Gist and Verbatim in Narrative Memory*

David A. Broniatowski[1] and Valerie F. Reyna[2,3]

1 **Center for Advanced Modeling in the Social, Behavioral, and Health Sciences**
Johns Hopkins University
Baltimore, MD, USA
broniatowski@jhu.edu

2 **Center for Behavioral Economics and Decision Research**
Cornell University
Ithaca, NY, USA
vr53@cornell.edu

3 **Cornell Magnetic Resonance Imaging Facility**
Cornell University
Ithaca, NY, USA

Abstract

A major concern regarding the study of narratives regards how they are indexed and retrieved. This is a question which touches on the structure of human memory in general. Indeed, if narratives capture the substance of human thought, then data that we have already collected regarding human memory is of central importance to the computational study of narrative. Fuzzy Trace Theory assumes that memory for narrative is simultaneously stored at multiple levels of abstraction and, whenever possible, decision-makers interpret a stimulus qualitatively and therefore operate on a simple – typically categorical – "gist" representation. Here, we present a computational model of Fuzzy Trace Theory applied to explain the impact of changes in a narrative upon risky-choice framing effects. Overall, our theory predicts the outcome of 20 experimental effects using only three basic assumptions: 1) preference for lowest level of gist, that is, categorical processing; 2) decision options that fall within the same categorical description are then interpreted using finer-grained (ordinal or verbatim) distinctions; and 3) once the options are mentally represented, decision preferences are generated on the basis of simple positive vs. negative valences stored in long-term memory (e.g., positive value for human lives). A fourth assumption – that negatively-valenced decision options are preferentially converted to positive decision options – is used when categories are not otherwise comparable.

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1 How Are Narratives Stored in Memory?

Narratives entail sequences of events that must be both recalled from the narrator's memory and stored in the memory of the audience. It has long been known that narratives are not only recalled, nor stored, in a verbatim manner – rather, memory for narratives tends to favor events that are central to the story's causal structure [17, 18] – i.e., events that communicate the narrative's meaning to its audience. For example, Dehghani et al. [4] have

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shown that changes in a narrative's surface form did not change how subjects responded to a questionnaire about how the narrative's main character was expected to respond, whereas changes in the narrative's underlying structure did lead to a change in the expected behavior of the main character. Dehghani et al. argue that changes in the narrative's surface form lead subjects to make inferences based on analogy with the original narrative, whereas changes in the underlying structure of the narrative preclude such an analogy from forming. Such observations motivate our research question: How are narratives stored in, and recalled from, memory?

2 Is Memory Schematic?

Modern psychological theories of memory storage and retrieval may be broadly classified into two categories: schema theories and association theories, both of which are widely found throughout the artificial intelligence (AI) and psychology literatures [7, 15]. Schema theories posit the existence of a schema or frame that is used to structure memory and experience such that what is recalled is coherent and confirms existing expectations. Such schemata are typically generated through repeated experience and may be part and parcel of membership within a given culture, domain of expertise, or any other situation in which frequent exposure to a set of regularities drives future expectations in a structured way. Schema, once formed, can drive perception and explanation, and may therefore be said to have an existence that is independent of the world features with which they interact. In contrast, association theories, assume that meaning emerges from co-occurrence patterns among world feature. Whereas schema models posit a higher-level data structure which guides surface feature recognition and interpretation, association models posit a bottom-up approach whereby surface feature co-occurrence drives meaning. In their classic paper, Alba and Hasher [1] synthesized evidence demonstrating that memory, although possessing several features of schematic representation, nevertheless also was strongly affected by surface form. In fact, that literature review documented robust but contradictory findings from these alternative theoretical perspectives. Empirical research suggests that elements of the schema and associationist models are both correct [13]. For example, phenomena such as false recognition, where "false" memories that are consistent with a given schema are recalled, support schema theory. On the other hand, phenomena such as false recognition reversal (higher levels of rejection for schema-consistent recognition items), have also been observed, supporting the recall of surface form. These contradictory findings have led to the development of "Fuzzy Trace Theory" (FTT) – a theory of memory for narrative that posits the simultaneous existence, and encoding, of two types of memory. Verbatim memory is memory for surface form and is typically detailed, yet brittle (i.e., quick to fade). Verbatim memory might include the specific words used in the telling of a narrative. On the other hand, FTT also posits the existence of gist memory, which captures the essential (often schema-consistent) meaning of a stimulus.

3 The Asian Disease Problem as a Testbed for Narrative Memory

The difference between gist and verbatim may be explained using a classic decision problem due to Tversky and Kahneman, known as the Asian Disease Problem (ADP) [19, 20], which is accompanied by the following pair of narratives: Assume that 600 people are expected to die from an outbreak of disease. You have a choice between two programs to combat the disease: (a) 200 people will be saved versus (b) a 1/3 probability that 600 people will be saved and a 2/3 probability that no one will be saved. The "people saved" version of the problem is described in terms of gains relative to a reference point of 0. The "people die" version of the same problem is: Assume that 600 people are expected to die from an outbreak of disease. You have a choice between two programs to combat the disease: (a) 400 people will die versus (b) a 2/3 probability that 600 people will die and a 1/3 probability that no one will die. This problem has been used to highlight a framing effect, which refers to the typical result that most people prefer the certain option in the gain frame, but they prefer the risky option (gamble) in the loss frame. FTT holds that the narrative described above is simultaneously encoded on two levels: gist and verbatim. The verbatim level behaves in a manner similar to traditional economic theory, whereby a comparison is made between two options of equal expected value, as follows:

(a) 200 people will be saved = 200 saved vs.
(b) 1/3 * (600) people will be saved = 200 saved

In contrast, the gist level represents the core meaning of each of the decision options. Thus, a representation of the above problem at the gist level might be:

(a) Some are saved vs.
(b) Maybe some are saved or maybe none are saved

This would lead a decision-maker to choose option a, consistent with empirical findings. Similarly, the gist of the negatively-framed alternative might be:

(d) Some die vs.
(e) Maybe some die or maybe none die

This framing would lead a decision-maker to choose option b, also consistent with empirical findings. Importantly, gist and verbatim interpretations are recorded in parallel – i.e., gist is not derived from a verbatim representation [13]. Furthermore, several levels of gist can exist, such as at the level of the word, the sentence, the paragraph, or the entire narrative. We are able to use the concepts of gist and verbatim to replicate the findings of 20 separate experiments from the psychology literature. These effects are the consequences of the following four assumptions:

1. preference for categorical representations that are simultaneously the most meaningful and least detailed
2. decision options that fall within the same categorical description are then interpreted using finer-grained (ordinal or verbatim) distinctions
3. once the options are mentally represented, decision preferences are generated on the basis of simple positive vs. negative valences stored in long-term memory (e.g., positive value for human lives).
4. negatively-valenced decision options are preferentially converted to positive decision options –when categories are not otherwise comparable. Following is a computational implementation of a risky decision-making problem of the sort outlined above, meant to further clarify the distinction between gist and verbatim.

Our computational model has the following elements:

1. Configuration space: A narrative must occur within a given context – what is known in literary theory as a small world [5]. In the case of our decision-making problem outlined above, we posit the existence of a configuration space [6], which serves as the contextual

```
create_configuration_space(num_dimensions, special_points)
for i=1:num_decision_alternatives
        category(i) = find_category(decision_alternative(i))
end

for i=1:total_decision_alternative_pairs
        representation = categorical_representation(i)
        if~(categories_comparable)
                representation = convert_negative_to_positive(i)
        end

        while(representation~=verbatim_representation(i))
                if(dominant_category_exists)
                        return dominant_option
                else
                        representation =
                add_precision(representation)
                end
        end
end
```

Listing 1 FTT Pseudocode.

grounding for our decision. In our context, a configuration space is a mathematical formalization of the universe of possible decisions that might be made. For example, for the ADP, there are two types of numbers that a decision-maker is required to understand. The first represents the number of people who are saved, and the second represents the probability with which the first number occurs. This may be represented as a 2-dimensional space, where one axis (ranging from 0 to 600) represents the number of people who might be saved under the different treatment conditions and the other axis (ranging from 0 to 1) represents the probability of success in the gamble option. Each decision option complement represents a point in this space. For example, the certain option is located at (200, 1) because there is a certain probability that 200 people will be saved. The non-zero complement of the gamble option is located at (600, 1/3) since there is a 1/3 probability that 600 people will be saved. Finally, the zero complement of the gamble option is located at (0, 2/3) since there is a 2/3 probability that 0 people will be saved under the gamble option.

2. Special points: We may subject points in the configuration space to certain constraints. Restricting points to a subset of this space reflects one such constraint. A concrete example of such a restriction might be that the total number of people saved equals zero which restricts all points to be on the vertical axis (i.e., the line $x = 0$). This corresponds to the statement "none are saved". Another example might be the horizontal line defined by the equation $y = 1$, corresponding to a certain outcome. Further, Feldman observes that constraints of this type are highly improbable by chance alone – i.e., a point chosen at random from the configuration space is highly unlikely to satisfy the constraint by accident. These values are associated with qualitatively different categories: an event happens or not, is certain versus uncertain, or is impossible versus possible. Thus, none saved ($x = 0$) is likely to be salient. All ($x = 600$) saved may be salient if it is made clear in the problem definition that 600 represents the entire population (therefore all are saved;

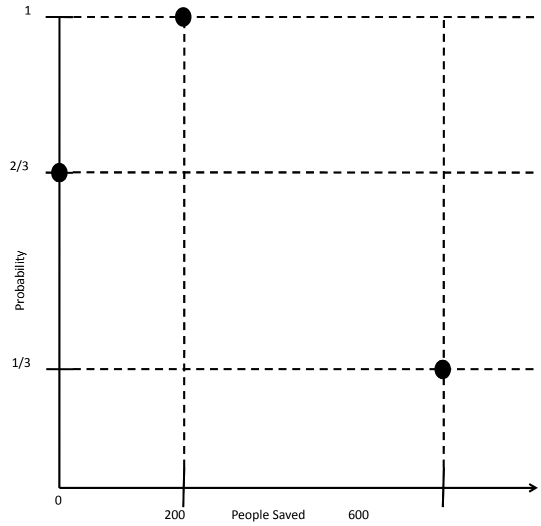

Figure 1 An example of a 2-dimensional configuration space for the Asian Disease Problem. Each point represents a decision complement.

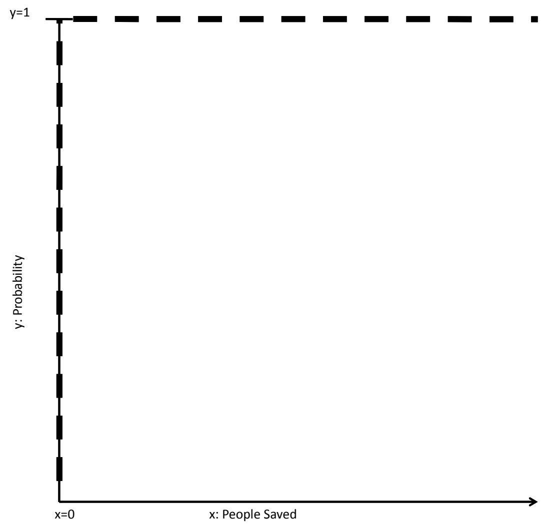

Figure 2 A 2-dimensional configuration space with 1-dimensional restrictions defined by the lines $x = 0$ and $y = 0$ (heavy dashed lines). The likelihood that a randomly chosen point in this 2-dimensional space will fall on either of these lines approaches 0.

see below). As noted above, the constraints that are salient in the configuration space are determined by biological, psychological, or socio-cultural factors. Given a configuration space, certain points within this space are psychologically special (or "non-accidental" see, e.g., [8]), and are therefore categorically different than other points in the space. In the ADP, "none saved" or "none die" are special points because they are categorically different from "some saved", or "some die". In this way, these special points define a set of categories in the configuration space. Although, formally, "0 die" is still part of the closed interval containing the "die" axis, and is therefore contained within the "some die category", it is preferentially interpreted by the most restrictive category available, consistent with Feldman's genericity principle. These categories therefore define a partial order over categories that may be thought of as a perception lattice [6]. For example, Kasturirangan [10] has proposed a narrative interpretation of non-accidental points whereby narrative contexts change whenever characters in a story encounter conflicts, which are non-accidental features in his framework.

3. Values: Given a pair of categories, one is either strictly preferred to the other, or they are unrelated. Such values allow a decision-maker to choose between these categories. For example, "some live" is preferred to "none live", whereas "none die" is preferred to "some die".

According to FTT, gist-level processing is preferred, explaining the framing effects observed by Tversky and Kahneman [19, 20]. This model has been implemented in GNU/OCTAVE and faithfully replicates 20 different experimental effects, including truncated and expanded versions of the ADP, and frequently-observed outcomes in the Allais paradox [2]. In each of these cases, minor changes in the narrative describing a decision-situation can lead to large changes in the decision outcome.

4 The 20 Effects Predicted

Our model has been tested against, and successfully predicts, the outcomes of the 20 experiments listed in the following table:

Effect	Stimulus	Gist Representation	Decision Outcome	Data Source
1	200 saved vs. 1/3 chance 600 saved OR 2/3 chance none saved	some saved vs. some chance some saved OR some chance none saved	A	[19]
2	400 die vs. 1/3 chance none die OR 2/3 chance 600 die	some die vs. some chance none die OR some chance some die	B	[19]
3	200 saved AND 400 not saved vs. 1/3 chance 600 saved OR 2/3 chance none saved	some saved AND some not saved vs. some chance some saved OR some chance none saved	Indifference	[11, 16, 3]
4	400 die AND 200 do not die vs. 1/3 chance none die OR 2/3 chance 600 die	some die AND some do not die vs. some chance none die OR some chance some die	Indifference	[11, 16, 3]
5	400 not saved vs. 1/3 chance 600 saved OR 2/3 chance none saved	some not saved vs. some chance some saved OR some chance none saved	B	[11]
6	200 do not die vs. 1/3 chance none die OR 2/3 chance 600 die	some do not die vs. some chance none die OR some chance some die	A	[11]
7	200 saved vs. 1/3 chance 600 saved	some saved vs. some chance some saved	Indifference	[14, 16, 12]
8	400 die vs. 2/3 chance 600 die	some die vs. some chance some die	Indifference	[14, 16, 12]

9	200 saved vs. 2/3 chance none saved	some saved vs. some chance none saved	A	[14, 12]
10	400 die vs. 1/3 chance none die	some die vs. some chance none die	B	[14, 12]
11	200 saved vs. 2/3 chance 600 die	some saved vs. some chance some die	A	[14]
12	400 die vs. 1/3 chance 600 saved	some die vs. some chance some saved	B	[14]
13	200 saved vs. 1/3 chance none die	some saved vs. some chance some saved	Indifference	[14]
14	400 die vs. 2/3 chance none saved	some saved vs. some chance none saved	A	[14]
15	200 saved vs. 1/3 chance none die OR 2/3 chance 600 die	some saved vs. some chance some saved OR some chance none saved	A	[14]
16	400 die vs. 1/3 chance 600 saved OR 2/3 chance none saved	some saved vs. some chance some saved OR some chance none saved	A	[14]
17	1m dollars with certainty 1m dollars with 0.89 chance OR Nothing with 0.01 chance OR 5m dollars with 0.10 chance	some money with certainty some money with some chance OR no money with some chance OR some money with some chance	A	[2]
18	Nothing with 0.89 chance OR 1m dollars with 0.11 chance Nothing with 0.90 chance OR 5m dollars with 0.10 chance	no money with some chance OR less money with some chance no money with some chance OR more money with maybe	B	[2]
19	200 saved vs. 1/3 chance all 600 saved OR 2/3 chance none saved	some saved vs. maybe all saved OR maybe none saved	Indifference	[22, 21, 9]
20	400 die vs. 1/3 chance none die OR 2/3 chance all 600 die	some die vs. maybe none die OR maybe all die	Indifference	[22, 21, 9]

Each of these effects is representative of a class of decision problems that share a similar structure.

5 Discussion

We began this paper by asking how narratives are stored in, and retrieved from, human memory. In order to answer this question computationally, we take steps towards formalizing Fuzzy Trace Theory – a theory of human memory. Although we focus on decision problems for tractability, the more general concepts of gist and verbatim representation are applicable to the study of narrative. Furthermore, decision problems are particularly relevant to the computational modeling of narrative because they entail short narratives that set up the decision situation. Minor changes in the way these narratives are framed can have major impacts on the ultimate decision made. We argue that this is central to the computational modeling of narrative because understanding may depend significantly on how a narrative is framed. Future work will focus on extending our formalization beyond the domain of the simple decision problems to more complex accounts of false memory and narrative structure.

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