Psychonomic Bulletin & Review
2004, 11 (1), 143-149

Effects of perceptual modality on verbatim and gist memory

DAVID R. GERKENS and STEVEN M. SMITH
Texas A&M University, College Station, Texas

In two experiments, predictions of the fuzzy-trace theory of memory were tested. Perceptual information may play a role in retrieval and recognition processes for verbatim, but not for gist, memory. Perceptual modality effects were assessed in the present study by presenting three-sentence stories (e.g., *The bird is in the cage. The cage is over the table. The bird is yellow*) and then testing recognition of probes that varied on three dimensions: (1) semantic accuracy (true vs. false), (2) wording (all original words vs. one novel word included), and (3) sentence type (premise vs. inference). In Experiment 1, study modality (auditory vs. visual) was manipulated, and in Experiment 2, both study and test modalities were manipulated. Despite replicating a number of findings consistent with fuzzy-trace theory (e.g., instruction and probe type effects), the results of both experiments failed to support the idea that perceptual information plays a role in performance on verbatim memory tests.

Fuzzy-trace theory is a global memory model developed to explain certain counterintuitive findings concerning the relationship between memory and reasoning in children (Brainerd & Reyna, 1992, 1993; Reyna, 1995; Reyna & Brainerd, 1995). Fuzzy-trace theory posits that there are two distinct types of memory traces formed for every experience: a verbatim trace of information components, such as surface form and source information, and a gist trace, "defined as an abstract representation of semantic content that does not incorporate details of surface form" (Reyna & Kiernan, 1994, p. 180). According to the theory, these different traces operate under different constraints.

The verbatim trace is subject to rapid decay, whereas the gist trace is long lasting (Brainerd & Reyna, 1996, 1998). Different tasks access different traces—that is, memory questions tap verbatim traces, and reasoning questions tap gist traces (Reyna, 1995). The verbatim trace is sensitive to retroactive interference, whereas the gist trace is resistant to interference (Brainerd & Reyna, 1993). The two types of traces are formed in parallel during encoding—that is, the types of traces are independent (Brainerd & Reyna, 1993, 1998). Finally, it is assumed that comparisons based on verbatim traces use an identity rule in which any stimulus that is not identical to the memory trace is automatically rejected. In contrast, gist-based comparisons rely on overall similarity (Brainerd & Reyna, 1998; Brainerd, Reyna, & Kneer, 1995).

Much of the research on fuzzy-trace theory has focused on the role of gist in false recall and recognition. Acceptance of critical lures (semantically related nonstudied items) on a recognition test has been thought to be the result of accessing the gist representation of targets, rather than the verbatim representation. When a gist trace is accessed, the memory decision is based on similarity, causing related lures to be accepted at a higher rate than unrelated lures. In cases in which the verbatim trace is accessed, related lures can be rejected, because an identity rule is used for the memory decision. The theory can account for false memory effects found using the associative list paradigm (e.g., Payne, Elie, Blackwell, & Neuschatz, 1996), short text passages (e.g., Brainerd & Mojardin, 1998; Reyna & Kiernan, 1994), and related word lists (e.g., Brainerd & Reyna, 1996; Brainerd, Reyna, & Brandse, 1995).

Less research has focused on the verbatim memory component of fuzzy-trace theory. The verbatim trace has been described as an accurate (i.e., nonelaborated) representation of experienced events. It has been implicated as the trace that is used to evoke a *remember* recognition response in Tulving's (1985) *remember/know* method (Wright & Loftus, 1998). Brainerd and Reyna (1998) have described the retrieval of verbatim memory in terms very similar to the *remember* instructions of the remember/know paradigm—for example, "Retrieval of verbatim traces produces access to representations of well-defined surface structures, leading to feelings of re-experiencing those surface structures" (p. 87). However, the types of information stored in verbatim traces are not well defined. Verbatim memory is differentiated from a sensory representation (Brainerd & Reyna, 1993) and from the articulatory loop (Reyna & Brainerd, 1995) but is thought to store information about surface form, including detailed episodic information (Brainerd & Reyna, 1993, 1998). These descriptions of the information stored in the verbatim trace suggest that perceptual information may be one of the types of information stored.

The research reported herein served to fulfill part of the requirements for the master's thesis of the first author. Please send correspondence to D. R. Gerkens, Department of Psychology, Texas A&M University, College Station, TX 77843-4235 (e-mail: drgerkens@neo.tamu.edu).

Other findings also suggest that perceptual information is a component of the verbatim memory trace. For example, Brainerd, Reyna, and Brandse (1995) found increased false alarms to nonpresented nonsense word lures that rhymed with presented nonsense words. False alarms to nonsense words that rhyme with presented nonsense words cannot be attributed to gist memory but, rather, must be attributed to verbatim memory. To further support this idea, Brainerd, Reyna, and Brandse tested the persistence of these false alarms, using the rationale that false alarms are due to accessing stable gist traces when meaning is involved (i.e., in the word condition), whereas hits are due to accessing verbatim traces. Therefore, false alarms should show greater persistence than hits. However, in Brainerd, Reyna, and Brandse's nonsense word condition, false alarms could not have been due to gist, because there was no meaning associated with the lures. Therefore, false alarms to rhyming nonsense words should not be persistent. These false alarms showed low persistence, much like hits. These results suggest that perceptual information, such as phonological or articulatory information, plays a role in verbatim memory access.

Brainerd, Wright, Reyna, and Mojardin (2001) stated that "increased physical resemblance makes distractors better retrieval cues for verbatim traces of the corresponding targets, leading to distractor rejection" (p. 308), again implying that perceptual information plays an important role in recognition memory tasks. Furthermore, the claim that source information is stored in verbatim traces implicates perceptual information. For example, Hicks and Marsh (2001) tested source information in which the only difference in conditions was the speaker's voice, a perceptual characteristic.

Other research has shown effects of perceptual information on memory tests. Many list-learning studies, which test verbatim memory, have shown that changes in speaker's voice between study and test influence recognition performance (e.g., Brainerd, Reyna, & Kneer, 1995; Geiselman & Bjork, 1980; Geiselman & Glenny, 1977; Goldinger, 1996; Hintzman, Block, & Inskeep, 1972; Palmeri, Goldinger, &, Pisoni, 1993; Pilotti, Bergman, Gallo, Sommers, & Roediger, 2000; Sheffert, 1998). Effects of modality switches, however, have been more equivocal; whereas some studies have found effects of modality switches on recognition (e.g., Dean, Yekovich, & Gray, 1988; Gallo, McDermott, Percer, & Roediger, 2001; Kellogg, 2001; Kirsner, 1974), others have not (e.g., Craik, Moscovitch, & McDowd, 1994; Hayman & Rickards, 1995; Pilotti et al., 2000). These results strengthen the hypothesis that perceptual information is part of the verbatim memory trace and, therefore, that manipulations of perceptual factors, such as modality, will affect verbatim tests of recognition memory.

If perceptual detail is stored in the verbatim memory trace and perceptual similarity influences the likelihood of accessing verbatim memory, changes in modality between study and test should adversely impact recognition performance in tests that tap verbatim memory. This prediction was tested in the present experiments. Three sentence passages adopted from Reyna and Kiernan (1994) were used in the present study. These passages were constructed so as to be similar to Bransford and Franks's (1971) passages in that they allow for inferences to be made about the relationships of objects, as well as directly stating some relationships. Two types of memory tests were given, verbatim and gist. Verbatim instructions stated that the participants should only respond *yes* if the test sentence was identical to a presented sentence. Gist instructions stated that the participants should respond *yes* whenever the test sentence was consistent in meaning with the presented sentences. If perceptual characteristics influence verbatim memory retrieval, changes in modality between study and test should adversely affect verbatim memory tests, but not gist tests. Failure to find a modality shift effect on verbatim tests would suggest that perceptual information is not utilized in memory for text passages.

EXPERIMENT 1

In Experiment 1, the participants studied three sentence passages and were given sentence recognition memory tests. The test modality was always visual, and study modality was either auditory (inconsistent modality) or visual (consistent modality). Instruction at test was manipulated as a within-subjects variable. The participants received verbatim instructions (i.e., the participants were told to respond *yes* only if the probe sentence was exactly, word for word, the same as the sentence from the story) on half of the trials and gist instructions (i.e., the participants were told to respond *yes* whenever the probe sentence had the same meaning as the sentence from the story, even when it was not word for word the same) on the other half. Test items included presented sentences, nonpresented inferences, and sentences that were true or false in relation to the semantic context of the presented stories. In addition, some of the test sentences contained novel words, whereas others consisted entirely of presented words (see Table 1).

Table 1
Example Story and the Nine Variations of Test Sentence Types

Story
The bird is inside the cage.
The cage is under the table.
The bird has yellow feathers.
Test Sentences
TPO: The bird is inside the cage.
TPO: The cage is under the table.
TPN: The table is above the cage.
TIO: The bird is under the table.
TIN: The table is above the bird.
FPO: The table is under the cage.
FPN: The bird is above the cage.
FIO: The table is under the bird.
FIN: The bird is above the table.

Note—T, true; F, false; P, premise; I, inference; O, original; N, novel. Half the stories represented spatial relations (e.g., *the one above*), and the other half were linear relations (e.g., $a > b$, $b > c$).

The claim that physical characteristics influence verbatim recognition leads to the prediction that, given verbatim instructions, correct recognition would be greater and false recognition of differently worded true premises or inferences would be lower in the consistent modality condition, as compared with the inconsistent modality condition. There should not be a modality effect on false probes, because they should all be easily rejected regardless of instruction condition. As in previous studies, there should be more false alarms to true test sentences than to false ones and more false alarms to test sentences consisting entirely of original words than to those containing novel words. The gist instruction condition typically produces a high proportion of *yes* responses to all true test sentences and a low acceptance rate of all false test sentences. The more semantically similar the presented and the test sentences, the more *yes* responses should occur. A modality shift effect in the gist instruction condition was not predicted.

Method

Participants. Fifty-six students received partial course credit in their introductory psychology course for their participation in the experiment. Participation was voluntary, and other options were available to earn equal credit.

Materials. Eight three-sentence stories were presented to each participant (see Table 1). Two of the three sentences in each story described relationships among objects. The third always stated a tangential fact. The test sentences varied on three dimensions. First, each test sentence was either true or false regarding the relationships stated in the story. Second, test sentences stated either premises or inferences from the story. Third, either the test sentences were entirely made up of original words from the story or an antonym of the adjective describing a relationship in the story replaced the original adjective. A tape player was used for the auditory story presentation condition. Visual story presentation was done using a JavaScript program that runs through Netscape Navigator. All the participants completed a distractor task and the test on the computer. Story presentation and test sentences were presented in fixed random order. The order of tests always matched the order of story presentation.

Procedure. Each experimental group session ranged in size from 10 to 20 participants, and each session was held in a computer laboratory classroom. The experimenter first walked the group through an example of the procedure, in which the participants responded to one story for which verbatim instructions were used and another story for which gist instructions were used. In the visual presentation condition, the text of each story was shown for 6 sec on a computer screen. In the auditory presentation condition, the participants heard the stories being read at a rate of 2 sec per sentence (6 sec per story). The stories were recorded by a female experimenter and were played on an audiotape deck during the experimental sessions. Following story presentation, the participants had a perceptual identification task. This task created a delay between story presentation and test, and it helped the participants to get accustomed to timed responding on the computer keyboard. After the perceptual identification task, the participants saw a brief instruction reminding them of the meanings of the two different recognition questions. Each story had its own test page. Test sentences were presented one at a time. There were nine test sentences for each story (see Table 1). Each participant completed one block of four stories and tests for which the verbatim instructions were used and one block of four stories and tests for which the gist instructions were used (i.e., there were two cycles of study and test).

Results

A 2 (study presentation) × 2 (instruction) × 8 (test sentence type) analysis of variance (ANOVA) was computed, using the proportion of *yes* responses as the dependent measure. Instruction and test sentence type were within-subjects manipulations, and study presentation was a between-subjects factor. None of the effects involving modality was statistically significant (all $ps > .10$; see Table 2). These results fail to support the hypothesis that perceptual information is utilized in verbatim recognition tasks of verbal material. Other typical fuzzy-trace theory predictions, however, were supported.

There was a significant main effect of instruction [$F(1,54) = 88.19$, $MS_e = 0.073$; partial $r^2 = .62$], with more *yes* responses for the gist instruction than for the verbatim instruction. There was also a main effect of test sentence type [$F(7,378) = 122.61$, $MS_e = 0.051$; partial $r^2 = .69$], and a test sentence type × instruction interaction [$F(7,378) = 32.63$, $MS_e = 0.043$; partial $r^2 = .38$; see Table 2]. All other effects failed to reach statistical significance.

Simple main effect analyses revealed a significant effect of test sentence type in both the verbatim [$F(7,385) = 65.23$, $MS_e = 0.044$; partial $r^2 = .54$] and the gist [$F(7,385) = 98.30$, $MS_e = 0.050$; partial $r^2 = .64$] instruction conditions.

Table 2
Mean Proportion of *Yes* Responses to Test Sentences as a Function of Test Instruction and Study Modality (Auditory or Visual) in Experiment 1

	Instruction									
	Verbatim					Gist				
		Auditory (n = 20)		Visual (n = 36)			Auditory (n = 20)		Visual (n = 36)	
Sentence Type	Response Type	*M*	*SE*	*M*	*SE*	Response Type	*M*	*SE*	*M*	*SE*
TPO	hit	.78	.039	.77	.036	hit	.89	.028	.81	.027
TPN	fa	.14	.056	.19	.046	hit	.63	.059	.56	.050
TIO	fa	.36	.056	.36	.049	hit	.89	.038	.75	.041
TIN	fa	.11	.046	.19	.048	hit	.65	.046	.58	.053
FPO	fa	.36	.056	.32	.044	fa	.16	.038	.26	.040
FPN	fa	.08	.037	.13	.029	fa	.13	.034	.15	.032
FIO	fa	.10	.033	.10	.029	fa	.16	.045	.18	.031
FIN	fa	.11	.029	.15	.034	fa	.09	.088	.20	.038

Note—T, true; F, false; P, premise; I, inference; O, original; N, novel; fa, false alarms.

In the verbatim instruction condition, paired t tests indicated a significant difference in test sentence acceptance between hits and false alarms [$t(55) = 14.18, SE = 0.04$]. The participants were reliably better at rejecting test sentences with a novel word than sentences composed entirely of presented words [$t(55) = 13.19$, $SE = 0.03$, for true test sentences and $t(55) = 4.54$, $SE = 0.02$, for false test sentences; Table 2]. False premise with original wording probes were accepted 33% of the time. The other false test sentences were never accepted more than 15% of the time. In the gist instruction condition, paired t tests revealed that true test sentences were accepted more often than false test sentences [$t(55) = 12.84, SE = 0.04$]. Again, test sentences with all original wording were accepted more often than were test sentences that included a novel word [$t(55) = 7.32, SE = 0.03$, for true probes and $t(55) = 2.44$, $SE = 0.02$, for false probes; see Table 2].

Discussion

Experiment 1 failed to support the hypothesis that perceptual information is an active component of the verbatim memory trace during recognition. According to fuzzy-trace theory, recognition judgments made under the verbatim instruction condition should be based primarily on identity judgments. The test sentence should activate the verbatim representation of the item, and if the test sentence differs from the memorial representation, it should be rejected. The failure of a modality shift between study and test to impact these identity judgments clearly suggests that perceptual features of the test sentences are not part of this verbatim recognition process. These results appear to be at odds with the results of many studies that imply that perceptual characteristics are part of the verbatim trace. Furthermore, it is difficult to reconcile the claim that source information is a component of the verbatim trace with the apparent lack of perceptual information in that memory trace.

Novel words helped the participants to reject items appropriately in the verbatim instruction condition, whereas novel words inhibited acceptance of true test sentences inappropriately in the gist instruction condition. The latter finding, that participants appear to be making similarity-based judgments when they should be processing meaning, replicates the verbatim-exit bias found by Brainerd and Reyna (1993), who used 5-year old participants. It is striking that this exit bias was seen with adults, who should be able to perform the semantic processing requested without too much effort. Adult participants would not be expected to resort to a simple novelty check rule. One reason for finding the verbatim-exit bias could be the relatively high level of verbatim memory in the present study, as compared with that found with young children (e.g., Brainerd & Reyna, 1993). That is, the ready accessibility of verbatim memory traces may have biased the participants to invoke a novelty check rule. The effect of wording in the gist instruction reflects the use of a novelty check verbatim-exit bias even though the participants should have processed meaning, rather than surface form.

With the exception of the true inference with original wording and the false premise with original wording test sentences, false recognition was low in the verbatim instruction condition. This fits with the fuzzy-trace theory explanation, because these test sentences were most similar in surface form to the presented sentences.

EXPERIMENT 2

In Experiment 1, modality effects were examined with procedures commonly used to study fuzzy-trace theory, but there is a possibility that effects found with that procedure are due to differences in encoding in the differing study modalities, rather than being the result of a shift in perceptual modality. To separate these differences, the modality of both study and test sessions were independently manipulated in Experiment 2. This manipulation provided an opportunity to replicate the lack of a modality shift effect and to test whether the huge auditory advantage found in Maylor and Mo (1999) would hold with material other than associative lists. It was also clear that the participants in Experiment 1 were able to discern which type of test they would receive for a given story prior to its presentation. As has been shown by Murphy and Shapiro (1994), this also may have influenced verbatim responding. Experiment 2 was designed to prevent the participants from knowing which type of test they would receive for any given story (during encoding).

Method

Participants. One hundred twenty-three students received partial course credit in their introductory psychology course for their participation in the experiment. Participation was voluntary, and other options were available to earn equal credit.

Materials. The materials in Experiment 1 were used again in Experiment 2. In addition, an audiotape recording of the test sentences was used at test, with a 4-sec delay between test sentence presentations for the auditory testing condition.

Procedure. The procedure was the same as that used in Experiment 1, with three exceptions. First, an auditory test was used in half of the conditions, resulting in conditions in which there were visual-study–visual-test (VV), visual-study–auditory-test (VA), auditory-study–auditory-test (AA), and auditory-study–visual-test (AV) conditions. Second, in the visual study conditions, story presentations were changed so that each sentence of the story was presented for 2 sec individually, rather than displaying the entire story for 6 sec. Finally, instruction was varied in a fixed but unpredictable order. The participants did not know which instruction they would use on any given test until the test page appeared or the test reading began. The instruction condition was presented on the top of each test page for the visual test condition and was stated in between the announcement of the test number and the first test sentence for each test in the auditory test condition.

Results

A 2 (instruction) × 2 (study modality) × 2 (test modality) × 8 (test sentence type) ANOVA was performed using the proportion of *yes* responses as the dependent measure. As in Experiment 1, instruction and test sentence type were within-subjects factors. Modality at study and test were both between-subjects factors. Notably, the study modal-

Table 3
Mean Proportion of *Yes* Responses to Test Sentences as a Function of Test Instructions, Study Modality, and Test Modality in Experiment 2

Test Sentence Type	Auditory/Visual (n = 30)		Visual/Visual (n = 33)		Auditory/Auditory (n = 33)		Visual/Auditory (n = 27)	
	M	*SE*	*M*	*SE*	*M*	*SE*	*M*	*SE*
Verbatim Instruction								
TPO / hit	.85	.021	.77	.027	.82	.029	.81	.033
TPN / fa	.33	.054	.34	.053	.42	.057	.34	.070
TIO / fa	.43	.052	.52	.050	.52	.068	.40	.060
TIN / fa	.33	.063	.32	.052	.37	.065	.31	.063
FPO / fa	.23	.043	.28	.037	.17	.037	.18	.042
FPN / fa	.11	.029	.14	.029	.10	.027	.09	.036
FIO / fa	.09	.025	.08	.023	.08	.026	.10	.033
FIN / fa	.15	.043	.12	.027	.11	.027	.10	.036
Gist Instruction								
TPO / hit	.86	.024	.87	.023	.91	.022	.88	.022
TPN / hit	.58	.042	.54	.042	.77	.041	.70	.050
TIO / hit	.84	.044	.73	.039	.86	.038	.87	.039
TIN / hit	.63	.048	.55	.053	.76	.038	.69	.049
FPO / fa	.21	.036	.27	.044	.20	.043	.21	.044
FPN / fa	.10	.023	.13	.033	.09	.028	.16	.038
FIO / fa	.13	.033	.18	.031	.14	.039	.13	.034
FIN / fa	.06	.026	.13	.029	.13	.033	.11	.031

Note—T, true; F, false; P, premise; I, inference; O, original; N, novel; fa, false alarms.

ity main effect, the test modality main effect, and the study modality × test modality interaction all failed to reach statistical significance ($ps > .13$; see Table 3). That is, the lack of a modality shift effect seen in Experiment 1 was replicated. As was expected, the instruction main effect, the test sentence type main effect, and the test sentence type × instruction interaction were significant [$F(1,119) = 100.53$, $MS_e = 0.093$, $F(7,833) = 397.79$, $MS_e = 0.047$, and $F(7,833) = 35.68$, $MS_e = 0.043$, respectively; see Table 3]. These effects were quite large (partial $r^2 = .46$, .77, and .23, respectively).

A simple main effect analysis showed that for the verbatim instruction condition, there was an effect of test sentence type [$F(7,854) = 153.63$, $MS_e = 0.047$], and paired *t* tests revealed a pattern very similar to that found in Experiment 1; the true premise with original wording test sentences were accepted at a higher rate than all the other test sentence types [$t(122) = 25.21$, $SE = 0.02$], and true test sentences were accepted more often than false test sentences [$t(122) = 16.56$, $SE = 0.02$]. Again, novel words appeared to help the participants to reject test sentences, and the sentences with all original words were difficult for the participants to reject for true probes [$t(122) = 15.59$, $SE = 0.02$] and for false probes [$t(122) = 2.56$, $SE = 0.01$; see Table 3]. There was also an effect of test sentence type in the gist instruction condition [$F(7,854) = 301.30$, $MS_e = 0.046$]. Paired *t* tests again showed a pattern similar to the one found in Experiment 1. Hits were accepted at a higher rate than false alarms for false probes [$t(122) = 24.24$, $SE = 0.02$]. Novel words appeared to inhibit the ability of the participants to accept true test sentences—that is, the verbatim-exit bias was replicated for true probes [$t(122) = 11.86$, $SE = 0.02$] and for false probes [$t(122) = 5.22$, $SE = .01$; see Table 3]. Acceptance of false test sentences was always less than 28%. These results mirror those of Experiment 1 and Reyna and Kiernan (1994) and support some of the basic assumptions of fuzzy-trace theory.

There were also significant instruction × test modality and test sentence type × test modality interactions [$F(1,119) = 4.98$, $MS_e = 0.093$, and $F(7,833) = 3.61$, $MS_e = 0.047$, respectively]. These effects were much smaller than the standard fuzzy-trace theory findings reported above (partial $r^2 = .02$ and .01, respectively). Because these interactions do not involve study modality, they are not theoretically relevant to the primary hypothesis, but follow-up Tukey tests were performed for the sake of completeness. These tests revealed that test modality did not influence verbatim responding but that, for gist instructions, acceptance rates were higher in the auditory test condition than in the visual condition. The second set of Tukey tests showed that acceptance rates were higher for the true premise with novel wording and the true inference with novel wording test sentences in the auditory testing than in the visual testing condition. Although these findings lack theoretical relevance, they are important because they demonstrate the statistical power to detect small effects even for interactions involving a between-subjects variable.

Discussion

The result of theoretical interest in Experiment 2 was the failure to find a study modality × test modality interaction on responses that tap the verbatim memory trace.

Given the claim that physical resemblance plays a role in determining access of verbatim memory traces, fuzzy-trace theory predicts a decrement in correct recognition and an increase in false recognition for true items, regardless of whether the shift is from auditory to visual or from visual to auditory. On the basis of Maylor and Mo's (1999) results, one would expect an advantage in the auditory study condition. This advantage should have been especially apparent in the auditory test condition, because the hypothesized adverse effects of the modality shift were removed. In the present study, no auditory study advantage was found. This finding replicates the results of Experiment 1 and stands in contrast to the results of Maylor and Mo, which have also been challenged by the results of Gallo et al. (2001).

Potential problems due to differential encoding across instruction conditions were also addressed in Experiment 2. The present results support Murphy and Shapiro's (1994) finding that knowledge of a verbatim test prior to study enhanced performance. Performance on verbatim recognition was better in Experiment 1 than in Experiment 2, numerically speaking. Although the number of hits were roughly equivalent in both experiments, acceptance of lures was somewhat lower in Experiment 1 than in Experiment 2.

GENERAL DISCUSSION

In the present experiments, the role of perceptual features in recognition memory tests was examined. Assumptions of fuzzy-trace theory and the treatment of verbatim memory in the literature suggest that perceptual features influence the access of verbatim memory on recognition tests. For example, Brainerd, Reyna, and Brandse (1995) stated that false alarms to nonsense words that rhymed with presented nonsense words were caused by the verbatim memory trace. These errors must have been based on the verbatim memory trace, because there presumably was no semantic representation of nonsense words (i.e., gist trace). Furthermore, source information has been identified as a component of the verbatim memory trace. Hicks and Marsh (2001) manipulated speaker in Experiments 2a and 2b as their source manipulation to ensure that only perceptual characteristics differentiated the two sources. That is, their source identification could be based only on perceptual differences in the voices. Consequently, one must infer that perceptual characteristics should be a component of the verbatim memory trace.

In the present study, two experiments failed to support the idea that perceptual features are involved in recognition memory of prose, a task that should tap verbatim memory. According to fuzzy-trace theory, the more similar a test sentence is to a presented sentence, the higher the probability that the verbatim representation of the presented sentence will be accessed. Test sentences that match in perceptual characteristics, as well as wording, should increase the probability of accessing the verbatim memory trace. The results from the present experiments do not support the idea that perceptual characteristics influence the probability that the verbatim trace is accessed. If they do, switching modality between study and test should adversely influence recognition under verbatim instructions. No modality shift effect was found in either of the present experiments.

The present results are consistent with recent findings in which correct recognition of compound words, composite errors, and feature errors was compared (Jones, Jacoby, & Gellis, 2001). The materials in Jones et al.'s study were very similar to those used in the present experiments. For example, a composite lure in their study was analogous to the true inference with original wording test sentences used in the present study. The similarities between studies, including the failure to find a modality shift effect in both, suggest that the findings are not simply due to a lack of statistical power but, rather, represent a true non-effect. The failure to find modality shift effects in the present experiments and in Jones et al.'s study suggests that these effects may be specific to the list-learning paradigms in which they are sometimes found.

REFERENCES

Brainerd, C. J., & Mojardin, A. H. (1998). Children's and adults' spontaneous false memories: Long-term persistence and mere-testing effects. *Child Development*, **69**, 1361-1377.

Brainerd, C. J., & Reyna, V. F. (1992). Explaining "memory-free" reasoning. *Psychological Science*, **3**, 332-339.

Brainerd, C. J., & Reyna, V. F. (1993). Memory independence and memory interference in cognitive development. *Psychological Review*, **100**, 42-67.

Brainerd, C. J., & Reyna, V. F. (1996). Mere memory testing creates false memories in children. *Developmental Psychology*, **32**, 467-476.

Brainerd, C. J., & Reyna, V. F. (1998). Fuzzy-trace theory and children's false memories. *Journal of Experimental Child Psychology*, **71**, 81-129.

Brainerd, C. J., Reyna, V. F., & Brandse, E. (1995). Are children's false memories more persistent than their true memories? *Psychological Sciences*, **6**, 359-364.

Brainerd, C. J., Reyna, V. F., & Kneer, R. (1995). False-recognition reversal: When similarity is distinctive. *Journal of Memory & Language*, **34**, 157-185.

Brainerd, C. J., Wright, R., Reyna, V. F., & Mojardin, A. H. (2001). Conjoint recognition and phantom recollection. *Journal of Experimental Psychology: Learning, Memory, & Cognition*, **27**, 307-327.

Bransford, J. D., & Franks, J. J. (1971). The abstraction of linguistic ideas. *Cognitive Psychology*, **2**, 331-350.

Craik, F. I. M., Moscovitch, M., & McDowd, J. M. (1994). Contribution of surface and conceptual information to performance on implicit and explicit memory tasks. *Journal of Experimental Psychology: Learning, Memory, & Cognition*, **20**, 864-875.

Dean, R. S., Yekovich, F. R., & Gray, J. W. (1988). The effect of modality on long-term recognition memory. *Contemporary Educational Psychology*, **13**, 102-115.

Gallo, D. A., McDermott, K. B., Percer, J. M., & Roediger, H. L., III (2001). Modality effects in false recall and false recognition. *Journal of Experimental Psychology: Learning, Memory, & Cognition*, **27**, 339-353.

Geiselman, R. E., & Bjork, R. A. (1980). Primary versus secondary rehearsal in imagined voices: Differential effects on recognition. *Cognitive Psychology*, **12**, 188-205.

Geiselman, R. E., & Glenny, J. (1977). Effects of imagining speakers' voices on the retention of words presented visually. *Memory & Cognition*, **5**, 499-504.

Goldinger, S. D. (1996). Words and voices: Episodic traces in spoken word identification and recognition memory. *Journal of Experimental Psychology: Learning, Memory, & Cognition*, **22**, 1166-1183.

Hayman, C. A. G., & Rickards, C. (1995). A dissociation in the effects of study modality on tests of implicit and explicit memory. *Memory & Cognition*, **23**, 95-112.

Hicks, J. L., & Marsh, R. L. (2001). False recognition occurs more frequently during source identification than during old–new recognition. *Journal of Experimental Psychology: Learning, Memory, & Cognition*, **27**, 375-383.

Hintzman, D. L., Block, R. A., & Inskeep, N. R. (1972). Memory for mode of input. *Journal of Verbal Learning & Verbal Behavior*, **11**, 741-749.

Jones, T. C., Jacoby, L. L., & Gellis, L. A. (2001). Cross-modal feature and conjunction errors in recognition memory. *Journal of Memory & Language*, **44**, 131-152.

Kellogg, R. T. (2001). Presentation modality and mode of recall in verbal false memory. *Journal of Experimental Psychology: Learning, Memory, & Cognition*, **27**, 913-919.

Kirsner, K. (1974). Modality differences in recognition memory for words and their attributes. *Journal of Experimental Psychology*, **102**, 579-584.

Maylor, E. A., & Mo, A. (1999). Effects of study–test modality on false recognition. *British Journal of Psychology*, **90**, 477-493.

Murphy, G. L., & Shapiro, A. M. (1994). Forgetting of verbatim information in discourse. *Memory & Cognition*, **22**, 85-94.

Palmeri, T. J., Goldinger, S. D., & Pisoni, D. B. (1993). Episodic encoding of voice attributes and recognition memory. *Journal of Experimental Psychology: Learning, Memory, & Cognition*, **19**, 309-328.

Payne, D. G., Elie, C. J., Blackwell, J. M., & Neuschatz, J. S. (1996). Memory illusions: Recalling, recognizing, and recollecting events that never occurred. *Journal of Memory & Language*, **35**, 261-285.

Pilotti, M., Bergman, E. T., Gallo, D. A., Sommers, M., & Roediger, H. L., III (2000). Direct comparison of auditory implicit memory tests. *Psychonomic Bulletin & Review*, **7**, 347-353.

Reyna, V. F. (1995). Interference effects in memory and reasoning: A fuzzy-trace theory analysis. In F. N. Dempster & C. J. Brainerd (Eds.), *Interference and inhibition in cognition* (pp. 29-59). San Diego: Academic Press.

Reyna, V. F., & Brainerd, C. J. (1995). Fuzzy-trace theory: Some foundational issues. *Learning & Individual Differences*, **7**, 145-162.

Reyna, V. F., & Kiernan, B. (1994). Development of gist versus verbatim memory in sentence recognition: Effects of lexical familiarity, semantic content, encoding instructions, and retention interval. *Developmental Psychology*, **30**, 178-191.

Sheffert, S. M. (1998). Contributions of surface and conceptual information to recognition memory. *Perception & Psychophysics*, **60**, 1141-1152.

Tulving, E. (1985). Memory and consciousness. *Canadian Psychology*, **26**, 1-12.

Wright, D. B., & Loftus, E. F. (1998). How misinformation alters memories. *Journal of Experimental Child Psychology*, **71**, 155-164.

(Manuscript received November 14, 2001;
revision accepted for publication October 24, 2002.)