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TRUE AND FALSE MEMORIES IN CHILDREN AND ADULTS: A Cognitive Neuroscience Perspective

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The authors consider evidence concerning accuracy and distortion in children's recollections within the broader context of recent research on memory that has used the methods and conceptual framework of cognitive neuroscience. They focus on 3 phenomena—source amnesia, confabulation, and false recognition—that have been observed in young children and in adults who have sustained damage to the frontal lobes. Similarities and differences between the memory performance of young children and frontal lobe patients are noted, and evidence concerning frontal lobe maturation and cognitive development is examined. The literature provides suggestive but not conclusive support for the hypothesis that some aspects of memory development and cognitive development are associated with immature frontal functioning. The authors conclude by considering several cognitive and temperamental factors that may be related to suggestibility and memory distortion in young children.

Bruck and Ceci (1993/1995) have provided a useful overview of scientific research concerning accuracy and distortion in children's memory. Their discussion emphasizes that conditions exist in which young children can provide accurate reports about past episodes but also shows convincingly that examiners who use suggestive or leading questions may introduce serious distortion into children's recollections. Indeed, some of the recent research that Bruck and Ceci reviewed has revealed that a significant proportion of preschool children can be induced to create detailed narrative recollections of events that never happened. Many of these children seem firmly convinced that their memories are real and resist attempts to convince them otherwise. The subjectively compelling nature of these false recollections may be one reason why experienced professionals who are shown videotapes of preschoolers recounting their experiences are unable to discriminate reliably between children who are relating accurate memories of actual events and those relating false memories of suggested events (Ceci, in press; Leichtman & Ceci, 1995). As Bruck and Ceci pointed out, much of this recent research has important implications for attempting to understand such cases as the Wee Care Nursery School incident that led to the conviction of Kelly Michaels (*State v. Michaels*, 1993).

The purpose of this article is to consider studies of accuracy and distortion in children's recollections within the broader context of recent research on memory that has used the methods and conceptual framework of cognitive neuroscience.

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Cognitive neuroscience is an interdisciplinary enterprise that seeks to illuminate the relation between the brain and cognition and includes investigations of memory, perception, language, action, problem solving, and so forth (for an introduction to cognitive neuroscience, see Gazzaniga, 1995; Kosslyn & Koenig, 1992). Cognitive neuroscience analyses of memory have taken a variety of approaches, including studies of patients with memory disorders that result from damage to particular brain structures; research with neuroimaging techniques that allow the investigation of brain function in normal, non-brain-damaged individuals, such as positron emission tomography and functional magnetic resonance imaging; studies of memory impairments that are produced by discrete brain lesions in nonhuman primates and other animals; and computational modeling of memory performance using neural networks and related methods. The cognitive neuroscience orientation has proved fruitful in the study of memory and has led to significant advances in understanding the role played by various brain systems and subsystems in different forms of memory (for a recent overview, see Schacter & Tulving, 1994).

In this article we consider cognitive neuroscience research that bears directly on issues of accuracy and distortion in memory. The most pertinent findings derive from studies of brain-damaged patients who exhibit various kinds of memory distortions that we believe have potentially significant implications for understanding false recollections in young children. Specifically, we consider three different yet related phenomena that provide information concerning possible neural bases of false memories: source amnesia, confabulation, and false recognition. We focus on evidence from patients with lesions to specific brain structures—the frontal lobes—and consider the hypothesis that some manifestations of memory distortion in young children are related to immature frontal functions. We conclude by considering other cognitive and affective factors that may be relevant to the understanding of suggestibility and false recollection in young children.

Memory Distortion in Frontal Lobe Patients: Comparisons With Developmental Memory Distortions

The cognitive neuroscience of memory has been profoundly influenced by observations of memory impairments in a neurological condition known as the *amnesic syndrome.* The amnesic syndrome entails a severe and selective impairment in the ability to remember recent events and learn new information. Amnesic patients have great difficulty remembering day-to-day events and exhibit poor performance on laboratory tests of long-term memory, even though intelligence and other cognitive functions are spared. The amnesic syndrome typically results from damage to structures in the medial or inner sectors of the temporal lobes, including the hippocampus, or to related structures in the diencephalon (for reviews, see Parkin & Leng, 1993; Squire, 1992).

During the past decade, increasing attention has been paid to the role of frontal lobe structures in memory. The frontal lobes occupy the anterior regions of the cerebral cortex. They can be divided roughly into posterior motor–premotor areas and a more anterior region known as the prefrontal cortex, which itself can be divided into a number of distinct subregions (e.g., Fuster, 1989; Stuss & Benson, 1986). Patients with damage to the frontal lobes do not ordinarily exhibit the kind of severe amnesic syndrome that is typically observed as a consequence of lesions to medial temporal or diencephalic structures. Patients with frontal lobe damage, however, exhibit a variety of more subtle impairments of episodic memory (for reviews, see Schacter, 1987; Shimamura, 1995; Stuss, Eskes, & Foster, 1994). For example, a number of studies have revealed that patients with frontal lobe damage have difficulty remembering the correct order in which recent events occurred (Butters, Kaszniak, Glisky, Eslinger, & Schacter, 1994; McAndrews & Milner, 1991; Milner, Corsi, & Leonard, 1991; Milner, Petrides, & Smith, 1985; Petrides, 1985). Such patients are also impaired when asked to judge the frequency of occurrence of recent events (Smith & Milner, 1988) and have problems with recall tasks that require the use of effortful retrieval strategies (Jetter, Posner, Freeman, & Markowitsch, 1986; Stuss et al., 1994). Patients with frontal lesions also have difficulty judging or monitoring how well they will be able to remember specific items and facts (Janowsky, Shimamura, & Squire, 1989).

These observations have been complemented by recent studies that have used functional neuroimaging techniques, such as positron emission tomography, to examine memory functions in the intact human brain. A number of experiments have shown that regions within the prefrontal cortex are consistently activated during encoding or retrieval of information acquired during a specific recent episode (e.g., Schacter, Reiman, et al., 1995; Shallice et al., 1994; Squire et al., 1992; Tulving, Kapur, Craik, Moscovitch, & Houle, 1994). One consistent pattern that has emerged is that left frontal regions are especially active during encoding of new information into episodic memory, whereas right frontal regions are particularly active during episodic retrieval (see Tulving et al., 1994). Thus, it seems clear that frontal regions play a role in episodic memory for incidents and events in one's personal past (e.g., Tulving, 1983).

Most important with respect to the present concerns, several studies have provided evidence that patients with frontal damage exhibit memory distortions that resemble some of the phenomena that have been observed in studies of young children, as summarized by Bruck and Ceci (1993/1995). We consider three different yet related phenomena: source amnesia, confabulation, and false recognition (see also Schacter & Curran, in press).

Source Amnesia

Source amnesia occurs when people recall a fact or occurrence from the past but fail to remember the source of their knowledge—who told them the fact, whether an event actually occurred or was merely imagined, and so forth. Schacter, Harbluk, and McLachlan (1984) demonstrated source amnesia in experiments with patients with amnesic syndromes that were caused by various kinds of brain lesions. Schacter et al. observed that these amnesic patients could sometimes learn new "fictitious facts" that were imparted to them by one of two experimenters (e.g., "Bob Hope's father was a fireman"). However, when the patients managed to recall one of these newly learned "facts" correctly, they were rarely able to remember the correct source. Indeed, they frequently failed to recollect that either experimenter had told them a fact and instead claimed that they were guessing or that they had acquired the fact from an extraexperimental source, such as television or radio.

A number of neuropsychological studies have provided evidence that susceptibility to source amnesia is associated with damage to the prefrontal cortex. Schacter et al. (1984) examined the relationship between source amnesia and neuropsychological tests that are known to be sensitive to frontal lobe dysfunction. They found that amnesic patients who performed poorly on frontal-sensitive tests exhibited more source amnesia than did patients who performed well on frontal-sensitive tests. By contrast, degree of source amnesia did not correlate significantly with IQ, suggesting that the observed correlation with frontal-sensitive tests was not simply a reflection of the general severity of a patient's cognitive deficit. Shimamura and Squire (1987) conducted similar studies in amnesic patients, and they too reported correlational evidence linking damage to the prefrontal cortex with susceptibility to source amnesia. More directly, Janowsky et al. (1989) demonstrated that patients with lesions restricted to the prefrontal cortex, who are not globally amnesic, nevertheless exhibit extremely high levels of source amnesia.

In addition to this neuropsychological evidence, studies of normal elderly populations also support a link between impaired source memory and frontal lobe dysfunction. Craik, Morris, Morris, and Loewen (1990) reported that normal elderly adults exhibit significant amounts of source amnesia in the Schacter et al. (1984) fictitious facts paradigm. More important, they reported a significant correlation between susceptibility to source amnesia and performance on frontal-sensitive tests. Schacter, Kaszniak, Kihlstrom, and Valdiserri (1991) likewise reported that impairments of source memory in elderly adults are correlated significantly with performance on some tests that are sensitive to frontal lobe dysfunction. More recently, Glisky, Polster, and Routhieaux (1995) examined both item memory and source memory in elderly adults who were classified as "high frontal" or "low frontal" according to their performance on neuropsychological tests. Source memory was impaired in low-frontal compared with high-frontal elderly adults, whereas there was no corresponding impairment in item memory.

In summary, much converging evidence supports the idea that prefrontal regions are specifically associated with deficits in source memory. This observation is especially germane to the present concerns because research with normal adults has revealed that when people fail to recollect the source of their knowledge, they are subject to various kinds of memory illusions and distortions, such as confusing real and imagined events (M. K. Johnson, 1991; M. K. Johnson & Raye, 1981), making incorrect attributions about why something seems familiar (Jacoby, Kelly, Brown, & Jasechko, 1989), or failing to remember whether something actually happened or was only suggested (Lindsay, 1990; for review, see M. K. Johnson, Hashtroudi, & Lindsay, 1993; Schacter, in press). Moreover, as Bruck and Ceci (1993/1995) pointed out, young children appear to be quite susceptible to source amnesia.

As noted by Bruck and Ceci (1993/1995), important evidence concerning children's source monitoring abilities was provided by Foley and Johnson (1985). Their studies underscore the contextual sensitivity of developmental trends in source monitoring, illustrating that the retention of source information is affected by the nature of the source. For example, both 6- and 9-year-old children performed at the same level as adults when required to distinguish between an action that they themselves had performed and a similar action performed by another person. By contrast, a steep developmental trend was evident when the children were required to distinguish between a task that they themselves had actually performed and another that they had only imagined performing. Even with a delay interval as brief as only several minutes between the acquisition of information and its retrieval, both 6- and 9-year-olds exhibited a striking inability to gain access to the origin of their knowledge in this condition. These findings establish that conditions exist in which source memory is substantially impaired even in children who are older than the preschoolers that are the focus of Bruck and Ceci's commentary.

In addition to studies of source attribution errors that are mentioned by Bruck and Ceci (1993/1995), we note two other relevant reports concerning younger children. Gopnik and Graf (1988) examined source memory in preschool children. In their experiments, 3- to 5-year-olds obtained information about the contents of a set of drawers in three different ways: visually, by verbal instruction, or by inference. The children were queried about the source of this information with multiple-choice questions immediately following the exposure phase; they were similarly queried after a brief delay. A marked developmental progression favoring older children was obtained. When tested immediately after learning, two thirds of the 3-year-olds were unable to remember accurately how they acquired information about the contents of the drawers, whereas most 5-year-olds were able to do so. Moreover, the few younger children who performed well on the immediate source identification task demonstrated a clear inability to retain and retrieve source information several minutes later, in contrast to the more successful 5-year-olds. These results, then, indicate that very young children have difficulties encoding or retrieving the source of acquired information even when tested immediately and also forget source information faster than do older children.

Recent work by Taylor, Esbensen, and Bennett (in press) provides additional insight into the source memory deficits of preschoolers. In a series of four studies, Taylor et al. explored the question of how sensitive young children are to the way in which they acquire new knowledge. In those experiments, 4- and 5-year-olds were exposed to novel and familiar facts and were questioned a short time later to determine whether they recognized that they had acquired the novel facts in the experimental setting. The central finding is that across various types of information, preschool children tended to report that, and behave as though, they had known the novel facts for a long time—even though they had actually acquired them only minutes earlier. This phenomenon was particularly exaggerated in the 4-year-olds, who appeared to have virtually no awareness of the source of their knowledge. Whereas performance varied to some extent on the basis of task parameters such as the domain of information and the salience of the learning task, the overall message of Taylor et al.'s experiments is straightforward: Young children are disproportionately likely to fail at tasks that require them to identify the source of their current knowledge.

There is no direct evidence, of course, that supports the hypothesis that the source memory difficulties exhibited by preschoolers in the foregoing studies, or others cited by Bruck and Ceci (1993/1995), are specifically attributable to immature frontal lobe functioning. However, in view of the seemingly pervasive finding of source memory deficits in young children and the converging evidence from studies that link failures of source memory with frontal lobe dysfunction in adults, the hypothesis seems well worth pursuing.

Confabulation

Confabulation is a symptom that occurs in a variety of neurological and psychiatric syndromes. The major feature of confabulation is an inaccurate and sometimes bizarre narrative account of a present or past event. It is important to note that the term *confabulation* is sometimes applied rather broadly to almost any kind of false memory or memory distortion, including relatively benign memory errors such as intruding an incorrect word on a free-recall test (e.g., Roediger, Wheeler, & Rajaram, 1993). Following Kopelman (1987), we think that it is important to distinguish between the inaccurate stories or narratives that are produced by clinical populations on the one hand, and the more benign intrusion errors that even normal individuals exhibit on the other. We use the term *confabulation* solely in reference to the former phenomenon.

Moscovitch (1989, in press) characterized confabulation as "honest lying," in the sense that patients believe what they are saying even though it is demonstrably false. In cases of brain damage, confabulation is often observed in connection with lesions to ventromedial aspects (the lower and inner parts) of the frontal lobes (for reviews, see M. K. Johnson, 1991; Moscovitch, in press). However, although most investigators agree that frontal lobe damage is strongly associated with confabulation, there is also reason to believe that damage to the frontal lobes alone may not be sufficient to produce confabulation (e.g., Dalla Barba, 1993). DeLuca (1993), for example, has suggested that additional damage in the structures that comprise the nearby basal forebrain may be necessary for extensive confabulation to occur.

Confabulation is observed most readily when patients are asked about personal experiences (episodic memory); it is observed relatively rarely when patients are asked about general knowledge (semantic memory; cf. Dalla Barba, 1993; Moscovitch, in press). Many studies of confabulation in neurologically impaired patients have revealed a distinction between two different manifestations of the phenomenon: a memory distortion in which actual events from the past are confused in time, and a fantastic or bizarre fabrication that contains implausible contents and is based on figments of imagination (M. K. Johnson, 1991). However, Moscovitch (in press) has argued that source amnesia is implicated in both kinds of confabulation. When confabulations are built on actual events, patients confuse when and where they occurred. In cases of bizarre confabulations, patients may incorporate fragments of dreams, fantasies, or even features of the current environment into their narratives. Yet they do not recognize the source of these mental contents and attribute them to actual events that never occurred.

Although source amnesia clearly plays an important role in confabulation, it is probably not the entire story, because patients often believe their confabulations even when they are logically implausible. Moscovitch (in press) has reported on a patient who claimed to have been married only 4 months—yet he acknowledged that he had four children, and he remembered their names and ages relatively accurately (in fact, the patient had been married for more than 30 years). Clearly, something more than simple source amnesia must be operating for the patient to maintain such a logically inconsistent belief. Similar considerations apply to the rare phenomenon of *reduplicative paramnesia,* sometimes referred to as *Capgras syndrome,* which has been observed in some patients with frontal lobe pathology. Such patients believe that a familiar person or place has been "duplicated" (for a review, see Stuss, 1991). For example, Stuss (1991) describes a patient with frontal lobe damage who insisted that his entire family had been replaced with a group of highly similar substitutes. His strong subjective confidence in his beliefs and memories was not undermined by his awareness of their logical implausibility. The foregoing considerations indicate that high-level cognitive processes that normally monitor and evaluate mental contents are disturbed in some patients who offer bizarre or fantastic confabulations.

Theoretical understanding of confabulation and of the role that prefrontal regions play in the genesis of the phenomenon is rather modest. Nevertheless, a few hypotheses concerning the nature of confabulatory deficits have been offered. For example, Moscovitch (in press) suggests that confabulation arises when automatic retrieval processes are intact, so that memories frequently spring to mind. At the same time, strategic search and monitoring processes are impaired, so that source, plausibility, and other aspects of the memories are not evaluated properly (see also Dalla Barba, 1993; M. K. Johnson, 1991; Mercer, Wapner, Gardner, & Benson, 1977).

As Bruck and Ceci (1993/1995) pointed out, a number of studies have shown that some young children can be induced to produce extensive false narratives when cued by external factors such as leading and suggestive questions, strong stereotypes, or repeated visualizations of nonexistent events. In several qualitative ways, the elaborate false narratives provided by children in the handful of studies documenting this effect bear a strong resemblance to those of confabulating adults. For example, many preschool children in both the mousetrap study cited by Bruck and Ceci and a similar subsequent experiment (Ceci, Crouteau Huffman, Smith, & Loftus, 1994; Ceci, Loftus, Leichtman, & Bruck, 1994) created false narratives in response to an experimental context that encouraged repeated visualizations over many weeks. A striking aspect of the elaborated narratives reported in the final sessions of these experiments is their automatic quality; as in the description of Moscovitch's patients, the narratives seem to spring to mind rapidly and effortlessly in response to both open-ended and probing questions. As in adult confabulations, children's false narratives contain a considerable amount of detail, which at least on some occasions appear to be embraced with strong conviction by the child. For example, when the interviewer misunderstood the child's answer concerning a point embedded in a false narrative, it was typical for the child to correct spontaneously the interviewer's interpretation of her comments. Often, as in the narratives of confabulating adult patients, children's reports had a strong autobiographical quality. At appropriate moments, for instance, verbatim "conversations" from various persons implicated in the children's stories would sometimes be provided. Moreover, children often insisted on the accuracy of their stories, even in the face of potentially disconfirming evidence (e.g., "some of these things really didn't happen," "didn't your mom and dad tell you that this never happened?"). To the extent that the evidence provided was discrepant with the child's account (e.g., "but your mother was there, and she didn't see that") yet caused only a mild revision of it ("but Mommy left by then"), these findings bring to mind the responses of confabulating patients who are faced with the logical implausibility of the facts in their narratives.

Despite these surface similarities, it is essential to underscore the critical difference between the contexts in which false narratives are produced by patients with frontal lobe damage and those in which false narratives are produced by children. Research on the general development of autobiographical memory (e.g., Fivush, 1994; Fivush, Gray, & Fromhoff, 1987; Pillemer, Picariello, & Pruett, 1994) and on children's suggestibility (e.g., Leichtman & Ceci, 1995; Ceci & Bruck, 1993; Poole & Lindsay, in press; Poole & White, 1991, 1993; Saywitz & Moan-Hardie, 1994) clearly indicates that in the absence of factors that specifically bias children toward report distortion, elaborated false narratives like the ones described here are unlikely to be produced. Children provide such reports when the demand characteristics of the situation have been constructed to elicit them and are most likely to be observed after repeated, heavy-handed exposure to misleading questions, elaborated stereotypes or expectations, or visualizations of false events. In contrast, patients with frontal lobe damage appear to confabulate independently of these factors. Whereas it requires a good deal of effort and exposure to a suggestive environment to elicit extended false narratives in children, patients with frontal lobe damage will confabulate even when no particular effort has been made to construct a suggestive environment that elicits a confabulation.

False Recognition

In a typical laboratory experiment, recognition memory is assessed by using some variant of a procedure in which experimental participants first study a series of words, objects, or other materials. After a delay interval, subjects are exposed again to the target materials along with new distractor or lure items, and they are asked to indicate which items had appeared earlier on the study list. During the past few years, several patients have been described who exhibit a marked tendency toward false recognition—that is, they frequently claim that distractor or lure items, which they had not encountered previously, appeared on the study list. In view of the material covered in previous sections, it is perhaps not surprising that all of these patients are characterized by frontal lobe pathology.

One such patient, R. W., was described by Delbeq-Derouesné, Beauvois, and Shallice (1990). R. W. underwent an operation to repair a ruptured anterior communicating artery aneurysm, a condition that is known to produce memory disorders. A CT scan revealed bilateral damage in the medial aspects of the frontal lobes and in several other posterior cortical regions. R. W. consistently made an abnormally large number of false recognitions and expressed a great deal of confidence in them. J. B., another patient who developed memory problems as a consequence of a ruptured aneurysm and associated frontal lobe damage, also made a large number of false recognitions that were accompanied by high confidence. J. B. often said that he was "sure" that he had been exposed to target materials when in fact he had not (Parkin, Bindschaedler, Harsent, & Metzler, 1994).

Schacter, Curran, Galluccio, Milberg, and Bates (in press; see also Schacter & Curran, in press) described a similar patient, B. G., who had sustained a stroke that produced extensive damage to his right prefrontal cortex. Across a variety of experimental paradigms, B. G. made many more false alarms to nonstudied words, nonsense syllables, sounds, and pictures than did matched control participants—even though his response to studied words (his "hit rate") was entirely normal. In each of these experiments, when B. G. said that a test item was "old" (i.e., had appeared on the study list), he also was asked to indicate whether (a) he possessed a specific recollection of encountering the word previously, such as an image or association that he made when he studied the word (a "remember" response), or (b) he just "knew" that the item appeared on the list, even though he did not have a specific recollection of having encountered it (a "know" response). This remember–know procedure was devised by Tulving (1985) as a way of probing the nature of a person's recollective experience and has generated a large experimental literature showing that "remember" and "know" responses differ qualitatively from one another and most probably are based on different underlying processes (see Gardiner & Java, 1993, for a review of relevant research). B. G.'s false-alarm responses to nonstudied items were frequently accompanied by "remember" responses, whereas matched control participants hardly ever made "remember" false alarms.

Schacter et al. (in press) were able to stop B. G. from making large numbers of false alarms by using lure items that came from different categories than did the items in the study list. For example, after seeing a series of pictures of inanimate objects that included items of furniture and clothing, B. G. made virtually no false alarms to pictures of animals (whereas he made many false alarms to nonstudied pictures drawn from the categories of furniture and clothing; see Parkin et al., 1994, for a similar result with patient J. B.). Schacter et al. suggested that B. G.'s pathological false-alarms responses are attributable to defective search processes: He tended to say that a test item appeared on the list as long as it resembled the class or category of item that had appeared on the study list; he did not carry out the more extensive search processes necessary to determine whether the *specific* test item had indeed appeared on the list. These observations suggest that right frontal regions play a role in search processes that are defective in Patient B. G. As noted earlier, recent positron emission tomography studies have revealed that right frontal regions are consistently more activated during episodic retrieval of recently studied items than during encoding or study of those items (Tulving et al., 1994). It is possible that the activation of right frontal regions during episodic retrieval in normal individuals reflects the search processes that Schacter et al. hypothesized are defective in Patient B. G. and that underlie his false recognition responses.

False recognition responses have also been observed in numerous studies with young children. Traditionally, the false recognition phenomenon was predicted to increase with age, along with the propensity to draw constructive inferences at the time of encoding that might create distortion in memory by transforming mental representations of the target test items (Piaget & Inhelder, 1973). However, as Reyna and Kiernan (1994) pointed out in a recent review, actual experimental evidence is equivocal, with only a few studies showing the predicted increase in false recognition responses with age (e.g., J. W. Johnson & Scholnick, 1979). Instead, a number of studies indicate either no correlation between developmental level and the tendency toward misrecognition of a distractor item or different developmental patterns in different experimental conditions (e.g., Paris & Carter, 1973; Paris & Mahoney, 1974).

Most pertinent to our present discussion is that several recent studies conducted from the perspective of fuzzy-trace theory (Brainerd & Kingma, 1984) suggest that under some conditions, younger children might actually demonstrate higher rates of false recognition than older children and adults (Brainerd, Reyna, & Kneer, in press). Indeed, in a word recognition paradigm with 5- and 8-year-old children, this was shown to be true in conditions in which "verbatim" memory for particular types of words was required (Brainerd et al., in press). Similarly, in a study involving sentence recognition, younger children were more likely than older children to falsely recognize sentences that required the separation of gist, or inference, and verbatim aspects of the memory trace (Reyna & Kiernan, 1994). Adding to the developmental picture of this phenomenon, Brainerd, Reyna, and Brandes (1994) have further shown that under some conditions, young children may demonstrate a greater tendency to maintain their false recognition responses over time than older ones. In summary, although a variety of developmental patterns have been observed in false recognition paradigms, recent studies indicate that conditions exist in which young children, like patients with frontal lobe damage, are especially susceptible to false recognition. Whether and to what extent the resemblances are more than superficial remains to be determined.

Frontal Lobes and Memory Development: What Kind of Relation?

The material considered in the preceding section indicates that three kinds of memory distortions observed in patients with frontal lobe damage—source amnesia, confabulation, and false recognition—have also been observed in young children. We would not wish to claim that the false memory phenomena exhibited by patients with frontal lobe damage and young children are similar in all respects, and we have already noted some of their differences. Nevertheless, the resemblances between the kinds of distortions observed in these patients and young children are suggestive enough to address a related question: To what extent, if any, could the false memory phenomena reviewed by Bruck and Ceci (1993/1995) reflect incomplete or immature development of the frontal lobes in young children? Stated slightly differently, is there empirical evidence that some of the cognitive and memory abilities of young children are comparable with the cognitive and memory abilities of adult patients with frontal lobe damage?

The development of frontal lobe functions has received increasing attention in research concerning both humans and animals (e.g., Case, 1992; Diamond & Doar, 1989; Goldman-Rakic, 1987; Stuss, 1992). As Smith, Kates, and Vriezen (1992) pointed out in an excellent review, various indexes of anatomical development support the claim that the frontal lobes mature more slowly than do many other brain regions and by some measures do not attain adult levels until the adolescent years or beyond. For example, the density of neurons in frontal cortex does not reach adult levels until age 7 (Huttenlocher, 1990), and the frontal lobes begin myelinization quite late, with the process continuing into adulthood (Yakovlev & LeCours, 1967). It has been suggested that changes in interconnections between cortical regions can be measured indirectly by examining the coherence or synchrony of electroencephalographic (EEG) activity in different cortical areas (e.g., Thatcher, 1992). Measurement of EEG coherence over frontal regions reveals that changes extend into adulthood (Epstein, 1986; Thatcher, Walker, & Giudice, 1987). There is also some evidence that specific regions within the frontal lobes develop according to their own timetables. For example, Thatcher (1992, p. 39) has noted that his EEG coherence data suggest that "a uniquely localized right frontal growth spurt was present around the age of 4.5 to 5.0 years" and has also pointed toward a developmental distinction between the lateral and medial regions of the frontal lobe.

Although the data concerning anatomical development of the human frontal lobes are still relatively sparse, available evidence suggests that frontal regions are not fully developed in the preschool children who are the focus of Bruck and Ceci's (1993/1995) discussion. However, the relevance of this observation to the children's cognitive and memory performance is not known. Somewhat more direct evidence has been provided by behavioral studies in which young children perform cognitive and memory tasks on which patients with certain kinds of frontal lobe damage are known to exhibit impairments. For example, several studies have provided evidence that children's performance on a categorization task that is a sensitive indicator of adult frontal lobe damage, the Wisconsin Card Sorting Test, does not reach adult levels until about 10 years of age (e.g., Chelune & Baer, 1986; Chelune & Thompson, 1987; Levin et al., 1991; Welsh, Pennington, & Grossier, 1991). Other studies have provided evidence of similar—or even later—attainment of adult levels of proficiency on tests of attention, motor sequencing, and planning that are sensitive to frontal lobe lesions in adult populations (for a review, see Smith et al., 1992). However, as Smith et al. pointed out, questions can be raised about whether it is appropriate to use the attainment of adult performance levels on standardized neuropsychological tests as an indication of frontal lobe development. Adult tests may not be developmentally appropriate for young children, and the failure of young children on such tests may not specifically reflect frontal lobe immaturity. Instead, such failures may simply indicate that the tasks are generally too difficult for young children to perform adequately, for any number of reasons.

Within the domain of memory, one of the most consistently observed deficits in adult patients with frontal lobe damage concerns their difficulty remembering temporal order, such as judging which of two previously presented stimuli appeared more recently or recalling the correct order of an arbitrarily ordered sequence of items (for a review, see Milner et al., 1985). Although children can exhibit memory for a familiar or overlearned sequence of events at a quite early age (e.g., Bauer & Mandler, 1990; Nelson, Fivush, Hudson, & Lucariello, 1983), a number of studies suggest that the ability to remember the absolute or relative temporal order of arbitrarily ordered stimuli—the kind of ability that is impaired in adult patients with frontal lobe damage—shows strong developmental trends, particularly between the ages of 5 and 8 (e.g., Fivush & Mandler, 1985; Mathews & Fozard, 1970; Von Wright, 1973).

In an attempt to maximize task comparability between young children and adult patients with frontal lobe damage, Kates and Moscovitch (1994) administered several different temporal memory tasks used previously with patients to 5-, 7-, 9-, and 11-year-old children. Five-year-old children exhibited deficits on all of these tasks. Performance on a task that required relative judgments of temporal order—a recency judgment task in which individuals indicated which of two previously presented pictures occurred more recently—attained adult levels in children between ages 5 and 7; memory for absolute temporal order, as assessed by a task in which individuals had to memorize the order of recently presented pictures, attained adult levels between 7 and 9 years; and performance on a self-ordered pointing task that requires strategic organization of temporal processing (Petrides & Milner, 1982) attained adult levels between the ages of 9 and 11 years. To the extent that these tasks specifically tap frontal lobe functioning in children, Kates and Moscovitch's data suggest that different aspects of the frontal lobes become fully functional at different stages in development. However, it must be emphasized that there is no direct evidence from these experiments that the poor performance of younger children is specifically attributable to frontal lobe dysfunction. As with the non-memory studies cited earlier, the validity of this inference is based on the assumption that young children fail the tests for the same reasons that adult patients with frontal lobe damage do. Although this assumption may turn out to be valid, it must be treated cautiously pending more direct evidence that temporal memory deficits in young children reflect immature or inadequate functioning in frontal regions.

Putting together the evidence considered in this section with the data concerning memory distortion reviewed in the previous section, it seems clear that there are grounds for taking seriously the hypothesis that some of the false memory phenomena reviewed by Bruck and Ceci (1993/1995) are attributable, at least in part, to incomplete or immature frontal lobe functioning in preschool children. Young children, like patients with frontal lobe damage, can be quite susceptible to source amnesia and false recognition and can occasionally exhibit confabulatory narratives. They also perform poorly on tasks that require memory for temporal order and have difficulties with a number of standardized neuropsychological tests of cognitive performance. At the same time, however, it would be a gross and unwarranted oversimplification to argue for any direct equation between the cognitive–memory performance of an adult patient with frontal lobe damage and the cognitive–memory performance of a preschool child (Smith et al., 1992). There are many other differences in knowledge, ability, and experience between an adult patient with frontal lobe damage and a non-brain-damaged young child—differences that render suspect any attempt to offer one population as a simple model for the other. Moreover, as we stressed earlier, the notion that immature frontal functioning is specifically responsible for performance deficits in children on tasks that are sensitive to frontal lobe damage in adults is based on indirect inferences; we pointed out that the basis of those inferences can be questioned. Thus, we would suggest that evidence relevant to the hypothesis that false memories in young children are partly attributable to immature frontal functioning is best characterized as suggestive—but not conclusive. The evidence is, however, suggestive enough to merit more direct tests of this hypothesis with modern functional neuroimaging techniques that permit direct examination of the contributions of specific brain regions to particular cognitive and memory tasks.

Summary and Additional Considerations

Whatever the ultimate fate of the hypothesis that some false memory phenomena in young children are attributable, at least in part, to immature or incomplete frontal lobe development, it seems clear that a variety of cognitive and affective factors are likely to be relevant to the complex real-world environments in which the accuracy of young children's recollections play a crucial role, as exemplified by the Kelly Michaels case that motivated Bruck and Ceci's (1993/1995) article. We close by commenting briefly on a few such factors that are especially relevant to preschool children and that may merit attention in future research.

One of the important cognitive advances that is inherent in the Piagetian stage of concrete operations (Piaget & Inhelder, 1973) is the ability to relate two events and to appreciate the complementary relation between an event and the context in which it occurs. The ability to solve conservation or class inclusion problems, which define concrete operations, require this ability (Kagan, 1984). The preschool child fails the conservation of mass problem because he or she does not relate an earlier event, in which two balls of clay were equal in mass, with the present event, in which one is elongated and the other is not. In the class inclusion problem, the child does not relate a part and a whole. For example, the examiner places on a table four red balls and two white balls and says, "I have four red balls and two white balls. Do I have more red balls or more balls?" The 4-year-old child says "More red balls." The 7-year-old child, who is able to relate the part (four red balls) to the whole (all six balls) responds correctly, "More balls."

Perhaps these general cognitive limitations contribute to the preschool child's susceptibility to source amnesia and false memory. The young child has difficulty separating what was actually experienced in the past—the background event—from the thoughts and ideas that are generated by the suggestions of others. Future research on source amnesia and false memory in young children could usefully examine the relation between these phenomena and other aspects of cognitive development (cf. Reyna & Kiernan, 1994).

A second cognitive quality that separates the preschool from the school-age child is the excessive impulsivity of the former. The 3- to 4-year-old child is typically impulsive in situations in which he or she has to match a standard with a set of similar variants (Kagan, 1984). An impulsive approach and the absence of reflection over the quality or validity of a reply tempt the child to agree with a suggestive statement or question. The preschool child typically lacks a standard that dictates a concern with accuracy. As a result, the child is not motivated to implement a reflective style in the service of evaluating the validity of a response. Research that examines the relation between impulsivity and false memory would be desirable.

Finally, temperamental factors may contribute to young children's memory performance and susceptibility to suggestion. Of the many temperamental factors that have been discovered, two of the most extensively investigated are known as inhibited and uninhibited to the unfamiliar (Kagan, 1994). The inhibited child, who is an irritable and easily aroused infant (called high reactive), typically becomes a shy, subdued toddler who is made excessively anxious by disapproval or punishment from adult authority figures. Because of a vulnerability to this particular form of fear, the inhibited 4-year-old is reluctant to oppose the request of authority and will even act in ways that he or she knows to be wrong because of the uncertainty generated by opposing an adult request. For example, Jerome Kagan has seen in the laboratory a group of 110 children aged 4.5 years who were selected from a larger sample because they were either high or low reactive. Thirty-seven of the children were classified as high reactive at 4 months, and many were shy, subdued, and fearful in the second year. The remaining children were low reactive at 4 months and relatively bold, sociable, and fearless by the second year.

In one of the tasks, the examiner asks each child to implement each of 12 acts. Six of the acts are not prohibited by most parents (e.g., make some marks on a blank piece of paper, pour water from one cup to another). However, 6 of the acts are usually subject to mild punishment by middle-class parents (e.g., throw a ball at the examiner's face, pour cranberry juice onto the table, hit the examiner's head, or tear up a color photograph of the examiner). Compared with the low-reactive–uninhibited children, the high-reactive–inhibited children are generally more obedient, less likely to refuse the requests, and less likely to ask why an act should be carried out. A nice demonstration of this conclusion is seen in behavior to the item in which the examiner shows the child a color photograph of herself, gives it to the child, and then says, "Tear up my favorite photograph." Every inhibited child meekly tore a part of the photograph. More of the uninhibited children delayed and asked why they should perform the act. Three of them flatly refused the request, placed the photograph back into the book, and added that they would not carry out the act. This anxiety-free resistance to an adult request is extremely rare in inhibited children.

In view of these observations, it seems appropriate to speculate that an inhibited child who is interrogated by an adult about a past event will be more likely to respond to suggestion than an uninhibited child. Only a subset of preschool children appear to be susceptible to the suggestion-induced false narratives that have been observed in the laboratory (cf. Ceci, in press; Goodman, Quas, Batterman-Faunce, Riddlesberger, & Kuhn, 1994; Pezdek & Roe, 1994) and that appear to play an important role in the Kelly Michaels case. Little is known about psychological distinctions between children who are more or less likely to incorporate suggestive influences into a confabulatory narrative, and temperamental variations might provide one source of insight concerning individual differences in the development of true and false memories.

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