healthcare (compared to verbatim information). Extracting the relevant, correct gist requires knowledge, which laypeople and inexperienced patients often do not have, but this can be supplied through risk communication that focuses on essential meaning (see also Wolfe et al., 2015). Thus, the review of the literature in Chapter 2 laid the groundwork for the development of health and medical interventions that I tested in Chapters 3 and 4.

Chapter 3 consists of three experiments describing the development of an obesity-prevention intervention grounded in fuzzy-trace theory. In Experiment 1, I tested the first gist-

enhanced intervention to prevent obesity in a randomized controlled experiment using fuzzy-trace theory's principles as applied to information on nutrition and fitness—GistFit: Getting the gist of healthy eating and exercise. The intervention emphasized the bottom-line meaning of nutrition and fitness in a static text-based format, in accordance with research on fuzzy-trace theory (e.g., Reyna & Mills, 2014; Wolfe et al., 2015). In addition to presenting verbatim facts, the tutorial emphasized the essential decision-relevant meaning of information. Moreover, in GistFit, short bottom-line summaries of important points were provided at the end of each lesson, designed to facilitate the encoding and long-term retention of core information. Two hundred female undergraduate students were randomly assigned to either the experimental (GistFit) or control condition (with different content).

In Experiment 2, we used a novel approach to help women prevent obesity with an intelligent tutoring system (ITS) to provide more active tutoring than traditional static text-based interventions can provide, $\text{GistFit}_{\text{ITS}}$. The tutorial was built using a Sharable Knowledge Objects (SKO) platform, which is a computer-based system using artificial intelligence techniques to mimic one-on-one tutoring. Throughout the SKO, a talking avatar presented information orally and in text, while simultaneously illustrating content with figures (e.g., examples of food from each nutrient and sequence of images demonstrating how to correctly perform aerobic exercises). Like in Experiment 1, Experiment 2 was a randomized controlled experiment conducted to assess the effectiveness of the obesity prevention intervention with 213 female participants. Additional measures were included to better assess the effectiveness of the intervention (e.g., attitudes) including a new measure of gist knowledge (to avoid ceiling effects from Experiment 1 and capture understanding from learned content).

Experiment 3 was a new randomized controlled experiment with 251 female participants, in which the ITS version of $GistFit_{ITS}$ was further refined to account for recent research findings about nutrition and fitness (e.g., Levitsky & Pacanowski, 2013). New measures of verbatim knowledge and gist comprehension (designed to facilitate encoding and long-term retention of core information) were included in addition to measures that capture other dimensions of risk taking that are likely to contribute to risk taking—sensation seeking, impulsivity, and self-control (Figner, Mackinlay, Wilkening, & Weber, 2009; Reyna et al., 2011; Wilhelms & Reyna, 2013). (A full copy of the surveys from Chapter 3 can be found in the Appendix. The survey from Experiment 1 can be found in Appendix A, from Experiment 2 in Appendix B, and from Experiment 3 in Appendix C.)

Finally, in Chapter 4 I further examine the benefits of using a Web-based ITS that applies artificial intelligence to create a scalable and cost-effective way to engage people in actively learning about obesity prevention. One of the greatest advantages of computer tutors is their ability to mimic human tutors in helping learners to "connect the dots" and to provide immediate feedback, facilitating the integration between current and prior experiences, known advantages of one-on-one tutoring (Chi, Siler, Jeon, Yamauchi, & Hausmann, 2005; Lloyd & Reyna, 2009). The effectiveness of the ITS was tested in a randomized, controlled experiment with 251 female participants. Participants were randomly assigned to either the obesity prevention tutorial or a control tutorial on a different content using the same technology. Participants were then given tests of knowledge about nutrition and exercise, measures of gist comprehension and gist principles, and questions about their behavioral intentions and behavior. I further investigated the engagement in dialogues with the tutorial in comparison to performance on subsequent knowledge tests, gist comprehension, and endorsement of healthy values. (A copy of the

measures embedded within the tutorial can be found in Appendix D.) Using this approach I expect that encouraging active learning (instead of passive learning) will contribute to learning in such a way that influences behavior change akin to that observed via one-on-one tutoring, a gold standard for communicating information (e.g., Wolfe et al., 2012, 2013). $\text{GistFit}_{\text{ITS}}$ could prove to be a scalable and cost-effective way "where any person could find instruction in any study" (Ezra Cornell, personal communication October 7, 1868).

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CHAPTER 2

A FUZZY-TRACE THEORY OF JUDGMENT AND DECISION MAKING IN HEALTHCARE: EXPLANATION, PREDICTION, AND APPLICATION

In this chapter, we discuss how an evidence-based theory of human behavior and decision-making—Fuzzy-Trace Theory (FTT)—can be used to better understand and improve public health and medicine. Initially, we present an overview of the theory, describing its core principles as well as illustrative evidence. That evidence includes research prior to FTT as well as current research from independent laboratories. Applications are discussed in the areas of risk perception, prevention, detection and diagnosis of disease, as well as decision making regarding treatment. We then present findings from interventions designed to improve health judgments and medical decision making. FTT provides guidelines for development of such interventions because it predicts reactions to health messages and explains the causal mechanisms of judgment and decision making. Specifically, FTT has been applied to designing public health programs and patient education tools that effectively communicate risks and benefits, and to tools for healthcare providers. By focusing on theoretically motivated mechanisms of judgment and decision making, old interventions can be enhanced and new ones can be designed. Examples of interventions are given from HIV-AIDS prevention, genetic risk of breast cancer, biologic therapy for arthritis, and cardiovascular disease. Finally, we present implications and recommendations for future research.

Background: Fuzzy-Trace Theory

FTT is a theory of memory, reasoning, judgment, and decision making that also describes how these develop across the lifespan (Reyna, 2012a, b). Central to the theory are five components of social cognition that are relevant to the medical decisions of patients and providers: (a) background knowledge; (b) mental representations of new inputs; (c) retrieval of principles and social values; (d) application of principles and values to representations (which can elicit processing interference, as in probability judgments), and (e) individual differences, notably, the ability to inhibit interference (Reyna & Brainerd, 1995; 2011). Background knowledge refers to information stored in long-term memory that affects how a person processes incoming stimuli such as health messages. This knowledge could be understanding of numbers, other educational knowledge, or personal experience (Reyna, 2012b; Reyna, Nelson, Han, & Dieckmann, 2009).

Stimuli, such as auditory and visual inputs, are encoded in two kinds of mental representations in parallel: verbatim and gist (Reyna, 2011). A verbatim representation is a memory of the precise surface form (e.g., exact words, numbers, or pictures), whereas a gist representation is a qualitative understanding of the deeper or bottom-line meaning of an event or stimulus (Reyna, 2008, 2012b). The verbatim representation reflects the objective facts, whereas the gist reflects a subjective and impressionistic interpretation. In addition, retrieval cues differ in their tendency to elicit verbatim versus gist representations, which means that judgments about the same event can vary depending on the cues in questions (e.g., Mills, Reyna, & Estrada, 2008). In fact, FTT is the only theory that can predict these specific inconsistencies in health judgments within individuals.

Knowledge helps shape gist representations, and these representations are also influenced by personal characteristics such as culture, prejudices, beliefs, and worldview, among other factors that affect understanding (Mills et al., 2008; Reyna & Adam, 2003). People typically extract multiple gist representations of the same input (Reyna & Brainerd, 1995). For example, consider a 55-year-old female who is trying to determine her risk for breast cancer by using the Breast Cancer Risk Estimation Tool from the National Cancer Institute website (http://www.cancer.gov/bcrisktool/). Suppose further that the online estimation tool determines that her lifetime risk is 20%. From this information, the woman encodes a verbatim representation of "20%." She also typically extracts multiple gist interpretations of what that percentage *means*.

When considering breast-cancer risk estimates derived from the online tool, two women may view a risk of 20% differently. One may see 20% as a "high risk" relative to an average woman's risk of 12.2%, whereas a second woman may not know the average woman's risk and view 20% as a "low risk" because it is substantially lower than 50% (i.e., it probably won't happen; Brewer, Tzeng, Lillie, Edwards, Peppercorn, & Rimer, 2009). Background knowledge—knowledge of the average risk—influences how the gist of the risk estimate of 20% is interpreted, as high or low (Fagerlin, Zikmund-Fisher, & Ubel, 2005). Although gist representations are subjective, and thus differ across individuals, they are not arbitrary. Usually, a small number of gist representations encompass most people's interpretations of risks for the same information—especially if those people share background knowledge.

Gist representations are encoded at multiple levels in a hierarchy that roughly correspond to levels of measurement, from the most crude to the most fine-grained level of precision (Reyna, 2004, 2008, 2012b; Reyna, Lloyd, & Brainerd, 2003). Thus, a crude level of gist for

quantities (e.g., number of patients who survived whose cancer was detected early; numerical probability of developing breast cancer) corresponds to the simplest distinctions about quantities, namely, nominal or categorical level (e.g., "All of the early-detection patients survived" or "I am at risk for developing breast cancer"). In parallel, a person might also encode a representation of the same information at an ordinal level of precision (e.g., "My risk of breast cancer is higher than average"), and then again at yet more precise levels, such as interval or ratio levels (e.g., "My risk is 1 in 5").

Note that "1 in 5" is technically not a representation of the verbatim stimulus, which was 20% in our example, but is, rather, verbatim-*based* because it involves a computation performed on the exact number presented (Reyna & Brainerd, 2008). People who are higher in numeracy (the ability to understand and use numbers) are more likely to spontaneously perform such computations (e.g., Reyna et al., 2009). These computations do not necessarily bring decision makers closer to the right decision, which hinges instead on distilling the essential qualitative gist of the options (Reyna, 2008).

Once information is encoded in gist and verbatim representations, decision makers retrieve principles and personal values that are applied to these representations (Reyna, 2004, 2008; Reyna & Brainerd, 2011). Consider the example of a woman deciding whether to have a lumpectomy or a mastectomy after being diagnosed with early-stage breast cancer. Studies have shown that long-term survival for lumpectomy (plus radiation therapy) is similar to that for mastectomy, but recurrence rates are slightly higher for lumpectomy (American Cancer Society, 2012). For many patients, values relevant to this decision include survival, recurrence, and cosmetics in that order of priority. However, there are two main ways to interpret the gist of the risks depending on whether a small increase in recurrence is understood as "same" or "higher":

One gist interpretation is that survival is the same, recurrence is the same, and therefore the decision hinges on cosmetics, which favors lumpectomy. Another gist interpretation is that survival is the same, but recurrence rates are higher with lumpectomy, which favors mastectomy. Cosmetics do not figure in the latter decision because they would be considered only if the preceding dimensions were equivalent. This example shows that the representation of options helps determine which values are retrieved and applied.

Retrieving moral and social values is a cue-dependent process. Thus, according to FTT, value clarification methods can help patients by prompting retrieval (Fagerlin et al., 2013). As our example with lumpectomy illustrated, a primary value that is retrieved concerns survival (life is better than death) and a cancer diagnosis can be initially equated with death. A patient retrieving only this value would likely choose surgery (e.g., to "remove" the cancer and avoid death; see Reyna, 2008). However, decision aids often elicit additional values, such as quality of life, that are not easily retrieved, despite their relevance. The accessibility of values in memory is a result of overall priority for that individual as well as contextual cues (Reyna, 2008), which together determine which values are applied to decisions.

Applying retrieved principles to representations is a distinct phase of information processing (Reyna, 2012a). According to FTT, this processing can be interfered with by confusion caused by overlapping classes, such as the class of women with breast cancer and the class of women with genetic mutations (e.g., BRCA 1 or 2) that increase the probability of breast cancer (Reyna, 1991; Reyna & Brainerd, 1994; Reyna & Mills, 2007a). For example, people confuse the probability that a woman might develop breast cancer given that she has a genetic mutation with the probability that a woman has a genetic mutation given that she has breast cancer (Reyna, Lloyd, & Whalen, 2001). Research has shown that such confusion, which

produces errors in probability judgment, is a result of overlapping and nested classes rather than lack of understanding of ratios and probabilities (Reyna, 2004; Reyna et al., 2003, 2009). This class-inclusion effect will be further explored under detection and diagnostic tests. The ability to inhibit interference, for example from overlapping classes, increases from childhood to adulthood, but, nonetheless, varies across adults. This ability to inhibit helps people think coherently about combining different probability (and risk) judgments relevant to health (e.g., cancer risk and genetic risk; Reyna et al., 2009).

An Explanatory Approach to Health Decisions

FTT originated from extensive evidence in psychology, both basic and applied science. The upshot of this work is that bottom-line meaning (i.e., gist) is key for how people encode information and decide about health promoting choices (Reyna, 2008, 2012b). In the next section, we review some of the applications of FTT in providing a bridge between health information—which has limited effects on judgments and decisions when expressed in highly precise form—and effective communications that influence medical decision making (Reyna, 2008). We first address the pre-existing knowledge patients and health providers bring to decisions (e.g., numeracy). We then discuss how risks and benefits of health information are perceived, including lifestyle risks in the sexual health domain (e.g., in HIV-AIDS prevention) and vaccination risks, and how these perceptions are related to healthy choices. In the final sections, we discuss how the results of diagnostic tests are commonly misjudged (due to interference in processing), how gist representations determine treatment decisions, and whether patients truly understand and consent to risks of medication or surgery.

Background Knowledge and Health Decisions

As our earlier discussion about knowledge illustrated, the role of knowledge in FTT goes beyond arbitrary associations, recitation of facts, or mindless computational skills (e.g., Reyna, Chapman et al., 2012). According to FTT, knowledge allows decision makers to understand causal mechanisms that underlie health messages, and, thus, extract appropriate representations. For example, the knowledge of laypeople is limited with respect to transmission of sexually transmitted infections (STIs; Adam & Reyna, 2005; Reyna & Adam, 2003). Most laypeople assume that sexual transmission of infections occurs only through exchange of bodily fluids; hence, methods such as condoms must be effective because they provide a mechanical barrier that blocks this exchange. Therefore, people overestimate the effectiveness of condoms in preventing skin-to-skin transmission of STIs such as herpes simplex virus (HSV) and human papillomavirus (HPV). Reyna and Adam (2003), for example, found that students overestimated effectiveness of condoms significantly more than physicians and public health experts.

Similarly, few people have sufficient knowledge to understand public health messages about the rationale for vaccination, including such concepts as herd immunity (Reyna, 2012b). Even worse, vaccinations occur in the context of meaning threats—mysterious illnesses (whose cause is unknown, e.g., autism or narcolepsy) that co-occur with vaccinations. Meaning threats produce a greater impetus for people to "connect the dots" to understand their world and the mysterious adverse events that are happening in it (Betsch et al., 2012). FTT offers an explanatory framework in which to understand how anti-vaccination messages can be more effective in this context than official information sources, such as government Web sites.

Consistent with this framework, Downs, Bruine de Bruin, and Fischhoff (2008) have demonstrated that, to those with little background knowledge, health communications from

official sources are cryptic, whereas anti-vaccination messages tell a compelling and plausible story. Such web sites that produce more coherent and meaningful gist will be more influential in decision making, which can be an obstacle for public health (Betsch et al., 2012; Reyna, 2012b). To take one example among many, anti-vaccination messages have associated the measles, mumps, rubella (MMR) vaccine with the development of autism as a result of alleged mercury in the vaccine. Autism develops around the same age that the MMR vaccine is administered. Little is known about the causes of autism and the number of children with the disease is increasing; autism constitutes a "meaning threat" because of its mysterious origin. However, if an individual has the background knowledge that the MMR vaccine is a live vaccine and the presence of mercury in a live vaccine would kill it, the anti-vaccine explanation becomes implausible. Therefore, if people *understand* how vaccines work, there should be less reason to avoid the MMR vaccine (Reyna, 2012b).

Lack of knowledge is also exemplified with respect to innumeracy, associated with serious errors of probability and risk estimation in medicine and public health (Reyna & Brainerd, 2008; Reyna et al., 2009). Despite the surfeit of resources containing health information, many people still lack basic numerical understanding, in particular, ratios and probabilities, that is required to process this information to maintain health (consistent with FTT's predictions; see Detection and Diagnosis).

Much of the health information available to patients is expressed as numerical risks, such as risk of neurologic disorders from measles vaccine being 1 out of 3,333 doses (Stratton, Ford, Rusch, & Clayton, 2012). The ability to extract the gist from this numerical information—that 1 person out of 3,333 is a small frequency of neurologic disorder *relative to* how common measles was before the vaccine—is associated with training in public health and medicine, as this

knowledge introduces meaning to numbers (Reyna, 2012b; Reyna & Lloyd, 2006). However, FTT's conception of numeracy goes beyond traditional theories, which focus on analytical, quantitative ability, to emphasize qualitative understanding of the meaning (gist) of numerical information (Reyna & Brainerd, 2008). As an example, Peters, Slovic, Västfjäll, & Mertz, 2008, emphasize affective meaning, but their theory relies on traditional dualism between low-level intuition and high-level analysis, the latter subsuming numeracy.

In summary, differences in background knowledge have an effect on how information is understood, influencing the gist representations that are encoded in decision making. Research has shown that people rely on simple gist in decision making even when they can recall exact information (Kühberger & Tanner, 2010; Reyna, 2012a; Reyna & Brainerd, 1995). Gist representations incorporate meaning; they reflect inferences or connecting the dots among inputs. Background knowledge supplies some of the missing dots that allow people to go beyond the literal language of health facts. In the presence of meaning threats (mysterious adverse events), stories that seem to explain adverse events fill the vacuum of inadequate knowledge.

Risk Perceptions and Judgments: Effects of Retrieval Cues

In the previous section, an overview of errors of knowledge was presented, in which education played an important role in understanding risks. Risk estimation, however, is not only dependent on knowledge. Evidence suggests that different retrieval cues have varied (and sometimes paradoxical) effects on how individuals estimate risks, even those with advanced training.

Reyna and Adam (2003) investigated this point by asking the same question about the risk of a young woman to contract STIs in two different ways: the first question asked about risk of STIs, (including HPV) and the second question was identical except that it "unpacked" the

concept of STIs by enumerating examples, such as HIV-AIDS, chlamydia, genital herpes, syphilis, or gonorrhea. The 174 physicians, other health care professionals, and medical students surveyed were aware of what STIs were; knowledge did not change when different STIs were specified. Nevertheless, across all groups, there was a significant within-subject effect of "unpacking" the question. Subjects raised their risk estimates (closer to the correct estimate) for the "unpacked" version (although estimates were still lower than the factual answer of 50%). However, the "unpacking" provided more specific retrieval cues that improved accuracy of risk estimates. This unpacking effect for health risk judgments was replicated in a sample of 120 health-education professionals (Adam & Reyna, 2005).

In addition to changes in risk judgment, retrieval cues have also been shown to change personal risk perception estimates when knowledge remains the same (Mills et al., 2008; Reyna, Estrada, DeMarinis, Myers, Stanisz, & Mills, 2011). Mills et al. (2008) have called these effects on risk perception *paradoxical* because perception of risk is sometimes positively correlated, and sometimes negatively correlated, with risk taking for the same individual (see also Brewer et al., 2004). FTT predicts that verbatim cues to risk perceptions (e.g., estimation of exact personal risk of unprotected sex using a 0 to 100% scale) will have positive correlations with risk taking, whereas gist cues to risk perception (e.g., estimation of personal risk of unprotected sex using global categories, such as "low," "medium," or "high") will have negative correlations with risk taking. This reversal occurs because, on the one hand, risk takers tend to estimate lower vulnerability when asked global questions (retrieving their gist representations, which reflect limited understanding of their risk), but they acknowledge higher risk when cued for specific behaviors. On the other hand, those who avoid risk tend not to have risky behaviors available to retrieve, yielding lower specific estimates of risk (e.g., on 0- to-100% scales). Nevertheless, risk

avoiders perceive high risk when asked for their global judgments (e.g., associated with sexual behavior).

This paradoxical prediction was borne out in a study with 596 adolescents that used various measures of risk perception to investigate risky sexual behavior (Mills et al., 2008). The measures of risk perception included scales with verbatim cues versus gist cues (see Reyna, 2008, and Reyna & Brainerd, 1995, for details of predictions). In addition to the 0-to-100% scale, the verbatim scales included a measure of specific risk, containing items that mentioned concrete consequences of risky sex (e.g., pregnancy/STIs in the next 6 months), and asked for personal estimates of those risks. The global gist scales included measures of categorical thinking (e.g., "Even low risks happen to someone"), gist values/principles (e.g., "Avoid risk,"), and global risk categories of "low," "medium," or "high." Behavioral measures of risk taking (outcomes) included intentions to have sex, whether the subject had initiated sex, and number of sexual partners. As predicted, each of the verbatim measures correlated positively with risk taking outcomes, and each of the global gist measures correlated negatively with those outcomes. Reyna et al. (2011) replicated these reversals with 153 adolescents and young adults, and showed that the verbatim and gist scales loaded on orthogonal dimensions in a principal components analysis.

In summary, judgment and perception of risk are associated with the retrieval cues used to measure them, and the simple shift in cue from verbatim to gist produces changes in reported perception of risk and reversals in responses to public health questions (Mills et al., 2008; Reyna et al., 2011). This effect of retrieval cues for verbatim versus gist representations can affect both patients and health care professionals, because it does not depend on training or knowledge

(what is stored in memory), but rather on the nature of the cue that retrieves what is stored (Adam & Reyna, 2005; Reyna & Adam, 2003; Reyna & Lloyd, 1997).

Gist and Preventive Health in Light of Representation and Retrieval

As noted in the section on risk perception, whether gist or verbatim representations are endorsed and retrieved is associated with how much risk a person takes in their lifestyle choices (e.g., number of sexual partners). More can be predicted, however, by considering which gist principles are endorsed. Mills et al. (2008) made an additional distinction separating those who endorse the categorical avoidance of risk, "No risk is better than some risk" and those who endorse the ordinal gist principle, "Less risk is better than more risk." The FTT prediction (consistent with the negative correlations discussed in the previous section between gist representations of risk and risk taking) is that endorsement of simplest, categorical principles should be associated with less (unhealthy) risk taking and endorsement of relative, ordinal principles should be associated with more (unhealthy) risk taking.

The FTT rationale for this prediction is as follows: Although both principles express the view that risk is bad, the relative principle makes finer distinctions than the categorical principle. In contrast to other theories, a core principle of FTT is that *advanced* cognition is gist-based. Development progresses from more precise verbatim-based analysis to simpler gist-based intuition, a result supported by studies comparing children to adults and novices to experts, including medical experts (e.g., Reyna, Chick, Corbin, & Hsia, 2014; Reyna & Farley, 2006; Reyna & Lloyd, 2006). Therefore, adolescents are more likely to think more precisely about risks than adults, and those who think more precisely are more likely to take unhealthy risks.

Results were consistent with these predictions. Adolescents who only endorsed the relative principle were more than twice as likely to have initiated sex (61% compared to 30%)

than if they endorsed only the categorical principle. Endorsement of both or neither principle resulted in intermediate level of being sexually active (44% and 46%, respectively). Although both categorical and relative principles are based on gist (categorical and ordinal levels of gist), the less precise principle (i.e., categorical) was associated with endorsement of protective health behaviors (Mills et al., 2008). More generally, decision processes that rely on less precise mental representations are more developmentally advanced than those that rely on more precise representations.

In summary, as predicted by FTT, endorsement of categorical gist principles (e.g., "No risk is better than some risk") was associated with risk prevention in public health (compared to endorsement of more precise principles). This tenet of FTT that associates reliance on simple (categorical) gist representations regarding sexual behavior with protective effects, instead of the trade offs of risks and benefits, has been used to explain the decrease in risk-taking that occurs from adolescence to adulthood (see Reyna et al.'s 2011 study comparing adolescents to young adults, as well as Reyna & Farley's 2006 literature review in multiple domains of public health). Overall, these studies suggest that emphasis on gist-based thinking about risk avoidance has a protective effect on health behaviors.

Detection and Diagnosis: Base Rates and Combining Probabilities

In the preceding sections, we discussed how gist-based decision processes support advanced cognition. In particular, categorical gist is often used to cut to the essential bottom line of important decisions, and to avoid tradeoffs between risks and rewards when those tradeoffs obscure what is most important (e.g., not acquiring an incurable, deadly disease, HIV-AIDS). Studies of medical experts making diagnostic decisions further support this hypothesis: Physicians who were the most accurate according to evidence-based guidelines used the

simplest, categorical distinctions to make decisions about patients (Reyna & Lloyd, 2006). Gist-based processing also has the advantage of being less vulnerable to interference. In this section, we show how such interference can compromise the way physicians and patients process information about the results of diagnostic tests.

In a classic study, Eddy (1982) asked physicians to estimate the probability that a woman had breast cancer given a positive diagnostic test result. The base rate of breast cancer (i.e., the probability of breast cancer in the population) was given as 1% and the test sensitivity (i.e., the probability of a positive result for women with breast cancer) as 80% (the false-positive rate was 9.6%). Most physicians estimated the post-test probability of cancer for this woman around 75%, but the correct answer was much lower than that, around 8%. This phenomenon has been called base-rate neglect because post-test probability judgments display insufficient adjustment for base rates. Although some have claimed that these probability judgments are not "natural" based on speculation about evolution, an early explanation from FTT for the phenomenon (and how to fix it) had to do with confusions about overlapping classes (e.g., Reyna, 1991; Reyna & Brainerd, 1994, 2008). This explanation has been tested in many experiments and accounts for data from multiple laboratories (e.g., Barbey & Sloman, 2007; Reyna & Mills, 2007a).

The explanation leads to a number of important predictions that are relevant to decision making about health. As expected by FTT, confusion of conditional probabilities in clinical judgment of post-test probability (base-rate errors) occurs for most people, including both patients and physicians (Reyna et al., 2001). That is, processing errors in probability estimation do not reflect lack of reasoning competence or low levels of knowledge or experience in healthcare (Reyna et al., 2003). To assess processing errors independently of disease knowledge, Reyna and Adam (2003) asked physicians and other healthcare professionals to make post-test

probability judgments about an *unknown* disease with a base rate of 10% in the general population. They were informed that the patient tested positive and that the diagnostic test had 80% sensitivity and 80% specificity (i.e., the proportion of patients without the disease who tested negative; both sensitivity and specificity were defined for subjects). To minimize computational burden, subjects were asked whether the correct post-test probability was either around 30% or 70%.

Only 31% of physicians selected the correct option, which is significantly below chance (the only group to respond around chance at 55% correct were experts in public health, for whom base-rate neglect is a common topic). Other healthcare professionals scored below 30% correct and different groups of undergraduates who were not healthcare professionals ranged from 36% to 45% correct (Adam & Reyna, 2005; Reyna & Adam, 2003). High-school students scored 33% correct, similar to trained physicians (Reyna, 2004). The fact that the effect was obtained for both untrained high-school students and trained physicians supports the FTT prediction that processing interference is not related to knowledge or expertise, but instead is a judgment error that is present in advanced reasoners as a result of class-inclusion confusion (Reyna, 1991; Reyna et al., 2003). Individual differences in the ability to inhibit interference—an "executive" function in the brain—mitigate susceptibility to class-confusion errors (Reyna & Mills, 2007b).

Specifically, people confuse sensitivity with post-test probability, which are conditional probabilities (analogous to confusing breast cancer risk given a BRCA mutation with mutation risk given breast cancer). Focal classes are in the numerators, and people tend to forget about denominators in their confusion about overlapping classes (Reyna & Brainerd, 1994, 2008). Ergo, they think of sensitivity as though it were post-test probability (and vice versa) because the numerators are the same (the joint probability of both having disease and testing positive); only

the denominators (which are momentarily forgotten about) differ. Naturally, neglecting base rates (or pre-test probabilities) can produce large errors in diagnostic judgments (Eddy, 1982; Lloyd & Reyna, 2001; Reyna et al., 2001; Reyna & Lloyd, 2006).

In summary, accurate detection and diagnosis of diseases involves combining probability estimates about overlapping classes, such as the classes of patients with disease and of patients with positive test results. These combined judgments are subject to errors that occur as a result of confusion about overlapping classes, producing denominator neglect and base-rate neglect. Experts as well as laypeople are vulnerable to these errors, as predicted by FTT. As we discuss in the next section, interventions that reduce these errors have been developed and tested for experts and laypeople.

Interventions Based on Evidence: Theory and Data

Specific interventions for health and medical decision making are suggested by the principles of FTT and have been evaluated in research (e.g., Brewer, Richman, DeFrank, Reyna, & Carey, 2012; Fraenkel et al., 2012; Lloyd & Reyna, 2001; Reyna et al., 2008). Although the focus of other interventions has been on increasing how much people know about health facts, interventions based on FTT also take into consideration how health knowledge is mentally represented, retrieved, and processed coherently in decision making, as well as how interference is inhibited. The goal is to transmit knowledge while encouraging people to extract the appropriate gist for the decision (e.g., “My risk is high” so I should get screening for breast cancer), retrieve relevant values and principles (e.g., “Avoid recurrence”), and implement such values so as to reduce interference from class-inclusion confusion (Reyna, 2008; Reyna & Brainerd, 2011). In this section, we review some of the public health and medical interventions that are motivated by FTT and discuss how they accomplished these goals.

Interventions Targeting Representation and Retrieval of Values

Unlike other approaches, FTT implies that health communication and decision support should begin with the message in mind (Reyna, 2008). In other words, the first step in designing an intervention is to identify the gist that is to be communicated, the functionally significant "bottom line" of the information in as integrated a form as possible. As we have discussed, there can be more than one such bottom line generated from different perspectives. Experienced patients and providers can provide iterative drafts of proposed gist representations, which naturally should be informed by the most rigorous scientific evidence. In addition to developing new materials, it is also possible to transform existing communications or interventions—to "gistify" them—by translating arbitrary facts into meaningful messages (e.g., deciding which facts are essential to decision making, explaining the reasons behind the essential facts, integrating facts, and deleting irrelevant details) in order to improve efficacy. Despite the simplicity of this approach of focusing on simple meaning and on causal understanding of that meaning, initial results from a variety of interventions have been surprisingly successful.

For example, the effectiveness of representation-targeted risk communication techniques was investigated in Brewer et al.'s (2012) study about breast cancer recurrence risk. One hundred thirty-three patients were interviewed who were eligible for the Oncotype DX genomic test. This genomic test estimates 10-year risk of distant recurrence of early stage estrogen receptor–positive breast cancer. The results help patients decide whether to add adjuvant chemotherapy to endocrine therapy to prevent recurrence. Risk of recurrence varies along a continuum, but there are values that can be roughly categorized as low, intermediate, and high. Subjects were randomly assigned to different descriptions of risk of recurrence, which varied in complexity, and included a detailed standard report from a commercial assay with 1) a simple

explanation of risk, 2) the explanation followed by a simple graphic presenting recurrence risk information on a continuum (gist), 3) both explanation and graphic accompanied by a description of the graphic and confidence interval reports, or 4) an additional format that involved an icon array. Subjects were asked to estimate risk of 10-year recurrence as well as to rate their understanding and easiness of understanding of the material.

The standard detailed report generated a greater number of errors in estimating level of risk (low, intermediate, or high) compared to simpler formats, whereas the newly developed gist-based risk continuum format generated the fewest errors in risk estimation (Brewer et al., 2012). Moreover, the standard report format was rated as least understandable and the least liked format, whereas the gist-based risk continuum graphical format was rated among the most understandable and most liked formats. Consistent with FTT, simple but meaningful presentation of risk (e.g., as a continuum with qualitative categories), not merely numbers, enhanced understanding (Reyna, 2008, 2012b; Brust-Renck, Royer, & Reyna, 2013). Simple line graphs readily convey relative ordering or trends across time, but other graphical displays highlight different relationships among numbers. According to FTT, the use of the correct type of graphic facilitates the process of extracting the relevant gist (see also Fraenkel et al., 2012).

Interventions aimed at representation and retrieval have also been implemented in an FTT-based intervention in a randomized control trial of 734 adolescents focusing on reducing the risk of pregnancy and STIs from unprotected sex (Reyna, 2008; Reyna et al., 2008). The gist-based intervention was compared to 1) a standard multicomponent intervention ("Reducing the Risk"; Reyna, Adam, Poirier, LeCroy, & Brainerd, 2005) and 2) an unrelated control group. The experimental intervention was based on FTT and included the same content as the standard intervention but emphasized gist representations of risk (e.g., "Even low risks happen to

someone”), as well as identification and automatic retrieval of gist values (e.g., “Avoid risk”; “Better to not put my partner at risk”). All three interventions consisted of 14-hour classes in small groups of high school students either in school settings or after school programs. Effectiveness of the interventions was assessed via testing that occurred prior to the intervention, immediately after, and 3, 6, and 12 months later.

Overall, the goal of the gist-based intervention was to reduce (or avoid) pregnancy and STIs from unprotected sex. High school students were encouraged to understand the gist of information about risky behaviors (gist lasts longer in memory compared to memorization of verbatim details), recognize risky situations rapidly, retrieve relevant values, and engage in automatic gist-based thinking (that is faster than verbatim and deliberative analysis of risk (Reyna, 2008; Reyna et al., 2008). Such gist-based intuitive and automatic thinking should provide additional benefits in emotional situations; gist is more resistant to interference from emotion and stress (Rivers et al., 2008). Results comparing the three interventions (i.e., gist-enhanced, standard, and control) demonstrated that the enhanced curriculum produced significant improvements (relative to controls) for 17 out of 26 outcomes, and was more effective than the others across a range of outcomes (e.g., knowledge, attitudes, and behaviors), lasting as long as 12 months after program delivery (Reyna et al., 2008; also Reyna & Farley, 2006, Table 4).

Interventions Targeting Processing Interference Due to Class-Inclusion Confusion

In 1991, Reyna extended the analysis of class-inclusion confusions to the conjunction fallacy, logical reasoning biases (e.g., syllogisms), and other errors of probability judgment. As FTT explained, such confusions “can be diminished by, for example, providing a notational scheme such as Venn diagrams … or superordinate-set tags” (p. 319) (Reyna & Brainerd, 2008). The thrust of those interventions is to keep the classes discrete—to separate, for example, the

class of people who had breast cancer and a positive test result from other classes, such as the people without breast cancer who also had a positive test result. Once classes can be considered separately, they can be more easily recombined (assembled from the separate judgments) in different ways to yield conjunction judgments, conditional probabilities and other combinatorial judgments. For example, when classes are separated, it is possible to "flip the denominators" more easily, to consider *among those who had a positive test result*, how many had cancer versus did not have cancer.

This hypothesis has been tested in a variety of populations, ranging from expert physicians to the general population, using diagrams, 2 X 2 tables (and asking for separate estimates for each of the four classes in each cell of the table), and icon arrays that label classes distinctively so that denominators can be easily flipped visually. Even children's probability judgments are improved with such interventions (e.g., Reyna & Brainerd, 1994). Although presenting probabilities (e.g., .01) in terms of frequencies (e.g., 1 in 100) often accomplishes this same separation of classes, frequencies are not inherently easier to manipulate than probabilities. For example, Cuite, Weinstein, Emmons, and Colditz (2008) studied 16,133 people's performance on multiple computational tasks involving health risks and found that performance was very similar for frequency (55% accurate) and probability (57% accurate) versions.

Many scholars have assumed that emphasizing numbers and providing calculators should improve health-related judgments and decisions (see Reyna et al., 2009). Lloyd and Reyna (2001) compared the use of a Bayesian online clinical calculator to an icon array that visually represented base rates, sensitivity, and specificity using the principles of FTT. Residents and medical students estimated the post-test probability of disease given a positive or negative test result. Results showed that subjects would often miss the question using the Bayesian calculator

(despite being taught Bayes' theorem), for example, when estimating the probability of a test being negative rather than the probability of the patient having a disease given a negative test result (a class-inclusion confusion).

Rather than focusing on precise calculation, the goal of the FTT intervention was to increase gist-based thinking and decrease interference from overlapping classes. The intervention therefore focused on teaching subjects to visually estimate relative magnitude on a 10-by-10 grid with 100 squares (each square represented a woman with potential ischemic heart disease). Once the grid was constructed, squares were completed with pre-test information regarding the chances of ischemic heart attack and of coronary heart disease; then sensitivity and specificity were added by writing in + or – signs above each square. The grid accounted for all relevant classes, making it possible to visually estimate positive and negative predictive value (the probability of disease given a positive test result and the probability of no disease given a negative test result, respectively). The key to the intervention was to represent each class discretely (patients with the disease and either a positive or a negative result, and patients without the disease and either a positive or a negative result). Because classes were represented discretely, diagnostic errors were reduced, as predicted by FTT (Lloyd & Reyna, 2001).

Conclusions and Future Directions: Gist in Public Health and Medical Decision Making

Remarkably often, experts in public health are at a loss when asked what the point of information on a public Web page is other than to "provide information"—but toward what end? Similarly, experts in medical decision making frequently disavow helping patients make any particular decision, and restrict decision making support to situations in which there is no right or wrong choice, variously referred to as "equipoise" or "preference-sensitive" decisions (Elwyn, Frosch, & Rollnick, 2009).

Although it is certainly important to help people face tough choices when there is no right answer, according to FTT, the mental representations that are encoded, the values that are retrieved, and the application of values to representations all hinge on the functional significance of information—the meaning that matters (i.e., gist). Human information processing suppresses details to arrive at an essential bottom line: which option provides life rather than death, relief rather than suffering, mobility rather than disability. When people lack background information, they become lost in details; it is difficult for them to summarize the main point of information and to demonstrate an appreciation of the gist of key facts that should inform their decision making. People encode both verbatim and multiple gist representations of information into memory independently, but tend to rely on the gist in judgment and decision making (Reyna, 2008; Reyna & Brainerd, 1995). Hence, people can get the verbatim facts right, and still not derive the proper meaning, which is necessary for informed consent (Reyna & Hamilton, 2001).

This theoretical approach implies that judgment and decision making cannot be stripped of meaningful content. Instead, the work of extracting the essential gist of options for different prevention, diagnosis, and treatment situations must be performed using systematic techniques for surveying patients and providers (e.g., Fraenkel et al., 2012; Table 2.1). A number of valid and reliable scales have been developed that have been successfully transferred across health situations (e.g., categorical thinking scales; Mills et al, 2008; Reyna, 2008). Although progress has been made in research on meaning in multiple disciplines, humans remain far better at extracting gist than artificial systems.

In contrast to other theoretical approaches, the goal in FTT is not numerical precision or trading off precise numerical outcomes (e.g., the number treated who survived) against precise degrees of risk (e.g., the number of adverse events in the treatment group)—although in some

difficult decisions the devil is in the details. Rather, the goal is to integrate the facts into a bottom line that captures the qualitatively important distinctions, not the quantitative minutia. Implementing this FTT approach would represent a significant change in current approaches to decision analysis and decision support for patients, and in education for healthcare providers (Lloyd & Reyna, 2009).

FTT does not claim that numbers are unimportant, but that numbers lack meaning out of context and that the meaning that matters is usually simple (Reyna, 2013). It is not informed consent to know that one's risk of death from surgery is exactly .02 and to be able to precisely differentiate that quantity and easily transform it into decimals and fractions without having a clue about whether that number represents a low or high (and whether to feel worried or relieved). To be sure, understanding that a risk of .02 is higher than .002 is helpful for patients and providers, especially given a rising tide of research knowledge; this ability is assessed in current measures of numeracy (Reyna et al, 2009). However, research needs to be conducted on how to measure *gist numeracy*, the ability to extract the qualitative essence of numbers—what numbers mean in context, including the relevant qualitative relations among numbers.

Although we emphasize the significance of content and context, unlike some theorists, we do not argue that conjunction fallacies, base-rate neglect, and other biases are not errors. On the contrary, the interventions summarized in this chapter were designed to curb such errors by applying evidence-based understanding of the mechanisms that generate them. In this connection, FTT has been used to design effective public health programs and patient education tools, ranging from adolescents' HIV-AIDS prevention, to patients' arthritis medication choices, to physicians' judgments of cardiac risk (e.g., Reyna & Lloyd, 2006).

One of the implications of this work for future research is to better understand how developmental differences in judgment and decision making play out on in health and medicine. Lifestyle choices, such as diet and exercise, begin to take root in adolescence as young people gain more independence, and these choices have long-term impact on major killers, such as cancer and heart disease. For the first time in history, increases in heart disease are now being predicted because of poor diet and exercise in adolescence (Shay, Ning, Daniels, & Lloyd-Jones, 2011). However, FTT predicts that decision making in adolescence about health will differ from mature decision making in adults (e.g., Reyna et al., 2011). As we have discussed, reliance on gist processing increases with age and expertise (Reyna et al., 2003, 2013; Reyna & Brainerd, 2011). The implications of these differences for obesity prevention and lifestyle choices (and for public health programs) have not been investigated.

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Table 2.1

Empirically Supported Applications of a Fuzzy-trace Theory of Judgment and Decision Making

Processing problem	Intervention	Theoretical framework	Results
Failure to retrieve knowledge in context (i.e., misinterpretations of messages) generates biases in risk assessment, even when explicit, specific cues relevant to mode of transmission are mentioned.	Asking a patient in the emergency room whether he is "taking anything for pain" instead of asking whether he is taking ibuprofen (Reyna & Lloyd, 1997).	Relevant gist-based retrieval cues can help patients remember health information.	When cued with the gist of "medication for pain," the patient accurately recalled the name of the medication, however the verbatim drug name "ibuprofen" failed to elicit the accurate response with same patient the first time he was asked.
Communication of a precise estimate of risk tailored for the patient does not necessarily mean that the patient extracts the essential gist of whether the risk is low or high (ordinal gist distinction).	Presenting two bar graphs, positioned side-by-side, to demonstrate the benefit of adding a specific medication to a traditional disease-modifying anti-rheumatic treatment (clear language such as "higher bar is better" was also used (Fraenkel et al. 2012).	Presentation of meaningful graphical formats affects the ease with which people extract the gist of those inputs (e.g., meaning of the numerical relations).	Using this gist-based tool to promote accurate gist representations increased knowledge and patient willingness to escalate care in a pre- and post-test comparison.
Failure to endorse the appropriate values about risk that elicits global meaning of risk-relevant behaviors results in compensatory decision making (i.e., risk vs. benefit trade off) and less risk avoidance.	Presenting values that arthritis patients could endorse (e.g., "It is important to reduce my chances of becoming disabled, even if it means taking medications with a risk of serious side effects") followed by feedback about options to better control their arthritis (Fraenkel et al. 2012).	Relying on meaning and endorsing simple, categorical (gist) principles are associated with less (unhealthy) risk taking.	The tool substantially increased the proportion of patients making an informed value-concordant choice (i.e., those who favored medication use to minimize disease activity were more likely to show interest in changing their medication to better control their arthritis).
Failure to inhibit a salient and compelling gist (e.g., the meaning or essence of the target category that seems to fit the query) pulls reasoning toward the class-inclusion error.	Illustrating relations between classes using analogies (e.g., the relation between AIDs and immune disorders are "like the relation between roses and flowers;" Wolfe & Reyna, 2010)	Semantic manipulations make the gist of the classes more evident and more resistant to interference from class-inclusion.	Analogies that highlighted set relations increased semantic coherence by helping people to accurately constrain their gist-based probability judgments to fit the appropriate set relations.
Interference from nested class-inclusion relations (e.g., basal cell carcinoma and nonmelanoma) pushes reasoning away from the correct path.	Making nested relations discrete and transparent through the presentation of 2 X 2 tables (subjects made separate probability judgments for each cell; Wolfe & Reyna, 2010)	Separating nested classes reduces denominator neglect by making class-inclusion relations transparent.	Teaching the use of optimal strategies reduced denominator neglect (i.e., 2 X 2 tables) reduced reasoning fallacies about meaningful information.

Recommendations for Practice

Do not stop at the numbers.

Provide qualitative representations that capture the meaning (gist) of information to achieve understanding of risk; the gist is the essential element in informed consent.

Just because patients can repeat an exact probably (e.g., 20%), does not mean that they comprehend what that specific probability means (e.g., whether risk is low or high).

Give meaningful reasons for facts.

Provide a more coherent and meaningful gist by explaining *the reasons behind* the directives to effectively communicate health information to those with little background knowledge.

For example, explain that the reason that HIV, HPV, and herpes simplex are incurable and can not treatable with antibiotics is because they are viruses.

Begin with a bottom-line message in mind.

Identify the gist that is meant to be communicated, the bottom-line, relevant meaning of information, by distilling its simplest qualitative essence.

You cannot communicate a message if you do not know what it is.

Find the qualitative pivot points.

Find the qualitative pivot points in a decision (i.e., the consequences that are categorically different from other consequences); focus on the bottom line of messages that represent the simplest distinction between options.

Make distinctions between life vs. death, being unable to work vs. being able to work, irreversible permanent damage vs. reversible damage (e.g., joint damage in rheumatoid arthritis), or bearable pain vs. an unbearable peak of pain (e.g., colonoscopy).

Encourage the endorsement of simple healthy principles and values.

Lifestyle gist principles represent patients' own personal values (e.g., survival, quality of life) and can be practiced sufficiently to be automatically retrieved in the context of risky choices.

Endorsing categorical avoidance of risk, such as "Avoid risk" and "No risk is better than some risk," has been associated with protective effects regarding risky behavior.

Use graphs that facilitate extracting a salient gist.

Provide meaningful graphical representations that facilitate perceptual estimation of the gist relation; the picture should match the concept.

People can intuitively grasp gross differences in heights in visual displays (e.g., simple bar graphs and risk ladders) to signify the gist of relative magnitude (e.g., which treatment has "higher" and which was "lower" risk).

Keep classes of events separately.

Explain the probabilities separately of overlapping classes to reduce confusion about probability judgment: for example, probability of getting cancer without the cancer gene; of having the gene without the cancer; of getting cancer with the cancer gene; and of having the gene with cancer.

Use a 2 X 2 table to separate each class of events and to make clear the different probabilities of false positives, false negatives, true positives, and true negatives.

CHAPTER 3

A WEB-BASED RANDOMIZED CONTROLLED EXPERIMENT TO PREVENT OBESITY APPLYING FUZZY-TRACE THEORY

Obesity and being overweight are common risk factors for negative health outcomes. Heart disease, hypertension, dyslipidemia, limited mobility, type II diabetes, and metabolic syndrome (a collection of risk factors) are all possible consequences of being overweight or obese, and are largely associated with increased morbidity and mortality (Lavie, McAuley, Church, Milani, & Blair, 2014; Must & Strauss, 1999). Nutrition habits are often set in childhood and adolescence, and currently 1/3 of people aged 2-19 are categorized as either overweight or obese (American Heart Association, 2011). The proportion of adolescents categorized as obese has tripled (5% to 18%) over the past three decades (Ogden, Carroll, & Flegal, 2008; see also Ng et al., 2014). Many interventions have focused on prevention and have, thus, targeted youth to establish good habits. However, intervening with youth requires focusing on not just individual decisions but family context and lifestyle activities (Carroll, 2013; Gillespie & Johnson-Askew, 2009). In fact, decisions related to diet and fitness are influenced by a variety of factors, including culture, peer and parental influence, socioeconomic factors, and information about food presented by the media (Bleich & Rutkow, 2013; Kortzinger, Neale, & Tilston, 1994; Peters, 2009; Rothman, Gillespie, & Johnson-Askew, 2009). However, such factors (e.g., broader culture, socioeconomic status, or the broad media) are difficult to change and, ultimately, people are free to make good or bad choices about food (i.e., even minors make

food choices). Thus, our intervention, GistFit, targets judgment-and-decision processes that research suggests change behavior (National Institutes of Health, 2013).

Obesity Prevention Interventions

Several interventions have been designed and tested to affect psychosocial mediators of dietary and fitness behavior. For example, one such health intervention has been EatFit, a goal-oriented intervention designed to improve healthy habits in 9 lessons taught in person in a classroom setting (Horowitz, Shilts, & Townsend, 2004). Based on Social Cognitive Theory, the original tutorial has been effective with sixth graders in a pre- and posttest design (post-test was immediately after intervention; Shilts, Townsend, & Horowitz, 2004) and with eight graders in a randomized controlled trial (Shilts, Horowitz, & Townsend, 2009). EatFit's lessons included nutrition and fitness basics as well as information about energy balance, food labels, fast food, and advertising. Results demonstrated that the use of guided goal setting promoted intention to change dietary and physical activity behavior (see also Carlson, Sallis, Ramirez, Patrick, & Norman, 2012; Patrick et al., 2011; Soureti, Hurling, van Mechelen, Cobain, & ChinAPaw, 2012; Springvloet, Lechner, & Oenema, 2014). This perspective has also motivated work that considers how anticipated affect (e.g., regret) resulting from choices influences attitudes about the consequences of a behavior, as well as subsequent behavior itself (Ajzen, & Sheikh, 2013).

Another successful intervention was the Healthy Children, Healthy Families: Parents Making a Difference! (HCHF) curriculum, which targeted parents of children ages 3 to 11 and addresses key behavioral objectives such as eating more vegetables or fruit, limiting high-sugar and high-fat foods, playing actively, limiting sedentary time (e.g., television) and reducing serving sizes (Lent, Hill, Dollahite, Wolfe, & Dickin, 2012). This curriculum was also based on social cognitive theory, positing that behavior is changed not merely because of increased

knowledge and skills, but that a sense of self-efficacy is required to choose and engage in healthier activities. To build self-efficacy in subjects, workshops were based around hands-on activities and role-playing to introduce the key objectives of the curriculum. This intervention was found to be effective in changing behaviors specifically targeted by the objectives: reduced soda and fast food intake; higher vegetable, fruit and low-fat dairy intake; and more active play and less television watching.

One recent intervention aimed at considering social context in health behaviors has been the NuFit program, aimed specifically at building community partnerships in neighborhoods with predominantly minority backgrounds in which childhood overweight rates are particularly high (McKinney et al., 2014). Similarly based in social cognitive theory, the NuFit program was based on the supposition that people learn behaviors indirectly by modeling observed behavior in those with whom they identify. Subsequently, the program focused on peer leadership and peer-to-peer outreach. Subjects in the NuFit curriculum were found to be more likely to use food labels in making decisions of what to eat, less likely to eat fast food, and were also found to have an increase in healthy attitudes toward nutrition and fitness at posttest (compared to pretest).

However, a common result has been that even if verbatim facts are learned and behavior is changed in the short term, effects dissipate over time, or subjects are not followed over the long term (e.g., Cooper et al., 2010). In particular, as adolescents grow into emerging adults and leave their parents' homes, an important concern is whether the altered behaviors represent lasting changes in the subjects' habits, routines, and decision making processes, or are limited to the context in which they were learned. Thus, in order to enduringly influence behavior, interventions should be designed with specific attention to how memory representations are

stored and retrieved over time, as well as how they specifically influence choice in health contexts (Reyna & Farley, 2006).

Fuzzy-Trace Theory

In a series of experiments, we designed and tested an intervention for nutrition and fitness based on fuzzy-trace theory, building on the success of similarly motivated studies that demonstrated changes in behavior that lasts over time (e.g., Reyna & Mills, 2014). Fuzzy-trace theory is a theory of memory and decision making, which explains that how these processes develop over time (Reyna, 2012; Reyna & Brained, 2011). The theory relies primarily on the distinction between two types of memory representations of information, verbatim (literally encoded information in exact surface form) and gist (bottom line meaning of information). Verbatim representations are precise and thus can be used to perform rote analyses; they do not consist of meaningful interpretation or inference. Gist representations are intuitive and encode meaningful representations of information. They are also imprecise (i.e., *fuzzy*), incorporating culture, education, emotion, and experiences, all of which can affect the meaning of information (Rivers, Reyna, & Mills, 2008). Gist processing is often not primitive, but rather is a result of extracting the essence of information through advanced insight (Reyna, 2013).

According to the theory, most adults prefer to base decisions on gist representations of information (i.e., a *fuzzy processing preference*). Fuzzy-trace theory differs from most approaches to decision making primarily in stating that intuition (based in gist) is distinct from impulsivity, and that reliance on analysis of verbatim facts can be a unique route to risky behavior. For example, an expected value framework of weighing risks and benefits might lead an adolescent to have unprotected sex if the benefits are high and the risks are low; mature adult thinking focuses on the categorical gist that death (or HIV infection) is a non-negligible and

catastrophic outcome of unprotected sex, and would avoid it categorically (Mills, Reyna, & Estrada, 2008; Reyna & Farley, 2006; Reyna et al., 2011). This categorical way of thinking, influenced by culture, worldview, emotion, and motivation, also tends to be retrieved by adults more automatically and without the need for conscious reflection (Rivers et al., 2008).

Interventions grounded in fuzzy-trace theory have found success in increasing knowledge and comprehension, improving decisions, and changing behavior in the long term (Brust-Renck, Reyna, Wilhelms, & Lazar, in press). One such example was an intervention to reduce sexual risk-taking and teenage pregnancy based in fuzzy-trace theory (Reyna & Mills, 2014). This intervention took the form of a classroom curriculum delivered to adolescents who were contacted to assess outcomes up to a year later. The intervention was effective at reducing sexual initiation six months after it was delivered, when many subjects were beginning sexual activity. Improvements in outcomes were also stable up to a year later, specifically improving on a control curriculum that taught the same verbatim facts, but without gist-based emphasis on the bottom-line meaning of the health messages.

Success has also been found in relying on fuzzy-trace theory to design web-based health interventions—of particular relevance for the present experiments. One online intervention designed to inform rheumatoid arthritis patients of risks and benefits of biologic therapy tested three different methods of communication (Fraenkel et al., 2012). Each piece of numeric (or graphic) information used to communicate the benefits from different medications or risks of side effects was accompanied by its essential gist (meaning of the number, its ordinal and categorical gist), as identified by experts and patients. Results showed that providing the gist improved knowledge and clarity of values, while substantially increasing willingness to escalate

care, and likelihood of making an informed choice in a pre- and post-test comparison (from 35% at pre-test to 64% at post-test).

Another example of such an intervention used an intelligent tutoring system (ITS) to increase knowledge and comprehension regarding genetic testing for breast cancer risk (Wolfe et al., 2013, 2015). This intervention used Sharable Knowledge Objects (SKO) to deliver content regarding BRCA genetic mutations, genetic testing and base rates, and knowledge of how breast cancer spreads, and was compared to merely reading of highly similar content from the National Cancer Institute website. The experimental conditions using SKOs were also theoretically motivated by fuzzy-trace theory and designed to help people understand the bottom-line meaning—the gist—of complex information. Subjects who received the gist-based intelligent tutor scored higher on knowledge and comprehension tests, and also recommended less testing for women without risk factors than did less knowledgeable subjects. In these experiments, ITS technology showed promise in helping laypeople learn complex health-related information to make healthier medical decisions.

Current Experiments

Because health interventions based on fuzzy-trace theory were successful in increasing comprehension and changing behavior in many health domains, we designed an obesity-prevention intervention using similar principles as applied to information on nutrition and fitness—GistFit: Getting the gist of healthy eating and exercise. In Experiment 1, we tested the first fuzzy-trace theory-based intervention to prevent obesity in a randomized controlled experiment. The first version of GistFit was a static text-based intervention. In Experiment 2, we took a novel approach to helping prevent obesity by using an ITS to provide more active tutoring than traditional text-based interventions can provide—$\text{GistFit}_{\text{ITS}}$. As in Experiment 1,

Experiment 2 was a randomized controlled experiment conducted to assess the effectiveness of the obesity prevention intervention. Additional measures were included to better assess the effectiveness of the intervention, including a new measure of gist knowledge (to avoid ceiling effects from Experiment 1 and to capture understanding from learned content). Finally, Experiment 3 was another randomized controlled experiment in which we further refined $GistFit_{ITS}$ to account for recent research findings about nutrition and fitness. In this final experiment, we also examined relations between other measures that are likely to contribute to risk taking—sensation seeking, impulsivity, and self-control (Figner, Mackinlay, Wilkening, & Weber, 2009; Galvan, Hare, Voss, Glover, & Casey, 2007; Reyna et al., 2011; Weller, Cook, Avsar, & Cox, 2008; Wilhelms & Reyna, 2013).

Experiment 1

Method

Design. A two-group randomized controlled experiment was conducted to assess the effectiveness of the obesity prevention intervention. Subjects were randomly assigned to each group (experimental and control) and did not differ significantly in baseline characteristics prior to the intervention.

Subjects. Subjects were 200 female undergraduate students recruited from the subject pools at two universities in the Mid-west and Eastern United States. All subjects provided written consent, and the project was approved by each university's Institutional Review Board. Subjects were recruited online and received course credit for participation or volunteered. The mean age of subjects was 19.72 (SD = 1.37). Overall, 69% of subjects identified themselves as Caucasian, 9.1% as African American, 15.7% as Asian, and 6.2% as mixed or other races. In addition, 10.7% identified as Hispanic. There were 67 subjects in the experimental condition

and 133 in the control condition. We did not find demographic differences between experimental and control conditions. (The number of subjects is larger in the control condition compared to the experimental because there were two control groups—67 subjects were assigned to an online intervention and 65 to a text-based intervention of the same length as the experimental intervention. However, no differences between control groups were found on all measures.

Materials.

Interventions. GistFit is an adapted version of EatFit (Horowitz et al., 2004; Shilts et al., 2004). Our adapted version shares some of the content of EatFit (i.e., all the facts covered in EatFit were also covered in GistFit). However, the language and examples were improved so that they could be presented to an adult population. The new intervention also emphasizes the bottom-line meaning of nutrition and fitness, such as "Making small improvements is better than not trying at all," according to research on fuzzy-trace theory (e.g., Reyna & Mills, 2014; Wolfe et al., 2015). In addition to presenting verbatim facts, the tutorial emphasized the essential decision-relevant meaning of information. For example, a verbatim fact would be "Limit fat to 30 percent of dietary calories daily. This is equivalent to 73 grams of fat per day, based on a daily 2,200-calorie diet. Reducing fat intake decreases the likelihood of obesity, heart disease, and cancer," which we replaced with the gist "Limit solid fats in order to reduce your risk of heart disease, obesity and diabetes." Moreover, in GistFit, short bottom-line (gist) summaries of important points were provided at the end of each lesson, designed to facilitate the encoding and long-term retention of core information in a simple form. For example, to summarize the lesson above, we emphasized, "Being a healthy weight is important to prevent diseases."

For example, the risks associated with maintaining an unhealthy diet or not exercising regularly were mainly characterized as qualitative gist as opposed to detailed, quantitative, and verbatim. Instead of listing statistics about diseases or recommended numbers of calories, the cumulative probability that consequences would occur was emphasized (that they are virtually certain if risky behavior is engaged in repeatedly over time). These gist representations, however, do not replace verbatim information about what nutrients to consume and how to actually perform exercises, but emphasizes the pragmatic bottom-line. For example, the GistFit tutorial recommends a balanced diet of *mostly* fruits and vegetables, *any amount* of exercise each week is better than not exercising, and maintaining independence around friends and family.

Another important aspect of GistFit is that it encourages storage of relevant risk-avoidant values and facilitates subjects' ability to retrieve those values at the time a decision is made. Subjects were asked to write about values early on and then reminded to relate back to them as healthy principles were referenced throughout the tutorial. The GistFit intervention was delivered in a static, text-based format. Subjects had 60 minutes to read the material and could not proceed until the time limit expired.

Since GistFit involved providing information in a short text-based format in addition to summarizing that information, certain parts of the original EatFit had to be changed. For example, in-class exercises were replaced with illustrative examples and key points. When material needed to be removed, concepts that were deemed to have a superficial relevance to the topic at hand were de-emphasized (e.g., nutrition label reading and calorie count). Improvements were also made to the content from the original EatFit intervention based on recent research when possible.

The control group received one out of two interventions about an unrelated health topic (genetic testing and breast cancer risk). Time on task was the same as the experimental group (60 minutes). One of the control interventions used an ITS to provide more effective tutoring to patients using a conversational tutorial, while the other was standard static, text-based material.

Knowledge quiz. Subjects provided answers to 16 items assessing knowledge about nutrition, use of nutrition labels, and fitness in open-ended questions from the original EatFit materials (Horowitz et al., 2004; Shilts et al., 2004). For example, subjects were asked to name a low-fat food they could choose if they were at a fast food restaurant and to give an example of each type of physical activity (e.g., aerobic, strength). Items were rated as correct or incorrect, and responses were averaged, with higher scores representing better knowledge.

Norms and beliefs. Three scales were constructed to assess social norms in this experiment. The content of the first scale was descriptive (beliefs about what people do), whereas the second was injunctive (beliefs about what people should do), and the third included personal beliefs. The descriptive norms scale was constructed from items about peers and self, such as "Most of my friends eat healthy" and " I engage in moderate to intense physical activity on a frequent basis." The injunctive norms scale was constructed from ratings of items about adults and peers, such as "Most of my friends believe it is okay to consume non-nutritious food and sugary drinks in moderation" (reverse coded) and "Adults who are important to me believe it is important to exercise or have moderate activity often." The scale representing beliefs included items such as "I believe a person my age should always eat healthy and minimize or eliminate wasteful calories (non-nutritious foods)." Items were rated on a 5-point Likert scale from *strongly disagree* to *strongly agree*, and responses were averaged. Higher scores implied less permissive (or favorable) norms towards unhealthy nutrition and fitness.

Gist measures of risk and benefits perceptions. Gist measures contained general simple principles about nutrition (e.g., "I should avoid fried foods"), fitness (e.g., "Better to exercise at least a few times a week"), and lifestyle (e.g., "I have a responsibility to myself to stay healthy"). Subjects could endorse each item on a 5-point Likert scale from *strongly disagree* to *strongly agree*. Responses were averaged and higher scores indicated a greater tendency to endorse gist-based healthy principles.

Behavioral intentions. Measures of healthy intentions were included in the experiment based on the seven healthy behaviors from the American Heart Association's (AHA) national goals for cardiovascular health promotion and disease reduction (Lloyd-Jones et al., 2010). Subjects either agreed or disagreed with a series of intentions to perform healthy behavior in the domain of healthy nutrition (e.g., "Eat more whole grain foods"), physical activity (e.g., "Be active with friends and family"), healthy weight (e.g., "Increase physical activity to burn more calories than I eat"), smoking (e.g., "Plan activities that don't involve smoking"), blood pressure (e.g., "If overweight, lose weight"), blood cholesterol (e.g., "Eat fewer saturated and trans fats"), and blood sugar (e.g., "Eat modest food portions"). Responses were averaged and higher scores indicated intentions to engage in the healthier behaviors regarding each domain.

Behavioral measures. The primary outcome measure was taken from the AHA national goals for cardiovascular health promotion and disease reduction (Lloyd-Jones et al., 2010). Self-reported behavior included measures of healthy eating (e.g., healthy amounts of fruit, vegetables, fish, whole grain, sugar and sodium ingestion per week) and physical activity (less or more than 1.5 hours per week). We also assessed subjects' Body Mass Index—BMI (based on person's height and weight).

Procedure. The interventions were administered by undergraduate or graduate research assistants in a controlled environment. Subjects were informed prior to enrollment that they would be randomized to learn about one of two subjects (both control conditions were about the same subject). After the intervention, subjects answered a survey for about 60 minutes.

Data analyses. Data were analyzed using IBM SPSS Statistics (Version 21.0, IBM Corp., Armonk, NY) with 2 (*condition*) x 2 (*research site*) analyses of variance. The primary factor of interest was the experimental condition over control, but research site was included to control for selectivity of academic institutions.

Results and Discussion

Means, standard deviations, and reliabilities of each measure for Experiment 1 are presented in Table 3.1. Bivariate correlations of all measures, including self-reported behavior and behavioral intentions, were also conducted and are reported in Table 3.2. No significant differences were observed between conditions or sites, $Fs < 1$, in terms of behavior (healthy eating and physical activity) and BMI, which was expected given that assignment to different conditions was random and testing was conducted immediately after intervention. Nevertheless, white subjects were more likely to show higher knowledge scores [ρ (197) = .17, p = .02], higher behavioral intentions to improve healthy nutrition [ρ (197) = .14, p = .05], and healthier behavior [ρ (197) = .23, $p < .001$]. Overall, self-reported behavior significantly correlated with healthy nutrition intentions and intentions to have healthy weight (Table 3.2). In addition, no differences in intentions were found between the two conditions, as both groups indicated equally high behavioral intentions (see Table 3.1).

Endorsement of gist principles, such as "I should avoid fried foods," was significantly elevated in the GistFit intervention group relative to controls in all three domains: nutrition [F(1,

199) = 17.67, *MSE* = 2.46, $p < .001$, $\eta^2 = .08$], fitness [$F(1, 198) = 13.77$, *MSE* = 3.68, $p < .001$, $\eta^2 = .07$], and lifestyle [$F(1, 199) = 14.42$, *MSE* = 2.55, $p < .001$, $\eta^2 = .07$]. Higher endorsement of gist principles also significantly correlated with healthy behavior and intentions to perform healthier behavior (Table 3.2).

GistFit subjects' mean endorsement of injunctive norms was significantly higher than that of control subjects [$F(1, 198) = 11.09$, *MSE* = 2.42, $p = .001$, $\eta^2 = .05$]. Less permissive injunctive norms towards unhealthy nutrition and fitness also correlated with behavioral intentions to improve healthy nutrition, increase physical activity, have healthy weight, stop smoking, and reduce risks to blood pressure and blood cholesterol (Table 3.2). Less permissive descriptive norms towards unhealthy nutrition and fitness correlated with healthy behavior (Table 3.2). In addition, GistFit subjects' beliefs about healthy nutrition and fitness were significantly higher than control subjects [$F(1, 198) = 11.40$, *MSE* = 3.32, $p = .001$, $\eta^2 = .06$]. Beliefs also correlated with healthy behavior and behavioral intentions to improve healthy nutrition, increase physical activity, and have healthy weight (Table 3.2).

No differences in knowledge outcomes were found between the two conditions, as knowledge scores in both groups were near ceiling. Knowledge is necessary, although not sufficient, for behavior change (e.g., Reyna, Nelson, Han, & Dieckmann, 2009) and results seem to indicate that most people have basic knowledge about nutrition and fitness (e.g., control group scored equally high on knowledge quiz—see Table 3.1). Nevertheless, behavior and behavioral intentions correlated with other psychosocial mediators of behavior, such as gist principles and social norms (Table 3.2).

Furthermore, despite absence of differences in knowledge, our results support the concept that an intervention grounded in fuzzy-trace theory can improve endorsement of gist principles

(or simple social values), which suggests that the intervention might be robust in long term behavioral change. After exposure to the GistFit intervention, people were more likely to agree with gist principle statements such as "Eating some fruits and vegetables is better than not eating any at all," which were related to healthier behavior (i.e., healthy eating and physical activity) and behavioral intentions. They were also more likely to be less permissive and perceive others as less permissive to unhealthy behaviors and intentions to perform unhealthy behaviors.

Experiment 2

Methods

Subjects. Subjects were 213 female undergraduate students recruited from the subject pools at two universities in the Mid-west and Eastern United States. All subjects provided written consent, and the project was approved by each university's Institutional Review Boards. Subjects were recruited online and received course credit for participation or volunteered. The mean age of subjects was 19.17 (SD = 1.24). Overall, 69% of subjects identified themselves as Caucasian, 9.1% as African American, 15.8% as Asian, 6.1% as mixed or other races; 6.4% identified as Hispanic. There were 69 subjects in the experimental condition and 144 in the control. As in Experiment 1, there were two control conditions (78 subjects in one and 66 in the other), however no differences between control conditions were significant on all measures.

Materials.

Intervention. In this experiment, the content from our fuzzy-trace theory-based intervention GistFit was adapted to the new web-based format using artificial intelligence software to mimic one-on-one human tutoring. As in the static text-based version of GistFit, short bottom-line (gist) summaries of important points were provided at the end of each lesson, designed to facilitate the encoding and long-term retention of simple core information. The

tutorial was self-administered and time on tutorial was approximately 90 minutes, although some people could take longer depending on duration of interaction with the tutorial.

Our ITS version of the tutorial is called $GistFit_{ITS}$: Getting the gist of healthy eating and exercise. The $GistFit_{ITS}$ tutorial was built using Sharable Knowledge Objects (SKO) platform. SKO is a computer-based system using artificial intelligence techniques to mimic one-on-one tutoring. Throughout the SKO, a talking avatar presents information orally and in text, while simultaneously illustrating content with figures (e.g., examples of food from each nutrient and sequence of images demonstrating how to correctly perform aerobic exercises). Three female avatars were used with different apparent ethnicities to deliver information.

The new tutoring system allowed us to actively instill gist information about health in subjects, by engaging them in dialogue throughout the tutorial and providing feedback. For example, asking subjects to think and write about the reasons why they want to be healthy and helping them to extract a bottom-line value (i.e., gist principle). This was possible because $GistFit_{ITS}$ converses with people, responding to what they type, and processes subjects' verbal input using Latent Semantic Analysis (LSA). LSA compares sentences entered by subjects to expectation texts prepared by experts in nutrition, and responds appropriately by encouraging subjects to develop a theme or get back on track if they are off topic.

In addition to actively generating and elaborating on explanations of content materials, questions to test knowledge were also included to increase understanding throughout the tutorial. $GistFit_{ITS}$ included 7 instances of such questions. Each multiple-choice question was presented at key points of the tutorial. If the subject selected the wrong answer, then she had a chance to try one more time. If the subject selected the correct answer, she received feedback explaining

why the answer was correct before moving to the next lesson. (For more details about the role of tutorial interactions, see Brust-Renck et al., 2015).

Gist knowledge. A new measure of knowledge was included to assess understanding of intervention content, not just repetition of facts. Subjects provided answers to multiple-choice questions assessing knowledge about nutrition, use of nutrition labels, and fitness. For example, subjects were asked to indicate "What is a healthy reason to choose foods high in calcium?" among the options: (a) "Calcium-rich foods allow your cells to repair your bones," which is the correct answer, (b) "A high calcium intake is needed to properly absorb Vitamin D, a nutrient important for healthy teeth," which is the incorrect answer, and (c) "Calcium-rich foods usually taste good," which is a filler option. Items were rated as correct or incorrect, and responses were averaged, with higher scores representing more knowledge.

Norms and beliefs. We revised the scales from Experiment 1 to assess social norms and beliefs by adding five descriptive norms' items to improve on the scale. Injunctive norms and beliefs scales remained the same. The new descriptive norms' items included sentences such as "Most of my friends eat foods that have been processed (e.g., frozen dinners and packaged cookies) on a regular basis" (reverse coded) and "I go to the gym or play sports on a regular basis." Items on the descriptive norms scale were rated on a 6-point Likert scale from *strongly disagree* to *strongly agree*. Responses were averaged and higher scores implied less permissive (or favorable) norms towards unhealthy nutrition and fitness.

Attitudes. A measure of attitudes about nutrition and fitness was adopted from Baker et al. (2003) from ratings of 13 Likert-type items and of a 12-item global attitudes scale. (Note that Baker et al.'s attitudes scale originally had 14 items, however one of them—"A healthy diet will make my food taste worse"—correlated negatively with the remaining items and decreases scale

reliability, thus was excluded.) The nutrition scale included items such as "A healthy diet will help me control my weight" and the fitness scale contained items such as "Being physically active will make me feel in control," both rated on a 6-point scale from *strongly agree* to *strongly disagree*. Measures of global attitudes were constructed from ratings about how useful, beneficial, desirable, good, and enjoyable is to be physically active or a healthy eater. In all scales, responses were averaged and higher scores implied more favorable attitudes toward healthy nutrition and fitness.

Self-efficacy and perceived behavioral control. A measure of self-efficacy regarding beliefs about the ability to eat healthy and exercise was constructed from ratings of Likert-type items from Baker et al. (2003), such as "I could succeed in feeling good about myself" and "I know ways to have the body shape and muscles that I like." A measure of perceived behavioral control regarding confidence that the ease of performing a task is up to the subject was also constructed from ratings of Likert-type items about nutrition and fitness. The scale contained sentences regarding what can someone can do to be a healthy eater (e.g., "I can try hard enough at it") and to be physically active (e.g., "I can have enough self-discipline for it"). Items on these two measures were rated on a 6-point scale ranging from *strongly disagree* to *strongly agree* and averaged. Higher scores implied greater self-efficacy or perceived control over behavior.

Gist measures of risk and benefits perceptions. Gist-based perceptions were assessed in three ways. The first measure, gist principles, was the same from Experiment 1, assessing general simple principles about nutrition, fitness, and lifestyle. Subjects could endorse each item on a 5-point Likert scale from *strongly disagree* to *strongly agree*. Responses were averaged and higher scores indicated a greater tendency to endorse gist-based healthy principles. The second gist measure asked subjects to categorize the personal risk of *not* eating healthy (global risks of

nutrition) or *not* exercising (global risks of fitness) as *none*, *low*, *medium*, or *high*. Similarly, two global benefit measures asked subjects to categorize the personal benefit of eating healthy (or exercising) on the same rating scale (i.e., from *none* to *high*). Responses were averaged and higher scores indicated higher perception of risks and benefits.

Behavioral intentions and behavior. A measure of behavioral intentions of healthy eating and physical activity was constructed based on Baker et al.'s (2003) ratings to Likert-type items, such as "I plan to be a healthy eater" and "I plan to be physically active." The ratings were measured on a 6-point scale from *strongly disagree* to *strongly agree* and averaged. Higher scores implied greater intention to perform healthier behavior. Behavior was assessed using the same AHA items from Experiment 1, however we also included a measure of blood pressure for all subjects in the university in the Eastern United States.

Procedure. The interventions were delivered online and administered by undergraduate or graduate research assistants in a controlled environment. Subjects were informed prior to enrollment that they would be randomized to learn about one of two topics (both control conditions were about the same topic). After the intervention, subjects answered a survey for about 90 minutes.

Data analyses. The analysis procedure was the same as Experiment 1, using IBM SPSS Statistics (Version 21.0, IBM Corp., Armonk, NY), to test 2 (*condition*) x 2 (*research site*) ANOVA designs. Again, we assessed whether data provided evidence of superiority of the experimental condition over control (with differences between sites being of no theoretical interest but included to control for academic selectivity).

Results and Discussion

Means, standard deviations, and reliabilities of each measure are presented in Table 3.3. Bivariate correlations of all measures, including self-reported behavior and behavioral intentions, were also conducted and are reported in Table 3.4. No differences were observed between conditions or sites in terms of behavior (healthy eating and physical activity), BMI, and blood pressure, which was expected given that assignment to different conditions was random and testing was conducted immediately after intervention. Nevertheless, younger subjects were more likely to display healthy attitudes towards nutrition and fitness [ρ (207) = -.21, p = .01]. In addition, white subjects were also more likely to show healthier attitudes [ρ (205) = .19, p = .01], higher self-efficacy [ρ (205) = .21, p = .01], and healthier behavioral intentions [ρ (205) = .18, p = .01], while Hispanic subjects were more likely to show lower self-efficacy [ρ (204) = -.16, p = .03] and behavioral intentions [ρ (204) = -.16, p = .03], and to perceive fewer global benefits from nutrition and fitness [ρ (204) = -.17, p = .01, and ρ (204) = -.18, p = .01, respectively].

Overall, behavior significantly correlated with healthy nutrition intentions and intentions to have healthy weight. In addition, no differences in intentions were found between the two conditions, as both groups indicated equally high behavioral intentions (Table 3.3). Knowledge missed significance [$F(1, 217) = 2.84$, $MSE = 0.09$, $p = .09$, $\eta^2 = .01$] as exposure to $\text{GistFit}_{\text{ITS}}$ nearly increased performance on our new gist knowledge test compared to control.

Exposure to $\text{GistFit}_{\text{ITS}}$ intervention resulted in a significant increase in endorsement of gist principles, such as "I have a responsibility to myself to stay healthy" compared to controls in all three domains: nutrition [$F(1, 217) = 7.21$, $MSE = 1.48$, $p = .008$, $\eta^2 = .03$], fitness [$F(1, 217) = 6.48$, $MSE = 2.03$, $p = .012$, $\eta^2 = .03$], and lifestyle [$F(1, 217) = 3.73$, $MSE = 0.97$, $p = .05$, $\eta^2 = .02$]. In addition, gist principles correlated with behavioral intentions (Table 3.4). Behavioral

intentions also significantly correlated with global risks and benefits of nutrition, and behavior and behavioral intentions correlated with global benefits of fitness (Table 3.4).

In contrast to effects found on fuzzy-trace theory-based measures described above, our intervention did not influence other psychosocial mediators of behavior (e.g., social norms, attitudes). Nevertheless, social norms (descriptive and injunctive), beliefs, attitudes, self-efficacy, and perceived behavioral control were all correlated with behavior and behavioral intentions as shown in Table 3.4. All these measures also significantly correlated with the three measures of gist principles (Table 3.4).

Our results replicate those of Experiment 1 and support the concept that an intervention grounded in fuzzy-trace theory can improve endorsement of gist principles (or simple social values), which have been shown to improve healthy choices and behavior in previous studies (e.g., Reyna & Mills, 2014). Results are consistent with previous research (e.g., Reyna et al., 2011) showing that gist measures of risk perceptions elicited attitudes and perceptions that were associated with intentions to perform healthier behavior, which in turn were associated with healthier behavior.

Experiment 3

Methods

Subjects. Subjects were 251 female undergraduate students recruited from the subject pools at two universities in the Mid-west and Eastern United States. All subjects provided written consent, and the project was approved by each university's Institutional Review Boards. Like in the previous experiments, subjects were recruited online and received course credit for participation or volunteered. The mean age of subjects was 19.18 (SD = 1.68). Overall, 61.4% of subjects identified themselves as Caucasian, 9.1% as African American, 22.9% as Asian,

6.6% as mixed or other; 9.2% identified as Hispanic. There were 45 subjects in the experimental condition and 206 in the control condition. As in the previous experiments, there was more than one control condition—in this experiment, 5 conditions with the number of subjects ranging from 40 to 44. Differences among control conditions were mostly non-significant and the conditions were combined. We report specific differences in the supplemental materials online.

Materials and procedure. The same measures from Experiment 2 were used to assess gist knowledge, social norms (descriptive and injunctive), beliefs, attitudes, self-efficacy, perceived behavioral control, global risks and global benefits, behavioral intentions, and self-reported behavior. Changes were made to the gist principles scales, which are described below along with additional measures. The procedure and data analyses were the same as in Experiment 2.

Intervention. Experiment 3 used the same ITS intervention as in Experiment 2. Pictures were updated and added to further supplement the tutorial and a video was created that explicitly demonstrated how to perform a push-up, a crunch, and a squat, replacing previous pictures. We also updated content in light of recent evidence. For example, Levitsky and Pacanowski (2013) showed that skipping breakfast does not necessarily result in overcompensation of calories at subsequent meals, as suggested by some previous studies (and as taught in the original EatFit intervention). Another example was encouraging "moving as much as possible" because "sitting for long periods of time each day is not healthy," based on research about the effect of sedentary behavior on mortality (Seguin et al., 2014). Time on task was approximately 90 minutes for both experimental and control interventions. Five control conditions were included about a different topic (i.e., genetic risk and breast cancer).

Verbatim knowledge. A new measure of verbatim knowledge was included to assess specific content about nutrition, use of nutrition labels, and fitness. Subjects answered multiple-choice questions such as "What improves blood flow to muscles, reducing soreness? A. stretching, B. lifestyle activities, C. aerobic, and D. weight training" (the correct answer being A). Items were rated as correct or incorrect, and responses were averaged, with higher scores representing better verbatim knowledge.

Gist comprehension. A measure of gist comprehension was constructed to assess understanding of tutorial information about nutrition and exercise in this experiment. The scale was constructed from ratings of items such as "To lose weight, I should make consistent changes to my eating and exercise habits because most fad diets are unsafe or ineffective." Items were rated on a 6-point Likert scale from *strongly disagree* to *strongly agree*, and responses were averaged. Higher scores implied better gist comprehension.

Gist measures of risk and benefits perceptions. We revised the gist principles scales of nutrition, fitness, and lifestyle by reducing the number of items based on factor loadings on principal component analyses (by excluding items that loaded on their own factor). Subjects could endorse each item on a 5-point Likert scale from *strongly disagree* to *strongly agree*. Responses were averaged and higher scores indicated a greater tendency to endorse gist-based healthy principles.

Individual differences. Three measures were added to test for the effect of individual differences in learning and behavior. The first measure was sensation seeking, which is the need or desire to experience new and exciting situations. We used the Brief Sensation Seeking Scale (BSSS; Hoyle et al., 2002), which includes items such as "I would like to explore strange places." Items were rated on a 5-point Likert scale from *strongly agree* to *strongly disagree* and

responses were averaged. Higher scores implied intention to engage in risky and potentially dangerous behaviors as a means of achieving desired levels of arousal.

The second measure was impulsivity, which is defined as a failure of self-control or inhibition. We used the Monetary Choice Questionnaire (MCQ; Kirby, 2009), which assesses delay discounting (i.e., the tendency to weigh fewer immediate rewards more highly than higher delayed rewards) and self-control that is stable over one year. The scale contained a series of choices between some amount of money now or later, such as "Would you prefer (a) $34 today or (b) $35 in 186 days?" Both the amounts and the delay time changed through the questions. A hyperbolic discount rate was calculated. Higher scores indicated more impulsivity.

The third measure was an assessment of self-control of eating behavior. The scale was constructed from ratings of items from the Restrained Eating scale from the Dutch Eating Behavior Questionnaire (DEBQ; van Strien, Frijters, Bergers, & Defares, 1986). Subjects rated scales such as "Do you try to eat less at mealtimes than you would like to eat?" Items were rated on a 5-point scale from *never* to *very often*, and responses were averaged. Higher scores implied more self-control processes that monitor dieting behavior.

Results and Discussion

Means, standard deviations, and reliabilities of each measure are presented in Table 3.3. Bivariate correlations of all measures, including self-reported behavior and behavioral intentions, were also conducted and are reported in Table 3.5. No differences were observed between conditions or sites in terms of behavior (healthy eating and physical activity), BMI, and blood pressure, which was expected given that assignment to different conditions was random and testing was conducted immediately after intervention. Nevertheless, younger subjects were more likely to display healthy attitudes [ρ (243) = -.17, p = .01], higher self-efficacy [ρ (243) = -.13, p

= .04], and higher endorsement of gist principles of nutrition [ρ (243) = -.16, p = .01]. In addition, white subjects were more likely to show better gist comprehension [ρ (241) = .13, p = .04], higher self-efficacy [ρ (241) = .21, p < .001], higher control over perceived behavior [ρ (241) = .16, p = .01], less favorable descriptive norms towards unhealthy behavior [ρ (241) = .27, p < .001], more restrained eating [ρ (241) = .18, p = .01], healthier behavioral intentions [ρ (241) = .21, p < .001], and healthier behavior [ρ (241) = .22, p < .001].

Overall, behavior significantly correlated with healthy nutrition intentions and intentions to have healthy weight (Table 3.5). In addition, no differences in intentions were found between the two conditions, as both groups indicated equally high behavioral intentions (Table 3.3). Nevertheless, when controlling for psychosocial mediators of behavior (i.e., attitudes, global attitudes, social norms, beliefs, self-efficacy, or perceived behavioral control), exposure to $\text{GistFit}_{\text{ITS}}$ resulted in significantly higher behavioral intentions compared to control when covariates were either descriptive norms [$F(1, 250) = 121.91$, $MSE = 40.24$, $p < .001$, $\eta^2 = .33$] or global attitudes [$F(1, 250) = 151.58$, $MSE = 46.29$, $p < .001$, $\eta^2 = .38$]. (Note that we only have 45 subjects in the GistFit group, therefore we cannot include all measures at the same time.)

Exposure to the revised $\text{GistFit}_{\text{ITS}}$ intervention resulted in significantly higher scores on both gist and verbatim knowledge compared to controls [$F(1, 250) = 4.54$, $MSE = 0.14$, $p = .034$, $\eta^2 = .02$ and $F(1, 250) = 16.08$, $MSE = 0.33$, $p < .001$, $\eta^2 = .06$, respectively]. Higher scores on verbatim knowledge significantly correlated with healthy behavior and behavioral intentions (Table 3.5). The results are consistent with our predictions that verbatim knowledge should be most pronounced immediately following intervention, when memory for learned material is strongest. Gist knowledge, however, facilitates "transfer of training" from facts learned to applied situations, reflecting comprehension and retention.

As predicted, $GistFit_{ITS}$ subjects also scored significantly higher on gist comprehension than controls [$F(1, 250) = 4.14$, $MSE = 2.82$, $p = .043$, $\eta^2 = .02$]. Increased gist comprehension significantly correlated with healthy behavior and behavioral intentions (Table 3.5). Unlike knowledge measures, endorsing gist comprehension items, such as "I should avoid even small amounts of trans-fat to help prevent chronic illnesses," indicates that subjects understand the essential bottom-line decision-relevant meaning of that knowledge. Moreover, increased gist comprehension correlated with increased conventional knowledge measures, which is consistent with fuzzy-trace theory's predictions that comprehension aids people to better organize their knowledge and reconstruct details from their gist memory (as seen in Table 3.5).

As in the previous experiments, $GistFit_{ITS}$ subjects were more likely to endorse gist principles (healthy values) compared to control subjects in all three domains: nutrition [$F(1, 250) = 4.92$, $MSE = 1.21$, $p = .028$, $\eta^2 = .02$], fitness [$F(1, 250) = 4.22$, $MSE = 4.22$, $p = .041$, $\eta^2 = .02$], and lifestyle [$F(1, 250) = 3.86$, $MSE = 1.11$, $p = .050$, $\eta^2 = .02$]. All three measures of gist principles also significantly correlated with healthy behavior and behavioral intentions (Table 3.5). $GistFit_{ITS}$ subjects were also more likely to perceive global risk of not exercising (fitness) as higher than control [$F(1, 250) = 9.95$, $MSE = 8.84$, $p = .002$, $\eta^2 = .04$]. Healthy behavior and behavioral intentions also significantly correlated with global benefits of nutrition and fitness (Table 3.5).

Again, social norms, beliefs, attitudes, self-efficacy, and perceived behavioral control did not change compared to controls. However, these measures were significantly correlated with behavior and behavioral intentions as seen in Table 3.5. All these measures also significantly correlated with the three measures of gist principles (Table 3.5), suggesting that there is a gist-based intuitive component to logical and rational reasoning.

Finally, high sensation seekers were more likely to engage in healthy behavior and have higher intentions to perform healthy behavior (Table 3.5). Although this trait has been used as a predictor of problematic behavior such as alcohol use, dangerous driving, and smoking, the desire to explore strange places, seek thrills and adventure, like wild parties, and get bored easily are also traits from individuals who are physically active (and not sedentary). As expected, subjects who restrain more from eating (e.g., watch what they eat and try to eat less than they would like) were more likely to show healthy behavior and behavioral intentions (Table 3.5). (No differences were found between groups for any individual difference measure.)

Overall, results are consistent with previous experiments, showing our intervention improves endorsement of gist principles, even when controlling for other dimensions of risk taking as covariates (i.e., sensation seeking, impulsive behavior, and restrained eating behavior). Moreover, the revised version of $\text{GistFit}_{\text{ITS}}$ used in Experiment 3 also increased gist and verbatim knowledge and gist comprehension, which are necessary for behavioral change (even though verbatim knowledge is not always sufficient; e.g., Reyna & Mills, 2014).

General Discussion

Our results strongly support the hypothesis that gist-based interventions grounded in fuzzy-trace theory increased knowledge, enhanced gist comprehension, and improved endorsement of gist principles (healthy values) and gist perception of risks and benefits. Principles from fuzzy-trace theory have been used to amplify the effects of two versions of our obesity prevention intervention, GistFit: Getting the gist of healthy eating and exercise—one text-based intervention (Experiment 1) and one active intervention using ITS to communicate with subjects using natural language (Experiments 2 and 3). More specifically, the interventions affected memory and knowledge constructs described by fuzzy-trace theory that go beyond

traditional approaches. For example, in all three Experiments, subjects were more likely to agree with statements such as "I should avoid fried foods" and "Better to exercise at least a few times a week" (i.e., gist principles).

Previous research has shown that affecting psychosocial mediators—such as social norms, beliefs, attitudes, self-efficacy, perceived behavioral control, and gist principles—can produce behavior change (e.g., Reyna & Mills, 2014). The higher endorsement of gist principles observed in the experimental groups in all three Experiments is consistent with simple gist-based thinking about values, even though it is at odds with traditional approaches that stress knowledge and reasoning (e.g., Fishbein, 2008). However, most subjects—regardless of whether they were assigned to the experimental or control conditions—exhibited healthy attitudes and intentions towards healthy eating and physical activity, and even expressed the ability to do so and the confidence that they could easily perform such healthy behaviors (self-efficacy and perceived behavioral control), as demonstrated by bivariate correlations.

Knowledge is a target of both traditional and fuzzy-trace theory interventions because information is necessary for behavior change. However, our questions delineate content that can be merely memorized as rote knowledge (verbatim memory) that is rapidly forgotten over time (e.g., Reyna & Kiernan, 1994) from questions that require understanding and transfer of training (i.e., apply prior learning to novel instances) through encoding the gist of facts (Brainerd, Reyna, & Howe, 2009). Immediately after the intervention, both verbatim and gist knowledge still remain significantly higher than control. Verbatim representations generally fade after about a week thus cannot support long-term changes in behavior. Gist representations, however, are more resistant over time and often lead to meaningful inferences that go beyond surface (rote) facts learned (Lloyd & Reyna, 2009; Reyna & Kiernan, 1994; Wolfe et al., 2013, 2015).

Previous research suggests that the key to improved performance in our interventions is learning with gist understanding rather than rote memorization of verbatim facts (e.g., Reyna & Mills, 2014; Wolfe et al., 2015). The presence of increased gist comprehension levels in experimental conditions, unlike control, suggests that $GistFit_{ITS}$ was accurately promoting gist extraction of the bottom-line of nutrition and fitness. Nevertheless, long-term changes in behavior cannot be observed immediately after the intervention, and a follow up test would permit more detailed analyses over time. $GistFit_{ITS}$ was bolstered with gist principles meant to emphasize long-term consequences of healthy behaviors, and the interventions successfully instilled subjects with an understanding of these principles relating to nutrition and fitness. Future research could assess the long-term effectiveness of the intervention through following up with subjects in a longitudinal design, permitting more detailed analysis of specific improvements in behavior in the context of obesity prevention, mediated by retention of these gist principles (for other examples, see Reyna & Mills, 2014).

Thus, simple, theory-driven manipulations can effectively improve evidence-based programs to prevent obesity. Results of this randomized experiment support previous recommendations (e.g., Rivers et al., 2008) to incorporate gist-based manipulations into current public health approaches. Furthermore**,** a web-based ITS is a scalable and cost-effective way to reach people across the globe. When guided by a sound theoretical understanding, emerging discourse technologies may be fruitfully used to create gist-based interventions, guiding people to explain the gist of complex topics relating to nutrition and health in personal ways to facilitate improved decision-making.

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Table 3.1

Means, Standard Deviations, and Reliabilities of Measures in Experiment 1

					GistFit		Control	
Measures	n	Min	Max	α	M	SD	M	SD
Knowledge Quiz	16	0	1	.49	0.91_a	0.10	0.89_a	0.10
Norms and Beliefs								
Descriptive Norms	4	0	4	.69	2.76_a	0.82	2.69_a	0.71
Injunctive Norms	12	0	4	.74	2.78_a	0.56	2.53_b	0.41
Beliefs	6	0	4	.63	2.93_a	0.59	2.63_b	0.51
Gist Measures of Risk and Benefits								
Gist Principles of Nutrition	24	0	4	.86	3.38_a	0.42	3.13_b	0.38
Gist Principles of Fitness	9	0	4	.85	3.44_a	0.46	3.16_b	0.53
Gist Principles of Lifestyle	25	0	4	.94	3.40_a	0.40	3.15_b	0.43
Behavioral Intentions								
Intentions—Healthy Nutrition	10	0	1	.83	0.61_a	0.30	0.62_a	0.30
Intentions—Physical Activity	13	0	1	.85	0.55_a	0.29	0.49_a	0.28
Intentions—Healthy Weight	15	0	1	.82	0.50_a	0.24	0.45_a	0.23
Intentions—Smoking	9	0	1	.89	0.43_a	0.33	0.40_a	0.35
Intentions—Blood Pressure	6	0	1	.68	0.37_a	0.27	0.38_a	0.30
Intentions—Blood Cholesterol	6	0	1	.71	0.44_a	0.28	0.40_a	0.30
Intentions—Blood Sugar	10	0	1	.83	0.33_a	0.27	0.32_a	0.29
Behavior	2	0	6		3.22_a	1.43	3.15_a	1.38

Note. n = Number of items per measure; α = Reliability (Cronbach's coefficient alpha); M = Mean; SD = Standard deviation. Means with differing subscripts within rows are significantly different at the $p < .05$.

Table 3.2

Spearman Correlations Between Independent Variables and Behavior and Behavioral Intentions in Experiment 1

	KQ	DN	IN	Bel	GPN	GPF	GPL	IHN	IPA	IHW	IS	IBP	IBC	IBS
Knowledge Quiz	1													
Descriptive Norms	-.06	1												
Injunctive Norms	.02	.18**	1											
Beliefs	.06	.18*	.69**	1										
Gist Principles of Nutrition	.14	.16*	.49**	.54**	1									
Gist Principles of Fitness	.14	.23**	.42**	.49**	.72**	1								
Gist Principles of Lifestyle	.08	.24**	.51**	.56**	.75**	.80**	1							
Intentions—Healthy Nutrition	.14	.06	.18*	.23**	.32**	.35**	.31**	1						
Intentions—Physical Activity	.11	.01	.21**	.24**	.34**	.43**	.42**	.74**	1					
Intentions—Healthy Weight	.10	.08	.28**	.32**	.38**	.41**	.41**	.67**	.72**	1				
Intentions—Smoking	-.07	.22**	.16*	.06	.16*	.21**	.28**	.33**	.36**	.40**	1			
Intentions—Blood Pressure	.01	.10	.16*	.09	.21**	.24**	.24**	.56**	.60**	.53**	.38**	1		
Intentions—Blood Cholesterol	.02	.08	.15*	.10	.19**	.20**	.20**	.55**	.57**	.54**	.33**	.85**	1	
Intentions—Blood Sugar	-.01	.10	.13	.12	.19**	.19**	.20**	.54**	.59**	.49**	.34**	.81**	.85**	1
Behavior	.13	.32**	.06	.15*	.18*	.18*	.16*	.21**	.08	.181*	.11	.07	.02	.02

Note. KQ = Knowledge Quiz; DN = Descriptive Norms; IJ = Injunctive Norms; Bef = Beliefs; GPN = Gist Principles of Nutrition; GPF = Gist Principles of Fitness; GPL = Gist Principles of Lifestyle; IHN = Intentions—Healthy Nutrition; IPA = Intentions—Physical Activity; IHW = Intentions—Healthy Weight; IS = Intentions—Smoking; IBP = Intentions—Blood Pressure; IBC = Intentions—Blood Cholesterol; IBS = Intentions—Blood Sugar.
* $p < .05$. ** $p < .001$.

Table 3.3

Means, Standard Deviations, and Reliabilities of Measures in Experiments 2 and 3

				Experiment 2					Experiment 3				
					GistFit		Control			GistFit		Control	
Measures	#	Min	Max	α	M	SD	M	SD	α	M	SD	M	SD
Gist Knowledge	14	0	1	.72	0.80_a	0.17	0.76_a	0.18	.60	0.68_a	0.18	0.62_b	0.18
Verbatim Knowledge	22	0	1						.68	0.74_a	0.16	0.64_b	0.15
Gist Comprehension	14	0	5						.84	4.70_a	0.90	4.46_b	0.83
Attitudes	13	0	5	.96	4.43_a	0.57	4.41_a	0.63	.95	4.48_a	0.56	4.42_a	0.62
Global Attitudes	12	0	5	.91	4.25_a	0.60	4.31_a	0.66	.87	4.30_a	0.60	4.35_a	0.54
Self-Efficacy	14	0	5	.89	3.26_a	0.61	3.34_a	0.71	.88	3.42_a	0.78	3.41_a	0.60
Perceived Behavioral Control	20	0	5	.92	3.85_a	0.64	3.74_a	0.75	.90	3.76_a	0.71	3.80_a	0.65
Descriptive Norms	14	0	5	.87	3.31_a	0.76	3.35_a	0.70	.90	3.23_a	0.92	3.33_a	0.81
Injunctive Norms	12	0	4	.64	2.49_a	0.45	2.51_a	0.38	.66	2.49_a	0.43	2.44_a	0.43
Beliefs	6	0	4	.60	2.63_a	0.57	2.60_a	0.46	.58	2.73_a	0.50	2.60_a	0.53
Gist Measures of Risk and Benefits													
Gist Principles of Nutrition	[c]	0	4	.90	3.20_a	0.48	3.03_b	0.44	.91	3.45_a	0.49	3.27_b	0.50
Gist Principles of Fitness	[d]	0	4	.89	3.36_a	0.53	3.15_b	0.57	.83	3.37_a	0.49	3.20_b	0.55
Gist Principles of Lifestyle	[e]	0	4	.94	3.25_a	0.47	3.09_b	0.54	.91	3.54_a	0.52	3.38_b	0.54
Global Risks Nutrition	1	0	3		2.04_a	0.93	2.06_a	0.85		2.09_a	0.79	2.00_a	0.87
Global Benefits Nutrition	1	0	3		2.77_a	0.52	2.70_a	0.56		2.76_a	0.48	2.72_a	0.56
Global Risks Fitness	1	0	3		1.90_a	0.91	1.90_a	0.95		2.29_a	0.79	1.83_a	0.99
Global Benefits Fitness	1	0	3		2.68_a	0.61	2.72_a	0.60		2.73_a	0.54	2.71_a	0.56
Individual Differences													
Sensation Seeking	8	0	4						.87	2.24_a	0.75	2.20_a	0.87
Monetary Choice Questionnaire	27	0	1							0.03_a	0.05	0.04_a	0.06
Restrained Eating	10	0	4						.92	1.98_a	0.84	1.96_a	0.92
Behavioral Intentions													
Intentions (overall)	8	0	5	.93	4.02_a	0.91	4.01_a	0.89	.89	3.86_a	0.65	3.75_a	0.71
Healthy Nutrition	4	0	5	.90	4.01_a	0.94	3.97_a	0.93	.87	3.88_a	0.75	3.72_a	0.78
Physical Activity	4	0	5	.89	4.03_a	1.01	4.06_a	0.97	.88	3.85_a	0.75	3.78_a	0.84
Behavior	2	0	6		3.01_a	1.23	3.24_a	1.39		3.11_a	1.56	3.11_a	1.29

Note. n = Number of items per measure; α = Reliability (Cronbach's coefficient alpha); M = Mean; SD = Standard deviation. Means with differing subscripts within rows within experiments are significantly different at the $p < .05$.

[c, d, e] Number of items is different in Experiments 2 and 3 for gist principles scales: Nutrition: 24 and 15 items, Fitness: 9 and 8 items, Lifestyle: 25 and 8 items, respectively.

Table 3.4

Spearman Correlations Between Independent Variables and Behavior and Behavioral Intentions in Experiment 2

	GK	DN	IN	Bel	Att	GA	SE	PBC	GPN	GPF	GPL	GRN	GBN	GRF	GBF	BI
Gist Knowledge	1															
Descriptive Norms	.04	1														
Injunctive Norms	.20**	.24**	1													
Beliefs	.35**	.18**	.59**	1												
Attitudes	.15*	.21**	.36**	.42**	1											
Global Attitudes	.15*	.33**	.28**	.39**	.60**	1										
Self-Efficacy	.26**	.42**	.27**	.44**	.46**	.57**	1									
Perceived Behavioral Control	.23**	.39**	.24**	.29**	.39**	.48**	.51**	1								
Gist Principles of Nutrition	.27**	.19**	.38**	.45**	.48**	.35**	.37**	.24**	1							
Gist Principles of Fitness	.25**	.23**	.41**	.54**	.54**	.44**	.54**	.36**	.70**	1						
Gist Principles of Lifestyle	.16*	.27**	.46**	.51**	.52**	.38**	.41**	.30**	.72**	.75**	1					
Global Risks—Nutrition	-.06	-.01	.10	.20**	.12	.10	.03	.12	.13	.09	.18**	1				
Global Benefits—Nutrition	.13	.15*	.30**	.33**	.25**	.21**	.28**	.22**	.27**	.30**	.30**	2.00	1			
Global Risks—Fitness	-.02	-.04	.17*	.14*	.07	.05	.01	.06	.15*	.12	.16*	.60**	.17*	1		
Global Benefits—Fitness	.19**	.23**	.24**	.32**	.27**	.32**	.34**	.24**	.19**	.34**	.29**	.12	.45**	.13	1	
Behavioral Intentions	.18**	.48**	.24**	.41**	.52**	.59**	.64**	.55**	.35**	.43**	.41**	.14*	.28**	.08	.33**	1
Behavior	.14*	.24**	-.01	.14*	.08	.19**	.26**	.18**	.05	.08	.10	.03	.09	-.02	.14*	.29**

Note. GK = Gist Knowledge; DN = Descriptive Norms; IJ = Injunctive Norms; Bef = Beliefs; Att = Attitudes; GA = Global Attitudes; SE = Self-Efficacy; PBC = Perceived Behavioral Control; GPN = Gist Principles of Nutrition; GPF = Gist Principles of Fitness; GPL = Gist Principles of Lifestyle; GRN = Global Risks—Nutrition; GBN = Global Benefits—Nutrition; GRF = Global Risks—Fitness; GBF = Global Benefits—Fitness; BI = Behavioral Intentions.
* $p < .05$. ** $p < .001$.

Table 3.5

Spearman Correlations Between Independent Variables and Behavior and Behavioral Intentions in Experiment 3

	GK	VK	GC	DN	IN	Bel	Att	GA	SE	PBC	GPN	GPF	GPL	GRN	GBN	GRF	GBF	SS	Imp	RE	BI
Gist Knowledge	1																				
Verbatim Knowledge	.49**	1																			
Gist Comprehension	.46**	.46**	1																		
Descriptive Norms	-.15*	-.03	.06	1																	
Injunctive Norms	.10	.04	.19**	.33**	1																
Beliefs	.17**	.24**	.36**	.24**	.55**	1															
Attitudes	.07	.15*	.35**	.30**	.33**	.37**	1														
Global Attitudes	.17**	.22**	.38**	.37**	.35**	.52**	.54**	1													
Self-Efficacy	.14*	.24**	.45**	.44**	.20**	.38**	.55**	.49**	1												
Perceived Behavioral Control	.09	.03	.29**	.45**	.25**	.26**	.39**	.45**	.40**	1											
Gist Principles of Nutrition	.14*	.24**	.52**	.20**	.29**	.36**	.45**	.38**	.40**	.35**	1										
Gist Principles of Fitness	.07	.15*	.45**	.20**	.27**	.35**	.47**	.36**	.45**	.30**	.64**	1									
Gist Principles of Lifestyle	.19**	.21**	.50**	.19**	.33**	.49**	.52**	.49**	.45**	.34**	.68**	.63**	1								
Global Risks—Nutrition	.11	.09	.01	.04	-.01	.07	.01	.13*	.05	-.03	.08	.12	.12	1							
Global Benefits—Nutrition	.16*	.20**	.24**	.15*	.21**	.26**	.28**	.39**	.28**	.13*	.27**	.31**	.32**	.16*	1						
Global Risks—Fitness	.19**	.17**	.12	.03	.06	.14*	.14*	.12	.12	-.02	.12	.19**	.17**	.57**	.20**	1					
Global Benefits—Fitness	.11	.08	.17**	.15*	.21**	.16*	.29**	.32**	.31**	.18**	.22**	.30**	.29**	.08	.47**	.21**	1				
Sensation Seeking	-.06	.01	.08	.29**	-.03	.06	.16*	.08	.15*	.24**	.05	.15*	.05	.01	.04	-.03	.06	1			
Impulsivity	-.08	-.18**	-.06	.05	.06	.02	.08	.02	.01	.01	-.06	-.01	-.02	-.04	-.02	-.08	.04	-.03	1		
Restrained Eating	-.04	.15*	.12	.24**	.21**	.32**	.25**	.22**	.06	.16**	.12	.12*	.21**	.17**	.19**	.25**	.06	.14*	-.08	1	
Behavioral Intentions	.01	.15*	.33**	.56**	.28**	.48**	.48**	.60**	.59**	.40**	.37**	.37**	.44**	.04	.33**	.08	.28**	.24**	.02	.29**	1
Behavior	.03	.17**	.16*	.37**	.03	.15*	.14*	.15*	.32**	.27**	.17**	.20**	.19**	.08	.16*	.06	.14*	.14*	-.01	.20**	.40**

Note. GK = Gist Knowledge; VK = Verbatim Knowledge; GC = Gist Comprehension; DN = Descriptive Norms; IJ = Injunctive Norms; Bef = Beliefs; Att = Attitudes; GA = Global Attitudes; SE = Self-Efficacy; PBC = Perceived Behavioral Control; GPN = Gist Principles of Nutrition; GPF = Gist Principles of Fitness; GPL = Gist Principles of Lifestyle; GRN = Global Risks—Nutrition; GBN = Global Benefits—Nutrition; GRF = Global Risks—Fitness; GBF = Global Benefits—Fitness; SS = Sensation Seeking; Imp = Impulsivity; RE = Restrained Eating; BI = Behavioral Intentions.
* $p < .05$. ** $p < .001$.

Effects of Specific Control Groups from Experiment 3

Five control conditions were included in Experiment 3, but they are of no theoretical interest as they are all about a different topic (i.e., genetic risk and breast cancer). Nevertheless, they were included in as supplemental materials online. Out of the 206 control subjects, 40 were in Control Groups 1, 2, and 4, 44 were in Control Group 3, and 42 in Control Group 5. Significant results were organized by outcome (Means for $GistFit_{ITS}$ can be found on Table 3.3).

Verbatim Knowledge. $F(5, 239) = 5.04$, $MSE = 0.10$, $p < .001$, $\eta^2 = .10$ with $GistFit_{ITS}$ subjects scoring significantly higher than Control Groups 1, 2, 4, and 5 ($M = .64$, .59, .60, and .60, respectively). In addition, subjects in Control Group 3 scored significantly higher ($M = .67$) than those in Control Groups 2, 4, and 5.

Gist Comprehension. $F(5, 239) = 2.42$, $MSE = 1.62$, $p = .04$, $\eta^2 = .05$ with $GistFit_{ITS}$ subjects scoring significantly higher than Control Groups 2 and 4 ($M = 4.14$ and 4.29, respectively). In addition, subjects in Control Groups 1 and 3 scored significantly higher ($Ms = 4.58$) than those in Control Group 2.

Global Risks Fitness. $F(5, 239) = 2.92$, $MSE = 2.57$, $p = .01$, $\eta^2 = .06$ with $GistFit_{ITS}$ subjects perceiving risks from not exercising regularly as significantly higher than Control Groups 1, 4, and 5 ($M = 1.70$, 1.66, and 1.61, respectively).

CHAPTER 4

ACTIVE ENGAGEMENT IN A WEB-BASED TUTORIAL TO PREVENT OBESITY GROUNDED IN FUZZY-TRACE THEORY PREDICTS IMPROVED KNOWLEDGE, GIST COMPREHENSION, AND ENDORSEMENT OF HEALTHY VALUES

We report the results of a new approach to preventing obesity, which is a serious and growing problem in the United States and indeed much of the world (Ogden, Carroll, Kit, & Flegal, 2014). The novel approach is a web-based tutoring system with a talking pedagogical agent that interacts with learners in their natural language developed based on fuzzy-trace theory (Reyna & Brainerd, 1995, 2011). We incorporate relevant research and theoretical mechanisms involved in active learning environments to create a comprehensive account of processes that guide decision-making. First, we present traditional ways to communicate information broadly through static websites and modern web-based tutors based on artificial intelligence. Then we discuss the importance of theoretical underpinnings to efficient interventions, leading to the current experiment.

The success of traditional communication approaches relies on the idea that pertinent information is communicated and encoded so that it can be retrieved later. In particular, these approaches suggest that communicating information requires presenting detailed and precise information while also targeting misperceptions to change people's beliefs and behaviors (Li & Chapman, 2013). An obesity intervention or prevention program might, for example provide instruction on how to read nutrition labels or how to calculate the amount of calories consumed each day. However, emphasizing the learning of verbatim facts is often insufficient to change

either beliefs or behaviors (Brust-Renck, Royer, & Reyna, 2013; Peters, 2009; Reyna & Farley, 2006). A common result of such approaches is that behavior change is demonstrated in the short term, but are either not followed over the long term or effects dissipate over time (e.g., Cooper et al., 2010).

Few members of the public have sufficient knowledge to understand health and medical messages, such as those involving breast cancer risk, vaccination, HIV/AIDS, and obesity (e.g., Downs, Bruin de Bruine, & Fischhoff, 2008). Lack of background information to connect the dots (i.e., achieve global coherence) compromises comprehension and retention of messages (Lloyd & Reyna, 2009; Reyna & Adam, 2003). Those with the expertise to understand these messages and connect the dots, such as genetic counselors, are not available (as there is approximately one certified genetic counselor to every 100,000 people in the United States; ABGC, 2014) or are not always covered by insurance. Information available on the web and through social media does not necessarily solve this problem because the information is often not clear and easy to understand (in particular from official government sites; Betsch et al., 2012; Reyna, 2012b).

One classic theoretical approach to bridge the gap between learned materials and reality comes from Gestalt psychology through urging reasoners to "Think!" in order to decrease mindless reactions to a task and promote active thinking about what would be the best approach (e.g., Reyna, 1991; see also Reyna, Lloyd, & Brainerd, 2003). The mechanism behind this approach is the distinction between reproductive (or non-productive) and productive thinking. The former is a result of rote associations (e.g., students who are shown how to measure the area of a rectangle tend to mistakenly apply the same formula to a parallelogram) and the latter is a result of conceptual understanding that supports transfer to new instances (e.g., by realizing that

cutting off the triangle from one end of the parallelogram and placing it on the other side to form a rectangle, then the surfaces of both figures become similar and the area can be determined; Wertheimer, 1959; Wolfe & Reyna, 2010a, b; Wolfe, Fisher, Reyna, & Hu, 2012). According to Wertheimer, reproductive thinking is a recombination of learned associations (i.e., memorizing the content of the curriculum by forming associations among the words, much like Skinner described learning in rats), whereas productive thinking involves deep conceptual insight that support meaningful inferences from learned materials to superficially different but are conceptually similar examples. According to Gestalt psychology, information learned by productive thinking is better retained in memory (the essential features of learned material) than information learned by rote memorization (for a review, see Wertheimer, 2010).

Using this approach to encourage connections in learned information in such a way that influences behavior change has often required the same one-on-one tutoring, which is a gold standard for communicating information. Human tutors have the advantage asking questions, can immediately gauge progress and correct mistakes, and can encourage students to elaborate on answers to questions of knowledge and comprehension. This elaboration has benefits to one's own understanding. For example, elaboration on topics that people mistakenly think they understand has the effect of correcting confidence in understanding, particularly regarding concepts related to causal models (Fernbach, Rogers, Fox, & Sloman, 2013). More generally, actively generating explanations of material improves learning compared to passive reading or listening to lectures (Graesser, McNamara, & VanLehn, 2005). One promising direction has been that of automated tutoring systems to emulate the most effective strategies from one-on-one learning. As previously described, however, this can be expensive (i.e., it requires training) or otherwise unavailable (mostly due to location issues, time constraint, and scarcity of resources).

Progress has been made in creating automated instruction that can teach complex conceptual material with the efficacy of human tutors (Wolfe et al., 2013; Wolfe, Reyna, Widmer, Cedillos, et al., 2015). Intelligent Tutoring Systems (ITS; i.e., computer-based tutoring) have been developed to facilitate human-computer interactions and overcome hurdles resulting from the lack of a dynamic teaching environment and trained teachers (Graeser et al., 2004). One of the greatest advantages of computer tutors is their ability to mimic human tutors in helping learners to connect the dots and provide immediate feedback, much like one-on-one tutors, facilitating the integration between current and prior experiences, which are features from one-on-one tutoring (Chi, Siler, Jeon, Yamauchi, & Hausmann, 2005; Lloyd & Reyna, 2009).

ITS can be programmed to elicit elaborate explanations from students and can communicate with students using natural language. Examples of platforms for systems that use semantic decomposition to interact with people in natural languages are AutoTutor and Sharable Knowledge Objects (SKO; formerly Autotutor Lite; Hu, Han, & Cai, 2008; Hu, Cai, Han, Craig, Wang, & Graesser, 2009), which have been successfully applied to teaching about computer science, physics, and genetic risk of breast cancer, among other topics (e.g., Graesser et al., 2004; Wolfe et al., 2013; Wolfe, Reyna, Widmer, Cedillos, et al., 2015). In these systems, a talking avatar communicates information using conversational language, facial expressions, graphical displays, and videos. This platform accomplishes a tailored interaction through the use of curriculum scripts including ideal answers, responses for common misconceptions, and feedback for the student (i.e., questions are answered in an efficient and effective manner). Moreover, people can engage in dialogues with the tutorial to actively generate explanations in more effective and deeper ways than when people are just given static information (Arnott, Hastings, & Allbritton, 2008; Chi, 2009).

This strategy on its own, however, does not necessarily employ findings from the latest theories regarding how to successfully change behavior as a result of learned information, though it may be a useful tool with which to implement theoretical predictions. BRCA Gist (BReast CAncer Genetics Intelligent Semantic Tutoring), an ITS devised around fuzzy-trace theory, has been shown to lead to improvements in knowledge, comprehension, decision to undergo genetic testing based on one's personal risk, and assessment of risk from multiple scenarios in randomized, controlled experiments (Wolfe et al., 2013; Wolfe, Reyna, Widmer, Cedillos, et al., 2015). The web-based tutorial has multiple advantages as a method of instruction: it is asynchronous (can be accessed at any time of day and night), interactive, and multi-media (it transmits the information orally, in writing, and with figures and photographs). The tutorial allows users to interact with it through the use of natural language by asking deep level reasoning questions and providing feedback, encouragement, and additional information to aid understanding. The tutorial attempts to comprehend subjects' answers and to simulate replies from human tutors (VanLehn, 2011). In addition, results showed that not all active tutoring helped to improve outcomes, but the development of gist explanations (based on fuzzy-trace theory) was responsible for significant improvements (Wolfe, Reyna, Widmer, Cedillos-Whynott, et al., 2015).

Thus, we turn to fuzzy-trace theory, a theory modeled after the principles of Gestalt psychology, that emphasizes two processes of reasoning (i.e., gist and verbatim thinking) that reflect different sources of information processing (Reyna, 2012a, 2013; Reyna & Brainerd, 1995, 2011; Reyna et al., 2003). Gist thinking involves bottom-line (meaningful) understanding of conceptual information, the "substance" that exists irrespective of exact words, numbers, or pictures (and is derived from productive thoughts). Verbatim (literal) thinking is a more

fundamental process that relies on the surface form of information, the exact mental representation of the stimulus (which does not require productive thoughts). Fuzzy-trace theory predicts independent and parallel processing of verbatim-based and gist-based thinking (e.g., Brainerd, Reyna, & Howe, 2009; Reyna & Brainerd, 1992). In the context of communication, gist thinking relies on extracting the essential, bottom-line meaning of information, which results in insightful intuition, and retrieval of relevant knowledge and values, whereas verbatim thinking is a result of associative activation (i.e., mindless memorization of learned materials), which cannot predict far transfer of learning to novel instances.

In the present experiment, we used a randomized control trial to investigate the role of active learning using a web-based ITS that applies artificial intelligence to create a scalable and cost-effective way to engage many people in dialogue about obesity simultaneously. The novelty of our method for teaching involves combining fuzzy-trace theory with artificial intelligence. The ITS was developed to engage participants in a dialogue about the myriad issues associated with obesity prevention, from nutrition to exercise. Previous research has shown that generating arguments about a specific topic has been used to increase understanding (Chi, 2009; VanLehn, Graesser, Jackson, Jordan, Olney, & Rosé, 2007; Wolfe, Reyna, Widmer, Cedillos, et al., 2015). The prediction is that actively generating and elaborating on explanations of complex materials promotes understanding of bottom-line (gist) semantic meaning of information (Clariana & Koul, 2006; Lloyd & Reyna, 2001). Our methods take advantage of the fact that interactive dialogues with tutors providing immediate feedback increases meaningful processing of information that occurs during encoding and forges stronger memory traces of semantic meaning (Clariana & Koul, 2005, 2006; Reyna & Brainerd, 2011).

Moreover, our tutor was guided by theoretical principles from fuzzy-trace theory, particularly emphasizing active comprehension of bottom-line (gist) meaning from conceptual information and extraction of gist principles (i.e., healthy values). As mentioned previously, fuzzy-trace theory posits that meaningful understanding goes beyond the surface details and encourages connecting the dots between current and prior content (Reyna, 2013; Reyna et al., 2003). By supplying the "active ingredient" (i.e., the ability to extract gist) in an active environment (i.e., multiple-choice questions embedded within the tutorial and the engagement of participants in tutorial dialogues), we predicted that our tutorial would significantly improve knowledge and comprehension while instilling healthy values (i.e., gist principles). We also hypothesized that these measures would be associated with intentions to perform healthier behavior in the future. Further, we included measures of a traditional theory (i.e., Theory of Reasoned Action/Theory of Planned Behavior; Ajzen, 2011; Fishbein, 2008) to test alternative hypotheses about the possible benefits of the tutorial (i.e., beliefs, attitudes, and norms have been consistently linked to behavioral intentions and behavior). However, none of none of these variables were related to experimental groups or tutorial engagement, and will therefore not be reported here.

Method

Design

A two-group randomized controlled experiment was conducted to assess the effectiveness of the obesity prevention tutorial using an intelligent tutoring system (ITS), which provides more active tutoring than a traditional reading tutorial. Participants were randomly assigned to either an experimental or a control groups and did not differ on baseline characteristics by more than

chance levels prior to the tutorial. The experimental group was broken down into three levels where participants engaged with the tutorial in either none, some, or all questions.

Participants

Participants were 251 female undergraduate students recruited from the participant pools at two universities in the Midwest and Eastern United States; 25 did not complete the entire tutorial and 6 completed the survey too quickly (i.e., in less than half of the average time) and were excluded (8 from the experimental condition and 23 from control), leaving 220 participants. None of the dropouts were due to subjects deciding to not complete the tutorial. All the dropouts were due to a technical problem that affected all of the groups. We compared the experimental group with one control group with virtually identical attrition rate (6 out of 40 subjects) and the results were the same. All participants provided written consent, and the project was approved by each university's Institutional Review Boards. Participants were recruited online (though the study was conducted in the laboratory in-person) and they either received course credit or volunteered for participation. The mean age of participants was 19.21 (SD = 1.73). Overall, 61.5% participants identified themselves as Caucasian, 10% as African American, 21.8% as Asian, and 6.7% as mixed/other race; 9.1% identified as Hispanic. There were 37 participants in the experimental condition and 183 were assigned to one of five control conditions with unrelated content (participants in each control condition ranged from 31 to 41). The control groups differed in relatively minor ways, testing different ways of presenting the same information about breast cancer and genetic risk, and the results across controls groups for our curriculum were very similar. Thus we will treat the control conditions as a single control group in reporting the results.

Materials

Tutorial.

Our tutorial, GistFit, getting the gist of healthy eating and exercise (Brust-Renck, Reyna, Wilhelms, & Wolfe, 2015), is an adapted version of EatFit, a goal-oriented tutorial designed to improve healthy nutrition and exercising (Horowitz, Shilts, & Townsend, 2004; Shilts, Townsend, & Horowitz, 2004). Based on Social Cognitive Theory, the original tutorial was effective in sixth and eighth graders when administered as a 10-hour classroom setting in-person curriculum (e.g., Shilts, Horowitz, & Townsend, 2009). The tutorial's lessons included nutrition and exercise basics as well as information about energy balance, food labels, fast food, and advertising.

The adapted version shares the content of EatFit (i.e., all the facts covered in EatFit were also covered in GistFit), however, it also emphasizes the bottom-line meaning of nutrition and exercise according to research on fuzzy-trace theory (e.g., Reyna & Mills, 2014; Wolfe, Reyna, Widmer, Cedillos, et al., 2015). The tutorial was adapted for college-aged students by removing repeated information or superficially relevant content (e.g., overly emphasizing nutrition label reading and calorie count) or by adapting class exercises for online use (e.g., actual exercises were replaced with illustrative examples and key points). Factual information was updated from the original EatFit based on recent research, always in accordance with the principles guiding its design and content. In addition to presenting nutrition and exercise verbatim facts, the tutorial emphasized the essential decision-relevant meaning of information. Moreover, in GistFit, short bottom-line (gist) summaries of important points from each lesson were provided at the end of each lesson to facilitate the encoding and long-term retention of core information.

GistFit is an ITS built using SKO platform, which is a web-based system using artificial intelligence techniques to mimic one-on-one human tutoring. Throughout the tutorial, an avatar presents information orally and in writing, while simultaneously illustrating content with figures and images (e.g., examples of food containing each nutrient, a sequence of images demonstrating how to correctly perform aerobic exercises; Graesser, VanLehn, Rosé, Jordan, & Harter, 2001). A screen shot of GistFit from the learner's perspective can be found in Figure 1. Three female avatars (each of a different apparent ethnicity) deliver information throughout the tutorial. The tutorial is self-administered and, with this sample, took participants approximately 90 minutes to complete, although some engaged with the interactive elements of the tutorial for longer.

The control groups all received tutorials about an unrelated health topic: genetic testing and breast cancer risk. Delivery format was the same for all conditions (i.e., all tutorials were constructed using the SKO platform) and time on task was the same as GistFit (i.e., approximately 90 minutes).

Measures embedded within the tutorial.

Multiple-choice questions. Throughout the tutorial, participants were encouraged to actively think about content with the help of seven multiple-choice questions on the topics studied to check for understanding. Each multiple-choice question was presented at key points within the tutorial, such as "Is cholesterol ever good?" If the participant selected the wrong answer (i.e., "Yes. LDL is good, because you find it in egg yolks, which are healthy"), then they had a chance to try one more time. If they selected the correct answer (i.e., "Yes. HDL is good, because it helps clear your blood vessels"), they received feedback and a reminder of why HDL, and not LDL, is known as good cholesterol before moving to the next lesson. Items were rated

as correct or incorrect, and responses were averaged with higher scores representing better understanding.

Analytic questions. Participants were also encouraged to actively generate and elaborate on explanations of content materials through analytic questions (i.e., questions that require a student to not only know about concepts but apply those concepts to new situations; Arnot et al., 2008). Four questions were included throughout the tutorial: the reasons for why that participants would have to and want to improve and maintain their health, the actions they could take to eat healthily, the actions they could take to incorporate exercise into their routines, and the aspects of their lives under their control that could affect their food and exercise choices. These questions encouraged participants to engage in tutorial dialogues that took advantage of a Latent Semantic Analysis (LSA) feature of the SKO platform. LSA enables the avatars to process participants' verbal input and respond to what they type in conversation (Graesser et al., 2004; Graesser, Wiemer-Hastings, Wiemer-Hastings, Harter, 2000).

LSA compares conceptual and semantic similarities between text entered by participants and expectation texts prepared by experts in nutrition (i.e., list of ideal answers). The expectation texts included the core gist content of a good answer, such as "avoid becoming overweight" to answer the reasons to maintain and improve health. Because each person had a different answer, the tutorial responses were individualized depending on the level of relatedness between the input (e.g., "To avoid getting diseases in the future.") and the expectation text (e.g., "lower risk of disease"). The tutorial would then respond according to how the participant was doing. If the participant was doing well, the tutorial encouraged them to continue on the same theme (e.g., "Doing well so far"). If they were off topic, the tutorial encouraged the participant to get back on track (e.g., "You might be getting off track"). If the participant was repeating

information, the tutorial would point it out (e.g., “Right, but you said something similar before”). The ability to automatically tailor responses to each participant makes GistFit a unique obesity prevention tutorial (Lairson, Chan, Hang, Junco, & Vermon, 2011; Wolfe et al., 2013; Wolfe, Reyna, Widmer, Cedillos-Whynott, et al., 2015). To avoid cuing specific verbatim memories and instead increase recall of gist values retained by participants, we only provided general pumps (i.e., general encouragements) and not specific prompts (i.e., cues to say more about a specific topic) to avoid suggestive questions (Brainerd & Reyna, 2002).

To illustrate, the following selection was part of a dialogue between GistFit and a participant. Each response was judged to be appropriate and encouraged the participant to continue talking about her reasons to improve and maintain her health. Typos and spelling mistakes are included in these transcripts, demonstrating that GistFit performs robustly to such errors.

> Participant: Improving health will increease my life expectancy, reduce my stress and anxiety, and allow me to be a happier person.
> GistFit: Great job!
> Participant: Improving my health will also allow me to be more active.
> GistFit: Doing well so far!

In the previous example, GistFit recognized that the responses matched the expectation texts and encouraged the participant to continue writing. When the participant was asked to describe some of the aspects of her life that she could control that affected her food and exercise choices, GistFit recognized that a participant’s response was good but repetitive.

> Participant: The weather can affect my excersice choice, social situations can affect my eating habits.
> GistFit: Doing well so far!
> Participant: If I am upset or Happy I am more likley to eat more food.
> GistFit: You're doing great! Keep thinking specific factors that can affect your choices.
> Participant: If I am depressed I will also eat more food, I have to learn to eat for hunger and not anxiety.
> GistFit: Right, but you have said similar before.

With each reply from GistFit, the avatar reports an overall coverage (CO) score ranging from 0 to 1, based on the extent to which the total text input matched the expectation text. To prevent mere repetition of words from superficially inflating the CO score, SKO has a semantic processing engine that evaluates the participant response according to both the relevance and novelty, resulting in four possible designations of old-relevant, new-relevant, old-irrelevant, and new-irrelevant. If participant response matches more than one of these four designations, SKO can be set to select randomly among them (Wolfe et al., 2013). GistFit was programmed such that only new-relevant text would raise the CO score, while responses that fell in other categories would lower it. In order to establish the reliability of the tutorial CO scores of the semantic similarity of participants' answers, the score for each sentence was compared to expert judgment scores. Two independent judges blind to the tutorial's CO scores used the same rubric as the tutorial to rate each sentence. The two judges had .98 agreement. The mean score of the two judges was compared with the tutorial CO scores, resulting in a .91 agreement. The final CO score for each question (i.e., a measure of the degree to which the expectations have been met by all of the learner's responses, combined across all sentences entered by the participant) was used for analyses, and a higher value indicated more overall coverage of content compared to expectations texts.

In addition to CO score, participants were evaluated according to level of engagement in the dialogues with the tutorial (i.e., amount of interaction chosen by the respondent), categorized as either *none* (i.e., no response ever given to avatar) *some* (i.e., some avatar questions were answered) or *all* (i.e., every questions was answered). This variable could be treated as an ordinal scale grouping with three levels. Alternatively, it could be combined with the control

group to create a 4-point ordinal scale of engagement in tutorial dialogues (no tutorial, none, some, or all). A higher score on both scales implied a more active experience.

Survey measures.

Knowledge. Knowledge was assessed in two ways. The first scale was a measure of verbatim knowledge and included 22 multiple-choice questions assessing specific content about nutrition, use of the nutrition labels, and exercise ($\alpha = 0.65$). For example, participants answered questions such as "The number of calories you need per day varies depending on," from four options (i.e., "age," "sex," "genetics," or "all of the above"—the fourth option being the correct answer). The second scale was a measure of gist knowledge, which required participants to transfer knowledge from specific information presented in the tutorial to another application as a way of demonstrating general understanding about the topic. Participants provided answers to 22 multiple-choice questions assessing knowledge about nutrition, use of nutrition label, and exercise ($\alpha = 0.68$). For example, participants were prompted to answer "What is a healthy reason to choose foods high in calcium?" with one of the following options: "Calcium-rich foods allow your cells to repair your bones" (the correct answer), "A high calcium intake is needed to properly absorb Vitamin D, a nutrient important for healthy teeth," and "Calcium-rich foods usually taste good." In both scales, items were rated as correct or incorrect, and responses were averaged, with higher scores representing better knowledge.

Gist comprehension. A measure of gist comprehension was constructed to assess understanding of tutorial information about nutrition and exercise ($\alpha = 0.87$). The scale included 22 items such as "Highly processed food should be avoided because it often has excess sodium." Items were rated on a 6-point Likert scale from *strongly disagree* to *strongly agree*, and responses were averaged. Higher scores imply better gist comprehension.

Gist principles. Gist measures contained 57 general simple healthy values and principles that were organized according to three subscales: *lifestyle* (21 items, α = 0.95; e.g., "Better to eat food low in sugar now than to deal with health consequences later"), *nutrition* (20 items, α = 0.92; e.g., "Any amount of trans-fat is not good for you"), and *exercise* (16 items, α = 0.87; e.g., "Avoid watching TV for long periods of time"). Participants could endorsed each item on a 5-point Likert scale from *strongly disagree* to *strongly agree*. Responses were averaged and higher scores indicated a greater tendency to endorse gist-based healthy values.

Behavioral intentions. A measure of behavioral intentions of healthy nutrition and exercising was constructed from Baker, Little, and Brownell's (2003) ratings to 8 Likert-type items (α = 0.89), such as "I plan to be a healthy eater" and "I plan to be physically active." The ratings were measured on a 5-point scale from *strongly disagree* to *strongly agree* and averaged. Higher scores implied greater intention to perform healthier behavior.

Behavioral measures. Behavioral measures were taken from the American Heart Association's (AHA) national goals for cardiovascular health promotion and disease reduction (Lloyd-Jones et al., 2010), including measures of healthy nutrition (amount of fruit, vegetables, fish, whole grain, sugar and sodium ingestion per week) and exercise (number of hours per week).

Procedure

The tutorials were administered online by undergraduate or graduate research assistants in a controlled laboratory environment. Participants were informed prior to enrollment that they would be randomized to learn about one of two topics (all control conditions were about the same topic). After approximately 90-minute with the tutorial, participants answered a survey for about 90 minutes.

Data Analysis

Data were analyzed using IBM SPSS Statistics (Version 21.0, IBM Corp., Armonk, NY). First, we ran bivariate correlations to examine the extent to which measures of knowledge, gist comprehension, and gist principles shared common variance to explain behavior (of healthy nutrition and exercise) and behavioral intentions. The motivation was to corroborate existing literature demonstrating that behavioral intentions are predictive of actual health behavior, and that people tend to base health decisions on gist. Next, we ran bivariate correlations between survey measures and the measures embedded within the tutorial—multiple-choice questions, final CO score, and level of engagement in tutorial dialogue—to test associations between active learning and later improvement in knowledge, gist comprehension, and gist principles.

Then, to assess the success of the GistFit tutorial, we conducted a 4 (engagement) x 2 (research site) analyses of variance for each of the dependent measures. The factor *engagement* included the four levels described above, separating participants according to who engaged in *all* tutorial dialogues, *some* of them, *none* of the questions, or those who received the *control* tutorial. (Note that differences between research sites were not of theoretical interest but were included to control for differences in academic selectivity.) The goal was to determine whether engaging in dialogue had a role in better learning outcomes after engagement with an ITS.

Results

Behavioral Intentions and Endorsement of Gist Principles

We begin with effects on behavior and behavioral intentions because behavioral change was the ultimate guiding question of the research. We included a measure of behavior (i.e., amount of exercise and healthy food consumption) to determine that the groups did not differ prior to the tutorial (which was the case, $Fs < 1$), however there was no opportunity to observe

behavioral change in a single session. Thus, we rely on the association between behavior and behavioral intentions, because behavioral intentions are a strong and reliable predictor of behavioral outcomes (for a review, see Greaves et al., 2011; Webb & Sheeran, 2006). Measures of healthy nutrition and exercising correlated with behavioral intentions [r (218) = .36, $p < .001$, and r (218) = .31, $p < .001$, respectively], indicating that healthier intentions were associated with healthier behavior, with no differences between tutorials ($F < 1$).

In addition, healthier behavior was related to greater verbatim knowledge [healthy nutrition: r (218) = .17, p = .015, and healthy exercise: r (218) = .22, p = .001], which directly assessed tutorial content and is most pronounced immediately following delivery, when memory for learned material was strongest. Behavioral measures (of healthy nutrition and exercising) and intentions were related to gist comprehension [r (218) = .14, p = .035, r (218) = .17, p = .015, and r (219) = .38, $p < .001$, respectively], indicating that higher comprehension was associated with healthier intentions and healthy behavior.

Fuzzy-trace theory predictions also indicate that endorsement of healthy values (i.e., gist principles) are expected to elicit global attitudes and perceptions that are correlated with healthier behavior and intentions (e.g., Mills, Reyna, & Estrada, 2008; Reyna, Estrada, DeMarinis, Myers, Stanisz, & Mills, 2011). As expected, correlations between gist principles and behavior and behavioral intentions were observed for the current sample of participants for gist principles of lifestyle [r (218) = .17, p = .014, r (218) = .18, p = .008, and r (219) = .50, $p < .001$, respectively] and exercise [r (218) = .23, p = .001, r (218) = .17, p = .011, and r (219) = .47, $p < .001$, respectively], but only for healthy nutrition and behavioral intentions with gist principles of nutrition [r (218) = .20, p = .003, and r (219) = .43, $p < .001$, respectively].

Overall, these results support the fuzzy-trace theory prediction that endorsement of gist principles is protective and reduces risky (in this case unhealthy) behaviors.

Moreover, endorsement of gist principles was associated with improvements in verbatim and gist knowledge scores as well as gist comprehension. Results indicated that participants who endorsed gist principles of lifestyle, nutrition, and exercising had higher verbatim knowledge [r (220) = .19, p = .004, r (220) = .23, p < .001, and r (220) = .16, p = .015, respectively]. Similarly, participants who endorsed all three measures of gist principles also showed higher gist knowledge [r (220) = .18, p = .006, r (220) = .15, p = .029, and r (220) = .15, p = .029, respectively]. Finally, endorsing all three measures of gist principles was also associated with higher scores of gist comprehension [r (219) = .50, p < .001, r (219) = .43, p < .001, and r (219) = .47, p < .001]. Results supported the fuzzy-trace theory prediction that knowledge and comprehension are associated with differences in perception of risk due to reliance on bottom-line meaning (Reyna, 2012a; Reyna & Lloyd, 2006).

Tutorial Engagement

The GistFit participants who produced more correct answers to multiple-choice questions to check understanding embedded within the tutorial also showed better performance in gist knowledge [r (32) = .55, p = .001] and gist comprehension [r (32) = .45, p = .01]. The average correct response to multiple-choice questions was .78 (SD = .27). Although CO scores were unrelated to knowledge and comprehension (most likely due to restriction of range: approximately 60% of the answers were between .50 and .70), gist knowledge and gist comprehension were correlated with the ordinal measure of active engagement in tutorial dialogues. The higher the level of engagement from participants who were exposed to GistFit (using a three-point ordinal scale of engagement), the more likely they were to perform better in

gist knowledge questions [r (37) = .37, p = .025] and gist comprehension [r (37) = .35, p = .035]. These results suggest that actively taking the tutorial (i.e., answering knowledge questions within the tutorial and engaging in dialogues) contributed to better gist understanding.

These relationships were replicated when the control group was included in the ordinal measure of engagement (i.e., control group, and *none*, *some*, or *all* questions answered), as this latter measure was correlated with gist knowledge and gist comprehension [r (220) = .17, p = .011, and r (220) = .13, p = .05]. In addition, merely interacting with the tutorial also related to verbatim knowledge [r (220) = .30, p < .001] and endorsement of gist principles of lifestyle [r (220) = .14, p = .04]. Overall, these findings suggest that there is an increase in learning outcomes after engagement with an ITS. Participants who interacted more with the tutorial also retained more bottom-line gist understanding from content. This finding is consistent with fuzzy-trace theory's prediction that the ability to extract gist and the application of that ability in engaging in active reasoning (interacting with the tutorial) would improve performance (Reyna, 2013; Reyna, Chapman, Dougherty, & Confrey, 2012).

Further analyses comparing level of engagements within the tutorial (all, some, none, or control) showed significant effects for verbatim and gist knowledge [F (3, 216) = 7.10, p < .001, η_p^2 = .09, and F (3, 216) = 3.07, p = .029, η_p^2 = .04]. Consistent with our predictions, actively learning the gist of nutrition and exercise by engaging in *all* or *some* dialogues (M = 0.78, SE = 0.03, and M = 0.74, SE = 0.04, respectively) with the tutorial showed greater verbatim knowledge compared to not taking the tutorial (i.e., control group; M = 0.64, SE = 0.01). In addition, engaging in *all* dialogues with the tutorial (M = 0.77, SE = 0.04) showed greater gist knowledge compared to both answering *no* questions or the control group (M = 0.58, SE = 0.08, and M = 0.66, SE = 0.01, respectively). Thus, these results suggest that actively engaging in

dialogues with the tutorial was related to the extent to which participants remember information immediately after the tutorial. Note that these were not randomly assigned groups, but the level of engagement was self-selected, and causal conclusions cannot be made about engagement. However, we cannot dismiss the results of other studies that encouraging active learning and giving feedback stimulated students to extract gist understanding and construct their knowledge (proactive thinking; e.g., Chi, 2009; VanLehn et al., 2007; Wolfe et al., 2013; Wolfe, Reyna, Widmer, Cedillos, et al., 2015). One possible kind of self-selection might be that people who engage more in dialogues with the tutorial are smarter to begin with and that accounts for differences in outcome. In order to test this hypothesis, we used differences in numeracy as a rough proxy for intelligence (Cokely, Galesic, Schulz, Ghazal, & Garcia-Retamero, 2012; Liberali, Reyna, Furlan, Stein, & Pardo, 2012). Analyses showed those who differed in engagement with the tutorial did not differ significantly in numeracy ($Fs < 1$) using the 15-item objective numeracy scale (Lipkus, Samsa, & Rimer, 2001; Peters, Dieckmann, Dixon, Hibbard, & Mertz, 2007), therefore, a priori differences in intelligence did not seem to account for differences in outcomes that are associated with engagement with the tutorial.

Discussion

The results provide evidence that engaging in tutorial dialogues improved not only knowledge, but also transfer of that knowledge through an understanding of how to prevent obesity. Participants were encouraged to actively reason about the topics they learned and to extract gist understanding throughout the tutorial, which significantly improved performance in later knowledge and comprehension assessments. These results were an empirical test of the mechanisms postulated by fuzzy-trace theory because they highlight the distinction between verbatim-based (rote) analysis and gist-based intuition, the latter of which is productive thought

that supports the transfer of knowledge (i.e., apply prior learning to novel instances; Wolfe and Reyna, 2010a, b). ITS encourages productive thinking during learning periods, which uses context to connect the dots and make meaningful inferences that go beyond surface (rote) information learned (Lloyd & Reyna, 2009; Wolfe et al., 2013; Wolfe, Reyna, Widmer, Cedillos, et al., 2015). Those who responded more to the ITS by engaging in dialogue with the avatar found the most benefit in transfer of information, regardless of the quality of the interaction.

Factual knowledge is a target of both traditional and fuzzy-trace theory interventions because it is necessary for behavior change; however, it is not sufficient (e.g., Reyna & Brainerd, 1991; Reyna, Nelson, Han, & Dieckman, 2009). In GistFit, individuals learned both verbatim facts and bottom-line (gist) meaning of those facts and interactions with the tutor had a positive effect on knowledge, understanding, and endorsement of healthy values (i.e., gist principles). The fact that the experimental group outperformed the control group on these questions does not demonstrate that the gist enhancements drove the effects. However, other studies have demonstrated that gist-based reasoning improves knowledge and decision-making comparing verbatim and gist versions of curricula with similar content (e.g., Reyna & Mills, 2014; Wolfe, Reyna, Widmer, Cedillos, et al., 2015). Because the gist knowledge questions required transfer of knowledge (i.e., extrapolating thought concepts to novel questions), superior performance on these questions is a test of deeper understanding from active learning. Although verbatim knowledge was also superior for the experimental group who interacted more with the tutorial, previous research has shown that testing immediately after an event has been shown to reinforce verbatim memory, in particular after previous testing like the multiple-choice questions embedded within the tutorial (Brainerd & Reyna, 1996, 2002). Nevertheless, previous research has also demonstrated that merely memorized verbatim facts decay more rapidly over time (e.g.,

Brainerd et al., 2009), and do not have as strong an influence on behavior change (e.g., Reyna & Mills, 2014)

One limitation of the present study is that level of engagement was self-selected by subjects, and thus the significant differences may be due to causes other than engagement. However, other studies have shown that active engagement was causally related to increased knowledge (Chi, 2009; Wolfe, Britt, Petrovic, Albrecht, & Kopp, 2009). Future research should randomly assign subjects to different levels of engagement to test this hypothesis with GistFit. Another limitation is that the design included only a posttest without a pretest. It is a safe assumption that the random assignment of participants to the different tutorials adequately eliminated baseline differences, however a pretest would have permitted a more detailed analysis of specific learning gains. Another argument against prior differences is that the participants were very similar in their risk factors as measured by the AHA cardiovascular health promotion and disease reduction measures. Further research to confirm the effectiveness of this sort of tutorial could include assessing the effects of engaging in interactions with the tutorial on behavioral changes over time; we expect that the more people engage in dialogues, the more they will change over time. Although previous studies have shown that emphasizing the bottom-line gist of each lesson was effective at reducing risk taking over time (e.g., Reyna & Mills, 2014), no study to our knowledge has compared the effects of a fuzzy-trace theory-based ITS over time.

In sum, although the nutrition and exercise industry bombards the public with commercial messages, there are far too few theoretically-motivated interventions. There are even fewer approaches that combine artificial intelligence with the latest cognitive theories. Emerging discourse technologies have been successfully used to create effective interventions, encouraging subjects to engage in interactive behaviors as they construct their knowledge (Chi,

2009; VanLehn, 2011). When the use of technology is guided by a sound theoretical understanding, effective communication to influence understanding is likely to increase (e.g., Wolfe, Reyna, Widmer, Cedillos, et al., 2015; Wolfe, Reyna, Widmer, Cedillos-Whynott, et al., 2015). The current intervention was directed at changing knowledge, comprehension, values, and behavioral intentions by encouraging productive thinking and extraction of gist-based understanding through interactions with the tutor. Results of this randomized controlled experiment support previous recommendations to supply an "active ingredient" (i.e., the ability to extract gist) into current interventions. In particular, these findings highlight that actively helping participants to think about their own values in dialogues also helps them to practice extracting the gist of tutorial content and to map that gist onto their preexisting values.

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Figure 1. A screen shot of GistFit.

CHAPTER 5

CONCLUSION

The research presented here extends the existing literature on health and medical decision making based on fuzzy-trace theory in three important ways. First, I summarize current evidence from fuzzy-trace theory-based interventions and meaningful presentations of health and medical information that can improve communication and lead to better-informed decisions (Chapter 2). In particular, I discussed relevant research and theory pertinent to how people understand health risk information through the perspectives of fuzzy-trace theory (e.g., Brewer, Richman, DeFrank, Reyna, & Carey, 2012; Fraenkel et al., 2012; Lloyd & Reyna, 2001). Then, I discussed evidence of how gist-based communication can improve health and medical decisions and discussed how meaningful (gist) representations of risk (e.g., categorical gist and line graphs when relaying information about change over time) can enhance understanding (Brust-Renck, Royer, & Reyna, 2013; Reyna, 2004, 2008). The recommendations were grounded in the empirical literature and based on empirically supported tenets of fuzzy-trace theory, which predict that coherent decisions are made by understanding the meaning of numbers (gist-based processing), rather than just mere memorization (verbatim-based processing). Because meaning is at the core of how people process information (i.e., they have a fuzzy processing preference), communicating the right gist improves risk comprehension.

Second, I encourage health-promoting actions in the domain of nutrition and fitness through the development and testing of GistFit, a fuzzy-trace theory-based tutorial (Chapters 3 and 4). In GistFit, communication of health information was "gistified" by translating arbitrary

facts into meaningful messages (e.g., deciding which facts are essential to decision making, explaining the reasons behind the essential facts, integrating facts, and deleting irrelevant details) in order to improve message effectiveness similar to existing interventions, as discussed in Chapter 2 (e.g., Reyna & Mils, 2014; Wolfe et al., 2015). Overall, the theory-based intervention was successful in helping people understand obesity prevention. Effects of the intervention were enhanced for gist outcomes, such as gist principles (in all three experiments), and for scales that tapped gist comprehension (only included in Experiment 3).

Third, I demonstrate the effects of active reasoning about nutrition and fitness using a modern Web-based tutor, Sharable Knowledge Objects (Hu, Han, & Cai, 2008) in Chapter 4. Specifically, I show that participants who engaged in all dialogues with the tutorial also showed higher performance in gist and verbatim knowledge compared to control participants. Thus, results demonstrated that GistFitITS, the new theory-based Intelligent Tutoring System (ITS), instilled active understanding that promotes gist extraction, not a passive memorization of (verbatim) details, to assist people in making preventive health decisions. According to fuzzy-trace theory, gist messages can help people determine what their best decision will be, whether they are making decisions about every day health behaviors (e.g., exercising) or serious medical situations (e.g., treatment options for cancer). The meaningful communication of risk should ultimately promote better life outcomes, but more research on outcomes and long-term effects of GisFit in needed.

As discussed in these chapters, implementing fuzzy-trace theory-based interventions to communicate risk has been shown to substantially increase the proportion of subjects making informed choices. Future research would benefit from the use of meaningful (gist) tools to influence health decisions in conditions that require high levels of self-management, such as

insulin-dependent diabetes and vaccination (for a review on fuzzy-trace theory based tools to better communicate risk, see Brust-Renck et al., 2013; Reyna, 2008). Understanding the gist allows people to go beyond the literal level (specific amount of calories) to the underlying cause of obesity (whatever the cause may be). The research that I reviewed and experimental results presented together suggest that intuitive (gist) representations enable informed and healthier decision making.

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APPENDICES

APPENDIX A

SURVEY FROM EXPERIMENT 1 IN CHAPTER 3

Please Enter Researcher ID _____
Please Enter Subject Number _____

Your Location
a) Cornell University
b) Miami University

Questions About Food

Now we are going to ask you some questions about food. There is no right or wrong answer; we want to know what you think. Please answer every question; it is better to guess than to leave blank.

Match the following.

	You need this mineral for energy.	This will give you a quick boost of energy, but it won't last for long.	Eating plenty of these will help give you nice skin.	A diet high in this can lead to extra weight.	Dairy products are a good source of this mineral.
Calcium	❍	❍	❍	❍	❍
Iron	❍	❍	❍	❍	❍
Sugar	❍	❍	❍	❍	❍
Fat	❍	❍	❍	❍	❍
Fruits & Vegetables	❍	❍	❍	❍	❍

Give an example of each type of activity.
Aerobic Activity _____
Lifestyle Activity _____
Strength Activity _____
Flexibility Activity _____

Do you think you could set a goal for food and achieve it?
a. Yes, definitely
b. Yes, probably
c. Probably not
d. Definitely not

Do you think you could set a goal for fitness and achieve it?
a. Yes, definitely
b. Yes, probably
c. Probably not
d. Definitely not

If you were at a fast food restaurant, what is one low-fat food you could choose?
_____

When your heart beats faster during exercise,
a. you burn more calories
b. you burn fewer calories
c. there is no change in the number of calories burned

Name one benefit of exercising. _____

Name one benefit of eating breakfast. _____

Use the food label to answer the following questions.

Nutrition Facts	
Serving Size 1 cup (220g)	
Servings Per Container 2	
Amount Per Serving	
Calories 250	Calories From Fat 110
Total Fat 12g	
Saturated Fat 3g	18%
Trans Fat 3g	15%
Cholesterol 30mg	
Sodium 470mg	10%
Total Carbohydrates 31g	20%
Dietary Fiber 0g	10%
Sugars 5g	0%
Protein 5g	
Vitamin A	4%

What is the serving size for this food? _____

Is this a low-sugar food?
a. Yes
b. No

How many calories are in two servings of this food? _____

Which principles apply to your decisions about your LIFESTYLE?
There is no right or wrong answer; we want to know what you think. Please answer every question it is better to guess than to leave blank.

	Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
To have enough energy to do everyday activities I need to eat healthy.	○	○	○	○	○
I should drink water.	○	○	○	○	○
I should avoid getting snacks from vending machines.	○	○	○	○	○
I should eat breakfast at least a few times a week.	○	○	○	○	○
I should not skip meals.	○	○	○	○	○
Better to always eat healthy food.	○	○	○	○	○
I only get one body, so I should take care of it.	○	○	○	○	○
Staying in good physical shape is worth giving up unhealthy food.	○	○	○	○	○
To reach my full potential as a student I need to eat a healthy, well-balanced diet.	○	○	○	○	○
Why gamble with my life (i.e. by risking getting heart disease)?	○	○	○	○	○
If I want others to like me I have to eat healthy.	○	○	○	○	○
If I want others to like me I have to exercise regularly.	○	○	○	○	○
I have a responsibility to myself to stay healthy.	○	○	○	○	○
I have a responsibility to myself to watch how much food I eat.	○	○	○	○	○
I have a responsibility to myself to watch what type of food I eat.	○	○	○	○	○
I have a responsibility to myself to exercise.	○	○	○	○	○
I should eat food, mostly plants, and not too much.	○	○	○	○	○
If I don't want to have diabetes, I need to take steps to reduce my risk now.	○	○	○	○	○
If I don't want to have stroke, I need to take steps to reduce my risk now.	○	○	○	○	○

If I don't want to have osteoporosis (bone thinning), I need to take steps to reduce my risk now.	○	○	○	○	○
If I don't want to have osteoarthritis (painful joints), I need to take steps to reduce my risk now.	○	○	○	○	○
If I don't want to have high blood-pressure, I need to take steps to reduce my risk now.	○	○	○	○	○
If I don't want to have anemia, I need to take steps to reduce my risk now	○	○	○	○	○
If I don't want to have cancer, I need to take steps to reduce my risk now	○	○	○	○	○
If I don't want to have heart disease, I need to take steps to reduce my risk now.	○	○	○	○	○

What do you think? Which of the following principles apply to your decisions about EXERCISE?
There is no right or wrong answer; we want to know what you think. Please answer every question it is better to guess than to leave blank.

	Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
To have enough energy to do everyday activities I need to exercise regularly.	○	○	○	○	○
To prevent osteoporosis (bone thinning) it is important to do weight bearing activities (i.e. walking, running).	○	○	○	○	○
To prevent osteoporosis (bone thinning) it is important to do strength training (i.e. pushups, squats, weight lifting).	○	○	○	○	○
Avoid sedentary activities (i.e. watching tv, sitting at the computer, not moving around).	○	○	○	○	○
Better to exercise that be overweight.	○	○	○	○	○
Better to exercise at least a few times a week.	○	○	○	○	○
Staying healthy is worth spending the time exercising.	○	○	○	○	○
Avoid using the elevator.	○	○	○	○	○
Walk instead of drive.	○	○	○	○	○

Which principles apply to your decisions about EATING?
There is no right or wrong answer; we want to know what you think. Please answer every question it is better to guess than to leave blank.

	Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
When buying milk, it is better to go with fat-free than low-fat milk.	○	○	○	○	○
When buying milk, it is better to go with low-fat milk than whole milk.	○	○	○	○	○
If you are overweight or obese, a moderate reduction of caloric intake is better than no reduction at all.	○	○	○	○	○
If you are overweight or obese, a large reduction of caloric intake is better than a moderate reduction of caloric intake (within healthy limits).	○	○	○	○	○
Eating some fruits and vegetables is better than not eating any at all.	○	○	○	○	○
Eating more fruits and vegetables is better than eating a few fruits and vegetables.	○	○	○	○	○
Eating some whole grain products is better than not eating whole grain products at all.	○	○	○	○	○
Eating more whole grain products is better than eating few whole grain products (within healthy limits).	○	○	○	○	○
Even a five pound weight loss has significant health benefits when you are overweight or obese.	○	○	○	○	○
If you skip meals you will feel more tired throughout the day.	○	○	○	○	○
Eating some food products with calcium is better than not eating any food products with calcium.	○	○	○	○	○
Eating more food products with calcium is better than few food products with calcium.	○	○	○	○	○
I should avoid eating red meat.	○	○	○	○	○
Even a small decrease in the amount of animal products consumed is good for you.	○	○	○	○	○
Better to eat food high in calcium now than have osteoporosis (thinning bones) later.	○	○	○	○	○

I should avoid soda.	○	○	○	○	○
I should avoid processed food.	○	○	○	○	○
I should avoid fried food.	○	○	○	○	○
I should avoid food high in saturated fat.	○	○	○	○	○
I should avoid food high in salt.	○	○	○	○	○
I should avoid food with trans-fat.	○	○	○	○	○
I should avoid food with bad cholesterol (LDL cholesterol).	○	○	○	○	○
I should eat fish.	○	○	○	○	○
I should get the most nutrition out of calories.	○	○	○	○	○

Most of My FRIENDS believe...
Please answer every question it is better to guess than to leave blank.

	Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
It is okay to consume non-nutritious food and sugary drinks in moderation.	○	○	○	○	○
It is ok to eat unhealthy foods often as long as a person my age exercises frequently.	○	○	○	○	○
It is important to exercise or have moderate activity often	○	○	○	○	○
A person my age should always eat healthy and minimize or eliminate wasteful calories (non-nutritious foods).	○	○	○	○	○
A person my age must eat right if they want to look attractive.	○	○	○	○	○
It is important for a person my age to be in good physical shape.	○	○	○	○	○

Most of MY FRIENDS...
Please answer every question it is better to guess than to leave blank. We are asking about the behavioral practices of your FRIENDS.

	Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
Eat healthy	○	○	○	○	○
Engage in moderate to intense physical activity on a frequent basis	○	○	○	○	○

Most of ADULTS who are important to me believe...
Please answer every question it is better to guess than to leave blank.

	Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
It is okay to consume non-nutritious food and sugary drinks in moderation.	○	○	○	○	○
It is ok to eat unhealthy foods often as long as a person my age exercises frequently.	○	○	○	○	○
It is important to exercise or have moderate activity often	○	○	○	○	○
A person my age should always eat healthy and minimize or eliminate wasteful calories (non-nutritious foods).	○	○	○	○	○
A person my age must eat right if they want to look attractive.	○	○	○	○	○
It is important for a person my age to be in good physical shape.	○	○	○	○	○

I Believe...
Please answer every question it is better to guess than to leave blank.

	Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
It is okay to consume non-nutritious food and sugary drinks in moderation.	○	○	○	○	○
It is ok to eat unhealthy foods often as long as a person my age exercises frequently.	○	○	○	○	○
It is important to exercise or have moderate activity often	○	○	○	○	○
A person my age should always eat healthy and minimize or eliminate wasteful calories (non-nutritious foods).	○	○	○	○	○
A person my age must eat right if they want to look attractive.	○	○	○	○	○
It is important for a person my age to be in good physical shape.	○	○	○	○	○

I Believe I...
Please answer every question it is better to guess than to leave blank. We are asking about your own behavioral practices

	Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
Eat healthy	○	○	○	○	○
Engage in moderate to intense physical activity on a frequent basis	○	○	○	○	○

How tall are you?
(feet)
Select the option that applies

a. 1
b. 2
c. 3
d. 4
e. 5
f. 6
g. 7
h. 8
i. 9
j. 10
k. 11

(inches)
Select the option that applies

a. 1
b. 2
c. 3
d. 4
e. 5
f. 6
g. 7
h. 8
i. 9
j. 10
k. 11

Have you been diagnosed by a healthcare provider as having any of these conditions?- Coronary heart disease/ chest pain- Heart attack- Heart failure- Stroke/ TIA- Vascular disease- Congenital heart defects
a. Yes
b. No

Do you have diabetes? (either type 1 or type 2)
a. Yes
b. No

What is your weight? (in pounds) _____

How much physical activity do you get in a week?
You can include both moderate and vigorous activity levels. All types of activity count, such as gardening, walking briskly, or bicycling.
Note that:
- Moderate intensity: a person doing moderate-intensity aerobic activity can usually talk, but not sing, during the activity.
- Vigorous intensity: a person doing vigorous-intensity activity usually cannot say more than a few words without pausing for a breath.
_____ minutes of moderate activity

_____ minutes of vigorous activity

How much fruit do you eat in an average day? (in cups of fruit)
Note that 1 cup of fruit equals:
- 1 large orange or banana
- 1 medium pear of grapefruit
- 1 small apple - 8 large strawberries
- 15 grapes or 1/2 cup of raisins

a. 0	f. 2.5	l. 5
b. 0.5	e. 3	m. 5.5
c. 1	h. 3.5	n. 6
d. 1.5	i. 4	
e. 2	j. 4.5	

How much vegetables do you eat in an average day? (in cups of vegetables)
Note that 1 cup of vegetables equals:
- 1 large bell pepper or ear of corn
- 1 medium potato of large sweet potato
- 1 cup of cooked greens
- 2 cups raw greens (lettuce, spinach, etc.)
- 2 medium carrots or 12 baby carrots
- 2 large stalks of celery

a. 0	f. 2.5	l. 5
b. 0.5	e. 3	m. 5.5
c. 1	h. 3.5	n. 6
d. 1.5	i. 4	
e. 2	j. 4.5	

Do you eat 2 servings or more of fish weekly?
Note that a serving of fish is 3.5 ounces, approximately the same size as a deck of cards.
a. Yes
b. No

Do you eat 4 ounces of more of whole grains daily?
Note that whole grains include all whole grain products and whole grains used as ingredients.
a. Yes
b. No

Do you drink less than 36 ounces (450 calories) of beverages with added sugar weekly?
Note that added sugars are the sugars and syrups added to foods and beverages in processing or preparation.
a. Yes
b. No

Do you eat 1,500mg of sodium or less daily?
If you don’t track your daily sodium intake by reading the food label, to answer "yes" you should

do at least 2 of the following:
- Avoid eating prepackaged processed food or eat low-sodium versions
- Avoid eating out or ask for low-sodium preparation
- Cook at home without adding salt

a. Yes
b. No

What is your systolic blood pressure? (top or first number) _____ mm Hg
What is your diastolic blood pressure? (bottom or second number) _____ mm Hg
a. I don't know (one or both).
b. I take medication to lower my blood pressure.

What is your blood cholesterol? (total cholesterol) _____ mm/dL
a. I don't know (one or both).
b. I take medication to lower my cholesterol.

What is your blood sugar? (fasting blood sugar) _____ mm/dL
a. I don't know (one or both).
b. I take medication to lower my blood sugar.

Do you smoke?
Include cigarettes, pipes, and cigars (smoked tobacco in any form)
a. Select the option that applies
b. Current smoker
c. Smoked (in the last 30 days)
d. Smoked (more than 30 days ago)
e. Quit (1 - 12 months ago)
f. Quit (12 or more months)
g. Never smoked a whole cigarette
h. Never smoked

CHOOSE YOUR NEXT STEPS
Please choose the responses that best represent your position about your health in the following contexts.

Smoking status: (Select all that apply.)
- Keep up the good work
- Stay physically active
- Plan activities that don't involve smoking
- Eat a healthy diet
- Maintain a healthy weight
- Discuss medication options with my healthcare provider
- Get my support plan in place and use it
- Combine approaches to increase my chances of success
- Eat a healthy diet, but maintain a healthy weight

Healthy weight: (Select all that apply.)

- Continue my healthy habits
- Avoid trans and saturated fats and added sugars
- Learn more about the foods I eat
- Increase my fitness; add more physical activity to my routine
- See my healthcare provider for routine check-ups
- Plan to lose 10% of my current weight, as a first step
- Eat smaller portions and less food per day
- See a dietitian for guidance on healthier eating decisions
- Increase physical activity to burn more calories than I eat
- Join a support group or comprehensive weight-loss program
- See your healthcare provider for an individualized plan
- Reduce BMI by maintaining current weight while growing
- Be sure your child gets 60 minutes of physical activity each day
- Limit screen time to less than 2 hours each day
- Prepare healthy foods, avoid skipping meals

Physical activity: (Select all that apply.)

- Strive to double my weekly activity time
- Replace moderate-level activities with vigorous aerobic activities
- If I do strengthening activities 2 days a week, add an extra hour
- Write down what may be holding me back from moving more
- Be active with friends and family; a support network helps
- Start by doing what I can, and look for ways I can do more
- Set a personal goal to be physically active
- Pick an activity I like that fits into my life
- Limit screen time
- Replace inactivity with activity whenever possible
- Slowly increase activity in small steps and in enjoyable ways
- Participate in age-appropriate sports or games
- Join your child in sustained active play and recreation

Healthy diet: (Select all that apply.)

- Eat at least one fruit and vegetable with every meal
- Eat more whole grain foods
- Eat fish twice per week
- Limit foods and beverages with added sugars
- Choose processed foods less often to reduce sodium intake
- Know the number of calories that is right for me
- Keep saturated fat to less than 7% of calories and avoid trans fat
- Eat a variety of foods in the right amounts from all food groups
- Eat less than 2 servings per week of processed meats
- Include nuts, legumes, and seeds in my diet

Blood pressure (systolic and diastolic): (Select all that apply.)

- See my healthcare provider to learn my blood pressure numbers

- Learn to read food labels and choose foods with less sodium
- If I'm overweight, lose weight - even 10lbs makes a difference
- Be more physically active; aim for at least 150 minutes per week
- If I drink alcohol, limit to one drink per day for women and 2 drinks per day for men; if pregnant avoid alcohol
- Speak to my healthcare provider about medication options

Blood cholesterol (total cholesterol): (Select all that apply.)
- Get my cholesterol checked and learn my cholesterol numbers
- Speak to a dietitian to improve my eating habits
- Eat fewer saturated and trans fats
- Be more physically active
- Learn to read food labels to help me choose healthy foods
- Speak to my healthcare provider about medication options

Blood sugar (fasting): (Select all that apply.)
- Set up a plan with my healthcare provider and stick to it
- Test my blood sugar daily before I eat with a blood glucose mater (3 days in a row)
- Look for a pattern in my blood sugar test results
- Record my numbers and share with my healthcare provider
- Ask my healthcare provider to teach me what to do when my blood sugar is too low or high
- Make good food choices and eat modest food portions
- See my healthcare provider to learn my blood sugar number
- If I'm overweight, lose weight - even 10 lbs. makes a difference
- Be more physically active; aim for at least 150 minutes per week
- Learn to read food labels and choose foods with less sodium

Are you male or female?
a. Male
b. Female

Please enter your age. _____

Are you of Hispanic, Latino, or Spanish origin?
a. No, not of Hispanic, Latino or Spanish origin
b. Yes, Mexican, Mexican American, Chicano
c. Yes, Puerto Rican
d. Yes, Cuban
e. Yes, Central American (FILL IN): _____
f. Yes, South American (FILL IN): _____
g. Yes, Spanish (Spain)

You are:
a. White
b. Black/ African American

c. Asian Indian
d. Chinese
e. Filipino
f. Japanese
g. Korean
h. Vietnamese
i. Other Asian (FILL IN): _____
j. Native American/ American Indian/ Alaskan Native (FILL IN Tribe): _____
k. Native Hawaiian or Other Pacific Islander
l. Mixed Ethnicity (example: Chicano and Native American, FILL IN): _____
m. Other (FILL IN): _____

If this research study has made you feel anxious, please talk to the research assistant about what we can do to help. Your wellbeing is our first priority.

APPENDIX B

SURVEY FROM EXPERIMENT 2 IN CHAPTER 3

Please Enter Researcher ID _____
Please Enter Subject Number _____

Your Location
a) Cornell University
b) Miami University

Questions About Food

Now we are going to ask you some questions about food. There is no right or wrong answer; we want to know what you think. Please answer every question; it is better to guess than to leave blank.

Which of the following best describes the effects of eating low-calorie foods?
a. Low-calorie "superfoods" like oatmeal (150 calories) and veggies (30-80 calories) will "burn" the fat in my body.
b. Eating low-calorie foods and regularly exercising forces my body to use the energy it has stored as fat.
c. Low-calorie foods often contain lots of fiber.

You were running late this morning and didn't get breakfast at home, but now you're very hungry and need something in your stomach to focus. What should you choose?
a. Buy something that is filling, but low-calorie.
b. Pick up a pack of Twix from the vending machine because it's high in calories that give you energy.
c. Don't eat anything, because breakfast is unhealthy and should be avoided.

What is a healthy attitude toward foods high in calcium?
a. Calcium-rich foods usually taste good!
b. Eating foods with calcium is not worth the weight gain caused by dairy.
c. Calcium-rich foods allow your cells to repair your bones.

After meeting with your doctor, you discover that you need to reduce your saturated fat intake to keep your heart healthy. What should you decide at the dinner table tonight?
a. I should avoid eating animal fats.
b. Since butter melts into a liquid on warm dinner rolls, it is healthy unsaturated fat.
c. My doctor has a healthy heart and he has donuts every week.

You've noticed that you have pale skin, get dizzy often, and feel fatigued. What would be the best thing to try to solve your problem?
a. Eat some beans – the iron in beans will help you feel better.
b. Get a tan – the sun will make you feel and look healthier.
c. Eat lots of spinach – eating more will overcome your body's difficulty absorbing iron.

The nutrition label for a bag of walnuts says that 1 serving has 18 g of fat (160 calories from fat). What should be your decision about eating walnuts?
a. You shouldn't eat them because they are fatty.
b. Eat several servings a day to gain the health benefits in walnuts.
c. Eat them in small servings, because nuts contain healthy, unsaturated fats.

After keeping track of your eating for 2 weeks, you've figured out that you usually get less than the recommended daily values of vitamins A, E, or zinc. What should you do?
a. Choose foods high in calories so your body has more than enough energy.
b. Figure out which foods are good sources of these nutrients and incorporate more of them into your diet.
c. The past 2 weeks do not accurately reflect my overall diet. I think I usually get enough of the necessary nutrients.

Imagine that you have Type 2 diabetes and your doctor says you need to watch what you eat. When you look at a food label, what should you be especially careful of?
a. Go for foods that have a low sugar content compared to total carbohydrates.
b. Watch out for the health claims on the front – the food companies are just trying to sell their product and could be lying to me.
c. Check the nutrition facts for foods that provide high percentages of vitamins.

What would be a healthy attitude towards strength exercises (e.g., lifting weights, pushups, squats, etc.)?
a. Strength activities will make me bulk up. I need to lose weight, not gain it.
b. Doing strength exercises will help me burn more calories.
c. I'm strong enough already; I don't need to do strength exercises.

The exercise bike at the gym has "fat burner" (slower pace, but more resistance, alternating bursts of high and low heart rate) and "cardio" (faster pace, less resistance, heart rate is high all the way through) among its many functions. Which one should you choose to burn the most calories?
a. The fat burner function – the increased resistance and intervals will make me use more energy in less time.
b. Neither – I can burn more calories by sweating a lot in the sauna.
c. The cardio function – it is the most intense and more calories are needed to keep up the constant effort

I want to help my friend move out of her apartment, but I have trouble with heavy lifting. How can I get stronger muscles?
a. Getting stronger requires regular exercise and staying within calorie requirements.

b. To strengthen my muscles, I'll need to eat a high-protein diet.
c. Being toned and strong is genetic.

On your way to work, you see a shop with chocolate muffins in the case. You've already decided to go to the gym tonight. What should go through your head?
a. The treadmill says that I burn about 400 calories when I work out – that's more than enough to make up for a little treat.
b. The shop has a special coffee and muffin deal just for today, so I should get it.
c. The muffin is high in fat and cholesterol that will take away the benefits of my workout.

I wanted to get my health on track, so I committed to exercising 4 hours a week for the last month. I still haven't lost any weight! What should I think?
a. All my hard work was for nothing – I didn't get results, so exercise is a waste of my time.
b. Even if I didn't lose weight, my blood pressure is lower and I'm at a lower risk for having a stroke.
c. I should work out in the morning rather than in the afternoon if I want to lose weight.

After a long day at work, you feel tired and stressed. The gym is closed and it is raining outside. What is the healthiest choice of what to do when you get home?
a. Do some housework – if I keep moving, I will get relief from stress.
b. Catch up with my favorite T.V. show on the couch – I must be so tired from the calories I burned at work.
c. I should quit my job because it was so stressful today.

Which principles apply to your decisions about your LIFESTYLE?
There is no right or wrong answer; we want to know what you think. Please answer every question it is better to guess than to leave blank.

	Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
To have enough energy to do everyday activities I need to eat healthy.	○	○	○	○	○
I should drink water.	○	○	○	○	○
I should avoid getting snacks from vending machines.	○	○	○	○	○
I should eat breakfast at least a few times a week.	○	○	○	○	○
I should not skip meals.	○	○	○	○	○
Better to always eat healthy food.	○	○	○	○	○
I only get one body, so I should take care of it.	○	○	○	○	○
Staying in good physical shape is worth giving up unhealthy food.	○	○	○	○	○
To reach my full potential as a student I need to eat a healthy, well-balanced diet.	○	○	○	○	○

Why gamble with my life (i.e. by risking getting heart disease)?	○	○	○	○	○
If I want others to like me I have to eat healthy.	○	○	○	○	○
If I want others to like me I have to exercise regularly.	○	○	○	○	○
I have a responsibility to myself to stay healthy.	○	○	○	○	○
I have a responsibility to myself to watch how much food I eat.	○	○	○	○	○
I have a responsibility to myself to watch what type of food I eat.	○	○	○	○	○
I have a responsibility to myself to exercise.	○	○	○	○	○
I should eat food, mostly plants, and not too much.	○	○	○	○	○
If I don't want to have diabetes, I need to take steps to reduce my risk now.	○	○	○	○	○
If I don't want to have stroke, I need to take steps to reduce my risk now.	○	○	○	○	○
If I don't want to have osteoporosis (bone thinning), I need to take steps to reduce my risk now.	○	○	○	○	○
If I don't want to have osteoarthritis (painful joints), I need to take steps to reduce my risk now.	○	○	○	○	○
If I don't want to have high blood-pressure, I need to take steps to reduce my risk now.	○	○	○	○	○
If I don't want to have anemia, I need to take steps to reduce my risk now	○	○	○	○	○
If I don't want to have cancer, I need to take steps to reduce my risk now	○	○	○	○	○
If I don't want to have heart disease, I need to take steps to reduce my risk now.	○	○	○	○	○

What do you think? Which of the following principles apply to your decisions about EXERCISE?
There is no right or wrong answer; we want to know what you think. Please answer every question it is better to guess than to leave blank.

	Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
To have enough energy to do everyday activities I need to exercise regularly.	○	○	○	○	○

To prevent osteoporosis (bone thinning) it is important to do weight bearing activities (i.e. walking, running).	○	○	○	○	○
To prevent osteoporosis (bone thinning) it is important to do strength training (i.e. pushups, squats, weight lifting).	○	○	○	○	○
Avoid sedentary activities (i.e. watching tv, sitting at the computer, not moving around).	○	○	○	○	○
Better to exercise that be overweight.	○	○	○	○	○
Better to exercise at least a few times a week.	○	○	○	○	○
Staying healthy is worth spending the time exercising.	○	○	○	○	○
Avoid using the elevator.	○	○	○	○	○
Walk instead of drive.	○	○	○	○	○

Which principles apply to your decisions about EATING?
There is no right or wrong answer; we want to know what you think. Please answer every question it is better to guess than to leave blank.

	Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
When buying milk, it is better to go with fat-free than low-fat milk.	○	○	○	○	○
When buying milk, it is better to go with low-fat milk than whole milk.	○	○	○	○	○
If you are overweight or obese, a moderate reduction of caloric intake is better than no reduction at all.	○	○	○	○	○
If you are overweight or obese, a large reduction of caloric intake is better than a moderate reduction of caloric intake (within healthy limits).	○	○	○	○	○
Eating some fruits and vegetables is better than not eating any at all.	○	○	○	○	○
Eating more fruits and vegetables is better than eating a few fruits and vegetables.	○	○	○	○	○
Eating some whole grain products is better than not eating whole grain products at all.	○	○	○	○	○
Eating more whole grain products is better than eating few whole grain products (within healthy limits).	○	○	○	○	○

Even a five pound weight loss has significant health benefits when you are overweight or obese.	○	○	○	○	○
If you skip meals you will feel more tired throughout the day.	○	○	○	○	○
Eating some food products with calcium is better than not eating any food products with calcium.	○	○	○	○	○
Eating more food products with calcium is better than few food products with calcium.	○	○	○	○	○
I should avoid eating red meat.	○	○	○	○	○
Even a small decrease in the amount of animal products consumed is good for you.	○	○	○	○	○
Better to eat food high in calcium now than have osteoporosis (thinning bones) later.	○	○	○	○	○
I should avoid soda.	○	○	○	○	○
I should avoid processed food.	○	○	○	○	○
I should avoid fried food.	○	○	○	○	○
I should avoid food high in saturated fat.	○	○	○	○	○
I should avoid food high in salt.	○	○	○	○	○
I should avoid food with trans-fat.	○	○	○	○	○
I should avoid food with bad cholesterol (LDL cholesterol).	○	○	○	○	○
I should eat fish.	○	○	○	○	○
I should get the most nutrition out of calories.	○	○	○	○	○

Please choose the response that best represents your position about your exercise behavior.

	None	Low	Medium	High
Overall, for YOU the RISKS of not exercising regularly are...	○	○	○	○
Overall, for YOU the BENEFITS of exercising regularly are...	○	○	○	○

Please choose the response that best represents your position about your eating behavior.

	None	Low	Medium	High
Overall, for YOU the RISKS of healthy eating regularly are...	○	○	○	○
Overall, for YOU the BENEFITS of eating healthy foods are...	○	○	○	○

Most of My FRIENDS believe...
Please answer every question it is better to guess than to leave blank.

	Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
It is okay to consume non-nutritious food and sugary drinks in moderation.	○	○	○	○	○
It is ok to eat unhealthy foods often as long as a person my age exercises frequently.	○	○	○	○	○
It is important to exercise or have moderate activity often	○	○	○	○	○
A person my age should always eat healthy and minimize or eliminate wasteful calories (non-nutritious foods).	○	○	○	○	○
A person my age must eat right if they want to look attractive.	○	○	○	○	○
It is important for a person my age to be in good physical shape.	○	○	○	○	○

Most of MY FRIENDS...
Please answer every question it is better to guess than to leave blank. We are asking about the behavioral practices of your FRIENDS.

	Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
Eat healthy	○	○	○	○	○
Engage in moderate to intense physical activity on a frequent basis	○	○	○	○	○
Try to eat a balanced diet	○	○	○	○	○
Eat a diet that is mostly plant-based	○	○	○	○	○
Engage in lifestyle fitness activities on a regular basis (e.g., walking rather than driving, taking stairs rather than the elevator)	○	○	○	○	○
Are active when conveniences are available	○	○	○	○	○
Go to the gym or play sports on a regular basis	○	○	○	○	○

Most of ADULTS who are important to me believe...
Please answer every question it is better to guess than to leave blank.

	Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
It is okay to consume non-nutritious food and sugary drinks in moderation.	○	○	○	○	○
It is ok to eat unhealthy foods often as long as a person my age exercises frequently.	○	○	○	○	○
It is important to exercise or have moderate activity often	○	○	○	○	○
A person my age should always eat healthy and minimize or eliminate wasteful calories (non-nutritious foods).	○	○	○	○	○
A person my age must eat right if they want to look attractive.	○	○	○	○	○
It is important for a person my age to be in good physical shape.	○	○	○	○	○

I Believe...
Please answer every question it is better to guess than to leave blank.

	Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
It is okay to consume non-nutritious food and sugary drinks in moderation.	○	○	○	○	○
It is ok to eat unhealthy foods often as long as a person my age exercises frequently.	○	○	○	○	○
It is important to exercise or have moderate activity often	○	○	○	○	○
A person my age should always eat healthy and minimize or eliminate wasteful calories (non-nutritious foods).	○	○	○	○	○
A person my age must eat right if they want to look attractive.	○	○	○	○	○
It is important for a person my age to be in good physical shape.	○	○	○	○	○

I Believe I...
Please answer every question it is better to guess than to leave blank. We are asking about your own behavioral practices

	Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
Eat healthy	○	○	○	○	○
Engage in moderate to intense physical activity on a frequent basis	○	○	○	○	○
Try to eat a balanced diet	○	○	○	○	○
Eat a diet that is mostly plant-based	○	○	○	○	○
Engage in lifestyle fitness activities on a regular basis (e.g., walking rather than driving, taking stairs rather than the elevator)	○	○	○	○	○
Are active when conveniences are available	○	○	○	○	○
Go to the gym or play sports on a regular basis	○	○	○	○	○

Think about your attitude about your healthy diet and physical activity when answering the questions below.
There is no right or wrong answer; we want to know what you think. Please answer every question; it is better to guess than to leave blank.

A healthy diet will...

	Very Unlikely	Unlikely	Somewhat Unlikely	Somewhat Likely	Likely	Very Likely
help me control my weight.	○	○	○	○	○	○
give me more energy.	○	○	○	○	○	○
make me feel good about myself.	○	○	○	○	○	○
make me feel good in clothes.	○	○	○	○	○	○
make my food taste worse.	○	○	○	○	○	○
make me feel good and healthy.	○	○	○	○	○	○
help me feel in control of things.	○	○	○	○	○	○
help me look good.	○	○	○	○	○	○

Being physically active will...

	Very Unlikely	Unlikely	Somewhat Unlikely	Somewhat Likely	Likely	Very Likely
help me be fit and in shape.	○	○	○	○	○	○

help me be physically strong.	○	○	○	○	○	○
help me feel good about myself/proud.	○	○	○	○	○	○
help me control my weight.	○	○	○	○	○	○
help me have the body shape and muscles that I like.	○	○	○	○	○	○
make me feel in control.	○	○	○	○	○	○

Think about your attitude about your healthy diet and physical activity when answering the questions below.
There is no right or wrong answer; we want to know what you think. Please answer every question; it is better to guess than to leave blank.

	Very Useless	Useless	Somewhat Useless	Somewhat Useful	Useful	Very Useful
For me to be physically active would be...	○	○	○	○	○	○
For me to be a healthy eater would be...	○	○	○	○	○	○

	Very Harmful	Harmful	Somewhat Harmful	Somewhat Beneficial	Beneficial	Very Beneficial
For me to be physically active would be...	○	○	○	○	○	○
For me to be a healthy eater would be...	○	○	○	○	○	○

	Very Undesirable	Undesirable	Somewhat Undesirable	Somewhat Desirable	Desirable	Very Desirable
For me to be physically active would be...	○	○	○	○	○	○
For me to be a healthy eater would be...	○	○	○	○	○	○

	Very Bad	Bad	Poor	Fair	Good	Very Good
For me to be physically active would be...	○	○	○	○	○	○
For me to be a healthy eater would be...	○	○	○	○	○	○

	Very Boring	Boring	Somewhat Boring	Somewhat Interesting	Interesting	Very Interesting
For me to be physically active would be...	○	○	○	○	○	○
For me to be a healthy eater would be...	○	○	○	○	○	○

	Very Unenjoyable	Unenjoyable	Somewhat Unenjoyable	Somewhat Enjoyable	Enjoyable	Very Enjoyable
For me to be physically active would be...	○	○	○	○	○	○
For me to be a healthy eater would be...	○	○	○	○	○	○

Think about your INTENTIONS about your healthy diet and physical activity when answering the questions below.
There is no right or wrong answer; we want to know what you think. Please answer every question; it is better to guess than to leave blank.

I plan to...

	Strongly Disagree	Disagree	Somewhat Disagree	Somewhat Agree	Agree	Strongly Agree
be a healthy eater.	○	○	○	○	○	○
be physically active.	○	○	○	○	○	○

I will try to...

	Strongly Disagree	Disagree	Somewhat Disagree	Somewhat Agree	Agree	Strongly Agree
be a healthy eater.	○	○	○	○	○	○
be physically active.	○	○	○	○	○	○

How likely is it that...

	Very Unlikely	Unlikely	Somewhat Unlikely	Somewhat Likely	Likely	Very Likely
you will be a healthy eater over the next two weeks?	○	○	○	○	○	○
you will be physically active over the next two weeks?	○	○	○	○	○	○

Thinking of your behavior over the next 2 weeks...

	Very Unlikely	Unlikely	Somewhat Unlikely	Somewhat Likely	Likely	Very Likely
how often do you think you will be physically active?	○	○	○	○	○	○
how often do you think you will be a healthy eater?	○	○	○	○	○	○

What can you do when you want to be a healthy eater? I can...

	Strongly Disagree	Disagree	Somewhat Disagree	Somewhat Agree	Agree	Strongly Agree
try hard enough at it.	○	○	○	○	○	○
have enough self-discipline for it.	○	○	○	○	○	○
be lucky enough to prefer healthy foods.	○	○	○	○	○	○
have my parents help me.	○	○	○	○	○	○
ask my friends to help me.	○	○	○	○	○	○

What can you do when you want to avoid too much junk food? I can...

	Strongly Disagree	Disagree	Somewhat Disagree	Somewhat Agree	Agree	Strongly Agree
try hard enough at it.	○	○	○	○	○	○
have enough self-discipline for it.	○	○	○	○	○	○
be lucky enough to prefer healthy foods.	○	○	○	○	○	○
have my parents help me.	○	○	○	○	○	○
ask my friends to help me.	○	○	○	○	○	○

What can you do when you want to be physically active? I can...

	Strongly Disagree	Disagree	Somewhat Disagree	Somewhat Agree	Agree	Strongly Agree
try hard enough at it.	○	○	○	○	○	○
have enough self-discipline for it.	○	○	○	○	○	○
be lucky enough to like physical activities.	○	○	○	○	○	○
have my parents help me.	○	○	○	○	○	○

ask my friends to help me.	○	○	○	○	○	○

What can you do when you want to exercise or do active things? I can...

	Strongly Disagree	Disagree	Somewhat Disagree	Somewhat Agree	Agree	Strongly Agree
try hard enough at it.	○	○	○	○	○	○
have enough self-discipline for it.	○	○	○	○	○	○
be lucky enough to like physical activities.	○	○	○	○	○	○
have my parents help me.	○	○	○	○	○	○
ask my friends to help me.	○	○	○	○	○	○

Think about your feelings about a healthy diet when answering the questions below. There is no right or wrong answer; we want to know what you think. Please answer every question; it is better to guess than to leave blank.

	Strongly Disagree	Disagree	Somewhat Disagree	Somewhat Agree	Agree	Strongly Agree
I feel comfortable eating healthy.	○	○	○	○	○	○
I can eat a healthy diet to have more energy.	○	○	○	○	○	○
I am not sure if a healthy diet will make my food taste worse.	○	○	○	○	○	○
I could succeed in feeling good about myself.	○	○	○	○	○	○
I am not sure if I could control my weight.	○	○	○	○	○	○
I know ways to feel good and healthy.	○	○	○	○	○	○
I can eat healthy to feel in control of things.	○	○	○	○	○	○

Think about your feelings about physical activity when answering the questions below. There is no right or wrong answer; we want to know what you think. Please answer every question; it is better to guess than to leave blank.

	Strongly Disagree	Disagree	Somewhat Disagree	Somewhat Agree	Agree	Strongly Agree
I can do physical activity to give me more energy.	○	○	○	○	○	○

I would find it difficult to be physically active.	○	○	○	○	○	○
I know ways to have the body shape and muscles that I like.	○	○	○	○	○	○
I could succeed in doing physical activity to make myself feel good.	○	○	○	○	○	○
I can do physical activity to help me be physically strong.	○	○	○	○	○	○
I feel comfortable doing physical activities.	○	○	○	○	○	○
I am not sure if being physically active will make me be fit and in shape.	○	○	○	○	○	○

How tall are you?
(feet)
Select the option that applies

a. 1
b. 2
c. 3
d. 4
e. 5
f. 6
g. 7
h. 8
i. 9
j. 10
k. 11

(inches)
Select the option that applies

a. 1
b. 2
c. 3
d. 4
e. 5
f. 6
g. 7
h. 8
i. 9
j. 10
k. 11

Have you been diagnosed by a healthcare provider as having any of these conditions?- Coronary heart disease/ chest pain- Heart attack- Heart failure- Stroke/ TIA- Vascular disease- Congenital heart defects
a. Yes
b. No

Do you have diabetes? (either type 1 or type 2)
a. Yes
b. No

What is your weight? (in pounds) _____

How much physical activity do you get in a week?
You can include both moderate and vigorous activity levels. All types of activity count, such as gardening, walking briskly, or bicycling.
Note that:
- Moderate intensity: a person doing moderate-intensity aerobic activity can usually talk, but not sing, during the activity.
- Vigorous intensity: a person doing vigorous-intensity activity usually cannot say more than a few words without pausing for a breath.

_____ minutes of moderate activity
_____ minutes of vigorous activity

How much fruit do you eat in an average day? (in cups of fruit)
Note that 1 cup of fruit equals:
- 1 large orange or banana
- 1 medium pear of grapefruit
- 1 small apple - 8 large strawberries
- 15 grapes or 1/2 cup of raisins

a. 0	f. 2.5	l. 5
b. 0.5	e. 3	m. 5.5
c. 1	h. 3.5	n. 6
d. 1.5	i. 4	
e. 2	j. 4.5	

How much vegetables do you eat in an average day? (in cups of vegetables)
Note that 1 cup of vegetables equals:
- 1 large bell pepper or ear of corn
- 1 medium potato of large sweet potato
- 1 cup of cooked greens
- 2 cups raw greens (lettuce, spinach, etc.)
- 2 medium carrots or 12 baby carrots
- 2 large stalks of celery

a. 0	f. 2.5	l. 5
b. 0.5	e. 3	m. 5.5
c. 1	h. 3.5	n. 6
d. 1.5	i. 4	
e. 2	j. 4.5	

Do you eat 2 servings or more of fish weekly?
Note that a serving of fish is 3.5 ounces, approximately the same size as a deck of cards.
a. Yes
b. No

Do you eat 4 ounces of more of whole grains daily?
Note that whole grains include all whole grain products and whole grains used as ingredients.
a. Yes
b. No

Do you drink less than 36 ounces (450 calories) of beverages with added sugar weekly?
Note that added sugars are the sugars and syrups added to foods and beverages in processing or preparation.
a. Yes
b. No

Do you eat 1,500mg of sodium or less daily?
If you don't track your daily sodium intake by reading the food label, to answer "yes" you should do at least 2 of the following:
- Avoid eating prepackaged processed food or eat low-sodium versions
- Avoid eating out or ask for low-sodium preparation
- Cook at home without adding salt
a. Yes
b. No

What is your systolic blood pressure? (top or first number) _____ mm Hg
What is your diastolic blood pressure? (bottom or second number) _____ mm Hg
a. I don't know (one or both).
b. I take medication to lower my blood pressure.

What is your blood cholesterol? (total cholesterol) _____ mm/dL
a. I don't know (one or both).
b. I take medication to lower my cholesterol.

What is your blood sugar? (fasting blood sugar) _____ mm/dL
a. I don't know (one or both).
b. I take medication to lower my blood sugar.

Do you smoke?
Include cigarettes, pipes, and cigars (smoked tobacco in any form)
a. Select the option that applies
b. Current smoker
c. Smoked (in the last 30 days)
d. Smoked (more than 30 days ago)
e. Quit (1 - 12 months ago)
f. Quit (12 or more months)
g. Never smoked a whole cigarette
h. Never smoked

Are you male or female?
a. Male
b. Female

Please enter your age. _____

Are you of Hispanic, Latino, or Spanish origin?
a. No, not of Hispanic, Latino or Spanish origin
b. Yes, Mexican, Mexican American, Chicano
c. Yes, Puerto Rican
d. Yes, Cuban
e. Yes, Central American (FILL IN): _____
f. Yes, South American (FILL IN): _____
g. Yes, Spanish (Spain)

You are:
a. White
b. Black/ African American
c. Asian Indian
d. Chinese
e. Filipino
f. Japanese
g. Korean
h. Vietnamese
i. Other Asian (FILL IN): _____
j. Native American/ American Indian/ Alaskan Native (FILL IN Tribe): _____
k. Native Hawaiian or Other Pacific Islander
l. Mixed Ethnicity (example: Chicano and Native American, FILL IN): _____
m. Other (FILL IN): _____

If this research study has made you feel anxious, please talk to the research assistant about what we can do to help. Your wellbeing is our first priority.

APPENDIX C

SURVEY FROM EXPERIMENT 3 IN CHAPTER 3

Please Enter Researcher ID _____
Please Enter Subject Number _____

Your Location
a) Cornell University
b) Miami University

Questions About Food

Now we are going to ask you some questions about food. There is no right or wrong answer; we want to know what you think. Please answer every question; it is better to guess than to leave blank.

You were running late this morning and did not get breakfast at home, but now you are very hungry and in need of something in your stomach to focus. What should you choose?
a. Buy something that contains lean protein like skim milk. This will satisfy you.
b. Check the vending machine for something high in calories that will provide long-lasting energy.
c. Get a coffee or sugary drink to keep you alert until lunch.

What is a healthy reason to choose foods high in calcium?
a. Calcium-rich foods usually taste good.
b. A high calcium intake is needed to properly absorb Vitamin D, a nutrient important for healthy teeth.
c. Calcium-rich foods allow your cells to repair your bones.

After meeting with your doctor, you discover that you should reduce your saturated fat intake to keep your heart healthy. What healthy choice at the dinner table tonight will help you address this problem?
a. I should avoid eating animal fats.
b. Reduce intake of high-calorie foods, since caloric content is the biggest problem with saturated fats.
c. Skip the sugary alcoholic drink.

You noticed that you get dizzy and often feel fatigued. For the typical woman older than 12, the most likely explanation for this is that she isn't getting enough iron. What would be the best option to try to solve your problem?
a. Eat some lentils or kidney beans.

b. Get more sun exposure.
c. Drink tea with your spinach at dinner to increase your body's ability to absorb iron.

You forgot to set your alarm and woke up very late for your first day at work. What should be your reasoning to have/not have breakfast?
a. Since I'm already late, I should just skip breakfast and try to get to work as fast as I can.
b. I should at least drink coffee to allow the caffeine to keep me awake and energized the whole day.
c. Breakfast helps me jump start my day and perform better at work, so I should eat even a small, nutritious breakfast.

You had a rough day today and you're looking to go get some of your favorite ice cream from the local ice cream parlor to de-stress. As a 10-year anniversary event, they're selling a 32oz tub of your favorite flavor for only $.20 more. What should you do?
a. Since the 32oz is only $.20 more, I should buy it and keep it so that I can eat it for a while.
b. I shouldn't buy the larger tub of ice cream and just go for three scoops on a waffle cone instead.
c. I should just buy the small cup of ice cream instead of the waffle cone.

The nutrition label for a bag of walnuts says that 1 serving has 18g of fat (160 calories from fat)? Find protein sources with healthier fats.
a. Restrict other caloric intake because 3 servings per day are necessary to gain walnut's health benefits.
b. Eat them in small servings. This will allow you to get the healthy unsaturated fats that they contain without eating too many calories.

Imagine that you have Type 2 diabetes and your doctor says you need to watch what you eat. What should you look for when shopping for food?
a. Go for foods that have a smaller amounts of simple sugars (fructose, sucrose, etc.) compared to their total amount of complex carbohydrates (starches).
b. Food companies include health information on the front of packaging relevant to diabetes prevention.
c. Check the nutrition facts for foods that provide high percentages of minerals that will reduce spikes in blood sugar.

What would be healthy advice to give your friend with high blood pressure?
a. Try to reduce sodium intake because it can contribute to hypertension.
b. Cut out all sodium if possible, because it has no function in your body.
c. Add potassium and phosphorous to your diet.

How can you eat more fruit at work without attracting fruit flies to your desk?
a. Buy dried fruit and eat the same serving size as regular fruit.
b. Drink more juice.
c. Make an extra effort to buy fresh fruit and eat it before it goes bad.

The exercise bike at the gym has a “fat burner” (slow pace, but with intervals, alternating bursts of maximum and low heart rate) and “cardio” (faster pace, without intervals, heart rate is maximum all the way through) among its many functions. What should you do to burn the most calories?

a. The fat burner function - the smaller bursts of high heart rate activity will add up to burn more calories than moderate activity for a full 30 minutes.
b. Run in a heavy sweatsuit to increase sweating.
c. The cardio function - it is the most intense and more calories are needed to keep up the constant effort.

I want to help my friend move out of her apartment, but I have trouble with heavy lifting. How can I get stronger muscles?

a. Getting stronger require sticking with a regular exercise schedule that includes some strengthening activities.
b. To strengthen my muscles, I will need to increase the amount of daily strength exercises that I do by ten percent every 4 weeks.
c. It is important to include protein and healthy fats in my diet.

On your way to work, you see a shop with chocolate muffins in the case. You have already decided to go to the gym tonight. What should go through your head?

a. The treadmill says that I burn about 400 calories of when I work out - that is more than enough to make up for a little treat.
b. The shop has a special coffee and muffin deal just for today, so I should get it.
c. The muffin is high in fat and cholesterol that will take away from the full benefits of my workout.

After a long day at work, you feel stressed and wound up. The gym is closed and it’s raining outside. What is the healthiest choice of what to do when you get home?

a. Do some housework - if I keep moving, I'll get relief from stress.
b. Relax and catch up on TV because I must have burned many calories at work
c. I should go right to bed.

What is an example of a minor goal towards health?

a. Doing five push-ups each day
b. Meeting deadlines on time
c. Getting in shape
d. Drinking more soda

Using up more energy than you take in from food can lead to:

a. Release of stored energy
b. Weight loss
c. Low blood pressure
d. A and B

How many of the calories you eat per day should be from fat?
a. One-third
b. One-half
c. None
d. Any amount as long as it is unsaturated fat

Vitamin C helps
a. Absorb iron from vegetables
b. Absorb calcium from vegetables
c. Absorb iron from meat
d. Lower the iron in your blood

B vitamins from nuts, vegetables or meat
a. Transform molecules that make up food into energy
b. Take a long time to take effect
c. Are often found in very low quantities
d. All of the above

Fiber does all of the following except
a. Is often found in high calorie foods
b. Helps prevent colon cancer, constipation, and high cholesterol
c. Is filling
d. Helps regulate your body's response to glucose

What is true about protein sources?
a. Non-animal sources include chickpeas, seeds and nuts
b. Fish contain many nutrients, including omega-6s
c. Red meat is high in omega-3s
d. Only high-fat dairy products have sufficient protein

What is a high-cholesterol food?
a. Butter
b. Fish
c. White bread
d. Whole milk

The number of calories you need per day varies depending on
a. Age
b. Sex
c. Genetics
d. All of the above

What is a calorie?
a. A measure of how much chemical energy is stored in a food
b. A measure of how dense a food is
c. A measure of a food's volume

d. A measure of how nutritious food is

BMI accounts for
a. Genetics
b. Height and Weight
c. Sex
d. All of the above

What is false about cholesterol?
a. Low-density lipoproteins decreases risk of heart disease
b. It must bind to fat to move through the body
c. High-density lipoproteins help reduce plaque formation
d. HDL can be increased by exercise

Weight-bearing activities are
a. Useful to prevent getting osteoporosis
b. Not as important as cardio
c. Only effective if results are visible
d. Only for men

Having high blood pressure
a. Makes you more likely to have a stroke
b. Makes it less likely your arteries will harden
c. Helps prevent buildup of plaque of fatty material
d. Is unrelated to exercise

A faster heart rate is a sign that
a. You are burning more calories
b. You have low blood pressure
c. You have a low BPM
d. You are not eating enough vegetables

What is an advantage to having strong, toned muscles
a. Firm, strong muscles burn calories
b. Weight training burns as many calories as cardio
c. Strong muscles increase flexibility
d. To help prevent heart disease

What improves blood flow to muscles, reducing soreness?
a. Stretching
b. Lifestyle activities
c. Aerobic
d. Weight training

What is not an example of a lifestyle activity?
a. Lifting weights
b. Doing yard work
c. Taking the stairs
d. Carrying groceries

How many repetitions of body weight exercises should you do to really work your muscles?
a. Several sets of 10-15
b. Count to your age three times
c. Several sets of 5
d. Several sets of 30

Watching lots of TV
a. Burns fewer calories than sleeping
b. Has little influence on unrealistic expectations about appearance or life
c. Has no associations with excess weight gain
d. Is a great way to learn about companies

Which type of carbohydrates is better for you?
a. Simple carbohydrates
b. Complex carbohydrates
c. All carbohydrates are bad for me
d. All carbohydrates are good for me

Sugar in my diet should be
a. Artificial
b. Avoided at all costs
c. From mostly plants
d. Included in every meal

Please read each statement and use the scale to rate your level of agreement.
(indicates reverse coded items)*

	Strongly Disagree	Disagree	Somewhat Disagree	Neither Agree nor Disagree	Somewhat Agree	Agree	Strongly Agree
I need a lot of equipment to exercise because body weight exercises are hardly effective.*	○	○	○	○	○	○	○
Eating balanced meals regularly keeps your body fueled, so I should avoid skipping meals.	○	○	○	○	○	○	○

Breakfast is a very important meal because it gives your body the energy it needs to be productive during the day.	○	○	○	○	○	○	○
I need to lose several pounds per week to justify any exercise or diet plan.*	○	○	○	○	○	○	○
There is no way to avoid high-fat foods in certain restaurants so I should just eat what I want.*	○	○	○	○	○	○	○
I should finish all restaurant portions because it is rude to leave food on my plate.*	○	○	○	○	○	○	○
Eating is a healthy way to overcome boredom because it makes up for forgetting to eat when I am busy.*	○	○	○	○	○	○	○
I should keep my heart beating faster during exercise to increase my heart's health.	○	○	○	○	○	○	○
Exercising should only be performed at a proper gymnasium because it requires equipment and trainers.*	○	○	○	○	○	○	○
To lose weight, I should make consistent changes to my eating and exercise habits because most fad diets are unsafe or ineffective.	○	○	○	○	○	○	○
Foods with a relatively high number of calories and fat for the serving size are preferable because they are high energy.*	○	○	○	○	○	○	○
I can eat foods high in cholesterol, fat, and sugar because they have little effect on my health.*	○	○	○	○	○	○	○

Setting attainable goals (both major and minor) will help build discipline and change behavior.	○	○	○	○	○	○	○
I should avoid even small amounts of trans-fat to help prevent chronic illnesses.	○	○	○	○	○	○	○

Which principles apply to your decisions about your LIFESTYLE?
There is no right or wrong answer; we want to know what you think. Please answer every question it is better to guess than to leave blank.

	Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
To have enough energy to do everyday activities I need to eat healthy.	○	○	○	○	○
I only get one body, so I should take care of it.	○	○	○	○	○
To reach my full potential as a student I need to eat a healthy, well-balanced diet.	○	○	○	○	○
I have a responsibility to myself to stay healthy.	○	○	○	○	○
I have a responsibility to myself to watch how much food I eat.	○	○	○	○	○
I have a responsibility to myself to watch what type of food I eat.	○	○	○	○	○
I have a responsibility to myself to exercise.	○	○	○	○	○
Self-discipline is better than no self-discipline.	○	○	○	○	○

What do you think? Which of the following principles apply to your decisions about EXERCISE?
There is no right or wrong answer; we want to know what you think. Please answer every question it is better to guess than to leave blank.

	Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
To prevent osteoporosis (bone thinning) it is important to do weight bearing activities (i.e. walking, running).	○	○	○	○	○
To prevent osteoporosis (bone thinning) it is important to do strength training (i.e. pushups, squats, weight lifting).	○	○	○	○	○
Better to exercise at least a few times a week.	○	○	○	○	○

Staying healthy is worth spending the time exercising.	○	○	○	○	○
Avoid using the elevator.	○	○	○	○	○
Walk instead of drive.	○	○	○	○	○
Better to walk for at least a few minutes a day then to get no exercise at all.	○	○	○	○	○
Bike instead of drive.	○	○	○	○	○

Which principles apply to your decisions about EATING?
There is no right or wrong answer; we want to know what you think. Please answer every question it is better to guess than to leave blank.

	Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
If you are overweight or obese, a moderate reduction of caloric intake is better than no reduction at all.	○	○	○	○	○
Eating some fruits and vegetables is better than not eating any at all.	○	○	○	○	○
Eating some whole grain products is better than not eating whole grain products at all.	○	○	○	○	○
Eating more whole grain products is better than eating few whole grain products (within healthy limits).	○	○	○	○	○
I should not skip meals.	○	○	○	○	○
Eating more food products with calcium is better than few food products with calcium.	○	○	○	○	○
Better to eat food high in calcium now than have osteoporosis (thinning bones) later.	○	○	○	○	○
I should avoid processed food.	○	○	○	○	○
I should avoid fried food.	○	○	○	○	○
I should avoid food high in salt.	○	○	○	○	○
I should avoid food with bad cholesterol (LDL cholesterol).	○	○	○	○	○
I should eat fish.	○	○	○	○	○
I should eat lean meat.	○	○	○	○	○
Highly processed food is bad for you.	○	○	○	○	○
I should make smart choices from every food group.	○	○	○	○	○

Please choose the response that best represents your position about your exercise behavior.

	None	Low	Medium	High
Overall, for YOU the RISKS of not exercising regularly are...	○	○	○	○
Overall, for YOU the BENEFITS of exercising regularly are...	○	○	○	○

Please choose the response that best represents your position about your eating behavior.

	None	Low	Medium	High
Overall, for YOU the RISKS of healthy eating regularly are...	○	○	○	○
Overall, for YOU the BENEFITS of eating healthy foods are...	○	○	○	○

Most of My FRIENDS believe...
Please answer every question it is better to guess than to leave blank.

	Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
It is okay to consume non-nutritious food and sugary drinks in moderation.	○	○	○	○	○
It is ok to eat unhealthy foods often as long as a person my age exercises frequently.	○	○	○	○	○
It is important to exercise or have moderate activity often	○	○	○	○	○
A person my age should always eat healthy and minimize or eliminate wasteful calories (non-nutritious foods).	○	○	○	○	○
A person my age must eat right if they want to look attractive.	○	○	○	○	○
It is important for a person my age to be in good physical shape.	○	○	○	○	○

Most of MY FRIENDS...
Please answer every question it is better to guess than to leave blank. We are asking about the behavioral practices of your FRIENDS.

	Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
Eat healthy	○	○	○	○	○
Engage in moderate to intense physical activity on a frequent basis	○	○	○	○	○
Try to eat a balanced diet	○	○	○	○	○
Eat a diet that is mostly plant-based	○	○	○	○	○

Engage in lifestyle fitness activities on a regular basis (e.g., walking rather than driving, taking stairs rather than the elevator)	○	○	○	○	○
Are active when conveniences are available	○	○	○	○	○
Go to the gym or play sports on a regular basis	○	○	○	○	○

Most of ADULTS who are important to me believe...
Please answer every question it is better to guess than to leave blank.

	Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
It is okay to consume non-nutritious food and sugary drinks in moderation.	○	○	○	○	○
It is ok to eat unhealthy foods often as long as a person my age exercises frequently.	○	○	○	○	○
It is important to exercise or have moderate activity often	○	○	○	○	○
A person my age should always eat healthy and minimize or eliminate wasteful calories (non-nutritious foods).	○	○	○	○	○
A person my age must eat right if they want to look attractive.	○	○	○	○	○
It is important for a person my age to be in good physical shape.	○	○	○	○	○

I Believe...
Please answer every question it is better to guess than to leave blank.

	Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
It is okay to consume non-nutritious food and sugary drinks in moderation.	○	○	○	○	○
It is ok to eat unhealthy foods often as long as a person my age exercises frequently.	○	○	○	○	○
It is important to exercise or have moderate activity often	○	○	○	○	○
A person my age should always eat healthy and minimize or eliminate wasteful calories (non-nutritious foods).	○	○	○	○	○
A person my age must eat right if they want to look attractive.	○	○	○	○	○

It is important for a person my age to be in good physical shape.	○	○	○	○	○

I Believe I...
Please answer every question it is better to guess than to leave blank. We are asking about your own behavioral practices

	Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
Eat healthy	○	○	○	○	○
Engage in moderate to intense physical activity on a frequent basis	○	○	○	○	○
Try to eat a balanced diet	○	○	○	○	○
Eat a diet that is mostly plant-based	○	○	○	○	○
Engage in lifestyle fitness activities on a regular basis (e.g., walking rather than driving, taking stairs rather than the elevator)	○	○	○	○	○
Are active when conveniences are available	○	○	○	○	○
Go to the gym or play sports on a regular basis	○	○	○	○	○

Think about your attitude about your healthy diet and physical activity when answering the questions below.
There is no right or wrong answer; we want to know what you think. Please answer every question; it is better to guess than to leave blank.

A healthy diet will...

	Very Unlikely	Unlikely	Somewhat Unlikely	Somewhat Likely	Likely	Very Likely
help me control my weight.	○	○	○	○	○	○
give me more energy.	○	○	○	○	○	○
make me feel good about myself.	○	○	○	○	○	○
make me feel good in clothes.	○	○	○	○	○	○
make my food taste worse.	○	○	○	○	○	○
make me feel good and healthy.	○	○	○	○	○	○
help me feel in control of things.	○	○	○	○	○	○
help me look good.	○	○	○	○	○	○

Being physically active will...

	Very Unlikely	Unlikely	Somewhat Unlikely	Somewhat Likely	Likely	Very Likely
help me be fit and in shape.	○	○	○	○	○	○
help me be physically strong.	○	○	○	○	○	○
help me feel good about myself/proud.	○	○	○	○	○	○
help me control my weight.	○	○	○	○	○	○
help me have the body shape and muscles that I like.	○	○	○	○	○	○
make me feel in control.	○	○	○	○	○	○

Think about your attitude about your healthy diet and physical activity when answering the questions below.
There is no right or wrong answer; we want to know what you think. Please answer every question; it is better to guess than to leave blank.

	Very Useless	Useless	Somewhat Useless	Somewhat Useful	Useful	Very Useful
For me to be physically active would be...	○	○	○	○	○	○
For me to be a healthy eater would be...	○	○	○	○	○	○

	Very Harmful	Harmful	Somewhat Harmful	Somewhat Beneficial	Beneficial	Very Beneficial
For me to be physically active would be...	○	○	○	○	○	○
For me to be a healthy eater would be...	○	○	○	○	○	○

	Very Undesirable	Undesirable	Somewhat Undesirable	Somewhat Desirable	Desirable	Very Desirable
For me to be physically active would be...	○	○	○	○	○	○
For me to be a healthy eater would be...	○	○	○	○	○	○

	Very Bad	Bad	Poor	Fair	Good	Very Good
For me to be physically active would be...	○	○	○	○	○	○

For me to be a healthy eater would be...	○	○	○	○	○	○

	Very Boring	Boring	Somewhat Boring	Somewhat Interesting	Interesting	Very Interesting
For me to be physically active would be...	○	○	○	○	○	○
For me to be a healthy eater would be...	○	○	○	○	○	○

	Very Unenjoyable	Unenjoyable	Somewhat Unenjoyable	Somewhat Enjoyable	Enjoyable	Very Enjoyable
For me to be physically active would be...	○	○	○	○	○	○
For me to be a healthy eater would be...	○	○	○	○	○	○

Think about your INTENTIONS about your healthy diet and physical activity when answering the questions below.
There is no right or wrong answer; we want to know what you think. Please answer every question; it is better to guess than to leave blank.

I plan to...

	Strongly Disagree	Disagree	Somewhat Disagree	Somewhat Agree	Agree	Strongly Agree
be a healthy eater.	○	○	○	○	○	○
be physically active.	○	○	○	○	○	○

I will try to...

	Strongly Disagree	Disagree	Somewhat Disagree	Somewhat Agree	Agree	Strongly Agree
be a healthy eater.	○	○	○	○	○	○
be physically active.	○	○	○	○	○	○

How likely is it that...

	Very Unlikely	Unlikely	Somewhat Unlikely	Somewhat Likely	Likely	Very Likely
you will be a healthy eater over the next two weeks?	○	○	○	○	○	○
you will be physically active over the next two weeks?	○	○	○	○	○	○

Thinking of your behavior over the next 2 weeks...

	Very Unlikely	Unlikely	Somewhat Unlikely	Somewhat Likely	Likely	Very Likely
how often do you think you will be physically active?	○	○	○	○	○	○
how often do you think you will be a healthy eater?	○	○	○	○	○	○

What can you do when you want to be a healthy eater? I can...

	Strongly Disagree	Disagree	Somewhat Disagree	Somewhat Agree	Agree	Strongly Agree
try hard enough at it.	○	○	○	○	○	○
have enough self-discipline for it.	○	○	○	○	○	○
be lucky enough to prefer healthy foods.	○	○	○	○	○	○
have my parents help me.	○	○	○	○	○	○
ask my friends to help me.	○	○	○	○	○	○

What can you do when you want to avoid too much junk food? I can...

	Strongly Disagree	Disagree	Somewhat Disagree	Somewhat Agree	Agree	Strongly Agree
try hard enough at it.	○	○	○	○	○	○
have enough self-discipline for it.	○	○	○	○	○	○
be lucky enough to prefer healthy foods.	○	○	○	○	○	○
have my parents help me.	○	○	○	○	○	○
ask my friends to help me.	○	○	○	○	○	○

What can you do when you want to be physically active? I can...

	Strongly Disagree	Disagree	Somewhat Disagree	Somewhat Agree	Agree	Strongly Agree
try hard enough at it.	○	○	○	○	○	○
have enough self-discipline for it.	○	○	○	○	○	○
be lucky enough to like physical activities.	○	○	○	○	○	○

have my parents help me.	○	○	○	○	○	○
ask my friends to help me.	○	○	○	○	○	○

What can you do when you want to exercise or do active things? I can...

	Strongly Disagree	Disagree	Somewhat Disagree	Somewhat Agree	Agree	Strongly Agree
try hard enough at it.	○	○	○	○	○	○
have enough self-discipline for it.	○	○	○	○	○	○
be lucky enough to like physical activities.	○	○	○	○	○	○
have my parents help me.	○	○	○	○	○	○
ask my friends to help me.	○	○	○	○	○	○

Think about your feelings about a healthy diet when answering the questions below. There is no right or wrong answer; we want to know what you think. Please answer every question; it is better to guess than to leave blank.

	Strongly Disagree	Disagree	Somewhat Disagree	Somewhat Agree	Agree	Strongly Agree
I feel comfortable eating healthy.	○	○	○	○	○	○
I can eat a healthy diet to have more energy.	○	○	○	○	○	○
I am not sure if a healthy diet will make my food taste worse.	○	○	○	○	○	○
I could succeed in feeling good about myself.	○	○	○	○	○	○
I am not sure if I could control my weight.	○	○	○	○	○	○
I know ways to feel good and healthy.	○	○	○	○	○	○
I can eat healthy to feel in control of things.	○	○	○	○	○	○

Think about your feelings about physical activity when answering the questions below. There is no right or wrong answer; we want to know what you think. Please answer every question; it is better to guess than to leave blank.

	Strongly Disagree	Disagree	Somewhat Disagree	Somewhat Agree	Agree	Strongly Agree
I can do physical activity to give me more energy.	○	○	○	○	○	○
I would find it difficult to be physically active.	○	○	○	○	○	○
I know ways to have the body shape and muscles that I like.	○	○	○	○	○	○
I could succeed in doing physical activity to make myself feel good.	○	○	○	○	○	○
I can do physical activity to help me be physically strong.	○	○	○	○	○	○
I feel comfortable doing physical activities.	○	○	○	○	○	○
I am not sure if being physically active will make me be fit and in shape.	○	○	○	○	○	○

Please choose the response that best represents your position about your eating behavior.

	Never	Seldom	Sometimes	Often	Very Often
If you have put on weight, do you eat less than you usually do?	○	○	○	○	○
Do you try to eat less at mealtimes than you would like to eat?	○	○	○	○	○
How often do you refuse food or drink offered because you are concerned about your weight?	○	○	○	○	○
Do you watch exactly what you eat?	○	○	○	○	○
Do you deliberately eat foods that are slimming?	○	○	○	○	○
When you have eaten too much, do you eat less than usual the following days?	○	○	○	○	○
Do you deliberately eat less in order not to become heavier?	○	○	○	○	○
How often do you try not to eat between meals because you are watching your weight?	○	○	○	○	○

How often in the evening do you try not to eat because you are watching your weight?	○	○	○	○	○
Do you take into account your weight with what you eat?	○	○	○	○	○

How tall are you?
(feet)
Select the option that applies

a. 1
b. 2
c. 3
d. 4
e. 5
f. 6
g. 7
h. 8
i. 9
j. 10
k. 11

(inches)
Select the option that applies

a. 1
b. 2
c. 3
d. 4
e. 5
f. 6
g. 7
h. 8
i. 9
j. 10
k. 11

Have you been diagnosed by a healthcare provider as having any of these conditions?- Coronary heart disease/ chest pain- Heart attack- Heart failure- Stroke/ TIA- Vascular disease- Congenital heart defects
a. Yes
b. No

Do you have diabetes? (either type 1 or type 2)
a. Yes
b. No

What is your weight? (in pounds) _____

How much physical activity do you get in a week?
You can include both moderate and vigorous activity levels. All types of activity count, such as gardening, walking briskly, or bicycling.
Note that:
- Moderate intensity: a person doing moderate-intensity aerobic activity can usually talk, but not sing, during the activity.
- Vigorous intensity: a person doing vigorous-intensity activity usually cannot say more than a few words without pausing for a breath.
_____ minutes of moderate activity
_____ minutes of vigorous activity

How much fruit do you eat in an average day? (in cups of fruit)
Note that 1 cup of fruit equals:
- 1 large orange or banana
- 1 medium pear of grapefruit
- 1 small apple - 8 large strawberries
- 15 grapes or 1/2 cup of raisins

a. 0	f. 2.5	l. 5
b. 0.5	e. 3	m. 5.5
c. 1	h. 3.5	n. 6
d. 1.5	i. 4	
e. 2	j. 4.5	

How much vegetables do you eat in an average day? (in cups of vegetables)
Note that 1 cup of vegetables equals:
- 1 large bell pepper or ear of corn
- 1 medium potato of large sweet potato
- 1 cup of cooked greens
- 2 cups raw greens (lettuce, spinach, etc.)
- 2 medium carrots or 12 baby carrots
- 2 large stalks of celery

a. 0	f. 2.5	l. 5
b. 0.5	e. 3	m. 5.5
c. 1	h. 3.5	n. 6
d. 1.5	i. 4	
e. 2	j. 4.5	

Do you eat 2 servings or more of fish weekly?
Note that a serving of fish is 3.5 ounces, approximately the same size as a deck of cards.
a. Yes
b. No

Do you eat 4 ounces of more of whole grains daily?
Note that whole grains include all whole grain products and whole grains used as ingredients.
a. Yes
b. No

Do you drink less than 36 ounces (450 calories) of beverages with added sugar weekly?
Note that added sugars are the sugars and syrups added to foods and beverages in processing or preparation.
a. Yes
b. No

Do you eat 1,500mg of sodium or less daily?
If you don’t track your daily sodium intake by reading the food label, to answer "yes" you should do at least 2 of the following:
- Avoid eating prepackaged processed food or eat low-sodium versions

- Avoid eating out or ask for low-sodium preparation
- Cook at home without adding salt
a. Yes
b. No

What is your systolic blood pressure? (top or first number) _____ mm Hg
What is your diastolic blood pressure? (bottom or second number) _____ mm Hg
a. I don't know (one or both).
b. I take medication to lower my blood pressure.

What is your blood cholesterol? (total cholesterol) _____ mm/dL
a. I don't know (one or both).
b. I take medication to lower my cholesterol.

What is your blood sugar? (fasting blood sugar) _____ mm/dL
a. I don't know (one or both).
b. I take medication to lower my blood sugar.

Do you smoke?
Include cigarettes, pipes, and cigars (smoked tobacco in any form)
a. Select the option that applies
b. Current smoker
c. Smoked (in the last 30 days)
d. Smoked (more than 30 days ago)
e. Quit (1 - 12 months ago)
f. Quit (12 or more months)
g. Never smoked a whole cigarette
h. Never smoked

The purpose of the present study is to compare your preferences for different amounts of money. In this experiment you will be asked to make a series of decisions about hypothetical monetary alternatives. One monetary choice will be available immediately (now), while the other monetary alternative will be available after a certain time delay. Please keep in mind, that there are no "correct" answers. We are only interested in which option you would prefer. Please answer every question as truthfully as possible.

What would you prefer?
a. $54 now
b. $55, 117 days from now

What would you prefer?
a. $55 now
b. $75, 61 days from now

What would you prefer?
a. $19 now
b. $25, 53 days from now

What would you prefer?
a. $31 now
b. $85, 7 days from now

What would you prefer?
a. $14 now
b. $25, 19 days from now

What would you prefer?
a. $47 now
b. $50, 160 days from now

What would you prefer?
a. $15 now
b. $35, 13 days from now

What would you prefer?
a. $25 now
b. $60, 14 days from now

What would you prefer?
a. $78 now
b. $80, 162 days from now

What would you prefer?
a. $40 now
b. $55, 62 days from now

What would you prefer?
a. $11 now
b. $30, 7 days from now

What would you prefer?
a. $67 now
b. $75, 119 days from now

What would you prefer?
a. $34 now
b. $35, 186 days from now

What would you prefer?
a. $27 now
b. $50, 21 days from now

What would you prefer?
a. $69 now
b. $85, 91 days from now

What would you prefer?
a. $49 now
b. $60, 89 days from now

What would you prefer?
a. $80 now
b. $85, 157 days from now

What would you prefer?
a. $24 now
b. $35, 29 days from now

What would you prefer?
a. $33 now
b. $80, 14 days from now

What would you prefer?
a. $28 now
b. $30, 179 days from now

What would you prefer?
a. $34 now
b. $50, 30 days from now

What would you prefer?
a. $25 now
b. $30, 80 days from now

What would you prefer?
a. $41 now
b. $75, 20 days from now

What would you prefer?
a. $54 now
b. $60, 111 days from now

What would you prefer?
a. $54 now
b. $80, 30 days from now

What would you prefer?
a. $22 now
b. $25, 136 days from now

What would you prefer?
a. $20 now
b. $55, 7 days from now

Please indicate your agreement or disagreement with the following statements.

	Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
I would like to explore strange places.	○	○	○	○	○
I get restless when I spend too much time at home.	○	○	○	○	○
I like to do frightening things.	○	○	○	○	○
I like wild parties.	○	○	○	○	○
I would like to take off on a trip with no pre-planned routes or timetables.	○	○	○	○	○
I prefer friends who are excitingly unpredictable.	○	○	○	○	○
I would like to try bungee jumping.	○	○	○	○	○
I would love to have new and exciting experiences, even if they are illegal.	○	○	○	○	○

Are you male or female?
a. Male
b. Female

Please enter your age. _____

Are you of Hispanic, Latino, or Spanish origin?
a. No, not of Hispanic, Latino or Spanish origin
b. Yes, Mexican, Mexican American, Chicano
c. Yes, Puerto Rican
d. Yes, Cuban
e. Yes, Central American (FILL IN): _____
f. Yes, South American (FILL IN): _____
g. Yes, Spanish (Spain)

You are:

a. White
b. Black/ African American
c. Asian Indian
d. Chinese
e. Filipino
f. Japanese
g. Korean
h. Vietnamese
i. Other Asian (FILL IN): _____
j. Native American/ American Indian/ Alaskan Native (FILL IN Tribe): _____
k. Native Hawaiian or Other Pacific Islander
l. Mixed Ethnicity (example: Chicano and Native American, FILL IN): _____
m. Other (FILL IN): _____

If this research study has made you feel anxious, please talk to the research assistant about what we can do to help. Your wellbeing is our first priority.

APPENDIX D

LIST OF MEASURES EMBEDDED WITHIN THE TUTORIAL FROM CHAPTER 4

Multiple-Choice Questions

If you want to avoid diseases like cancer, vitamin deficiency anemia, or osteoporosis, which of the following choices is the best way to do it?

a. Guard against cancer with B-12, vitamin deficiency anemia with iron and vitamin C, and osteoporosis with calcium and vitamin D. The other nutrients aren't as important.
b. Make sure to eat a balanced diet with all the necessary vitamins and minerals – they work together to keep you healthy and strong. (CORRECT)
c. Stay away from things that cause allergies – the immune response causes disease symptoms, not lack of nutrients.

Is cholesterol ever good?
Yes. HDL is good, because it helps clear your blood vessels. (CORRECT)
Yes. LDL is good, because you find it in egg yolks, which are healthy.
If I don't have high blood pressure, then I don't need to worry about cholesterol

When you go out to eat, you are often presented with a wide range of choices in the form of a menu. Pick the smartest choice for dinner from this list.

a. Water, Garden salad with light dressing, Grilled salmon and asparagus. (CORRECT)
b. Water, Garden salad with honey mustard dressing, Bacon cheeseburger
c. Soda, Mozzarella sticks, Bacon cheeseburger

Which of the following options about fast food nutritional content is true?

a. A milkshake is high in calcium. (CORRECT)
b. Sour cream is a topping for tacos that contains a fruit or vegetable.
c. A piece of crispy chicken with skin has fewer grams of fat than 2 crispy chicken strips.

What should you look to on the nutrition label when deciding how much to eat?

a. Choose one target area such as total fat on the food label, and make a healthy decision of how much to eat based off of that information. (CORRECT)
b. Look at the serving size and eat exactly one serving.
c. As long as it doesn't have too much sugar, eat as much as you want.

If you want to lose weight, which of the following is a healthy way to do it?

a. Become workout buddies with a former classmate and do the South Beach diet together to look good for the reunion in a month.
b. I am not concerned about my weight.
c. Prepare meals with fewer calories, and stick with it in the long run. (CORRECT)

What is a health benefit of regular exercise?

a. Exercise can help me with health overall. (CORRECT)
b. Exercise can increase your blood pressure.
c. Exercise can help me look pretty.

Analytic Questions

Why would you like to improve and maintain your health?

How can you make sure to have enough time for breakfast?

How can you incorporate more lifestyle physical activities into your daily routine?

Describe some factors that can affect your food and exercise choices, which you can take control of, and how you would change it in your life.