5

Fuzzy trace theory

Memory and decision-making in law, medicine, and public health

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The way that information is encoded and processed in working memory, and then stored and retrieved from long-term memory, has implications not only for memories themselves but also for decision-making. Fuzzy trace theory (FTT), a dual-process theory of memory and decision-making, makes predictions about the ways information is mentally represented in working and long-term memory and how the type of representation relied on when making decisions influences decision-making and the outcomes that flow from those decisions.

Specifically, FTT posits that when most adults hear information, they encode both the literal information (referred to as the verbatim information) (e.g. the precise statistical risks and benefits associated with having a particular surgery or the height of a person observed committing a crime) and the 'gist' of the information. Gist is the bottom-line meaning that people extract from information, and can be encoded at varying levels of abstraction, from more precise ordinal distinctions (e.g. I am more likely to avoid a negative outcome if I have surgery than if I do not; the person I saw was taller than me) to less precise categorical distinctions (e.g. there is a nontrivial risk of serious long-term harm if I do not have the surgery that can be avoided by having the surgery; the person I saw was huge).

The form of mental representation used when recounting experiences and when drawing on information to make decisions has implications for both what is remembered and how decisions are made. For example, the representations that a decision-maker relies on regarding outcomes and their likelihoods (e.g. 'it only takes once' to contract the human immunodeficiency virus (HIV) from unprotected sex), combined with the values they apply to those representations (e.g. contracting HIV is bad), have been shown to influence their decisions regarding risk (Reyna, 2021). Note that, in the spirit of Baddeley (2000), who has influenced our work, the concept of 'memory' representations applies to situations in which people fully remember presented information or even when the information is displayed in front of them.

In this chapter, we begin by introducing the basic tenets of FTT, describing how these tenets have been supported in rigorous experimental and mathematical tests, highlighting how these tenets distinguish FTT from other related theories, and

outlining some general implications of these tenets for policy in applied contexts. We then discuss how insight provided by FTT can improve the way that we address a range of specific practical problems in society. First, we examine the FTT-informed conjoint recognition and other 'phantom' memory paradigms and their importance in assessing memory accuracy and in designing procedures to enhance memory accuracy in criminal investigations. Next, we review FTT's predictions relating to how people evaluate evidence (including numerical evidence) and use this evidence to form conclusions. We review the ways in which this work can help us to understand and improve evaluations of evidence and related judgements in a range of contexts including enhancing understanding of medical test results, helping civil juries appropriately translate judgements of harm severity into damage awards, and helping people more effectively identify and discount misinformation and disinformation. Finally, we examine FTT's predictions relating to decisions under risk. We describe how FTT predicts and explains rational and technically irrational (but typically adaptive) decisions, specifically the risky-choice framing effect, and show how understanding the influence of mental representations on decisions under risk can help us to understand and improve a variety of decisions including decisions as to whether to plead guilty in criminal trials, decisions as to whether to engage in crime, and decisions as to whether to have unprotected sex. We conclude by discussing why evidence-based theory is more informative regarding practical solutions to applied problems than are empirical results that are not motivated by questions of mechanism.

Introducing fuzzy trace theory

Origins and the independence of gist and verbatim memory

FTT is a dual-process theory of memory and decision-making. Its core concepts are informed by work in psycholinguistics, where the distinction between verbatim and gist, discussed above, was first established (e.g. Kintsch, 1974). However, that literature considered gist memory as being derived from verbatim memory, that people extracted gist from verbatim memory and then discarded verbatim information (e.g. Clark & Clark, 1977). FTT adopts the distinction between gist and verbatim, but rather than assuming that gist is extracted from verbatim, FTT predicts—and evidence supports—that gist and verbatim are encoded, stored, and retrieved separately (Reyna, 2012).

   The claim that gist and verbatim memories are encoded, stored, and retrieved separately has been tested and supported across multiple experiments seeking to isolate verbatim and gist memory (e.g. Reyna & Brainerd, 1995). For example, research examining memory for narrative sentences has shown that memory for presented sentences (verbatim memory) and for inferences that can be drawn from those

sentences (gist) are stochastically independent from each other. In other words, memory for gist does not depend on memory for verbatim (see Reyna & Kiernan, 1994; 1995; Singer & Remillard, 2008). For example, in experiments with children and with adults, participants were asked to remember specific sentences (e.g. the bird is in the cage, the cage is under the table, the bird has yellow feathers) and then later were asked to indicate which exact sentences they remembered. Recognition of the sentences (e.g. the bird is in the cage) was found to be independent of systematic misrecognition of true inferences (e.g. the bird is under the table) (e.g. Reyna & Kiernan, 1994).

Research has also shown that gist can be encoded in the absence of full verbatim encoding (e.g. participants can remember themes from a word list even when it is presented too fast for individual words to be encoded; see Brainerd & Reyna, 2005) and verbatim can be encoded in the absence of gist (e.g. when meaningless syllables are presented; Brainerd, et al., 1995). The independence of gist and verbatim memories has also been tested and supported through the use of mathematical models (Reyna & Brainerd, 2011; Stahl & Klauer, 2008, 2009).

This independence result shows that verbatim and gist representations differ and both are required to explain behaviour. However, the effect can be manipulated per FTT by varying the cues in questions (e.g. whether presented information is provided on the test) and the context (e.g. delay between study and test): When participants perform a short 'buffer' task between sentence presentation and test, *independence* is observed. When the test occurs immediately and verbatim stimuli have been repeatedly studied, *negative dependence* is observed; gist-consistent inferences are rejected based on recollecting verbatim stimuli. When a longer delay occurs between study and test (e.g. a week), *positive dependence* is observed; both gist-consistent inferences and verbatim stimuli are accepted based on consistency with gist (semantically *in*consistent sentences are still mainly rejected). All three relationships—independent, negative, and positive—have been observed for the identical stimuli and even for the same participants under theoretically specified conditions.

In fact, FTT predicts that gist-consistent false memories (never-presented stimuli) will be better 'remembered' than true memories (presented stimuli) under specific conditions, a counterintuitive result that challenges widespread assumptions about memory (Brainerd & Reyna, 1998). In this connection, Wixted and Roediger (Chapter 4, this volume) assert that 'the key assumption of signal detection theory' is that 'because the innocent suspects do not correspond to the perpetrator (and therefore do not usually provide a strong match to the witness's memory of the perpetrator), the mean of the innocent suspect distribution is relatively low. For guilty suspects, everything is the same except that the mean of the distribution is higher because the guilty suspect provides a better match to the witness's memory of the perpetrator.' In other words, false memories—what was not witnessed—cannot be stronger than true memories of what was witnessed. However, per FTT, the mean of the false

memory distribution significantly exceeded the mean of the true memory distribution for 106 of 617 data sets on recognition memory (most reported in Brainerd & Reyna, 2018). The effect varied predictably as a function of the accessibility of gist memories. This theoretically predicted violation of a key assumption indicates that the scope of memory theories must be expanded to include gist as well as verbatim memories.

Other core concepts

Other tenets of FTT concern the characteristics of gist and verbatim memory, and associated decision-making. Understanding these tenets can help us understand both what people are likely to remember and how they are likely to draw on memories when making decisions. Four core tenets with particular relevance to policy are discussed below: intuitive decision-making is distinct from 'hot' or 'fast' decision-making, there is a developmental trajectory from reliance on more verbatim memory to more gist memory, task characteristics can determine reliance on gist or verbatim memory, and individual differences can determine reliance on gist or verbatim memory.

Intuitive decision-making is distinct from 'hot' or 'fast' decision-making

Although FTT is characterized as a dual-process theory, it differs from traditional dual-process theories. Traditional dual-process theories rely on a distinction between 'type 1' and 'type 2' processes to explain decision-making. Type 1 processes are fast and intuitive whereas type 2 processes are slow and deliberative (e.g. Evans & Stanovich, 2013; Kahneman, 2011). These theories are termed 'default interventionist' since type 1 processing is often seen as the default method of processing, that can be overridden by higher-order type 2 processing (Kahneman, 2011; but see also Barbey & Sloman, 2007). FTT distinguishes intuitive thinking from 'fast' thinking, separating the role of impulsivity (or lack of inhibition) from the role of intuitive (as opposed to detailed) cognition, which is determined, according to FTT, by the type of memory representation relied on. Thus, according to FTT, inhibition per se is not a reasoning mode, but instead acts to withhold thoughts or actions (Hare et al., 2008; Reyna & Brainerd, 2011).

Work drawing on FTT has therefore recognized three distinct components important in the decision-making process—rewards and other motivational benefits (which might be termed a 'hot' influence), inhibition (which might be termed a 'cold' influence), and memory representation relied on (gist or verbatim) (Reyna, Wilhelms, et al., 2015).

There is a developmental trajectory from reliance on more verbatim memory to reliance on more gist memory

The recognition that reliance on gist is distinct from 'hot' or 'fast' cognitive processes relates to another central tenet of FTT. While traditional dual-process theories typically expect reasoning to become more analytical and less intuitive with age (e.g. Stanovich et al., 2008), FTT recognizes reliance on gist memory as being

developmentally advanced (Reyna & Brainerd, 2011). Both verbatim- and gist-based abilities have been found to develop during childhood, alongside an increasing preference for reliance on gist (Brainerd et al., 2011; Reyna & Farley, 2006).

According to FTT, reliance on gist memory is advanced and increases with age (i.e. experience) and with expertise, meaning that decision-makers increasingly rely on simpler but more meaningful distinctions (see, e.g. Reyna & Lloyd, 2006). This recognition allows FTT to predict systematic developmental reversals in both memory (Brainerd, et al., 2011) and decision-making (e.g. Klaczynski & Felmban, 2014; Morsanyi et al., 2017; Reyna et al., 2014; Reyna & Ellis, 1994). Put simply, where the development of false memories or systematic biases are the result of reliance on gist, FTT predicts developmental reversals.

Thus, for example, FTT predicts developmental reversals in risky-choice biases, namely, that children are less biased than adults: that is, children do not reverse their preferences for risk when the same net outcomes are described as gains versus losses (Reyna & Farley, 2006). However, adults do show such a bias that has been linked to gist thinking, preferring to avoid risk for gains (e.g. winning prizes) but to seek risk for losses (e.g. losing prizes from an initial endowment of 'house money' such that outcomes feel like losses but they are actually equivalent net gains). Moreover, showing these gist-based 'framing' biases is associated with healthier real-world risk-taking and lower levels of criminal behaviour (Reyna, Estrada et al., 2011; Reyna, Helm et al., 2018). Although traditional approaches to rationality emphasize trading off the magnitudes of reward (number of prizes) against magnitudes of risk—precise and objective verbatim analysis—research using eye-tracking data suggests that *younger* people (adolescents) are more likely to process decision options in this precise and balanced way than adults; they acquired more information than adults in a more thorough manner than adults, engaging in trade-offs prior to making a decision (Kwak et al., 2015). As predicted by FTT, adults are less likely to trade-off magnitudes of risk and reward, instead relying on categorical gist, such as 'it only takes once' or 'winning something is better than maybe winning nothing'. In an independent but dramatic demonstration of this theoretical principle that more advanced thinkers are less likely to rely on risk–reward trade-offs, Decker et al. (1993) showed that criminals' willingness to offend varied 'rationally' as a function of level of risk and reward (though not penalty), whereas matched controls were unwilling to offend regardless of the magnitudes of risk and reward.

As a corollary of the developmental trajectory from reliance on verbatim to reliance on gist, adults are thought to have what is known as a fuzzy-processing preference in decision-making, meaning that they will rely on the simplest gist possible to make a decision (e.g. if two options are distinguished from one another on a categorical level, they will rely on this distinction; if not, they will move to consider any ordinal distinction, and so on; see figures in Reyna, 2012). This preference is the opposite of that which would be predicted by information processing theories, which assume that elaborate reasoning proceeds until excessive cognitive load forces simpler processing (Reyna & Brainerd, 2011).

Task characteristics can determine reliance on gist or verbatim memory

Although FTT predicts a developmental trajectory from reliance on more verbatim memory to reliance on more gist memory, the memory relied on can also be influenced by specifics of a task that a decision-maker is presented with, at least when gist and verbatim representations of information are both accessible. This prediction is important from a policy perspective, since policymakers may have the ability to control the specifics of the task that a person is facing, and in this way shift the type of memory that this person is relying on (Thaler & Sunstein, 2008). First, a task can require reliance on either gist or verbatim mental representations. For example, if a person is asked to remember exact words or numbers that do not have particular meaning (e.g. remember the number 137), this will push them to rely more on verbatim representations.

A person will also be pushed more towards verbatim processing when asked to choose between two options that have the equivalent gist. For example, a person faced with a decision of whether to plead guilty or go to trial might know that both plea and trial involve a short custodial sentence. Therefore, to decide whether to plead guilty or go to trial, a person would have to consider more fine-grained information (e.g. 2 months vs 3 months). Decision-makers considering narrative information (e.g. jurors considering a legal case) can be encouraged to rely on gist by presenting information in a 'story' format, giving clearer meaning to information and facilitating the extraction of gist, as opposed to a scrambled or arbitrary order (see Dewhurst et al., 2007; Pennington & Hastie, 1992; Reyna & Brainerd, 1995). When plea options differ qualitatively (e.g. non-felony vs felony conviction), as with other decisions, this, too, elicits gist-based processing (e.g. Helm & Reyna, 2017). Although we speak of verbatim-based and gist-based processing, FTT assumes all processes occur roughly in parallel and that different processes predominate based on the task (e.g. whether options can be discriminated based on gist) and on the people performing the task (Reyna & Brainerd, 1995).

Finally, reliance on gist or verbatim may be dependent on delay. Gist is more stable over time, and a person will be forced to rely on gist when verbatim memory is no longer accessible (Kintsch, 1974; Reyna & Kiernan, 1994; 1995). However, depending on cues in questions (verbatim or gist content) and the granularity required in responses (ranging from simple dichotomous choice to exact numerical judgements), reliance on gist predominates even when exact information remains visible or when delays are short.

Individual differences can determine reliance on gist or verbatim memory

In addition to age and task characteristics, reliance on gist or verbatim can be determined by individual differences in decision-makers in several ways. First, individual differences may determine the extent to which an individual is able to extract gist from information. (As noted above, where information has no meaning to people, they are pushed to rely on verbatim information.) So, for example, more skilled readers with more background knowledge are likely to be better able to

extract gist from a narrative even when information lacks a clear structure (Van den Broek, 2010).

Second, individual differences in metacognitive monitoring and need for cognition help a person to recognize that two options are equivalent from a verbatim perspective and to override the natural tendency to rely on gist (e.g. Stanovich & West, 2008). (Need for cognition is the desire to engage in effortful cognition, as distinguished from the ability to do so.) For example, a person with a high level of need for cognition is more likely to recognize that gain and loss versions of framing problems are equivalent from a verbatim perspective (because they engage in spontaneous computations and comparisons) and to inhibit their tendency to rely on gist as a result (Broniatowski & Reyna, 2018).

Third, certain individual differences influence the tendency to rely on gist or verbatim representations despite the general fuzzy-processing preference. For example, research suggests that some individuals with autism may be more likely to rely on verbatim memory and less likely to rely on gist memory than their peers (see Reyna & Brainerd, 2011). This prediction is supported by findings showing that autistic individuals are less prone to the risky-choice framing effect (De Martino et al., 2008) and conjunction fallacies (Morsanyi et al., 2010), effects associated with gist-based processing (e.g. Kühberger & Tanner, 2010), and are less likely to draw gist-based inferences (Jolliffe & Baron-Cohen, 2000) and to exhibit gist-based false memories (Griego et al., 2019).

Importance for policy

As described above, FTT makes predictions involving how people encode information in memory, and how people then retrieve this information in order to make decisions. This understanding is important in informing policy in applied contexts (Reyna, 2021). Among other things, it allows policymakers to consider what information people are likely to be relying on and what biases people might be susceptible to when making decisions and to ensure that the way decisions are being made in practice adheres with normative goals in society. It can also help to highlight individuals who may make decisions in a way that is different from that envisioned by policymakers, and to provide necessary interventions to ensure appropriate outcomes for those people and others affected by decisions. In the remainder of this chapter, we discuss specific implications of FTT for identifying and addressing problems in society across a range of applied contexts.

Meaning-consistency, suggestion, and susceptibility to false memory

Being able to assess where a memory is particularly likely to be false (as opposed to real) is important, particularly in the legal context where research suggests that

(1) witness testimony is often important evidence in legal cases (Brainerd, 2013), (2) witness testimony is one of the most convincing types of evidence for legal decision-makers (Semmler et al., 2011), and (3) witness testimony is a key contributor to wrongful convictions (Evidence-Based Justice Lab, n. d.; Helm, 2021c; National Registry of Exonerations, n. d.; see also Toglia & Berman, 2021; Wixted & Roediger, Chapter 4, this volume). Effectively assessing the likelihood that a witness's memory is false (or contains false elements) has the potential to increase the accuracy of convictions and acquittals, and the allocation of responsibility in civil lawsuits. Through introducing the distinction between gist and verbatim memory, FTT provides key insight into the cognitive processes underlying false memory, and, relatedly, cues that are probative in assessing whether a particular memory is likely to be false.

Introducing conjoint recognition

FTT's predictions relating to memory have been tested using what is known as the 'conjoint recognition' paradigm (Reyna et al., 2016). (Recall models have also been developed; see Reyna, 2012.) This paradigm allows the separation and identification of distinct memory processes through a multinomial measurement model.

The model separates three distinct memory processes: identity, similarity, and recollection rejection. First, an identity judgement is essentially recognition of the exact thing seen or heard through retrieving the original verbatim trace and matching it to the test item. Second, a similarity judgement is of meaning consistency with the thing seen or heard, based on the gist trace; although not identical in surface form, the test item agrees with the substance of what was seen or heard. Finally, recollection rejection involves recognizing that an item that is familiar or meaning-consistent with a viewed item is not the viewed item itself; retrieving the original verbatim trace reveals a mismatch between the test item and what was seen or heard (e.g. Lampinen et al., 2006). Instructional conditions allow the isolation of these processes: asking respondents to say yes only to exact items they have seen, asking respondents to say yes to items that are true regardless of whether seen, and asking respondents to say yes only to items that are true that are not the exact item they have seen (Reyna & Kiernan, 1994; Stahl & Klauer, 2008). Examining responses to varying cues across these conditions allows researchers to estimate how memory operates under different conditions, for example, given different cues (recognition probes) and given the accessibility of different kinds of representations. Examining memory in this way is important, since simply analysing whether a memory is true or false does not unambiguously prove its psychological origin (see Reyna et al., 2016) and therefore cannot provide reliable and generalizable insight. This insight is key in understanding false memory; the ability to influence policy is enhanced by rigorous experimental work testing the predictions and conclusions outlined below in a variety of settings.

Mechanisms underlying false memory

According to FTT, false memory can arise in two primary ways: from meaning-consistency in the absence of verbatim retrieval and as a result of external suggestion.

False memory resulting from meaning-consistency

According to FTT, retrieval of both gist and verbatim traces, provided that what is encoded is accurate, support true memory. Both traces help individuals remember events, and both will lead to the correct identification of targets. Although gist and verbatim reinforce each other for true items, they work in opposition to each other for meaning-consistent but unpresented items on verbatim tests (Brainerd & Reyna, 2005; Reyna & Kiernan, 1994). For example, in witness testimony, it is essential to identify an exact individual as opposed to someone who resembles the perpetrator (see Bruce & Burton, Chapter 3, this volume, although the dimensions of meaningful similarity are not fully understood for faces, but see Bartlett et al., 2009). While verbatim memory can generally suppress false memory on such tests, gist memory can promote it. Specifically, retrieval of gist traces supports false memories for similar or meaning-consistent events (although note that in some cases gist memory may be necessary to provide probative information, for example, if a witness is asked whether a person was behaving strangely; see Reyna et al., 2016).

A person remembering the gist of an event may accept a meaning-consistent event (called a 'related distractor' in the false recognition paradigm) as what they have seen as a result of retrieving encoded gist (or reconstructively processing gist in recall), especially when the person does not access the verbatim trace that can suppress this type of false memory through recollection rejection. So, for example, a witness might remember a person they saw as a young blonde woman (gist). If they are then asked whether a different young blonde woman is the person that they saw, they might be susceptible to making a misidentification (i.e. saying yes) as a result of gist-based similarity. However, if they remember the verbatim face of the person that they saw they can use this to recognize that the new woman is not the person they saw, despite gist consistency (Wixted & Wells, 2017). When verbatim memory is not retrieved, gist-based similarity can be strengthened, for example, through repeatedly cueing gist (Reyna, 2000; Reyna et al., 2016). When this happens, false memories that are clear and vivid can arise as a result of strengthened gist memory. This phenomenon is known as *phantom recollection* and it can occur either simply through repeated retrieval of gist (as in repeated discussion or interrogation about a crime) or it can occur because when people process gist, they can recover realistic contextual details that make the memories appear real (Arndt, 2012; Brainerd & Reyna, 2019; Reyna, 2000). For example, the image of a gist-consistent person as an offender might be accompanied by memory for real or imagined details of the crime such as the location, the weather, and the behaviour of a victim or bystanders. The redintegration of veridical or plausible details with vivid gist memories has been well documented (Reyna & Brainerd, 1995). This process can also be exacerbated by asking

what seem to be neutral recognition or recall questions; analogous to the Heisenberg uncertainty principle, merely measuring memory alters it (Reyna, 2000; Reyna et al., 2007). Thus, there is no such thing as testing memory without manipulating it (cf. Wixted & Roediger, Chapter 4, this volume), but there are measurement approaches, such as conjoint recognition, that disentangle these processes.

False memory resulting from suggestion

Verbatim memory therefore generally has a protective effect against false memory for meaning-consistent information, through the process of recollection rejection. One exception to this rule occurs when verbatim memory has been corrupted (Reyna et al., 2016). When external suggestion occurs, people may retrieve verbatim traces of suggestions rather than true events (Brainerd & Reyna, 2019). In this case, verbatim memory would support rather than suppress false memory. Therefore, FTT predicts two distinct types of false memory. First, 'spontaneous' false memory, caused by meaning connections and reliance on gist and, second, false memory arising from suggestion. By recognizing that false memory depends on verbatim and gist retrieval as well as surrounding circumstances, FTT makes a number of predictions that are important for practice and policy.

Eyewitness identifications are predictably unreliable

As noted above, FTT predicts that false memory is likely to occur either as a result of meaning consistency, where gist memory is relied on in the absence of verbatim retrieval, or where verbatim memory is corrupted as the result of suggestion. Memory is therefore compromised in situations where a person other than the offender is meaningfully similar to the offender and verbatim memory is not retrieved, or where verbatim memory has been corrupted.

Whether verbatim memory is retrieved is likely to depend on both the individual decision-maker and the circumstances in which they are being asked to remember witnessed events. Certain characteristics of investigations can make it less likely that witnesses will retrieve verbatim memory, and therefore make it more likely that they will develop false memory for meaning-consistent others. For example, as noted above, verbatim memory is less stable than gist memory (Kintsch, 1974; Reyna & Kiernan, 1994, 1995). As a result, increasing time periods between an event and the retrieval of memory increase the chance that gist will be retrieved in the absence of verbatim, and relatedly the risk of false memory for meaning-consistent others. In terms of the corruption of verbatim memory, corruption may occur where a witness is presented with suggestive information about a case. One common type of suggestion used is suggestive questioning in legal interviews. FTT shows that such questioning increases the risk of false memory and decreases the integrity and reliability of legal investigations.

However, it is also important to note that FTT predicts that spontaneous false memories occur routinely even in the absence of suggestion or time delay. This inaccuracy can arise purely as the result of a line-up procedure, in which a witness is asked to pick out the person they saw from a set of similar looking people. When one person in the line-up is a better match for the gist of the target than the others, the person making the identification will be susceptible to falsely and confidently recognizing that person as the offender. This susceptibility provides an explanation for the low levels of accuracy seen in some experimental research examining memory for faces (e.g. Haber & Haber, 2001) and also for the role of faulty identifications in wrongful convictions in practice (see National Registry of Exonerations, n. d. For an example of a wrongful conviction resulting from inaccurate witness identification, see the case of Ronald Thompson; O'Neill, 2001).

Although fair line-ups and using 'pristine' procedures for memory interrogation can reduce gist-based misidentifications (Wixted & Wells, 2017), it is important to recognize that meaning-based processing occurs from the onset of police investigations (e.g. witnesses use knowledge and prejudices to point a finger at plausible suspects) to later testimony under oath, often after substantial delays. Testimony encompasses many memory reports beyond face recognition judged with line-ups, such as what, when, and where a crime happened and what victims, bystanders, and suspects did or said. To exhort the legal system to ignore any evidence gathered after an initial memory test and then include evidence only from fair line-ups composed of unfamiliar participants (see Wixted & Roediger, Chapter 4, this volume), is not only unrealistic but it can lead to miscarriages of justice. To take just a handful of examples, an 'initial' memory test can occur days, weeks, months, or years after a crime, all of which are not immediate and thus likely to draw on memory for gist. Witnesses can recant initial statements under cross-examination at trial because it is revealed that their confidence was never high or they had an axe to grind with respect to the defendant or they misinterpreted the gist of events, as examples, that a victim was 'attacked' or that a defendant had a fearful expression; such judgements are rife with gist-based processing that cannot be dismissed simply because they contradict initial statements.

Witnesses with false memory can be confident

The phenomenon of phantom recollection explains findings in the literature whereby people report memories confidently and in detail that are known to be false (e.g. Ceci et al., 1994; Loftus, 2003). The fact that people can have confident and vivid false memories is important in the legal system because some jurors still believe that eyewitness identifications are especially likely to be accurate when accompanied by statements of strong confidence (Brainerd & Reyna, 2019). Research has shown that laypeople are significantly less likely than experts to endorse the idea

that confidence can be influenced by factors other than memory accuracy (Benton et al., 2006; Helm, 2021a; Kassin et al., 2001). One study found that almost 40% of laypeople interviewed (but no memory experts) believed that the testimony of one confident eyewitness should be enough to convict a defendant of a crime (Simons & Chabris, 2011). There is therefore a risk that those making important judgements about how to weight memory evidence in the legal system are equating confidence with accuracy and convicting defendants on memory evidence that is weak from a scientific perspective. Although legal procedure can require a warning to be given to jurors that confident witnesses are not always accurate (e.g. a Turnbull direction in England and Wales), further work needs to be done to ensure such instructions are effective in influencing juror knowledge (Dillon et al., 2017; Helm, 2021a).

Recent research has challenged the assumption that high confidence witness iden-tifications are inaccurate, drawing on impressive evidence from laboratory and field studies (see Wixted & Roediger, Chapter 4, this volume). However, as suggested above, the conditions under which confidence is a highly reliable cue are limited. Although those conditions can be enforced to some degree for face recognition, memory in everyday life is frequently based on true and false memories of the gist of events or information. Therefore, understanding how gist memories influence judgements and decisions, and what factors contribute to confidence and accuracy, are all essential for practical applications, such as those in the legal system.

Children are not always less reliable witnesses than adults

Understanding developmental trends in false memory has particular relevance for deciding how to treat reports made by children both generally and when children's accounts conflict with accounts given by adults. FTT suggests that current legal ap-proaches that focus on the comparative reliability of adult memory and unreliability of child memory (e.g. McAuliff et al., 2007) are oversimplified as a result of general-izations across different types of false memory (see also Otgaar et al., 2017).

Although increased responsiveness to suggestion in children is likely to make children more susceptible to false memory arising as a result of suggestion (see, e.g. Bruck & Ceci 1997; Ceci & Friedman 2000), FTT suggests a different pattern in false memories arising spontaneously as a result of meaning-consistency in the absence of verbatim retrieval. Specifically, FTT predicts that false memories of this type (more specifically, false memories resulting from relying on meaningful gist; see Reyna et al., 2016) will generally increase with age (Brainerd et al., 2011). Less reliance on gist as opposed to verbatim representations with age (e.g. Reyna & Ellis, 1994) means that children are less likely to rely on meaning connections among objects that would lead them to allocate them with a common gist (Ceci et al., 2010; Hritz et al., 2015). For example, given a list of common fruits using age-normed vocabulary, children

do not spontaneously rely on the gist of the list as being about fruit; their false memories for unpresented fruit words are lower than those of older participants. A simple instruction noting that the words are examples of fruit is enough to increase false memories for unpresented fruits. Age increases in false memory have been demonstrated in a wide range of experimental work across various contexts (e.g. Brackman et al., 2019; Dewhurst et al., 2007; Fisher & Sloutsky, 2005; Ross et al., 2006).

Drawing on FTT to recognize the more nuanced nature of developmental trends in false memory is important in the forensic context. Children's memory can be the central evidence in investigations and court cases, and is often especially important in cases involving domestic abuse, in which children are frequently complainants or key witnesses. Ensuring that children's memory is not peremptorily dismissed and is properly considered even in the face of competing adult memory is important in maximizing accuracy and fairness in these cases. Adopting a nuanced approach based on theory supported by experimental work is key in avoiding both believing children who are likely to be unreliable and dismissing children making genuine reports. Research has also begun to draw out the policy implications of FTT for ageing witnesses, specifically highlighting the risk that older people remember gist in the absence of verbatim and will therefore be susceptible to false memory based on meaning-consistency (Reyna & Brainerd, 2011). Gist-based processing in ageing may also contribute to sound judgements and decisions in the legal system in the many instances in which literal verbatim thinking is inappropriate (e.g. juries judging whether a 'reasonable' person would have used deadly force to stop a fleeing unarmed shoplifter).

False memory research: benefits to society

Through providing insight into the cognitive mechanisms underlying false memory, FTT can help legal systems more accurately assign probative value to witness accounts and relatedly to achieve greater accuracy in legal convictions. To take one example of many legal cases in which FTT has been applied, Reyna et al. (2002) illustrate how repeated questioning that induced gist processing produced self-incriminating testimony from a defendant who was subsequently convicted of manslaughter. The defendant began with high confidence that the allegations were untrue but ended up believing with high confidence that they were true, apparently contrary to fact. FTT shows that false memory can be complex and can result from distinct processes involving distinct cognitive mechanisms. This complexity highlights the need to move away from procedures allowing reliance on 'common-sense' principles in assessing memory, and towards procedures where decision-makers assessing witness testimony are properly informed about false memory (Brainerd & Reyna, 2019). FTT can help to inform these procedures, including improved methods for interrogating memory (Reyna et al., 2007).

Evaluation of evidence

Through describing how information is encoded in memory and retrieved from memory, FTT also makes predictions about how people encode evidence and draw on it to make decisions, for example, in medical and legal contexts. Understanding how evidence is utilized in decisions increases understanding of these decisions, facilitates evaluation of whether those decisions are consistent with policy goals, and informs interventions where necessary. Below we explore areas in which FTT has informed research that has examined the influence of memory representations (gist or verbatim) on the evaluation of evidence and related decision-making.

Interpretation of medical information

First, through recognizing the distinction between gist and verbatim and the role of gist in developmentally advanced decision-making, FTT has informed interventions to improve comprehension of information relating to health, and associated health judgements (e.g. Reyna, Broniatowski, & Edelson, 2021; for a systematic review identifying 94 studies testing FTT's predictions; see Blalock & Reyna, 2016).

As noted above, FTT predicts that people encode both gist and verbatim representations of information, and that adults tend to rely on gist. However, reliance on accurate gist will only be possible where people are able to understand and extract meaning from information. Where information is meaningless to them, people may fall back on fragile verbatim information. For example, when patients are deciding whether to undergo an unfamiliar procedure, informed choice requires that they accurately understand meaningful differences between their options rather than purely being able to recall precise verbatim statistics (Reyna, 2008). It is therefore important that interventions to help patients are aimed at enhancing their ability to attach meaning to information, as opposed to just providing information. Where patients are not able to extract accurate gist, they will not be able to rely on it, despite the natural tendency to do so. Facilitating reliance on gist through helping patients attach meaning to information is also predicted to be important in avoiding errors in the interpretation of information relating to medical risks, such as probabilities of adverse outcomes.

Note that getting the gist of information in FTT goes far beyond notions of plain language, basic literacy, and numeracy (Reyna et al., 2009). Literate and numerate patients can encode the risk of a disease or treatment when presented with plain language that includes numbers, but that is not the same thing as getting the gist—for example, whether a 20% lifetime risk of invasive breast cancer is high or low (Reyna, 2008). Errors in interpreting numbers can be caused by a lack of knowledge or a failure to encode information accurately. Some of these errors might be

reduced through greater numeracy but not errors that involve failing to get the gist (e.g. Peters, 2020).

In addition, there is another class of errors that is more straightforward to address—errors arising from what is known as processing interference, confusion when information about overlapping classes of events is presented, such as a genetic risk of developing breast cancer and the base rate, or unconditional, risk of developing breast cancer. Base rate neglect is an example of the tendency to give too little weight to the denominator in a probability (e.g. judging 40/100 as being more likely than 4/10; Bar-Hillel, 1980). This processing error is known as a class-inclusion error in FTT and it can be reduced significantly by using two-by-two tables or Venn diagrams to make classes and their probabilities distinct (non-overlapping; Wolfe et al., 2015).

Base rate neglect can have important implications in applied decision-making. Consider the following example:

> The pre-test probability of a disease is 10%. Eighty per cent of people with the disease will test positive and 80% of people without the disease will test negative (i.e. the test has 80% sensitivity and 80% specificity).

Given a choice between 30% and 70%, decision-makers think that the probability that a person who has a positive test result has the disease is relatively high; they overwhelmingly choose 70%. However, the correct answer is closer to 30% because among those who test positive, very few will actually have the disease due to the pretest probability of 10%. These errors are not necessarily resolved by increasing numeracy (Portnoy et al., 2010; Reyna et al., 2009). As a result, even highly numerate people can have difficulty with understanding numerical information such as conditional probabilities. FTT provides a route through which this difficulty can be ameliorated by recognizing the distinction between verbatim and gist, as well as disentangling numerator and denominator information. According to FTT, these errors can be corrected by encouraging decision-makers to rely on gist as opposed to verbatim representations and by presenting diagrams or labels that separate classes of events. Reliance on gist has a protective effect against such mistakes since gist involves understanding the meaning of numbers rather than analytical quantitative calculations that are sensitive to interference (Reyna et al., 2009). Therefore, according to FTT, interventions in this area (e.g. base-rate neglect and conjunction or disjunction fallacies), should not necessarily target precise verbatim details and mathematical ability to reduce class-inclusion biases because people who commit this error are often high in those abilities but should enhance decision-makers' understanding of and reliance on meaningful gist (see Wolfe & Reyna, 2010). This conclusion is consistent with work showing that advanced practitioners in the medical field tend to rely on gist rather than verbatim information in their area of expertise (Lloyd & Reyna, 2009).

Interventions based on FTT have been developed in order to enhance decision-makers' reliance on gist, and as a result promote informed choice and reduce errors in comprehension.

For example, the BRCA Gist (BReast CAncer and Genetics Intelligent Semantic Tutoring) system has been introduced in order to communicate genetic risk of breast cancer to those receiving test results. BRCA Gist is an intelligent web-based tutoring system that uses artificial intelligence to encourage people to form flexible gist representations of numerical information relating to breast cancer risk (Wolfe et al., 2015). BRCA Gist has been shown to be more effective than existing interventions in increasing comprehension relating to breast cancer risk, and thus can play a role in ensuring that patients make informed decisions. Another web-based decision support tool that was developed to promote reliance on gist focused on effectively informing patients with rheumatoid arthritis about complex information about the disease and the need for escalating care after failing traditional disease-modifying antirheumatic drugs. Research showed that this tool improved knowledge, willingness to escalate care appropriately, and the likelihood of making an informed and value-concordant choice relating to care (Fraenkel et al., 2012). The success of these interventions in the medical context has led to suggestions that gist-based interventions might be used in other areas where decision-makers are required to utilize complex information, such as information relating to forensic testing in criminal adjudication (Helm et al., 2017).

Juror damage awards

One area in which people are asked to evaluate evidence to reach decisions is in the justice system. In the US, jurors evaluate case evidence in both civil and criminal cases and reach determinations of responsibility. In the civil context, they are also often required to award damages to the plaintiff in the event that a defendant is found responsible for causing harm to them. Damages awarded by jurors in civil cases are designed to put a plaintiff back in the position they would be in had the harm not been done to them, and cover both pecuniary loss (e.g. loss of income or medical expenses) and non-pecuniary loss (e.g. pain and suffering). FTT has provided important insight into how jurors allocate damages for non-pecuniary loss (Hans & Reyna, 2011), a process that commentators have described as 'rudimentary and elusive' (Greene & Bornstein, 2003). Understanding this process is important in ensuring that the civil jury process is fair to both plaintiffs and defendants, particularly given widespread criticism over the unpredictability of the civil jury (e.g. Hans & Eisenberg, 2010).

The 'Hans–Reyna' model of damage award decision-making outlines FTT-informed predictions relating to how civil jurors draw on evidence, and how that evidence is used to make damage award decisions. As described above, FTT posits

that people encode both gist and verbatim representations of information, and the representation relied upon in decision-making will be determined by the decision-maker (with adults having a preference for relying on the simplest gist they can) and the requirements of the task (with tasks that cannot be resolved through reliance on gist pushing even adult decision-makers towards finer grained distinctions). When considering evidence, jurors are predicted to represent and encode each piece of evidence as gist and as verbatim, and also to represent the body of evidence in a gist-based way (similar to the 'story' predicted by Pennington & Hastie, 1986, 1992) and a verbatim way (a list of specific pieces of evidence; see Kintsch, 1974). Jurors will then generally rely on the simplest gist that they can to complete a given task.

In allocating damage awards, the Hans–Reyna model predicts that jurors will rely largely on gist, making gist-based judgements relating to whether damages are warranted or not (a categorical judgement), and to categorize the level of deserved damages, for example, as low, medium, or high (Reyna, Hans, et al., 2015). To reach a precise damage award, jurors will allocate a precise number to the gist of the deserved damages (e.g. allocating a 'high' number when it is determined that an injury warrants a 'high' level of damages; Hans & Reyna, 2011). This model has implications for jury decision-making. For example, the model provides insight into the mechanisms through which anchors are predicted to influence juries. Anchors are numerical values that can bias decision-makers' judgements in the direction of the anchor value (Bystranowski et al., 2021). According to FTT, the stage of the decision-making process at which precise numbers are relevant is the stage at which a number is allocated to a gist (i.e. when numbers are mapped to low, medium, or high gists). Therefore, one influence of numerical anchors on damage awards will be in influencing which specific numbers are considered low, medium, or high. This influence should be greatest where a number is meaningful, since that meaning will allow jurors to put the size of awards in perspective so they can be understood as low, medium, or high (Reyna, Hans, et al., 2015). This greater influence of meaningful as opposed to meaningless anchors has been shown in a line of experimental work (Hans et al., 2018; Helm et al., 2020; Reyna, Hans, et al., 2015). This work can help inform interventions such as judicial instructions or attorney guidance that utilize anchors to appropriately guide jurors by helping them to contextualize numbers rather than biasing them (Helm et al., 2020).

Information consumption

Recent research has also drawn on FTT in order to further our understanding of how online media platform users decide to act on and share received information (Broniatowski & Reyna, 2020; Reyna, 2021). FTT's approach to the consumption of information online builds on the existence of gist and verbatim memory representations and the fact that, as noted above, adults are generally driven by reliance on gist

representations where possible. Therefore, presented information is most likely to influence opinions when people can extract a clear gist from it (e.g. 'vaccines are safe and effective' or 'COVID-19 vaccine side effects are nil').

One way to facilitate the extraction of gist (and therefore the tendency of individuals to subsequently rely on that gist) is to ensure that information is presented in a way that is conducive to the extraction of gist. Stories that make sense to a reader allow them to extract a coherent gist and are more likely to be accepted and acted upon (Broniatowski & Reyna, 2020). Previous research has shown that creating a coherent order for pieces of information, as in a 'story' format, helps participants to extract and rely on gist by increasing comprehensibility and allowing the extraction of meaning (e.g. Dewhurst et al., 2007; Pennington & Hastie, 1992; Reyna, 2012). Extraction of gist from narratives with poorly defined causal structures may only be possible for skilled readers or those with sufficient background knowledge (Van den Broek, 2010). As stated in one recent paper, 'more difficult texts are likely to appeal only to those subjects possessing the willingness and ability to expend the effort to comprehend them' (Broniatowski & Reyna, 2020, p. 435). This role of meaning extraction is predicted to combine with motivational factors and social values in influencing decisions to share information online (Reyna, 2021). These predictions have been supported by recent experimental work (Broniatowski et al., 2016) and have been developed into a model of online media platform users' decisions to act on and share information (see Broniatowski & Reyna, 2020).

Importantly, from a policy perspective, official communications are typically more likely to focus on literal facts (e.g. information on how vaccines work) rather than emphasizing causal relations among facts in a way that is conducive to the extraction of gist. By contrast, fake news often provides a narrative focusing specifically on causal explanations. This contrast creates a risk that fake news can be more comprehensible and memorable than official communication (Reyna, Broniatowski, & Edelson, 2021). Official communications should seek to more clearly emphasize causal relations and meaning in order to avoid being less comprehensible and less memorable and therefore less likely to be acted on than fake news.

Evaluating evidence: benefits to society

Through making the distinction between gist and verbatim representations, and showing the impact that each can have on the evaluation of evidence, FTT provides insight into the factors that influence evidence evaluation and interventions to ensure that evidence evaluation takes place in a way that is conducive to healthy outcomes. The areas considered here highlight some key areas where the distinction between gist and verbatim is likely to be important and work in these areas highlights key principles with the potential to be important to a wide range of policy: (1) generally, decision-making based on gist promotes informed consent, and reduces

errors associated with processing of information; (2) meaningful cues are likely to be most helpful in assisting decision-makers allocating specific numbers to a gist; and (3) information is most likely to influence behaviour when an individual can extract gist from it.

Decisions under risk

Another area in which FTT can provide insight with the potential to benefit society is when considering decision-making under risk, for example, decisions where a person is choosing between a sure option with a certain outcome and risky option with the potential for a better outcome or a worse outcome when compared with the sure option. Through the distinction between gist and verbatim representations, FTT explains and predicts observed effects in the literature on decision-making under risk, most importantly the risky-choice framing effect, and provides insight into the way decisions are made that has the potential to be important in informing policy.

The risky-choice framing effect

The risky-choice framing effect is important to understand, since the inconsistencies in risk preference involved in the effect provide insight into the mechanisms underlying risky choice. The risky-choice framing effect is the tendency of decision-makers to pick the sure outcome when a decision is framed as a gain but the risky option when the same decision is framed as a loss (Tversky & Kahneman, 1981, 1986). In gain-framed problems, decision-makers choose between a sure option and a gamble typically of equal expected value (e.g. gaining $1000 for sure vs a 50% chance of gaining $2000 and a 50% chance of nothing). In loss-framed problems, decision-makers might be given an endowment (e.g. of $2000) and must choose between losing some money for sure and a gamble, again typically of equal expected value (e.g. losing $1000 for sure vs a 50% chance of losing $2000 and a 50% chance of losing nothing). In both frames, decision-makers are essentially choosing between keeping $1000 and a 50% chance of keeping $2000. However, adults tend to be more likely to choose the sure option in the gain frame and more likely to choose the risky option in the loss frame.

FTT explains the framing effect as the result of reliance by most adults on gist (e.g. Kühberger & Tanner, 2010). As noted above, adults have a preference for relying on the simplest level of gist possible. Thus, where there are meaningful categorical distinctions between options, adults will rely on these distinctions to differentiate options and dictate their decisions. In the gain frame, decisions boiled down to their simplest gist become gaining something for sure versus maybe gaining something

and maybe gaining nothing. This gist promotes selection of the sure option. In the loss frame, decisions boiled down to their simplest gist become losing something for sure versus maybe gaining something and maybe gaining nothing. This gist promotes selection of the risky option.

Thus, FTT predicts the framing effect, which was also predicted in early theories of decision-making under risk such as prospect theory. The latter has been compared to FTT with results supporting FTT and with new effects introduced by FTT (for a review, see Broniatowski & Reyna, 2018). Experimental research has tested FTT's explanation for framing effects and has provided support for this explanation when compared to competing explanations (most notably the explanations of prospect theory; Kühberger & Tanner, 2010; Reyna, Brainerd, et al., 2021). Importantly, the fact that reliance on gist is predicted to increase with age and experience also predicts and explains counterintuitive developmental reversals that have been found in the literature, where adults and experts are more likely than children and novices to show framing effects, as discussed (Reyna et al., 2014; Reyna & Ellis, 1994). Work utilizing framing effects to test FTT predictions therefore provides support for the predicted importance of gist in risky decisions in adults, but also the greater importance of verbatim in risky decisions in children. This importance of gist has implications in applied contexts that are important in society. Two such contexts are considered here.

Deciding whether to plead guilty

When defendants are accused of crimes in criminal justice systems (including the systems in the US, England and Wales, Scotland, and Northern Ireland), they face a choice of whether to plead guilty. Research shows that some innocent defendants plead guilty and that plea decisions are determined by more than just factual guilt and innocence (Blume & Helm, 2014; Dervan & Edkins, 2013; Zimmerman & Hunter, 2018). Examining plea decisions as risky choices can be helpful in understanding those decisions. If defendants do plead guilty, they will typically receive a sentence that is less severe than the one that they would receive if convicted at trial. Therefore, defendants making guilty plea decisions are choosing between accepting guilt and a certain punishment versus pleading not guilty and facing a potentially worse punishment (if convicted at trial) or no punishment at all (if acquitted at trial). In this way, guilty plea decisions are similar to the decisions under risk described above, where decision-makers must pick between a sure and a risky option, but with the added complication of factual guilt (a gist-based consideration; see Helm, 2018). FTT can therefore provide important insight into these decisions, which can help to ensure that decisions are being made in a way that is consistent with normative legal goals.

First, FTT predicts that plea decisions in typical adults will be driven by reliance on gist. Therefore, decisions will be determined by the simplest meaningful

differences between options that will resolve the decision. On the one hand, where outcomes when pleading guilty and convicted at trial are meaningfully similar (e.g. both would involve a short period in custody), guilt or innocence may be the main gist-based distinction relevant to the problem and therefore should be determinative of decisions (provided that it is important to the decision-maker). On the other hand, where outcomes when pleading guilty and convicted at trial are not meaningfully similar (e.g. a defendant would face a period in custody if convicted at trial but would not if they pled guilty), the gist-based difference between the options has the potential to compete with factual guilt or innocence and to lead factually innocent defendants to plead guilty. This prediction has been supported in experimental work (see Helm, 2022). Real cases also illustrate this phenomenon, for example, several of the now-acquitted defendants in the UK Post Office scandal have described how they pleaded guilty despite believing they were innocent since pleading guilty would mean they would (or so they thought) avoid jail (see Helm, 2021b). To protect innocent defendants from pleading guilty, FTT therefore suggests that, as far as possible, plea and trial outcomes should not incentivize pleading guilty to escape confinement. Categorical gist differences between outcomes, such as the ability to still 'have a life' despite incarceration, should be explained to defendants.

Second, FTT predicts that there are certain groups that are likely to be driven more by verbatim representations. Important groups thought to be more reliant on verbatim processing are youthful defendants and developmentally less advanced adults. As a result, children and adolescents are more likely to rely on verbatim information when deciding whether to plead guilty. Importantly, since factual guilt or innocence is a meaningful rather than quantitative dimension in the decision, FTT predicts that youth are particularly susceptible to neglecting factual guilt or innocence (and other meaningful distinctions in plea decisions) despite understanding them at a literal level. Thus, youth may plead guilty even when innocent on the basis of relatively small sentence discounts (Helm et al., 2018). This prediction has been supported by experimental work suggesting that factual guilt and innocence is less important in plea decisions in youth and that this does not reflect a difference in relevant underlying values, such as the value of not pleading guilty to a crime one has not committed (Helm et al., 2018). Adults with a tendency to rely more on verbatim processing have similarly shown a relative lack of responsiveness to factual guilt or innocence (Helm & Reyna, 2017). This FTT-informed finding has important implications for the criminal justice system, which must protect these defendants, particularly from pleading guilty when innocent (Helm & Reyna, 2017).

Risky decisions, unprotected sex, and crime

FTT can also help inform understanding of decisions to engage in risky activity, such as decisions to engage in unprotected sex, and decisions to engage in crime. Put simply,

FTT predicts that reliance on gist representations will generally have a protective effect against unhealthy risk-taking while reliance on verbatim representations can promote unhealthy risk-taking (e.g. Reyna & Farley, 2006). This protective effect of gist and negative effect of verbatim occurs specifically in situations in which risks of adverse outcomes are low and benefits are high. In such situations, precise trade-offs of risk and rewards (resulting from reliance on precise and superficial representations) can promote risky behaviour. In contrast, reliance on meaningful contextual processing (resulting from reliance on meaningful representations) results in more fuzzy processing based on categorical distinctions (e.g. based on the distinction between no chance of a serious disease and some chance of a serious disease, or no chance of criminal conviction and some chance of criminal conviction) which is driven by values and recognizes that certain outcomes are not worth risking even if rewards are high (Helm & Reyna, 2018). In this way, FTT recognizes a route to unhealthy risk-taking based on reliance on verbatim processing, in addition to existing recognized routes based on impulsivity and lack of control (e.g. Casey et al., 2011; Steinberg, 2007).

The fact that reliance on gist increases with age and thus is lower in adolescents can also explain or partly explain the increased tendency towards risk-taking observed in adolescence compared to later adulthood. In fact, a recent meta-analysis of experiments on risky decision-making showed that risk preference actually declines from childhood to adolescence to adulthood, contrary to a peak in adolescence in unhealthy risk-taking based on impulsivity and lack of control as is commonly assumed (Defoe et al., 2015).

FTT's predictions in this area have been examined and supported in the context of many health decisions, for example, whether to risk HIV or other sexually transmitted infections by engaging in unprotected sex. The risk of HIV infection from a single act of unprotected sex is relatively low (roughly 0.08% from one incident of unprotected sex; see Boily et al., 2009). As a result, reliance on verbatim processing, which promotes precise and superficial weighing up of risks and rewards, could lead a person to engage in unprotected sex. Thus, on the one hand, the low probability of infection with HIV along with high perceived benefits of sexual activity rationalize unprotected sex. On the other hand, reliance on gist representations results in more fuzzy processing based on categorical distinctions which recognizes that certain outcomes (such as HIV) are not worth risking even if rewards are high (Helm & Reyna, 2018). Experimental work provides support for this explanation for unhealthy risk-taking (Mills et al., 2008; Reyna et al., 2011), which also predicts and explains the paradoxical finding that adolescents simultaneously rate unprotected sex as being riskier than adults do and yet are more willing to engage in unprotected sex (Mills et al., 2008). The demonstrated relationship between mental representations relied on and risky behaviours in this area has informed the development of a curriculum for adolescents (Reducing the Risk Plus (RTR+)) aimed at promoting risk reduction and the avoidance of premature pregnancy and sexually transmitted infections by emphasizing gist representations (Reyna & Mills, 2014). RTR+ has been shown to be more effective than existing curricula in achieving the majority of desired outcomes

(Reyna & Mills, 2014), and its success shows the importance of cueing gist representations in preventing unhealthy risk-taking.

The route from reliance on verbatim to unhealthy risk-taking also has the potential to be important in understanding some types of decision to engage in crime. Importantly, many decisions to engage in criminal behaviour involve perceived high rewards and low risks. Thus, in this common situation where rewards are high and risks are low (i.e. the chances of getting caught are objectively small for each instance of criminal risk-taking), FTT predicts that reliance on verbatim representations would produce an increased risk of criminal offending (Helm & Reyna, 2018; Reyna et al., 2018). Reliance on gist representations is likely to have a protective effect against risk-taking by promoting reliance on categorical avoidance of catastrophic outcomes, such as conviction of a crime, rather than rationally trading-off risks for rewards. Note that both offenders and non-offenders typically have a strong desire to avoid conviction but gist thinkers are more likely to choose in accordance with their values. As discussed earlier, this hypothesis is supported by research indicating that residential burglars consider the risk of being caught and the potential reward (though these considerations apparently outweigh the consideration of penalties) whereas matched controls consider none of these factors and categorically avoid risk-taking (Decker et al., 1993). The hypothesis has also been supported by research in neuroscience and law, which has found an increase in neural activation in areas of the brain associated with increased cognitive effort as levels of criminal behaviour increase, when making framing consistent choices (thought to show reluctant reliance on gist; Reyna et al., 2018). Real-world self-reported risk-taking, criminal and non-criminal, was correlated with lower levels of framing bias, that is, more objective processing of risks and rewards (Reyna et al., 2018). FTT therefore adds an additional component to existing accounts of cognitive factors involved in criminal behaviour, which include differential processing of rewards/benefits (Buckholtz et al., 2010), reduced attention and inhibition (Freeman et al., 2015; Larson et al., 2013), and abnormal processing of emotional stimuli (Marsh & Cardinale, 2012).

Recognition of this additional component has the potential to inform new policy interventions aimed at the reduction of criminal behaviour. Previous interventions to reduce crime have been based primarily on encouraging high-risk individuals to think 'slowly' (i.e. to prioritize deliberation and inhibition over motivational factors; see Heller et al., 2015). However, FTT's predictions and supportive findings (e.g. Reyna et al., 2018; Reyna & Mills, 2014) suggest that while it is important to encourage inhibition, it may also be important to encourage reliance on qualitative gist representations in order to reduce crime.

Decisions under risk: benefits to society

By recognizing that unhealthy risk-taking can be promoted by reliance on verbatim representations of risk as opposed to gist, FTT recognizes a novel path to unhealthy

risk-taking. Understanding this path has the potential to inform interventions that can more effectively address unhealthy risk-taking and promote healthy behaviour, both in the areas discussed above, and more broadly.

Conclusion

Through recognizing the distinction between gist and verbatim representations, FTT provides important insight into both memory and associated decision-making. The basic tenets of FTT, which have been supported in experimental work, have informed applied work examining memory and decision-making in practice and informed specific interventions to ensure that the realities of memory and decision-making are recognized in practice and policy across a wide variety of contexts. Basing applied work on FTT in this way has had three key advantages.

First, it has generated counterintuitive predictions that have been tested and supported in empirical work, such as higher rates of 'recognition' for events that are gist-consistent but were never experienced, compared to events that were truly experienced, and developmental reversals in false memory and decision biases, that is, children are less biased than adults. These counterintuitive predictions have the potential to be important in practice in protecting certain groups, and some related policies have been implemented in practice. For example, this research has influenced guidelines for children's testimony around the world, protecting the welfare of children making legal and medical reports that conflict with those made by adults.

Second, FTT has informed work separating relevant underlying constructs and has thus facilitated nuanced predictions that effectively differentiate memories or decisions that are meaningfully different from one another. For example, by separating gist and verbatim and recognizing reliance on gist or verbatim as separable from suggestibility, FTT has allowed different types of false memory to be differentiated from one another, and different trends in false memory to be identified. In doing so, the theory can inform policy that treats memories that ought to be treated differently, differently from one another.

Third, the theory provides insight not only into decisions or memories but also into how they are generated. This insight is important where the way a decision or memory is formed is important to protect human welfare. For example, in the guilty plea context, a preference for pleading guilty in itself is not problematic (and in fact, it has been argued that it can be good that innocent people have the chance to plead guilty; see Garrett, 2015). However, it may be problematic when the decision resulted from pressures undermining the influence of guilt or innocence, rather than from the true preference of a defendant (see Helm et al., 2022). Knowing how decisions and memories are generated is also important in designing policy interventions that are likely to not only be effective, but to be effective *for the right reasons*. For example, interventions can reduce unprotected sex in young people not due to fear, but due

to mature decision-making and recognition of the meaning of risk-communication messages. The three advantages outlined above make FTT well placed to consider in designing experimental work and policy interventions in order to ensure the benefits of science are felt in society in practice.

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