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Using Fuzzy-Trace Theory to Understand and Improve Health Judgments, Decisions, and Behaviors: A Literature Review

Susan J. Blalock and

Division of Pharmaceutical Outcomes and Policy, University of North Carolina

Valerie F. Reyna

Human Neuroscience Institute, Department of Human Development, and Center for Behavioral Economics and Decision Research, Cornell University

Abstract

Objective—Fuzzy-trace theory is a dual-process model of memory, reasoning, judgment, and decision making that contrasts with traditional expectancy-value approaches. We review the literature applying fuzzy-trace theory to health with three aims: evaluating whether the theory's basic distinctions have been validated empirically in the domain of health; determining whether these distinctions are useful in assessing, explaining, and predicting health-related psychological processes; and determining whether the theory can be used to improve health judgments, decisions, or behaviors, especially in comparison to other approaches.

Methods—We conducted a literature review using PubMed, PsycInfo, and Web of Science to identify empirical peer-reviewed papers that applied fuzzy-trace theory, or central constructs of the theory, to investigate health judgments, decisions, or behaviors.

Results—79 studies were identified, over half published since 2012, spanning a wide variety of conditions and populations. Study findings supported the prediction that verbatim and gist representations are distinct constructs that can be retrieved independently using different cues. Although gist-based reasoning was usually associated with improved judgment and decision making, four sources of bias that can impair gist reasoning were identified. Finally, promising findings were reported from intervention studies that used fuzzy-trace theory to improve decision making and decrease unhealthy risk taking.

Conclusions—Despite large gaps in the literature, most studies supported all three aims. By focusing on basic psychological processes that underlie judgment and decision making, fuzzy-trace theory provides insights into how individuals make decisions involving health risks and suggests innovative intervention approaches to improve health outcomes.

Keywords

fuzzy-trace theory; health behaviors; decision making; risk-taking; behavior change

Address correspondence to Susan J. Blalock, Division of Pharmaceutical Outcomes and Policy, Eshelman School of Pharmacy, University of North Carolina at Chapel Hill, Chapel Hill, NC 27599-7573, USA. Phone: 1-919-962-0080. s_blalock@unc.edu.

Fuzzy-trace theory (FTT) is a comprehensive, dual-process model of memory, reasoning, judgment, and decision making that has been used to study how individuals across the life span make decisions that involve risk (Reyna, 2004, 2008, 2012). It explains and predicts variation in (1) recognition and recall of past experiences; (2) judgments and decisions, especially those that involve risk; and (3) behaviors that people perform in specific situations by explicating the cognitive mechanisms that translate thought into action. The aims of this paper are to: (1) evaluate whether the theory's basic distinctions have been validated empirically in the domain of health; (2) determine whether these distinctions are useful in assessing, explaining, and predicting health-related psychological processes; and (3) determine whether the theory can be used to improve health judgments, decisions, or behaviors, especially in comparison to other approaches. We begin by describing FTT's basic distinctions and articulating five key predictions derived from the theory. We then report the results of a literature review assessing whether these predictions have been supported by empirical research in the health domain.

Overview of Fuzzy-Trace Theory

FTT posits that, when an individual is exposed to any meaningful stimulus (e.g., a graph describing treatment risks), two types of representations of the stimulus are encoded in memory, a verbatim representation and one or more gist representations. Verbatim representations capture the exact words, numbers, or images included in the stimulus, whereas gist representations capture the essential, bottom-line meaning of the stimulus to the person, including its emotional meaning. These representations are initially encoded, roughly in parallel, into working memory (e.g., as a patient hears and thinks about the information provided) and ultimately transferred to long-term memory, although verbatim representations generally become rapidly inaccessible.

Evidence from many experiments on memory supports the FTT hypothesis that people generally encode multiple representations of a single stimulus varying in level of specificity (e.g., Reyna & Brainerd, 1995). In particular, people encode both categorical and (more precise) ordinal gist representations of quantities. For example, told that there is a 2% risk of stroke associated with a particular type of surgery, a person might simultaneously encode the gist that: (1) the surgery has some risk of causing a stroke and (2) the risk of surgery causing a stroke is low. The first example illustrates a categorical gist representation (i.e., some versus no risk), whereas the second example illustrates an ordinal gist representation (i.e., low versus high risk). Further, although different gist representations may be consistent with the information provided in a given situation (e.g., some people may consider the 2% risk described above as high rather than low), individuals can also fail to understand the information – leading to the formation of inaccurate gist representations. For example, if the individual described above did not understand that the surgery could cause a stroke and formed the gist representation that there was no risk of stroke during surgery, this gist representation would be inaccurate in a fundamental way— patients who think surgery has *no* risks are not able to give truly informed consent because they do not understand that they are accepting a risk (Reyna & Hamilton, 2001). In contrast, patients who misremember the risk as 5% rather than 2%, although inaccurate from a verbatim perspective, still understand

the essential gist that the surgery has some risk. (Table 1 describes how to identify the gist of decision options and assess gist comprehension.)

In decision-making situations, simple values or gist principles (e.g., it is good to avoid risk if possible) are applied to gist representations of the options to reach a judgment/decision. FTT views gist-based reasoning as intuitive and as occurring primarily at an unconscious level (e.g., Reyna, 2008; Reyna et al., 2011). Intuition involves knowing or understanding something without the need to analyze details about how or why we know it. For example, when asked if they would shoplift, most adults would say "No" automatically, without having to think about why they would not. Most adults know intuitively that shoplifting is wrong, without analyzing the advantages and disadvantages of shoplifting (Haidt, 2007; Haidt & Kesebir, 2008). Moreover, FTT makes an important distinction between the actions that people take that are guided by this type of intuitive, gist-based reasoning and those that are mindless or result from a failure of impulse control. From this perspective, people sometimes do things they know are wrong due to a failure of self-control mechanisms to inhibit impulsive behavior. Thus, intuition and impulsivity are distinct concepts in FTT.

People often engage in both verbatim and gist reasoning about the same information — and these two types of reasoning compete when they favor different options. However, given that gist representations capture the essential meaning of information, FTT predicts that the tendency to rely on gist rather than verbatim representations should increase with development from childhood to adulthood and from novice to expert, which has been observed (e.g., Brainerd, Reyna, & Ceci, 2008). In non-health contexts, research has also confirmed that adults and individuals with specialized expertise tend to rely on the least precise memory representations needed when making judgments or decisions (e.g., Reyna, Chick et al., 2014), which is referred to as a *fuzzy processing preference*. Due to this fuzzy processing preference, gist reasoning often involves thinking about risk and risk reduction in categorical terms (e.g., Getting vaccinated could save my life; I could get HIV if I have unprotected sex). Since risking death (or becoming infected with HIV) is undesirable, FTT predicts that this type of gist-based reasoning will lead to the adoption of behaviors that reduce risk (e.g., vaccination) and the avoidance of behaviors that increase risk (e.g., unsafe sexual activity). In contrast, verbatim-based reasoning involves thinking about risk and risk reduction in more precise (e.g., numerical) terms.[1] In many public health contexts, the probability of harm from engaging in a particular behavior is low for a single act (e.g., the risk of becoming infected by HIV through a single act of unsafe sex). Hence, FTT predicts that verbatim-based reasoning often promotes risk taking—a high-likelihood of benefit compensates for a low-likelihood of harm. Similarly, FTT predicts that verbatim-based reasoning often reduces the uptake of precautionary behaviors (e.g., adult vaccinations for conditions such as influenza, pneumonia, and shingles) because the certainty of incurring costs (e.g., time, money) can offset a low-likelihood of benefit (i.e., most people do not get sick even if they are not vaccinated).[2]

[1]When a person is faced with two or more options that have identical representations when reduced to categorical terms (e.g., two medications used to treat the same condition and having the same potential side effects with different probabilities), choosing one option may require using ordinal gist representations or even more precise verbatim representations (Reyna, 2012).

[2]The view of adaptive decision-making posited by FTT contrasts with expectancy-value approaches such as the theory of planned behavior (Ajzen, 1991) and heuristics-and-biases frameworks (Kahneman, 2011) that view deliberation about behavioral options and

Predictions Derived from Fuzzy-Trace Theory

In this paper, we critically review evidence to determine whether the following predictions derived from FTT have been supported by empirical research in the health domain:

1. People form *distinct* verbatim and gist mental representations when exposed to health-relevant information; two examples of this hypothesis are:

1a. The specificity of retrieval or eliciting cues in questions affects the types of representations retrieved from memory (less specific, but meaningful, cues elicit gist; more specific cues elicit verbatim representations), influencing people's estimation of health risks and altering the relationship between risk perceptions and health behavior.

1b. Gist representations are retained in memory longer than verbatim representations.

2. The preference for gist-based reasoning over verbatim-based reasoning increases with development and the acquisition of expertise.

3. Compared to verbatim-based reasoning, gist-based reasoning is associated with: (a) improved judgment and decision making (as evaluated using an external criterion such as medical expertise), (b) increased adoption of behaviors recommended to reduce health risks, and (c) improved health outcomes.

4. Four sources of bias contribute to errors in gist-reasoning: knowledge deficits, conceptually incomplete or inaccurate gist representations, failure to retrieve relevant knowledge and values from memory when making judgments and decisions, and processing interference caused by overlapping classes (e.g., the probability of having breast cancer, the probability of having a positive mammogram).

5. Compared to traditional (e.g., facts education or expectancy-value) approaches, interventions designed to facilitate gist-based reasoning will result in: (a) improved judgment and decision-making (again, as evaluated using an external criterion such as medical expertise), (b) increased adoption of behaviors recommended to reduce health risks, and (c) improved health outcomes.

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the likelihood of outcomes associated with each option as critical to advanced reasoning (see Fukukura, Ferguson, & Fujita, 2013). Unlike fast-and-frugal approaches, gist is not simply processing less information. Gist involves meaning--integrating dimensions of information to distill its essence--not just processing a few dimensions of information because they are "good enough" (Marewski & Gigerenzer, 2012). For example, a heuristic such as "trust your doctor" would not be viewed as a reasoning principle in FTT if it involves mindlessly following authority as opposed to understanding the gist of health information. The fast-and-frugal approach also assumes that heuristics are mental shortcuts that are used due to memory limitations, whereas research using FTT has demonstrated memory-judgment independence (Reyna & Brainerd, 1995).

Method

Eligibility Criteria

Studies were eligible for inclusion if they: (1) were empirical; (2) examined any health-related issue, with the exception of violent crime (e.g., intimate partner violence, child sexual abuse); and (3) reported findings relevant to FTT. Studies using only qualitative methods were excluded. Studies limited to children under the age of 13 were also excluded because the few studies involving children identified focused primarily on the veracity of children's memory.

Search Strategy

PubMed, PsycInfo, and Web of Science were searched using the terms: fuzzy-trace theory OR gist NOT gastrointestinal tumor. The search was limited to papers published between database inception and December 22, 2014.[3] A citation search was also conducted using Web of Science to identify articles that referenced papers on the topic written by the developers of the theory (VF Reyna and CJ Brainerd). Finally, reference lists of all included studies were reviewed to identify additional eligible studies.

Study Selection and Data Extraction

One reviewer screened all titles and abstracts of the records retrieved via the electronic searches to identify potentially eligible studies. Full-text articles were reviewed to determine eligibility based on the criteria specified above. Data from each study were extracted by the primary reviewer onto a data collection form developed specifically for this purpose. Data abstracted included: participant characteristics, sample size, study design, and methods, outcome variables, and primary findings relevant to the theoretical predictions being evaluated.

Results

As shown in Figure 1 (see Appendix), a total of 5,958 unique records were retrieved via the electronic database searches. Seventy-one of these met study inclusion criteria. One additional paper was identified from searching the references of included papers, bringing the total number of included papers to 72. These papers reported the results of a total of 79 studies, of which 42 were relevant to the specific predictions being evaluated. Tables 2 and 3 summarize methods and findings from these 42 studies (see Appendix).

Effects of Cues on the Retrieval of Gist Versus Verbatim Memory Representations

Eight studies reported findings relevant to the prediction that the specificity of retrieval/eliciting cues in questions affects the types of representations retrieved from memory (Baghal, 2011; Bigman, 2014; Brown & Morley, 2007; Brown, Nowlan, Taylor, & Morley, 2013; Mills, Reyna, & Estrada, 2008; Reyna et al., 2011). Two of these studies focused on adolescent sexuality (Mills et al., 2008; Reyna et al., 2011). The questions designed to cue

[3]The search was updated on March 12, 2016. Information concerning 15 studies published between December 2014 and March 2016 is provided in supplemental materials available online.

retrieval of verbatim representations asked participants about their likelihood of experiencing several specific outcomes (e.g., getting pregnant or making someone pregnant within the next six months) and their chances on a precise 0–100 scale of currently having a sexually transmitted disease (STD). Applying FTT's models of recognition memory, the investigators hypothesized that, because these risk-perception questions are precise, they are more likely to cue true memories of past behaviors, which then are used to estimate risk (e.g., Brainerd & Reyna, 2005; Fischer & Hawkins, 1993; Reyna & Brainerd, 1995). Thus, because responses reflect the riskiness of past behaviors, higher scores should be associated with a *higher* likelihood of being sexually active and intending to have sex. In contrast, to assess gist representations, the investigators used questions designed to cue global risk perceptions that could be answered without recall of verbatim information. These included: categorical risk perceptions (e.g., It only takes ONCE to get pregnant), gist principles (e.g., Better safe than sorry), and a global estimate of the risks associated with having sex (low, medium, or high). The investigators expected these measures to capture differences between thinking about risk in gist terms (e.g., categorically avoid lethal risks) and thinking about risk in verbatim (e.g., quantitative) terms (accept risks when potential benefits are sufficiently large — i.e., trade off risks and benefits). Therefore, they hypothesized that higher scores on the gist measures would be associated with a *lower* likelihood of being sexually active and intending to have sex, just the opposite pattern predicted for the verbatim measures. All of these hypotheses were confirmed in both studies: the verbatim measures were positively associated with risk taking and the gist measures were negatively associated with risk taking.

Two other studies examined young adults' perceptions concerning risks associated with alcohol consumption (Brown & Morley, 2007; Brown et al., 2013). These studies also used different measures to cue retrieval of gist versus verbatim memory representations. In both studies, participants rated the probability that they would experience specific alcohol-related problems on a visual analogue scale with endpoints labeled "no chance" and "completely certain." However, one set of instructions directed participants to place a single mark on the line to estimate this probability (i.e., a unitary point estimate). The other set of instructions asked participants to place two marks on the line to define the fuzzy boundaries of the estimate, that is, the area likely to include the true probability. This bounded risk estimate (less precise than the unitary estimate) was designed to be more likely to cue retrieval of vague gist representations. In both studies, the investigators hypothesized that respondents would be more motivated to underestimate their alcohol problems with point estimates, but the fuzziness of bounded estimates would allow such problems to be less obvious. Thus, they hypothesized that the bounded estimates would be less affected by the self-enhancement bias often observed in point estimates of personal risk (i.e., viewing oneself as at lower risk of experiencing adverse health outcomes compared to similar others). This hypothesis was supported in both studies.

The unitary versus bounded risk estimates also changed in predicted ways in response to experimental manipulations. For example, unitary risk estimates were lower when made before bounded estimates, whereas bounded estimates were not affected by question order (Brown & Morley, 2007). In addition, unitary estimates were higher in the presence of an

accountability manipulation designed to reduce self-enhancement, whereas bounded estimates were not affected by this manipulation (Brown et al., 2013).

Another study used two methods to assess perceived risk of smoking (Baghal, 2011). One method cued retrieval of verbatim representations by asking participants to estimate the absolute risk of dying from lung cancer among (1) smokers and (2) non-smokers (i.e., 0% to 100%). Participants' responses to these questions were also used to derive measures of perceived relative risk and absolute risk difference. (Note that unlike the other studies described in this section, the verbatim risk measure did not ask participants to estimate their personal risk of experiencing the outcome. Therefore, one would not expect it to cue retrieval of true memories of risk-relevant behaviors, which is the basis for predicting a positive association between perceived risk and risk taking.) The second method asked participants to provide a fuzzier estimate of the risk of smoking by answering the question: "In your opinion, would smoking everyday be very risky for your health, somewhat risky, a little risky or not at all risky for your health?" (p. 355). Estimates made using both methods predicted current smoking status, with greater perceived risk associated with a lower likelihood of smoking (i.e., greater risk avoidance). Consistent with FTT, estimates made on the fuzzier, ordinal scale produced stronger relationships, despite the measurement advantage of more points on the numerical scale. In addition, consistent with the FTT prediction that reliance on gist-based reasoning increases with development, estimates made on the fuzzier scale predicted smoking status better among adults than adolescents.

In summary, findings from these studies support the FTT prediction that the specificity of retrieval cues in questions can affect the types of representations retrieved from memory. The ability of investigators to differentially cue retrieval of verbatim versus gist representations in predictable ways suggests that they are distinct with different psychological properties.

Retention of Gist Versus Verbatim Memory Representations

Three studies reported findings relevant to the prediction that gist representations are retained in memory longer than verbatim representations (Gaissmaier et al., 2012; Ruiz et al., 2013; Witteman & Tollenaar, 2012). Two of these studies assessed verbatim and gist memory of information contained in experimental stimulus materials (Gaissmaier et al., 2012; Ruiz et al., 2013). The experimental materials in the study by Gaissmaier et al. (2012) conveyed information concerning (1) medications risks/benefits and (2) the risk of smoking using different types of graphic and numerical formats. In the study by Ruiz et al. (2013), the experimental materials conveyed personal cardiovascular risk information using different formats (e.g., frequencies, percentages). In both studies, memory was assessed while viewing the materials, 15 to 30 minutes later following a distractor task, and two to three weeks later. Both studies observed a rapid decline in verbatim memory during the 15–30 minute period following information exposure. However, gist memory remained relatively high even at the two to three week follow-up. Another study compared the memory of mental health clinicians for detailed versus abstract (gist-like)[4] information contained in

[4]We use the terms verbatim-like and gist-like to differentiate between measures more likely to reflect verbatim and gist memory representations, respectively.

vignettes describing hypothetical patients with symptoms of specific psychological disorders (Witteman & Tollenaar, 2012). Memory was assessed: (1) immediately after reading the vignettes and (2) one week later. Consistent with the other studies, they found that memory for detailed information (e.g., precise diagnosis) was lower when assessed one week after information exposure, but that memory for gist (e.g., global description of the type of problem, such as a problem in parent-child interactions) was higher when assessed after the one week delay. Thus, findings from all three studies support the prediction that gist representations are retained in memory longer than verbatim representations (dozens of lab studies support this prediction). This result is important because it suggests that individuals' behavior is more likely to be influenced by the gist representations that are formed in response to exposure to health-relevant information (because they are retained longer and accessed more easily) than the verbatim representations (which tend to dissipate quickly over time).

Fuzzy Processing Preference

Five papers reported the results of eight studies relevant to the prediction that the preference for gist-based reasoning over verbatim-based reasoning increases with development and the acquisition of specialized expertise (Evans, Georgian-Smith, Tambouret, Birdwell, & Wolfe, 2013; Feenstra, Ruiter, & Kok, 2011; Krupinski, Graham, & Weinstein, 2013, Reyna & Lloyd, 2006; Witteman & Tollenaar, 2012). Consistent with FTT, Reyna and Lloyd (2006) found that, when evaluating scenarios that described hypothetical patients at different levels of cardiac risk, more experienced physicians processed information more globally (i.e., ignored information not relevant to the decision at hand) than less experienced physicians, making sharper all-or-none distinctions among patients at different levels of risk (i.e., either discharging patients from the emergency department or admitting patients to the intensive care unit rather than "hedging their bets" by admitting patient to an unmonitored hospital bed). In two other studies, Witteman and Tollenaar (2012) examined memory differences among psychologists with different levels of clinical experience. Participants read vignettes describing hypothetical patients with symptoms of specific psychological disorders. As predicted by FTT, more experienced psychologists tended to remember more abstract (i.e., general description of the type of problem), but less detailed, information (i.e., precise diagnosis) from the vignettes than those with less experience.

Another group of investigators conducted three separate studies examining the ability of experts and non-experts to identify the presence of abnormality in images obtained from diagnostic tests (e.g., mammograms) (Evans et al., 2013). These studies showed that experts, but not non-experts, were able to detect the presence of abnormality in an image even when the image was viewed for as little as 250 milliseconds — the blink of an eye. Nonetheless, when the experts were asked to identify the precise area of abnormality within the image, their performance fell to the level of chance. Thus, consistent with FTT, the experts appeared to be processing the visual information in the images globally and intuitively, able to sense when something in an image was wrong, without being able to articulate the cause for their concern.

Another study involving the interpretation of laboratory tests found that pathology residents processed breast biopsy images more globally as they gained experience, taking less time to identify (and focus on) the most relevant areas and ignoring irrelevant areas in the images (Krupinski et al., 2013). Finally, Feenstra et al. (2011) compared the time it took adolescent boys versus adult men to determine whether specific behaviors associated with highway safety (e.g., Being drunk behind the wheel) were good or bad ideas. Again, consistent with FTT, adults responded to questions more quickly than adolescents, suggesting the use of more gist-like, intuitive reasoning, rather than verbatim reasoning which would require a more time-consuming consideration of the possible outcomes that could result from engaging in the behavior.

In summary, the studies reviewed support the FTT prediction that the preference for gist-based reasoning increases with development and the acquisition of specialized expertise. The consistency of these findings across a range of health issues and methodological approaches suggests that they are robust and not methodological artifacts.

Predicted Associations Between Gist-Based Reasoning and Improved Judgment, Decision Making, Behavior, and Health Outcomes

Clinical decision making—Five studies examined issues involving clinician decision making. Three of these studies (Evans et al., 2013; Krupinski et al., 2013; Reyna & Lloyd, 2006) found that greater clinical experience was associated with greater reliance on global, gist-based processing and improved judgment and decision making. Only one study found that gist-based processing might have a detrimental effect on judgment/decision making. In that study (Witteman & Tollenaar, 2012), when a week elapsed between reading clinical vignettes describing hypothetical patients with symptoms of specific psychological disorders and providing diagnoses for the patients, more experienced psychologists, who remembered more of the gist but fewer of the details contained in the vignettes, made judgments that were judged as less accurate than those made by students with little experience. Most of the errors made by the experienced psychologists were gist-like in nature. That is, they were consistent with the gist of the information contained in the vignettes, but did not correspond to a precise DSM diagnostic classification. It remains unclear whether the types of errors made by the experienced clinicians would affect the appropriateness or quality of care delivered to patients. This is an important issue to address in future research.

Finally, Norman et al. (2014) hypothesized that encouraging second-year medical residents to work carefully and consider all the data presented (cuing deliberative, verbatim reasoning) when making diagnoses for 20 hypothetical clinical vignettes would reduce their error rate compared to encouraging them to work as quickly as possible without making errors (cuing more gist-like reasoning). Overall accuracy was about 45% in both conditions. Because residents may have lacked the knowledge needed to support gist-based reasoning, additional insight could be gained by replicating the study with a sample of more experienced physicians.

High risk behaviors—Six studies focused on risky behaviors (i.e., adolescent sexuality, drinking, smoking, speeding). In this context, FTT predicts that gist-based reasoning often

will be associated with risk avoidance and verbatim-based or more precise reasoning will be associated with risk taking. All of these studies found some support for this prediction. However, there were some mixed findings as well. Consistent with the prediction, both Mills et al. (2008) and Reyna et al. (2011) found that measures designed to cue retrieval of gist representations relevant to adolescent sexuality were associated with greater risk avoidance, whereas measures designed to cue retrieval of verbatim representations were associated with greater risk taking. Moreover, Mills and colleagues also asked participants whether they endorsed two gist principles: *No risk is better than some risk* and *Less risk is better than more risk*. The first principle reflects categorical gist reasoning, but the second principle reflects more precise ordinal gist reasoning. Participants were less likely to be sexually active if they endorsed only the categorical principle than if they endorsed only the ordinal principle, 30% versus 61%, respectively, supporting the FTT prediction that gist reasoning, particularly reasoning at the least precise level, increases the likelihood of behaving in ways that avoid unnecessary risks; this effect was replicated by Reyna et al. (2011). Similarly, Reyna et al. (2013) found that first-year college students who endorsed the categorical gist principle: "I have a responsibility to myself to wait until I am legal to drink" were less likely to (1) drink and (2) be harmed (e.g., experience an injury) as a result of drinking. Finally, Baghal (2008) demonstrated that participants who rated smoking as riskier on an ordinal (gist-like) scale were less likely to smoke (i.e., avoided risk) and that this measure predicted smoking status better than a numerical (verbatim-like) measure of perceived risk.

Brown et al. (2013) found only mixed support for the prediction that gist-based reasoning increases risk avoidance. Consistent with FTT, they found that higher scores on a bounded estimate of perceived risk of drinking (designed to capture gist representations) was associated with greater intention to reduce drinking, whereas higher scores on a unitary estimate (designed to capture verbatim representations) was not associated with intention. However, they also found that higher scores on both measures were associated with higher scores on a measure of problem drinking, although FTT predicts that higher scores on a gist (i.e., bounded) measure of risk perception should be associated with lower scores on the problem drinking measure. The difference in this finding from those reported in the earlier studies by Mills et al. (2008) and Reyna et al. (2011) is likely due to differences in how the gist risk representations were measured. In the earlier studies, the gist measures were intentionally constructed to be general and to avoid cuing memories of past risk-relevant behaviors. In contrast, the bounded estimates used by Brown and colleagues, which required participants to place two marks on a line to define the area likely to include their true probability of experiencing adverse outcomes due to drinking (although fuzzier than the unitary point estimates) were still relatively precise numerical estimates (not categories or ranks). Hence, bounded numerical estimates could cue memories of past risk-relevant behavior — perhaps creating the observed positive association.

In the final study focused on a risky behavior, Brown and Gould (2012) found that people who endorsed the gist principle, *Speeding feels unsafe*, prior to a media-based anti-speeding campaign, were less likely to report speeding after the campaign. However, people who endorsed the gist principle, *Speeding is OK on long straight roads*, prior to the campaign, were more likely to report speeding after the campaign. Although the second finding does not support the prediction that gist reasoning increases risk avoidance, the gist principle,

Speeding is OK on long straight roads, may differentiate people who think about speeding in categorical gist terms (e.g., safe versus unsafe) from those who think of it in more qualified (more precise) terms, distinguishing degrees of risk depending on the kinds of roads. This finding exemplifies the care that needs to be taken in clarifying theoretical concepts and in constructing measures that clearly differentiate between levels of gist (e.g., categorical vs. ordinal) and verbatim reasoning.

Patient decision making—Two studies examined issues involving patient decision making. Both found support for the FTT prediction that gist reasoning is associated with improved decision making and adoption of behaviors to reduce health risks. Using a hypothetical scenario that described two medications that reduce the need for cardiac bypass surgery, Hawley et al. (2008) found that gist understanding, assessed by two questions asking participants which of the two medications was more effective/safer, was a better predictor of choosing the medically superior medication than verbatim knowledge (e.g., probability of experiencing a particular side effect). In the other study, Smith et al. (2014) found that better gist understanding, operationalized as participant awareness of the possibility of having a false positive/negative test result, was associated with an increased likelihood of participating in colorectal cancer screening.

Eating disorders—The final study (Lang, Lopez, Stahl, Tchanturia, & Treasure, 2014) was a systematic review and meta-analysis of data from 12 observational studies to determine if a bias toward more local (detailed) over gist processing (i.e., weak central coherence[5]; see Reyna & Brainerd, 2011) might contribute to the development of eating disorders (e.g., anorexia). The meta-analysis found that individuals with eating disorders displayed superior local processing, but poorer global processing, compared to individuals without such disorders. These findings are consistent with the prediction that gist processing is associated with healthier functioning under many circumstances.

In summary, the studies reviewed provide support for the prediction that, compared to verbatim reasoning, gist reasoning is associated with improved judgment and decision making, increased adoption of behaviors recommended to reduce health risks, and improved health outcomes. However, the correlational nature of most research in this section makes it impossible to infer causality. Future studies should use multiple measurement strategies to assess gist and verbatim reasoning as well as mathematical models of underlying processes, including investigating bounded risk estimates, gist principles (differentiating categorical vs. ordinal gist principles), and categorical risk perceptions. Research is needed to better understand the extent to which different measurement approaches tap the same latent concepts. More experiments on health that manipulate gist versus verbatim reasoning are also needed.

Sources of Bias in Gist-Reasoning

Three studies reported findings examining at least one of the four predicted sources of error in gist reasoning (Adam & Reyna, 2005; Reyna & Adam, 2003; Wolfe, Fisher, & Reyna,

[5]Weak central coherence is a cognitive style involving a bias towards processing detailed information at the expense of global integration or gist processing.

2013). Two of these studies examined health care professionals' estimates of teenagers' risk for acquiring a sexually transmitted infection (STI). Both studies used a questionnaire specifically designed to disentangle the four different sources of error predicted by FTT (Reyna & Adam, 2003; Adam & Reyna, 2005). The sample in one study was limited to health educators with specialized training in STI risk (Adam & Reyna, 2005). The sample in the other study included physicians, other health care providers, and medical and graduate students in public health (Reyna & Adam, 2003). To begin, the investigators hypothesized that knowledge deficits would result in mis-estimation of some STI risks (e.g., females have greater biological susceptibility to infection than males) such that individuals with more advanced training specific to STIs (e.g., sexual risk health educators) would be more accurate; this was observed. To assess the effect of conceptually incomplete gist representations, the investigators hypothesized that individuals would overestimate the effectiveness of condoms in reducing the risk of HPV transmission. This hypothesis was confirmed in both studies. Although most respondents probably knew that HPV is spread via skin-to-skin contact, the gist representation of STIs is the "typical" fluid transmission that is blocked with condoms. Because condoms do not cover all areas that may be infected by HPV, however, they provide less protection against HPV transmission.

To assess the effect of errors caused by failure to retrieve relevant information from memory when making judgments/decisions, the investigators manipulated retrieval by asking some risk estimation questions in two formats, a format that "unpacked" the STI category (listing infection types, thereby facilitating retrieval) and a global format that did not provide specific cues. As predicted by FTT's retrieval models (Reyna & Brainerd, 1995, 2011), participants in both studies provided higher, and more accurate, numerical risk estimates when the question provided more retrieval cues.

Finally, to assess the effect of errors caused by processing interference due to overlapping classes (e.g., having or not having a disease, testing positive or negative for the disease), the investigators gave respondents information concerning the prevalence of a disease in the general population (e.g., 10%) and the sensitivity and specificity of a diagnostic test (e.g., 80%). They then asked respondents to choose the probability that a person who tested positive for the disease did in fact have the disease from the options of 30% or 70%. Although this question provided all the information needed to answer correctly, over two-thirds of participants in both studies indicated that the probability of disease given a positive test result was 70%, rather than the true value of just under 30%. These findings confirm the prediction that processing interference caused by overlapping classes can lead to errors in reasoning, even among individuals with advanced expertise. Similar findings were observed in another study that required participants to estimate the risk of various outcomes that required combining information about (1) the probability of having a genetic mutation that increased the risk of breast cancer (BRCA) and (2) the probability of developing BRCA (Wolfe et al., 2013). (For detailed processing assumptions, including the role of gist, see Reyna & Brainerd, 2008).

Together, findings from these studies support the FTT prediction that errors in gist reasoning can arise from the four sources identified. It follows that interventions designed to reduce or

eliminate these sources of bias will have beneficial effects on health behavior and decision making. We review evidence concerning this prediction in the next section.

Effectiveness of Interventions Designed to Facilitate Gist-Based Reasoning

As shown in Table 3, 15 studies examined the effectiveness of interventions designed to facilitate gist-based reasoning. The types of interventions evaluated are quite diverse.

Cognition and social adjustment—In a randomized controlled trial, Hogarty et al. (2004) compared the effects of cognitive enhancement therapy (CET) on cognition and behavior to state-of-the-art enriched supportive therapy in a sample of symptomatically stable patients with schizophrenia or schizoaffective disorder. As the authors described, CET "attempts to facilitate the attainment of adult social cognitive milestones, such as perspective taking and social context appraisal, by shifting an alleged early developmental reliance on effortful, serial, and verbatim (concrete) cognitive processing to a more "gistful," spontaneous abstraction of social themes through structured but unrehearsed in vivo social interactions" (p. 868). Positive effects of CET on measures of neurocognition and processing speed were evident after 12 months of treatment. At the end of the 24-month treatment program, positive effects were also observed on measures of cognitive style, social cognition, and social adjustment. Most of the positive effects observed were sustained one year after treatment ended (Hogarty, Greenwald, & Eack, 2006).

Gist reasoning—Four other studies (three using experimental designs) evaluated the effects of a gist reasoning intervention developed to train people how to develop a deeper understanding of complex information by abstracting gist meanings. As described by the investigators, "Skills addressed included higher-level cognitive strategies such as eliminating unimportant information (i.e., strategic attention), abstracting information in one's own words (i.e., integrated reasoning), generating multiple interpretations and perspectives (i.e., elaborated reasoning), coming up with the personally applicable 'take-home' messages, and applying new learning to create novel individually relevant ideas (i.e., innovation)" (Cook, Chapman, Elliott, Evenson, & Vinton, 2014, p.4). This program demonstrated positive effects on gist reasoning among: adults with traumatic brain injury (Vas, Chapman, Cook, Elliott, & Keebler, 2011), adolescents with traumatic brain injury (Cook et al., 2014), and cognitively normal older adults (Anand, Chapman, Rackley, Keebler, Zientz, & Hart, 2011; Chapman et al., 2015). Chapman et al. (2015) also found beneficial effects of treatment on cerebral blood flow and functional connectivity in the default mode and central executive networks. Each of these studies used very small samples, however, ranging from 20 to 37. Therefore, more research is needed to assess the generalizability of the promising findings.

Decision-making and behavior—In a randomized controlled trial (N=734), Reyna and Mills (2014) used FTT to create a "gist-enhanced" version of an existing sexual education program, Reducing the Risk (RTR; Hubbard, Giese, & Rainey, 1998; Kirby, Barth, Leland, & Fetro, 1991). The "gist-enhanced" version of the program (RTR+) covered the same topics included in the original program, but also included activities that emphasized framing sexual decisions in categorical ways (e.g., even small risks add up over time). This was accomplished by promoting: extraction of the bottom-line gist associated with each class

activity, automatic retrieval of relevant values and reasoning principles, and automatic application of values and reasoning principles to gist representations. The RTR+ curriculum produced positive effects on 17 of the 26 outcomes examined relative to a control group that received communication skills training unrelated to sexual health. For nine of the outcomes, effects in the RTR+ group were also significantly greater than those observed in a group that received training using the original RTR curriculum. Perhaps most important, at the end of the 12-month follow-up period, 9.5% of participants in the RTR+ group reported having initiated sexual activity since baseline, compared to 18.9% and 15.9% in the communication skills and RTR groups, respectively.

FTT was also used to augment standard approaches in two randomized controlled trials evaluating an intelligent tutoring system, BRCA Gist, designed to educate users about breast cancer and genetic risk for this condition (Wolfe et al., 2015). The BRCA Gist tutor emphasizes the formation of gist representations that are consistent with the bottom-line meaning of the information presented, rather than memorization of verbatim information. For example, the program emphasizes that only women with a strong family history of breast cancer are good candidates for genetic screening and that most women who develop breast cancer do not have relevant genetic mutations. Thus, the developers of the BRCA Gist tutor hypothesized that it would enable users to: better discriminate among women at different levels of genetic breast cancer risk (low, medium, high); make more appropriate testing recommendations for women at different levels of risk; and decrease personal interest in genetic testing, since few women are at high risk for genetic susceptibility to breast cancer. Both studies found that the BRCA Gist tutor produced greater improvements in breast cancer knowledge relative to two control groups — one that reviewed breast cancer materials available on the NCI website and one that completed an unrelated nutrition tutorial. The BRCA Gist group also exhibited better gist comprehension than either control group. On the remaining outcomes, the BRCA Gist group consistently outperformed the Nutrition Tutorial control group and often outperformed the NCI website control group. However, differences between the BRCA Gist and NCI groups were not always significant on all measures across studies (see Fisher et al., 2013; Wolfe et al., 2015).

Patient and clinical decision-making—Three studies evaluated medical decision aids. First, Fraenkel et al. (2012) used FTT to develop a web-based, decision support tool to inform patients with rheumatoid arthritis about the risks and benefits of biologic therapy. The tool promoted accurate gist representations by emphasizing qualitative contrasts concerning treatment risks and benefits, and aligning information to simple values (i.e., gist principles). Using a pretest-posttest design, the investigators found that the tool increased knowledge, value clarity, willingness to take a biologic, and the percentage of patients making value-concordant decisions, which increased from 35% to 64%. Second, Smith et al. (2015) used a randomized controlled trial design to evaluate the effectiveness of a 3-page leaflet, *The Gist*, designed to inform the public about colorectal cancer. *The Gist* leaflet emphasized the bottom-line gist that screening is an effective way to reduce colorectal cancer risk, but did not include persuasive messages encouraging screening. Compared to a control group who received a 15-page booklet about colorectal cancer used by the English National Health Service Bowel Cancer Screening Program, those who also received *The*

Gist leaflet were more likely to exhibit adequate knowledge. The two groups did not differ on a measure of behavioral intention, however. Third, Lloyd and Reyna (2001) found that a web-based tool designed using FTT reduced information processing errors caused by overlapping classes (i.e., the probability of testing negative for a disease, the probability of having the disease) when used by medical students and residents to estimate the post-test probability of disease given a negative test result.

Physical and mental performance and weight loss—Last, three experimental studies examined the hypothesis that providing individuals with vague, rather than precise, information about themselves (e.g., describing the amount of a performance enhancing substance consumed as falling somewhere within a range, rather than providing the exact amount consumed) would result in improved performance, including behavioral change (Mishra, Mishra, & Shiv, 2011). This hypothesis was based on the assumption that vague information allows people to form self-enhancing gist representations (e.g., representations of the information that reflect the most favorable interpretation of a person's potential to reach a goal) and that these self-enhancing representations can boost subsequent performance. The hypothesis was confirmed in all three experiments. Individuals who received vague information about their abilities and potential performed better on tests of mental acuity and physical strength and attained a more desirable weight. The investigators also demonstrated that the relative advantage provided by vague information disappeared in the presence of an accuracy prime designed to make it difficult for participants to distort the vague information in a self-enhancing manner. Thus, contrary to conventional wisdom, these results are "in praise of vagueness" as a tool for behavior change, per the title of the article.

Summary—The findings reported above support FTT's prediction that, compared to traditional intervention approaches, interventions designed to facilitate gist-based reasoning will often result in: better decision-making, increased adoption of behaviors recommended to reduce health risks, and improved health outcomes. Most of the studies used randomized controlled trial designs. Although the samples in some of the studies were small, the consistency of findings across studies examining diverse health issues and using different intervention strategies to facilitate gist-based reasoning add credence to the robustness of the findings reported.

Other Studies

The remaining 37 studies did not report findings relevant to the specific predictions evaluated. Information concerning these studies is provided in supplementary materials online.

Discussion

This literature review supports the emergence of FTT as a generative theory in health behavior research in the sense that it has generated research about new and surprising ideas (e.g., that vagueness can have a salutary effect on health behaviors). The theory is also generative in the sense that it is predictive, having been spelled out in specific processing models that have begun to be tested in health contexts. Seventy-nine studies, over half

published since 2012, have used FTT, or central constructs from the theory, to better understand the determinants of health behaviors or to develop interventions that promote the adoption and maintenance of recommended behaviors. These studies span a wide variety of health conditions and populations, including adolescents and adults, as well as health care professionals. Forty-two of the studies addressed the specific predictions derived from FTT that were evaluated in this review. Findings from these studies provide considerable support for all of the predictions. Nevertheless, there are gaps, ambiguities, and some conflicting findings in this growing literature, as we discuss below.

First, as predicted, people appear to form *distinct* verbatim and gist mental representations when exposed to health-relevant information; for example, gist representations were retained in memory longer than verbatim representations. Moreover, the types of representations retrieved from memory could be manipulated by varying cues in questions and stimulus materials. Second, preference for gist-based reasoning over verbatim-based reasoning increased with development and the acquisition of expertise. Third, findings from most of the studies also supported the prediction that, compared to verbatim-based reasoning, gist-based reasoning is associated with improved judgment and decision making, and increased adoption of behaviors recommended to reduce health risks. In addition, predicted sources of bias in gist reasoning (i.e., inadequate knowledge; incomplete gist representations; failure to retrieve relevant knowledge, representations, and values when making decisions; and processing interference caused by overlapping classes) were also observed. Thus, gist reasoning is not without perils. Finally, we found considerable support for the prediction that, compared to traditional intervention approaches, interventions designed to facilitate gist-based reasoning result in improved judgment and decision-making, increased adoption of behaviors recommended to reduce health risks, and improved health outcomes.

The observation that cues in questions and response options affect the memory representations retrieved when responding has important implications for the measurement of many constructs central to health psychology, including health beliefs and attitudes. As the specificity of the measure and precision of the response scale increases, respondents are more likely to retrieve relevant verbatim memories when providing a response. When answering more general (but meaningful) questions, however, respondents are more likely to retrieve gist representations; these verbatim/gist cuing effects are consistent with FTT's recognition models (e.g., see Brainerd & Reyna, 2005; Reyna & Brainerd, 2011). As demonstrated in several studies reviewed, these differences in question format can alter the relationship between measures of risk perception and behavior (Baghal, 2011; Brown et al., 2013; Mills et al., 2008; Reyna et al., 2011).

Although effects of question format were generally consistent with FTT's predictions, expected reversals of correlations were not always found. Future research should systematically vary the precision of the cues (e.g., from exact numbers, ranges of numbers, ranks to categories) and assess the precision of the memories that are retrieved in response to these cues for a variety of health judgments (e.g., perceived diabetes risk, cardiovascular risk). Because all of the reviewed studies were conducted within the context of unhealthy risk taking, more research is needed to determine if the findings extend to measures of other types of risk perceptions (e.g., perceived susceptibility to illness) and to other constructs

included in traditional theories of health behavior (e.g., perceived benefits/barriers of adopting recommended precautions).

Further, although innovative methods have been developed to measure verbatim and gist representations as distinct constructs and to separate the effects of different sources of bias that affect risk judgments and interfere with reasoning, more explicit methods for measuring gist in the context of health psychology are needed. For example, measures of ideal or informed gist representations need to be distinguished from normative measures (i.e., what most patients who are not experts would extract as the gist of a health communication). More research is also needed to examine the effects of gist versus verbatim processing among older adults, the largest consumers of health-related products (Reyna & Brainerd, 2011). In addition, specialized techniques used in basic science research can be applied to measure verbatim and gist representations relevant to health decisions (e.g., a set of procedures and models called "conjoint recognition," which is not the same as conjoint analysis; see Reyna, 2012).

Effective gist reasoning requires being able to distill complex information to identify the essential bottom-line meaning. The medical laboratory studies by Evans et al. (2013) and Krupinski et al. (2013) also highlight the global (gist-like) information processing strategies that experts use when processing complex information — allowing them to sense that something in an image from a laboratory test is not quite right, without being able to identify the precise location of the abnormality. Although expertise is not an experimental manipulation, research on FTT has used experimental manipulations to mimic predicted effects of expertise (Reyna et al., 2014).

Similarly, effective gist reasoning in other areas requires that individuals have adequate knowledge to support health judgments and decisions (Reyna & Adam, 2003). However, knowledge of facts is not enough. Instead, teaching adolescents intuitive recognition of high-risk situations and strategies to avoid risk is likely to reduce risky behavior (e.g., Reyna & Mills, 2014). Effective gist reasoning also requires that individuals: have fully developed gist representations (i.e., understand the bottom-line gist associated with major options); retrieve relevant values and reasoning principles from memory at the time decisions are being made; are able to process available information intuitively, with minimal interference from unnecessary, detailed verbatim information; and can inhibit impulsive choices (Reyna, 2008, 2012).

These findings have important implications for the design of interventions to promote the adoption of behaviors to reduce health risks and improve individual and population health outcomes. FTT suggests that health interventions should emphasize the bottom-line gist of the information being conveyed. Doing this requires organizing the information and deciding what is important, not just shortening the message. The developer of the intervention must determine if there is consensus among clinical experts and experienced patients about the gist of the options, which, in practice, often occurs (Fraenkel et al., 2012). If consensus cannot be reached, the major alternative interpretations of the gist of the options must be presented. This guards against the introduction of bias and infringements on individual autonomy. Gistifying a health message means that some facts are cut entirely (because they

are trivial), others recede into the background as less important, facts are interpreted and connected with one another so that overarching patterns and high-level (macro or integrative) inferences are foregrounded, and the purpose of the message—its functional significance—drives this process and is transparent.

To the extent that different message and graphical formats have differential effects on verbatim knowledge versus gist understanding, those that favor gist understanding are likely to have the greatest impact on improving decision making. In addition, because knowledge, values, gist representations and reasoning principles that are stored in memory will not impact decision making unless they are retrieved when decisions are being made, FTT suggests that interventions should include retrieval cues and other strategies that promote automatic (i.e., without conscious deliberation) responding in high-risk situations. Role-playing activities using common scenarios that differ in details may be helpful to achieve this goal of automatization (Reyna & Mills, 2014). Finally, when developing interventions, it is important to understand misconceptions that exist in the target population (e.g., only women get breast cancer) that may interfere with appropriate gist processing. Unless fundamental misconceptions are recognized and addressed, it is unlikely that individuals will be able to extract an accurate bottom-line gist.

In conclusion, by drawing on research on basic cognitive processes, FTT provides insights into how individuals make judgments and decisions that are supported by carefully controlled laboratory experiments. These insights seem to generalize to health decisions. FTT suggests a need for intervention approaches that facilitate intuitive, gist-based information processing. This review supports the development of such applications as a promising area for future research.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Table 1

Guidelines for Identifying the Gist of Health Decisions and Assessing Gist Comprehension

	Step	Explanation
1.	Differentiate between gist and verbatim representations of decision options.	The verbatim representation consists of the literal details about the decision options, such as lists of facts and figures. The most basic gist representation of decision options captures the essential meaning or bottom line of decision options. Multiple gist representations are typically encoded at different levels of precision, beginning with the most basic level of categorical representations (e.g., Surgery has *some* risk of death as opposed to no risk), and moving to more differentiated levels of precision, such as ordinal representations (e.g., Surgery has a *lower* risk of death than not having surgery).
2.	Elicit the essential meaning, or bottom line, of decision options from informants with relevant expertise and experience that provides insight, usually clinical experts and experienced patients.	Gist is a simple, imprecise summary of the main points of information, as defined in psycholinguistics (e.g., Clark & Clark, 1977). Thus, gist involves distinguishing details from the main points—what is important for making a decision. Prescriptive gist—what an informed decision maker would take to be the gist—should be distinguished from psychologically descriptive gist—what a decision maker with limited experience, knowledge, or insight would take to be the gist of the options. Example: "The important thing is to make sure the public understands that there is no substantial risk from vaccines and that the benefits are very significant" (Ben Carson, February 12, 2015, The Florida Times-Union).
3.	Determine whether there is consensus among clinical experts and experienced patients about the gist of the options, which, in practice, often occurs (e.g., Fraenkel etal., 2012).	If consensus is not possible, identify major alternative interpretations of the gist of the options; present each of these to patients.
4.	Verbatim representations can be assessed through recall or recognition tests for resented information, or through rote computation (e.g., reading off a number from a bar graph).	Passing verbatim tests does not establish understanding because they can be passed by retrieving memorized information. "Informed" consent in current practice typically involves passing tests of verbatim recognition (e.g., Lloyd et al., 2001).
5.	In contrast, gist representations should be assessed by testing comprehension, inference, or transfer (i.e., extrapolating beyond memorized information to demonstrate learned knowledge with materials that differ superficially from presented information).	Understanding the basic gist of risk involves distinguishing functionally significant categories: Does a 2% risk of death from surgery involve no risk or some risk, low risk or high risk?; Will death probably happen or probably not happen?; Is death certain or uncertain? Example: "The marking scheme was designed to capture whether participants had encoded gist representations of the numbers such as whether the numbers were increasing or decreasing (i.e., "screening reduces bowel cancer deaths"), or whether the magnitude of the difference between numbers is large or small (i.e., "screening only saves a few lives")" (p. 5, Smith et al., 2014). According to FTT, informed consent requires passing tests of qualitative comprehension, inference, or transfer of basic gist.