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Expert Decision making: A Fuzzy-trace Theory Perspective

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Expert Decision making: A Fuzzy-trace Theory Perspective.

Research has shown that expert decision makers often make decisions in their area of expertise that are superior to those of lay people – for example expert physicians are better at discriminating levels of cardiac risk (Reyna & Lloyd, 2006), chess masters can identify the most promising moves during a game of chess (Chase & Simon, 1973; deGroot, 1978) and judges (but not jurors) are able to distinguish between qualitatively different types of harm in a legal case (Eisenberg, Rachlinski, & Wells, 2002). However, research has also shown experts are fallible and susceptible to many of the cognitive biases that affect lay people (Tversky & Kahneman, 1974). For example, expert physicians make different choices based on whether the same information is presented in positive or negative terms (known as a framing effect) and fail to adjust sufficiently for population base rates when judging a conditional probability (e.g., the chances that a 40-year-old woman has breast cancer conditional on a positive diagnostic test) (e.g., Croskerry, in press; McNeil, Pauker, Sox, & Tversky, 1982; Reyna, 2004; Reyna & Lloyd, 2006; Shanteau & Stewart, 1992). In fact, research has shown that under certain circumstances experts can be more biased than novices in their area of expertise (Reyna, Chick, Corbin, & Hsia, 2014). In this chapter, we discuss decision making of experts including physicians, judges, and intelligence officers. Using the lens of fuzzy-trace theory (FTT), we provide a framework to explain why experts often make superior decisions, and when they are likely to be as susceptible or more susceptible to bias (systematic departures from applicable normative rational theory; Gilovich, Griffin, & Kahneman, 2002) than laypeople.

Although findings of biases among experts are counterintuitive, FTT predicts these outcomes and simultaneously accounts for the ability of experts to make better decisions in many real-life situations. The key, as we illustrate, is the distinction between meaning-driven as

opposed to rote mental representations. We begin by introducing FTT as a dual-process account of memory and reasoning. We then describe how FTT applies in a wide range of domains and can serve broadly to explain, predict, and improve expert decision making.

Traditional Dual-process Theories

Traditional dual-process theories – which propose that two basic processing types underlie decision making – differentiate Type 1 processes that are "automatic, fast, and intuitive" and Type 2 processes that are "slow, sequential and correlated with measures of general intelligence" (Evans & Stanovich, 2013; Thompson, 2014). These theories are often described as "default interventionist" because Type 1 processing is the default way of thinking, whereas Type 2 "higher order" processing is evoked occasionally and can be used to intervene by overriding Type 1 thinking (Evans & Stanovich, 2013; Kahneman, 2011; but see Barbey & Sloman, 2007, for a parallel competitive view). Dual-process theories associate biased judgments with Type 1 thinking and "rational" judgments with Type 2 thinking (Epstein, 1994; Guthrie, Rachlinski, & Wistrich, 2007), although they recognize that Type 1 processing often leads to correct answers and Type 2 can produce biases in some circumstances (Evans & Stanovich, 2013).

Traditional dual-process theory has been applied to expert decision making in two primary ways, both of which recognize that "intuition" plays a role in expert decision making and are based on the assumption that intuitive judgments and preferences have the characteristics of Type 1 processing in that they are automatic, arise effortlessly and often come to mind without immediate justification (Kahneman & Klein, 2009; Thompson, 2014). The first approach, the Heuristics and Biases (HB) approach, suggests that experts (and laypersons) are subject to intuitive biases because they take mental shortcuts called "heuristics" (Guthrie,

Rachlinski, & Wistrich, 2007; Tversky & Kahneman, 1971). This approach has been mischaracterized as focusing on flaws in cognitive performance. However, Tversky and Kahneman (1974) pointed out that "It is not surprising that useful heuristics…are retained, even though they occasionally lead to errors in prediction or estimation." (p. 1130). Nevertheless, in this view, one way that experts can avoid such biases is by overriding Type 1 thinking with Type 2 thinking (e.g., Evans & Stanovich, 2013; Guthrie, Rachlinski, & Wistrich, 2007; Tversky & Kahneman, 1971).

The second approach to expert decision making arising from a traditional dual-process theory perspective is Naturalistic Decision Making (NDM) (Kahneman & Klein. 2009). NDM focuses on the success of expert intuition, suggesting that experts often rely on intuition (defined as the recognition of patterns stored in memory, Chase & Simon, 1973) and use cues and tacit knowledge to make good judgments without directly comparing options (Kahneman & Klein, 2009). Based mainly on anecdotal observations in real-world contexts, expertise is said to be developed by learning cues in a "valid" environment--an environment that offers stable relationships between objectively identifiable cues and subsequent events between cues and the outcomes of possible actions (Kahneman & Klein, 2009; Schraagen, in press). Thus, NDM researchers argue that "intuition" in experts can be explained in terms of recognition of familiar elements (Schraagen, in press; Simon, 1981; 1992). That is, the claim is that cue-action pairs stored in long term memory (after considerable experience with the environment) and generalized schemas (pattern matching or feature matching) are applied to make decisions (Schraagen, in press), a process called "recognition-primed decisions" (Klein, Calderwood, & Clinton-Cirocco, 1986). In atypical situations, which cannot easily be explained through

recognition of familiar elements, experts are said to gather additional information and clarify the situation through story building (Schraagen, in press).

NDM and HB both acknowledge that intuitive judgments can arise from genuine skill and be beneficial, but can also arise from inappropriate application of heuristic processes (Kahneman & Klein, 2009). They also both suggest that the determination of whether intuitive judgments can be trusted requires examination of the environment in which the judgment is made and the opportunity the judge has had to learn from the regularities of that environment.

FTT originated as an alternative to the HB approach, but with the goal of accounting for those empirical findings and predicting new findings that are not captured by prior approaches (Reyna & Brainerd, 1994, 1995). FTT also shares some assumptions with NDM, for example, incorporating models of recognition and recall to explain decision making, and vice versa, but it is grounded in specific experimental tests and mathematical models as well as naturalistic observations (Reyna, 2012). To take one example, FTT relies on the extensive evidence undermining schema theory (e.g., Alba & Hasher, 1983), substituting the empirically supported construct of gist. Moreover, FTT provides a different explanation of expert decision making, based on the distinction between reliance on *surface level* verbatim representations and *meaning-based* gist representations, which are processed in parallel. In addition, FTT is a developmental theory that predicts greater reliance on gist representations, as opposed to verbatim representations, in judgment and decision making as experience in a domain increases. For such development to occur, experience must afford not only the opportunity for feedback about whether successful outcomes are associated with cues, but also the opportunity for meaningful conceptual learning about *why* those outcomes are associated with those cues (Reyna, 2008).

FTT predicts counterintuitive findings in the literature that are not predicted by HB or NDM for reasoners generally (e.g., see Reyna & Brainerd, 1995, 2008) as well as for experts (e.g., Reyna & Lloyd, 2006). According to FTT, experts are not just better reasoners due to greater knowledge and recognition of recurrent patterns, but because the nature of their cognitive processing in a domain changes, becoming more gist-based, as they develop expertise in that domain. In FTT, cognitive development from novice to expert is predicted to be similar to that from child to adult when the latter reason about everyday domains, and, as we discuss, evidence supports this prediction. By "gist-based," we mean based on simple (but central), meaningful representations, per definitions in psycholinguistics (e.g., Kintsch, 1974). This developmental shift in processing produces paradoxical effects, such as experts using simpler processing (e.g., fewer dimensions of information) to make better decisions than novices, but also being more subject to gist-based biases, such as "false" memories for events that represent inferences about those events (e.g., see Table 2 in Reyna & Lloyd, 1997, 2006). HB and NDM theories have not made such predictions; these and many other FTT predictions do not follow naturally from the core assumptions of HB and NDM. Indeed some research on FTT rules out HB's and NDM's predictions (e.g., HB theory is ruled out in Reyna et al., 2014; and recognition memory ideas used in NDM are ruled out in Reyna & Brainerd, 1994), although recent work has sought to reconcile these views (see Toplak, in press). In sum, applying detailed processing models of tasks that have been tested in experiments and mathematical models, including relevant research findings from HB and NDM approaches, FTT predicts when reasoning is likely to be superior with expertise, and when reasoning biases are likely to increase with expertise, depending on specific features of a task (Adam & Reyna, 2005; Reyna, Lloyd, & Brainerd, 2003; Wilhelms, Corbin, & Reyna, 2015).

FTT Background

FTT is a dual-process theory of decision making grounded in research on memory, reasoning, judgment, and decision making – and their development from children to adults and novices to experts. FTT proposes that two basic types of memory representation – verbatim and gist – are encoded, stored, retrieved, and forgotten separately, and roughly in parallel (Reyna, Corbin, Weldon, & Brainerd, 2016). Verbatim memory is memory for surface information, for example, memory representations of exact words, numbers, and pictures (e.g. "there is a 20% chance of snow today" or "there is a 20% chance of death from this medical procedure"). Verbatim memory is a symbolic, mental representation of the stimulus, not the stimulus itself. Gist memory is a symbolic, mental representation for essential bottom line meaning, the "substance" of information irrespective of exact words, numbers, or pictures (e.g. "there is a low chance of snow today" or "there is a high chance of death from this medical procedure"). This means that the same surface form of "20% chance" can have a different gist depending on context – in the examples above a 20% chance of snow is likely to be considered a relatively low risk, but a 20% chance of death is likely to be considered a relatively high risk (Reyna, 2008). According to FTT, informed (e.g., expert) decisions pivot on appreciating the gist of relevant facts, such as 20% chance, not on merely remembering the verbatim numbers, and prior work has shown that these are independent processes (Reyna & Hamilton, 2001).

For example, when deciding whether to have a medical procedure known as "carotid endarterectomy" to remove obstructions in the carotid artery, informed adults should ideally appreciate that surgery has a non-trivial risk of death (a categorical some-risk vs. no-risk distinction), rather than just recalling the fact there is a 2% risk of death (a more specific, fine

grained distinction; Reyna & Hamilton, 2001). More fine-grained distinctions are required, however, if decision options cannot be distinguished with simplest gist. For example when choosing between two operations, both of which have a non-trivial risk of death, a patient would rely on a more finely grained distinction, such as a higher versus a lower risk of death because both options have some risk, and categorical gist does not distinguish the options (Reyna, 2012).

Verbatim and simplest categorical gist exist at opposite ends of a continuum and multiple representations are usually encoded at varying levels of precision between these extremes (e.g., a 20% chance of snow, a less than 50% chance of snow, a low chance of snow, some chance of snow; Rivers, Reyna, & Mills, 2008). Simplest gist is the least precise representation, such as some chance of snow in the previous example. These levels of precision from verbatim (a 20% chance of snow) to simplest gist (some chance of snow) are roughly analogous to scales of measurement (exact numerical values, ordinal, and categorical distinctions; Reyna, 2012). Verbatim and gist representations are independent of each other and are retrieved independently, predictions supported by research in the basic science literature, as illustrated in Table 1.

FTT posits that there is a developmental trend from reliance on verbatim representations to reliance on increasingly simple gist representations. Therefore, as an individual becomes more experienced in a domain—so long as that experience provides the opportunity to gain conceptual insight--they will rely on increasingly simple gist to make decisions. Reliance on gist and verbatim representations both develop with experience, but a preference for simple gist-based processing (the processing that occurs when gist-based representations are relied on, which gives it certain characteristics, for example, it is more fuzzy and impressionistic than verbatim-based processing) emerges with experience in a domain. This means that in familiar everyday decisions that people are repeatedly exposed to, such as risky decisions for rewards, we see a development

from reliance on verbatim to simplest gist from childhood to young adulthood (Reyna & Ellis, 1994; Reyna & Farley, 2006) and beyond young adulthood for professionals who must deal frequently with high-stakes risks (Reyna et al., 2014).

Gist-based processing is therefore developmentally advanced based on several considerations, such as later emergence in development with experience and reflection of meaningful distinctions that matter in judgment and decision making. Importantly, FTT differs from NDM in that gist is not about processing entire cue matters, but rather decision making based on bottom-line meaning rather than superficial surface detail (Reyna 2012). Gist-based processing is distinguished from the "satisficing" strategies in the HB or NDM traditions and, unlike in HB or NDM, the key to gist-based processing is *meaning*. Gist-based processing is not about doing less doing less or exerting less cognitive effort (as tested in many experiments); it is about understanding simple meaning and, thus, getting to the nub of a decision (e.g., Adam & Reyna, 2005; Lloyd & Reyna, 2009; Reyna & Lloyd, 2006). For example, patients' symptoms cannot be easily reduced to a "cookbook" that provides lists of symptoms and diagnoses, and even sophisticated computer programs to accomplish such a cookbook have generally failed (Lloyd & Reyna, 2009; Reyna et al, 2003). Instead, the best diagnosticians understand disease mechanisms. According to FTT, good decision making, then, is based on the essence of what really matters, rather than superficial details (Reyna, 2013).

However, reliance on gist is also predicted to (and has been shown to) result in bias when content and context foment a semantic bias that goes beyond literal information, as in framing biases, false memories, conjunction fallacies and hindsight biases (e.g., Reyna, 2013; Reyna et al., 2002; Reyna, 2005). In addition, gist-based processing is distinguished from "fast" impulsive processing. FTT recognizes that inhibiting impulses is important in decision making, but

separates this from reliance on gist or verbatim representations (Reyna, Wilhelms, McCormick, & Weldon, 2015).

FTT and Expert Decision Making

As discussed, according to FTT, development is a process of acquiring meaningful experience, which tends to increases with age for everyday decision making and with domain-specific expertise (Reyna et al, 2014). This developmental process leads to more than knowledge acquisition, but rather to a tendency to rely on gist representations that reflect meaning, despite processing and remembering verbatim details. Therefore, FTT makes two specific predictions that traditional dual-process theories do not make. First, experts will rely on simpler distinctions (gist) when making decisions in their area of expertise. Second, experts will show *more* bias that novices--called a "developmental reversal" in FTT--in tasks in which bias is caused by reliance on gist, such as framing tasks (see Reyna et al, 2014, and discussion below), and hindsight bias tasks (see Reyna, 2005, and discussion below). We now discuss each of these predictions in the context of research into expert decision making in different domains.

Medical Experts

One of the most important areas for studying and improving expert decision making is in the domain of medical decision making. In addition to life or death decisions, doctors must make many choices that temporarily or permanently affect the well-being and life satisfaction of their patients – such as whether to prescribe a blood thinner that will reduce the likelihood of a heart attack but also interfere with an active lifestyle or whether to diagnose a clinically borderline

child with a disorder that allows insurance coverage but also leaves the child permanently labeled.

Several studies of medical decision making have confirmed FTT's counterintuitive predictions that experts rely more on gist than novices, as reflected in processing fewer, but the most meaningful, dimensions of information and making simpler all-or-none distinctions. For example, cardiologists who have greater experience with heart disease than generalist physicians have been shown to make more accurate diagnostic judgments about chest pain, but they rely on fewer pieces of information and make cruder all-or-none admission decisions—mainly discharging the patients who have chest pain (with follow-up) or sending them to intensive care (Reyna & Lloyd, 2006). Generalist physicians make more nuanced decisions than cardiologists do, processing more dimensions of information more elaborately and sending patients to wider range of destinations, such as levels of monitored hospitalization as well as discharge or intensive care. The tendency to process simple gist is even greater among the most expert cardiologists. Similarly, emergency medical technicians have been shown to know more about practice guidelines and to make better decisions that are guideline-consistent, but they rely on more vague, intuitive gist, and fewer dimensions of information (Lazar, 2012). This reliance on gist is revealed when patients do not fit the guidelines, and more experienced technicians violate the verbatim rules of the guideline but offer superior medical care. This prediction was tested by constructing patient profiles that orthogonally crossed the factors of correct/incorrect gist of medical care with agreement/disagreement with verbatim guidelines. Experts scored higher than novices on correct gist and guideline-agreement patients but "lower" (fewer technically correct answers) than novices for correct gist and guideline disagreement patients.

Research into expert decision making in the medical domain has also provided support for FTTs second prediction, that experts will show *more* bias that novices in their area of expertise in tasks in which bias is caused by reliance on gist. Despite extensive medical education, however, nurses, physicians and other medical personnel have repeatedly been shown to fall victim to decision biases such as being influenced by alternate framing of the same information (Hux, Levinton & Naylor, 1994; Forrow, Taylor, & Arnold, 1992; McGettigan et al., 1999), and errors in disjunctive probability judgments (Reyna & Lloyd, 2006) (for a summary of other biases in clinical decision making, see Croskerry, in press). These biases are two biases that are associated with reliance on gist (see Weldon, Corbin, & Reyna, 2013). Therefore, FTT would predict that in their area of expertise medical experts would be more susceptible to alternate framing of the same information (for a detailed discussion of FTT predictions regarding framing, see the section on intelligence agents below), and errors in disjunctive probability judgments.

There is research to support the contention that medical experts are more susceptible to being influenced by alternate framing of the same information *in their domain of expertise* than novices. Christensen et al. (1991) presented twelve gain or loss framed clinical scenarios to medical students, residents, and physicians. For each scenario, subjects had to choose between two options – surgery or medical treatment. Gain-framed scenarios described the chance of survival or treatment success whereas loss-framed scenarios described the chance of death or treatment failure. Medical students, who were the least advanced developmentally in this study, showed no significant framing effect for any of the clinical scenarios. As predicted by FTT, the more experienced medical personnel (residents and physicians) showed greater framing effects; they were more likely to prefer the medical treatment in the gain versus loss frame. Thus, a

developmental reversal was found in that increases in expertise were associated with greater reliance on gist processing and greater susceptibility to decision biases.

Intelligence and Security Experts

Intelligence and security experts are a group of professionals who are expert in making risky decisions (for example decisions about national security). Therefore, FTT predicts that when making decisions involving risk, intelligence and security experts should rely on simpler distinctions than controls and show more biases associated with gist-based processing.

Consistent with FTT predictions, research has suggested that security experts make superior decisions and that this is due to reliance on gist. In one experiment, Pachur and Marinello (2013) compared the decision strategies and choice patterns of airport customs officers and a group of novices regarding which passengers should be submitted to a search prior to boarding an airplane, specifically looking at two different decision strategies – compensatory strategies representing straightforward implementations of the notion that decisions involve the evaluation of multiple cues (Klein, 1998), and "take-the-best" strategies where cures are inspected in descending order of validity and inspection of cues is stopped as soon as the alternatives differ on a given cue (Gigerenzer & Goldstein, 1996). Based on interviews with a separate group of customs officials, a list of eight cues considered valid for identifying passengers was compiled, along with the respective values considered diagnostic of an individual trying to smuggle drugs. Cues included the country in which the flight originated, gender, the speed of the passenger's gait, and the amount of luggage they carried, while values ranged from those indicating a low likelihood of drug smuggling (Europe, Female, Normal walking speed, Several bags) to those indicating a higher likelihood of smuggling (South America, Male,

Hurried, One bag). Pairs of passenger profiles were then constructed using this information and participants were asked to decide which of the two passengers would be more likely to smuggle illegal drugs. Participants also ranked the importance of each cue in forming their decisions and how confident they were in their cue rankings.

Customs officers were not only more consistent in their cue rankings (a characteristic of rational decision making) – all but one ranked "flight origin" as the most important cue – their cue rankings showed greater discrimination (i.e., dispersion) than the group of novices. By weighting the cues more differentially, customs officers were also able to rely on fewer cues and were more confident in their cue rankings (customs officers focused on one cue, whereas novices were more likely to use a compensatory strategy in which several cues were individually weighted). Finally, the cue rankings generated by the customs officers were more consistent with the chief customs officer who had the highest "success" rating according to internal airport statistics, suggesting that although they considered less information overall, customs officers were able to make more accurate screening decisions than the less experienced group of novices. This is similar to the finding in Reyna & Lloyd regarding medical decision making – experts are making better decisions based on fewer dimensions of information, suggesting reliance on bottom line meaning rather than complex weighing of a number of different factors. This result has also been found when investigating decision making of experienced burglars, police officers, and a novice group of graduate students (experts processed fewer cues) regarding how likely a given house is to be burgled (Garcia-Retamero & Dhani, 2009).

Research into expert decision making in the intelligence and security domain has also provided support for FTTs second prediction, that experts will show *more* bias that novices in their area of expertise in tasks in which bias is caused by reliance on gist. Intelligence agents are

experts in making risky decisions (for example decisions concerning national security). One bias in risky decision making that FTT associates with gist-based processing is risky choice framing.

Before we discuss expertise, we should explain framing effects: Changes in the positive (gains) or negative (losses) wording of the same objective information, known as framing, can have a large impact on judgments and risk preferences (Reyna et al., 2014; see Levin, Schneider, & Gaeth, 1998, and Kühberger & Tanner, 2010 for reviews). For example, in the so-called Asian Disease Problem (Tversky & Kahneman, 1981), in the gain frame, the options are "200 lives saved for sure" and "1/3 chance of 600 saved or 2/3 chance of 0 saved"; most people choose the risk-free option in the gains frame (to save 200 lives for sure). In the corresponding loss frame, the choice is between "400 lives lost for sure" and "2/3 chance of 600 lost or 1/3 of 0 lost"; most people choose the risk-seeking option in this condition (2/3 chance of 600 lost or 1/3 of 0 lost). Because 600 are expected to die in all scenarios, 200 save is equivalent to 400 die. Therefore, difference in choice selection across frames is viewed as a violation of preference consistency (the options are the same), a basic axiom of rational decision making (Machina, 1982; Savage, 1954; Von Neumann & Morgenstern, 1944).

FTT predicts framing effects by proposing that the typical choice problems differ in the gist that each frame generates. Specifically, in the gain frame, the gist of the risk-free option (200 lives saved for sure) is "saving some lives", whereas the gist of the risky option (1/3 chance of 600 saved or 2/3 chance of 0 saved) is "saving some lives or saving none." Given that most people value saving some lives over saving none, they select the sure option in the gain frame. In the loss frame, however, the gist of the risk-free option (400 lives lost for sure) is "losing some lives" whereas the gist of the risky option (2/3 chance of 600 lost or 1/3 of 0 lost) is "losing some lives or losing none." (The distillation to none vs. some is not arbitrary but is the simplest gist of

the numerical information in this problem.) Here, because most people prefer to lose no lives rather than some lives, the risk-seeking option is typically chosen in the loss frame. Thus, increasing gist-based processing is predicted to increase framing effects.

Several critical tests have consistently supported this interpretation (Kühberger & Tanner, 2010; Mandel, 2001; Reyna & Brainerd, 1991; Reyna, et al., 2014; Stocke, 1998). In one, Reyna et al. (2014) presented the same preamble to subjects but modified the format of the risky-choice decision option to either emphasize categorical some / none distinctions between the options (to encourage reliance on gist) or to emphasize the equal expected value of the options (to encourage reliance on verbatim) (Reyna et al. 2014). Take the example of an original framing problem that had 600 lives at stake and the original gain frame choice was between (a) definitely saving 200 and (b) a 1/3 chance of saving 200 and a 2/3 chance of saving 0. In the gist condition, the preamble would be identical, but the options would be presented as (a) definitely saving 200 and (b) a 2/3 chance of saving 0 (i.e. (a) **some** v (b) **none**). In the verbatim condition, again the preamble would be identical, but the options would be presented as (a) definitely saving 200 and (b) a 1/3 chance of saving 600 (i.e. (a) **some** v (b) **some**). Although the missing information was available in the preamble and subjects reported understanding the full range of options, framing effects were pronounced when the gist (categorical contrast) was emphasized but eliminated when verbatim processing was encouraged. This supports FTT's prediction (described above) that gist-based processing increases framing effects.

Because FTT views framing as a bias caused by reliance on gist, the theory predicts an increase in framing with expertise. Therefore, in the area of risky decision making, FTT predicts that intelligence agents should show more framing than controls. Reyna et al. (2014) investigated this by providing intelligence agents, college students and post-college adults with a

series of risky-choice framing tasks involving lives and other values outcomes that varied in frame (gain or loss) and truncation (the risky option presented was either the standard option, or truncated to encourage reliance on categorical differences (gist) or analytic calculation (verbatim) (as described above). These problems were intended to be in the intelligence agent's area of expertise due to their focus on risking lives and other valued outcomes.

As predicted by FTT, because of training and regular experience in making life or death decisions, intelligence agents showed overall framing biases that were larger than those of college students and marginally larger than those of post-college adults. No group showed framing effects in the condition encouraging verbatim processing, the framing effect shown by intelligence agents in the standard condition (not truncated to encourage reliance on gist or verbatim processing) was similar to the framing effect shown by college students in the condition designed to encourage reliance on gist. This suggests that by encouraging college students to rely on gist, we can make their decision making more comparable to that of experts. This supports FTTs contention that experts are cognitively disposed to reliance on gist-based processing. These effects were observed for the dependent variables of subject's choices and their strength of preference. An analysis of confidence ratings also revealed that the intelligence agents were more confident in their responses than either of the other two groups. Thus, intelligence agents were not only more biased than students (they framed more), they were also more confident in their decisions.

This is not predicted by traditional dual-process theories. Such theories often associate framing with Type 1 thinking (Peters et al, 2006), or at least associate more within-subjects framing (where each participant receives problems in the gain frame and the loss frame) with more Type 1 thinking (see Stanovich & West, 2008). Most decision theories predict that

increases in analytical reasoning ability – such as that gained by increases in age and expertise – should reduce or eliminate framing effects by revealing the equivalency of the options and increasing the consistency of preferences. As illustrated above, empirical research supports FTT predictions that framing effects increase with expertise.

Explanations of developmental reversals (specifically reversals from children to adults) that are consistent with traditional dual process theory have been provided based on the fact children (or those with less expertise) may be responding randomly or may not have developed certain knowledge (such as stereotypes) that may interfere with rational responding (see Toplak, in press). However, these explanations do not fit the data showing developmental reversals from children to adults, which show that children do have knowledge and competence in probability (Reyna & Brainerd, 1994), that children's responses vary systematically with risk and outcome – as the probability of getting nothing goes up in the gamble, they choose this less (Reyna & Ellis, 1994), and are not always based on knowledge such as stereotypes (for example in the case of risky choice framing) (see Reyna & Ellis, 1994).

Legal Experts

Legal experts, most notably judges, make important decisions routinely. Judges decide approximately as many cases at trial as juries (Clermont & Eisenberg, 1992) and the judicial role also includes ruling on dispositive motions and ruling on matters of law (for example whether evidence is admissible or whether a witness is competent to testify). This means that the quality of decisions that judges make is important for the legal system and individuals more generally. Because of this, it is important to understand how judges make decisions, and any biases they are subject to that could lead to harmful consequences in the real world.

In the legal literature, research into judicial decision making has focused on the debate between formalism (when judges apply the law in a clear, uniform, and consistent way and realism (when judges use their interpretation of facts and the law to decide cases and then use law to provide a post hoc rationale) (Neuborne, 1992; Posner, 1986; Leiter, 1999). Legal formalism states that judges apply the law to the facts of a case in a clear, uniform, and consistent way, without regard for social interests and public policy (Leiter, 1999). In contrast, legal realism suggests that judges' decisions are highly influenced by their own interpretations of facts and the law, reacting primarily to the facts of the case involved, and then using the law to provide a post-hoc rationale for a decision (Leiter, 1999). This debate has several parallels to traditional dual-process accounts that have recently been applied to judicial decision making (Kahneman & Frederick, 2002; Guthrie, Rachlinski, & Wistrich, 2007). According to traditional theories, judges make initial intuitive judgments (using Type 1 processing), much like legal realism, but they can override their initial judgments with deliberation (using Type 2 processing), and make decisions more in line with legal formalism. So, according to these models intuitive decision making is responsible for inaccurate and inconsistent judicial decisions (Guthrie, Rachlinski, & Wistrich, 2007).

FTT provides an alternative explanation of judicial decision making, consistent with the empirical research that has been conducted on judicial decision making and the broader research on decision making in experts (for example the research on medical experts discussed above). This is a new kind of intuitionism, recognizing that experts are cognitively disposed to rely on intuition to a greater extent than novices, but that this facilitates advanced decision making, which can result in superior decision making through understanding of meaning and the "nub" of a decision, but can also result in bias where context foments a semantic bias (see Weldon,

Corbin, & Reyna, 2013). Specifically, and as noted above, reliance on gist results in bias where context foments a semantic bias.

Research in to the decision making of legal experts has supported FTT's prediction that experts rely on simpler gist-based distinctions (rather than surface level similarities) when making decisions. One study examining real legal cases regarding punitive damage awards (monetary awards intended to punish a defendant and deter them from engaging in the same conduct again, rather than just to compensate a claimant) showed that non-expert legal decision makers (but not judges) award the same ratio of punitive to compensatory damages regardless of the nature and extent of the injuries involved in the case (bodily injury or non-bodily injury; Eisenberg, Rachlinski, & Wells, 2002). This was true despite the fact that inflicting bodily injury on someone is generally considered more heinous and deserving of punishment than inflicting non-bodily injury. Thus, non-expert decision-makers were less able than judges at assigning damages that were consistent with the nature of harm in the case, suggesting that they rely less on gist processing because they have a lower level of understanding of the facts and relative magnitudes in the case. This is consistent with FTT as jurors (novices) are predicted to rely more on verbatim processing which would not distinguish between qualitatively different types of harm (as it is based on surface level detail, such as numbers). Judges, who rely more on gist processing would be predicted to take account of more qualitative factors due to reliance of bottom line meaning in a decision.

In addition, research has shown that judges are susceptible to biases associated with reliance on gist-based processing. One bias relevant to judicial decision making that has been associated with gist-based processing is hindsight bias (the inclination to see an event as having been predictable after it has occurred; Reyna, 2005). Hindsight bias is an example of a verbatim-

gist dissociation effect (see Reyna, 2005). An individual relying on verbatim would make the same decision in foresight or in hindsight (as the facts are the same) but an individual relying on gist would be influenced by inferences based on meaning or context which may lead them to judge a situation differently in hindsight (similar to constructive memory).

Research has shown that judges are susceptible to hindsight bias in their area of expertise (Guthrie, Rachlinski, & Wistrich, 2001). Guthrie et al. asked judges to predict the Court of Appeals' response to an appeal from the District Court. They were given specific facts regarding a case decided by the district court and were told that the decision of the district court in this case had been appealed to the court of appeals. They were then split into three conditions. A third of participants were told that the court of appeals had sent the case back to the district court for imposition of a lesser sanction, a third of participants were told the court of appeals had affirmed the district court's decision and the final third of participants were told that the court of appeals had overturned the decision of the district court. Judges from all three conditions were then asked to judge retrospectively which of the three actions the court of appeals was most likely to have taken, considering the case facts. In this case, the judges displayed hindsight bias because knowing the outcome in the court of appeals significantly affected their assessments.

Judges have also been shown to be susceptible to hindsight bias in considering the types of evidence that they frequently consider, for example evidence regarding "probable cause" (Rachlinski, Guthrie, & Wistrich, 2011). Probable cause is the standard used to determine the legality of police searches (in hindsight or in foresight), and requires that there be a reasonable chance the search will turn up evidence of a crime. Usually a judge will assess this before the search has been conducted, but in some cases the police can conduct a search without a warrant. In these cases, the police still need probable cause but whether this was present is judged

retrospectively. Over three experiments, Rachlinski, Guthrie, and Wistrich (2011) presented hypothetical cases to 900 state and federal judges and asked them to make a determination of probable cause either in foresight (asking for a warrant) or in hindsight (where a police search had been conducted and incriminating evidence had been found). They found that hindsight affected judge's ability to assess the likely outcomes of the search (although it should be noted that this did not ultimately affect their rulings, perhaps because the change in probability estimates was not large enough to push the case from one judgment to the other).

In these experiments judges were not compared directly with non-expert controls. It is likely that hindsight bias would also have influenced non-experts in these situations where there is no special knowledge involved (most adults would make inferences that once evidence has been found it was more likely to be found, or once a decision has been made it was more likely to be made that way). Future research should test this prediction and also consider situations in which expertise would lead to specific inferences that would promote greater susceptibility to hindsight bias.

Ultimately, FTT provides an alternate explanation to formalism, realism or traditional dual-process theory when considering judicial decision making. Future experiments could test this theory by providing judges and non-experts with identical materials and investigating how decisions are being made.

Educational Experts

FTT can also lend valuable insight into decisions made by other experts in their areas of expertise, such as the educational decisions made by superintendents and principals. Such decisions can affect large numbers of students for extended periods of time when those decisions

implement policies that might be resistant to change. In a study of middle and junior high school principals, Miller, Fagley and Casella (2009) found that the framing of information did have a significant impact on policy decisions in an educational setting. Variants of the classic risky-choice framing vignette appropriate for a school setting were constructed that included a choice between a certain (risk-free) option and a riskier but possibly more successful option. In one scenario, the success rate of a remedial reading program was varied – the risk-free program offered a certain success rate of 40% (failure rate of 60%), whereas the riskier program was described as having a 40% chance of being successful for all students and a 60% chance of being successful for no students (or a 40% chance of failing for no students and a 60% chance of failing for all students). As with professionals in the previously reviewed domains, principals were more likely to select risky options when the information was framed in a negative way than when information was framed in a positive way.

FTT's account of this violation of preference consistency is similar to previous domains. That is, according to FTT, principals (like other experts) have developed a strong reliance on gist processing that typically aids decision making by capitalizing on knowledge, experience and intuition, but also increases the susceptibility to specific biases. In the gain frame, because some students succeeding is better than no students succeeding, the certain outcome of a 40% success rate was chosen most often. In the loss frame, however, because some students failing is worse than no students failing, the risky option was chosen most often in which potentially no students would fail. Such phrasing of decisions elicits a gist that violates a basic axiom of rational decision making i.e. preference consistency) when gains (successes) and losses (failures) do not differ, however sensitivity to context is generally an adaptive approach to decision making.

Conclusions and Differences with Other Theories.

In this chapter we have discussed a theoretical perspective – fuzzy trace theory – that explains and predicts counter-intuitive empirical results in the expert decision making literature. We then applied the theory to specific areas of expert decision making to highlight the various insights FTT provides. The theoretical predictions and empirical evidence examined in this chapter support the hypothesis that, as individuals gain greater experience and expertise, their decision making becomes increasingly gist-based. This advanced intuition leads experts to make decisions based on simpler distinctions and fewer dimensions of information, compared to those used by novices, that are also often more accurate. For example, research showed that doctors and customs officials with relatively greater experience and expertise in their area made more accurate decisions based on fewer dimensions of information and judges (but not jurors) were able to distinguish meaningfully different cases from one another, recognizing what was truly important in cases that were quantitatively comparable. However, this can also lead to increased biases in experts (in their domain of expertise) where context foments a semantic bias (e.g. in the framing task) – research showed intelligence officers to be more susceptible to framing bias than college students in risky choice framing tasks, and medical experts to be more susceptible to framing bias than medical students when making medical decisions.

FTT's account differs from traditional dual-process theory by recognizing a developmental shift from surface level verbatim processing to meaning based gist processing. This shift explains not only the superior decision making of experts where an understanding of meaning is required, but also developmental reversals where reliance on meaning can result in predictable bias. Although traditional dual-process theory expects that experts can make superior

decisions but also be subject to heuristics and biases, it does not provide an explanation for why we see developmental reversals in specific types of bias from novice to expert.

Understanding where we are likely to see superior reasoning in experts and where we might see similar reasoning or even inferior reasoning to novices can not only provide insight into the decision making of experts, but can also inform policy. Knowing when a gist-based approach might cause bias in experts and when it is essential for good decision making can provide insight into which decisions should be made by experts, and which could be delegated to less experienced colleagues, or even advanced machines.

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Table 1: FTT predictions and support for these predictions in the basic science literature.

FTT Prediction	Critical Test	Empirical Support
Information is encoded in multiple representations with varying levels of precision (from gist to verbatim)	Can cue retrieval of gist or verbatim trace by manipulating cue given to participants.	Reyna & Kiernan, 1994; Reyna & Kiernan, 1995.
Verbatim and gist representations are independent	Manipulations that improve verbatim memory for numbers or sentences should not improve gist memory.	Brainerd & Gordon, 1994; Reyna, 1992; Reyna, 1995; Reyna & Brainerd, 1995.
Verbatim and gist representations are retrieved independently	Misrecognizing gist should be independent of memory for verbatim information.	Reyna & Kiernan, 1994; Reyna & Kiernan, 1995.