

Chapter 2

A Brief History of Memory Development Research

Most developmental scientists probably agree that memory development has been one of the most-studied topics in all of cognitive development, and deservedly so. In fact, an impressive number of scientific studies on this issue have been published within the last four decades, stimulated by a shift away from behaviorism theories toward considerations of information processing. The discovery of Piaget by American developmental psychologists also supported the cognitive “Zeitgeist” in developmental psychology (Ornstein 1978).

Whereas many people believe that scientific research on memory development did not begin before the 1960s, in fact, the history of this research paradigm goes back to the beginning of the experimental study of memory near the end of the nineteenth century. Accordingly, experimental studies of memory are as old as scientific psychology. When Ebbinghaus (1885) was beginning his classic experiments on memory and forgetting in 1879, Wundt had just founded the first psychological laboratory in Leipzig, Germany. Although this is widely known, it is not equally well-known that research on memory **development** also began at about that time. Around the turn of the century, numerous studies were being conducted in Europe to investigate developmental and individual differences in children’s memory. From the beginning, these studies included examples of research conducted in the field on the one hand and in the laboratory on the other. For example, both Darwin (1877) and Preyer (1882) published naturalistic case studies of their own children’s development, including the development of memory and other cognitive skills.

There were three rather independent lines of research that contributed to this early trend. First, whereas the development of children did not attract much interest before the end of the nineteenth century, carefully conducted case studies of young children’s development (which also included systematic observations of memory development in early childhood) received a lot of attention, leading to the scientific foundation of child psychology in Germany. Examples of such observational diary studies on the “mind of the child” include the aforementioned research

by Darwin and Preyer as well as William and Clara Stern's extremely detailed diary on the development of their children (1913). Child psychology clearly flourished during the time between 1890 and 1915, with the founding of more than 20 child psychology journals and university departments devoted to this topic during those years (see Weinert and Weinert 1998). As a consequence of this new research trend, several textbooks on child development were published early in the twentieth century (e.g., Bühler 1918; Koffka 1921; Stern 1914; Werner 1926), all of which included long chapters on memory development.

A second line of research was directly derived from memory experiments with adults. Some of these studies explored whether findings obtained for adult populations could be easily generalized to children of different ages. For instance, using laboratory-based methods, Jacobs (1887) reported age differences in digit span, and Kirkpatrick (1894) observed developmental changes in free-recall performance. Other investigations were less basic in nature and were driven by educational interests. These studies tested common (mis)conceptions held at that time; for example, those children, because they practice their memory skills in school almost every day, are better at remembering verbal material than adults. Also, many of these studies examined the popular assumption that boys have better memories than girls. As the issue of coeducation was at stake in Germany around the turn of the century, this question was of high practical relevance.

The third line of research on children's memory was even more applied, focusing on children's and adults' testimonial competence. The prevailing legal attitude had been one of the skepticism about the testimony of child witnesses. Nonetheless, interest in children's eyewitness memory competencies was particularly strong in Germany and France, where systematic research on this issue flourished at the beginning of the twentieth century (e.g., Stern 1910; Whipple 1909, 1911). Most studies focused on children's suggestibility, developing methodologies that are still in use in modern research on the topic.

All three of these lines of research share the characteristic that they focused on children's episodic memory, that is, on memory for personally experienced events that range from briefly presented stimuli to significant life events (cf. Baker-Ward and Ornstein 2014; Schneider 2000a). In the next section, the major findings of early research on memory development will be briefly summarized. Three different time periods that clearly differed in their research focus will be distinguished.

1880–1935

Evidence from Child Psychology Studies

As noted above, Preyer (1882) careful observations of his son during the first 3 years of life represented the beginning of scientific child psychology. Preyer voted for an explicit, systematic, and methodologically controlled observational approach that allowed for the construction of an age-graded behavioral inventory. His own inventory included numerous cognitive features such as sensorimotor

skills, perception, speech acquisition, learning, memory, and the development of conscious thought. Given that many others adopted this observational approach, a rich database on the course of (early) cognitive development was available around the turn of the century. This new knowledge base was represented in several textbooks written by leading German child psychologists of that time. The emphasis of this research was on long-term memory (LTM), recognition, and imagery. Statements about short-term memory (STM) were rare and not very specific. All of the authors agreed that imagination is the result of memory processes, conceivable as a replicable memory trace that is independent of actual perception but can be influenced by knowledge structures. Most textbook writers also made a distinction between verbal and visual LTM.

One topic of interest was very young children's recognition memory. All researchers of that time agreed that "stimulus-bound" recognition memory can already be observed in young infants, indicating that this skill develops very early in life (but not before the age of 4 months). Its main function was understood to be the categorization of input stimuli and the reduction of input complexity. Recognition memory was assumed to improve considerably during the second year of life, accompanied by a dramatic increase in retention span, which could last for several months (cf. Bühler 1930). By contrast, "free" memory activities such as recall were assumed to develop considerably later, beginning by about 4 years of age. Most authors also agreed that visual memory functions were less deficient in young children than verbal ones. Accordingly, these authors assumed that developmental changes were more pronounced for verbal than for visual memory.

Several studies at that time investigated what is called "infantile amnesia" today (see Offner 1924). That is, researchers were interested in determining the age at which children begin to be able to permanently store memories of specific events, a question that was examined using samples of older children and adults. Early research by the French scientists Henri and Henri (1897) suggested that memories could date back to the second year of life when the events in question were particularly dramatic. However, subsequent studies did not confirm such an early onset, indicating that the earliest events that participants could remember occurred when they were 3 or 4 years old. This finding from retrospective analyses squared well with the observation that children who had moved away from their birthplace before the age of 4 could not remember any details about their original homes (Bühler 1930; Offner 1924).

Findings from Early Experimental Studies

Although most observational child psychology studies were creative, they had the major shortcoming of being fraught with methodological problems. Thus, this research was quickly followed by studies that were conducted in the laboratory and often involved the manipulation of independent variables. The second line of research outlined above was directly derived from general experimental

psychology and was later labeled “experimental memory psychology based on children” by Schumann-Hengsteler (1995). Typically, these studies adopted research paradigms developed in the tradition of Georg Elias Müller and his student Hermann Ebbinghaus. The major goal was to describe changes in memory performance across the life span. Children were treated as a special population that was used to evaluate the generalizability of findings from studies with adults. Large samples of children from different ages were included in most of these studies. In contrast to the child psychology studies summarized above, the majority of these experimental studies focused on **short-term** (immediate) **memory**.

Ebbinghaus (1885, 1887) himself was concerned with the capacity of memory span at different age levels, and he had a particular interest in identifying the developmental memory span curves for various types of materials. His findings were based on children and young adults and indicated that considerable age effects could be observed across various materials even though age differences were least pronounced for meaningless words and syllables. Subsequent research (e.g., Lobsien 1902; Netschajeff 1900) confirmed this result in that memory span performance increased with age for all types of items, and memory was better for objects and labels than for sounds and abstract concepts. Other studies also demonstrated that meaning played a significant role in determining the amount recalled (e.g., Netschajeff 1902). For instance, whether nonsense words were one or two syllables in length had little impact on span. On the other hand, Binet and Henri (1894a, b) found that preschoolers exhibited substantially better memory for sentences with many words than for short lists of meaningless items. As a rule, the core verbal units that suggested meaning were remembered best. These studies were the first to emphasize the constructive aspects of immediate memory. As noted by Baker-Ward and Ornstein (2014), Binet and Henri had anticipated the constructivism knowledge-driven approaches to memory reflected in Bartlett’s (1932) work as well as in more modern developmental studies of prose memory (e.g., Paris 1978).

In their reviews of the literature, Meumann (1907) and Offner (1924) regarded these studies as particularly valuable because these studies highlighted the existence of several memory functions that did not develop in parallel. Thus, the same 9-year-old children who could produce about 30 % of a list of nonsense syllables were more successful when the trial consisted of numerical series of the same length (about 60 % recall) or meaningful word lists (about 70 % recall; e.g., Jacobs 1887; Lobsien 1902; Pohlmann 1906). These findings were replicated in several studies (see Meumann 1907) and generally confirmed in experiments on immediate memory span that used the “word-pair method,” the forerunner of the paired-associate learning technique. For instance, Nagy (1930) conducted a study of 700 schoolchildren between the ages of 7 and 19 and found that abstract word pairs were harder to remember than concrete ones regardless of age.

Although there was broad agreement that children’s immediate memory is less developed than that of adults, researchers disagreed about the course of memory development from childhood to adulthood. Bühler (1930) assumed that developmental gains are most pronounced in 10- to 12-year-old children and then again after puberty. Experimental studies by Bourdon (1894) and Chamberlain (1915) suggested

considerable increases in memory capacity during the late elementary school years, with only minor further improvements until early adulthood (see also Nagy 1930). By contrast, Meumann (1907) own studies of children and adults showed rather slow improvements in immediate memory until the age of 13, followed by rapid improvements between the ages of 13 and 16. Peak performance was achieved by the age of 25 and followed by a period of stagnation and stability until the age of 46 (i.e., the oldest participants in his study). Despite these differences in results, researchers have agreed that memory development is characterized by nonlinear trends and that developmental patterns vary as a function of material and memory task.

Although studies on STM dominated the field at this time, there were also investigations of **LTM** and **forgetting**. Interestingly, one of the first studies of children's and adults' long-term retention and forgetting of verbal materials (Radossawljewitsch 1907) was stimulated by criticisms of Ebbinghaus' experimental method. Meumann, Radossawljewitsch's advisor, doubted Ebbinghaus (1885) classic findings on forgetting curves because neither Meumann nor his collaborators had been able to replicate them and because they were not in accord with the experiences of everyday life and work. The participants in Radossawljewitsch's study (16 adults and 11 children between the ages of 7 and 13) learned nonsense syllables and meaningful poems and were tested on immediate memory and relearning after lapses of 5, 20 min, 1, 8 h, and subsequently after 2, 6, 14, 30, and 60 days. Compared to adults, children needed a very large number of repetitions to learn a series for the first time, but the children forgot less of the material that was learned, and their rate of forgetting seemed less than that of adults. Although the slopes of forgetting were different for children and adults, the most important finding was that the forgetting curves obtained for the two groups did not correspond to the curve obtained by Ebbinghaus. The discrepancy between these two sets of data was great—Ebbinghaus who used himself as a subject forgot more information in 1 h than adults in Radossawljewitsch's study did in 8 h.

Subsequent studies by Vertes (1913, 1931) using the word-pair method mentioned above assessed LTM and forgetting in children and adolescents 6–18 years of age. Again, there was no support for Ebbinghaus' findings because forgetting occurred at much slower rates. Although the curves were generally in accord with the assumption that forgetting is a decelerating function of time, they were considerably flatter than those reported by Ebbinghaus. Interestingly, children older than 10 years of age remembered more after 1 week than they had on the previous tests, a phenomenon that is now called *reminiscence*.

All in all, the developmental studies on LTM and forgetting revealed that learning and forgetting rates differed as a function of age. Whereas it took children considerably longer than adults to learn the stimulus lists, they did not forget at faster rates. The fact that Ebbinghaus' findings could not be replicated was assumed to be largely due to the relatively rapid rate of self-presentation in that study and the fact that Ebbinghaus was the subject of his studies and the experimenter at the same time. An alternative explanation is that Ebbinghaus forgot so much so quickly because he experienced a high amount of interference from the many lists he had learned previously (i.e., proactive interference; Underwood 1957).

Children's Eyewitness Memory

Although there was little interest in children's testimonial competence in the United States at the beginning of the twentieth century, systematic research on testimonies by both adults and children flourished in Europe, particularly in Germany and France (for a detailed review, see Ceci and Bruck 1993). Early reviews by Whipple (1909, 1911) covered child's suggestibility research in Europe, indicating that young children are highly suggestible and capable of making serious errors in testimonies, even when reporting on events of significant personal relevance.

One of the earliest studies on children's testimonies was carried out by Binet (1900). Binet assumed that suggestibility reflected the impact of two classes of factors. The first class was labeled "autosuggestion" and referred to the influence of a prominent thought that develops within the individual without obvious external cause. Autosuggestion was supposed to paralyze the critical senses and memories of past events. The second class of factors was assumed to be external to the individual, reflecting mental obedience to significant others, particularly adults. Although Binet's autosuggestion techniques are no longer of interest in modern studies, his research paradigms for examining external forces are still used today. For instance, children carefully examined a number of objects for a short time and were then tested on their memory. Some of the children had to write down everything they had seen, whereas others were asked direct (unbiased) or mildly leading questions. The major finding was that free recall yielded the most accurate reports, followed by direct questioning. Highly misleading questions resulted in the most inaccurate statements, regardless of age. Binet ascribed children's suggestibility to social factors, namely their desire to comply with adult beliefs, thereby ignoring their own accurate memories. Most important, Binet's work also demonstrated that suggestions were not always incorporated into the memory record, thus demonstrating that children's suggestibility was not long-lasting as they were still able to realize their errors on subsequent occasions. As emphasized by Ceci and Bruck (1993), Binet's major contributions to the field were that (1) he distinguished between errors of reporting caused by actual memory changes versus those caused by social conformity and (2) his early research is of high importance for the current debate regarding whether the original memory trace is itself impaired or simply allowed to "coexist" with the traces produced by suggestion.

In Germany, early research on eyewitness testimony was stimulated by Clara and William Stern's observations of their own children (Stern 1910, 1914; Stern and Stern 1913). They explored their children's abilities to remember in tandem with the children's abilities to resist suggestion. Stern and Stern distinguished "memory deceptions" from intentional lies, defining such deceptions as objectively incorrect statements that were based on subjective confidence. The problems that young children had with correctly recalling the circumstances and contents of previous experiences were attributed to their poorly developed understanding of time. Preschool and kindergarten children not only lack the ability to coordinate experienced events with specific time markers, but they are also not interested in such relations. Given that most questions in eyewitness testimony situations address the time issue, it does

not come as a surprise that children are prone to err under these circumstances. For instance, the question of whether the child saw the policeman yesterday on her way to kindergarten will immediately activate the image of the policeman and lead to a positive response regardless of whether the policeman was seen today, yesterday, or a week ago. According to Stern (1914), the major finding of research on young children's testimony is that spontaneous reports provide much more correct information than specific questions even though children do not offer as much information spontaneously. In his view, interviewers need to know that specific questions can produce two different effects: A positive effect is that a child may remember a correct detail that had not been offered spontaneously. On the negative side, a child may generate answers that are based on diffuse memories of the event and that are mainly incorrect. The latter possibility is highly probable during inquisitory assessments particularly when questions are leading and suggestive. In such cases, the length of the child's path to the answer "yes" seems much shorter than the path to the answer "no," with the suggestibility of the child decreasing with increasing age.

In order to support his assumptions, Stern developed two types of experiments that reflected two different paradigms and that are still in use today. In the first experiment, participants were shown a picture and asked to study it for a short period of time. They were then asked to recall what they had seen and were also asked a series of direct (unbiased) and misleading questions. The second experiment was developed to represent situations that were closer to real life. Here, participants observed staged events and were then asked questions about details from the scenario. Several of Stern's observations seem still relevant today. For instance, he cautioned against repeated questioning of the same event, claiming that a person may better remember the answers he or she gave during the first memory assessment than the actual events themselves (Stern 1910). Also, his research indicated that although younger children were most suggestible to misleading information, even adults could be misled by suggestive questions.

It seems fair to state that Stern and Stern's (1909) exploration of children's memory and suggestibility were inspired by issues related to children as witnesses in legal settings, anticipating many of the core research themes of recent work on children's eyewitness testimony. Thus, as noted by Ceci and Bruck (1993) as well as by Ornstein and Elischberger (2004), early European work on eyewitness testimony conducted by the Sterns and their colleagues foreshadowed a large proportion of the findings that were to appear in modern literature.

Assessment of "General" Memory Development

Given the broad disagreement regarding the general course of memory development described above, Brunswik et al. (1932) conducted a developmental study that was aimed at providing a general description of STM and LTM in school-age children and adolescents. This study also differed from earlier investigations in that the issues addressed were directly derived from truly developmental theory;

that is, Charlotte and Karl Bühler's doctrine of phases and stages (e.g., Bühler 1930). The research was stimulated by Charlotte Bühler and carried out at the then famous Vienna department of psychology. The study was also unique compared with previous research in that statistical significance tests were used, mainly due to the assistance of Paul Lazarsfeld, who became internationally known for his methodological expertise several years later. A large variety of memory tasks were presented to a sample of about 700 participants, ranging from 6 to 18 years of age. Tests involved STM and LTM for nonsense and real words, colors and numbers, as well as memory for poems. Moreover, several nonverbal memory tasks such as memory for motor actions and their correct sequence were included.

Undoubtedly, the study by Brunswik et al. (1932) represents a valuable contribution to research on memory development. The use of more precise methods and various learning materials gave rise to more specific hypotheses concerning age differences in memory development. The disparate growth curves obtained for different memory functions were consistent with the data in previous studies (e.g., Netschajeff 1900, 1902; Offner 1924). The attempt to construct a curve of the general development of immediate memory ("memory strength") is particularly interesting. The curve was based on scores of all participants and represented an aggregation across all measures included in the study (see Fig. 2.1 in Schneider and Pressley 1997, for a reconstruction of the graphical representation). The outcomes were compatible with findings from other early studies in that linear and steep increases in memory performance were found from 6 to 11 years of age and that there was a plateau in performance during pre- and early adolescence.

One obvious problem with the study was that the authors tried hard to make their findings compatible with the Bühlers' perspective. Accordingly, they claimed to have found support for Bühler's position that memory development during the early years is dominated by rote-associative processes ("mechanical learning"), whereas the kinds of learning and memory predominant in older children and adults are based on the creation of meaning ("logical memory"). A closer inspection of findings revealed that the theoretical position was not entirely supported by the data: In fact, younger children required more practice to learn nonsense syllables than meaningful words with continuous improvement in the learning of nonsense syllables up to age 18. Nonetheless, subsequent reports on the Brunswik et al. study emphasized the qualitative shift from mechanical to logical memory (for instance, see H. Werner's comments on the findings by Brunswik et al. in the thoroughly revised third edition of his textbook, which appeared in 1953). There is no doubt that this perspective of memory development dominated the field in the forties and fifties, particularly in Germany. However, the basic assumptions by Brunswik et al. (1932) were subsequently questioned by Russian psychologists such as Rubinstein (1973; originally published in 1940) and Smirnov (1948; cited in Smirnov 1973) and later also empirically falsified by Fechner (1965), Smirnov (1973), and Weinert (1962). For instance, Weinert found that 6-year-olds learned word pairs composed of familiar words much more easily than they learned pairs consisting of meaningless unfamiliar syllables. Smirnov's work further indicated that the superiority of logical memory over rote memory was more pronounced in elementary

schoolchildren than in adolescents. Thus, whereas the developmental curve regarding improvements in memory performance was in accord with many findings of the early period and also validated in subsequent investigations, the assumptions concerning qualitative shifts in memory development favored by the Böhlers and Brunswik and colleagues were not compatible with the existing database.

1936–1965

Overall, this time period represents the “dry middle years” (Ceci and Bruck 1993) not only for research on children’s eyewitness memory but for research on memory development in general. However, the situation differed somewhat for the then leading research communities as will be shown below.

German Research

The great progress made by German researchers in the early twentieth century came to a halt as war exploded across Europe. Many leading child psychologists such as the Böhlers, Koffka, the Sterns, and Heinz Werner left the country and began new careers in the United States. Theoretical perspectives that predominated in the immediate postwar period (i.e., Gestaltist, phenomenological) did not encourage analytical research on memory development. As a consequence, no empirical studies on memory development were published in Germany between 1933 and 1961.

American Research

The situation was much different in America. Behaviorism dominated the field, and theories of verbal learning were very popular. The verbal learning theorists were not particularly interested in developmental issues, however, because their primary concern was the identification of general laws (e.g., Goulet 1968; Keppel 1964). They were inclined to assume that the laws of memory are the same at all ages. Consequently, Keppel (1964) stated in his review that the developmental study is of little interest to the verbal learning theorist unless differential results could be expected on theoretical grounds. In this sense, the conclusion made by contemporary authors (Brainerd and Pressley 1985; Kail and Strauss 1984) regarding a dearth of research on memory development prior to 1965 applies to American developmental psychology between 1936 and 1965.

Most of the verbal learning studies with children were descriptive, and many were conducted at a single age level, but there were a few notable exceptions. For instance, Koppenaal et al. (1964) used a paired-associate learning paradigm

to test the developmental hypothesis that older children should experience greater interference when tested on highly associative learning materials than younger children. This assumption was based on the observation that verbal associative strength is determined by children's prior knowledge and that prior knowledge is richer for older compared to younger children. Koppenaal et al.'s (1964) study was conducted with preschoolers, kindergarteners, and third graders. The results were consistent with the developmental hypothesis in that third graders showed significant retroactive and proactive inhibition, which was not true for the younger children.

Another important developmental study focusing on free recall was conducted by Bousfield et al. (1958). These authors compared the degree of associative clustering in free recall of third grade, fourth grade, and college students. The theoretical rationale was derived from Werner's assumption that organizational principles change during development such that perceptual-sensory categorization is initially dominant but is replaced later by a tendency to organize stimuli conceptually. An important aspect of this study was that it included measures of clustering presumed to tap processing more directly than simply the amount of material recalled. As a main result, it was demonstrated that both recall and conceptual clustering increase as a function of age. Contrary to expectations, color clustering was low in all age groups. Although the findings concerning color clustering were not in accord with Werner's theory, this did not necessarily contradict the theory given that the age range was restricted and that younger children (e.g., preschoolers and kindergarten children) were not included in the sample.

Although developmental changes in memory were not the core concerns of North American verbal learning researchers, the findings by Bousfield et al. (1958) and Koppenaal et al. (1964) provided evidence for the importance of developmental differences, thus falsifying the view that the processes mediating verbal learning and memory at different age levels are qualitatively identical. In fact, Goulet's (1968) review of verbal learning in children published only 4 years after Keppel's overview differed considerably from the latter, pointing to the lack of correspondence between data on children and adults. The few developmental studies carried out at the end of the 1950s or the beginning of the 1960s already anticipated a great deal of work that was conducted after 1965 on children's paired-associate and list learning.

Russian Research

The research situation in Russia was clearly different from those in Germany and the United States. Relative to the Western researchers of the day, Russian scientists placed more emphasis on the development and evaluation of particular theoretical positions (cf. Meacham 1977). For instance, Vygotsky's position that highlighted the importance of social origins for the development of higher mental functions such as attention, memory, and volition was already influential. Russian developmental researchers were particularly interested in the development of "logical"

(meaningful) memory compared to rote “mechanical” learning. They emphasized the relevance of conscious, independent, and goal-oriented memory activity as the causal origin of memory development (see reviews by Meacham 1977; Smirnov and Zinchenko 1969). Two major concerns can be distinguished in these empirical studies. One was the study of **involuntary memory**, which occurs when the ultimate goal of the person is not memory but something else, often comprehension in the Russian studies. In such cases, memory is involuntary in that it is a by-product of comprehension. The second focus was **voluntary memory**, which was defined as a product of activities that are driven by the goal to remember. Most Russian researchers believed that superior (higher order) forms of memory develop on the basis of the transition from natural involuntary memorizing to subject-controlled and voluntary memory involving the use of mediating processes and cues.

A classic example of research on voluntary memory was provided by Istomina (1948, cited in Istomina 1977). This study sought to determine the conditions under which voluntary memorizing and recall first emerge. In a laboratory condition, the experimenter read five words to the children (preschoolers and kindergarteners), and the children had to recall the words after a short delay. In a game condition, the children were asked to go on an errand to a store and buy five items for the kindergarten. As a main result, children’s memory performance was much better for the shopping task. Istomina concluded from this that recall differences were due to different motivational incentives for the children. Whereas remembering was an intrinsically important goal and had real meaning in the shopping situation, this was not true in the laboratory situation.

One typical feature of the Russian studies on voluntary memory was the focus on learning from text. For example, Korman (1944, 1945, cited in Yendovitskaya 1971) studied preschool children’s memory for connected material (fairy tales). Korman was impressed by the children’s ability to recall the main events of the story correctly. Recall differences between 4-year-olds and 5-year-olds and 6-year-olds were primarily quantitative. Subsequent research by Smirnov (1948; cited in Smirnov 1973) with schoolchildren focused on the impact of text structure on children’s recall. Participants (second, fourth, and sixth graders) were presented two texts with sentences organized in either a coherent fashion or randomly. After two attempts to recall the two texts, children were instructed to break up the texts into pieces of information that went together (done from memory). The most important finding was that the youngest children were not able to reorganize the random text and that only a small percentage of the older participants were able to do so. Interestingly, although most of the children could indicate that random texts were harder to break up than coherent texts, they were not consciously aware of the structural differences between the texts. Smirnov concluded that meaningful grouping processes first proceed in an unconscious way before becoming conscious activities.

Several studies investigated the relation between voluntary and involuntary memory in children. Research by Leontjev, Smirnov, Zinchenko, and others revealed that involuntary memorization instructions produced better recall than voluntary memorization instructions for preschoolers, whereas this was not true for schoolchildren and adults (for details, see Schneider and Pressley 1997). Correlational studies

undertaken by Istomina and others indicated that correlations between involuntary and voluntary memory varied considerably with the age of the participants and the type of task used. Aggregated across tasks, the mean correlation was 0.80 for preschoolers but only 0.45 for kindergarteners. Mean correlations decreased steadily up to Grade 8 (0.10) but increased again up to 0.25 for college students. The interindividual differences were explained in the sense that whereas the younger preschool children behaved the same way when given involuntary and voluntary memorization instructions, older children's and adults' memory behaviors differed considerably as a function of experimental condition, with more memorizing activity and higher levels of recall when voluntary memorization instructions were provided.

All in all, it seems fair to conclude that most of the research on memory development conducted between 1936 and 1965 took place in Russia. In particular, the outcome of this research improved our knowledge about preschoolers' memory activities, foreshadowing later investigations on children's implicit and explicit memory. The Russian finding suggested that preschool children generally do not show intentional memory behaviors when instructions to remember are provided. However, their memory could be improved by manipulations that increased their meaningful processing of materials. They also indicated that the first signs of goal-directed memory activities in the memorization of objects, pictures, and words were observed among 5-year-olds, although children of this age usually did not possess the means to achieve their memory goals.

Other major accomplishments of this period include the analysis of developmental differences in children's text processing and recall and the study of processes that influence the encoding and storage of verbal materials, such as repetition and self-checking. Whereas the repertoire of memorizing methods seemed rather restricted in kindergarteners and young schoolchildren, the number and quality of mediating activities increased considerably between the second and fifth grades. In accordance with earlier findings (e.g., Brunswik et al. 1932), memory development appeared to be more dramatic for the elementary school years than for later periods.

Transition to the Modern Era

How does modern research on memory development differ from the historical approaches? One of the crucial differences concerns a shift from an emphasis on describing developmental differences in memory to an emphasis on identifying the underlying mechanisms of change. Another difference concerns the theoretical framework used. Since the mid-sixties, research on memory development has been influenced strongly by theoretical models derived from information processing and neuroscience approaches (see the reviews by Bauer 2006; Kail 1990; Schneider and Bjorklund 1998; Schneider and Pressley 1997). Memory researchers were clearly affected by the "cognitive revolution" that was taking place in experimental psychology around that time (see Miller et al. 1960; Neisser 1967). Developmental psychologists began looking at changes in children's thinking in terms of a computer

metaphor. From this perspective, memory development can be seen as reflecting either **hardware** (the capacity of memory systems and the speed with which information can be processed) or **software** (e.g., use of strategies). From the mid-sixties on, memory development has been conceptualized in terms of interacting information processing components, with memory development as a product of developing components in ever more complex interactions. Developmental research was strongly influenced by multistore memory models that distinguished between a sensory register, a short-term store, and a long-term store (e.g., the model developed by Atkinson and Shiffrin 1968). Regarding the contents of the long-term store, it was proposed that information can be represented in two ways. **Explicit** or **declarative** memory refers to our capacity for the conscious recollection of names, places, dates, or events and comes in two types, episodic and semantic. Whereas episodic memory concerns events and experiences that can be consciously retrieved, semantic memory refers to our knowledge of language, rules, and concepts. By contrast, **implicit or procedural memory** represents a variety of nonconscious abilities, including the capacity to learn habits and skills and some forms of classical conditioning.

During the 1970s, an extensive literature on memory development in infants, children, and the elderly began to accumulate. The first line of research was already initiated by John Flavell in the mid-sixties, who investigated the development of memory strategies, looking for “mediators” that influenced children’s verbal memory performance (e.g., Flavell et al. 1966). When Flavell (1971) asked in a symposium held at the biennial meetings of the Society for Research in Child Development (SRCD), “What is memory development the development of?” he set a new field in motion (see Bauer and Fivush 2014). Reports of memory development research that had previously been limited to occasional papers and symposia at SRCD meetings occupied a solid chunk of SRCD programs from 1975 on. By the late seventies, there was clear evidence for an active community of developmental memory researchers as documented in the volumes by Kail and Hagen (1977) and Ornstein (1978). As noted by Miller (2014), hundreds of studies conducted during the 1970s and 1980s investigated age differences in the spontaneous production of memory strategies such as rehearsal and clustering and the impacts of task and instructional differences on the outcomes. The development of strategic competence in children was probably attractive to memory researchers because it seemed at that time that there were qualitative differences in strategy use as a function of time. Moreover, numerous cross-cultural studies explored the issue of whether strategy development is universal, that is, not only observed in America and Europe but also evident in non-Western samples (for reviews, see Rogoff and Mistry 1985; Schneider and Pressley 1989). Most of these studies documented the impact of schooling on memory development, demonstrating that strategy use was either less frequently or not at all observed in nonschooled samples of children.

A second line of research that began in the mid-seventies and was again initiated by John Flavell focused on the developmental processes that underlie the acquisition of memory strategies. The basic idea behind this approach was that the application of memory strategies should lead to insight and knowledge about the usefulness of such techniques and that children’s understanding of memory

processes (i.e., their metamemory) should in turn facilitate their strategy use (Flavell and Wellman 1977). Although early studies on the relation between memory and metamemory were disappointing in that they yielded rather low correlations, subsequent research based on more sophisticated theoretical models of the relation and also on more advanced methods provided more promising results, underlining the importance of general metacognitive knowledge for memory development and noting that this metacognitive knowledge seemed to increase with age. Subsequently, researchers also explored the impact of domain-specific knowledge on memory development, demonstrating that advanced knowledge of a subject domain (such as chess or physics) was closely related to superior strategy use and better memory of materials in that particular domain (e.g., Chi 1978).

A third line of research that began in the early 1970s focused on STM and LTM development in children and adolescents. This research investigated the development of “basic processes,” that is, the development of encoding and retrieval processes and their relative contributions to memory development. In the beginning, the dominant view of STM was in line with the early work on memory span conducted at the turn of the century and mainly based on the Atkinson and Shiffrin (1968) model’s assumptions that information is read into a limited-capacity short-term store, in which it may be maintained by rehearsal and then forwarded to LTM. This conception of STM was challenged and abandoned by Baddeley and Hitch (1974) who replaced it with a fragmented conception of “working memory,” which consisted of three components: a “central executive,” which can be conceived of as a control center that selects and operates on various processes; a “phonological loop,” which maintains verbal stimuli through subvocal rehearsal; and a “visuospatial sketchpad,” a buffer responsible for the processing of nonverbal information. Several researchers subsequently assumed that STM and working memory were separate and functionally distinct systems (see Case 1978; Dempster 1985). Whereas STM was conceived of as a rather passive storage system, working memory was supposed to act as a sort of central computing space where information being held in the short-term system was transformed. Although the concept of STM was discussed controversially at that time, there was general agreement that its capacity is limited, probably increasing with age, and that information not further processed in STM will be lost.

Later on in the 1980s, another line of memory research that was not based on experimental studies but on interviews in everyday environments was stimulated by Katherine Nelson (1986) and her colleagues. The focus was on children’s “scripts,” that is, their memory of specific recurring events such as meals, nighttime rituals, or birthday parties. Research carried out in the 1980s and 1990s showed that even very young children organize their recall of everyday routines in a script-like fashion. As noted by Baker-Ward and Ornstein (2014), research on scripts led naturally to the study of children’s autobiographical memory of events that had been experienced only once. This kind of research has attracted a lot of attention among memory researchers, and it is probably fair to state that autobiographical memory has become the most active area of research on memory today (Miller 2014).

In sum, there is no doubt that the “cognitive revolution” of the 1960s as well as Flavell’s pioneering work on memory strategy development led to a dramatic

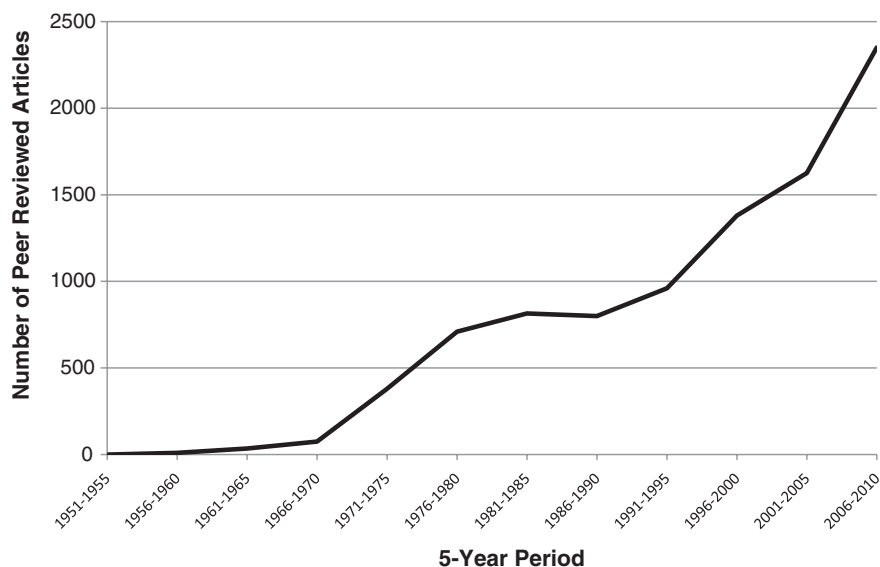


Fig. 2.1 Number of peer-reviewed journal articles on children's memory by 5-year publication period (slightly modified after Baker-Ward and Ornstein 2014, p. 50)

increase in research on children's memory. There are several ways to demonstrate that the interest in this research paradigm is still growing. For instance, Bauer and Fivush (2014) refer to the fact that the two volumes of the 1983 *Handbook on Child Development*, a required reading for all developmental psychologists, had only one chapter on "learning, memory, and understanding" (Brown et al. 1983), whereas their own new handbook consists of 43 chapters reviewing different aspects of memory development. Another demonstration comes from an analysis of the PsycINFO abstracting and indexing database carried out by Baker-Ward and Ornstein (2014), in which they identified all peer-reviewed English-language articles published between 1950 and 2010 including the keywords "memory" and "children (0–12)." The findings are summarized in Fig. 2.1. As can be seen in this figure, the number of publications assessed in 5-year intervals increased considerably from the mid-sixties on, with another rapid increase in production after 1990. There is little doubt that the focus of research on memory development has shifted over the years, from laboratory research on the impact of memory capacity, strategies, and knowledge to more applied field research on autobiographical memory and eyewitness memory. Laboratory research on memory development has continued to exist, with the predominant cross-sectional studies complemented by longitudinal work. Compared with the situation at the beginning of the research paradigm in the 1960s and 1970s, the situation today is much more complex, and new research areas such as evolutionary perspectives, memory in atypical populations, and the study of the brain basis of memory have emerged.

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