ON THE RESISTANCE OF PRESCHOOLERS' MEMORIES TO POSTEVENT MISINFORMATION

TAMMY A. MARCHE

On the Resistance of Preschoolers' Memories to Postevent Misinformation

By

Tammy A. Marche

A thesis submitted to the
Department of Psychology
in partial fulfilment of the requirements for the
Doctor of Philosophy Degree

Department of Psychology
Memorial University of Newfoundland
July, 1993

St. John's Newfoundland

Abstract

The primary aim of the present research was to explain the variability in findings across past studies regarding the effects postevent misinformation has on preschoolers' testimony and memory. It is argued that the appearance and disappearance of such effects is due to at least three limitations of past research. The first limitation concerns the failure to equate the degree to which original information is learned both across conditions within a study and across studies. The second concerns the failure to use analytical techniques that are sensitive to the different processes involved in retention (e.g., forgetting and reminiscence). The third limitation involves past failures to examine both the potential constructive and destructive effects that exposure to misinformation may have on testimony and memory. By addressing these limitations it was possible to determine whether exposure to postevent misinformation encourages preschoolers to report erroneous information, as well as whether, and how, misinformation affects memory for a witnessed event. It was also possible to examine the effects of providing consistent postevent information on preschoolers' testimony and memory. A recently developed model of long-term retention that eliminates the problems of differences in initial learning and analytical insensitivity is used to examine the effects of consistent and inconsistent information on testimony and memory. Preschoolers were presented with a slide sequence about a little girl anxious to attend a Halloween party. Half of the children received a single trial and the remaining half learned the material to criterion. Following acquisition, children received one of the following: (a) no postevent information; (b) correct information concerning peripheral event details three weeks after acquisition, presented in either narrative or questionnaire form; or (c) misleading information concerning peripheral event details three weeks after acquisition, presented in either questionnaire or narrative form. Four weeks following acquisition, all of the children received 4 test trials without further study opportunity. The results indicate the following: (a) exposure to misleading information encouraged preschoolers to report misinformation; (b) although the effects of misleading information on memory were rare, there were more story details unavailable for recall in one of the misled than nonmisled conditions; (c) the transient effects of misinformation on memory and testimony are likely influenced by the limitations of past studies mentioned above; (d) re-exposing preschoolers to story details that were embedded in a narrative increased recall; and (e) performance increased across test trials with the recall of original information, but it did not differ as a function of experimental manipulation. These results demonstrate that when initial learning is controlled and appropriate measurement techniques are used, the potential misinformation may have to impair memory could play a role in preschoolers' reporting of this information.

Acknowledgements

I would like to express my most sincere thanks to my supervisor, Dr. Mark L. Howe, for his continued encouragement, guidance, and advice. To my committee members, Dr. Mike Rabinowitz and Dr. Shannon Moeser, thank you. My appreciation is also extended to the preschoolers, their parents, and the directors of the daycares and preschools for their cooperation. Finally, a special thanks to my family for their support and patience throughout my program.

Table of Contents

Tables

Figures

On the Resistance of Preschoolers' Memories to Postevent Misinformation

The Salem Witch trials in 1682 marked the first time in American history that children testified in criminal court cases. Existing documents indicate that uncontrolled fear and panic at the time, along with adult suggestion, stirred young children's imaginations and resulted in a totally biased recollection of events on the part of the children (Ceci, Ross, & Toglia, 1987b). Since these infamous trials there has been great concern about children's competency as eyewitnesses. The longstanding belief, despite the lack of empirical evidence, has been that young children have limited memory capacity, are unreliable, untrustworthy, inaccurate, vulnerable to suggestion, and unable to distinguish fantasy from reality; children are not to be believed (e.g., Ceci et al., 1987b; Lipmann, 1911; Stern, 1910; Whipple, 1909, 1911, 1912, 1918; Yuille, 1988). Such opinion concerning children's memory and testimony can still be found today among lay people, legal experts, and eyewitness researchers (e.g., Goodman, Golding, & Haith, 1984; Lieppe & Romanczyk, 1987; Yarmey & Jones, 1982, 1983).

Beliefs such as these prompted past judicial systems to be biased against relying on young children's eyewitness reports and in some cases resulted in the banning of children's testimony from courts (Zaragoza, 1987). In fact, until recently in Canada (January, 1988, when Bill C-15 was introduced and amendments were made to the "Canada Evidence Act" and the "Criminal Code"), it was mandatory for a child's testimony to be verified by another individual before it could be accepted as evidence in court (Wells, 1990). However, during the last few years the attitude toward children's testimony has started to change (e.g., Goodman, Rudy, Bottoms, & Aman, 1990; Saywitz, Goodman, Nicholas, &

Moan, 1991). It is the opinion of some individuals that if children are provided with appropriate preparation and proper interview methods are utilized, then even very young children can provide trustworthy testimony (Berliner & Barbieri, 1984; Yuille, 1988).

Given the growing number of reported cases of child physical and sexual abuse (see Archdiocesan Commission, 1990; Russell, 1983; Yuille, 1988) and given that children are often the sole witnesses to such crimes, it is essential to know whether, and to what degree, children's testimony is trustworthy. One of the more common concerns regarding children's eyewitness testimony is the vulnerability of their memory to misleading postevent information (e.g., Ceci et al., 1987b; King & Yuille, 1987; Whipple, 1909; Zaragoza, 1987). In fact, much of the past research concerning eyewitness testimony, in both children and adults, pertains to the vulnerability of memory and testimony to postevent misinformation (see Zaragoza, 1987). Children are frequently exposed to different types of information after they witness or experience an event (e.g., questioning by parents, lawyers, social workers, or police; media coverage of the event). Therefore, it is critical to determine whether, and how, postevent information influences children's memory and testimony for events.

Most of the researchers who have examined how memory and testimony are affected by postevent information have concentrated on what has been termed the "misinformation effect" (see Zaragoza, 1987). The misinformation effect refers to the tendency individuals have to incorporate misinformation about a previously encoded event into their later recollections of that event (Howe, 1991). This effect has inexplicably appeared and disappeared across studies examining eyewitness memory in young children (see reviews in Ceci, Ross, & Toglia, 1987a; Cole & Loftus, 1987; Howe, 1991; Johnson & Foley, 1984; Loftus & Davies, 1984; Zaragoza, 1987). In addition to its now-you-see-it (e.g., Ceci et al., 1987a) now-you-don't (e.g., Zaragoza, 1987) nature, there is little agreement across studies as to the role memory impairment plays in misinformation effects. That is, there is debate over the type of memory impairment that occurs and whether it occurs at all. Due to its theoretical and practical importance, the conditions that produce the inconsistencies across the studies examining the effect of misinformation on memory and testimony must be uncovered (Howe, 1991).

In the present investigation, three limitations of past research are examined to help explain not only the transient effects of misinformation, but also how misleading information influences memory for an event. The first limitation concerns the failure to control the degree to which preschoolers learn original information both across conditions within a study and across studies. The second concerns the failure to adequately operationalize and isolate storage-based and retrieval-based contributions to the effects of misinformation on memory. That is, the sensitivity of past analytical techniques has not been sufficient to measure storage- and retrieval-based forgetting and reminiscence of original information. Forgetting refers to the inability to recall information that was recalled previously and reminiscence typically refers to the ability to recall information that was previously forgotten (however, it may also refer to the enhanced recall of previously recalled items). The third limitation pertains to past failures to examine the potential that exposure to misinformation may have to reactivate and redintegrate the original memory. That is, the primary focus has been with the destructive effects of misinformation on memory and testimony, with little or no concern for its possible constructive effects (also see Ornstein, Larus, & Clubb, 1991).

Brief literature overviews concerning the misinformation effect and children's vulnerability to postevent misinformation are presented first. The issues concerning initial learning confounds, analytic insensitivity, and the dual effects of postevent misinformation are then delineated. This is followed by a description of the recently developed trace-integrity framework and model (Howe & Brainerd, 1989). The framework and model are presented as a means of eliminating the problems of initial learning and analytic insensitivity, so that both the potential constructive and destructive effects of misleading information can be examined. In the subsequent sections, an experiment is described in which the three limitations are addressed and the role of memory impairment in preschoolers' reporting of misinformation is examined.

The "Misinformation Effect"

The misinformation effect is presumably the laboratory equivalent of modifications that can occur in an individual's testimony in real-life after exposure to misinformation. Typical investigations of misinformation effects involve three stages: (a) an encoding stage where subjects first experience an event, either a staged live event, videotaped event, slide sequence, or story; (b) a postevent information stage where misleading, consistent, or neutral information is presented either through narrative description, questions, or statements; and (c) a retention stage where subjects, after some time interval, are given a test of memory for the original event, typically a two-alternative forced choice recognition test. Loftus and her colleagues (e.g., Loftus, 1975, 1979a, 1979b, 1979c, 1980; Loftus & Loftus, 1980; Loftus, Miller, & Burnes, 1978) were the first to argue that the memory report of an original event can be impaired by misleading postevent information. Loftus et al.'s (1978) subjects watched a slide sequence of an auto-pedestrian accident that involved a stop sign. The subjects were then given misleading information that implied that the stop sign was a yield sign, and were later asked whether they saw a stop or yield sign. Subjects presented with the misinformation selected the yield sign significantly more than subjects who had not been misled.

Since the mid-1970's there have been numerous studies from around the world that demonstrate that when subjects are exposed to misinformation about certain details of a previously witnessed event, they tend to report the misinformation on subsequent memory tests (e.g., Bekerian & Bowers, 1983; Christiaansen & Ochalek, 1983; Loftus, 1975, 1977, 1979a, 1979b, 1979c; Loftus, Donders, Hoffman, & Schooler, 1989; Loftus & Hoffman, 1989; Loftus & Loftus, 1980; Loftus, Schooler, & Wagenaar, 1985; McCloskey & Zaragoza, 1985b; Sheehan & Tilden, 1986; Wagenaar & Boer, 1987; Weinberg, Wadsworth, & Baron, 1983; Zaragoza & Koshmider, 1989; Zaragoza & McCloskey, 1989). For example, it has been shown that hammers are remembered as screwdrivers (Belli, 1989; McCloskey & Zaragoza, 1985a), breakfast cereal is recalled as eggs (Ceci et al., 1987a, 1987b; Ceci, Toglia, & Ross,, 1988), cans of Planter's peanuts are mistaken for Coke cans (Zaragoza, McCloskey, & Jamis, 1987), a mustache is recalled on a clean-shaven man (Gibling & Davies, 1988), and a Mademoiselle magazine is mistaken for Vogue (Tversky & Tuchin, 1989). It appears that postevent exposure to misleading information promotes erroneous reporting.

Something is also known about how to produce, as well as diminish, misinformation effects. For example, the likelihood that subjects will report misleading rather than original information increases when the memory for the original information is poor or nonexistent (e.g., Loftus, 1975; Yuille, 1984) and as the time between the exposure to original information and the presentation of misinformation increases (Loftus et al., 1978). In addition, subjects are more likely to report misinformation when it targets peripheral information (i.e., trivial or background story details) as opposed to central information (i.e., information relevant to the theme or ongoing action of an event; Dodd & Bradshaw, 1980; Goodman, Aman, & Hirschman, 1987; King & Yuille, 1987; Yuille, 1980). There are also a number of manipulations that are effective in preventing misinformation effects: (a) exposing subjects to blatant misleading information (i.e., information that is implausible given the context of the event, e.g., a city scene containing a water pump; Loftus, 1979a); (b) warning subjects that misinformation exists prior to its exposure (Christiaansen & Ochalek, 1983; Greene, Flynn, & Loftus, 1982); (c) informing subjects that the source of the misinformation is unreliable (Dodd & Bradshaw, 1980; Turtle & Wells, 1987); and (d) excluding the misinformed items from a recognition test (McCloskey & Zaragoza, 1985a, 1985b). There is also evidence that the more knowledge subjects' have for an event and the higher their level of interest in the event, the less likely it is that misinformation effects will be observed (e.g., Powers, Andriks, & Loftus, 1979).

The predominant explanations of the misinformation effect include two versions of the "memory impairment hypothesis" ([a] the single trace hypothesis and [b] the separate trace hypothesis) and the "no-impairment hypothesis."[1] According to the memory impairment explanation, impairment in memory for the original event is the primary cause of erroneous reporting after exposure to misinformation. Proponents of the **single trace hypothesis**, led by Loftus and her colleagues (e.g., Loftus, 1975, 1977, 1979a, 1979b, 1979c, 1989; Loftus & Greene, 1980; Loftus & Hoffman, 1989; Loftus, Korf, & Schooler, 1989; Loftus & Loftus, 1980; Loftus et al., 1978; Loftus et al., 1985), believe that misleading information is incorporated into the original trace. Misinformation then either alters (i.e., adds to or partially replaces) or overwrites (i.e., completely replaces) memory for the original event. Other mechanisms involved in single trace impairment have also been proposed. These include a blending of misleading and original information (e.g., Belli, 1988; Metcalfe, 1990), an "unlearning" of original information (e.g., Reynolds, 1977), as well as a "disintegration" of the bonds integrating original trace features (e.g., Howe, 1991). The single trace version of the memory impairment hypothesis has not been readily accepted because it opposes the popular view of memory as a permanent storage medium where forgetting is due to trace inaccessibility (Loftus & Hoffman, 1989).

Supporters of the **separate trace hypothesis** (e.g., Bekerian & Bowers, 1983; Bowers & Bekerian, 1984; Christiaansen & Ochalek, 1983; Christiaansen, Sweeney, & Ochalek, 1983; Morton, Hammersley, & Bekerian, 1985; Pirolli & Mitterer, 1984) maintain that original information is intact and not lost from memory. According to this explanation, original and misleading information are likely stored in different traces where they compete with one another at output. Although both original and misleading information coexist, the latter is recalled on a subsequent memory test because misleading information interferes with the recall of original information. This may either be because misinformation inhibits or suppresses original information or simply because misinformation is more active in memory. It has also been argued that forgetting in the retroactive interference paradigm may be due to the removal of retrieval cues by interpolated trials (Tulving & Psotka, 1971). With the retroactive interference paradigm, subjects may learn, for example, a list of paired-associates, after which they learn a second list containing different target items, and then are asked to recall the original list. Because of the similarity between the two paradigms, forgetting in the misinformation paradigm may also be due to the removal of appropriate retrieval cues. However, regardless of the cause, it is believed that with the proper retrieval support the original information will become accessible again.

Proponents of the **no-impairment hypothesis** (e.g., Bowman & Zaragoza, 1989; McCloskey & Zaragoza, 1985a, 1985b; Zaragoza et al., 1987) maintain that misleading postevent information does not affect memory for the original event. They argued that although both original and misleading information are accessible, problems with the commonly used "Loftus Test," such as demand characteristics and response biases, encourage the reporting of misleading information. (Recall that with the Loftus Test subjects are asked to choose between the original and misleading item.) That is, misinformation effects are brought about by factors other than memory impairment. The critical difference between the no-impairment and the separate trace hypotheses is simply that with the former the misleading information is claimed not to interfer with the recall of original information. That is, according to the separate trace version of the memory impairment hypothesis, misinformation is reported because this information interfers with the retrieval of original information. However, according to the no-impairment hypothesis, subjects choose to report misinformation either because of demand characteristics or reponse bias.

To eliminate the problems with the Loftus Test, McCloskey and Zaragoza (1985a, 1985b) designed a "Modified Test" (for a description of a "Modified Modified Test" procedure see Zaragoza, 1992). The Modified Test is identical to the Loftus Test with the exception that test questions concerning the critical information ask subjects to choose between an original item and a new item, as opposed to an original item and a misled item as in the Loftus Test situation. The Modified Test has also been adapted for recall procedures; stimulus materials and test questions are designed in such a way that the items used as misleading information are not appropriate responses to the critical test questions (see Zaragoza et al., 1987). Using the Modified Test with both recognition (McCloskey & Zaragoza, 1985a, 1985b) and recall procedures (Zaragoza et al., 1987), Zaragoza and associates found no difference in the frequency with which misled and control subjects recognized or recalled the original information. McCloskey and Zaragoza also replicated Loftus' (e.g., Loftus et al., 1978) results when subjects were asked to choose between the original and misleading information. They concluded that the presentation of misleading information after an event does not cause impairment of memory for that event. Rather, including misleading information in the forced-choice recognition test promotes response bias and conformity, prompting subjects to choose misleading information for reasons other than memory impairment.

Although Zaragoza and associates' (e.g., McCloskey & Zaragoza, 1985a, 1985b; Zaragoza et al., 1987) methodological criticisms of the Loftus procedure are sound, researchers have also criticized McCloskey and Zaragoza's (1985a, 1985b) methodology (i.e., their Modified Test) and interpretation of misinformation effects (e.g., Belli, 1989; Chandler, 1989; Green et al., 1982; Lindsay & Johnson, 1987a; Loftus et al., 1989; Loftus et al., 1985; Tversky & Tuchin, 1989; Weinberg et al., 1983). For example, Loftus et al. (1989) found that when they examined only the accuracy of responding with the McCloskey and Zaragoza (1985a, 1985b) Modified Test, it appeared as if misinformation had no affect on performance. The frequency with which the misled and control subjects chose the original information was similar. However, when they examined speed of responding, the misled subjects took longer to select the original information. Loftus et al. suggested that further research is necessary to determine why misinformation slows subjects' responding on tests where the misled detail is not available. It is possible that misinformation impaired memory for original information, but because something of the original information still existed, subjects chose the more familiar original item over the unfamiliar new item.

Attempts to settle the debate over the type of memory impairment that occurs after exposure to misinformation (i.e., impairment in availability or accessibility) or whether it occurs at all, constitutes most of the research in this area. However, past attempts have been unsuccessful, primarily because there has been inadequate operationalization and isolation of storage-based and retrieval-based contributions to misinformation effects (Howe, 1991). Worse, the forms of operationalizations that have been used tend to confuse theoretical constructs with empirical manipulations (see Howe, 1988; Howe & Brainerd, 1989, for an extensive description of this general problem). That is, although it is possible to directly observe and measure memory behaviours (e.g., mean recall), it is not possible to directly observe the hypothetical memory subprocesses employed to explain behaviour (e.g., storage and retrieval).

To achieve sufficient operationalization of memory subprocesses and to appropriately analyze modifications in these subprocesses (i.e., to allow the storage/retrieval locus of misinformation effects to be determined), it is necessary to implement formal measurement techniques (see Howe & Rabinowitz, 1989, 1990). Such techniques make explicit the relationship between visible empirical results and invisible hypothetical subprocesses. Attaining this analytic precision will permit assessment of how well a trace is stored in memory, its level of retrievability, as well as determine the locus of retention differences. A formal measurement technique known as the trace-integrity model (Howe, 1991; Howe & Brainerd, 1989; Howe, Kelland, Bryant-Brown & Clark, 1992) achieves such analytic precision and can help determine whether misinformation effects are storage-based, retrieval-based, or both. Before I turn to a description of this model, I provide a literature overview concerning children's vulnerability to misinformation. As well, I also provide a discussion of other limitations of past work that have made it impossible to determine what role memory impairment plays in misinformation effects.

Children's Vulnerability to Postevent Misinformation

Although investigations of children's suggestibility date back to the turn of the century, most of these studies were methodologically flawed (see Goodman, 1984). The primary focus in the contemporary literature has been with the effect postevent misinformation has on adult eyewitness testimony and memory. Nonetheless, attention has recently steered toward the empirical investigation of children's vulnerability to misleading information. However, investigations to date reveal inconsistencies across studies regarding children's vulnerability to postevent misinformation.

On the one hand, there is evidence that a young child's memory report is especially vulnerable to misleading information (e.g., Cohen & Harnick, 1980; Dale, Loftus, & Rathburn, 1978; Goodman et al., 1987; Goodman & Reed, 1986; King, 1984, cited in Ceci et al., 1987b; King & Yuille, 1986, cited in King & Yuille, 1987; Sah, 1973, cited in Ceci et al., 1987b). For example, Ceci et al. (1987a; also see Ceci et al. 1987b; Ceci et al., 1988) presented biased information to children 3 to 12 years of age and to college students a day after they were presented with a story about a little girl's first day at school. Three days after story presentation the children were found to be vulnerable to misleading postevent information on a recognition memory test for details of the original story. The younger children, 3- and 4-year-olds, were especially vulnerable (however, see Brainerd & Reyna, 1988).

On the other hand, there are findings that indicate that a child's memory report is no more vulnerable to misinformation than is an older child's or an adult's (e.g., Marin, Holmes, Guth, & Kovak, 1979; Murray, 1983, cited in Loftus

& Davies, 1984). As an example, in Marin et al.'s (1979) study, subjects aged 5 to 22 years witnessed a brief argument between a confederate and an experimenter over the use of the testing room. Subjects were asked to provide a description of the event and to answer some questions about the incident, two of which contained either misleading or nonmisleading information. A subsequent memory test two weeks later revealed that when questions contained misleading information, recall was inferior; however, no developmental differences in vulnerability were found.

There is also evidence that young children resist incorporating misleading information into their subsequent recollections (e.g., Rudy & Goodman, 1991; Saywitz, 1987; Yuille, Cutshall, & King, 1986, cited in King & Yuille, 1987) and that they may even be more resistant than older children and adults (e.g., Duncan, Whitney, & Kunen, 1982). As an example of the latter, Duncan et al. (1982) asked 6- to 10-year-old children and college students either leading or nonleading questions after they watched a slide sequence of cartoons. Children and adults were found to be equally influenced by postevent information. However, when Duncan et al. controlled the amount of information remembered, older subjects' recollections were more influenced by misinformation than were younger subjects' recollections.

Just as there is disagreement as to whether young children have a tendency to report misinformation and whether developmental differences in erroneous reporting exist, there is also little agreement as to the effect (if any) that misinformation has on young children's memory of an original event. To illustrate, in a series of studies by Zaragoza and associates (Zaragoza, 1987, 1991;

Zaragoza, Dahlgren, & Muench, 1992), children from 3 to 6 years of age viewed either a slide sequence of story-book illustrations or a slide sequence of a live event. The children were then presented with neutral or misleading information about particular details of the original event, followed by a test for memory of the event. Zaragoza and associates found no evidence that misinformation impaired memory, even when children were misled twice. Preschoolers also showed resistance to memory impairment across different sets of stimulus materials, various retention intervals, at different levels of memory for the original information (manipulated by varying the levels of control performance), and on tests of both recognition and recall. Zaragoza and associates concluded that there was no evidence that misinformation produced memory impairment in preschoolers. Children's erroneous reporting, they maintained, was due to social and methodological factors such as demand characteristics and response bias.

In the Ceci et al. (1987a) study mentioned earlier, demand characteristics were in fact found to play a role in erroneous reporting. Children's vulnerability to misleading information was greatly reduced when a 7-year-old child, as opposed to an adult, presented the misinformation. However, misinformation effects and developmental differences in erroneous reporting were not completely eliminated. Ceci et al. argued that even after demand characteristics were statistically controlled, preschoolers' reports were still vulnerable to misinformation (i.e., preschoolers incorporated erroneous postevent information into their subsequent recollections).

Thus, there is debate concerning the following: (a) whether young children have a tendency to report erroneous information after exposure to misinformation; (b) whether young children are more likely to erroneously report misleading information than are older children and adults; (c) whether the tendency to erroneously report misinformation (if such exists) is merely indicative of response bias and conformity on the part of subjects or whether it indicates memory impairment of original information; and (d) given that exposure to misinformation produces memory impairment, whether it impairs the storage or retrieval of original information, or both. Although various reasons have been proposed for the inconsistencies found across studies concerning the erroneous reporting and memory impairing effects of misinformation, no systematic differences have been located (for a review see Cole & Loftus, 1987). However, answers may lie not so much in the differences across studies, as in the limitations inherent in much of the previous work in this area. I turn now to a discussion of some of these limitations.

Limitations of Past "Misinformation Effect" Studies

Three issues related to the appearance and disappearance of both misinformation effects and the memory impairing effects of exposure to misinformation were examined in the current investigation. These issues were (a) initial learning confounds (i.e., failure to equate levels of learning across experimental conditions and studies), (b) analytic insensitivity (i.e., failure to isolate both forgetting and reminiscence processes and storage- and retrieval-based processes), and (c) the dual effects of postevent misinformation (i.e., failure to consider both the reactivation and redintegration as well as erroneous reporting and memory impairing properties of misinformation presentation). These limitations are examined in the following sections.

Interpretation Problems of the Misinformation Paradigm

Howe (1991) argued that the variation in findings across different misinformation effect studies may be due to problems associated with the three-stage design typically used in such experiments (i.e., initial learning - - postevent misinformation - - retention testing). This three-stage structure does not allow one to unequivocally attribute differences in recollection across conditions to processes activated during the misinformation stage. Recollection differences may instead result from differences in initial learning or rate of forgetting, independent of the misinformation manipulation.

First, consider the consequences of failing to equate initial encoding across various experimental conditions and studies, and the interpretation problems that result. Researchers using the typical misinformation paradigm fail to equate levels of learning across various experimental conditions. In such studies, subjects typically receive a fixed number of presentations of the original information, with a single presentation being the norm (e.g., Ceci et al., 1987b; Zaragoza, 1987). Because subjects differ in their learning ability and because they will learn easier items before more difficult ones, fixed-trials designs do not guarantee that learning is equated for all subject/item combinations at the end of acquisition (e.g., Underwood, 1964). This problem is maximized in single presentation designs because learning is negatively accelerated. In addition, degree of learning may vary across conditions and studies, and if vulnerability to misleading information depends on extent of initial encoding (e.g., Loftus, 1975; Yuille, 1984), then different outcomes across studies may result. Because it is possible that the degree to which original information is encoded varies across different items, subjects, and conditions, differences in recollection cannot be unambiguously attributed to the misinformation stage. As well, differences across studies in the initial encoding of original information only contribute further to the interpretation problems in this area.

Spurious misinformation effects may also arise because of differences that can occur during the retention interval. Differences in forgetting, reminiscence, or both across items or subjects may result in differences in recollection between misled and nonmisled conditions that cannot be attributed to the misinformation stage. Suppose that exposure to misinformation does not affect memory or testimony for an event, but that event details differ in their forgetting or reminiscence rates and that subjects differ in the rate with which they forget or reminisce event details. Differences across conditions in forgetting or reminiscence may produce what appear to be erroneous reporting or memory impairment effects. That is, it is possible that subjects may forget more in the misled condition or reminisce more in the nonmisled condition. Thus, the variation in outcomes across the different studies may be due to different degrees of forgetting, reminiscence, or both across items, subjects, and conditions.

Problems with interpretation are even more pronounced when examining developmental differences in vulnerability to misinformation. Because younger subjects take longer to learn information than older subjects (e.g., see reviews in Howe & Brainerd, 1989; Howe, Kelland et al., 1992), resulting age differences in recollection cannot be attributed to vulnerability differences, but may instead be due to age differences in initial learning. In addition, studies of children's long-term retention in which levels of learning have been equated demonstrate that forgetting declines with age (e.g., Brainerd, Kingma, & Howe, 1985; Howe, Kelland et al., 1992). Although there may be no developmental changes in vulnerability to misinformation (however see Ceci & Bruck, 1993), if vulnerability depends on trace strength (i.e., it increases as trace strength for the original event decreases), then interactions of age with initial learning and forgetting may produce what appear to be developmental differences in vulnerability. Therefore, due to the nature of the three-stage design used in misinformation studies, recollection differences should not be attributed to processes activated during the misinformation stage. Processes that operate at any (or all) of the stages may produce differences in recollection.

Inadequate Measurement and Analysis

Howe (1991) argued that many of the interpretation problems of the misinformation paradigm are directly related to issues of measurement and analytic insensitivity. The first measurement issue he discussed concerned the positive and negative subprocesses involved in retention and the importance of disentangling these components formally. Two opposing tendencies, forgetting and reminiscence, occur at an item-specific level in children's long-term retention (e.g., Howe, Kelland et al., 1992). Recall that forgetting is defined as the failure to recall an item (event) that was recalled on an earlier test trial, whereas reminiscence is the successful recall of an item (event) that was not recalled previously.

Past studies of long-term retention in general, and misinformation effects in particular, have failed to satisfactorily isolate factors that weaken performance on long-term retention tests (forgetting) from factors that heighten performance on such tests (reminiscence). Whereas summary statistics used in previous studies (e.g., recall or recognition performance) combine these distinct tendencies with an attendant loss of precision, partitioning retention into forgetting and reminiscence subprocesses makes it possible to accurately interpret general retention outcomes. In other words, although net declines in recall may imply that forgetting surpassed reminiscence, reminiscence may still have occurred for some items. Similarly, although net increases in recall may imply that reminiscence surpassed forgetting, forgetting may still have occurred for some items.

Howe (1991) also pointed out that it is important to distinguish between forgetting and reminiscence tendencies when examining the effect of misinformation on original information. This is because differences between control and misled groups in the net recall of original information may not be due to differences in forgetting alone; differences in reminiscence tendencies (i.e., the ability to reconstruct weakened traces) may contribute to overall differences in recall. Similar arguments also apply when interpreting developmental differences in misinformation effects, where it is assumed that younger children, more so than older children, fail to reconstruct weakened traces (e.g., see Dent & Stevenson, 1979; Eugenio, Buckout, Kostes, & Ellison, 1982; Scrivner & Safer, 1988). Because retention performance is determined by the interaction between forgetting and reminiscence, it is important that these subprocesses be segregated and directly measured in order to fully comprehend misinformation effects.

The second measurement issue raised by Howe (1991) was mentioned earlier; it concerns the importance of adequately operationalizing and isolating storage-based and retrieval-based contributions to misinformation effects. Recall that there has been considerable controversy over whether the memory impairing effects of misinformation (if such exist) are due to changes in the storage of information, the retrievability of information, or both. Although the goal of most misinformation studies (as well as most long-term retention studies; see the review in Howe & Brainerd, 1989) is to distinguish between storage-based and retrieval-based explanations, previous studies have offered only minimal operationalizations of storage and retrieval subprocesses. In addition, these operationalizations tend to confuse theoretical constructs with empirical manipulations (see Howe, 1988; Howe & Brainerd, 1989). To settle such issues, formal modelling procedures are necessary (see Howe & Rabinowitz, 1989, 1990), procedures that make explicit the relationship between visible empirical results and invisible hypothetical subprocesses (see Howe & Brainerd, 1989 for further discussion). Such analytic precision will permit assessment of how well the trace is stored in memory, its level of retrievability, as well as determine the locus of retention differences.

Thus, it is impossible to determine, based on previous research, whether misinformation affects forgetting, reminiscence, or both, and whether it alters stored information directly, interferes with retrieval, or both. (In terms of developmental studies of misinformation effects, it is impossible to determine which factors influence age changes in vulnerability to misinformation.) To get at such issues, sufficient operationalization of the process(es) under investigation is necessary (see Howe & Brainerd, 1989 for further discussion). The trace-integrity model (Howe, 1991; Howe & Brainerd, 1989; Howe, Kelland et al., 1992) achieves such analytic precision. This model can help determine whether the memory impairing effects of misinformation (if such exist) are due to differences between misled and nonmisled conditions in the tendency to reconstruct weakened traces (reminiscence) or in the rate of information loss (forgetting), or both. It can also help determine whether the memory impairing effects of misinformation are storage-based, retrieval-based, or both, and whether such forgetting is impermanent. Before I turn to a brief description of this framework and model, I shall discuss the last issue believed to be related to the empirical discrepancies found across misinformation studies. This is the failure to consider the potential misinformation has to both constructively and destructively affect original information.

Failure to Consider The Dual Effects of Misinformation

The focus of past research has been on the destructive or negative effects of presenting postevent misinformation (i.e., erroneous reporting and memory impairment); there has been little consideration of its positive or constructive effects. Because misinformation is never presented alone but is always embedded in a context that incorporates aspects of the original event (e.g., narrative description, questionnaire, or statements concerning the event), presenting postevent misinformation may remind subjects of the original event and positively affect recall of original information. Therefore, misinformation could have either destructive or constructive effects, or both (as well as no effect) on memory for an event. Given that exposure to misinformation may have dual effects on memory, variation in outcomes across different studies could result if the constructive and destructive effects of misinformation, or their interaction, differ across them.

In the following, I first discuss the potential of misinformation to reinstate an event and refresh its trace in memory. I then describe how failure to consider the reinstatement properties of misinformation along with its negative effects may explain the transient effects of erroneous reporting and memory impairment.

The Potential of Misinformation to Reinstate. Reinstatement was first defined as "periodic partial repetition of an experience such that it maintains the effects of that experience through time" (Campbell & Jaynes, 1966, p. 478). Basically, "reinstatement" refers to any procedure in which subjects are re-exposed to part or all of an original event, either during the retention interval or at retention testing. "Reinstatement effects" refer to the benefits received at long-term retention when part or all of an original event is re-experienced. There is ample empirical evidence with infants (e.g., Greco, Rovee-Collier, Hayne, Griesler, & Earley, 1986; Rovee-Collier & Hayne, 1987; Rovee-Collier & Shyi, 1992; Rovee-Collier, Sullivan, Enright, Lucas, & Fagen, 1980), children (e.g., Fivush & Hammond, 1989; Hoving & Choi, 1972; Hoving, Coates, Bertucci, & Riccio, 1972; Howe, Courage, & Bryant-Brown, in press), and adults (e.g., Fisher, Geiselman, Raymond, Jurkevich, & Warhaftig, 1987; Geiselman, 1988; Eich & Birnbaum, 1988; Kerr & Winograd, 1982; Smith, 1979; Smith, Glenberg, & Bjork, 1978), as well as with animals (e.g., Deweer, Sara, & Hars, 1980; Gatti, Pais, & Weeks, 1975; Hars & Hennevin, 1990; Miller, Kasprow, & Schachtman, 1986) that partially reinstating the original event either prior to or during testing enhances subsequent retention.

For example, in a recent series of experiments, Howe et al. (in press) asked 2- to 3-year-olds to learn a series of object-location pairings to a strict criterion. Three weeks later the children were given postevent information that was consistent with the information provided at acquisition (i.e., the children were shown the objects only). One week later (four weeks after acquisition) the children received four test trials with no further study opportunities. Reinstatement significantly improved preschoolers' long-term retention; providing consistent information during the retention interval reactivated (i.e., primed, refreshed, or recycled) children's memories and served to insulate those memories from storage-related forgetting in particular. Therefore, forgetting can be alleviated by providing reminders of an original event prior to (or during) a retention test.

Thus, re-encountering some aspect of the original event (i.e., reinstatement) can increase availability (e.g., Howe et al., in press) and accessibility (e.g., Rovee-Collier & Shyi, 1992; Spear, 1973) of the original trace.[2] In particular, reinstatement is believed to (re)activate some of the features and bonds in the original trace, with the result that (re)activation spreads to other features and bonds, thereby producing an overall increase in the trace's level of activation. (Re)activation of the entire trace is likely to increase the trace's degree of integration. That is, the trace becomes redintegrated (i.e., restored to its original state) with increased (re)activation of the trace's features and bonds (e.g., see Horowitz & Prytulak, 1969; Howe, Kelland et al. 1992). Of course, increased trace redintegration enhances availability or accessibility of the original memory. Reinstatement, then, may explain how memories are preserved for a long time after events are originally encountered.[3]

Although reinstating a portion of an original experience may reactivate the entire trace, trace reactivation may do more than just increase availability or accessibility of the original memory, it may also alter the contents of what is stored in memory. Rovee-Collier and Hayne (1987) have pointed out that "... while memories are undoubtly reactivated again and again, they may be modified to incorporate new information. ... Thus, over successive retrievals, the contents of memory may gradually change and become reorganized..." (p. 231). Thus, trace reactivation may have the opposite effect than that which is expected; it may diminish rather than enhance retention of one's memory for specific aspects of an event.

Because misinformation is typically embedded in a context that reinstates part of the original event (e.g., narratives, questions, statements), correct information available in the postevent reminder may reactivate the corresponding information encoded in the original trace (i.e., the information not targeted by the misinformation). Reactivation of the nontargeted information may cause reactivation to spread to other trace features, with the result that the entire trace is reactivated. It is possible that the more the trace is reactivated, the less likely it is that misinformation will be incorporated into that trace. Thus, the more the trace is reactivated, the less likely it will be that misinformation will impair memory. However, it is also possible that reactivation of the trace may instead promote the incorporation of misinformation into that trace, with the result that the retention of targeted information is attenuated rather than enhanced. Therefore, it is possible that exposure to misleading information negatively affects the targeted information but prevents, rather than promotes, forgetting of the surrounding or nontargeted information.

Recently, Rovee-Collier, Borza, Adler, and Boller (1993) have offered another possibility. Based on the results of their study with three-month-olds, they argued that once an encoded event leaves primary memory, it is protected. That is, only a copy can be retrieved and modified in the future. To impair original information, then, misinformation must be presented at a time when both types of information are simultaneously active in primary memory and before original information leaves primary memory and is copied. Therefore, if misinformation is presented after original information has been stored in long-term memory, it is possible that misinformation reactivates and preserves the initial copy of original information (because this information is accessed), as well as intefers with a retrieved copy of the original information.

The potential postevent misinformation has to reinstate the original event and reactivate the original trace may help explain the transient effects of exposure to misinformation. In the following, two issues are discussed that may explain how the outcome of a study (i.e., whether negative, positive, or null effects are found) is influenced by the potential misinformation may have to constructively and destructively affect memory. The first issue concerns differences in the reactivation power of various methods of presenting misinformation and how this influences whether, and the extent to which, memory impairment and erroneous reporting effects are found. The second issue concerns differences in experimental design (that may interact with differences in reactivation power) and how such differences may influence the outcome of a study examining the effects of misinformation.

Explaining the Inconsistencies. Consider the Zaragoza and associates (Zaragoza, 1987, 1991; Zaragoza et al., 1992) and Ceci et al. (1987a) studies mentioned earlier. Both used Zaragoza's Modified Test procedure; that is, subjects were asked to choose between the original item and a new item on a recognition test. Although, Zaragoza and her colleagues found no difference in recall performance between misled and control subjects, Ceci et al.'s (1987a) misled subjects recalled less of the original details than did control subjects. Despite the fact that Zaragoza et al. (1992) examined a number of differences between their studies and Ceci et al.'s (1987a) and that they replicated Ceci et al.'s fourth experiment, they never found a difference between the control and misled groups when they used the Modified procedure. Zaragoza et al. were especially puzzled with the results of the replication study. Both they and Ceci et al. found differences, as expected, between the misled and control conditions when they used the Loftus Test procedure (i.e., subjects are asked to choose between the original and misled item). However, Zaragoza et al.'s misled performance was much higher; 63% of the original information was recalled in Zaragoza et al.'s study vs 46% in Ceci et al.'s study. In addition, although Zaragoza used older children from higher socioeconomic classes, her control performance was still lower than Ceci et al.'s (81% vs 88%, respectively).

In a recent study, Toglia, Hembrooke, and Ceci (cited in Toglia, Ross, Ceci, and Hembrooke, 1992) used a slide sequence similar to that used by Zaragoza and her colleagues (e.g., Zaragoza et al., 1992) and they tested children with the Modified Test procedure. For approximately 50% of their stimuli, misled preschoolers recalled less of the original information than children in a control condition. That is, using stimuli that were very similar, Toglia et al. found preschoolers to be vulnerable to memory impairment, whereas Zaragoza and her colleagues did not.

Belli et al. (1982), in a series of experiments, appeared to resolve the descrepancy between studies as to whether or not the Modified Test produces impaired memory performance following misinformation. Belli et al. manipulated the delay interval between exposure to original information and misinformation and found that as long as the interval was three-five days, the Modified Test produced the misinformation effects observed with the Original Test. When the interval was shorter, it did not. However, Zaragoza (1992), in a series of experiments, determined that the exposure to original information - misinformation interval could not explain the differences observed between studies utilizing the Modified Test.

The inconsistencies found between the Zaragoza and colleagues' (e.g., Zaragoza, 1987, 1991; Zaragoza et al., 1992) and Ceci and colleagues' (e.g., Ceci et al., 1987a; Toglia et al., cited in Toglia et al., 1992) studies may be due to differences in the reactivation potential between their methods of presenting misinformation. That is, a study's outcome may depend on the degree to which the reminder containing misinformation reactivates the original trace. As stated earlier, it is possible that the more the original trace is reactivated, the less likely it may be that the information contained in that trace will be impaired. However, it is also possible that the more reactivation power the misinformation reminder has, the more likely it may be that misinformation is incorporated into the original trace and, therefore, the stronger its representation may be in that trace. The greater extent to which misinformation is represented in the original trace, the more likely it may be that the original trace updates itself with the misinformation. That is, the more likely it may be that misinformation affects targeted information (or nontargeted information), by either partially replacing, blending with, or completely overwriting the original information. It is also possible that the more reactivation power the misinformation reminder has, the more likely it may be that misinformation has both effects, namely, reactivation and preservation of the original trace as well as integration with original information.

However, when the misinformation reminder promotes little or no reactivation of the original memory, the misleading information may be more likely encoded in an entirely different trace, with the result that misinformation does not integrate with or alter the trace containing the original event. Assuming that both the original and misleading information are available, output interference may then be a problem, especially if subjects are forced to choose between the two types of information. However, when subjects are given the opportunity to respond twice at recall, there should be no output interference. This does not mean that misinformation will not affect access to the original trace; for example, misinformation may still suppress or inhibit original information, thus, affecting retrieval of the trace. Therefore, the potential that postevent misinformation has to reactivate the original tra. : may influence whether erroneous reporting and memory impairing effects of misinformation are found, as well as whether misleading information affects trace storage, retrievability, or both.

The degree of reactivation potential that postevent misinformation possibly has may depend on the way in which the information is presented (e.g., narrative description, questionnaire, statements). Presentation methods may vary in reinstatement strength from those that have little or no power to reactivate original trace features and bonds, to those that have great potential to do so. For example, (mis)information presented in forms such as questionnaires, as opposed to narratives or statements, may make it more likely that subjects will access the original trace because answers to questions are required (Howe, 1991). This may increase the degree to which either the nontargeted information or the entire original trace is reactivated. with the result that misinformation may be strongly represented in the original trace when presented in questionnaire form. That is, erroneous reporting and memory impairment effects may be more prevalent when misinformation is embedded in a question answering format than when subjects passively listen to an additional narrative that contains the misinformation.

In fact, differences in the reactivation potential between questionnaire and narrative presentation methods may explain the variation in outcomes between the Zaragoza and colleagues' (e.g., Zaragoza, 1987, 1991; Zaragoza et al., 1992) and Ceci and colleagues' (e.g., Ceci et al., 1987a; Toglia et al., cited in Toglia et al., 1992) studies. For example, in Ceci et al.'s four experiments, children were asked questions that contained misinformation. In all but one of Zaragoza's studies, misinformation was embedded in a narrative. (Zaragoza et al. stated that they employed the same materials and procedures when they replicated Ceci et al.'s fourth study, however, they failed to explicitly describe the method by which misinformation was presented.) The reactivation capability of Ceci and colleagues' question answering method of presenting misinformation may have been greater than Zaragoza and colleagues' narrative presentation. Therefore, misinformation may have had a greater chance to impair original information in the Ceci et al. studies. This would explain Ceci et al.'s lower misled performance in the Loftus Test compared to that found in Zaragoza et al.'s replication study.

Zaragoza and colleagues (e.g., Zaragoza, 1987, 1991; Zaragoza et al., 1992) did consider the strength of the misinformation manipulation as a possible reason for the differences between their studies and those of Ceci and his colleagues (Ceci et al., 1987a; Toglia et al., cited in Toglia et al., 1992). For example, Zaragoza (1987) conducted two experiments in which preschoolers were presented with a series of slides and then exposed to misleading information. The two experiments were identical with the exception that preschoolers were exposed to misleading information only once in the first experiment but twice in the second (i.e., the synopsis of the event containing misinformation was presented twice in immediate succession). Although the Modified Test provided no evidence of memory impairment in either experiment, there was a difference in recall levels between experiments.

Following one exposure to misinformation, recall performance in the misled and control conditions were 74% and 71%, respectively. When the preschoolers were misled twice, performance in the misled and control conditions were 69% and 70%, respectively. Although not a large difference, there was indication that stronger manipulations of misinformation (i.e., presenting misinformation twice) were more likely to impair memory of original information (74% vs 69% correct with one and two presentations of misinformation, respectively). In fact, in a study with adults, Zaragoza (1992) found that misinformation did not impair memory of original details when the subjects were misled once, but did when subjects were misle . nore than once. But she noted that the observed memory impairment effects were small and did not replicate consistently. However, despite Zaragoza's small effects, there is reason to suspect that the differences between the Ceci et al. (e.g., Ceci et al., 1987a; Toglia et al., cited in Toglia et al., 1992) and Zaragoza (e.g., Zaragoza, 1987, 1991; Zaragoza et al., 1992) studies are due to differences in the strength of the misinformation manipulation. Therefore, the stronger reactivation potential that the questionnaire presentation method may have had possibly explained Ceci et al.'s lower misled performance in the Loftus Test compared to that found in Zaragoza et al.'s replication study.

But what explains the lower control performance in Zaragoza et al.'s (1992) study? Another factor probably contributing to the transient effects of misinformation concerns the type of experimental design used. Zaragoza et al. used a within-subjects targeted-control manipulation; that is, all subjects were exposed to misinformation about half the items and the remaining items served as the control. However, Ceci et al. (1987a) used a between-subjects manipulation; half the subjects were misled and the other half received no misinformation at all. It is possible, as Zaragoza et al. pointed out, that exposure to misinformation weakens the entire trace of the event, and not solely the targeted items. In other words, there may be some form of negative spread from targeted to nontargeted items. Because all of Zaragoza et al.'s subjects were exposed to misinformation about half the critical items, their control items may have been negatively affected by the misinformation. So Zaragoza et al.'s control performance may have been inadvertently lowered, with the result that any effects that misinformation may have had would not have been detected. Therefore, the outcome of a study on the effects of misleading information may depend on whether misinformation is manipulated within- or between-subjects, as well as on the degree of reactivation power the presentation method has.

The above discussion illustrates the importance of examining reinstatement, trace reactivation/redintegration, and the spread of constructive and destructive effects among trace elements to understand the effect, if any, misinformation has on memory for an event. Specifically, there is a need to know whether postevent misinformation reactivates the original memory, and if so, whether this enhances or diminishes retention of specific details of the event. In addition, provided that reactivation/ redintegration or memory impairment occur, we also need to know what portion of the trace is affected and if these effects spread to other trace elements. If misinformation does impair or improve certain portions of memory for an event, then the principle theoretical question concerns whether these effects occur at storage, retrieval, or both. In order to answer this question, a technique is required that will separate and measure storage- and retrieval-based processes. As mentioned earlier, the trace-integrity theory and its mathematical implementation were used to isolate these effects in the present thesis. Before turning to the study itself, I provide a description of this theory and model.

The Trace-Integrity Framework and Mathematical Model

The trace-integrity framework and associated model offer a theoretical and mathematical factoring procedure that separates the forgetting and reminiscence tendencies at retention and determines their storage-based and retrieval-based origins. The framework and model are described first, followed by a comparison of formal modelling procedures with traditional methods of analysis.

Description of the Trace-Integrity Theory and Model

Consistent with other theories (e.g., Ackerman, 1987; Chechile, 1987), the trace-integrity framework (see Brainerd, Reyna, Howe, & Kingma, 1990; Howe, 1991; Howe & Brainerd, 1989; Howe, Kelland et al., 1992) regards storage and retrieval as lying on a continuum, where the viability of a trace is determined by the degree or "strength" of bonding between primitive trace elements (e.g., features, nodes, etc.). According to this theory, as information is acquired, trace elements integrate to the extent that they first become formed in memory with some minimum probability of recall. This early stage of trace formation is associated with storage processes. With continued trace integration, elements comprising the trace become unified to a degree where recall occurs with probability 1. This later stage of trace integration is associated with the process of learning to retrieve stored information. During the retention interval, the trace is believed to either remain integrated with probability of recall remaining at 1 (no forgetting), dissipate to a point where the trace can be recalled with some probability between 0 and 1 (retrieval-based forgetting), or weaken to a level where it is no longer possible to recall the trace (storage-based forgetting).

Recall that redintegration is a process whereby activation of some of the features in a trace spreads to other features, thereby resulting in an overall increase in the trace's degree of integration. Reminiscence is indicative of the degree of redintegration a trace undergoes and, like forgetting, is segregated into storage-based and retrieval-based processes. The re-establishment of traces in this manner explains the spontaneous recovery that is commonly observed on tests of long-term retention. Note that storage-based reminiscence is possible because the availability of traces does not have to be an all-or-none event. Rather, it can be determined by the position of the trace on the integrity continuum. That is, traces that have fallen below the zero recall threshold may not have disappeared from memory, but may simply be undetectable due to background noise. Because it is conceivable that some degree of trace integrity may exist, albeit small, it is possible to reactivate trace bonds and redintegrate the trace with multiple test opportunities.

The mathematical implementation of the trace-integrity framework separates forgetting and reminiscence tendencies, and partitions the contributions of storage and retrieval processes to these tendencies in terms of the model's parameters (see Brainerd et al., 1990; Howe, 1991; Howe & Brainerd, 1989; Howe, Kelland et al., 1992). This mathematical model pertains to designs where retention involves a sequence of four (or more) test trials with no further opportunity for study. Analytic sensitivity is accomplished with 9 parameters that capture the retention data from multi-trial Ebbinghaus-like experiments (i.e., experiments in which subjects are given repeated study trials, followed by a retention interval, and then a testing session). Refer to Table 1 for a summary of the theoretical definitions of the trace-integrity model's parameters.

The disintegrative or forgetting processes are partitioned using two parameters; one parameter measures the probability of storage failure ($\underline{S}$) and the other measures the probability of retrieval failure ($\underline{R}$). Specifically, $\underline{S}$ provides the unconditional probability that an item is not available for recall after the retention interval. For items that are available at retention (1-$\underline{S}$), $\underline{R}$ provides the conditional probability that the items are inaccessible. Zero recall indicates storage failures and recall probabilities between zero and one are indicative of retrieval failures.

Redintegrative processes are captured by seven parameters, one that measures the probability of storage-based reminiscence ($\underline{a}$) and six that assess retrieval-based reminiscence as it relates to preceding test-trial successes ($\underline{r}_i$) and errors ($\underline{f}_i$). More precisely, the parameter $\underline{a}$ provides the conditional probability that an item that was not available for recall during the first retention test trial (signified by $\underline{S}$) is later redintegrated to a point above the zero recall level. The retrieval-based reminiscence parameters measure the conditional probabilities of item retrieval across the retention test trials and only pertain after the first test trial. The success-contingent reminiscence parameters evaluate the probability that retrieval is successful after one, two, or three consecutive successes ($\underline{r}_1$, $\underline{r}_2$, and $\underline{r}_3$, respectively). The error-contingent reminiscence parameters measure the probability that retrieval is successful after one, two, or three consecutive errors ($\underline{f}_1$, $\underline{f}_2$, and $\underline{f}_3$, respectively).

Table 1
Theoretical Definitions of the Trace-Integrity Theory's Parameters

Process and Parameter	Description
Forgetting	
$\underline{S}$	The probability of storage failure
$\underline{R}$	The probability of retrieval failure of information in storage
Reminiscence	
$\underline{a}$	The probability that information not in storage is redintegrated to a level above zero recall
$\underline{r}_1$	The probability of a success following one success
$\underline{r}_2$	The probability of a success following two consecutive successes
$\underline{r}_3$	The probability of a success following three consecutive successes
$\underline{f}_1$	The probability of a success following one error
$\underline{f}_2$	The probability of a success following two consecutive errors
$\underline{f}_3$	The probability of a success following three consecutive errors

Note. Adapted from Howe (1991).

<u>The Advantages of Formal Modelling Procedures</u>

Howe et al. (in press; also see Howe, 1991) discussed three advantages of formal modelling procedures over the more traditional analysis of variance (ANOVA) and covariance (ANCOVA) techniques used in memory development research. A reiteration of their arguments follows. The first advantage is that the theoretical, measurement, and statistical assumptions are clearly stated with formal models. In addition, statistical procedures are typically used to assess goodness of fit of those assumptions for each data sample before testing hypotheses. Traditional ANCOVA procedures are commonly utilized to compensate for possible under- or overlearning effects at long-term retention where for instance, errors at acquisition are used as the covariate and errors at retention serve as the dependent variable. In addition to controlling for residual learning differences, it is also believed that ANCOVA procedures control for any other differences that may occur at acquisition and consequently influence retention (e.g., age or ability differences). However, unlike formal models, ANCOVA assumptions are rarely tested explicitly. That is, unlike ANOVA and ANCOVA, formal models are assessed to determine their fit to the data. It is the good fit of the model to the data that generates power.

It is because ANOVA and ANCOVA are meant to be general-purpose analytical tools that their power is limited in comparison with formal models. Formal models are designed around particular paradigms (e.g., Ebbinghaus-like retention experiments) and sets of theoretical issues (e.g., the contribution of storage and retrieval factors to forgetting and reminiscence processes). As Riefer and Batchelder (1988, p. 318-319) claim, a procedure such as the ANOVA or the ANCOVA " ... usually (does) not permit one to measure directly underlying mental variables but instead provides a method for assessing whether cognitive processes act in conjunction to create differences between conditions. In this approach, one's cognitive theory motivates the selection of experimental conditions, but the theory itself is not reflected in the statistical tools used to analyze the experimental data." Because formal models clearly state assumptions concerning the nature of the underlying memory process (i.e., they are theoretically driven), it is possible to determine the influence of these processes on observable memory performance (also see Bogartz, 1990; Howe, 1991; Riefer & Batchelder, 1988).

The second advantage of formal analyses pertains to the way individual differences within a condition are treated. In ANCOVA, variation across individuals within a condition is regarded as noise and is consigned to error variance. However, in formal analyses, empirical information is obtained from such variation and is employed when making theoretical inferences (see Greeno, James, DaPolito, & Polson, 1978; Howe, 1991; Howe, Kelland et al., 1992).

The final difference between the two methods of analysis concerns the richness of the information extracted from the data. When goodness-of-fit tests show that a particular model provides an adequate account of the data, it is possible to localize effects within specific parameters. This partitioning of the information in the data is much more detailed and precise than that which is possible with standard ANCOVA techniques. Part of the reason for this is that any global performance statistic that is subjected to an ANCOVA (e.g., total correct) is derived from a number of parameters that typically combine in a complicated (and oftentimes nonlinear) fashion. In addition, data in ANCOVA are treated in a purely linear fashion, as is the relationship between the covariate and the dependent variable. Therefore, it is not surprising to discover that manipulations that produce no observable differences between conditions in an ANCOVA, have clear effects on parameters in more representative formal models (also see Brainerd, Howe, & Desrochers, 1982).

Howe et al. (in press) noted that given the many differences between the general purpose ANCOVA procedures and the formal models, it would be surprising if they did not lead to different interpretations of the data under study. In the present experiment, the ANCOVA was used to provide a summary of the general trends and a traditional interpretation of the results. The trace-integrity model was used to give a clearer and more precise assessment of the effects of misinformation on preschoolers' testimony and memory.

The Present Study: Using the Trace-Integrity Model to Examine the Dual Effects of Misinformation

The Howe (1991) study has been the only investigation to date of children's vulnerability to misinformation in which the trace-integrity model has been used to address limitations of past research. In his study, the initial learning and analytic insensitivity issues were addressed in an examination of misinformation effects in young children. Kindergarten and grade 2 children were presented with a story about a child's birthday party and were then given information (in either statement or questionnaire form) that was either consistent or inconsistent with an aspect of the story's theme. After a retention interval of either two or nine days, the children received four recall-buffer trials without further study opportunity (i.e., the children were required to recall the story and then perform a short distractor task four times).

Misled subjects did not report misinformation more frequently than nonmisled subjects (i.e., misinformation effects were not found). In addition, inferior recall of original information in the inconsistent information conditions was quite rare, occurring on only one occasion in each of Howe's (1991) two experiments. These effects were related to rate of forgetting, where higher storage failure rates occurred in misled than nonmisled conditions. Interestingly, memory impairment was not related to age, indicating in this case that kindergarten children were no more vulnerable to memory impairment than grade 2 children. Howe argued that such findings are consistent with the belief that when memory impairment effects occur, they impact what is stored in the original trace (e.g., Loftus, Hoffman, & Wagenaar, 1992), and with trace blending theories of memory impairment (e.g., Metcalfe, 1990).

There are three possible reasons for the absence of misinformation effects and the small memory impairing effects found in Howe's (1991) study. First, the misinformation manipulation was directed at the theme of a subevent in a story. The likelihood that subjects will report misled rather than original information apparently increases when misinformation concerns peripheral information (i.e., specific details of an event that are not essential to understanding or interpreting the nature of an event) as opposed to central information (i.e., information relevant to the theme or ongoing action of an event; e.g., Dodd & Bradshaw, 1980; Goodman et al., 1987; King & Yuille, 1987; Yuille, 1980). Thematic information is obviouslv very hard to disrupt, which is important because it assures us that the gist of testimony is accurate. However, memory impairment and erroneous reporting effects may be more likely when misinformation targets the peripheral details of an event.

The second reason for the relatively small effects in Howe's (1991) study may be the misinformation manipulation itself. In his study, children heard only a single statement or were asked a single question (that could lead to an inference) that was consistent or inconsistent with an aspect of the story's theme. The effects of misinformation may be more prevalent when children are directly misled about many items. The final reason for Howe's scarce effects may be, of course, that children are in fact highly resistant to the effects of misleading information.

The present experiment is an extension of Howe's (1991) study. Preschoolers were presented with a narrated slide sequence. Although all to-be-remembered peripheral story details were visually presented in the slides, only half were directly mentioned in the narrative. Three weeks later, preschoolers were given specific information about 10 of the 20 to-be-remembered story details. That is, half of the to-be-remembered details were specifically targeted by the postevent information and half were not. In addition, half of the targeted and nontargeted details were mentioned in the original narrative and half were not. The postevent information was either consistent or inconsistent with the original information. After a one week retention interval (four weeks since acquisition), the children received four recall trials without further study opportunity.

The principal motivation for the experiment was to use the trace-integrity theory and model to examine the degree to which reinstatement effects, the dual effects of misinformation, and preschoolers' retention in general, were controlled by forgetting and reminiscence processes. In addition, the model was used to determine whether changes in these processes were localized at storage, retrieval, or both.

Consider the questions that could be answered with the trace-integrity model concerning the effects of exposing preschoolers to consistent information. Provided that reinstatement had benefits for long-term retention, it was possible to determine whether reinstatement affected forgetting (i.e., whether presenting consistent information acted to forestall or alleviate forgetting), reminiscence (i.e., whether reinstatement helped reconstruct weakened traces), or both. Because consistent information was delivered during the retention interval and not immediately before the retention test, the primary effect of reinstatement was expected to be that of forestalling forgetting (i.e., affecting the $\underline{S}$ or $\underline{R}$ parameters, or both) rather than changing reminiscence patterns (i.e., affecting the $\underline{a}$, $\underline{r}_1$, or $\underline{f}_1$ values, or a combination of the three; Howe et al., in press). Given this, and the fact that Howe et al. (in press) found reinstatement to affect forgetting more so than reminiscence, reinstatement effects in the present experiment were expected to be localized at forgetting.

It was also possible to determine whether reinstatement affected only the retrievability of traces in memory (as measured by the parameter $\underline{R}$), the storage of those traces (as measured by the parameter $\underline{S}$), or both. There is a great deal of evidence that children's forgetting is dominated by storage, not retrieval, failures (e.g., Brainerd et al., 1990; Howe, 1991; Howe, Kelland et al., 1992). Moreover, Howe et al. (in press) found that although reinstatement affected both storage and retrieval processes, the greatest effects led to inoculating long-term memories against storage-related forgetting. Therefore, greater beneficial effects were expected with the parameter S than R when preschoolers were presented with consistent information.

It was also possible to examine whether reactivating some of the features in a memory structure positively affected surrounding or related trace features (i.e., whether spread of reactivation occurred). That is, did reinstatement of some story details (i.e., those details specifically mentioned in the postevent reminder) produce reactivation of corresponding trace features, with the result that reactivation spread to surrounding trace features (i.e., those details not mentioned in the postevent information)? The idea that (re)activation of some memory elements can spread to other related memory elements has been salient in both episodic (e.g., Horowitz & Prytulak, 1969) and semantic (e.g., Collins & Loftus, 1975) theories of long-term memory for quite some time. Because the spread of reactivation from targeted to surrounding or nontargeted details would help explain how memories are preserved over long retention intervals, the effects of reinstatement on nontargeted details were examined in the present experiment.

Thus, the primary reasons for exposing preschoolers to consistent information were to determine whether it had the beneficial effect on retention that has been reported in the literature (e.g., see Howe et al., in press) and whether spread of reactivation effects exist. As well, it was also of interest to compare the effects of including consistent information in the postevent reminder with that of including misleading information.

Consider next how the trace-integrity model can be used to examine the dual effects of misinformation. Recall that exposure to a postevent reminder containing misinformation was expected to reactivate the original trace, thereby either preventing or promoting the incorporation of misinformation into the trace (or a copy of the trace). Given that the reactivation of the original trace prevents the incorporation of misinformation into the original trace, beneficial effects similar to those outlined above for consistent information were expected. However, given that the reactivation promotes the incorporation of misinformation into the trace, it was anticipated that this would benefit recall of the nontargeted information but would have memory impairing effects for the targeted details. If the surrounding or nontargeted information was positively affected by exposure to the misinformation reminder, then recall performance of the nontargeted details in the misled condition should be greater than recall of those same details in the control condition. Any constructive effects were expected to be localized at forgetting, with greater alleviation of storage- than retrieval-based forgetting (i.e., greater beneficial effects should be observed with the parameter $\underline{S}$ than $\underline{R}$).

If misinformation impaired memory for the targeted information, then the trace-integrity model could be used to answer the following questions: (a) whether the misleading information primarily affected the storage of original information or whether the effects were confined to retrieval failure; (b) whether storage and retrieval-based reminiscence of the information was possible; and (c) whether impairing some of the features in a memory structure negatively (or positively) affected surrounding or related features (i.e., whether misinformation affected not only the targeted information but the nontargeted information as well).

To understand how the model could be used to examine these questions, consider the two versions of the memory impairment hypothesis discussed earlier, namely, the single trace and separate trace hypotheses. According to either hypothesis, the presentation of misinformation should decrease, whether temporarily or permanently (in terms of the traditional storage-impairment theories), the probability of recalling original information. That is, misled subjects should recall less of the original information than nonmisled or control subjects. However, these hypotheses differ with respect to the reasons they give for forgetting and whether reminiscence of original information is possible (see also Howe, 1991).

Recall that according to the separate trace hypothesis, the original and misleading information are stored in different traces. It is claimed that forgetting occurs either because of competition between the two responses at output, because the cues at test are insufficient for retrieval, because misinformation inhibits or suppresses original information, or some combination of the three. However, whatever the mechanism, because the effects of misinformation are said to result from retrieval failure, the model can test the veracity of the separate trace hypothesis. Basically, any differences in forgetting should be expressed primarily in changes in the value of parameter $\underline{R}$ (not $\underline{S}$). In addition, because the original information was never destroyed, reminiscence is possible (i.e., it is possible to recover original information) and reminiscence differences should be expressed in the parameters $\underline{r}_i$ and $\underline{f}_i$ (not $\underline{a}$).

According to the single trace hypothesis, misinformation may either blend with original information (the "trace-blending" hypothesis; e.g., Belli, 1988; Metcalfe, 1990) or completely overwrite original information (the "overwriting" hypothesis; e.g., Loftus & Loftus, 1980). Consider the scenario where both original and misleading information are blended in one trace. Because new bonds are being formed, some of the bonds holding the elements of the original information together may loosen to a point where recall of the elements are no longer possible (storage failure), others may loosen to a point where element recall is possible on some occasions (retrieval failure), while others may not be affected at all by this blending process. Therefore, changes should be observed in both retrieval-based forgetting ($\underline{R}$) and reminiscence ($\underline{r}_i$ and $\underline{f}_i$) and storage-based forgetting ($\underline{S}$) and reminiscence ($\underline{a}$). However, the magnitude of these effects should not be the same at storage as at retrieval; there should be at least as much (if not more) storage-based forgetting and reminiscence. If original information is completely overwritten by misinformation, then more storage-based than retrieval-based forgetting is expected (i.e., larger $\underline{S}$ than $\underline{R}$ values). However, according to the traditional storage-impairment view, reminiscence becomes impossible, because original information is supposedly lost forever.

The model also made it possible to examine whether, and the extent to which, the spread of the destructive effects of misinformation occurs. That is, it was possible to determine whether exposure to misinformation dampens memory of the entire original event and the extent of the dampening. The potential negative effects of misinformation (e.g., disintegration of trace bonds) may spread from those trace elements that were directly targeted by the misinformation to surrounding elements. If this is the case, then there should be more forgetting (larger $\underline{S}$ values, $\underline{R}$ values, or both) or less reminiscence (smaller $\underline{a}$, $\underline{r}_i$, or $\underline{f}_i$ values, or some combination of the three), or more forgetting and less reminiscence, of both targeted and nontargeted information in the misleading information than control conditions.

Therefore, with the use of the model's parameters, it was possible to test the veracity of the single and separate trace hypotheses. According to the separate trace hypothesis, any differences in forgetting should be expressed primarily in changes in the value of parameter $\underline{R}$ (not $\underline{S}$), and reminiscence differences should be expressed in the parameters $\underline{r}_i$ and $\underline{f}_i$ (not $\underline{a}$). According to the trace-blending hypothesis, both storage- and retrieval-based forgetting and reminiscence can occur, but the magnitude of forgetting differences should be larger at storage (i.e., larger $\underline{S}$ than $\underline{R}$ values, and smaller $\underline{a}$ than r_i and $\underline{f}_i$ values). However, in terms of the overwriting hypotheses, only forgetting is possible, with effects greater at storage than retrieval (i.e., larger $\underline{S}$ than $\underline{R}$ values).

Thus, the major aim of the present study was to use the trace-integrity theory and model to examine the degree to which the effects of providing consistent and inconsistent information are controlled by forgetting and reminiscence processes, and whether these processes are localized at storage, retrieval, or both. However, other questions of interest included the following: (a) whether differences in initial learning (i.e., the degree of trace integration at acquisition) produce differences in the degree of reinstatement, erroneous reporting and memory impairment effects observed; (b) whether providing a testing opportunity during the retention interval has beneficial effects on recollection; (c) whether mentioning or not mentioning story details'^U the original narrative and during postevent information produces differences in the degree of reinstatement, erroneous reporting, and memory impairment effects observed; and (d) whether the effects of reinstatement and presenting misinformation are more prevalent when misleading information is presented in question rather than narrative form.

Methodology

Subjects

A total of 216 children (108 females and 108 males; mean age = 4 years, 6 months; SD = 5 months) participated in the study. All children were enroled in a preschool or daycare program in the St. John's or surrounding area, and consent was obtained from the school directors, as well as from the parents of all participants.

Materials and Procedure

The children were visited at their preschools/daycares and were asked if they would like to hear a story and help with the experimenter's homework. With their consent, the children were taken individually into a room in their school, where they engaged in friendly conversation with the experimenter until the first phase of the study began.

Initial Learning. During the acquisition phase, the children were presented with a slide sequence about a little girl anxious to attend a Halloween party. The experimenter narrated (see narrative in Appendix A) as the slides were presented at a rate of 4-8 seconds each. The children were told that they were to see some pictures while the experimenter told them a story and that they must pay close attention to both in order to answer questions that would be asked later. Only half of the to-be-remembered details were directly mentioned in the narrative. That is, while all to-be-remembered story details were visually presented, half of the details were presented both verbally and visually. Following the slide presentation, the experimenter asked specific questions about 20 story details (see Appendix B). The subjects were manually recorded. The children were asked to answer based on what they remembered seeing in the slides and they were given approximately 30 seconds to answer before the next question was posed. Story and narrative construction, as well as target detail selection, were simply based on the observation of a colleague's daughter preparing for a party

Half of the children were then quasi-randomly assigned (attempting to keep the sex ratio constant) to a one-trial condition and the remaining half to a criterion condition. For children in the one-trial condition, acquisition consisted of only one study-recall trial. Children required to reach criterion continued through the sequence until all 20 questions were answered correctly on two consecutive tests. The procedure, dependent on the condition to which the child had been randomly preassigned, was explained to each participant before the acquisition phase began.

Neither the slide sequence nor the cued recall questions were randomly presented. The slides of course had to be presented in the order in which they occurred in the story. The cued-recalled questions were not randomized so as to avoid confusion among preschoolers as to the story's sequence of events and, more importantly, to avoid spurious effects. Bekerian and Bowers (1983) showed that if subjects are systematically taken through the to-be-remembered event at test, rather than asked questions in random order, they are more likely to recall the original information. Any differences in event recall that may be found in the present study, then, are not likely due to a lack of overlap in external retrieval cues between acquisition and test. However, because (at least) two minutes elapsed between the time a slide was shown and the question concerning a detail in the slide was asked, serial position and short term memory effects were prevented.

Because less information was encoded in the one-trial than criterion condition, there should be more storage failure, retrieval failure, or both (i.e., larger $\underline{S}$ or $\underline{R}$ values) with preschoolers' recall in the former than latter condition. However, based on previous research (e.g., Howe, 1991), initial learning was not expected to influence reminiscence rates. If mentioning story details in the original narrative and during postevent information increased trace strength, then recall of those details at retention should be superior to recall of nontargeted details with one-trial learning (i.e., smaller $\underline{S}$ or $\underline{R}$ values, or higher $\underline{a}$, $\underline{r}_i$, or $\underline{f}_i$ values, or both smaller forgetting and higher reminiscence values). However, criterion recall of the details targeted and not targeted at both acquisition and during postevent information was expected to differ little at retention, because the trace strengths of both should be very similar at the end of acquisition.

__Postevent Information Presentation__. Following acquisition, the children were quasi-randomly assigned to one of the following six conditions: (a) one of two control conditions, where subjects were either tested for recall of original details at three weeks and again at four weeks (control-3/4) or at 4 weeks only (control-4); (b) one of two consistent postevent information conditions where subjects received this information in either narrative or questionnaire form; and (c) one of two misleading postevent information conditions where subjects received this information in either narrative or questionnaire form. Three weeks after acquisition, children in the postevent information conditions (two-thirds of the children) received either consistent or misleading information concerning 10 of the 20 story details tested at acquisition. That is, half of the to-be-remembered details were directly targeted by the postevent information and half were not (half of the targeted and nontargeted details were mentioned in the original narrative).[4] This information was embedded in either questions or in a narrative (see Appendices C and D). Children who received postevent information were told that because it had been such a long time since their initial visit, the experimenter was visiting again to help them remember the story.

The control-3/4 condition was included for three reasons. The first reason was to determine the state of memory for original information at the time postevent information was presented (i.e., to determine the extent to which forgetting occurred). The second was to examine whether providing an additional test opportunity attenuates forgetting. There is much evidence that subsequent test opportunities retard forgetting of information (e.g., Allen, Mahler, & Estes, 1968; Richardson, 1985; Runquist, 1986; Slamecka & Katsaiti; 1988). Thus, the recall performance of preschoolers in the control-3/4 condition was expected to be superior to the performance of preschoolers in the control-4 condition. As for the third reason, it was of interest to know whether reinstatement (i.e., providing consistent information) slows forgetting in a way similar to additional test opportunities.

In terms of the consistent postevent information conditions, as mentioned earlier, reinstatement effects were expected to be localized at forgetting, particularly storage-based forgetting. In other words, greater beneficial effects should be observed with the parameter S than R. Specifically, if reinstatement effects occur, then there should be a greater alleviation of forgetting of targeted story details in the consistent information conditions than in the control-4 condition. In addition, if reactivation of targeted details spreads activation to nontargeted details, then recall of nontargeted details in the consistent information conditions should be superior to recall of those details in the control-4 condition.

As for the effects of presenting inconsistent information, if presenting misinformation reactivates nontargeted story details, targeted story details, or both, then greater alleviation of storage-based forgetting is expected with the recall of these details in the misled conditions than in the control-4 condition. As well, if presenting inconsistent information increases erroneous reporting and memory impairment of targeted details, then there should be more intrusions (e.g., misinformation), and more forgetting, less reminiscence, or both, in misled than nonmisled conditions. If such effects are more likely when memory for the original information is poor or nonexistent (i.e., with one-trial learning or nontargeted details), then more intrusions, and more forgetting or less reminiscence, is expected with the recall of nontargeted than targeted details in the one-trial than criterion conditions. In addition, both misled and nonmisled criterion conditions are expected to show superior recall compared to both one-trial groups.

I previously mentioned that information presented in questionnaire format may reactivate the original trace more than does narrative presentation. One consequence of this may be that postevent information will be more strongly represented in the original trace when it is embedded in questions rather than in a narrative. If this is the case, then there should be a greater reduction of storage-based forgetting of, at least, targeted details when consistent information is embedded in questions versus in a narrative. In addition, there should be either more erroneous reporting, memory impairment, or both, of at least targeted details with questionnaire than narrative presentation of misinformation.

Long-Term Retention Testing. Three weeks after acquisition for the control-3/4 group and four weeks following acquisition for all six groups, the children received four recall trials without further study opportunity (see Appendix B). Again, serial position and short-term memory effects posed no problem given that (at least) one minute elapsed between consecutive presentations of the same question. Preschoolers were also given an opportunity to provide a second response to each question during each of the four test trials. They were told that because it had been such a long time since they saw the slides depicting the story, they would be asked the same questions four times and they would have two chances each time to answer correctly. On the first trial, the experimenter encouraged the children to give a second response by telling them after each question was asked that they may give another answer "just in case the first one was not right". The preschoolers were then only reminded at the beginning of each of the next three test trials that they may provide a second answer whenever they were unsure of their first response. Only the first two responses were manually recorded.

Although reminiscence of the original details was anticipated (see Brainerd et al., 1990), reminiscence rates were not expected to vary as a function of the experimental manipulations (see Howe, 1991; Howe, Kelland et al., 1992). Recall of misinformation, as well as other intrusions, was also expected to increase across trials, provided that this information was incorporated into preschoolers' memory structure of the original event. In terms of preschoolers' retention of original information, recall that Zaragoza (e.g., 1987) argued that demand characteristics may operate when children are asked questions about a witnessed event (i.e., although children remember the original information, they feel pressured to report misinformation). If this is the case, then when the preschoolers give both responses, they should report misleading information as their first response more often than original information.

Scoring

In terms of the analyses involving the recall of original information, responses were scored as correct at both acquisition and retention if subjects recalled the original details presented in the story. However, two different scoring systems were employed at retention, strict and lenient. With strict scoring, only subjects' first responses were scored. With lenient scoring, both responses were examined (i.e., subjects' answers were scored as correct if either the first or second response was the original story detail). If the effects of misinformation are due to demand characteristics and not memory impairment, then erroneous reporting should be more evident with strict than lenient scoring.

As for the analyses concerning intrusion production (responses other than original and misleading information), all intrusions at acquisition and retention were recorded and scored for their relevance to the general story script and to the specific question asked. Because the results of Howe's (1991) study indicated that intrusions were relevant to the original story, preschoolers' intrusions in the present experiment were expected to be germane to the original event. In addition to the general analysis of intrusions, an examination was carried out concerning the production of misleading information during recall of the ten targeted story details. For these analyses, responses were scored as correct if subjects recalled the misinformation. If exposure to misinformation promotes erroneous reporting of such information, then preschoolers in the misled conditions should report more misleading information that those in the nonmisled conditions. More importantly, if the strength of misinformation in memory influences impairment, then there should be either less forgetting (smaller $\underline{S}$ or $\underline{R}$ values, or both), more reminiscence (larger $\underline{a}$, $\underline{r}_i$, or $\underline{f}_i$ values, or some combination of the three), or both less forgetting and more reminiscence of misinformation in those conditions where the recall of original information is inferior.

Results

Analysis of the number of story details correctly recalled at acquisition revealed, as expected, that there were fewer details recalled with one-trial (M = 14.28, SD = 3.31) than criterion learning (where preschoolers recalled all 20 story details) [$t(214) = -17.90$, $p < .0001$]. The retention data were then examined to determine the effects of the experimental manipulations on the production of original and erroneous information. In terms of the preschoolers' recall of original information, analyses were carried out to determine the following: (a) whether, and how, misinformation impaired or enhanced memory for original information; (b) whether reinstatement effects occurred when preschoolers were given consistent postevent information or a testing session during the retention interval; and (c) whether the recall of original information was influenced by the degree to which this information was learned, by the mentioning of story details during the original and postevent presentation, by the method of misinformation presentation, and by multiple test opportunities at retention. In terms of the preschoolers' production of erroneous information, analyses were conducted to determine the following: (d) whether exposure to misinformation encouraged the reporting of erroneous information (i.e., misleading information and other intrusions); (e) whether there were differences across the inconsistent information conditions with respect to the retention of misinformation; and (f) whether the effects of misinformation were influenced by the extent of learning of original information, the method of misinformation presentation, and multiple test opportunities at retention.

The Effects of Experimental Manipulation on Original Information Recall: A Global Analyses

Preliminary analysis of the variable, acquisition reference to story details, revealed no differences at retention between the details that were mentioned ($M = 16.95$) and not mentioned ($M = 17.15$) in the narrative at acquisition. This variable was, therefore, excluded in the subsequent analyses. In addition, because the preschoolers' performance did not vary with strict or lenient scoring (as revealed by an analysis of covariance with both types of scoring methods), only the general trends for the retention data obtained with lenient scoring are reported (for the factors and covariates, see below). Thus, if subjects did not respond correctly the first time, they were likely to be incorrect on their second response as well. Results are also reported for only the four week recall performance in the control-3/4 condition because a series of t-tests indicated no difference in long-term retention between the third and fourth week recall performances.

The number of story details correctly recalled at retention was analyzed using a 2 (initial learning: one-trial vs criterion) x 6 (condition: control-3/4 vs control-4 vs consistent narrative vs misleading narrative vs consistent questionnaire vs misleading questionnaire) x 2 (postevent reference to story details: targeted vs nontargeted) x 4 (trial) analysis of covariance. The first two factors were between subjects, the last two were within, and mean total number of details correctly recalled per trial at acquisition served as the covariate. Note that the design of the present study did not fit with traditional linear modelling techniques. The within subject manipulation, postevent reference to story details (i.e., whether story details were targeted or not in postevent information), applied to only four of the six conditions. However, it was of interest to compare the recall of the targeted and nontargeted story details in the postevent information conditions with the recall of those same details in the control conditions. That is, those story details that were separated in the postevent information conditions (i.e., the targeted and nontargeted items) were compared to the same story details in the control conditions, although no postevent information was given concerning story details in the control conditions. Therefore, this manipulation was treated as within subjects for all six conditions, although there was no actual story detail manipulation in either control condition.[5] In addition to permitting comparison between the recall of the targeted and nontargeted story details across groups, this design also provided a check to ensure that the targeted and nontargeted story details were not intrinsically different (i.e., the control-4 condition). It was also possible using this design to examine reminiscence of story details, as well as any effects initial learning, condition, and postevent reference to story details had on reminiscence.

As for the results of the analysis, the covariate was significant and was adjusted for both between subject factors [$F(1,203) = 104.00$, $p < .01$, $r^2 = .34$, $eta^2 = .34$] and for the within subject factor, postevent reference to story details [$F(1,203) = 21.30$, $p < .01$, $r^2 = .08$, $eta^2 = .09$][6]. Thus, individual differences in the number of story details recalled at acquisition influenced recall performance at retention. After the retention scores were adjusted for learning differences, all four main effects were significant: initial learning [$F(1,203) = 425.09$, $p < .01$, $eta^2 = .68$], condition [$F(5,203) = 4.19$, $p < .01$, $eta^2 = .09$], postevent reference to story details [$F(1,203) = 25.00$, $p < .01$, $eta^2 = .11$], and trial [$F(3,612) = 19.12$, $p < .01$, $eta^2 = .09$]. In addition, there was one first order interaction, initial learning x postevent reference to story details [$F(1,203) = 9.97$, $p < .01$, $eta^2 = .05$].

One-trial subjects (M = 15.40) recalled less than criterion subjects (M = 18.70) and the recall of targeted story details (M = 17.29) was superior to the recall of nontargeted details (M = 16.81). Neuman-Keuls post-hoc examination revealed that the misleading questionnaire condition (M = 16.48) differed significantly from the control-3/4 (M = 17.48) condition. It also revealed that retention on trial 1 (M = 16.88) was significantly poorer than retention on trials 2 (M = 17.01), 3 (M = 17.11), and 4 (M = 17.20), and as well retention on trial 2 was inferior to trial 4 retention.

Further examination of the initial learning x postevent reference to story details interaction revealed that recall of both targeted (M = 15.79) and nontargeted (M = 15.01) story details in the one-trial condition was inferior to recall of both targeted (M = 18.79) and nontargeted (M = 18.61) details in the criterion condition. The interaction occurred because more targeted than nontargeted details were recalled in the one-trial condition, however, there was no recall difference between targeted and nontargeted details in the criterion condition.

To summarize the global trends, as expected, fewer story details (both targeted and nontargeted) were recalled in the one-trial than criterion condition. Although making reference to story details in the postevent information did not influence criterion subjects' recall (likely because their performance was near ceiling), providing specific information about story details improved recall for one-trial subjects. As anticipated, performance improved across trials and reminiscence rates did not differ as a function of experimental manipulation.

Of particular interest was the apparent lack of memory-impairing effects of misinformation. Although the misled subjects displayed the poorest retention of story details, their performance was not significantly different from that of the control-4 subjects. However, the performance of subjects in the misleading questionnaire condition was different from the performance of subjects in the control-3/4 condition. This difference may simply reflect the tendency that the three-week retention test had to improve performance at four weeks (control-4: M = 16.62; control-3/4: M = 17.39) and that exposure to misinformation had to decrease recall in the misleading questionnaire condition (M = 16.32). To better understand the effect that misinformation (as well as the other experimental manipulations) had on memory for the original event, the trace-integrity model was used to localize the ANCOVA effects in terms of the storage and retrieval loci of changes in forgetting and reminiscence. I turn now to the trace-integrity analysis of original information recall.

<u>The Effects of Experimental Manipulation on Original Information Recall: The Trace-Integrity Analysis</u>

<u>Application of the Model to the Data</u>. As this is the reader's first encounter in this dissertation with the mathematics involved when applying the trace-integrity model to retention data, the analytical steps are described in detail. To determine the effect of some manipulation on the theoretical processes measured

by the model, it is necessary to first assess the fit of the model to the data and to obtain numerical estimates of the parameters. Due to the theory of maximum likelihood, there are clearly defined methods available for parameter estimation and assessment of a model's fit to data. In what follows I describe the five-step process involved in applying the mathematical implementation of the trace-integrity framework to data generated in long-term retention paradigms (also see Howe, 1991; Howe & Brainerd, 1989; Howe et al., in press).

The data space must first be converted into an empirical probability space and then the empirical probability space is used to derive a function that gives the a posteriori probability (or likelihood) of the data. The data space for four-trial experiments such as the present one consists of 16 different performance patterns: $C_1C_2C_3C_4$, $C_1C_2C_3E_4$, ..., $E_1E_2E_3C_4$, $E_1E_2E_3E_4$, where C signifies a correct response, E signifies an error, and the subscripts 1-4 signify the four retention tests for each item. This data space is then converted into an empirical probability space by determining the probabilities of each of the outcomes in the data space: $p[C_1C_2C_3C_4]$ (the probability that an item is correctly recalled on all four trials), $p[C_1C_2C_3E_4]$ (the probability that an item is recalled correctly on all but the last trial),..., $p[E_1E_2E_3C_4]$ (the probability that an item is incorrectly recalled on all but the last trial), $p[E_1E_2E_3E_4]$ (the probability that an item is incorrectly recalled on all four trials). Taking advantage of the theory of maximum likelihood, the a posteriori probability (likelihood) of any sample of data can be expressed in a function that has 15 degrees of freedom and takes the form,

$$L_{15} = p[C_1C_2C_3C_4]^{N[CCCC]} \times p[C_1C_2C_3E_4]^{N[CCCE]} \times \ldots \times p[E_1E_2E_3C_4]^{N[EEEC]} \times p[E_1E_2E_3E_4]^{N[EEEE]}. \quad (1)$$

The base of each term refers to the probability that the event occurred and the exponent refers to the frequency with which the event occurred.

The second step involves translating this empirical probability space into a mathematical probability space and then obtaining the theoretical likelihood function corresponding to the mathematical space. To achieve this, the 16 empirical probabilities are expressed in terms of the model's parameters. (Refer to Table 2 for a display of the theoretical probabilities for each of the empirical events obtained with this procedure.) This mapping procedure is significant in that it transforms the typically unobservable theoretical events that underlie memory performance into observable or measurable units. To derive the theoretical likelihood function, the equations in Table 2 (signified below in Equation 2 by the term $\underline{h}$) are simply substituted for the 16 terms in Equation 1. The resulting function has 9 degrees of freedom (because only 9 parameters comprise the 16 expressions) and takes the form,

$$\underline{L}_9 = \underline{h}(\underline{p}[\underline{C}_1\underline{C}_3\underline{C}_3\underline{C}_4])^{N[\underline{CCCC}]} \text{ X } \underline{h}(\underline{p}[\underline{C}_1\underline{C}_3\underline{C}_3\underline{E}_4]^{N[\underline{CCCE}]} \text{ X } \ldots$$
$$\text{X } \underline{h}(\underline{p}[\underline{E}_1\underline{E}_2\underline{E}_3\underline{C}_4]^{N[\underline{EEEC}]} \text{ X } \underline{h}(\underline{p}[\underline{E}_1\underline{E}_2\underline{E}_3\underline{E}_4]^{N[\underline{EEEE}]}. \quad (2)$$

The third step in applying the model to data consists of counting the number of times each of the 16 events occur in the sample data and substituting these numbers for the corresponding exponents in Equation 2. Then a standard computer optimization routine (e.g., SIMPLEX) is used to maximize the function. The optimum solution produces the value of the likelihood function $\underline{L}_9$ as well as numerical estimates for the model's 9 parameters. The $\underline{L}_9$ value (which is typically calculated using the log transform $-2\ln\underline{L}_9$) is then used to assess the goodness of the model's fit to the data (step 4) and to test hypotheses concerning differences between parameter estimates both between and within experimental treatments (step 5).

Step four consists of assessing whether the model provides a satisfactory representation of the sample data. To achieve this, Equation 1 is maximized (using the log transform -2ln) with the same data as was used with Equation 2, producing an estimate of the likelihood of the data before the model was introduced (i.e., with 15 degrees of freedom, $\underline{L}_{15}$). The estimated value of $\underline{L}_{15}$ will always be the maximum likelihood for that set of data because all of the available information in the data are exhausted in Equation 1. The estimated likelihood of Equation 2 will always be a little smaller because the trace-integrity model does not exhaust all the available information (i.e., it only has 9 degrees of freedom, not 15). To evaluate goodness of fit, likelihood ratio tests are used that determine whether or not this difference is statistically significant. The null hypothesis that the trace-integrity model fits the data is evaluated with the following test,

$$X^2(6) = (-2\ln\underline{L}9) - (-2\ln\underline{L}_{15}) \qquad (3)$$

For the data in the present analysis refer to Tables 3 and 4 for the numerical results of these goodness of fit tests, where the data were scored with strict and lenient methods, respectively. Because there was close agreement with the model and the data for both scoring methods (there were only two rejections in Table 3 and no rejections in Table 4), the model provided an acceptable account of these data.

Table 2
Theoretical Expression for the Empirical Outcome Space

Outcome Probability	Expression
$p(C_1C_2C_3C_4)$	$(1-S)(1-R)r_1r_2r_3$
$p(C_1C_2C_3E_4)$	$(1-S)(1-R)r_1r_2(1-r_3)$
$p(C_1C_2E_3C_4)$	$(1-S)(1-R)r_1(1-r_2)f_1$
$p(C_1E_2C_3C_4)$	$(1-S)(1-R)(1-r_1)f_1r_1$
$p(E_1C_2C_3C_4)$	$Sa(1-R)r_1r_2 + (1-S)Rf_1r_1r_2$
$p(C_1C_2E_3E_4)$	$(1-S)(1-R)r_1(1-r_2)(1-f_1)$
$p(C_1E_2C_3E_4)$	$(1-S)(1-R)(1-r_1)f_1(1-r_1)$
$p(E_1C_2C_3E_4)$	$Sa(1-R)r_1(1-r_2) + (1-S)Rf_1r_1(1-r_2)$
$p(C_1E_2E_3C_4)$	$(1-S)(1-R)(1-r_1)(1-f_1)f_2$
$p(E_1C_2E_3C_4)$	$Sa(1-R)(1-r_1)f_1 +(1-S)Rf_1(1-r_1)f_1$
$p(E_1E_2C_3C_4)$	$S(1-a)a(1-R)r_1 + SaRf_1r_1 +(1-S)R(1-f_1)f_2r_1$
$p(C_1E_2E_3E_4)$	$(1-S)(1-R)(1-r_1)(1-f_1)(1-f_2)$
$p(E_1C_2E_3E_4)$	$Sa(1-R)(1-r_1)(1-f_1) + (1-S)Rf_1(1-r_1)(1-f_1)$
$p(E_1E_2C_3E_4)$	$S(1-a)a(1-R)(1-r_1) + SaRf_1(1-r_1) + (1-S)R(1-f_1)f_2(1-r_1)$
$p(E_1E_2E_3C_4)$	$S(1-a)^2a(1-R) + S(1-a)aRf_1 + SaR(1-f_1)f_2 + (1-S)R(1-f_1)(1-f_2)f_3$
$p(E_1E_2E_3E_4)$	$S(1-a)^3 + S(1-a)^2aR + S(1-a)aR(1-f_1) + SaR(1-f_1)(1-f_2) +$ $(1-S)R(1-f_1)(1-f_2)(1-f_3)$

Note. C = correct response; E = incorrect response. Each probability in the left column appears in the empirical likelihood function. In the likelihood function for the trace-integrity model, these probabilities are replaced by the corresponding expression in the right column. Adapted from Howe (1991).

Testing hypotheses about the theoretical processes underlying memory is carried out in the fifth and final step. Due to their identifiability (see Howe & Brainerd, 1989), the model's parameters can be used to test hypotheses involving between-condition and within-condition differences in forgetting and reminiscence rates, as well as the storage and retrieval loci of these differences. The statistical process for testing hypotheses is simple and consists of a series of likelihood-ratio tests referred to as an experimentwise test, conditionwise tests, and parameterwise tests. Before these tests were used to examine the preschoolers' forgetting and reminiscence of original information, the model was used to determine whether the number of hypotheses to be tested could be reduced. That is, first it was determined whether memory impairment was more prevalent when the data were scored with the strict than lenient criterion (i.e., whether two sets of analyses were required). Then it was determined whether providing a testing opportunity during the retention interval benefited the recall of original information (i.e., whether there were differences between the two control conditions).

The Role Played by Social Pressure: Analysis of Strict versus Lenient Scoring. Recall that the motivation for using the two scoring methods was to determine whether permitting two responses during question answering rather than one influenced the degree to which memory impairment effects were found. That is, previous findings of memory impairment (e.g., Ceci et al., 1987a) may have been the result of the pressure young children felt to report misinformation when only a single response was permitted, despite the fact that they also remembered the original information (e.g., see Zaragoza, 1987). If this was the case in the present study, then the preschoolers may have had a tendency to report misinformation as

Table 3
Statistical Adequacy of the Trace-Integrity Model for Strict Scoring

Condition		$-2\ln L_0$	$-2\ln L_{15}$	$X^2(6)$
<u>1-Trial Learning</u>				
Control-3/4	Targeted	481.56	479.22	2.34
	Nontargeted	480.59	475.82	4.77
Control-3/4	Targeted	425.82	409.41	16.41
	Nontargeted	497.50	491.83	5.67
Control-4	Targeted	481.20	480.78	.42
	Nontargeted	400.63	398.78	1.85
Consistent Narrative	Targeted	384.91	379.08	5.83
	Nontargeted	446.65	440.95	5.70
Misleading Narrative	Targeted	442.90	434.84	8.06
	Nontargeted	498.07	489.95	8.12
Consistent Questionnaire	Targeted	420.11	403.97	16.14
	Nontargeted	470.65	458.55	12.10
Misleading Questionnaire	Targeted	414.07	410.11	3.96
	Nontargeted	509.86	507.43	2.43
<u>Criterion Learning</u>				
Control-3/4	Targeted	243.25	215.18	28.07*
	Nontargeted	263.78	246.57	17.21*
Control-3/4	Targeted	150.80	150.25	.55
	Nontargeted	346.89	338.41	8.48
Control-4	Targeted	272.33	269.01	3.32
	Nontargeted	311.57	304.68	6.89
Consistent Narrative	Targeted	284.30	270.99	13.31
	Nontargeted	380.27	379.95	.32
Misleading Narrative	Targeted	365.94	364.41	1.53
	Nontargeted	345.22	343.34	1.88
Consistent Questionnaire	Targeted	294.83	285.24	9.59
	Nontargeted	325.53	325.25	.28
Misleading Questionnaire	Targeted	449.23	445.79	3.44
	Nontargeted	413.80	413.09	.71

Note. In order to demonstrate goodness of fit the $X^2(6)$ value must not exceed 16.81, *$p < .01$.

Table 4
Statistical Adequacy of the Trace-Integrity Model for Lenient Scoring

Condition		$-2\ln L_9$	$-2\ln L_{15}$	$X^2(6)$
1-Trial Learning				
Control-3/4	Targeted	469.76	462.53	7.23
	Nontargeted	467.71	462.96	4.75
Control-3/4	Targeted	418.91	404.99	13.92
	Nontargeted	469.33	461.12	8.21
Control-4	Targeted	478.18	476.26	1.92
	Nontargeted	392.14	390.45	1.69
Consistent Narrative	Targeted	366.87	366.60	.27
	Nontargeted	412.40	403.66	8.74
Misleading Narrative	Targeted	437.74	430.71	7.03
	Nontargeted	455.07	453.45	1.62
Consistent Questionnaire	Targeted	420.11	403.96	16.15
	Nontargeted	453.93	440.21	13.72
Misleading Questionnaire	Targeted	416.38	409.44	6.94
	Nontargeted	488.50	478.87	9.63
Criterion Learning				
Control-3/4	Targeted	173.07	160.16	12.91
	Nontargeted	194.56	185.49	9.07
Control-3/4	Targeted	125.02	124.69	.33
	Nontargeted	297.25	289.72	7.53
Control-4	Targeted	240.97	237.68	3.29
	Nontargeted	263.18	254.40	8.78
Consistent Narrative	Targeted	248.64	247.57	1.07
	Nontargeted	348.64	346.79	1.85
Misleading Narrative	Targeted	321.13	315.90	5.23
	Nontargeted	268.29	259.11	9.18
Consistent Questionnaire	Targeted	249.83	239.93	9.90
	Nontargeted	253.92	253.12	.80
Misleading Questionnaire	Targeted	414.79	411.74	3.05
	Nontargeted	338.85	330.90	7.95

Note. In order to demonstrate goodness of fit the $X^2(6)$ value must not exceed 16.81, $^*p < .01$.

their first response rather than original information. Recall of original information, then, should have been poorer when the data were scored with the strict rather than the lenient criterion.

A conditionwise test, which is similar to a _t_-test, was used to evaluate the null hypothesis that the parameters' numerical values did not vary between the strict and lenient scoring methods. The numerical results of these $X^2(9)$ tests, which are provided in Table 5, indicated that the results did not vary with scoring method. Therefore, the original information was not merely considered a second choice by preschoolers; when they reported original information, they gave it as their first response. This indicated that the preschoolers, probably because they were given two opportunities to respond, did not feel pressured to report misinformation before original information.

The data obtained with the lenient scoring were chosen for further analysis because there were no rejections when the model's fit was evaluated, and because it provided a more conservative test of the hypotheses examined in this dissertation. The numerical estimates of the model's parameters obtained with lenient scoring are displayed in Table 6. Hypotheses testing of these data began with the experimentwise test, which is similar to the omnibus _F_-test. The experimentwise test is used to examine the null hypothesis that, on average, the model's parameters do not differ between conditions. The result of this X^2 test revealed that the null hypothesis could be rejected [$X^2(243) = 1278.38$, $p < .01$]. Because the experimentwise hypothesis was rejected, a series of conditionwise tests was used to determine which pair(s) of conditions differed with respect to the model's parameters. Due to the large number of comparisons of interest and the consequently large number of conditionwise tests, the next series of analyses determined whether it was necessary to include both control groups (i.e., control-3/4 and control-4) in all subsequent conditionwise comparisons.

Prior Tests and the Alleviation of Forgetting. Recall that one of the reasons for including the control-3/4 condition was to determine whether a testing opportunity during the retention interval aided preschoolers' recall of the original event, as has been reported in past studies (e.g., Howe, Kelland et al., 1992; see Richardson, 1985 for a review). Additional interests were to determine the state of memory when postevent information was given at three weeks, as well as to compare the effects of previous testing with any effects arising from the presentation of postevent information.

A total of 12 $X^2(9)$ conditionwise tests were used to evaluate whether the numerical values of the parameters differed between the control conditions. Four tests were used to compare the three week retention performance with the four week performance of control-3/4 subjects. Four tests were used to compare the three week performance of control-3/4 subjects with the performance of subjects in the control-4 condition. As well, 4 tests were used to compare the control-3/4 subjects' retention at four weeks with the retention of subjects in the control-4 condition. All comparisons were insignificant (refer to Table 7). Because there were no differences between the control conditions, the traditional control, control-4, was used in the subsequent conditionwise and parameterwise tests. To reiterate, retention performance at four weeks did not differ from performance a

Table 5
Conditionwise Test Results For Strict Versus Lenient Scoring

Condition		$-2\ln L_9$	$-2\ln L_{18}$	$X^2(9)$
<u>1-Trial Learning</u>				
Control3&4	Targeted	940.01	938.32	1.69
	Nontargeted	948.73	948.30	.43
Control3&4	Targeted	847.03	844.73	2.30
	Nontargeted	967.69	966.83	.86
Control4	Targeted	963.50	959.38	4.12
	Nontargeted	793.67	792.77	.90
Consistent Narrative	Targeted	753.49	751.78	1.71
	Nontargeted	861.70	859.05	2.65
Misleading Narrative	Targeted	882.72	880.64	2.08
	Nontargeted	954.08	951.14	2.94
Consistent Questionnaire	Targeted	840.22	840.21	.01
	Nontargeted	925.08	924.58	.50
Misleading Questionnaire	Targeted	833.38	830.45	2.93
	Nontargeted	1002.12	998.36	3.76
<u>Criterion Learning</u>				
Control3&4	Targeted	416.32	411.13	5.19
	Nontargeted	463.95	458.34	5.61
Control3&4	Targeted	276.83	275.82	1.01
	Nontargeted	645.56	644.14	1.42
Control4	Targeted	516.21	513.30	2.91
	Nontargeted	578.87	574.75	4.12
Consistent Narrative	Targeted	535.88	532.94	2.94
	Nontargeted	723.39	721.41	1.98
Misleading Narrative	Targeted	687.08	684.07	3.01
	Nontargeted	620.98	613.51	7.47
Consistent Questionnaire	Targeted	546.75	544.66	2.09
	Nontargeted	587.25	579.45	7.80
Misleading Questionnaire	Targeted	866.31	864.02	2.29
	Nontargeted	746.83	742.65	4.18

Note. In order to reject the null hypothesis the value in the $X^2(9)$ column must exceed 21.67 ($p < .01$).

Table 6
Estimates of the Trace-Integrity Model's Theoretical Parameters for Original Information Recall

Condition	S	R	a	r_1	r_2	r_3	f_1	f_2	f_3
1-Trial Learning									
Control-4									
Targeted	.42	.20	.02	.90	.99	.99	.49	.26	.22
Nontargeted	.36	.31	.02	.96	.99	.99	.2[illegible]	.00	.03
Consistent Narrative									
Targeted	.37	.04	.05	.99	1.00	.98	.97	.03	.98
Nontargeted	.36	.17	.00	.94	.98	.99	.30	.29	.00
Misleading Narrative									
Targeted	.39	.00	.02	.89	.98	.98	.36	.33	.96
Nontargeted	.47	.11	.00	.88	.98	.96	.51	.53	.00
Consistent Questionnaire									
Targeted	.20	.21	.00	.93	.98	.99	.25	.14	.00
Nontargeted	.29	.35	.00	.91	.94	1.00	.21	.10	.00
Misleading Questionnaire									
Targeted	.25	.30	.03	.90	1.00	1.00	.20	.00	.03
Nontargeted	.48	.17	.00	.88	.88	1.00	.43	.48	.00
Criterion Learning									
Control-4									
Targeted	.06	.08	.00	.98	.99	1.00	.57	.14	.00
Nontargeted	.07	.10	.00	.99	.99	1.00	.56	.23	.18
Consistent Narrative									
Targeted	.10	.02	.14	.99	.98	.98	.72	.00	.93
Nontargeted	.15	.05	.11	.96	.99	.99	.82	.00	.00
Misleading Narrative									
Targeted	.08	.10	.59	.96	.99	.99	.39	.00	.00
Nontargeted	.08	.07	.00	.99	.97	1.00	.79	.97	.00
Consistent Questionnaire									
Targeted	.07	.04	.27	.97	.99	.99	.58	.00	.00
Nontargeted	.08	.09	.13	.98	1.00	1.00	.47	.00	.00
Misleading Questionnaire									
Targeted	.13	.07	.00	.92	.96	.98	.49	.24	.46
Nontargeted	.12	.07	.00	.96	.99	.99	.76	.44	.64

week earlier for control-3/4 subjects. In addition, neither the third nor fourth week performance of control-3/4 subjects differed from the performance of control-4 subjects. Interestingly, these results appear inconsistent with previous studies (e.g., Howe, Kelland et al., 1992; see Richardson, 1985 for a review) because an interpolated test during the retention interval did not lead to abatement in forgetting. That is, preschoolers' fourth week performance in the control-3/4 condition was not significantly different from preschoolers' performance in the control-4 condition. However, there was no evidence that a prior test attenuated forgetting because there was little forgetting of story details between the third and fourth week of retention (i.e., there was little forgetting to alleviate). Despite the insignificant outcome, recall that there was a tendency (refer to the previous ANCOVA results) for preschoolers who received a retention test at three weeks to recall more story details at four weeks (M = 17.39) than preschoolers who received no subsequent information or testing during the retention interval (M = 16.62).

Not only was there little forgetting of story details from the third to fourth week of retention, there was very little forgetting three weeks after acquisition. The one-trial subjects recalled an average of 14.28 story details at acquisition and 15.58 details during the third week of retention, and the criterion subjects recalled 19.22 details at three weeks (of course, they recalled all 20 story details at acquisition). If the memory-impairing effects of misinformation depend upon the forgetting of original story details (i.e., a poor or weak trace of the original event), then the preschoolers' lack of forgetting of story details would explain the apparent absence of memory impairment effects obtained with the ANCOVA.

Precis of the Conditionwise Test Results. As for the next step in the analysis, conditionwise tests were used to examine the preschoolers' forgetting and reminiscence of the original information. A total of 52 $X^2(9)$ conditionwise tests were used to locate the origin of the experimentwise difference, 10 for the potential initial learning effects, 32 for the potential condition effects, and 10 for

Table 7.
Conditionwise Tests Used to Compare Control-3/4 and Control-4

Comparison	Targeted Details	Nontargeted Details
1-Trial Learning		
Control-3/4 vs. Control-3/4	10.71	1.48
Control-3/4 vs. Control-4	7.65	7.34
Control-3/4 vs. Control-4	15.24	8.91
Criterion Learning		
Control-3/4 vs. Control-3/4	9.09	14.58
Control-3/4 vs. Control-4	7.11	8.93
Control-3/4 vs. Control-4	14.48	7.83

Note: In order to reject the null hypothesis the values in the targeted details and nontargeted details columns [the $X^2(9)$ statistics] must exceed 21.67, *$p < .01$.

the potential postevent reference to story details effects. The numerical results of these tests are given in Tables 8a and 8b.

The results of the tests revealed that the experimentwise difference was due primarily to initial learning, in which all 10 comparisons were significant. That is, the effects of condition and postevent reference to story details were quite small. In terms of the condition effects, recall that more forgetting, less reminiscence, or both was expected in the misleading information conditions than in the control-4 condition, if misinformation impaired memory for the targeted details. Of the eight possible comparisons, only one was significant, namely the comparison involving the recall of nontargeted details in the one-trial misleading questionnaire condition. Thus, the destructive effects of misinformation on original information were rare.

Also expected were reinstating effects of providing postevent information, particularly when the information was consistent with the original information. That is, the alleviation of storage-based forgetting was anticipated when recalling nontargeted details in the inconsistent information conditions and when recalling targeted and possibly nontargeted details in the consistent information conditions. Although there were no significant positive effects of providing inconsistent information for the recall of targeted details as expected, there was a significant difference in the forgetting of nontargeted story details between the one-trial misleading questionnaire condition and the control-4 condition. Only two of the possible eight comparisons concerning consistent information were significant, namely that involving the one-trial and criterion subjects' recall of targeted details that were presented in narrative form. The significant effect concerning

Table 8a.
Conditionwise Tests for Initial Learning, Condition, and Postevent Reference to Story Details Effects

Effect	Targeted Details	Nontargeted Details
Initial Learning Effects		
Control-4	84.16*	84.76*
Consistent Narrative	49.44*	54.17*
Misleading Narrative	67.90*	101.29*
Consistent Questionnaire	53.54*	23.11*
Misleading Questionnaire	49.07*	91.40*
Condition Effects		
Misleading Information Effects (vs. Control-4)		
1-Trial Learning		
Misleading Narrative	16.51	13.96
Misleading Questionnaire	10.72	23.19*
Criterion Learning		
Misleading Narrative	8.36	4.88
Misleading Questionnaire	18.31	6.00
Consistent Information Effects (vs. Control-4)		
1-Trial Learning		
Consistent Narrative	21.74*	10.27
Consistent Questionnaire	15.74	10.73
Criterion Learning		
Consistent Narrative	24.49*	7.96
Consistent Questionnaire	7.52	3.66
Consistent vs. Misleading Information		
1-Trial Learning		
Narrative Presentation	23.66*	7.57
Questionnaire Presentation	13.44	7.15
Criterion Learning		
Narrative Presentation	14.72	10.55
Questionnaire Presentation	19.74	9.12
Narrative vs. Questionnaire		
1-Trial Learning		
Consistent Information	16.33	6.74
Misleading Information	19.32	10.38
Criterion Learning		
Consistent Information	8.09	8.18
Misleading Information	17.07	9.72

Table 8b
Conditionwise Tests for Initial Learning, Condition, and Postevent Reference to Story Details Effects Continued

Effect	1-Trial Learning	Criterion Learning
Reference to Details Effects		
Control-4	8.09	2.86
Consistent Narrative	17.29	11.94
Misleading Narrative	13.18	15.61
Consistent Questionnaire	14.27	8.49
Misleading Questionnaire	31.83*	7.72

Note. Values are $X^2(9)$ statistics that are significant at $^*\underline{p} < .01$ (21.67).

presentation of consistent information in narrative form to one-trial learners was responsible for the only reliable comparison between consistent and misleading information, that involving narrative presentation of targeted details to one-trial learners.

In terms of the manipulation involving presentation method, the differences that had been anticipated between the narrative and questionnaire presentation methods were also nonexistent. The effects of presenting consistent or misleading information to either one-trial or criterion learners did not differ as a function of the type of presentation.

As for the manipulation of referencing story details during postevent information, only one of the ten comparisons proved reliable, namely that involving the one-trial misleading questionnaire comparison. That is, consistent with the ANCOVA findings, there was no difference between the recall of the targeted and nontargeted details with criterion subjects (there were, however, ceiling effects). Although the ANCOVA results indicated that one-trial subjects recalled more targeted than nontargeted details, this effect was apparently due to a performance difference in the misleading questionnaire condition only. In other words, only one-trial subjects presented with inconsistent information in questionnaire form exhibited a recall difference between targeted and nontargeted details. This outcome was a consequence of the poorer recall of the nontargeted details in the one-trial misleading questionnaire condition than in the control-4 condition.

Another issue of interest concerning the postevent reference to story detail manipulation was whether the effects of manipulating story details, be they positive or negative, spread to other to-be-remembered details. However, there was no evidence of a spreading of such effects, probably because targeting story details with consistent or inconsistent information had little constructive or destructive effects.

To summarize the results of the conditionwise comparisons, the locus of the experimentwise difference was at initial learning. Although the effects of condition were not prevalent, there was indication that, under certain circumstances, both inconsistent and consistent information may influence preschoolers' memory of the original event. In the last phase of this analysis, parameterwise tests were used to examine further the effects of providing misinformation in questionnaire form to one-trial subjects, the effects of providing consistent information in narrative form to one-trial and criterion subjects, and as well the effects of manipulating initial learning. Each of the parameterwise tests evaluates the null hypothesis that a particular parameter has the same value for two conditions. Because these $X^2(1)$ tests are both space and time consuming to report, only a summary of the significant effects is provided below.

The Dual Effects of Misinformation. If the presentation of misinformation had constructive or destructive effects on original information in the present study, then there should have been differences in the forgetting rates, reminiscence rates, or both between the misled and nonmisled conditions. However, as just mentioned, the only significant effect involved the recall of nontargeted details by one-trial subjects between the control-4 and misleading questionnaire conditions. Examination of this effect with parameterwise tests revealed that, in terms of forgetting, there was more storage failure (as measured by the parameter $\underline{S}$) and less retrieval failure (as measured by the parameter R) in the misleading questionnaire (S = .48, R = .17) than in the control-4 (S = .36, R = .31) condition. Although the effects of misinformation on original information were not pervasive, misinformation may have the potential to destructively and constructively affect original information. That is, these results indicate that misleading information may alter the storage of nontargeted story details; there were more nontargeted story details unavailable for recall in the one-trial misleading questionnaire condition than in the control-4 condition. Interestingly however, retrieval of those nontargeted story details that were available was more likely in the misleading information condition than in the control-4 condition. Therefore, exposure to misinformation appeared to weaken the trace bonds of some nontargeted details to a point where they were no longer available for recall, as well as strengthen the bonds of some of those nontargeted details that were available. Thus, misleading information may have had both constructive and destructive effects on those story details that were not targeted by the misinformation (at least for one-trial learners presented with misinformation in questionnaire form).

As for reminiscence, there was no difference in storage-based reminiscence (as measured by the parameter a) of nontargeted details between the misleading questionnaire and control-4 conditions for one-trial learners. However, there were a few differences between the two conditions with respect to retrieval-based reminiscence of nontargeted details. Concerning success-contingent reminiscence (as measured by the r_i parameters), the average probability of retrieving nontargeted details on the first trial and the average subsequent probabilities in the control-4 and misleading questionnaire conditions were $(1\text{-}R) = .69$, $r_1 = .96$, $r_2 = .99$, $r_3 = .99$, and $(1\text{-}R) = .83$, $r_1 = .88$, $r_2 = .88$, $r_3 = 1.00$, respectively. Because the probability of successful recall increased across trials, success-contingent reminiscence occurred in both conditions (although performance reached ceiling in the control-4 condition by the second trial). The only significant difference between the two conditions concerned the parameter r_2; there was a smaller chance of a success following two consecutive successes in the misleading questionnaire ($r_2 = .88$) than in the control-4 ($r_2 = .99$) condition.

In terms of error-contingent reminiscence (as measured by the f_i parameters), the average probability of failing to retrieve nontargeted details on the first trial and the subsequent probabilities of success following one error, and two and three consecutive errors in the control-4 and misleading questionnaire conditions were $R = .31$, $f_1 = .20$, $f_2 = .00$, $f_3 = .03$, and $R = .17$, $f_1 = .43$, $f_2 = .48$, $f_3 = .00$, respectively. Error-contingent reminiscence, then, tended to decline across trials in both conditions. There were, however, a few differences between conditions. Specifically, there was a greater probability of success following one error and two consecutive errors in the misleading questionnaire ($f_1 = .43$ and $f_2 = .48$) than in the control-4 condition ($f_1 = .20$ and $f_2 = .00$). Thus, the preschoolers in the misleading questionnaire condition apparently learned more from previous errors than previous successes.

To summarize, the locus of retention differences between the one-trial misleading questionnaire and the control-4 conditions was at forgetting (i.e., there were differences in both storage- and retrieval-based forgetting). There were no systematic differences between learning conditions with storage-based reminiscence. However, there was some evidence that preschoolers exposed to misinformation after one-trial learning were more likely to learn to retrieve nontargeted story details following an incorrect rather than a correct response.

Of great interest was the lack of memory impairment of the original event; preschoolers appeared to be quite resistant to the memory impairing effects of misinformation. However, there was also some evidence that misinformation, under certain circumstances, may not only impair particular features of the original memory trace, but may also simultaneously enhance retrieval of other features in that trace. That impairment of the original memory may have occurred in the present study is consistent with the trace-blending hypothesis discussed earlier. Recall that according to this hypothesis, both storage- and retrieval-based forgetting and reminiscence can occur, but that the magnitude of the differences should be larger at storage. Although there was no evidence of retrieval-based forgetting, the results are most consistent with the trace-blending theory. Thus, when preschoolers with one-trial learning were asked questions containing misinformation, the misleading information may have been incorporated into the trace containing original information, with the result that some of the nontargeted details underwent storage-based forgetting.

That storage-based forgetting as well as the alleviation of retrieval-based forgetting occurred in a misled condition is consistent with the thesis proposed earlier concerning the potential of misinformation to have dual effects on memory. What was somewhat surprising, however, was that these effects involved the recall of nontargeted rather than targeted details. That is, there were no constructive or destructive memory effects for those details that were targeted by the misinformation. To summarize, the effects that misinformation had on original memory were small. However, misinformation may possess the ability to constructively and destructively affect particular details of an event (i.e., those details that are not encountered again during the retention interval).

To understand why performance was inferior with only the recall of the nontargeted story details in the one-trial misleading questionnaire condition, it was important to know whether there were differences across conditions in the degree to which misinformation was represented in memory. Before I turn to the analysis of misinformation recall, a discussion of the effects concerning the presentation of consistent information and the manipulation of initial learning is presented.

<u>**Reinstating Effects of Consistent Information**</u>. If providing consistent postevent information reinstated the original event and thereby enhanced the recall of original information, then there should have been either greater alleviation of forgetting, more reminiscence, or both in these conditions as compared to the control-4 condition. Recall however, that such effects were rare. The only significant differences found were between the control-4 and the consistent narrative conditions with both one-trial and criterion recall of targeted details.

With one-trial learning, preschoolers experienced less retrieval-based forgetting of targeted story details (as measured by the parameter <u>R</u>) in the consistent narrative (<u>R</u> = .04) than in the control-4 (<u>R</u> = .20) condition. In terms of reminiscence, there were no systematic differences between conditions in either storage-based or success-contingent retrieval-based reminiscence (as measured by the parameters $\underline{a}$ and $\underline{r}_i$, respectively). Although learning to retrieve targeted details after previous successes increased across the first three trials in the control-4 condition (1-$\underline{R}$ = .80, $\underline{r}_1$ = .90, $\underline{r}_2$ = .99, $\underline{r}_3$ = .99), this was not the case, because of ceiling effects, in the consistent narrative condition (1-$\underline{R}$ = .96 $\underline{r}_1$ = .99, $\underline{r}_2$ = 1.00, $\underline{r}_3$ = .98).

Error-contingent retrieval-based reminiscence tended to decline across trials in the control-4 condition ($\underline{R}$ = .20, $\underline{f}_1$ = .49, $\underline{f}_2$ = .26, $\underline{f}_3$ = .22). Such a decline was also evident in the consistent narrative condition until the last trial, at which there was a significant increase in reminiscence ($\underline{R}$ = .04, $\underline{f}_1$ = .97, $\underline{f}_2$ = .03, $\underline{f}_3$ = .98). There was a greater chance of a success following one error and three consecutive errors in the consistent narrative than in the control-4 condition ($\underline{f}_1$ = .97 and .49, respectively; $\underline{f}_3$ = .98 and .22, respectively). Thus, providing consistent information in narrative form to preschoolers with one-trial learning appeared to help alleviate retrieval-based forgetting of targeted story details as well as to aid error-contingent retrieval relearning of those details.

Differences between the consistent narrative and the control-4 conditions ^R targeted detail recall by the preschoolers who had learned to criterion were confined to reminiscence. Restorage of story details was more likely when the preschoolers received consistent information during the retention interval ($\underline{a}$ = .14) than when they received no information at all ($\underline{a}$ = .00). In terms of success-contingent reminiscence, because performance was so high on the first trial, there was little evidence of this type of reminiscence in either the control-4 (1-$\underline{R}$ = .92, $\underline{r}_1$ = .98, $\underline{r}_2$ = .99, $\underline{r}_3$ = 1.00) or the consistent narrative condition (1-$\underline{R}$ = .98, $\underline{r}_1$ =

.99, $\underline{r}$ = .98, $\underline{r}_3$ = .98), and consequently there were no differences between conditions.

Error-contingent reminiscence tended to decline across trials with the preschoolers in the control-4 condition ($\underline{R}$ = .08, $\underline{f}_1$ = .57, $\underline{f}_2$ = .14, $\underline{f}_3$ = .00). Although there was also a tendency for reminiscence to decline across trials in the consistent information condition, there was a large increase in error-contingent reminiscence from the third to the fourth trial ($\underline{R}$ = .02, $\underline{f}_1$ = .72, $\underline{f}_2$ = .00, $\underline{f}_3$ = .93). Because of this, the only systematic difference between conditions involved the parameter $\underline{f}_3$. Subjects were more likely to respond correctly following three errors with the consistent narrative presentation than with no postevent presentation ($\underline{f}_3$ = .93 and .00, respectively). Therefore, providing consistent information in narrative form to preschoolers who had learned to criterion basically helped maintain targeted story details in memory, as well as enhance retrieval of those details after previous errors.

To summarize the effects of providing consistent information, exposure to the original story details that were presented in narrative form to one-trial learners appeared to help alleviate retrieval-based forgetting and to aid error-contingent retrieval relearning. Consistent information in narrative form also helped preschoolers who had learned to criterion maintain targeted story details in memory as well as retrieve these story details after previous errors. The locus of the effects of providing consistent information in narrative form was, therefore, at retrieval.

<u>**The Effects of Degree of Initial Learning on Retention**</u>. Recall that the primary reason for manipulating initial learning was to determine whether

differences in the degree of learning produced differences in the degree of reinstatement, memory impairment and erroneous reporting effects observed. Interestingly, there was no interaction between initial learning and condition with the recall of original information. That is, potential differences in trace strength in and of itself did not appear sufficient for reinstatement or memory impairment. However, there was indication from the results discussed above, that a poor or weak trace, although not sufficient, may make memory impairment more likely.

Despite the lack of an initial learning x condition interaction, there was evidence, not surprisingly, that the extent of learning of the original information influenced the retention of that information. Recall that because one-trial learning is thought to produce weaker traces than criterion learning, retention differences between the two learning conditions were expected to be localized at forgetting, primarily storage-based forgetting. This was the case. Although manipulating initial learning affected both forgetting and reminiscence processes, forgetting, particularly storage-based forgetting, played the primary role in the retention differences between the one-trial and criterion conditions. As expected, there was more storage failure (as measured by the parameter $\underline{S}$) in the one-trial than criterion learning groups (all comparisons), where the average rate of storage failure in the one-trial and criterion conditions was .36 and .09, respectively. One-trial learners also experienced more retrieval failure (as measured by the parameter $\underline{R}$) than criterion learners (in 7 of the 10 comparisons), where the average rate of retrieval failure for the seven significant comparisons was .24 and .07, respectively. Whereas storage failure was more common than retrieval failure with one-trial learning ($\underline{S}$ = .36 and $\underline{R}$ = .19), there was very little forgetting of either type with criterion learning ($\underline{S}$ = .09 and $\underline{R}$ = .07). Therefore, not surprisingly, the traces established with criterion learning appeared to be stronger (i.e., the story details appeared to be better integrated) compared to those formed with one-trial learning.

In terms of reminiscence, there was less storage-based reminiscence (as measured by the parameter $\underline{a}$) in the one-trial than criterion conditions (in 5 of the 10 comparisons), where the average rate of reminiscence for the five significant comparisons was .01 and .25, respectively. Interestingly, restorage of story details typically occurred whenever preschoolers who had learned to criterion received consistent postevent information. Given that the event trace appeared to be quite strong with criterion learning, restorage of story details seems to be more likely if trace details are reasonably well integrated when a portion of the original experience is encountered.

Although success-contingent retrieval-based reminiscence (as measured by the $\underline{r}_i$ parameters) was apparent in only the one-trial condition, there were no consistent differences between conditions. In the one-trial condition, the average probability of retrieving a stored trace on trial 1 and the average subsequent probabilities were (1-$\underline{R}$) = .81, $\underline{r}_1$ = .92, $\underline{r}_2$ = .97, and $\underline{r}_3$ = .99. For criterion learning, the values were (1-$\underline{R}$) = .93, $\underline{r}_1$ = .97, $\underline{r}_2$ = .99, and $\underline{r}_3$ = .99. The null result with criterion learning is obviously confounded by ceiling effects; the average retrieval probability on the first trial was so high that it left little room for improvement.

In terms of error-contingent retrieval-based reminiscence (as measured by the $\underline{f}_i$ parameters), the only systematic difference between learning conditions involved the probability of success following one error (as measured by the parameter $\underline{f}_1$). There was less chance of a success following one error in the one-trial than criterion conditions (in eight of the ten comparisons), where the average rate of retrieval following one error ($\underline{f}_1$) for the significant comparisons was .38 and .65, respectively. There was a tendency for error-contingent reminiscence to decline across trials in both learning conditions. With one trial learning, the average probability of retrieval failure on trial 1 was $\underline{R}$ = .19, and the subsequent probabilities of success following one error, and two and three consecutive errors were $\underline{f}_1$ = .39, $\underline{f}_2$ = .22, and $\underline{f}_3$ = .22, respectively. Similarly, with criterion learning, the average probabilities were $\underline{R}$ = .07, $\underline{f}_1$ = .62, $\underline{f}_2$ = .20, and $\underline{f}_3$ = .22.

To summarize the effects of manipulating initial learning, consistent with other studies (e.g., Howe, 1991, Howe et al., in press; Howe, Kelland et al., 1992), both forgetting and reminiscence processes contributed to the preschoolers' retention across the learning conditions. The locus of retention differences was also at forgetting, particularly storage-based forgetting. As for reminiscence, the preschoolers were more likely to restore story details after they had learned to criterion and received consistent postevent information. Although there was evidence of retrieval-based reminiscence, neither success- nor error-contingent reminiscence differed systematically with respect to extent of learning. That is, consistent with past research (e.g., Howe, 1991, 1993), recall performance increased across test trials, but reminiscence did not differ as a function of learning.

<u>Summary of the Trace-Integrity Analysis</u>. Basically three outcomes of interest emerged from the trace-integrity analysis of original information recall. First,

differences in original information retention were due primarily to the initial learning manipulation. Both forgetting and reminiscence processes contributed to the preschoolers' retention, however, the locus of retention differences was at forgetting, particularly storage-based forgetting. Although the recall of the original story details increased across test trials, reminiscence did not differ systematically as a function of the extent of learning.

Second, the effects of exposure to inconsistent information on the recall of original information, both constructive and destructive, were quite rare. Of importance, preschoolers were quite resistant to memory impairment and they also appeared not to feel pressured to report misinformation before original information. There was indication, however, that misinformation may, under certain circumstances, blend with the original information and impair portions of memory for the original event (i.e., the nontargeted story details). As well, misinformation may simultaneously enhance retrieval of the features in a trace (the nontargeted story details in the present case). Thus, it is possible that misinformation has dual effects on memory.

Third, the benefits of providing a testing session during the retention interval were nonexistent and the reinstating effects of providing consistent postevent information were not as large as expected. However, re-exposing preschoolers to story details in narrative form helped restore details, as well as prevented retrieval failure and aiding retrieval relearning.

Surprisingly, then, there were very few significant postevent information effects obtained with either the ANCOVA or the trace-integrity analysis. It was very obvious from the results that the preschoolers acquired the information readily and forgot very little of the story details over four weeks. It is quite possible that consistent and inconsistent information would have had much stronger effects on memory had there been more forgetting of story details.

Although the effects of misinformation on the original memory trace were rare in the present study, this does not mean that the exposure to misleading information had little affect on the preschoolers' performance. Exposure to misinformation can also influence what is reported. Therefore, it was of interest to know whether misinformation was incorporated into preschoolers' recollections of the original event. The results of an analysis of covariance that was used to examine preschoolers' production of misinformation are reported below. To understand why performance was inferior with only the one-trial misleading questionnaire recall of nontargeted details, it was necessary to determine whether there were differences across the misleading information conditions in the extent to which misinformation was represented in memory. To accomplish this, a trace-integrity analysis of misinformation recall was carried out. A description of both analyses follows.

Preschoolers' Reporting of Misinformation

Because the interest was in whether preschoolers reported misinformation when given the opportunity, both responses were examined for misinformation production (i.e., the data obtained with the lenient rather than the strict scoring method were used). The number of times preschoolers produced misinformation was analyzed using a 2 (initial learning: one-trial vs criterion) x 6 (condition: control-3/4 vs control-4 vs consistent narrative vs misleading narrative vs consistent questionnaire vs misleading questionnaire) x 4 (trial) analysis of covariance. The first two factors were between subjects, the last factor was within, and the covariate was the mean total number of times misinformation was produced per trial at acquisition. An ANCOVA, as opposed to an ANOVA, was carried out to control for the production of misinformation, by chance, during acquisition. Both the control-3/4 condition and the two consistent information conditions were included in this analysis simply for comparison purposes. Because a series of t-tests indicated no difference in long-term retention performance between the two control conditions, results are reported for only the control-4 condition.

Not surprisingly, the covariate was insignificant; any production of misinformation by chance at acquisition did not affect the frequency with which preschoolers produced misinformation at retention. Two main effects were significant, initial learning [$F(1,203) = 55.35$, $p < .01$, $eta^2 = .21$] and condition [$F(5,203) = 9.38$, $p < .01$, $eta^2 = .19$]. Also significant were one first-order and one second-order interaction, condition x trial [$F(15,612) = 3.23$, $p < .01$, $eta^2 = .07$] and initial learning x condition x trial [$F(15,612) = 2.46$, $p < .01$, $eta^2 = .06$].

As expected, the preschoolers produced more misinformation in the one-trial ($M = .87$) than criterion ($M = .21$) conditions. Post-hoc Neuman-Keuls examination of the condition effect revealed a larger production of misinformation in both the misleading conditions than in either of the consistent conditions or the control-4 condition [misleading questionnaire ($M = .98$), misleading narrative ($M = .95$), consistent questionnaire ($M = .32$), consistent narrative ($M = .34$), control-4 ($M = .39$)]. As can be seen in Figure 1, and as Neuman-Keuls examination of the condition x trial effect confirmed, all four trials in both the misleading narrative and misleading questionnaire conditions were significantly different from all four trials in the two consistent conditions and the control-4 condition. In addition, more misinformation was produced on trial 1 in the misleading narrative condition than on trial 4 in both misleading conditions, and as well on trial 1 in the misleading questionnaire condition than on trials 2, 3, and 4 of both misleading conditions.

As can be seen in Figure 2, and as post-hoc examination of the initial learning x condition x trial effect confirmed, this interaction occurred basically because there was more misinformation produced across trials in both one-trial misleading information conditions than in all other one-trial and criterion conditions. Although there was also a tendency for criterion subjects to produce more misinformation across trials in the misleading conditions than in the consistent and control conditions, this effect was not significant. Therefore, exposure to misleading information increased preschoolers' tendency to erroneously report misinformation when they witnessed a single presentation of the original event.

The Representation of Misinformation in Memory

The trace-integrity model was used to better understand the effect that exposure to misinformation had on the recall of original information as well as on the production of misleading information and other intrusions. The model helped determine whether there were any differences between the inconsistent information conditions in the retention of misleading information. Specifically, the model was used to examine whether initial learning and method of

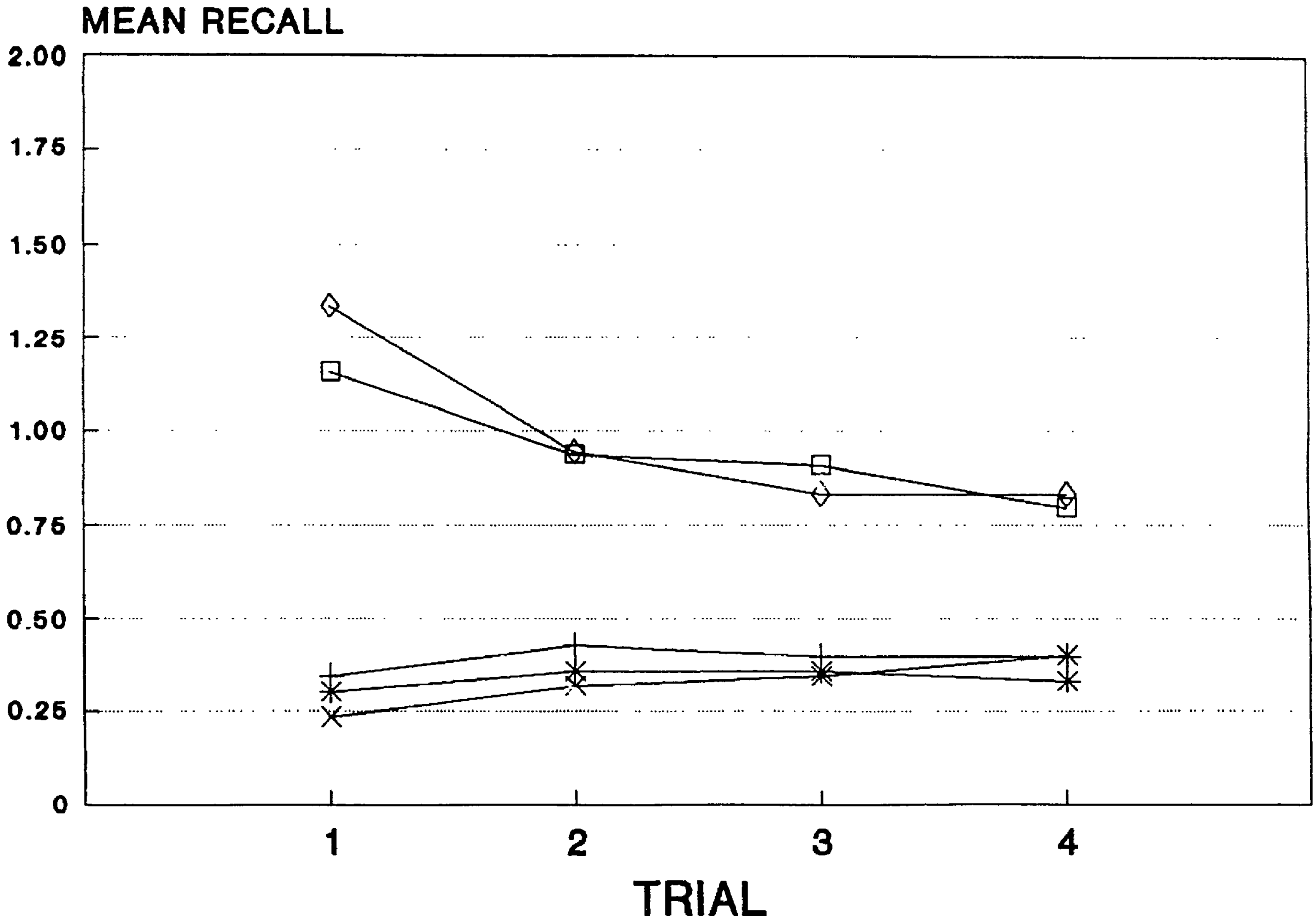

Figure 1. Mean number of times misinformation was produced for the condition x trial interaction (◻ = control-4, + = consistent narrative, ☐ = consistent questionnaire, * = misleading narrative, x = misleading questionnaire).

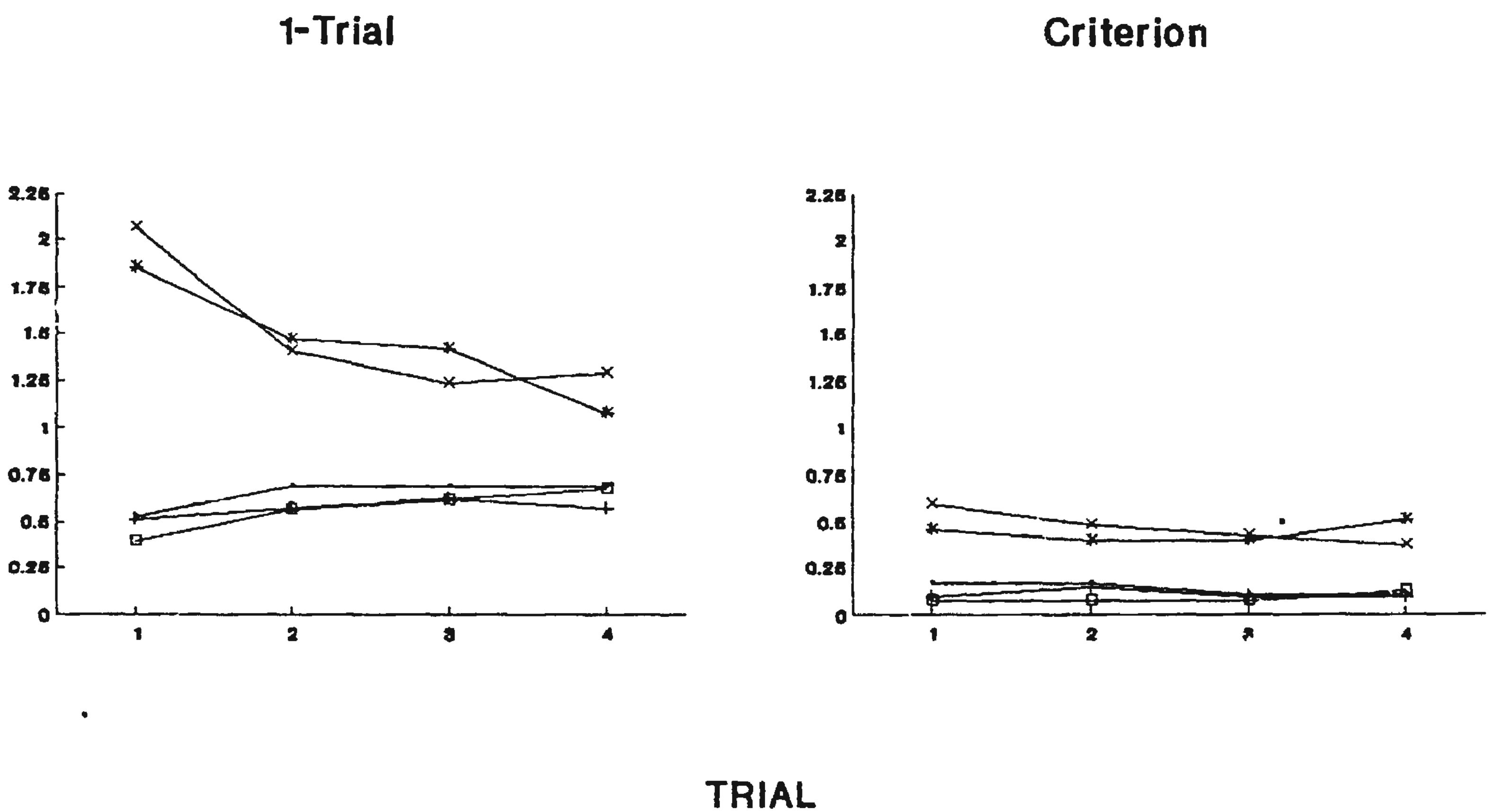

Figure 2. Mean number of times misinformation was produced for the initial learning x condition x trial interaction (⊡ = control-4, + = consistent narrative, □ = consistent questionnaire, * = misleading narrative, x = misleading questionnaire).

presentation influenced forgetting and reminiscence processes with respect to the preschoolers' recall of misinformation. Responses were scored as correct if the preschoolers reported the misinformation, regardless of whether it was their first or second response.

The model provided an adequate account of the misinformation data; the numerical results of these goodness of fit tests are provided in Table 9. The numerical estimates of the parameters are given in Table 10. The experimentwise test was significant [$X^2(27) = 55.27$, $p < .01$] and the results of the four $X^2(9)$ conditionwise tests used to locate the source of the experimentwise difference revealed effects of initial learning only, for both the narrative (25.98) and questionnaire (21.94) presentation. Parameterwise tests were then used to examine the effects of initial learning on misinformation retention.

Recall that the initial learning variable refers to the acquisition of original information, not misinformation; preschoolers in both the one-trial and criterion learning conditions received only a single presentation of misinformation. It is, therefore, interesting that there are initial learning effects with respect to the retention of misinformation. Examination of the parameterwise differences (all were significant at $p < .05$ only) indicated that the most prominent effect of manipulating learning of original information on the retention of misinformation was at forgetting. On average, there was more storage-based forgetting (as measured by the parameter $\underline{S}$) in the one-trial than criterion conditions ($\underline{S} = .74$ and .61, respectively) and more retrieval-based forgetting (as measured by the parameter $\underline{R}$) in the criterion than one-trial conditions ($\underline{R} = .47$ and .26, respectively).

Table 9
Statistical Adequacy of the Trace-Integrity Model for Misinformation Data

Condition	$-2\ln L_9$	$-2\ln L_{15}$	$X^2(6)$
1-Trial Learning			
Misleading Narrative	332.85	322.26	10.59
Misleading Questionnaire	297.82	289.79	8.03
Criterion Learning			
Misleading Narrative	130.67	128.94	1.73
Misleading Questionnaire	152.23	139.22	13.01

Note. In order to demonstrate goodness of fit the $X^2(6)$ value must not exceed 16.81, *p <.01.

Table 10
Estimates of the Trace-Integrity Model's Theoretical Parameters for Misinformation Recall

Condition	S	R	a	r_1	r_2	r_3	f_1	f_2	f_3
Narrative									
1-Trial	.77	.21	.00	.65	.80	.79	.21	.32	.00
Criterion	.96	.00	.00	.64	.98	1.00	.00	.33	.31
Questionnaire									
1-Trial	.70	.31	.00	.64	.88	.95	.09	.03	.00
Criterion	.25	.93	.59	.62	.87	.83	.00	.00	.00

Not surprising, the average rates of storage and retrieval failure produced when preschoolers recalled misinformation were large with both learning conditions. No less surprising, the average rate of storage failure was greater than the average rate of retrieval failure in each condition. That is, many of the misinformed details were not available for recall after the retention interval and many of the details that were available were not retrieved. Such high levels of storage and retrieval failure were expected given the single presentation of misinformation and given that this information probably contradicted what preschoolers had in memory.

Interestingly, the average forgetting rates mask differences in storage and retrieval failure that occurred as a function of the postevent presentation method. With narrative presentation of misinformation, there was more storage-based forgetting in the criterion than one-trial condition ($\underline{S}$ = .96 and .77, respectively) but more retrieval-based forgetting in the one-trial than criterion condition (R .21 and .00, respectively). However, the reverse was true with the questionnaire presentation; there was much more storage-based forgetting in the one-trial than in the criterion condition ($\underline{S}$ = .70 and .25, respectively) but more retrieval-based forgetting in the criterion than in the one-trial condition ($\underline{R}$ = .93 and .31, respectively). Thus, the availability and accessibility of misleading information was influenced by the way the misinformation was presented.

In terms of the narrative presentation, the results indicated that there was a greater probability that the misinformed details were available with weaker encoding. Although some of available misinformed details were inaccessible in this one-trial condition, available details in the criterion condition were always accessible (i.e., there was no retrieval-based failure in this criterion condition). Therefore, when the criterion subjects incorporated misinformation (that had been embedded in a narrative) into their memory structure of the original event, the representation of these details was strong. Although one-trial subjects were more likely to encode misleading details, they had problems retrieving at least some of these details. However, because the ANCOVA results indicated a higher production of misinformation in the one-trial than criterion condition for narrative presentation, there must have been more occasions when the targeted details were both available and accessible in the one-trial than criterion condition.

The results involving the questionnaire presentation of misinformation indicated that there were more misinformed details unavailable for recall in the one-trial than criterion condition. Based on the previous ANCOVA results, one would expect a greater availability, rather than unavailability, of misinformed details in the one-trial condition. However, although the availability of mislead details may have been greater in the criterion condition, one-trial subjects retrieved more of the available traces than did criterion subjects. That is, there were again more occasions in the one-trial than criterion condition when misinformed details were both available and accessible.

Therefore, fewer misinformed details were reported in the criterion than one-trial condition with both the narrative and questionnaire presentation. However, misinformation was more likely to be available for recall with the narrative presentation of misinformation when the trace containing original information was weak, but was more likely to be available with stronger traces when misinformation was presented in questionnaire form. Therefore, the way in which the misinformation was presented interacted with the degree of initial learning of original information to determine the extent to which misinformation was stored in memory. It is possible that for criterion learners, the contradiction of original information with misinformation was more obvious with the questionnaire rather than the narrative presentation because of the attempts to access the original trace during question answering. Preschoolers with criterion learning, then, may be more likely to attend to and encode misinformation when it was presented in questionnaire form. However, such a difference in the availability of misinformation was not evident with one-trial learners probably because the story details were not integrated strongly enough within the trace for such a contradiction to be apparent.

It is interesting that despite the greater availability of misinformation in the criterion than one-trial condition with questionnaire presentation, there was a greater production of misinformation after one-trial learning. Recall that the original trace appeared to be stronger in the criterion than one-trial condition (refer to the trace-integrity analysis of original information recall). It appears, then, that regardless of the presentation method, the strength of the original information obviously influenced whether the misleading information was accessible. Therefore, preschoolers with criterion learning may have been more confident that the original information was correct than preschoolers in the one-trial conditions, with the result that the misleading information was either not encoded into memory or was not accessed during recall in those conditions. Thus, as expected, and consistent with the ANCOVA results, the extent of learning of original information appears to influence the reporting of misleading information.

In terms of reminiscence, there were no systematic differences between the one-trial and criterion conditions with respect to storage-based reminiscence. There was more restorage of targeted details (as measured by the parameter $\underline{a}$) in the criterion than one-trial condition ($\underline{a}$ = .59 and .00, respectively) with questionnaire presentation only. As for success-contingent reminiscence, performance tended to improve from the first to the last trial with both the one trial (1-$\underline{R}$ = .74, $\underline{r}_1$ = .65, $\underline{r}_2$ = .84, $\underline{r}_3$ = .87) and criterion (1-$\underline{R}$ = .53, $\underline{r}_1$ = .63, $\underline{r}_2$ = .93, $\underline{r}_3$ = .89) conditions. The only differences between learning conditions in success-contingent reminiscence involved narrative presentation; there was a greater chance of success following two and three consecutive successes in the criterion than one-trial condition ($\underline{r}_2$ = .98 and .80, respectively; $\underline{r}_3$ = 1.00 and .79, respectively). There was very little error-contingent reminiscence with either one-trial ($\underline{R}$ = .26, $\underline{f}_1$ = .15, $\underline{f}_2$ = .18, $\underline{f}_3$ = .00) or criterion learning ($\underline{R}$ = .47, $\underline{f}_1$ = .00, $\underline{f}_2$ = .17, $\underline{f}_3$ = .16) and there were no differences between the learning conditions with either presentation method.

To summarize the analyses of misinformation production and retention, the availability and accessibility of misleading information were influenced by the way the misinformation was presented. However, regardless of the presentation method, misinformation was more likely to be both available and accessible when initial encoding was weak than when it was strong (i.e., with one-trial rather than criterion learning). That is, exposure to misleading information increased the preschoolers' tendency to erroneously report this information after they witnessed a single presentation of the original event. However, differences in the retention of misinformation did not appear to produce the effect found with the recall of the nontargeted story details in the one-trial misleading questionnaire condition; there were no significant differences in the retention of misinformation between the one-trial misleading narrative and questionnaire conditions.

It would have been informative to know the status of the misinformation in memory. That is, it was not possible to determine whether misinformation was very well represented in memory and simply not reported (possibly because the preschoolers knew it was incorrect) or whether, because of the small degree of forgetting of story details, that misinformation was not incorporated at all. It is possible that directly asking the children about the status of misinformation in memory might have revealed this. (Thanks to Dr. Mary Courage for this suggestion).

<u>Preschoolers' Production of Intrusions</u>

Exposure to misinformation may not only increase the likelihood that preschoolers report misinformation, it may also encourage the reporting of other intrusions (i.e., responses other than the original and misleading information). To better understand the influence that exposure to misinformation, as well as the other experimental manipulations, had on erroneous reporting, an examination was made of the frequency with which the preschoolers produced intrusions, as well as how relevant these intrusions were to the original story. Because the preschoolers' production of intrusions was not a primary interest in this thesis, only a general examination of intrusions was conducted. That is, the frequency of intrusion production and the relevance of intrusions to the general story script and to the specific question asked were not analyzed using the trace-integrity model.

Because the interest was in whether preschoolers reported intrusions when given the opportunity, both responses were examined in all intrusion analyses. To determine whether the experimental manipulations influenced the reporting of intrusions, the number of intrusions produced at retention was analyzed using a 2 (initial learning: one-trial vs criterion) x 6 (condition: control-3/4 vs control-4 vs consistent narrative vs misleading narrative vs consistent questionnaire vs misleading questionnaire) x 2 (postevent reference to story details: targeted vs nontargeted) x 4 (trial) analysis of covariance. The first two factors were between subjects, the last two were within, and the covariate was the mean total number of intrusions produced per trial at acquisition. Because there were no significant differences between the two control conditions, as revealed by a series of t-tests, only the results involving the control-4 condition are reported.

The covariate was significant and was adjusted for both between subjects factors [$F(1,203) = 37.34$, $p < .01$, $r^2 = .25$, $eta^2 = .16$] and for the within subject factor, postevent reference to story details [$F(1,203) = 8.83$, $p < .01$, $r^2 = .04$, $eta^2 = .04$]. Thus, individual differences in the number of intrusions produced at acquisition influenced intrusion production at retention. After the retention scores were adjusted for the differences at acquisition, two of the four main effects were significant: (a) initial learning [$F(1,203) = 147.19$, $p < .01$, $eta^2 = .42$], where one-trial subjects ($M = 2.60$) produced more intrusions per trial than criterion subjects ($M = .77$); and (b) postevent reference to story details [$F(1,203) = 82.66$, $p < .01$, $eta^2 = .29$], where more intrusions were produced with the nontargeted story detail recall ($M = 2.11$) than with the recall of details that were targeted in postevent information ($M = 1.26$).

There was also one first order interaction, initial learning x postevent reference to story details [$F(1,203) = 42.14$, $p < .01$, $eta^2 = .17$]. Further examination of this effect revealed that more intrusions were produced when recalling both targeted ($M = 1.89$) and nontargeted ($M = 3.30$) story details in the one-trial condition than when recalling both targeted ($M = .63$) and nontargeted ($M = .91$) details in the criterion condition. However, the interaction occurred because although there was no significant difference in intrusion production when recalling targeted and nontargeted details with criterion learning, more intrusions were produced when recalling nontargeted than targeted details with one-trial learning. To summarize, although incorrect responses were more likely when story details were not directly re-encountered during postevent information after one-trial learning, exposure to misinformation did not encourage the reporting of intrusions.

Because of the interest to know how relevant or irrelevant preschoolers' intrusions were, intrusions were analyzed in terms of their relevance to the particular question asked and to the story's general script. Two sets of analyses were carried out that included the same variables as in the intrusion analysis above with one exception, the postevent reference to story detail manipulation was replaced with a relevance variable. That is, intrusions were scored for their relevance or irrelevance to either the story's general script in one analysis or to the specific question asked in the other. Because the initial learning, condition, and trial effects were no different from those reported above, only the effects pertaining to the relevance of story details are summarized below. The statistical values for the question and story analyses are $F(1,203) = 163.85$, $p < .01$, $eta^2 = .45$ and $F(1,203) = 140.23$, $p < .01$, $eta^2 = .41$, respectively.

Preschoolers produced more story relevant (five times as many) and question relevant (three times as many) than irrelevant intrusions. Although there were more story relevant intrusions in the one-trial than criterion conditions, there was no difference between learning conditions with respect to story irrelevant intrusions. However, both question relevant and irrelevant intrusions were more prevalent with one-trial learning than with criterion learning. The number of irrelevant intrusions produced across conditions did not differ in either the story or question analysis. However, preschoolers in the misleading questionnaire condition produced more question relevant intrusions than did preschoolers in the consistent narrative and consistent questionnaire conditions. There were also more question relevant intrusions produced in the control-4 and misleading narrative conditions than in the consistent narrative condition. Therefore, whenever the preschoolers produced intrusions, they were usually related to the specific question asked or the general script of the story. That is, whenever the required information was not available or accessible, the preschoolers appeared to provide the best answer they could based on the knowledge they had.

Discussion

The primary motivation for the present research was to determine what role (if any) memory impairment plays in misinformation effects and to explain the transient nature of the erroneous reporting and memory impairing effects in young children. I argued that the appearance and disappearance of such effects is likely the direct consequence of limitations in past research. To address these limitations, the trace-integrity framework and model were used to eliminate the problems of initial learning and analytic insensitivity so that the dual effects of misinformation could be examined.

In the following a discussion is given of the role that memory impairment played in the preschoolers' erroneous reporting. Considered next are how differences across conditions and studies in initial learning, the dual effects of misinformation, differences across studies in experimental design, and analytical insensitivity help explain the transient effects of misinformation. The issues of preschoolers' reliability as eyewitnesses in courts of law and the importance of examining the effects of consistent postevent information on memory are then briefly examined. The discussion ends with a description of the role that forgetting and reminiscence, and their storage and retrieval loci, played in the preschoolers' retention in general.

The Role of Memory Impairment in Misinformation Effects

Before I discuss the role that memory impairment played in the reporting of misinformation in the present study, I will give a brief summary of the findings concerning the preschoolers' erroneous reporting and the vulnerability of their memories to impairment. Consistent with a large number of studies that indicate that adults as well as young children erroneously report misinformation (e.g., see Cole & Loftus, 1987; Zaragoza, 1987, for reviews), exposure to misleading information did encourage the preschoolers to report this information. In particular, misled preschoolers with one-trial learning reported more misinformation than nonmisled preschoolers. Interestingly however, such exposure did not influence the reporting of other types of erroneous information. That is, preschoolers produced just as many intrusions (i.e., responses other than the original or misleading information) in the nonmisled as in the misled conditions. The effects of misinformation on reporting, then, appear to be quite specific; preschoolers are more likely to produce misleading information rather than other types of erroneous information after they encounter misinformation during the retention interval.

Although misleading information that targets peripheral event details encourages the reporting of misinformation, this appears not to be the case when misinformation concerns central or thematic information. Recall that in Howe's (1991) study the misinformation was directed at the theme of a subevent in a story and that although there was evidence of memory impairment, the misled children did not report the inconsistent information more frequently than the nonmisled children. Both Howe's study and the present one are consistent with past research that indicates that misleading information is more likely to be reported when misinformation concerns peripheral rather than central or thematic aspects of an event (e.g., Dodd & Bradshaw, 1980; Goodman et al., 1987; King & Yuille, 1987; Yuille, 1980). Importantly, such findings indicate that the central or thematic aspects of young children's testimony are accurate. Therefore, there is a need to detail which aspects of a witnessed event young children perceive as peripheral and are likely to misreport and which portions of their testimony are likely to be reliable. For example, there is evidence that children are often unable to answer questions about aspects of an event such as its timing and the age of the participant(s) (Rudy & Goodman, 1991). It needs to be determined whether event aspects such as these are more likely than others to be vulnerable to misinformation?

In terms of the memory impairing effects that misinformation had in the present study, recall that such effects were rare. However, this absence of widespread memory impairment is consistent with previous research. Zaragoza and associate's (e.g., Zaragoza, 1987; 1991; Zaragoza et al., 1992) 3- to 6-year-olds and Howe's (1991) 5- to 7-year-olds were quite resistant to memory impairment. The misinformation manipulation employed in the current study likely provided one of the strongest tests of the memory impairment hypothesis to date. That is, 10 of the 20 to-be-remembered peripheral story details were misled compared to the traditional 2 of 4 items. It appears, then, that peripheral story details are very resistant to memory impairment three weeks after preschoolers witness an event. Therefore, both peripheral and central aspects of an event appear to be impervious to the potential memory impairing effects of misleading information. Interestingly, in a recent review by Ceci and Bruck (1993), it was concluded that there are reliable age differences in suggestibility. However, the preschoolers in the present study were quite resistant to memory impairment and, with sufficient learning of original information, did not erroneously report misinformation.

Of significance, however, was that despite the rarity of memory impairment, preschoolers who were given misleading information embedded in questionnaire form after one-trial learning experienced more storage failure of the nontargeted story details than did preschoolers in the control-4 condition. Howe (1991) also found a higher storage failure rate in his misled than nonmisled conditions.

These results are consistent with the trace-blending scenario put forth earlier; although only storage-based forgetting was evident in the present study, reminiscence, especially restorage, processes were present. It appears, then, that misleading and original information may be incorporated into a single trace. It also appears that by blending with the original information, misinformation may produce such a disintegration of the features or the bonds integrating trace features, that some of the original information is no longer available. These results are consistent with other work that has shown that children's memories are potentially alterable (see Loftus et al., 1992; Toglia et al., 1992).

It is possible, then, that misinformation may have the potential to damage original information. However, the problem is that the inferior recall performance of the nontargeted story details in the misleading questionnaire condition may instead be due to differences in initial learning, rate of forgetting, or both. That is, the misinformation manipulation itself may have had nothing to do with the storage impairment of the nontargeted details in the misled condition.

In summary, the preschoolers presented with inconsistent information reported this information at retention. However, the preschoolers' memories were quite impervious to impairment. Although there was indication that misinformation may blend with information in the original trace and alter the storage of specific portions of that information, it is not possible to determine whether this was in fact the case. What role, then, does memory impairment play in preschoolers' erroneous reporting?

According to the "no impairment" hypothesis, the reporting of misinformation occurs for reasons other than memory impairment. In particular, Zaragoza (e.g., Zaragoza, 1987) claimed that misinformation effects occur solely as a consequence of both conformity on the part of subjects (i.e., demand characteristics) and response bias. Recall that there is evidence that demand characteristics can, in fact, play a role in what children report concerning a witnessed event (e.g., Ceci et al., 1987a). If demand characteristics were operating in the present study, then the preschoolers may have been more likely to report misinformation before original information, given that they were allowed two opportunities to respond to each question. That is, they may have felt pressure to first report what the experimenter said they saw, than what they believed they saw themselves. Although the reporting of both the original and misleading information was not common either within a test trial or across test trials, in those cases where both were reported, misinformation was just as likely to precede as succeed original information.[7] It appears that the preschoolers did not feel compelled to first recall misinformation when given the opportunity to respond twice (also refer to the analysis involving strict versus lenient scoring). However, this does not mean that there was no conformity on the preschoolers' part.

In terms of response bias, it is possible that the children reported the misinformation because it was the only response that was accessible. Misinformation may have been reported either because the original information was forgotten (i.e., was no longer available or accessible) or because the original information was never encoded to begin with (see Zaragoza, 1987). Approximately half the time that the preschoolers reported misinformation, they failed to report original information.[8] If the preschoolers reported misinformation in these cases merely because it was the only response that was available or accessible, then there should have been no differences in the forgetting or reminiscence of original information between any of the inconsistent information conditions and the control-4 condition. But this was not the situation with the recall of the nontargeted details in the one-trial misleading questionnaire condition. Response bias also does not explain why the preschoolers reported the misinformation when the original information was accessible. Granted, misinformation may have been reported in some instances because the original information was not encoded at acquisition or because it became inaccessible or unavailable during the retention interval, but this cannot explain all erroneous reporting.

Assuming that the inferior recall of the nontargeted details in the one-trial misleading questionnaire condition indicates memory impairment, then the ability of misinformation to impair memory may explain why misinformation was reported when the original information was, and was not, recalled. Surprisingly, the preschoolers did not report the misleading information because the story details targeted by the misinformation had been impaired. In fact, there was an insignificant trend for the recall of the targeted information to be greater in the one-trial misleading information condition than in the control-4 condition. However, this does not imply that it was impossible for memory impairment to play a role in preschoolers' erroneous reporting. To impair the storage of nontargeted story details, the misinformation would likely have to blend with the information in the original trace. Because the misinformation would become part of the preschoolers' memory for the original event, they would include it in their recollections of that event.

One potential problem with this memory impairment explanation is that the misleading information was also reported in the conditions in which no storage impairment was observed. However, just because there was a significant amount of impairment with only the one-trial misleading questionnaire condition does not rule out the possibility that the misinformation blended with the original information to some extent in the other inconsistent information conditions. But there still may have been sufficient trace integration in these conditions for the recall of nontargeted story details. If this were the case, then more frequent reporting of misinformation would be expected with larger degrees of impairment of nontargeted information (i.e., with greater degrees of blending of misinformation into the original trace). In fact, there was somewhat more misinformation produced in the one-trial misleading questionnaire condition than in the other inconsistent information conditions. Thus, there is some indication that misinformation may blend with the original trace, damaging that information, with the result that subjects report misleading information.

However, recall that although Howe (1991) also found evidence that misinformation may blend with original information, the misled children in his study did not report misleading information more frequently than did the nonmisled children. It is possible that although blending of original and misleading information occurs, children are more likely to report inconsistent information when they are asked specific questions about an event, rather than when they are asked to freely recall the event. That is, the reporting of misinformation may be due to both the blending of misinformation into the original trace and the pressure felt by subjects to provide a response.

What, then, can be said of the role that memory impairment plays in the reporting of misinformation? If in fact misinformation impaired the storage of nontargeted details in the one-trial misleading questionnaire condition, then it is possible that memory impairment contributed to preschoolers' reporting of misinformation. If this is indeed the case, then it is obvious that very little impairment of original information is needed for preschoolers to report misleading information. It is likely, then, that memory impairment was not the sole reason for such reporting. In addition, there are studies that indicate that factors other than memory impairment contribute to misinformation effects, factors such as conformity on the part of subjects, response bias, an inability to adequately monitor the source of information, and an incongruence between the child's linguistic and cognitive functioning and the type of question asked (e.g., Ceci et al., 1987a; Lindsay & Johnson, 1987a; Saywitz et al., 1991; Zaragoza et al., 1992). In agreement with others (e.g., Loftus & Hoffman, 1989; Tversky & Tuchin, 1989) then, many factors such as memory impairment, demand characteristics, and response bias possibly contribute to preschoolers' reporting of misinformation.

Explaining the Transient Effects of Misinformation

Interestingly, the now-you-see-it now-you-don't nature of the effects of misinformation were apparent in the present study. Although misleading information was reported in all inconsistent information conditions, the number of times misinformation was produced with criterion learning, unlike one-trial learning, was not significantly greater in the misled than in the nonmisled conditions. In addition, a significant degree of storage failure was evident in only one of the inconsistent information conditions. There was evidence from the present study that there are at least four factors that contribute to the appearance and disappearance of erroneous reporting and memory impairment effects. As was anticipated from previous studies, these factors are again failure to control degree of learning of original information (and possibly misinformation), failure to examine the dual effects of misinformation, the use of different experimental designs, and the utilization of insensitive measurement and analytical techniques.

Failure to Control Initial Learning. Earlier in the thesis I argued that the transient effects of misinformation may be due to differences across studies in the strengths of the original and misleading trace. There was support for part of this claim in the present study.

In terms of the strength of the original information, recall that the preschoolers reported fewer story details at acquisition in the one-trial than in the criterion condition and that retention was inferior with one-trial than criterion learning in the control-4 condition. Thus, it is likely that the integrity of the trace for the original event was poorer in the one-trial than criterion conditions. Also recall that both erroneous reporting and memory impairment were expected to be more likely with one-trial rather than criterion learning. In fact, the anticipated initial learning x condition (i.e., control vs misled) interaction was evident with the preschoolers' reporting of misinformation. There was more misinformation produced in both one-trial misleading conditions than in all other one-trial and criterion conditions. Although postevent exposure to inconsistent information did not influence intrusion production (i.e., responses other than misleading or original information), more intrusions were produced with one-trial than criterion learning. Not surprisingly, then, it appears that erroneous reporting is much more likely with weaker traces of the original information. Intrusion production was also less likely when preschoolers were exposed to story details during the retention interval; that is, more intrusions were reported with nontargeted than targeted detail recall after one-trial learning. However, although there was a tendency for targeted details to be more available and accessible than nontargeted details in the one-trial conditions, this tendency was not significant. Nonetheless, because there were degree of learning effects, there is evidence that the reporting of both misinformation and other intrusions is influenced by the strength of the original information. Differences across studies, then, in the degree to which subjects learn original information will influence whether, and the degree to which, misinformation effects are reported.

However, can the same be said of memory impairment? As stated earlier, it is not possible to determine whether the inferior performance in the one-trial misleading questionnaire condition was actually due to impairment by misinformation. Therefore, it is not possible to determine whether the probability of such impairment was greater when the strength of original information was weaker. However, because the inferior recall performance in the misled condition would typically have been interpreted as memory impairment, it is possible to determine whether memory impairment is more likely to be reported when the strength of original information is weaker. Despite the fact that the initial learning x condition (i.e., control vs misled) interaction was not apparent with the preschoolers' recall of original information, there was some indication that the strength of original information may influence whether memory impairment is reported. That is, the only incidence of storage failure was with one-trial learning. Although the only case of impairment in Howe's (1991) first experiment was with criterion learning, storage-failure was evident when testing occurred at 9 versus 2 days. Consistent with the present study, the only evidence of impairment in his second experiment was with one-trial learning. Thus, it is more likely that impairment will occur, or that it will be reported to occur, when the strength of original information is weak, as the result of either inferior initial learning or longer retention intervals.

There was also some indication that recall may be influenced by whether preschoolers are re-exposed or not to story details during the retention interval; storage failure occurred with the recall of nontargeted, rather than targeted, details in the one-trial misleading questionnaire condition. However, although there was a tendency for story details to be more available with targeted than nontargeted detail recall in the inconsistent information conditions than in the control-4 condition, this tendency was not significant. Nonetheless, it is possible that the combination of one-trial learning with the lack of exposure to story details during the retention interval, made the portion of the original trace containing the nontargeted details the weakest part of the trace. There does appear, then, to be some evidence that memory impairment is more likely to be reported when the original trace, or a portion of the trace, is not sufficiently integrated when misleading information is presented.

To summarize, there was evidence that the strength of the original information influences whether erroneous reporting and memory impairment effects will be reported. These results are consistent with the retroactive interference literature (e.g., see Crowder, 1976; Postman & Underwood, 1973, for reviews) that indicates that a weak rather than a strong memory for the original list is more susceptible to the interfering effects of the interpolated list(s). Thus, the present findings do not support claims that the effects of misinformation are larger with stronger traces of original information (i.e., higher levels of control performance; cf. Chandler, 1989). Importantly, then, failure to control subjects' acquisition of original information across conditions within a study, as well as across studies, likely contributes to the appearance and disappearance of erroneous reporting and memory impairment effects.

Although there was some indication that memory impairment is more likely to be reported with weaker traces of original information, storage failure was not found with the nontargeted detail recall in the one-trial misleading narrative condition. This is consistent with past studies that have found it difficult to demonstrate a link between trace strength and memory impairment (e.g., Howe, 1991; Zaragoza et al., 1992). Therefore, despite the indication that the reporting of impairment may be more likely with smaller degrees of trace integration, it appears that a weak trace alone is not sufficient. Whether memory impairment will be reported at all, as well as the extent of this effect, must depend on more than the degree of trace integration at the time misinformation is presented. One factor that may interact with the trace strength of original information to produce erroneous reporting and memory impairment effects is the trace strength of misleading information.

If the trace strengths of both the original and misleading information interacted to produce what appear to be memory impairment effects, then there should have been differences in the retention of misinformation between the one-trial questionnaire and narrative conditions, given that inferior recall was found only in the former condition. (This is assuming, of course, that the integrity of nontargeted details was similar in the two conditions at the time of postevent presentation.) But recall that there were no significant differences in the forgetting or reminiscence of misleading information between the one-trial narrative and questionnaire conditions. However, the lack of difference in the retention of misinformation between these conditions is not surprising, given that there was also little difference in the forgetting and reminiscence rates between the two conditions with the recall of nontargeted information. That is, although the only indication of storage failure was with the questionnaire presentation, there appeared to be a similar effect on nontargeted detail recall with narrative presentation. It is not clear why a significant amount of storage failure occurred in only the one-trial questionnaire condition.

Because the manipulation of the presentation method did not influence the retention of misinformation, it was not possible to determine whether differences in the trace strength of inconsistent information also contribute to the transient effects of misinformation. However, because it is possible that misinformation blends with original information, it is plausible that differences in the extent to which misinformation is represented in the original trace influences whether, and the degree to which, erroneous reporting and memory impairment effects are reported. If there had been forgetting of story details or stronger manipulations of misinformation strength (e.g., one-trial versus criterion learning of misleading information) in the present study, then the anticipated interaction between the strengths of the original and misleading information may have emerged. If the effects of misinformation are determined by the degree of integrity of the entire memory structure (i.e., the relative strengths of both the original and misleading information), then it is important to control the degree of learning of both types of information (see also Ceci et al., 1988; Howe, 1991).

Failure to Examine the Dual Effects of Misinformation. Recall that the misleading information was expected to reactivate the original trace, with the result that there would be less forgetting, more reminiscence, or both of nontargeted details and more forgetting, less reminiscence, or both of targeted details. However, as discussed earlier, there were no destructive or constructive effects of exposure to misinformation for targeted information. But there were both constructive (i.e., alleviation of retrieval-based forgetting) and destructive (i.e., storage-based forgetting) effects with the recall of the nontargeted details in the one-trial misleading questionnaire condition. Again what is important is that the effects on nontargeted detail recall occurred with only one-trial learning. The dual effects of misinformation that are reported across studies, then, may differ depending on the extent to which original information, and possibly misinformation, are learned. In order to understand the transient effects of misinformation, the conditions under which misinformation promotes reinstatement versus impairment of targeted, as well as surrounding information, need to be identified. Therefore, it is important that researchers examine both the destructive and constructive effects of misinformation, as well as identify and control those factors that influence dual effects.

If these dual effects are indeed due to the misinformation manipulation, then the targeted details should have been as susceptible, if not more so, to such effects as the nontargeted details. However, there was instead a tendency for the targeted detail recall to be greater in the misled than in the control-4 condition. Had there been a greater degree of forgetting of original information, misinformation may have significantly enhanced performance or alleviated forgetting of targeted details. It is interesting, then, that misinformation may have the opposite effect on memory than that which is expected.

Differences in Experimental Design. I argued earlier that the constructive and destructive effects of misinformation may spread from targeted to nontargeted details, or vice versa, and that given the different experimental designs used across studies, this might contribute to the appearance and disappearance of erroneous reporting and memory impairment effects. Although there was no evidence of a spread of either positive or negative effects between story details, there was indication that manipulating subjects within or between conditions can influence the outcome of a study. Because there was evidence of storage failure with the nontargeted detail recall, the control performance in studies where within-subjects manipulations have been used, may have been inadvertently lowered. It may not necessarily be the case, then, that misleading some details in an event has no affect on remaining event details or that it is unproblematic to use the recall of nonmisled details to measure control performance.

Indeed, using within-subjects manipulations in studies examining the effects of misinformation can lead to problems with interpreting a study's outcome. For example, in one of Zaragoza's (1991) studies, in which a within-subjects manipulation was used, subjects recalled slightly more misled than control items. Was this because misinformation enhanced recall of misled items or weakened recall of control details? Thus, the type of experimental design used can influence the outcome of a study and differences in design across studies likely contribute to the transient effects of misinformation. It is also of interest to note that if only the targeted detail recall had been examined in the present study, it would have appeared as if there were no differences in forgetting rates between misled and nonmisled conditions. It is, therefore, important that both the constructive and destructive effects of misinformation be examined with targeted as well as nontargeted information.

Inadequate Measurement and Analytical Techniques. It is quite obvious from the present results that inappropriate measurement and analytical techniques also contribute to the problems with interpreting the outcome of studies in this area, as well as with the transient effects of misinformation. Because the trace-integrity model localized effects within specific parameters, unlike the general purpose ANCOVA, it was possible to observe effects that were apparent with the former and not the latter. One such example was the dual effects on the recall of nontargeted details observed in the one-trial misleading questionnaire condition. Because the partitioning of the data was more detailed and precise with the model, manipulations that produced no observable differences with the recall of these details in the ANCOVA, had clear effects on the parameters in the model.

Therefore, in order to understand how misinformation affects preschoolers' memory and testimony, it is necessary to operationalize and isolate the underlying mental variables of interest. To do so, techniques must be designed around particular paradigms (e.g., Ebbinghaus-like retention experiments) and sets of theoretical issues (e.g., the contribution of storage and retrieval factors to forgetting and reminiscence processes). It is, therefore, necessary to use formal measurement techniques, such as the trace-integrity model, that spell out the relationship between visible empirical results and invisible hypothetical subprocesses.

Explaining the Inconsistencies in Children's Studies. How can the discrepancy between the Ceci and colleagues (e.g., Ceci et al., 1987a; Toglia et al., cited in Toglia et al., 1992) and Zaragoza and colleagues (e.g., Zaragoza, 1987; 1991; Zaragoza et al., 1992) studies be explained? Although one-trial learning was used in both studies, it is very likely that differences existed in initial learning. In fact, Zaragoza reported a lower control performance than did Ceci and his colleagues. Based on the present results, the reporting of memory impairment should then have been more likely in Zaragoza's study. In fact, Zaragoza may have found impairment. Because she used a within-subjects manipulation, it is possible that the inconsistent information impaired memory for the nontargeted information, the very information that was being used to indicate control performance. Although misinformation had no significant effect on targeted or nontargeted information in the narrative condition in the present study, Zaragoza's procedure was not identical to the present one. Therefore, there may have been significant destruction of the control items in her studies, but any damage that misinformation may have had on targeted (or nontargeted) information would not have been evident. This would also explain why Ceci et al. obtained a higher control performance than did Zaragoza, despite the fact that she used older children from higher socioeconomic classes.

It is also possible that differences in the strength of misinformation in memory across the two studies contributed to the inconsistency. Regardless of the lack of presentation effects in the present study, other procedural differences may have influenced the degree to which misinformation was represented in memory. This, along with differences in the strength of original information, may have produced differences in the way misinformation constructively and destructively influenced memory across the two sets of studies.

Preschoolers' Reliability as Witnesses

Although it is not possible to generalize from this study to conclusions about preschoolers' competency to testify about their experiences in courts of law, the present results are encouraging. The types of experiences that young children are frequently asked to testify about, namely physical and sexual abuse, are likely to be more strongly encoded in memory than the kinds of activities used to test children's vulnerability to inconsistent information in misinformation studies. Physical and sexual abuse involves salient, traumatic, frequently occurring events that the child typically participates in with familiar adults, and there is plenty of evidence that children's memory for such events is quite strong. For example, memory for activities (e.g., who did what, where did it happen, what exactly took place) is of particular interest in abuse cases and young children have very good memories for activities that they and others are involved in (e.g., Fivush, Gray, & Fromhoff, 1987; Fivush, Hudson, & Nelson, 1984). In fact, there is much empirical evidence that preschoolers', and even infants', memory for events in general is very accurate (e.g., Fivush et al., 1987; Fivush & Hammond, 1989; Nelson, 1988; Nelson & Ross, 1980; Rovee-Collier & Shyi, 1992; Todd & Perlmutter, 1980; however, see Leippe, Romanczyk, & Manion, 1991; Rudy & Goodman, 1991). Consistent with these studies, the preschoolers' memories in the present study were quite robust; one-trial subjects recalled 77% of the story details and criterion subjects recalled 96%. More importantly, there was very little forgetting of story details with either learning condition over the four week period.

Typical abuse questions focus on activities that take place during the abuse as opposed to trivial background information, which is commonly examined in misinformation studies. We know that young children are more accurate, and less vulnerable to inconsistent information, when recalling central aspects of their experience than when recalling peripheral details (e.g., Goodman et al., 1990). There is also little evidence that children are more vulnerable to inconsistent information than are older children and adults when it comes to reporting central (e.g., Cole & Loftus, 1987) or thematic (e.g., Howe, 1991) aspects of an event (however see Ceci & Bruck, 1993).

In addition, participation in real-life events enhances children's memory and their resistance to suggestion as compared with bystanders who merely witness an event (again typical of many misinformation studies; e.g., MacWhinney, Keenan, & Reinke, 1982; Rudy & Goodman, 1991). Physical and sexual abuse also usually occur more than once and the present study showed that preschoolers' memory for frequently occurring events (i.e., criterion learning) is quite good and that such memories are very resistant to the destructive effects of misinformation. Thus, the experiences that young children are typically asked to give testimony about are likely to be very strongly encoded in memory, and may as a result, be quite resistant to misleading information. In fact, Saywitz et al. (1991) found young children to be especially resistant to abuse-related suggestions.

Therefore, it is possible that most of the research conducted to date concerning children's vulnerability to misinformation has underestimated their ability to resist inconsistent information (see Rudy & Goodman, 1991). Considering this, as well as the fact that children are unlikely to falsely report physical and sexual abuse (e.g., Jones, 1985, cited in King & Yuille, 1987), it would appear that their competency to testify in court may be greater than previously believed. However, despite the strong memories for story details that the children had in the present study and the relatively short retention interval (i.e., four weeks), misinformation promoted the reporting of misleading information and possibly impaired portions of memory for the original event for preschoolers with one-trial learning. What would misleading information do to memory and testimony when memory is months or even years old, as has been the case in many instances of abuse (e.g., Archdiocesan Commission, 1990)? Because of the concern regarding children's testimony in physical and sexual abuse cases, more research is needed that examines how misinformation affects children's memory for activities related to actual acts of abuse (e.g., being hit, touched, hugged, etc.) and for activities that occurred in the distant past.

Due to its theoretical and practical implications for the reliability of young children's eyewitness memory and testimony, as well as its relevance to theories of forgetting, event representation, and integrative and constructive memory processes (Zaragoza et al., 1992), it is obvious that the study of misinformation phenomena is of extreme importance. However, it is equally important to determine how subsequent encounters with previously encoded information affect memory. I turn now to a discussion of the effect that consistent information had on preschoolers' recollection of story details.

<u>**Improving Preschooler Recollection**</u>

Recall that it is of interest to determine whether re-encountering correct portions of a witnessed event or receiving additional testing opportunities produce hardier memories of that event, and whether it does so by affecting the cohesion of the trace in storage, by altering its retrievability, or both. Although the effects of providing consistent information were not as large as had been expected, likely because there was very little forgetting of story details, there was evidence that such information reinstated/reactivated preschoolers' memories.

Consistent information embedded in narratives alleviated retrieval-based forgetting and enhanced error-contingent retrieval relearning of targeted details in the one-trial conditions and as well aided restorage and error-contingent retrieval relearning of targeted details in criterion conditions. It was interesting, however, that correct postevent information did not merely alleviate forgetting or reactivate the trace to its original level (because there was little forgetting to alleviate), but rather improved preschoolers' retention of the original event.

Therefore, consistent with previous work (e.g., Howe et al., in press), providing correct subsequent information about a witnessed event affected both forgetting and reminiscence processes, with the result that long-term retention for directly re-experienced details was improved. Howe et al. found that re-encountering consistent information during the retention interval significantly decreased the rate at which originally encoded information was lost from storage and lead to better redintegrated traces on test trials. However, the effects of correct postevent information on preschoolers' memory in the present study appeared to be localized at retrieval. Had there been forgetting of original information, providing consistent postevent information may have affected the storage of the trace.

Also consistent with past research (e.g., Howe et al., in press; Slamecka & Katsaiti, 1988), reinstating a portion of an original event (i.e., mentioning only some of the to-be-remembered details) did not spread reactivation to the entire event (i.e., to the to-be-remembered details that were not re-encountered). That is, there was no difference in nontargeted detail recall between the control-4 and consistent information conditions. Thus, as Howe et al. (in press) pointed out, it is important not to presume that re-experiencing part of an original event reactivates or redintegrates the entire trace.

Interestingly, unlike providing consistent information, giving an additional testing opportunity did not significantly enhance preschoolers' retention. Thus, consistent with Howe et al. (in press), providing correct subsequent information had greater reinstating power than did providing an additional testing opportunity. This is expected given that providing consistent information permits a more complete re-encounter with the originally learned information than does practice on test trials.

Because potential court eyewitnesses are likely to encounter previously encoded information, it is important to understand how consistent information influences young children's memory and testimony for a witnessed event. As Howe et al. (in press) pointed out, it is necessary to (a) identify those conditions that postpone or alleviate forgetting, (b) determine whether reinstatement can promote the restoration of memories for original events even after exposure to misleading information, (c) determine whether the benefits derived from reinstatement are as long lasting as those induced by original learning, and (d) determine whether there is a critical time period after which reinstatement has no benefits. Understanding the reinstating properties of consistent postevent information may lead to the development of methods that enhance young children's recollection of experienced events, and this, of course, would be of great benefit to the judicial process.

<u>Preschooler Forgetting and Reminiscence</u>

The primary motivation of the thesis was to use the trace-integrity theory and model to examine not only the dual effects of misinformation and the effects of reinstatement, but to examine preschoolers' retention in general. It was obvious that forgetting and reminiscence made independent contributions to the preschoolers' retention. Forgetting played the larger role in the recall of both original and misleading information. In terms of original information, forgetting primarily served as the main locus of initial learning effects where, as expected, storage failures and, to a smaller extent, retrieval failures were more frequent when initial learning was weak (one-trial learning) than when it was strong (criterion learning). Although the effects of condition and postevent reference to story details effects were infrequent, when they were observed, they tended to be confined to forgetting (with the exception of the consistent information effects). Forgetting also contributed to the retention of misinformation more than did reminiscence, however, localization at storage or retrieval was dependent on the method of misinformation presentation.

Consistent with other research findings (e.g., Dent & Stevenson, 1979), although reminiscence played a role in preschooler retention, in contrast to forgetting, it was not systematically affected by experimental manipulation. In terms of the preschoolers' retention of original information, storage-mediated reminiscence was confined primarily to the criterion consistent information conditions. As for retrieval relearning, success-contingent reminiscence improved moderately across trials, whereas error-contingent reminiscence generally tended to decline. With regard to preschoolers' retention of misleading information and other intrusions, reminiscence contributed uniformly to performance. Restorage of misleading information occurred only when inconsistent information was given in questionnaire form after the preschoolers learned to criterion. Although success-contingent reminiscence increased somewhat across trials, there was a lack of error-contingent reminiscence. Overall, then, there was very little reminiscence of misinformation; as can be seen in Figure 2, misinformation production tended to decline across trials in the one-trial condition but remained relatively stable with criterion learning. Similarly, no effect of trial was observed with intrusions;

that is, preschoolers' production of intrusions did not increase across trials. Enhanced recall of original information with no subsequent increase in the recall of misinformation and other intrusions highlights the importance of providing multiple testing opportunities during long-term retention, particularly after noncriterion learning. That is, any negative effects of exposure to misleading information on memory are more likely to dissipate with repeated testing.

It is obvious from the present study, as well as from previous studies (e.g., Howe, Kelland et al., 1992) that forgetting and reminiscence make independent contributions to retention. Therefore, in order to accurately interpret outcomes of studies concerning children's long-term retention in general, and studies of misinformation and reinstatement effects in particular, measurement and analytical techniques are required that disentangle the positive and negative subprocesses involved in retention.

Concluding Comments

It appears that the time has come for a change in beliefs concerning children's memory and their competency to testify in courts of law. Based on the large amount of evidence indicating that children's memory for past events is accurate and that their memories are resistant to misleading information, it appears that children can be believed to a greater extent than was once thought. However, as enduring and as resistant to impairment as children's memories might be, the present study, along with others (e.g., Howe, 1991), has provided evidence that young children's recollections can be tampered with. Importantly, despite the accuracy of memory for preschoolers with one-trial learning (i.e., they experienced no forgetting), they still reported a significant amount of misleading information. I agree with Ceci and his colleagues (Ceci et al., 1987b) that more research is necessary before the legal community can feel confident to accept or reject the testimony of children (and adults).

There are a number of avenues that future researchers can take. We can continue to identify those conditions that make memory impairment and erroneous reporting more likely and to spell out those aspects of memory and testimony that are most vulnerable to inaccuracies. For example, it could be argued that administering the memory tests one week after the misinformation treatment may have reduced the size of the effects of misinformation because the strength of misinformation in memory may have been weakened as time passed. Therefore, it may be the case that a shorter interval between misinformation presentation and retention testing will produce stronger effects of misinformation. As well, we also need to identify those conditions under which postevent information benefits children's retention.

As our understanding of children's memory and testimony advances, so too will the development of interviewing techniques that improve the accuracy of what children report. The design of interviewing methods that are sensitive to the many different factors that influence children's recall is of interest because what is retrieved from a child's memory is often dependent on factors such as who asks the questions (Toglia et al. 1992) as well as on how the questions are framed (Ornstein, Gordon, & Baker-Ward, 1992).

One important outcome of the present study was the indication that misinformation may be incorporated into the same trace as the original information. One would expect that if the preschoolers had been asked to report the source of both the misleading and original information, that they would have attributed both to the original event. Although there has been no examination of whether children believe that they actually saw story details that were suggested to them, there is evidence from the reality monitoring literature that indicates that children have problems distinguishing between perceived and imagined events (e.g., Johnson & Foley, 1984). Obviously, children's source monitoring abilities need further examination.

As for other avenues of research, Howe, O'Sullivan, and Marche (1992) mentioned the need to better detail the role that memory strength plays in misinformation effects and retention in general. It is obvious that we need a clearer conceptualization of the nature of trace composition. Only when we have some way of measuring trace durability will we be able to identify those conditions that protect traces from mutation, as well as those conditions that promote changes in what has been stored in a trace. Howe, O'Sullivan et al. also spoke of the need for more studies that examine what children know about maintaining information in memory. That is, we need to examine what children know about forgetting, in particular what they know about the potential sources of interference in memory and what they believe can be done to forestall or prevent forgetting.

Another potential area of research concerns individual differences in the accuracy of young children's eyewitness memory and in their ability to provide reliable testimony. For the most part, the preschoolers performed quite similarly with respect to the reporting of both original and misleading information.

However, there were a few children who rarely provided erroneous information (i.e., if they did not know the answer they gave no answer) and there were a few others who responded nearly every time a question was asked (i.e., it appeared as if they always guessed when they did not know the answer). Because of the serious consequences that such a child as the latter would have for the legal system, it may be necessary to develop some form of character profile that describes the reliable child witness.

Therefore, although progress has been made in our understanding of misinformation phenomena, reinstatement effects, and of children's retention in general, it is very obvious that our comprehension is far from complete. If our understanding is to advance, researchers must concern themselves with the limitations that have been inherent in past work. For example, researchers must be cognizant the need (a) to control the learning of original and misleading information, (b) to use better manipulations of misinformation (ones that resemble the prolonged and repeated questioning that young children likely experience), (c) to examine the potential constructive and destructive effects of misinformation, and (d) to use retention intervals that resemble those typical of abuse cases. Caution also needs to be employed when using within-subjects manipulations because of the potential damage that misinformation may have to the information used to measure control performance. As well, researchers need to concern themselves with ways of assessing children's memory and testimony other than the typical two-alternative forced-choice recognition test. Because it is of interest to know whether both original and competing information are in memory and because relying on only correct responses will not give a complete and accurate assessment of children's vulnerability to misleading information, response methods that permit the recall of both types of information must be used. In addition, because memory impairment is likely only one of the many factors that contribute to the effects of misinformation, it is important that researchers use methods that segregate memorial and nonmemorial factors.

Of most importance for future investigations of reinstatement, erroneous reporting, and memory impairment effects, as well as for studies of retention in general, is the use of proper measurement and analytical techniques. The time has come for memory to no longer be viewed as a permanent storage medium where forgetting is due to retrieval failure. Both storage and retrieval processes play a role in the development of children's long-term retention (e.g., see Howe, Kelland et al., 1992). As in other studies (e.g., Brainerd et al., 1990; Howe, 1991, Howe, Kelland et al., 1992), changes in forgetting rates, particularly storage failures, were the driving force in preschoolers' retention in the present study. Indeed, there is a growing amount of acceptance and empirical support for the idea that changes in long-term retention are mediated by alterations in the memory representation itself (e.g., Howe, 1991; Loftus et al., 1992; Rovee-Collier & Shyi, 1992). Because it is likely that storage and retrieval represent different aspects of a single memory process and not two distinct processes (e.g., Howe & Brainerd, 1989; Howe, Kelland et al., 1992), researchers also need to consider reconceptualizing their constructs of these processes.

It is evident that theoretical advancement in this area depends on the development and implementation of formal measurement techniques. That is, techniques are required that unequivocally express the relationship between empirical results and the invisible hypothetical subprocesses under study. Because model-based measurements were used to separate forgetting and reminiscence and their storage and retrieval loci in the present study, it was possible to determine the storage/retrieval locus of the effects of reinstatement, misinformation, and retention in general.

Figure Captions

Figure 1. Mean number of times misinformation was produced for the condition x trial interaction (= control-4, = consistent narrative, = consistent questionnaire, = misleading narrative, = misleading questionnaire).

Figure 2. Mean number of times misinformation was produced for the initial learning x condition x trial interaction (= control-4, = consistent narrative, = consistent questionnaire, = misleading narrative, = misleading questionnaire).

10.00 10.00 10.00 10.00

Figure 1. Mean number of times misinformation was produced for the condition x trial interaction (□ = control-4, + = consistent narrative, □ = consistent questionnaire, * = misleading narrative, x = misleading questionnaire).

Figure 2. Mean number of times misinformation was produced for the initial learning x condition x trial interaction (□ = control-4, + = consistent narrative, □ = consistent questionnaire, * = misleading narrative, x = misleading questionnaire).

References

Ackerman, B.P. (1987). Children's retrieval deficit. In C.J. Brainerd & M. Pressley (Eds.), Basic processes in memory development: Progress in cognitive development research (pp. 1-46). New York: Springer-Verlag.

Allen, G.A., Mahler, W.A., & Estes, W.K. (1968). Effects of recall tests on longterm retention of paired-associates. Journal of Verbal Learning and Verbal Behaviour, 8, 463-470.

Anderson, J.R. (1980). Concepts, propositions, and schemata: What are the cognitive units? Nebraska Symposium of Motivation, 28, 121-162.

Archdiocesan Commission. (1990). The report of the archdiocesan commission of enquiry into the sexual abuse of children by members of the clergy. St. John's, Nf.: Archdiocese of St. John's.

Barnes, J.M. & Underwood, B.J. (1959). "Fate" of first-list associations in transfer theory. Journal of Experimental Psychology, 58, 97-105.

Bekerian, D.A. & Bowers, J.M. (1983). Eyewitness testimony: Were we misled? Journal of Experimental Psychology: Learning, Memory, & Cognition, 9, 139-145.

Belli, R.F. (1988). Colour blend retrievals: Compromise memories or deliberate compromise responses? Memory & Cognition, 16, 314-326.

Belli, R.F. (1989). Influences of misleading postevent information: Misinformation interference and acceptance. Journal of Experimental Psychology: General, 118, 72-85.

Berliner, L. & Barbieri, M.K. (1984). The testimony of the child victim of sexual assault. Journal of Social Issues, 40, 125-137.

Bogartz, R.S. (1990). Learning-forgetting rate independence defined by forgetting function parameters or forgetting function form; reply to Loftus and Bamber and to Wixted. Journal of Experimental Psychology: Learning, Memory, and Cognition, 16, 936-945.

Bowers, J.M. & Bekerian, D.A. (1984). When will postevent information distort eyewitness testimony? Journal of Applied Psychology, 69, 466-472.

Bowman, L.L. & Zaragoza, M.S. (1989). Similarity of encoding context does not influence resistance to memory impairment following misinformation. American Journal of Psychology, 102, 249-264.

Brainerd, C.J., Howe, M.L., & Desrochers, A. (1982). The general theory of two-stage learning: A mathematical view with illustrations from memory development. Psychological Bulletin, 91, 634-655.

Brainerd, C.J., Kingma, J., & Howe, M.L. (1985). On the development of forgetting. Child Development, 56, 1103-1119.

Brainerd, C.J., & Reyna, V.F. (1988). Memory loci of suggestibility development: Comment on Ceci, Ross, and Toglia (1987). Journal of Experimental Psychology: General, 117, 197-200.

Brainerd, C.J., Reyna, V.F., Howe, M.L., & Kingma, J. (1990). Development of forgetting and reminiscence. Monographs of the Society for Research in Child Development, 55 (3-4, Serial No. 222).

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

Campbell, B.A. & Jaynes, J. (1966). Reinstatement. Psychological Review, 73, 478-480.

Ceci, S.J., & Bruck, M. (1993). Suggestibility of the child witness: A historical review and synthesis. Psychological Bulletin, 113, 403-439.

Ceci, S.J., Ross, D.F., & Toglia, M.P. (1987a). Age differences in suggestibility: Narrowing the uncertainties. In S.J. Ceci, M.P. Toglia, & D.F. Ross (Eds.), Children's eyewitness memory (pp. 79-91). New York: Springer-Verlag.

Ceci, S.J., Ross, D.F., & Toglia, M.P. (1987b). Suggestibility of children's memory: Psycholegal implications. Journal of Experimental Psychology: General, 116, 38-49.

Ceci, S., Toglia, M.P., & Ross, D.F. (1988). On remembering ... more or less: A trace strength interpretation of developmental differences in suggestibility. Journal of Experimental Psychology: General, 117, 201-203.

Chandler, C.C. (1989). Specific retroactive interference in modified recognition tests: Evidence for an unknown cause of interference. Journal of Experimental Psychology: Learning, Memory, and Cognition, 15, 256-265.

Chechile, R.A. (1987). Trace susceptibility theory. Journal of Experimental Psychology: General, 116, 203-222.

Christiaansen, R.E. & Ochalek, K. (1983). Editing misleading information from memory: Evidence for the coexistence of original and postevent information. Memory & Cognition, 11, 467-475.

Christiaansen, R.E., Sweeney, J.D., Ochalek, K. (1983). Influencing eyewitness descriptions. Law and Human Behaviour, 7, 59-65.

Cohen, R.L. & Harnick, M.A. (1980). The susceptibility of child witnesses to suggestion. Law and Human Behaviour, 44, 201-210.

Cole, C.B. & Loftus, E.F. (1987). The memory of children. In S.J. Ceci, M.P. Toglia, & D.F. Ross (Eds.), Children's eyewitness memory (pp. 178-208). New York: Springer-Verlag.

Collins, A.M. & Loftus, G.R. (1975). A spreading of activation theory of semantic processing. Psychological Review, 82, 407-428.

Crowder, R.G. (1976). Principles of learning and memory. Hillsdale, NJ: Erlbaum.

Dale, P.S., Loftus, E.F., & Rathburn, L. (1978). The influence of the form of the question on the eyewitness testimony of preschool children. Journal of Psycholinguistic Research, 7, 269-277.

Dent, H.R. & Stevenson, G.M. (1979). An experimental study of the effectiveness of different techniques of questioning child witnesses. British Journal of Social and Clinical Psychology, 18, 41-51.

Deweer, B., Sara, S.J., & Hars, B. (1980). Contextual cues and memory retrieval in rats: Alleviation of forgetting by a pretest exposure to background stimuli. Animal Learning and Behaviour, 8, 265-272.

Dodd, D.H. & Bradshaw, J.M. (1980). Leading questions and memory: Pragmatic constraints. Journal of Verbal Learning and Verbal Behaviour, 19, 695-704.

Duncan, E.M., Whitney, P., & Kunen, S. (1982). Integration of visual and verbal information in children's memories. Child Development, 53, 1215-1223.

Eich, E. & Birnbaum, I.M. (1988). On the relationship between the dissociative and affective properties of drugs. In G.M. Davies & D.M. Thomson (Eds.), Memory in context: Context in memory (pp. 81-93). Chichester, England: John Wiley & Sons Ltd.

Eugenio, P., Buckout, R., Kostes, S., & Ellison, K. (1982). Hypermnesia in the eyewitness to a crime. Bulletin of the Psychonomic Society, 19, 83-86.

Fisher, R.P., Geiselman, R.E., Raymond, D.S., Jurkevich, L.M., & Warhaftig, M.L. (1987). Enhancing enhanced eyewitness memory: Refining the cognitive interview. Journal of Police Science and Administration, 15, 291-297.

Fivush, R., Gray, J.T., & Fromhoff, F.A. (1987). Two-year-olds talk about the past. Cognitive Development, 2,393-409.

Fivush, R. & Hammond, N.R. (1989). Time and again: Effects of repetition and retention interval on 2 year olds' event recall. Journal of Experimental Child Psychology, 47, 259-273.

Fivush, R., Hudson, J., & Nelson, K. (1984). Children's long-term memory for a novel event: An exploratory study. Merrill-Palmer Quarterly, 30, 303-316.

Gatti, S.V., Pais, N., & Weeks, J.R. (1975). Effects of reinstatement procedures on retention of differential appetitive responding. Bulletin of the Psychonomic Society, 6, 57-60.

Geiselman, R.E. (1988). Improving eyewitness memory through mental reinstatement of context. In G.M. Davies and D.M. Thompson (Eds.), Memory in context: Context in memory (pp. 245-266). Chichester, England: John Wiley & Sons Ltd.

Gibling, F. & Davies, G. (1988). Reinstatement of context following exposure to post-event information. British Journal of Psychology, 79, 129-141.

Goodman, G.S. (1984). Children's testimony in historical perspective. Journal of Social Issues, 40, 9-32.

Goodman, G.S., Aman, C., & Hirschman, J. (1987). Child sexual and physical abuse: Children's testimony. In S.J. Ceci, M.P. Toglia, & D.F. Ross (Eds.), Children's eyewitness memory (pp. 1-23). New York: Springer-Verlag.

Goodman, G.S., Golding, J.M., & Haith, M.M. (1984). Jurors' reactions to child witnesses. Journal of Social Issues, 40, 139-156.

Goodman, G.S. & Reed, R.S. (1986). Age differences in eyewitness testimony. Law and Human Behaviour, 10, 317-332.

Goodman, G.S., Rudy, L., Bottoms, B.L., & Aman, C. (1990). Children's concerns and memory and: Issues of ecological validity in children's testimony. In R. Fivush & J. Hudson (Eds.), Knowing and remembering in young children (pp. 249-284). New York: Cambridge University Press.

Greco, C., Rovee-Collier, C., Hayne, H., Griesler, P., & Earley, L. (1986). Ontogeny of early event memory: I. Forgetting and retrieval by 2- and 3-month-olds. Infant Behaviour and Development, 9, 441-460.

Greene, E., Flynn, M., & Loftus, E.F. (1982). Inducing resistance to misleading information. Journal of Verbal Learning and Verbal Behaviour, 21, 207-219.

Greeno, J.G., James, C.T., DaPolito, F.J., & Polson, P.G. (1978). Associative learning: A cognitive analysis. Englewood Cliffs, NJ: Prentice-Hall.

Hars, B. & Hennevin, E. (1990). Reactivation of an old memory during sleep and wakefulness. Animal Learning and Behaviour, 18, 365-376.

Horowitz, L.M. & Prytulak, L.S. (1969). Redintegrative memory. Psychological Review, 76, 519-531.

Hoving, K.L. & Choi, K. (1972). Some necessary conditions for producing reinstatement effects in children. Developmental Psychology, 7, 214-217.

Hoving, K.L., Coates, L., Bertucci, M., & Riccio, D.C. (1972). Reinstatement effects in children. Developmental Psychology, 6, 426-429.

Howe, M.L. (1985). Storage and retrieval of associative clusters: A stages-of-learning analysis of associative memory traces. Canadian Journal of Psychology, 39, 34-53.

Howe, M.L. (1988). Measuring memory development in adulthood: A model-based approach to disentangling storage-retrieval contributions. In M.L. Howe & C.J. Brainerd (Eds.), Cognitive development in adulthood: Progress in cognitive development research (pp. 39-64). New York: Springer-Verlag.

Howe, M.L. (1991). Misleading children's story recall: Forgetting and reminiscence of the facts. Developmental Psychology, 27, 746-762.

Howe, M.L. (1993). Interference effects in young children's long-term retention. Manuscript submitted for publication.

Howe, M.L. & Brainerd, C.J. (1989). Development of children's long-term retention. Developmental Review, 9, 301-340.

Howe, M.L., Courage, M.L., & Bryant-Brown, L. (in press). Reinstating preschoolers' memories. Developmental Psychology.

Howe, M.L., Kelland, A., Bryant-Brown, L., & Clark, S.L. (1992). Measuring the development of children's amnesia and hypermnesia. In M.L. Howe, C.J. Brainerd, & V.F. Reyna (Eds.), Development of long-term retention (pp. 56-102). New York: Springer-Verlag.

Howe, M.L., O'Sullivan, J.T., & Marche, T.A. (1992). Toward a theory of the development of long-term retention. In M.L. Howe, C.J. Brainerd, & V.F. Reyna (Eds.), Development of long-term retention (pp. 245-255). New York: Springer-Verlag.

Howe, M.L. & Rabinowitz, F.M. (1989). On the uninterpretability of dual-task performance. Journal of Experimental Child Psychology, 47, 32-38.

Howe, M.L. & Rabinowitz, F.M. (1990). Resource panacea? Or just another day in the developmental forest. Developmental Review, 10, 125-154.

Johnson, M.K. & Foley, M.A. (1984). Differentiating fact from fantasy: The reliability of children's memory. Journal of Social Issues, 40, 33-50.

Kerr, N.H. & Winograd, E. (1982). Effects of contextual elaboration on face recognition. Memory & Cognition, 10, 603-609.

King, M.A. & Yuille, J.C. (1987). Suggestibility and the child witness. In S.J. Ceci, M.P. Toglia, & F. Ross (Eds.), Children's eyewitness memory (pp. 24-35). New York: Springer-Verlag.

Leippe, M.R. & Romanczyk, A. (1987). Children on the witness stand: A communication/persuasion analysis of jurors' reactions to child witnesses. In S.J. Ceci, M.P. Toglia, & F. Ross (Eds.), Children's eyewitness memory (pp. 155-177). New York: Springer-Verlag.

Leippe, M.R., Romanczyk, A., & Manion, A.P. (1991). Eyewitness memory for a touching experience: Accuracy differences between child and adult witnesses. Journal of Applied Psychology, 76, 367-379.

Lindsay, D.S. & Johnson, M.K. (1987a). Reality monitoring and suggestibility: Children's ability to discriminate among memories from different sources. In S.J. Ceci, M.P. Toglia, & D.F. Ross (Eds.), Children's eyewitness memory (pp. 92-121). New York: Springer-Verlag.

Lindsay, D.S. & Johnson, M.K. (1987b). The eyewitness suggestibility effect and memory for source. Memory & Cognition, 17, 349-358.

Lipmann, O. (1911). Pedagogical psychology of report. Journal of Educational Psychology, 2, 253-261.

Loftus, E.F. (1975). Leading questions and the eyewitness report. Cognitive Psychology, 7, 560-572.

Loftus, E.F. (1977). Shifting human colour memory. Memory & Cognition, 5, 696-699.

Loftus, E.F. (1979a). Reactions to blatantly contradictory information. Memory & Cognition, 7, 368-374.

Loftus, E.F. (1979b). Eyewitness testimony. Cambridge, MA: Harvard University Press.

Loftus, E.F. (1979c). The malleability of human memory. American Scientist, 67, 312-320.

Loftus, E.F. (1980). The power of suggestion. In E. Loftus, Memory. Surprising new insights into how we remember and why we forget (pp. 149-169). Philippines: Addison-Wesley Publishing Company Inc.

Loftus, E.F. (1989). Distortions in eyewitness memory from postevent information. In H. Wegener, F. Losel, & J. Haisch (Eds.), Criminal behaviour and the justice system: Psychological perspectives (pp. 242-253). New York: Springer-Verlag.

Loftus, E.F. & Davies, G.M. (1984). Distortions in the memory of children. Journal of Social Issues, 40, 51-67.

Loftus, E.F., Donders, K., Hoffman, H.G., & Schooler, J.W. (1989). Creating new memories that are quickly assessed and confidently held. Memory & Cognition, 17, 607-616.

Loftus. E.F. & Greene, E. (1980). Warning: Even memory for faces may be contagious. Law and Human Behaviour, 4, 323-334.

Loftus, E.F. & Hoffman, H.G. (1989). Misinformation and memory: The creation of new memories. Journal of Experimental Psychology: General, 118, 100-104.

Loftus, E.F., Hoffman, H.G., & Wagenaar, W.A. (1992). The misinformation effect: Transformations in memory induced by postevent information. In M.L. Howe, C.J. Brainerd, & V.F. Reyna (Eds.), Development of long-term retention (pp. 159-183). New York: Springer-Verlag.

Loftus, E.F., Korf, N., & Schooler, J.W. (1989). Misinformation and memory. In J. Yuille (Ed.), Credibility assessment: A theoretical and research perspective (pp. 155-173). Boston: Kluwer.

Loftus, E.F. & Loftus, G.R. (1980). On the permanence of stored information in the human brain. American Psychologist, 35, 409-420.

Loftus, E.F., Miller, D.G., & Burnes, H.J. (1978). Semantic integration of verbal information into a visual memory. Journal of Experimental Psychology: Human Learning and Memory, 4, 19-31.

Loftus, E.F., Schooler, J.W., & Wagenaar, W.A. (1985). The fate of memory: Comment on McCloskey and Zaragoza. Journal of Experimental Psychology: General, 114, 375-380.

MacWhinney, B., Keenan, J.M., & Reinke, P. (1982). The role of arousal in memory for conversation. Memory & Cognition, 10, 308-317.

Marin, B.V., Holmes, D.L., Guth, M., & Kovak, P. (1979). The potential of children as eyewitnesses. Law and Human Behaviour, 4, 295-305.

McCloskey, M. & Zaragoza, M. (1985a). Misleading postevent information and memory for events: Arguments and evidence against memory impairment hypotheses. Journal of Experimental Psychology: General, 114, 1-16.

McCloskey, M. & Zaragoza, M. (1985b). Postevent information and memory: Reply to Loftus, Schooler, and Wagenaar. Journal of Experimental Psychology: General, 114, 381-387.

Metcalfe, J. (1990). Composite holographic associative recall model (CHARM) and blended memories in eyewitness testimony Journal of Experimental Psychology: General, 119, 145-160.

Miller, R.R., Kasprow, W.J., & Schachtman, T.R. (1986). Retrieval variability: Sources and consequences. American Journal of Psychology, 99, 145-218.

Morton, J., Hammersley, R.H., & Bekerian, D.A. (1985). Headed records: A model for memory and its failures. Cognition, 20, 1-23.

Nelson, K. (1988). The ontogeny of memory for real events. In U. Neisser & E. Winograd (Eds.), Remembering reconsidered: Ecological and traditional approaches to memory (pp. 244-276). New York: Cambridge University Press.

Nelson, K. & Ross, G. (1980). The generalities and specifics of long-term memory in infants and young children. In M. Perlmutter (Ed.), Children's memory: New directions for child development (pp. 87-101). San Francisco: Jossey-Bass.

Ornstein, P.A., Gordon, B.N., & Baker-Ward, L. (1992). Children's memory for salient events: Implication for testimony. In M.L. Howe, C.J. Brainerd, & V.F. Reyna (Eds.), Development of long-term retention (pp. 135-158). New York: Springer-Verlag.

Ornstein, P.A., Larus, D.M., & Clubb, P.A. (1991). Understanding children's testimony: Implications of research on the development of memory. Annals of Child Development, 8, 145-176.

Pirolli, P.L. & Mitterer, J.O. (1984). The effect of leading questions on prior memory: Evidence for the coexistence of inconsistent memory traces. Canadian Journal of Psychology, 38, 135-141.

Postman, L. & Underwood, B.J. (1973). Critical issues in interference theory. Memory and Cognition, 11, 101-104.

Powers, P.A., Andriks, J.L., & Loftus, E.F. (1979). Eyewitness accounts of females and males. Journal of Applied Psychology, 64, 339-347.

Reynolds, J.H. (1977). Unavailable and inaccessible information in retroactive inhibition of paired associates. Journal of Experimental Psychology: Human Learning and Memory, 3, 68-77.

Richardson, J.T.E. (1985). The effects of retention tests upon human learning and memory: An historical review and an experimental analysis. Educational Psychology, 5, 85-114.

Riefer, D.M. & Batchelder, W.H (1988). Multinomial modeling and the measurement of cognitive processes. Psychological Review, 95, 318-339.

Rovee-Collier, C., Borza, M.A., Adler, S.A., & Boller, K. (1993). Infants' eyewitness testimony: Effects of postevent information on a prior memory representation. Memory & Cognition, 21, 267-279.

Rovee-Collier, C. & Hayne, H. (1987). Reactivation of infant memory: Implications for cognitive development. In H.W. Reese (Ed.), Advances in child development and behaviour (Vol. 20, pp. 185-238). New York: Academic.

Rovee-Collier, C. & Shyi, G.C.-W. (1992). A functional and cognitive analysis of infant long-term retention. In M.L. Howe, C.J. Brainerd, & V.F. Reyna (Eds.), Development of long-term retention (pp. 3-55). New York: Springer-Verlag.

Rovee-Collier, C.K., Sullivan, M.W., Enright, M., Lucas, D., & Fagen, J.W. (1980). Reactivation of infant memory. Science, 208, 1159-1161.

Rudy, L. & Goodman, G.S. (1991). Effects of participation on children's reports: Implications for children's testimony. Developmental Psychology, 27, 527-538.

Runquist, W.N. (1986). Changes in the rate of forgetting produced by recall tests. Canadian Journal of Psychology, 40, 282-289.

Russell, D.E.H. (1983). The incidence and prevalence of intrafamilial and extrafamilial sexual abuse of female children. Child Abuse and Neglect, 7, 133-146.

Saywitz, K.J. (1987). Children's testimony: Age-related patterns of memory errors. In S.J. Ceci, M.P. Toglia, & D.F. Ross (Eds.), Children's eyewitness memory (pp. 36-52). New York: Springer-Verlag.

Saywitz, K.L., Goodman, G.S., Nicholas, E., & Moan, S.F. (1991). Children's memories of a physical examination involving genital touch: Implications for reports of child sexual abuse. Journal of Consulting and Clinical Psychology, 59, 682-691.

Scrivner, E. & Safer, M.A. (1988). Eyewitnesses show hypermnesia for details about a violent event. Journal of Applied Psychology, 73, 371-377.

Sheehan, P.W. & Tilden, J. (1986). The consistency of occurrences of memory distortion following hypnotic induction. International Journal of Clinical and Experimental Hypnosis, 34, 122-137.

Slamecka, N.J. & Katsaiti, L.T. (1988). Normal forgetting of verbal lists as a function of prior testing. Journal of Experimental Psychology: Learning, Memory and Cognition, 14, 716-727.

Smith, S.M. (1979). Remembering in and out of context. Journal of Experimental Psychology: Human Learning and Memory, 5, 460-471.

Smith, S.M., Glenberg, A., & Bjork, R.A. (1978). Environmental context and human memory. Memory & Cognition, 6, 342-353.

Spear, N.E. (1973). Retrieval of memories in animals. Psychological Review, 80, 163-194.

Stern, W. (1910). Abstracts of lectures on the psychology of testimony and on the study of individuality. American Journal of Psychology, 21, 273-282.

Tabachnick, B.G., & Fidell, L.S. (1989). Using multivariate statistics (second edition). New York: Harper and Row Publishers Inc.

Todd, C.M., & Perlmutter, M. (1980). Reality recalled by preschool children. In M. Perlmutter (Ed.), Children's memory: New directions for child development (pp. 69-85). San Francisco: Jossey-Bass.

Toglia, M.P., Ross, D.F., Ceci, S.J., & Hembrooke, H. (1992). The suggestibility of children's memory. A cognitive and social-psychological interpretation. In M.L. Howe, C.J. Brainerd, & V.F. Reyna (Eds.), Development of long-term retention (pp. 217-241). New York: Springer-Verlag.

Tulving, E. & Psotka, J. (1971). Retroactive inhibition in free-recall: Inaccessibility of information available in the memory store. Journal of Experimental Psychology, 87, 1-8.

Turtle, J.W. & Wells, G.L. (1987). Setting the stage for psychological research on the child eyewitness. In S.J. Ceci, M.P. Toglia, & D.F. Ross (Eds.), Children's eyewitness memory (pp. 230-248). New York: Springer-Verlag.

Tversky, B. & Tuchin, M. (1989). A reconciliation of the evidence on eyewitness testimony: Comments on McCloskey and Zaragoza. Journal of Experimental Psychology: General, 118, 86-91.

Underwood, B.J. (1964). Degree of learning and the measurement of forgetting. Journal of Verbal Learning and Verbal Behaviour, 3, 112-129.

Wagenaar, W.A. & Boer, H.P.A. (1987). Misleading postevent information: Testing parameterized models of integration in memory. Acta Psychologica, 66, 291-306.

Weinberg, H.I., Wadsworth, J., & Baron, R.S. (1983). Demand and the impact of leading questions on eyewitness testimony. Memory & Cognition, 11, 101-104.

Wells, M. (1990). Canada's law on child sexual abuse. A handbook. Ottawa, Ontario: Communications and Public Affairs, Department of Justice Canada.

Whipple, G.M. (1909). The observer as reporter: A survey of the psychology of testimony. Psychological Bulletin, 6, 153-170.

Whipple, G.M. (1911). The psychology of testimony. Psychological Bulletin, 8, 307-309.

Whipple, G.M. (1912). Psychology of testimony and report. Psychological Bulletin, 9, 264-269.

Whipple, G.M. (1918). The obtaining of information: Psychology of observation and report. Psychological Bulletin, 15, 217-248.

Yarmey, A.D. & Jones, H.P.T. (1982). Police awareness of the fallibility of eyewitness identification. Canadian Police College Journal, 6, 120.

Yarmey, A.D. & Jones, H.P.T. (1983). Is the study of eyewitness identification a matter of common sense? In S.M.A. Lloyd-Bostock & B.R. Clifford (Eds.), Evaluating witness evidence (pp. 13-40). Chichester, England: John Wiley & Sons Ltd.

Yuille, J.C. (1980). A critical examination of the psychological and practical implications of eyewitness research. Law and Human Behaviour, 4, 335-345.

Yuille, J.C. (1984). Research and teaching with police: A Canadian example. International Review of Applied Psychology, 33, 5-24.

Yuille, J.C. (1988). The systematic assessment of children's testimony. Canadian Psychology, 29, 247-262.

Zaragoza, M.S. (1987). Memory, suggestibility, and eyewitness testimony in children and adults. In S.J. Ceci, M.P. Toglia, & D.F. Ross (Eds.), Children's eyewitness memory (pp. 53-78). New York: Springer-Verlag.

Zaragoza, M.S. (1992). Misinformation and memory impairment: Evidence from a Modified Modified Free Recall Test. Unpublished.

Zaragoza, M.S. (1991). Preschool children's susceptibility to memory impairment. In J. Doris (Ed.), The suggestibility of children's memory (with special reference to the child witness). Washington, D.C.: American Psychological Association.

Zaragoza, M.S., Dahlgren. D., & Muench, J. (1992). The role of memory impairment in children's suggestibility. In M.L. Howe, C.J. Brainerd, & V.F. Reyna (Eds.), The development of long-term retention (pp. 184-216). New York: Springer-Verlag.

Zaragoza, M.S. & Koshmider III, J.W. (1989). Misled subjects may know more than their performance implies. Journal of Experimental Psychology: Learning, Memory, and Cognition, 15, 246-255.

Zaragoza, M.S. & McCloskey, M. (1989). Misleading postevent information and the memory impairment hypothesis: Comment on Belli and reply to Tversky and Tuchin. Journal of Experimental Psychology: General, 118, 92-99.

Zaragoza, M.S., McCloskey, M., & Jamis, M. (1987). Misleading postevent information and recall of the original event: Further evidence against the memory impairment hypothesis. Journal of Experimental Psychology: Learning, Memory, and Cognition, 13, 36-44.

Footnotes

[1]Although other explanations of the misinformation effect have been proposed (e.g., source misattribution, see Lindsay & Johnson, 1987a, 1987b), the concern in this thesis was with the role memory impairment played in the reporting of misinformation.

[2]Other reasons have been given for reinstatement effects. For example, consistent information available through reinstatement may couple with original information, making the trace stronger and less susceptible to forgetting (Howe et al., in press).

[3]The terms reinstatement and reactivation are sometimes used interchangeably in the literature (e.g., Rovee-Collier & Shyi, 1992). However, in the present thesis, reinstatement refers to any procedure whereby subjects re-encounter some aspect of an original event, whereas reactivation (or redintegration) refers to the theoretical mechanism proposed to account for reinstatement effects.

Spread of reactivation is conceivable because memory traces are primarily viewed as unitary, holistic structures where the basic features or elements within them are interconnected in some fashion (e.g., Anderson, 1980; Bransford & Franks, 1971; Howe, 1985; Metcalfe, 1990). Although the size of the trace likely depends on task demands and can range from letters and numbers to propositions and stories, the trace serves to integrate all of the available information into one closely knit configuration (Howe et al., in press). The conception in the present thesis is that the representation of an entire event is contained in a single memory trace.

[4]It was not possible, for practical reasons, to counterbalance the story details that were targeted with those that were not targeted in neither the narrative at acquisition nor during the postevent information (i.e., there were not enough of both types of details to do so). Any learning differences between targeted and nontargeted details were assessed and controlled with a series of t-tests for the narrative at acquisition, and with criterion learning and the analysis of covariance for the information presented during the postevent phase. However, the information concerning targeted details was counterbalanced; half of the subjects in the postevent information conditions received consistent information concerning targeted story details and the remaining half received misleading information.

[5]In all subsequent analyses, separation of the details in the control conditions into whether they were targeted or not in postevent information is for comparison purposes only and does not represent any actual manipulation of reference to story details.

[6]Due to the numerous comparisons made throughout this thesis and the consequent rise in Type I error, a significance level of .01 was adopted for all analyses. To calculate eta^2, the following formula was used, where SS denotes the

$$\text{eta}^2 = SS_{effect}/[SS_{effect} + SS_{error}],$$

sum of squares. Tabachnick and Fidell (1989) argued that for multifactorial designs, the size of eta^2 for a specific effect is partly determined by the strength of the other effects in the experiment. If there are many significant main effects and interactions, then eta^2 for a certain effect will be reduced because the other significant effects increase the size of the denominator. The denominator in the present eta^2 method is the adjusted sum of squares for the effect that is examined, plus the adjusted sum of squares for the corresponding error term for that effect.

[7]Of the responses preschoolers made, both original and misleading information were reported together within a test trial 1.9% of the time with one-trial learning and 1.5% with criterion learning. Misinformation preceded original information in 32% of the one-trial and 47% of the criterion cases. Examination of the first test trial only revealed a similar pattern; 8.7% of one-trial and 3.0% of criterion preschoolers' responses involved both original and misleading information. Forty-three percent of one-trial and 60% of criterion responses involved misinformation preceding original information. Producing both original and misleading information on different test trials, while more common than recalling them together within a test trial, was also an infrequent response pattern among preschoolers; 10.3% of one-trial subjects' and 5.2% of criterion subjects' responses involved recalling both original and misleading information on one or more of the four trials. Of the times preschoolers reported both, misinformation preceded original information 47% of the time with one-trial learning and 33% with criterion learning. So there was little evidence that when preschoolers had both responses available they felt pressured to first report misinformation.

[8]Of the preschoolers who were exposed to inconsistent information, 23% of their responses in the one-trial condition and 8% of their responses in the criterion condition contained misinformation. Misinformation was just as likely to be reported without, as with, original information; 45% of the time one-trial subjects reported misinformation and 66% of the time with criterion subjects', original information was also reported. That is, misinformation was just as likely

to "coexist" with original information as it was to "fill-in" information that was no longer, and possibly never was, available.

Appendix A

Narrative Accompanying the Slide Sequence

I'm going to tell you a story about a little girl named Cyndi. Cyndi had a real hard time falling asleep one night. She couldn't fall asleep because she was so excited about a Halloween party that she was going to the next day.

1. Finally, Cyndi fell asleep thinking about all the fun she will have at the Halloween party.
2. Then Cyndi's dog/cat comes in her room, jumps on her bed, and wakes her up.
3. She gets out of bed quickly and runs to her mom's room. She wants to find out if her mom finished making her Halloween costume.
4. And there it is. Sylvester is all finished. Cyndi can't wait to try it on.
5. Then Cyndi's mom comes in and says "Good Morning" to Cyndi. Cyndi keeps her Cookie Monster/Bunny Rabbit on top of her mom's dresser. Cyndi's mom asks Cyndi to get dressed and washed for breakfast.
6. So Cyndi goes to her bedroom and looks for something to wear.
7. After Cyndi is dressed, she leaves her room, and walks up the hallway to go to the bathroom.
8. Now Cyndi is in the bathroom getting ready.
9. Cyndi is really thirsty so she goes to the kitchen and pours herself something to drink.
10. Then Cyndi and her mom look for something for Cyndi to eat for breakfast.

11. Cyndi decides to have cereal/a boiled egg - she really likes this breakfast.
12. After breakfast Cyndi helps her mom clean the house.
13. Then she looks at the clock. There's still hours left before the party - she can't wait!
14. Since she has lots of time before the party, Cyndi decides to play for awhile.
15. After she's finished playing, she goes to her bedroom and waters her plant.
16. Then Cyndi and her dad make jello/muffins in the kitchen.
17. Later Cyndi's mom/Cyndi's dad reads Cyndi a story.
18. After Cyndi listens to the story, she colours for awhile; she uses the crayons in her favourite pink crayon box.
19. Then she gets hungry, so she gets an apple, and then stops to watch her goldfish. While Cyndi is watching her goldfish, her mom calls out and tells Cyndi that it's time to get ready for the party.
20. So Cyndi runs and gets her Sylvester costume and she starts to put it on.
21. But then she remembers that before she leaves, she has to say "goodbye" to her dog.
22. After Cyndi has her costume on she pretends she is Sylvester the Cat - she crawls on the floor, meowing.
23. Then Cyndi gets ready to go outside.
24. She asks her mom if she can take the umbrella, but her mom tells her to take her coat instead.
25. When Cyndi is ready she is carried to the car - it's really wet outside. They drive to the party.
26. Now Cyndi is at the Halloween party. You can't really see her but you can see her waving. Cyndi is playing all kinds of games and eating lots of good food. Is she ever happy!

Appendix B

Long-Term Retention Questionnaire

1. What jumped on Cyndi's bed and woke her up?
2. What did Cyndi keep on top of her mom's dresser?
3. Where did Cyndi look for something to wear - what did she look in?
4. What did Cyndi have to walk over in the hallway on her way to the bathroom -what was on the floor?
5. What did Cyndi do in the bathroom?
6. What did Cyndi pour herself to drink in the kitchen?
7. Where did Cyndi and her mom look for something for Cyndi to eat for breakfast - what did they look in?
8. What did Cyndi have to eat for breakfast?
9. What did Cyndi use to help her mom clean the house?
10. What did Cyndi play with on the floor in the hallway?
11. What colour was Cyndi's watering can that she used to water her plant?
12. What did Cyndi and her dad make in the kitchen?
13. Who read Cyndi a story?
14. What colour was Cyndi's favourite crayon case?
15. What type of snack did Cyndi get just before she looked at her goldfish?
16. Who told Cyndi it was time to get ready for the party?
17. Who did Cyndi have to say goodbye to before she left for the party?
18. To get ready to go outside, what did Cyndi put on her feet?
19. Before Cyndi went outside, what did Cyndi ask her mom if she could take?
20. Who carried Cyndi to the car?

Appendix C

Postevent Narrative

The last time I was here I told you a story about a little girl named Cyndi who was very excited about going to a Halloween party. Let's go over what happened in the story to make sure you remember it.

In the story Cyndi had a real hard time falling asleep one night. This was because she was so excited about a Halloween party that she was going to the next day. Finally, she fell asleep thinking about all the fun she would have at the Halloween party. Then Cyndi's dog/cat jumped on her bed and woke her up. She got up quickly and ran to her mom's room to see if her mom had finished making her Halloween costume. Her Sylvester costume was all finished and Cyndi couldn't wait to try it on. Then Cyndi's mom came in and said "Good Morning" to Cyndi, and asked her to get ready for breakfast. Cyndi kept her Cookie Monster/Bunny Rabbit on top of her mom's dresser. After Cyndi got dressed she went to the bathroom. She had to walk over a ball/a slinky that was left on the floor. Then Cyndi went to the kitchen and poured herself some milk/orange juice and then Cyndi and her mom looked in the cupboard/fridge for something for Cyndi to eat for breakfast. And then Cyndi ate her cereal/boiled egg. After breakfast, she helped her mom vacuum/sweep. Then Cyndi looked at the clock on the wall to see how much time there was before the party. There was lots of time! Later Cyndi and her dad made jello/muffins in the kitchen, then Cyndi's mom/Cyndi's dad read her a story, and then Cyndi coloured awhile. A little later it was time for Cyndi to get ready for the party. So Cyndi put her costume on and then she crawled on the floor pretending to be Sylvester the cat. Then she got ready to go outside - she put on her coat and boots/shoes. Then Cyndi went to the party where she was so happy because she was eating all kinds of good food and playing lots of nice games.

Appendix D
Postevent Questionnaire

The last time I was here I told you a story about a little girl named Cyndi who was very excited about going to a Halloween party. Remember? Let's go over what happened in the story to make sure you remember it.

In the story Cyndi had a real hard time falling asleep one night. Do you remember what Cyndi was so excited about? ... She was so excited about a Halloween party that she was going to the next day.

What was Cyndi dreaming about when she finally fell asleep? ... She was dreaming about all the fun she would have at the Halloween party.

After Cyndi's dog/cat jumped on her bed and woke her up, where did Cyndi run to? ... She ran to her mom's room to see if her mom had finished making her Halloween costume.

What was Cyndi's costume? ... Was her costume finished? ... Her Sylvester costume was all finished and Cyndi couldn't wait to try it on.

When Cyndi was in her mom's bedroom where she kept her Cookie Monster/Bunny Rabbit on top of her mom's dresser, who came in and said "Good Morning" to Cyndi? ... Her mom did and then her mom asked Cyndi to get ready for breakfast. So Cyndi went and got dressed.

Where was Cyndi going when she walked over a ball/a slinky that was left on the floor? ... She was on her way to the bathroom.

Where was Cyndi when she poured herself some milk/orange juice? ... She was in the kitchen.

Who helped Cyndi look in the cupboard/fridge for something to eat for breakfast? ... Her mom helped her look.

After Cyndi ate her cereal/boiled egg and helped her mom vacuum/sweep, what did she look at on the wall? ... She looked at the clock to see how much time there was before the party.

After Cyndi and her dad made jello/muffins in the kitchen and Cyndi's mom/Cyndi's dad read Cyndi a story, what did Cyndi do after that? ... She coloured for awhile.

Later it was time for Cyndi to get ready for the party so she put her costume on. But before she put on her coat and boots/shoes, what did she crawl on the floor pretending to be? ... She pretended to be Sylvester the cat. Then Cyndi went to the party.

Was Cyndi happy at the party? ... She was really happy because she was eating lots of good food and playing all kinds of nice games.