On Estimating the Diagnosticity of Eyewitness Nonidentifications

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The criminal justice system's practice of treating eyewitness lineup identifications of suspects as highly informative while treating nonidentifications (i.e., no-choice responses or choices of foils) as uninformative is questioned. A Bayesian model of information gain is used to mathematically prove that (a) if an eyewitness identification of a suspect increases the probability that the suspect is the criminal, then a nonidentification must decrease the probability that the suspect is the criminal; and (b) the relative diagnosticity of identifications versus nonidentifications (regarding the probability that the suspect is the criminal) is determined by the probability of obtaining an identification versus nonidentification, with nonidentifications being more diagnostic if they are relatively less frequent than identifications. An application of the Bayesian model to previously published data suggests that greater diagnosticity for nonidentifications than identifications is more than just a theoretical possibility; the available data show nonidentifications to be more than one and a half times as diagnostic as identifications regarding the probability that the suspect is the criminal. A breakdown of nonidentifications into two types, eyewitness choices of a lineup foil versus no-choice decisions, suggests that the latter is more informative than the former regarding the probability that the suspect is innocent. The cognitive mechanisms that may be responsible for criminal justice investigators' discounting of nonidentifications are discussed in relation to research on human judgment.

Recent experimental evidence suggests that jurors are highly influenced by eyewitness identification testimony (Wells, Lindsay, & Ferguson, 1979). Ironically, this influence works only one way. Neither jurors and judges nor police investigators place much faith in the eyewitness who says “this is not the man” (Clifford & Bull, 1978). Brandon and Davies (1973) were among the first to acknowledge the asymmetrical treatment of identifications versus nonidentifications in noting that “witnesses who fail to make an identification, or identify the wrong man, are not called [into court as witnesses]” (Brandon & Davies, 1973, p. 30). Nonidentifications are generally considered uninformative because of the belief that there are multiple plausible causes for nonidentification (e.g., memory failure). Sobel’s (1972) book, perhaps the most comprehensive and erudite treatment of the legal aspects of eyewitness identification, notes that failure to identify the suspect “is significant in determining that the witness has not retained the image of the perpetrator” (p. 136). The implication here is that nonidentifications are failures to retain in memory (i.e., forgetting) and are largely uninformative.

The current article calls into question the practice of treating nonidentifications as uninformative. A Bayesian model is presented that specifies certain mathematical relationships that must exist between identifications and nonidentifications in terms of their relative in-
formational value for determining the likelihood that the suspect in question is the actual criminal. The mathematics involved show that there is no justifiable logic for approaching a lineup procedure with a set for considering an identification of the suspect to be informative while considering a nonidentification to be uninformative.

That the criminal justice system has largely ignored nonidentifications by eyewitnesses is a fact that may have little surprise value for researchers in the area of cognitive performance. A considerable body of experimental literature has shown that certain tasks in human judgment are structured so that the respondent makes little use of highly diagnostic information (see Einhorn & Hogarth, 1978). Wason's (1968, 1969) research, for example, shows that people do not optimally use disconfirming information for making inferences. Wason (1968, 1969) presented subjects with four cards on which one letter or number appeared (A, B, 2 or 3) and asked subjects to verify the statement "all cards with a vowel on one side have an even number on the other" by turning over the minimum number of necessary cards. Subjects almost never turned over the card with a 3 on it. [Typical choices were A and 2 even though 2 is irrelevant.] Apparently, people try to test hypotheses by utilizing data that will confirm the hypothesis and inappropriately dismiss the relevance of information that could disconfirm the hypothesis. The criminal justice system, in intuitively judging the amount of information obtainable from eyewitnesses, is engaging in a task structure that is not unlike the judgment task that Wason presented to his subjects. Just as Wason's subjects failed to turn over the 3 card, so the criminal justice system fails to "turn over" the witness who makes a nonidentification. Just as Wason's subjects had a hypothesis (if there is a vowel on one side, there is an even number on the other), so too the criminal justice system operates on a hypothesis (that the suspect is the criminal); otherwise, there is no need to stage a lineup.1 Throughout this article we refer to conditions in which the suspect is the criminal (S = C) and conditions in which the suspect is not the criminal (S ≠ C). Because we are referring to situations in which only one member of the lineup is a suspect, these two conditions could also be considered conditions in which the criminal is in the lineup versus not in the lineup, respectively. In experimental eyewitness research (wherein a crime is staged and a lineup task is presented to the witnesses), it is known whether or not the suspect is the criminal. Therefore, it is possible to estimate certain parameters such as the probability of identifying the suspect given that the suspect is the criminal and the probability of identifying the suspect given that the suspect is not the criminal. As outlined later, measures of information gain obtained from identifications and nonidentifications will take the reverse form (e.g., the probability that the suspect is the criminal given that a witness identifies the suspect). This latter type of question requires some knowledge or belief regarding the prior probability that the suspect is the criminal. The fact that this prior probability is a strong determinant of the information value of identifications and nonidentifications presents no special problem for the current analysis. Although we have no way to empirically determine this prior probability, we can still specify the functional relationships between this prior probability and the remaining parameters of the model. Furthermore, in the section of this article where we apply actual data to the model, we can examine the influence of prior probability across the entire range of possible values (zero to one) because it is the only parameter that is not estimable in a staged-crime experiment.

Throughout the remainder of this article, we refer to the terms informativeness (or information gain) and diagnosticity. Informativeness refers to the absolute difference between the

1 Wason's (1968) card demonstration is merely an exemplar of one type of process involved in the dismissal of disconfirming evidence and is not perfectly analogous to the eyewitness situation for at least two reasons. First, the card task is somewhat abstract, whereas the eyewitness setting is characterized by realism, the latter tending to produce better performance (Johnson-Laird, Legrenzi, & Legrenzi, 1972). Offsetting the potential benefits of realism, however, is the fact that the card task involves absolute relationships (if a vowel, then an even number), whereas the eyewitness setting involves probabilistic judgments (if nonidentification, then the suspect may still be guilty). The vagaries of probabilistic judgments are well-known (Kahneman & Tversky, 1973; Tversky & Kahneman, 1974).
prior odds (before the witness makes a lineup choice) that the suspect is the criminal and the posterior odds (after the witness makes a lineup choice) that the suspect is the criminal. Informativeness is used in the apparent absence of any previously used term for this measure and because of its characteristic of being a measure of how much opinion revision is required by the information. Diagnosticity refers to how much potential impact that a datum (e.g., an identification or nonidentification) should have in revising one's opinion without regard to what the prior odds are. The diagnosticity measure is more traditionally referred to as the likelihood ratio in Bayesian statistics (e.g., see Phillips, 1973, p. 79). The likelihood ratio indicates how much more likely the data (e.g., identification or nonidentification) are to have occurred given the truth of one hypothesis (e.g., that the suspect is the criminal) relative to the other (e.g., that the suspect is innocent).

For purposes of the current article, diagnosticity is used in lieu of likelihood ratio because of its role of distinguishing, classifying, or diagnosing the meaning of the witnesses' actions.

In the remainder of this article, we attempt to accomplish the following: First, we use a quantitative model based on Bayesian statistics to prove that nonidentifications must be informative regarding a lowered probability that the suspect is the criminal as long as identifications of the suspect are informative regarding an increased probability that the suspect is the criminal. Second, we explore the relevant parameters of the model to show the conditions under which identifications of a suspect will be more, equally, or less informative than nonidentifications. Third, we apply the model to existing data obtained from a staged-crime experiment and expand the model to analyze two types of nonidentifications. Finally, we discuss the potential problems and realities of the criminal justice system's use of nonidentification data.

A Quantitative Model of Information Gain

A lineup is typically structured by placing one suspect among a set of distractors (Yarmey, 1979). The distractors, hereafter called foils, are known to be innocent by the police investigators (because the foils are police detectives, prisoners, or other nonsuspects). Although the police investigators never know whether the suspect is the true criminal, they do know that a witness's choice of a foil from the lineup is an error. Functionally, an identification of a foil is treated as a nonidentification as is a witness's choice of making no identification from the lineup (i.e., exercising a none-of-the-above option). Later, these two witness behaviors (i.e., identifications of foils and no identifications) are treated separately. For now, however, they have been combined and are called nonidentifications (IDS or nonidentification of suspect) in the model to be described. When the witness makes an identification from the lineup that turns out to be the suspect, the result is an identification (i.e., IDS or identification of suspect).

The informativeness of an eyewitness identification can be defined as some revision in the probability that the suspect is the criminal. That is, there is some prior probability that the suspect is the criminal before learning whether the witness identified the suspect from the lineup (i.e., \( p(S = C) \)), which is presumably revised upward given an identification of the suspect, yielding a posterior probability, i.e., \( p(S = C | IDS) \). Information gained from an identification can, therefore, be expressed as the absolute difference between the prior probability and the posterior probability; that is,

\[
\text{Information gained from an identification of suspect} = \left| p(S = C) - p(S = C | IDS) \right|
\]

Similarly, the informativeness of a nonidentification can be expressed as the absolute difference between the prior probability and the posterior probability that the suspect is the criminal given a nonidentification, that is,

\[
\text{Information gained from a nonidentification} = \left| p(S = C) - p(S = C | IDS) \right|
\]

Absolute values are used in Equations 1 and 2 because it is the absolute amount of change from prior to posterior probabilities, rather than the direction of that change, that deter-

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1 This is read as "the probability that the suspect is the criminal given an identification of the suspect."
mines the amount of information gained from the data in question (identifications and nonidentifications). If absolute values are not used, of course, it would be expected that Equation 1 would generally take on a negative value and Equation 2 would take on a positive value. Although it is mathematically possible for the posterior probability of identifications to be less than the prior probability, such a case would only occur if the probability of choosing the suspect when the suspect is guilty is less than the probability of choosing the suspect when the suspect is not guilty. In the remainder of this article, we assume that the probability of choosing the suspect who is the criminal is never less than the prior probability of choosing the innocent suspect [i.e., $p(\text{IDS}|S = C) \geq p(\text{IDS}|S \neq C)$].

Note that if the posterior probability for identifications is greater than the prior probability, then identifications of suspect will be informative. Similarly, if the posterior probability for nonidentifications is less than the prior probability, then nonidentifications will also be informative. More importantly for purposes of this article, it is mathematically necessary that whenever the posterior probability for identifications is greater than the prior probability, then the posterior probability for nonidentifications must be less than the prior probability (i.e., if Equation 1 > 0, then Equation 2 > 0). Thus, there is no way for identifications of the suspect to be informative and nonidentifications to not be informative. This is true because $p(\text{IDS}) + p(\overline{\text{IDS}}) = 1.0$ and because the prior probability is a weighted sum of the posterior probabilities; that is,

$$p(S = C) = p(S = C|\text{IDS})p(\text{IDS}) + p(S = C|\overline{\text{IDS}})p(\overline{\text{IDS}}).$$

(3)

Therefore, if an identification of the suspect increases the probability that the suspect is the criminal, then a nonidentification must decrease the probability that the suspect is the criminal.

Note that the above relationship between the information values of identifications and nonidentifications is true regardless of other considerations. For example, it might be argued that nonidentifications are less informative than identifications because nonidentifications are sometimes due to the witness's fear of personal safety associated with "fingerprinting" the criminal or that nonidentifications represent memory failure. However, neither this "fear hypothesis" nor the memory failure hypothesis has any bearing on the mathematical proposition that follows Equation 3. The fact is that if fear (or any other factor) serves to eliminate the information value of nonidentifications, then it will also eliminate the information value of identifications.

### The Question of Relative Informativeness of Identifications Versus Nonidentifications

The above derivations specify that informativeness for identifications must be associated with informativeness for nonidentifications but does not specify whether nonidentifications are more, less, or equal in informativeness to identifications. To answer the question of relative information gain, we note that the posterior probability associated with an identification of the suspect is

$$p(S = C|\text{IDS}) = \frac{p(\text{IDS}|S = C)p(S = C)}{p(\text{IDS}|S = C)p(S = C) + p(\text{IDS}|S \neq C)p(S \neq C)},$$

(4)

where the new term, $p(S \neq C)$, is the prior probability that the suspect is not the criminal, which is always $1 - p(S = C)$. Similarly, the posterior probability that the suspect is the criminal given a nonidentification is

$$p(S = C|\overline{\text{IDS}}) = \frac{p(\overline{\text{IDS}}|S = C)p(S = C)}{p(\overline{\text{IDS}}|S = C)p(S = C) + p(\overline{\text{IDS}}|S \neq C)p(S \neq C)},$$

(5)

Whenever the prior probability of an event is unknown (in this case, the prior probability that the suspect is the criminal), the potential informativeness of a datum is determined by the diagnosticity measure, sometimes termed the likelihood ratio. The likelihood ratio from the right-hand side of Equation 4 is

$$\frac{p(\text{IDS}|S = C)}{p(\text{IDS}|S \neq C)} = \text{Diagnosticity measure for identifications of suspect},$$

(6)
which determines the diagnosticity of an identification. Similarly,

\[
p(\text{IDS} | S = C) / p(\text{IDS} | S \neq C) = \text{Diagnosticity measure for nonidentifications. (7)}
\]

Because identifications and nonidentifications are exhaustive of witness behaviors, Equation 7 can be rewritten as

\[
1 - p(\text{IDS} | S = C) / (1 - p(\text{IDS} | S \neq C)).
\]

Thus, it must also be true that whenever Equation 6 is greater than 1.0, Equation 7 must be less than 1.0. This is simply another way to express the conclusion that followed Equation 3. However, it also allows for the definition of the relative diagnosticity of identifications versus nonidentifications. Specifically, comparisons of the relative diagnosticity of Equations 6 and 7 can be made by comparing the value obtained in Equation 6 with the value obtained from inserting Equation 7. Whichever value is greater is the one that is more diagnostic. Thus, the relative diagnosticity value can be expressed as:

\[
\frac{p(\text{IDS} | S = C)}{p(\text{IDS} | S \neq C)} / \frac{p(\overline{\text{IDS}} | S = C)}{p(\overline{\text{IDS}} | S \neq C)} = \text{Relative diagnosticity of identifications versus nonidentifications. (8)}
\]

Whenever Equation 8 is greater than 1.0, identifications of the suspect are more diagnostic than nonidentifications; whenever Equation 8 is less than 1.0, identifications are less diagnostic than nonidentifications, and whenever Equation 8 equals 1.0, identifications and nonidentifications are equally diagnostic.

We further note that because \( p(\text{IDS} | S = C) = 1 - p(\text{IDS} | S = C) \), and \( p(\overline{\text{IDS}} | S \neq C) = 1 - p(\overline{\text{IDS}} | S \neq C) \), and \( p(\overline{\text{IDS}} | S = C) \geq p(\overline{\text{IDS}} | S \neq C) \), then (a) if \( p(\text{IDS} | S = C) + p(\overline{\text{IDS}} | S \neq C) < 1.0 \), then Equation 8 will be more than 1.0; (b) if \( p(\text{IDS} | S = C) + p(\overline{\text{IDS}} | S \neq C) > 1.0 \), then Equation 8 will be less than 1.0; (c) and if \( p(\text{IDS} | S = C) + p(\overline{\text{IDS}} | S \neq C) = 1.0 \), then Equation 8 will equal 1.0. This leads us to conclude that identifications are more (less) diagnostic than nonidentifications to the extent that identifications are less (more) probable or frequent than nonidentifications. This is simply another way of saying that the value of a datum is negatively related to its prior probability of occurrence or that the need to revise one's prior assumptions is positively related to the occurrence of data inconsistent with those prior assumptions.

Informativeness rather than diagnosticity is what one would ultimately like to know, since informativeness measures the exact amount of revision rather than the potential revision in prior probabilities. But, to calculate informativeness one must know the prior probabilities of the suspect's guilt. Diagnosticity is important, therefore, because when one has no knowledge of the prior probability of the suspect's guilt, the relative diagnosticity ratio in Equation 8 is the "best guess" about the relative informativeness of an identification versus nonidentification.

**Applying the Information Gain Model to Data**

There are three reasons for including this section, which applies Equations 1 and 2 to actual data. First, some of the relationships described in the previous section are complex and may be best exemplified by the visual display of an obtained information-gain curve. Second, the question of relative diagnosticity depends on the relative frequency of obtaining identifications versus nonidentifications; this is a content issue that only data can answer. Finally, there are reasons to suspect that the two types of nonidentifications (i.e., choice of foils versus no choice) are not equally diagnostic. Probability theory does not give a definite answer to the latter issue, and it is, therefore, also an empirical matter.

Unfortunately, there exists only one published study that was designed in a way that allows for calculations of Equations 1 and 2 (Loftus, 1976). All other published experiments in the eyewitness identification literature either (a) failed to use two lineups, (i.e., one with the criminal and one with an innocent suspect) and/or (b) calculated choices of all foils as false identifications rather than only counting identifications of one suspect from a criminal-absent lineup.

Loftus (1976) exposed subject witnesses to a simulated aggressive exchange followed by a picture lineup in which the aggressor (criminal)
was or was not present. When the aggressor was not present, a bystander replaced the aggressor and was designated as the innocent suspect. The data revealed that (a) when the criminal was in the lineup, 84% of the witnesses chose him and 16% made nonidentifications; (b) when the criminal was absent from the lineup, 60% chose the innocent suspect and 40% made nonidentifications. Thus, the posterior probability that the suspect is the criminal given knowledge that the witness chose a suspect is

\[ p(S = C | IDS) = \frac{(0.84) p(S = C)}{(0.84) p(S = C) + (0.60) p(S \neq C)} \]

The posterior probability that the suspect is the criminal given a nonidentification is

\[ p(S = C | \overline{IDS}) = \frac{(0.16) p(S = C)}{(0.16) p(S = C) + (0.40) p(S \neq C)} \]

We calculated these posterior probability values for all possible values of \( p(S = C) \). We then calculated the absolute difference between the prior probability \( [p(S = C)] \) and the posterior and graphed an information-gain curve for identifications and nonidentifications as a function of the prior probabilities. Figure 1 presents these curves. The height of the curve at any point along the x-axis represents the measure of the amount of information gained for that particular prior probability (as specified in Equations 1 and 2). It is apparent that the area under the nonidentification curve is greater than the area under the identification-of-suspect curve. This simply means that the information to be gained in Loftus's study from the identification of a suspect is generally less than the information to be gained from a nonidentification.

Two types of nonidentifications. Earlier we noted that nonidentifications are of two types: (a) failures to make any identification (i.e., none-of-above responses), which will be designated NA, and (b) identifications of a nonsuspect (i.e., foil identifications), which will be designated FI. It can be noted that whenever an identification of a foil is made by a witness, it is obviously an error on the part of the witness. That is, regardless of whether the suspect is the criminal, an identification of a foil is known to be an error. However, an NA response may or may not be an error, depending on whether or not the suspect is the criminal. This suggests, but does not unequivocally prove, that NA responses are more diagnostic of whether or not the suspect is the criminal than are identifications of an FI. By using a simple extension of Equations 1 and 2,

\[ |p(S = C) - p(S = C | NA)| = \text{Information gained from } \overline{NA} \text{ responses}, \]
where

\[ p(S = C | NA) = \frac{p(NA | S = C) p(S = C)}{p(NA | S = C) p(S = C) + p(NA | S \neq C) p(S \neq C)} \].

Similarly,

\[ |p(S = C) - p(S = C | FI)| = \text{Information gained from identifications of a foil}, \]

where

\[ p(S = C | FI) = \frac{p(FI | S = C) p(S = C)}{p(FI | S = C) p(S = C) + p(FI | S \neq C) p(S \neq C)} \].

Loftus's (1976) data showed that 4% of the witnesses made NA choices and 12% chose a foil when the suspect was the criminal. When the suspect was not the criminal, 24% made NA choices and 16% chose foils. Thus, for Loftus's data,

\[ p(S = C | NA) = \frac{.04 p(S = C)}{.04 p(S = C) + .24 p(S \neq C)} \]

and

\[ p(S = C | FI) = \frac{(.12) p(S = C)}{(.12) p(S = C) + (.16) p(S \neq C)}. \]

We calculated the values obtained from these two equations for all possible values of \( p(S = C) \) and applied the results to Equations 9 and 11. The final results are graphed in Figure 2. Two things are immediately apparent. First, the NA responses of Loftus's witnesses were more informative than were FIs. Second, by comparing Figures 1 and 2, it is also apparent that the NA responses were more informative than identifications of the suspect. Furthermore, NA responses show greater information value than IDS at all levels of the prior probability variable except zero and 1.0 (where neither NA nor IDS have any information value). Thus, at least for Loftus's (1976) data, we found that eyewitnesses' NA responses were more informative regarding the probability that the suspect was the criminal than were eyewitnesses' identifications of the suspect or eyewitnesses' choice of foils.
The Psychology of Ignoring Informative Data

Earlier we noted that the task structure for criminal investigators begins with a hypothesis (that the suspect is the criminal) that leads to a search for confirming evidence and little or no utilization of disconfirming evidence. The fact that a previous hypothesis leads people to not optimally utilize subsequent data that could disconfirm the hypothesis has been demonstrated in a variety of settings (e.g., see Ross, Lepper, & Hubbard, 1975; Wells, 1980).

The “illusion of validity” regarding one’s decision practices is particularly difficult to detect if the decisions one makes affect the available data pool (Einhorn & Hogarth, 1978). For example, it is impossible for a male employer to test the validity of his assumption that he should not hire females if he already hires on the basis of that assumption, since, without females in his available data pool, the assumption can never be proven wrong. Similarly, if nonidentification witnesses are not a part of the sample appearing in court, one cannot be confronted with evidence that there is a positive relationship between nonidentifications and the likelihood of the suspects’ innocence.8

Generalization and Application Issues

We are not willing to suggest at this point that eyewitness nonidentifications will generally be more informative than eyewitness identifications regarding the probability that the suspect is the criminal. As outlined earlier, the relative diagnosticity of identifications versus nonidentifications depends on the relative frequency of identifications versus nonidentifications. Nonidentifications were more diagnostic than identifications in Loftus’s (1976) study because nonidentifications were relatively infrequent compared to the rate of identifications. Yet, we cannot expect nonidentification rates to always be lower than identification-of-suspect rates. The relative probabilities of identifications and nonidentifications depend on a number of factors such as the amount of pressure exerted on witnesses by the police authorities as well as the similarity of the lineup members to one another (Doob & Kirshenbaum, 1973; Wells, Leippe, & Ostrom, 1979).

Given these considerations, there are several approaches to the issue of how to treat identifications and nonidentifications with regard to their relative diagnosticity in an actual criminal case. First, it might be assumed that over the long run, identifications and nonidentifications will be equally diagnostic. [Or, because we cannot determine which is more diagnostic in a given real-world case, yet we know that if one is diagnostic the other must have some diagnosticity, they should be treated as equally diagnostic.] An alternative strategy would be to collect data from police departments on the relative frequencies of identifications and nonidentifications. We might then assume that the previous rates of identifications and nonidentifications represent the best guess about the expected probability of an identification versus nonidentification in a given case.

Both of these approaches, however, may be associated with problems. For example, how does one present a nonidentification in court? Presumably, a nonidentification witness would serve as a witness for the defense. But, can we assume that jurors will be influenced by nonidentification testimony? Such a question needs more research, but there is one promising note. Saks, Werner, and Ostrom (1975) used an information integration model (e.g., see Anderson, 1971) to estimate the typical juror’s prior judgments regarding the likelihood that a defendant is guilty. The information integration model allows one to use jurors’ final guilt judgments to calculate what their prior assumptions of guilt must have been. Saks et al.’s results indicated that prior to hearing the evidence for and against a defendant, the juror assumes the defendant to be innocent. This suggests that jurors may have a psychological set to accept the informativeness of a nonidentification. However, the jurors’

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8 Criminal justice investigators’ failures to bring nonidentification data to court parallels Greenwald’s (1975) observation that psychologists tend to not bring null results to the journals. Just as the criminal justice investigators tend to think that a witness’s failure to identify the suspect means something is wrong with the witness’s memory, psychological researchers may too often believe that null results indicate something was wrong in the experiment. It is likely that neither criminal justice investigators nor psychological researchers reduce their belief in their initial hypothesis as much as they should from knowledge of nonidentifications and null results, respectively.
acceptance of nonidentification evidence may be greater early in the trial than later in the trial at which time the jurors may have already revised their hypotheses. (The first evidence is presented by the prosecution.) This assumes, of course, that a person’s prior hypothesis (that the suspect is the criminal) accounts for the tendency to disregard nonidentifications.

Wells (1978) argued that it is unlikely that eyewitness researchers will ever be able to give precise probability-of-accuracy estimates in individual criminal cases. This is no justification, however, for not giving expert advice to the courts. As Loftus (1979) noted, there are certain nonintuitive aspects about human memory and judgment that may benefit judicial decisions.

References

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