often very low unless the sample size runs into thousands. This makes it all the more important to estimate the sampling variability of the estimates of the parameters on which the interpretation depends. Traditionally this has been done by finding asymptotic standard errors but these can be very imprecise. However, it is now possible to supplement these results by resampling methods such as the bootstrap.

There are other fields in which latent variable models are used which currently exist in isolation. An obvious generalization is to latent time series. Some work has been done for the case where the latent process is a Markov chain. In this area the term 'hidden' is used instead of 'latent' which helps to conceal the family connections (see *Neural Networks and Related Statistical Latent Variable Models*) (for an introduction see MacDonald and Zucchini 1997). An application in a more traditional time series context will be found in Harvey and Chung (2000). Also, there is work by economists on unobserved heterogeneity as it is called which, essentially, involves the introduction of latent variables into econometric models.

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D. J. Bartholomew

False Memories, Psychology of

A false memory is a mental experience that is mistakenly taken to be a veridical representation of an event from one's personal past. Memories can be false in relatively minor ways (e.g., believing one last saw the keys in the kitchen when they were in the living room) and in major ways that have profound implications for oneself and others (e.g., mistakenly believing one is the originator of an idea or that one was sexually abused as a child). False memories arise from the same processes as do true memories and hence their study reveals basic mechanisms of memory. This article describes empirical research investigating false memories and a theoretical approach—the source monitoring framework—for integrating the findings and guiding further investigation.

1. Selected Early Research

Psychologists have long been interested in memory distortions. A classic example from the 1930s is Bartlett's report of studies in which he told people a folk tale from an unfamiliar culture and asked them to recall it from memory. He noted that the memory errors people made brought the story more in line with their own culturally determined expectations. Another is Carmichael, Hogan, and Walter's demonstration that how forms are labeled influences how they are remembered. For example, people's reproductions from memory of two circles connected by a straight line were more likely to include a curved line if the form had been labeled as 'eyeglasses' than if it had been labeled as 'dumbbell.' Still another is work in the late 1950s and early 1960s by Deese (1959) and by Underwood (1965) demonstrating that people are very likely to falsely remember an item (e.g., needle) if they had earlier been presented with related items (e.g., thread, haystack, sharp).

In the 1970s, studies from a number of laboratories highlighted the fact that such memory distortions do not only occur for unfamiliar materials such as folk tales, or lists of words or pictures—they are a byproduct of our everyday understanding of, and memory for, information and events. For example, Bransford and Johnson's (1973) work on comprehension and memory demonstrated that recalling information often depends on engaging constructive processes by which information is related to prior knowledge or schemas at encoding. For example, memory for a sentence such as 'the haystack was

important because the cloth ripped' was much better when the idea of a parachute had been recently activated than when it had not. However, this work also showed that people are more likely to falsely claim that stories included information that was only inferred based on prior schemas or knowledge. People who heard a story that included the information that 'the spy threw the secret document into the fireplace just in time because 30 seconds longer would have been too late' were later likely to claim that 'the spy burned the document.' Thus distorted 'remembering' of information that might be, but is not necessarily, true (e.g., the spy could have been hiding the document in a fireplace that was not lit) is the potential downside of the intelligent, active processing of information.

Such findings led Johnson and Raye (1981) to suggest that memory distortions like those described above reflect errors arising from imperfect reality monitoring processes that are an integral part of remembering: that is, people sometimes confuse the information they generate during the initial encoding, the retention interval, or subsequent remembering of an event for information that came from the event. Reality monitoring is a special case of the more general ongoing function of source monitoring—making attributions about the origin of activated information in mental experience (Johnson et al. 1993). Thus, source monitoring errors include both confusions between internal and external sources and between various external sources (e.g., attributing something that was imagined to actual perception, an intention to an action, something read in a tabloid to a television program, an incident that occurred in place A or time A to place B or time B).

Of course, how serious any of these memory distortions are depends on what is at stake. A clear case where it matters is eyewitness testimony. In the 1970s, E. Loftus launched an influential research program investigating the impact on event memory of information that is suggested between the time of a witnessed event and the time people are required to 'testify.' In one study, people saw a film of an automobile accident and were asked some questions, including 'About how fast were the cars going when they smashed into each other?' Other people were asked the same question except that the words 'smashed into' were replaced with the word 'hit.' On a memory test a week later, the people in the first group were more likely to mistakenly say 'yes' to a question about whether they had seen broken glass in the film. To take another example from the Loftus laboratory, after seeing a film, participants were asked 'How fast was the white sports car going when it passed the barn while traveling along the country road?' Other participants were asked the same question without mention of the barn. In fact, there had been no barn in the film, but those people who had the barn mentioned in the question were later more likely to say that they had seen a barn in the film. Both of these examples likely involve source monitoring errors—the former a confusion between a self-generated inference based on the supplied information that the cars 'smashed into' each other and the latter a confusion between what was read and what was seen.

In sum, generation, elaboration, and integration of information across individual experiences from different sources reflects associative, imaginative, and reasoning processes that are necessary for all higher-order, complex thought. But, this very capacity for creativity makes us vulnerable to having false memories.

2. Source Monitoring

Perhaps the most comprehensive theoretical account of false memories to date is provided by the source monitoring framework (SMF) proposed by the present author and her colleagues. According to the SMF, it is not the case that memories are found (or not found), but rather that mental experiences are attributed to memory (or not) by ongoing judgment processes. The SMF further highlights several key aspects of these memory attributions:

(a) Memory attributions are based on various qualitative characteristics of the mental experience. For example, perceptual, spatial, temporal, or emotional details typically are taken as evidence that a mental experience reflects a true memory.

(b) Memory attributions are influenced by the embeddedness of the mental experience. Embeddedness depends on such factors as the availability of supporting memories, consistency with knowledge and beliefs (e.g., plausibility), and coherence of the information, and agreement with the reports of others about the event.

(c) Memory attributions are made according to flexible criteria (which qualities are considered and how they are weighted, how much evidence of any given type is needed). Hence, what may be taken for a memory under one set of circumstances might not be under another.

(d) Goals, beliefs, and motivational and social factors influence what characteristics are looked for, how much embedding occurs, and which criteria are applied.

According to the SMF, false memories occur because the mental experiences arising from events of different sorts (e.g., imagination and perception) overlap in characteristics (they are imperfectly differentiated) and because the processes that make judgments about these mental experiences are also imperfect (i.e., they not only operate on imperfectly differentiated data, they are not always fully engaged, they sometimes overweight nondiagnostic evidence or employ inappropriate criteria, they are subject to social influences, etc.). As do most theoretical accounts of false memories, the SMF assumes that the as-

sociative, constructive, elaborative, and integrative processes that are central to human perception and thought contribute information that may become a candidate for misattribution. However, the SMF has emphasized that these processes alone do not produce false memories. Rather, false memories arise when the products of these processes are taken *to be* memories. That is, it is not the fact that associations and other elaborations occur that produces false memories—for example one can make an inference and later attribute it to an inference, or imagine an event and later correctly attribute it to imagination. Survival would be difficult, if not impossible, if there were no differences between the memory records of things that happened and things we imagined, or between activities we observed or participated in and activities we only read or heard about. Fortunately, the imperfect system people have is usually good enough, and perhaps even has some advantages over a perfect system (e.g., life satisfaction may be higher when we remember things as better than they were, social relations may be better when we agree on a common account of events, or generalization between similar situations may be faster when we are not concerned about where inferences come from).

Some theorists (e.g., Gardiner, Jacoby, and Kelley) have proposed that there are two distinct types of memory experience, 'Knowing and Remembering,' or 'Familiarity and Recollection,' and have shown that errors often result from misattribution of familiarity which can sometimes be corrected with recollection. Within the SMF, these would represent ends (or a coarse categorization) of a continuum of mental experiences. Also, in the SMF, both true and false memories can be associated with a sense of familiarity and with a sense of recollection.

3. Investigating True and False Memories

Evidence for the propositions in Sect. 2 comes from laboratories in many countries working in many domains (the SMF can be thought of as a way of unifying this evidence), including work on familiarity-based attributions, cryptomnesia, the phenomenal qualities of memories, suggestibility, rehearsal, schema effects in memory, the impact of emotion, motivational and social effects in memory, interpersonal reality monitoring, and imagination. Several illustrative findings are briefly outlined here.

3.1 Memory Characteristics

When participants are asked to make ratings of the qualitative characteristics of their memories, memories for real events tend to have more perceptual and emotional detail than memories for imagined events. Moreover, when they are asked to justify why they

believe their own (or someone else's) memory they invoke these characteristics or are influenced by them. Manipulating these characteristics influences the accuracy of source monitoring. For example, if participants have imagined a word in another person's voice they are later likely to claim that person said the word. If they have seen a magnifying glass, they are likely to say they have seen a physically similar item that they only imagined (e.g., a lollipop). Furthermore, features are 'borrowed' or cumulated across modalities. For example, hearing the sound of a dog barking increases subsequent claims that an imagined dog was seen. In some experiments, people are as likely to claim to 'remember' their false as their true memories and to be as confident (or more so) about them. However, in several experiments using more detailed rating categories (e.g., asking for specific ratings of visual and auditory detail, emotional qualities) false memories were on average somewhat less vivid or detailed than true memories.

3.2 Evidence and/or Criteria used in Source Monitoring

Attribution processes are subject to task and social demands. If people are induced to, or have the opportunity to more carefully evaluate their memories, the probability of false memories decreases. Ways to decrease false memories include avoiding leading questions, asking people to explicitly consider the possible sources of their memories rather than simply asking about one source, having them rate the qualitative characteristics of their memories, and public as opposed to private remembering. Presumably, these manipulations decrease the degree that people will rely on a single type of information (e.g., familiarity or perceptual detail) and increase consideration of, and retrieval of, additional potentially useful information.

3.3 Rehearsal and Imagination

Thinking about events can increase the vividness of imagined events, the probability people will claim imagined events occurred, and their confidence that an event occurred. Imagining events can also make similar perceived events seem to have occurred more frequently. Furthermore, inducing subjects to generate images of suggested information increases later source misattributions.

3.4 Attention

Emotional self-focus or distraction during encoding or remembering can result in decreases in source accuracy without necessarily decreasing memory that an event

occurred. Such findings emphasize that memory 'strength' (in the sense of probability of recognition or recall) is not a perfect predictor of source memory. People can have strong memories for information for which they have only vague source cues, or strong-but-wrong source cues.

4. Are Some Memories Immune to Distortion?

In 1977 Brown and Kulick proposed that there is a class of 'flashbulb memories'—accurate, long lasting, and detailed—for highly significant, emotional events (e.g., where one was when one heard that Kennedy was assassinated or that the Challenger space shuttle exploded). However, subsequent research has shown that, like ordinary memories, these memories are subject to distortion.

The question of whether some memories might be immune to distortion resurfaced in the 1980s and 1990s, prompted in part, by high profile legal cases that involved either children's testimony in sexual abuse cases (e.g., New Jersey vs. Michaels), or adults' testimony about recovering previously repressed memories that they were sexually abused (e.g., Ramona vs. Ramona; Martinelli vs. Diocese of Bridgeport), or witnessed crimes (e.g., People vs. Franklin). Such cases greatly broadened the interest among the research community in the processes of memory distortion and the number of published papers related to memory distortion increased dramatically.

A central issue in discussions about these cases has been to what extent the findings and principles arising from laboratory research apply to real life, especially to traumatic memories. Some clinicians and authors of popular self help books encourage individuals experiencing psychological problems to freely imagine what might have happened to them as children and to think about why such events might have been likely. Although intended to help clients, the potential consequences of such practices are clearly problematic from the perspective of the SMF. Such practices encourage the client to generate details that may not be accurate, embed false information in a web of supporting knowledge and beliefs, and to adopt weak criteria for what constitutes evidence for a memory. At the same time, the conditions of laboratory studies cannot mirror those of real-life traumatic situations. Thus some have suggested that experimental results and some theoretical ideas do not always apply. They claim that certain classes of traumatic memory, including childhood sexual abuse, are unlikely to be false because the associated emotion is evidence of their authenticity.

Although there are obvious ethical limits to the types of laboratory situations that researchers can set up, researchers have demonstrated that false memories can be created for entire, complex, salient, and emotionally significant events—inducing both children and adults to believe that they remember autobiographical events that never happened. The general procedure in some of these studies is to obtain reports of actual events from a relative of the participant and then query the participants about these events. Embedded in the list of real events is a false event that did not happen to the participant. After reading the accounts and, especially after being encouraged to think about the events, some participants claim to remember the false event. For example, Loftus and Pickrell induced adult participants to remember being lost in a shopping mall as a child. Hyman and colleagues induced participants to remember being taken as a child to the hospital for an ear infection. These false memories can contain quite specific details not provided in the relative's account. Similarly, Ceci and his colleagues have found that some children will provide compellingly vivid accounts of complex events (e.g., having their finger caught in a mousetrap), particularly after repeated questioning about the event. Spanos and colleagues demonstrated that adult participants could also be led to report memories from infancy. For example, participants were told that, because they have good visual skills, they were likely to have been born in a hospital that hung mobiles over their cribs and then they were 'age regressed' to recover the memories. Groups that were hypnotized and groups that were not both reported a high incidence of 'infant memories.' Spanos and colleagues suggest that memories of past-life identities, UFO abductions, and satanic ritual abuse are similarly likely to be created in a social context where authoritative or trusted sources make such events seem plausible, create the expectation that the individual has had such experiences, and use techniques such as generating imagery or repeated questioning to facilitate recovery of such hidden memories. Ofshe has also argued that induction of hypnotic or dissociative states, in combination with specific suggestions from authority figures, can result in false memories and provided a chilling account of a criminal investigation in which leading questioning techniques induced a man to confess to the sexual abuse of his children.

Of course, it is quite difficult to isolate particular factors contributing to false autobiographical memories in these relatively complex, emotionally salient situations. Nevertheless, overall the results of these studies appear to reflect the processes proposed and they increase confidence in the generality of laboratory findings. Repeated questioning or thinking about an event increases the details that are remembered or confidence in the memory. Encouraging participants to embed a 'memory' in other supporting personally relevant details increases false memories. Individuals with high imagery ability seem to be more susceptible to induced false memories, presumably because they embellish more or create representations that are more like perceptions. In some studies, individuals who

score high on tests of hypnotizability or dissociative experiences are also more susceptible, perhaps because these individuals are high in imagery ability or easy to coax into using lax criteria for assuming something is a memory.

Studies that induce false autobiographical memories highlight the fact that remembering often takes place in a social context that can be a source of false information, can provide occasions for repeating and embellishing 'memories,' and can coax people to ignore the doubt that is an important cue during normal source monitoring. Therapy is itself a social context that potentially can have these characteristics. In 1995, Poole in the US and Lindsay in Canada, in collaboration with UK researchers Memon and Bull, reported results of a survey of therapists in the US and UK: 25 percent of the sampled therapists who work with adult female clients believe 'that recovering memories is an important part of therapy, think they can identify clients with hidden memories during the initial session, and use two or more techniques to help such clients recover suspected memories of [childhood sexual abuse].' They note that such techniques may be used with caution by many therapists, but that other therapists may be unfamiliar with the cognitive literature on processes of memory distortion, and may underestimate their own influence. As professional books and journals and, especially, the popular press, have provided wider exposure to theoretical issues and research findings, therapists are likely becoming better informed for making judgments about which techniques to use. Importantly, however, not only therapists, but also police officers, lawyers, social workers, parents, and many other trusted authorities (e.g., talk show hosts, Internet sites) are in a position to influence how people search and evaluate their memories. There is no reason to believe that memories cannot be accurate (they often are quite accurate in both laboratory and more naturalistic studies), and appropriate cueing and some conditions of social remembering can facilitate memory as well. Nevertheless, the potential for memories to be false is clear and the mechanisms of distortion are generally understood. Recent work has been directed at developing interview techniques for reducing false memories in both children and adults.

5. The Prefrontal Cortex and Source Monitoring

Based on the evidence that memory involves constructive and reconstructive processes (including the self-generation of retrieval cues, setting criteria, and evaluation of activated information), one would expect the region most associated with reflective or executive processes—the prefrontal cortex (PFC)—to be important for episodic memory, especially distinguishing between true and false memories. And, indeed, damage to PFC often produces memory deficits, including deficits in self-generated retrieval

necessary for autobiographical recall, increases in false recognition of related distracters, and, in some cases, clinically significant confabulation. Source memory deficits (and resulting false memories) are more likely in children (whose frontal lobes are slow to develop) and in older adults (who are likely to show increased neuropathology in PFC with age). PFC dysfunction may play a role in schizophrenia, which sometimes includes severe source monitoring deficits in the form of delusions. Furthermore, in cognitive tasks given to neurologically intact young adult participants, increasing the cognitive load (having the participant simultaneously engage in a secondary task) disrupts performance more on tasks requiring source identification than on tasks simply requiring old/new recognition. Presumably, the extra load taxes the recruitment, organization, and integration of cognitive component processes necessary for source identification that are subserved by PFC.

A few studies have directly examined the brain activity associated with true and false memories. These studies show that there is overlap in the brain regions activated for correct recognition of old items and recognition of semantically related lures, as would be expected based on the behavioral evidence of their confusion. However, evidence also suggests that the similarity of the brain activity associated with true and false memories depends on how people are tested (e.g., with targets and lures randomly intermixed or in separate lists). This is consistent with the idea that what people are looking for as they are remembering will influence the qualities of their memories.

6. Conclusions

Autobiographical memories are narratives that are influenced by expectations before events ever happen and by rumination after the fact. These narratives are also influenced by other experiences (photographs, other people's accounts, and even unrelated events) and our goals and motives at the time of remembering. False memories arise from the same encoding, rehearsal and source monitoring (memory attribution) processes that produce true memories; thus one can never be absolutely sure of the truth of any particular memory. Of course, in many contexts, minor (and even major) distortions are of little practical consequence. There may even be some advantages to certain kinds of false memories (e.g., remembering a vacation as having been more pleasant than it was). However, there are other contexts in which it does matter whether memory is accurate—when distorted memories result in consequences that are clearly undesirable from the personal (e.g., mistakenly believing one was a victim), social (e.g., giving erroneous testimony about someone's actions), or professional (e.g., appropriating someone else's ideas) perspectives. Furthermore, certain conditions of psychopathology or

brain damage result in clinically significant increases in false memories and beliefs—confabulations and delusions. Hence understanding the mechanisms underlying true and false memories can potentially help reduce their occurrence under everyday circumstances (e.g., in therapy, in police interrogations, in scholarship) and help specify more completely and assess cognitive dysfunction in clinical populations.

See also: Comprehension, Cognitive Psychology of; Confessions: Psychological and Forensic Aspects; Constructivism in Cognitive Psychology; Elaboration in Memory; Emotion in Cognition; Eyewitness Memory: Psychological Aspects; Inferences in Discourse, Psychology of; Interference and Inhibition, Psychology of; Memory and Aging, Cognitive Psychology of; Memory: Autobiographical; Memory Development in Children; Memory for Meaning and Surface Memory; Memory Retrieval; Mood-dependent Memory; Reconstructive Memory, Psychology of; Schemas, Frames, and Scripts in Cognitive Psychology

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M. K. Johnson

Familial Studies: Genetic Inferences

The twentieth century may be described as the century of genetics. It began with the rediscovery of Mendel's work by Johannsen (1903) and ended with the completion of the Human Genome Project (HGP). *Nature* (2001, **409**) published the *Initial sequencing and analysis of the human genome* by The Genome International Sequencing Consortium and *Science* (2001, **291**) published similar sequencing by Celera. The twenty-first century, particularly its first half, will see a spate of work related to gene manipulation and genetic disorders. We can confidently look forward to substantial developments in our understanding of our species.

We fear that even in the post-HGP era, some of the twentieth-century errors relating to inferences from genetic analyses of familial data will be repeated and some more will be added. Indeed, McGuffin et al. (2001) say 'The most solid genetic findings about individual differences in human behavior come from quantitative genetic research such as twin and adoption studies that consistently converge on the conclusion that genetic variation makes a substantial contribution to the phenotypic variation for all behavioral domains.' The conceptual and mathematical errors in behavior genetic models, therefore, need to