

How Does the Brain's Perception of Episodic Memory Change Over Time?

By Arjun Balasundaram

AUTHOR BIOGRAPHY

Arjun Balasundaram is currently attending Solon High School as a sophomore. He hopes to go into the medical field, specifically as a cardiologist, which has been his passion since his grandfather passed away.

ABSTRACT

Episodic memory is important and vital because it determines how someone views themselves and the world around them. The objective of this review was to understand how episodic memory develops over time and to determine whether there is a difference in perceiving episodic memories that changes with age. The studies selected were found on the Science Direct database, and the papers included were focused on how episodic memory develops over time for different age groups. This paper found that episodic memory improves rapidly during childhood, with structural development in early childhood, strategic developments in middle childhood, and strategic refinements and improvements in overall efficiency in adolescence, peaking with young adults, and some aspects declining with old age. This concluded that childhood is the most important time for episodic memory development. Further research needs to be done to understand how people perceive their own episodic memories, and more work needs to be done on how the perception of a memory can, if possible, be objectively rated for a more concrete approach and understanding.

Keywords: *Episodic, Memory, Early Childhood, Middle Childhood, Adolescence, Memory development, Prefrontal Cortex, Hippocampus, Brain, Neurological growth*

INTRODUCTION

Episodic memory is the ability to recall specific events from personal experiences, or, as Allen and Fortin (2013) described it, the ability to “mentally time travel” to reexperience individual events”. It is one of the primary types of memory and falls under the broader category of declarative memory. Declarative memory refers to knowledge that can be consciously recalled and expressed in words (Pause et al., 2013). It is commonly divided into two subtypes: episodic memory, which stores personal experiences tied to specific times and places, and semantic memory, which stores general facts and knowledge about the world (Pause et al., 2013).

Declarative memory itself is a branch of long-term memory, which also includes non-declarative memory. Non-declarative memory is unconscious and not easily revealed through skills and habits (Pause et al., 2013).

Episodic memory, then, is unique in that it allows us to re-experience past events vividly (Pause et al., 2013), such as the first day of school or a friend’s birthday party. However, episodic memory’s accuracy can be influenced by factors such as how much attention was paid during the original event or how much time has passed since it occurred.

The importance of studying episodic memory lies in the central role of our daily lives. A better understanding of how we recall events can have wide-ranging applications, from improving eyewitness testimony in criminal justice to enhancing learning and retention in education. Research into episodic memory also has implications for mental health. For example, knowing that memories of frightening or anxiety-provoking experiences may sometimes be exaggerated by the brain can help individuals reinterpret those experiences in less distressing ways (Pause et al., 2013).

Beyond practical applications, episodic memory is deeply tied to how people perceive themselves and the world. It shapes our identity and provides insight into the experiences of those around us, fostering empathy and social connection (Pause et al., 2013). Therefore, studying episodic memory not only advances our scientific understanding of how memory works but also deepens our understanding of human experience.

This review aimed to examine how episodic memory develops, summarize key findings in the field, and highlight areas where further research may be needed. By bringing these perspectives together, the goal was to provide a clearer picture of episodic memory as a fundamental part of the broader memory system.

METHODOLOGY

The literature search was conducted using the database Science Direct. The keywords used were "episodic memory development". To refine the results, the filter for article type was set to "research articles", while no restrictions were applied to publication type, subject area, access type, or publication year. The search and article retrieval were finalized on July 9th, 2025. To ensure relevance and quality, only peer-reviewed research articles published between 2000 and 2025 in English were included. Studies whose main focus was not the development of episodic memory across human life, or that worked with non-human subjects, were excluded from the paper collection.

The initial search identified 53 research papers. After following the inclusion and exclusion criteria, the number narrowed to nine papers, which seemed to focus on the understanding of episodic memory and its development in humans. These studies were organized according to the age groups investigated: early childhood, middle childhood, and late childhood/adolescence.

RESULTS

The final number of papers that followed all the inclusion criteria and were included in this review was nine, which together cover a significant portion of childhood as well as some aspects of adulthood (Table 1). These papers were divided into age groups, as most of the papers compared multiple age groups or focused on one age group in particular, so the highlighted findings in these papers will best relate to age groups.

Table 1.

Titles, authors, year, and age group are represented in the selected papers.

Title	Author and year	Age group
White matter structural connectivity and episodic memory in early childhood	Ngo et al. 2017	4 - 6 Early childhood
Hippocampal functional connectivity and episodic memory in early childhood	Riggin et al. 2016	4 - 6 Early childhood
Remembering the past to envision the future in middle childhood: Developmental linkages between prospection and episodic memory	Coughlin et al. 2014	5-9, and adults Early/middle childhood
Examining the development of memory for temporal context	Bettencourt et al.	7-12, adults

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and its underlying neural processes using event-related potentials	2021	Middle childhood
Developmental differences in the neural correlates of relational encoding and recall in children: An event-related fMRI study	Güler and Thomas 2013	8-13 Middle childhood
Changes in familiarity and recollection across the lifespan: An ERP perspective	Friedman et al. 2010	9-10, 13-14, 20-30, 65-85 Adolescence
The underlying processes of episodic memory development: From a unique contribution of representation to the increasing use of semantic organization supported by cognitive control	Frick et al. 2022	6-13 Middle childhood
Children's and adults' memory for the order of events in a museum: A preliminary study about temporal memory and its development using photo-taking and event-related potentials	Pathman et al. 2014	7-10 Middle childhood
Episodic memory during middle childhood: What is developing?	Guo et al. 2024	6-12 Middle childhood

Both papers that cover early childhood analyze facets of episodic memory and how changes in childhood affect the development of episodic memory.

First, Ngo et al. (2017) studied the brain's structural connectivity, focusing on the white matter, a part of the brain that is believed to be important for cognition and basic neural functions (Filley and Fields, 2016). The study aimed to analyze the differences in macro and microstructure of white matter in the brain and the effects of age on white matter. For the analysis of structural connectivity of white matter, diffusion-weighted imaging was used. This method allows researchers to better understand the structure of white matter in the brain (Schilling et al. 2023). Analyzing the macrostructure includes the physical volume of the tract and the extent of white matter, which connects the hippocampus to other brain structures. The analysis of the microstructure studies the fractional anisotropy (FA), which serves as a reference to understand the integrity of white matter in the brain. A difference in the FA could serve to show a difference in the white matter of the brain. Ngo et al. 2017 aim to explain how such changes in the brain could affect episodic memory.

To study how differences in white matter caused by age affect episodic memory, the researchers used different methods to understand the children's episodic memory. The methods the researchers used were the children's memory scale (CMS) episodic memory tasks. These methods help with the analysis and comparison between the children's abilities to form memories, ideas, and conclusions. The findings indicate that there is no significant correlation between age and white matter structural connectivity. However, there is some correlation between white matter structural connectivity and episodic memory abilities. The correlation can specifically be seen with Hippocampus-parietal connections, meaning more mature or higher densely packed, myelinated axons between the hippocampus and parietal regions of the brain lead to better episodic memories, or at least better recollection of them.

The results also find a correlation between age and episodic memory as the 6-year-olds performed significantly better than the 4-year-olds in the memory tests, showing that the period between four and six years of age is significant for the development of episodic memory recollection, although white matter does not significantly develop during this time period.

Riggins et al. 2016 also focus on early childhood. Riggins et al. 2016 aim to understand the organizational differences in the brain and their correlation to age. The method used by the researchers to analyze the episodic memory abilities was a behavioral memory task and fMRI. The behavioral memory task was a test where the children were given toys in different rooms, and each toy was associated with a task to do, such as hugging it or drumming it. After a 1-hour delay, the scientists analyzed what the children remembered and what they did not remember. This helped the scientists understand the children's item memory abilities as well as context memory abilities. When analyzing the fMRI, the scientists focused on the hippocampus and examined its connection to other regions such as the temporal, parietal, prefrontal, and precuneus regions. In addition, both anterior and posterior regions were analyzed to see if there was any longitudinal specialization.

The results of these tests gave significant insight into episodic memory development in early childhood. The six-year-olds did much better when compared to the 4-year-olds on the behavioral memory test. This means the age correlated positively with memory scores. The fMRI shows that the hippocampal connectivity networks resemble adult memory networks, showing that the hippocampus is significant for memory, even in early childhood. Evidence of specialization also appeared, showing that different areas of the hippocampus are somewhat specialized in early childhood. A unique result appeared when analyzing hippocampal connectivity with memory regions. Six-year-olds with stronger hippocampal connections to memory regions had better episodic memory, so there was a positive relation; however, in four-year-olds, a stronger connection had a negative association with memory. An interesting discovery was connections outside of the hippocampus memory networks, positively related to memory in four-year-olds, but had a negative relation to six-year-olds.

These results show how significant the hippocampus is in early childhood and also suggest that the memory networks in early childhood are in a transitional phase, where younger children don't always use the networks that adults predominantly use, and their memory relies on other regions as well. At six years old, the hippocampus becomes more important for memory and becomes the main region for memory-related networks. This transition also results in significant improvements in episodic memory capabilities.

Overall, early childhood is a time when the brain reorganizes its memory-related networks, becoming more specialized and starting to rely more on the hippocampus, as well as an increase in specialization and overall episodic memory abilities. This change in organizations carries through to adulthood, where similar networks can be seen, with reliance on the hippocampus being a significant development that occurs during early childhood.

The next age group covered was middle childhood. Guo et al. (2024) studied children aged 6-12 to analyze how well they performed in episodic memory tests. The researchers studied the children's episodic memory through a treasure hunt where children hid different items themselves, and after a certain time delay, the children were asked what object they hid, where they hid each object, and when they hid each object. These questions were used so the researchers could understand the WWW integrated memory. They checked whether the children could recall all three aspects at the same time or whether they struggled. Guo et al. (2024) ran different questioning systems, which varied in the level of support, with one version giving more support with the questioning by giving options to the children, whereas the other version gave less support and was more open-ended, requiring free recall. This allowed the researchers to analyze the strategic retrieval ability and associative binding abilities of the children.

The researchers found that the three aspects of memory tested improved with age being item, spatial, and temporal memory. The integration of these memories also improved with age. When support was given in the questions, the younger children benefited more, suggesting that strategic retrieval abilities begin to develop during middle childhood. The research showed that the associative binding abilities developed linearly; however, some analyses hint that associative binding abilities may develop faster around the age of 9. A hypothesized reduction in memory performance due to neural networks reorganizing at the age of 11-12 did not occur.

Bettencourt et al. (2021) studied three different age groups to better understand how episodic memory develops over time. The age groups are 7-9, 10-12, and young adults. The participants were given items paired with contextual information, which they were to study. During retrieval, the participants were to determine whether or not they were given a certain item, and if they were, the participant would also be expected to remember the context to go along with the item. An ERP analysis was also given to find differences when recalling old vs new items, and correct vs incorrect recollection.

The results showed that a higher age resulted in a better performance on the memory-related tests, where adults performed better than 10-12 year olds, who performed better than the 7-9 year olds. The ERP showed that the 7-9 and 10-12 age groups both had differences in the ERP readings when comparing old and new items, and the difference was in a similar fashion to the adults' readings. The difference between the children and the adults was mostly in the amplitude and the length, where the children had lower amplitudes and lasted longer. This difference in ERP readings correlates with less efficient and slower recall than adults; however, it shows that children in middle childhood have similar memory processes when compared with adults.

Overall, the results for the experiments show that temporal context memory improves significantly during middle childhood, and ERP findings illustrate that children have a similar thought process and generate the same neural signals; however, it is just less efficient and weaker than adults. Showing even more development occurs in later stages.

Pathman et al. (2024) focused on children aged 7-11 and compared them to adults. The participants visited a museum and they photographed around 120 exhibits in around 2 hours. As the participants took the pictures themselves, the events were personalized, as well as the order. After 1-2 days later the participants looked at pairs of photographs and they were supposed to decide which photo came earlier between the two. The researchers manipulated the distance between the events. Some were short as the 2 events were taken close to each other in time, while some were longer and had larger distances between each other. The researchers also manipulated the order of the given photos, as sometimes the photos were presented in the correct order, and sometimes the photos were given in the reverse order. During this process, ERP recordings were made. The ERP recordings were made to focus on whether short or long differences in temporal order changed the ERP results.

The results showed that both children and adults have a higher accuracy when the distance between the two events was longer, and the accuracy decreased as the distance between the two events in the pictures became shorter. Another observation was that adults showed a memory asymmetry effect as they performed better when the pictures were in the correct order of events, but this effect was mainly seen when there was a small time difference between events. The ERP showed a clear difference in neural responses when comparing short and long temporal distances, and this difference occurred in both children and adults. The ERP additionally showed higher sensitivity for the order of photos given.

Overall, these results showed that temporal order for episodic memory improves from middle childhood to adulthood, and children are not as sensitive to asymmetry; affect means that sensitivity develops in later stages of life. The ERPS suggest that both groups differentiate between close together events and faraway events, showing that this differentiation in neural processes has already developed before middle childhood.

Coughlin et al. (2014) focus mainly on middle childhood with five, seven, and nine-year-olds as well as

young adults. In the paper, the participants created stories about past and future events. The changes in these stories were the temporal distance, which was 1 week compared to 1 year, and the temporal direction was also changed, comparing the past and future. After this, the patients subjectively rated the story's clarity, how easy it was to remember, and their perspective when remembering or telling the story. These stories were then given to the parents of close people with the patient in order to determine the accuracy of the story or the event's plausibility.

The results showed significant improvement from the age of 5 - 9 when recalling events with contextual detail. Prospection or future stories were much less rich with contextual details than past events, and this was true in all age groups. The future events were considered harder to create stories for, and they were usually in a 3rd person perspective. Another finding in the paper was that the quality of the episodic memory of the past would correlate with the quality of episodic memories or the prospect of the future. This means that if a person has higher-quality memories of a past event, then that person is likely to have better-quality perspectives with more contextual details.

These results signify that episodic memory recall and prospection both improve; however, prospection does not improve consistently and is consistently worse than recalling past memories. The results also suggest that children rely on episodic memory to create prospects of the future, signifying another importance of episodic memory.

Güler and Thomas (2013) focused on the age 8 - 9 year olds and 12 - 13 year olds to analyze differences between the two age groups. The researchers analyzed episodic memory by analyzing fMRI scans of children associating different images. To explain a bit more, the Children were given pairs of unrelated objects and they were told to memorize them. There were two recall phases, one was silent and the other was verbal. In the silent recall phase, the children were given one item and told to press a button if they could recall the partner in their head. With verbal recall, the children were given the same objects and told to say the paired object aloud.

The results showed that the older children performed better than the younger children. The fMRI scans, when encoding the pairs of objects, younger children used the right dorsolateral PFC and right temporal cortex more than older children, whereas older children used the left ventrolateral PFC and parietal cortex more, and these areas are associated with encoding strategies. In recall, older children used the left ventrolateral PFC and the left interior parietal cortex, and during successful recall, these areas were used more strongly. However, younger children did not show specific areas of the brain that they used significantly, suggesting a more diffuse network.

These results signify a more specialized, concentrated neural network for recall and encoding as children move through middle childhood. The PFC is important for both encoding and recall, and a higher usage of the

PFC shows more effective strategies in middle childhood and the beginning of adolescence. The results also show that the maturing of PFC-parietal networks is significant for memory improvements, along with the hippocampus maturing as well.

Frick et al. (2022) studied children around the age of 8-13 to focus on middle childhood. The method used to study episodic memory was by using a free recall task. The free recall task required the children to study 20 words from 5 different semantic groups, and they then recalled them without any cues. The Adjusted Ratio of Clustering (ARC) then measured if the children's recall was organized semantically. The researchers then gave representation tasks to the children to study the children's knowledge base and semantic knowledge. Control tasks were given to measure cognitive control, which were given to measure the children's ability to apply strategies on their own. The results showed that some level of clustering does exist at the age of 8-9; however, clustering reliably improves recall at the age of 12-13. Younger children who used clustering usually did not have any benefit because of utilization deficiency, where they can not correctly utilize strategies, although they know of them. In 8-11-year-olds, the recall was supported mainly through representation, whereas in 12-13-year-olds, the recall was supported by both representation and clustering. The ARC only predicted recall in 12-13-year-olds.

The results from the paper highlight that a shift in recall occurs as 8-11-year-olds depend on knowledge representations, while older children's recall uses strategic organization to give better results.

Overall, in middle childhood, there are significant improvements in memory overall as a whole including information such as what, when, where, and the integration of these various aspects. Through brain scans, researchers have found that the neural networks in recall are more diffused in younger children and more concentrated and specialized in older children. Younger children in the middle childhood category begin to develop strategies for recall and organization. But it is not always effective. However, children on the older side of the middle childhood reliably use strategies for organization and recall, such as semantic clustering, which helps them perform significantly better in memory tasks, along with regions of the brain maturing on their own. Younger children will benefit more from support given when recalling than older children because of this difference in strategies for recall. Older children in the middle childhood category have similar neural networks to adults. However, they are still not as efficient, and that will develop at later stages.

The final paper, by Friedman et al. (2010), covers a diverse range of age groups, being 9-10, 13-14, 20-30, and 65-85. This paper will add information for the end of middle childhood and early adolescence, as well as adults, and even seniors. The paper gave the participants a list of words, and each word was studied for later recollection. In the test phase, the participants were given a mix of words that included words they had already given or old words, as well as words not previously given or new words. For each item in the list of words, the participants were to determine whether the word was old or new and whether they recognized the item with

specific details and had contextual detail to go along with it, or whether they recognized the item but did not think of it with contextual detail. This study was repeated 4 times. ERP recordings were also made to recognize familiarity versus recollection. Young adults performed the best in the study, and they also benefited the most from the repetition of the trials. Recollection also increased with repetition vs familiarity, which did not improve. The children relied mostly on recollection and did not use familiarity as frequently, while adolescents used both styles of recall. Low-performing individuals evidently had deficits in recollection, showing a significant variability in that age group.

Overall, familiarity-based recall develops at young ages around middle or even early childhood, while Recollection develops later and peaks in young adulthood, declining slowly through age.

DISCUSSION

The importance of episodic memory is evident in many domains. For example, its role in eyewitness testimony has critical implications for the justice system, while research on memory retention informs educational practices. Episodic memory also intersects with mental health: traumatic memories can profoundly affect well-being, and understanding how such memories are encoded, recalled, and potentially modified may point toward strategies to reduce their impact ([Pause et al. 2013](#)).

Across the reviewed studies, episodic memory shows substantial improvement throughout childhood. In all age groups, older children consistently outperform younger ones on memory-related tasks, reflecting the steady development of this system across early life. During early childhood, contextual details, such as when and where an event occurred, improve markedly. The hippocampus becomes more functionally integrated within the memory network, shifting from a more diffuse to a more specialized role. White matter pathways linking the hippocampus to other regions also predict memory performance, underscoring its growing importance during this period.

In middle childhood, strategic processes that support memory recall begin to emerge. While initially inefficient, they become increasingly reliable in older children. Temporal aspects of memory also develop significantly, and episodic memory capabilities improve not only due to regional maturation but also because of large-scale brain reorganization, bringing the neural network closer to the adult pattern.

By adolescence, both familiarity and recollection are well-established and used reliably, though not yet at full adult efficiency. In young adulthood, episodic memory becomes highly efficient, with robust and differentiated patterns supporting familiarity and recollection. In older adults, recollection declines while familiarity remains relatively stable. Importantly, there is considerable variability among seniors: high- and low-performing individuals differ markedly in recollection ability

Despite these insights, several research gaps remain. This review sought to understand developmental changes in episodic memory, yet many studies relied heavily on neural connectivity and activity measures (e.g., fMRI, ERP). Far fewer addressed how people *experience* episodic memories, such as their vividness or perspective (first-person vs. third-person). More research into these subjective aspects is needed.

Another limitation is the narrow age range of many studies. Most focused on one or two developmental stages, often leaving out transitions across the lifespan. Although challenging, studies that systematically include a broader range of age groups with comparable tasks would provide a more comprehensive picture of episodic memory development.

In addition, relatively few studies examined changes within adulthood. Young adults were often included only as a control or comparison group, and differences within adulthood were rarely analyzed in detail. This represents an important gap, given that episodic memory continues to change across the adult lifespan.

This review was also limited by its database coverage. Broader searches might have identified additional relevant studies, especially those focused on subjective aspects of memory rather than primarily neural correlates. Expanding database coverage could strengthen future reviews and help shift the focus toward how episodic memory is *perceived* as well as how it is supported neurologically.

Future research would benefit from including wider age ranges and examining both neural and phenomenological aspects of episodic memory. Understanding not only how memory changes across the lifespan, but also how individuals subjectively experience their memories, would offer a more holistic account of episodic memory development and decline.

CONCLUSION

This paper aimed to examine how episodic memory develops over time, with a particular focus on perspective, while also addressing underlying neural changes. Episodic memory is central to human cognition and identity, shaping how individuals perceive themselves and others. A clearer understanding of both its mechanisms and phenomenology deepens not only our knowledge of memory itself but also our insight into broader aspects of human behavior and interaction.

Developmentally, episodic memory begins in early childhood with the ability to recall past events, albeit in a rudimentary form. During early and middle childhood, memory performance improves significantly as white matter connectivity strengthens and neural networks become more specialized. Strategic retrieval processes also emerge, though they are not always efficient at first. By adolescence, these strategies become

increasingly reliable, and episodic memory capabilities continue to expand. In young adulthood, episodic memory reaches its peak, characterized by highly efficient and differentiated processes. With aging, some aspects of episodic memory remain stable, such as familiarity, while others, particularly recollection, begin to decline.

Overall, childhood represents a critical period for the growth of episodic memory, laying the foundation for later memory abilities. The capacities developed in these formative years not only shape lifelong memory performance but also influence identity, learning, social understanding, and mental health. Continued research into both the neural and experiential dimensions of episodic memory will further illuminate how it develops, how it changes, and how it shapes the human experience.

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