cortex 181 (2024) 194–203

Available online at www.sciencedirect.com

ScienceDirect

Journal homepage: www.elsevier.com/locate/cortex

Special Issue "New Perspectives in Neuropsychology: From Biology to Society"

# Exploring the development of past and future episodic memory in adolescents with autism spectrum disorder: A preliminary longitudinal study

*Rima Touati* [a], *Fabian Guénolé* [a,b], *Bérengère Guillery-Girard* [a,1] *and Prany Wantzen* [a,c,*,1]

[a] *Normandie University, UNICAEN, PSL Université Paris, EPHE, INSERM, U1077, CHU de Caen, GIP Cyceron, Neuropsychologie et Imagerie de la Mémoire Humaine, Caen, France*
[b] *Service de Psychiatrie de l'enfant et de l'adolescent, CHU de Caen, France*
[c] *LEAD-CNRS UMR5022, Université Bourgogne, Dijon, France*

ARTICLE INFO

*Article history:*
Received 26 May 2024
Reviewed 15 July 2024
Revised 9 September 2024
Accepted 8 October 2024
Published online 8 November 2024

*Keywords:*
Autobiographical memory
Autism spectrum disorder
Episodic memory
Future episodic thinking
Longitudinal study
Adolescents

ABSTRACT

Adolescence is a critical period where individuals build their identity and consolidate how they interact with others. However, for adolescents with autism spectrum disorder (ASD), the development of identity and social bounds is at stake. These challenges with the development of identity and social bonds could be linked to difficulties in autobiographical memory (AM), whether recalling past events (past episodic memory; past EM) or imagining future scenarios (episodic future thinking; EFT). To date, developmental patterns of AM over time remain poorly understood in ASD. Eleven adolescents with ASD or typical development (TD) completed an assessment of past EM and EFT once per year for three years. Preliminary results show that past EM becomes more detailed over the years for adolescents with ASD, while there is no change for TD adolescents. Interestingly, only the content elements of the narrated events are increasing, not the context elements. Furthermore, EFT evolves in the TD group but remains stable in the ASD group. This first multi-case longitudinal study of AM needs to be replicated with more participants, but it seems to indicate a heterogeneous evolution of AM in ASD. For future studies, these results will lead us to explore the hypothesis of developmental delay and the factors influencing AM development in ASD. Finally, understanding these developmental pathways highlights the importance of personalized therapeutic approaches to support social integration, identity construction, and future projects for adolescents with ASD.


* *Corresponding author*. Université de Bourgogne, LEAD, CNRS UMR5022 Bureau 248, Pôle AAFE, 11 Esplanade Erasme, 21000, Dijon, France.
E-mail address: Prany.Wantzen@u-bourgogne.fr (P. Wantzen).
[1] Equivalent contribution.
https://doi.org/10.1016/j.cortex.2024.10.016

## 1. Introduction

Autism Spectrum Disorder (ASD) is a neurodevelopmental disorder involving a deficit in social interactions and restricted and repetitive behaviors (DSM-5, American Psychiatric Association, 2022). In addition, closely related to these core traits, executive dysfunctions (Demetriou et al., 2018) and memory challenges (Desaunay et al., 2020) have been found in ASD. Importantly, complex memory processes, including autobiographical memory (AM), have been described to be altered in ASD (Bruck, London, Landa, & Goodman, 2007; Crane, Pring, Jukes, & Goddard, 2012; Goddard, Dritschel, Robinson, & Howlin, 2014; Robinson, Howlin, & Russell, 2017; Tanweer, Rathbone, & Souchay, 2010).

AM refers to the memory of an individual's life. It combines specific events that have been personally experienced (accompanied by a perceptual and sensory experience), corresponding to the episodic memory, and personal knowledge, referring to the semantic component. In our daily life, AM manifests as the coherence in our identity over time (identity function), our ability to solve problems using our past experiences to guide our choices, allowing us to adapt to future events (directive function), and to share and communicate with others (social function) (Bluck, Alea, Habermas, & Rubin, 2005; Bluck & Alea, 2011; Fivush, 2011). AM is closely linked to the sense of self, as it enables storing and retrieving memories consistent with the individual's personal goals and objectives, which allows us to build and maintain a sense of identity and continuity over time (Conway, 2005; Fivush, 2011; Habermas & Bluck, 2000). Furthermore, AM enables us to maintain social ties with others by recalling and sharing experiences, memories, and life stories.

Although 'memory' is a concept intuitively related to the encoding and retrieval of past events (i.e., past episodic memory; past EM), AM also refers to imagining and planning future events, a cognitive ability called episodic future thinking (EFT). EFT is the ability to project the self into the future to pre-experience an event (Atance & O'Neill, 2001). According to the theory of "constructive episodic simulation" (Schacter & Addis, 2007a; 2007b), imagining future events is based on recombining several details belonging to memories. These are then linked together through the semantic knowledge that would serve as the basis and support for constructing these future simulations according to the "semantic scaffolding hypothesis" (Irish & Piguet, 2013; La Corte & Piolino, 2016). In this line, AM can be divided between "past" and "future" components. However, this distinction is not sharp. Indeed, similar cognitive abilities were found between tasks involving imagining possible future events and recalling past episodes (D'Argembeau, 2021; D'Argembeau & Van der Linden, 2004). Furthermore, a similar subset of brain regions activates when subjects engage in tasks requiring remembering the past or imagining the future (Addis, Wong, & Schacter, 2007; Benoit & Schacter, 2015; Buckner & Carroll, 2007; Okuda et al., 2003).

Investigations of AM in ASD highlight difficulties in the past and future components. Previous investigations in children and adults with ASD reported impairments in past EM, including less specific, detailed, and coherent retrieved memories (Adler, Nadler, Eviatar, & Shamay-Tsoory, 2010; Bowler, Gardiner, & Grice, 2000; Cooper, Plaisted-Grant, Baron-Cohen, & Simons, 2016; Crane et al., 2012; Goddard, Howlin, Dritschel, & Patel, 2007, 2014; Tanweer et al., 2010). Concerning EFT, studies showed an impoverished EFT for ASD compared to typical development (TD) participants in both children (Anger et al., 2019; Ciaramelli et al., 2018; Lind, Bowler, et al., 2014; Marini et al., 2016; Terrett et al., 2013) and adults (Lind & Bowler, 2010; Lind, Williams, et al., 2014).

Altogether, individuals with ASD show poorer past EM and EFT performances than age-matched TD participants at different ages. However, the developmental trajectory of these abilities over time has been little investigated in ASD. In TD, AM appears to evolve progressively from childhood through adolescence and into adulthood (Reese, 2009, 2013). According to a review by Reese and colleagues (Reese, 2009), AM appears around 3-4 years old, while children can already provide the premises of comprehensible memories. These continue to be enriched in terms of structure and are completed up to the age of 8–9 years. Although eight years old children are still not capable of providing temporal connections between different past events (Bohn & Berntsen, 2008; Habermas & De Silveira, 2008). By the age of 12, the memories evoked continue to develop with a more precise spatiotemporal context and temporal connections. Additionally, experiences begin to become linked to one another in memory and this forms part of a more global life history. The personal meaning attributed to each memory, and consequently the link between AM and the construction of the self, does not really become established until the age of 16 and continues to develop until the end of adolescence (Habermas & De Silveira, 2008). Concerning EFT, while this function appears around 3-4 years old (Atance & O'Neill, 2005), it seems to be much less developed than the episodic memory passed on during childhood (Prabhakar & Ghetti, 2020). It is only from the age of 14 that adolescents develop detailed and complete projections into the future (Bohn & Berntsen, 2008).

A developmental study conducted on two groups with ASD of different ages showed better scores in episodic past EM in the second part of adolescence (12–18 years) than in early adolescence (8–12 years) (Goddard et al., 2014). The only longitudinal exploration of AM in ASD to date is a single case study conducted with a child (Bon et al., 2013), which pointed to limited development of past EM and a progressive forgetting of personal knowledge over time. To our knowledge, no study has yet explored the EFT development in ASD.

Cross-sectional research provides snapshots of AM capabilities at various ages but fails to capture the dynamic changes that occur as individuals age and develop. On the other hand, longitudinal studies offer valuable insights into how past EM and EFT develop and interact over critical developmental periods. This distinction is crucial for ASD, where developmental patterns may vary from those observed in the TD population. Therefore, it seems essential to deepen this work by considering the pivotal role of AM in constructing personal identity, social life, and problem-solving.

To fill this gap, we wondered how AM evolves in adolescents with ASD compared to their typically developing peers. Indeed, our study investigated the longitudinal development of past EM and EFT in adolescents with ASD compared to nonautistic controls. By following a cohort of adolescents over three years and assessing their AM abilities annually, we aim to identify specific development patterns. According to the literature, we hypothesized that AM evolves during adolescence in TDs. Concerning ASD, the first hypothesis is that AM difficulties remain stable during adolescence. The second hypothesis is that AM skills develop differently or more slowly during adolescence in comparison with TDs.

## 2. Materials and methods

### 2.1. *Participants*

Twenty-six children started this study (13 ASD and 13 TD), but some completed only one or two years; some did not want to continue, had moved, or were no longer reachable. We chose to keep only adolescents who participated the three times. Thus, six boys with ASD without intellectual disability and five TD adolescent boys, all aged from 12 to 18, were included. Controls were matched in age and intellectual skills with the ASD group (Table 1). Intellectual quotients were evaluated with the Wechsler scales (WISC-IV, Wechsler, 2003; WAIS-IV, Wechsler, 2008). Participants already had a diagnosis of ASD when they were included in the study. The diagnosis was based on the DSM-5 (American Psychiatric Association, 2022) criteria, using the Autism Diagnostic Interview-Revised (Rutter, Le Couteur, & Lord, 2003) and/or the Autism Diagnostic Observation Schedule-Generic (Lord et al., 2000) (Table 2). For all participants, exclusion criteria were attention-deficit disorder with or without hyperactivity, schizophrenia, history of head trauma with loss of consciousness, recent or regular use of alcohol or drugs, chronic neurological or endocrine disorder, medication use likely to interfere with memory measures, and intellectual disabilities assessed with the WISC IV or WAIS-IV. All participants and their parents signed for consent. The study followed international and local (CPP Nord-Ouest, ID-RCB: 2014-A00481-46) ethical procedures.

### 2.2. *Procedure*

Adolescents completed three assessment times (T0, T1, and T2) separated by one year. We used the “From Past to Future Task” developed by Anger et al. (2019) for the AM measure. Participants were asked to freely recall two past events that happened to them (the day before, i.e., recent and last summer vacation, i.e., remote) and to imagine two future events that would happen to them (tomorrow, i.e., recent and the next summer vacation, i.e., remote). Past events had to be real memories that happened to them (e.g., “Can you remember something that happened to you yesterday? I want you to recall it with plenty of details, as if you were reliving this event, and your description has to allow me to imagine this event too”), and future events had to be imagined (e.g., “Can you imagine what you might do tomorrow, either something planned or completely new, but I want you to imagine what could happen with plenty of details, as if you were living this event, and your description has to allow me to imagine this event”). There was no time or word limit, and the participant had to provide as much detail as possible. After 1 min without response, the interviewer asked the children an open-ended question (e.g., ‘What else do you remember?’). After a further minute with no response, the investigator asked the

**Table 1 – Participants' characteristics.**

| | | ASD ($n = 6$) | TD ($n = 5$) | *U* | *p* | *r* |
|---|---|---|---|---|---|---|
| Age at T0<br>Median (inter-quartile range) | | 16.2 (12.7–18.3) | 14.3 (12.5–15.4) | 21.5 | .272 | .317 |
| IQ | Full scale IQ | 95.5 (86.5–110.5) | 105 (97–108) | 10 | .409 | .238 |
| Median (inter-quartile range) | VC | 104 (97–114) | 106 (101–120) | 11.5 | .583 | .158 |
| | PR | 96 (92.5–106) | 107 (96–124) | 11.5 | .583 | .158 |
| | WM | 106 (88–109) | 97 (88–106) | 15 | 1 | 0 |
| | PS | 89.5 (85–92) | 102 (96–103) | 9 | .329 | .282 |

TD: Typically Developing participants; ASD: participants with Autism Spectrum Disorders; IQ: Intellectual Quotient; VC: Verbal Comprehension; PR: Perceptive Reasoning; WM: Working Memory; PS: Processing Speed; U value was calculated using Mann–Whitney test; *r*: Effect size calculated with Rosenthal’s *r*.

**Table 2 – Autism Diagnostic Interview-Revised and Autism Diagnostic Observation Schedule-Generic scores for the ASD group.**

| Participants with ASD | ADI_RSI | ADI_COM | ADI_RRSPB | ADOS_COM | ADOS_RSI | ADOS_total |
|---|---|---|---|---|---|---|
| ASD_1 | 11 | 4 | 2 | / | / | / |
| ASD_2 | 23 | 20 | 5 | / | / | / |
| ASD_3 | / | / | / | 1 | 6 | 7 |
| ASD_4 | / | / | / | 6 | 9 | 15 |
| ASD_5 | 10 | 10 | 4 | / | / | / |
| ASD_6 | 12 | 8 | 6 | 3 | 4 | 7 |

ASD: participants with Autism Spectrum Disorders; ADI: Autism Diagnostic Interview-Revised; ADOS: Autism Diagnostic Observation Schedule-Generic; ADI_RSA: Reciprocal Social Interaction score; ADI_COM: Communication score; ADI_RRSPB: Restricted, Repetitive, and Stereotyped Patterns of Behavior score; ADOS_COM: Communication score; ADOS_RSI: Reciprocal Social Interaction score; ADOS_total: Autism Diagnostic Observation Schedule total score; “/”: the participant has received only one of the two tests.

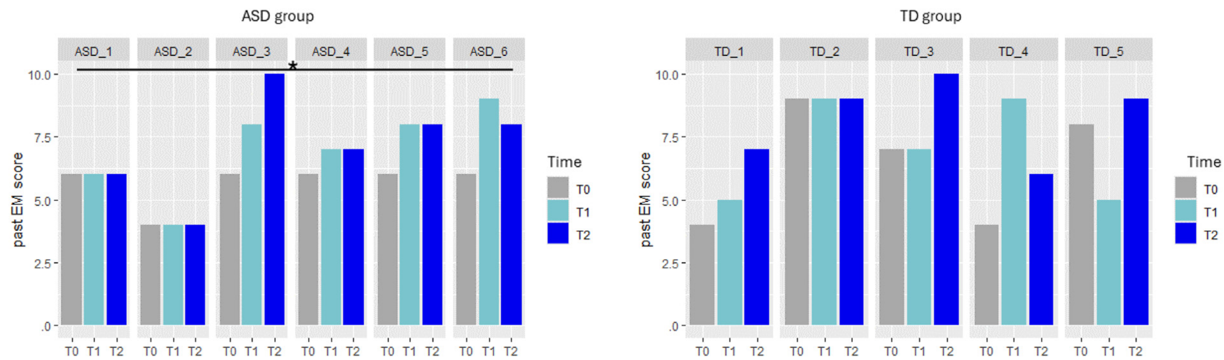


**Fig. 1 – Past EM score over T0, T1, and T2 in the ASD and TD groups. TD: Typically Developing participants; ASD: participants with Autism Spectrum Disorders; past EM: past Episodic Memory. *$p$ < .05 obtained with the Friedman's ANOVA test comparing past EM at the three assessment times in each group: ASD group ($n$ = 6) and TD group ($n$ = 5).**

children more specific questions about the event (not considered in the scoring of this study).

Each event was scored out of 5, with 1 point for each of the following elements: "when", "where", "what", "who", and "how". We added the scores of the two past events to obtain a past EM score (out of 10) and, similarly, with the two future events for an EFT score. The higher the score, the more detailed the events (see Anger et al., 2019, for more methodological details). Then, we explored context elements (the "where" and "when" details) and content elements (the "what", "who", and "how") separately. Scoring was performed individually by two raters. Any disagreements were resolved by discussion. The Cohen's Kappa coefficient between the two raters was .79, with a confidence interval of .66–.93, representing a moderate to high agreement (Landis & Koch, 1977).

### 2.3. *Statistical analyses*

Non-parametric statistical analyses were performed using the software R. We performed a between-groups comparison (TD versus ASD) at each time individually with a Mann–Whitney test. We conducted an intragroup comparison using Friedman's ANOVA to evaluate the evolution over the three assessment timepoints: T0, T1, and T2. Then, the same analysis was repeated by separating content items ("what", "who", and "how") and context items ("when", and "where"). Post-hoc comparisons were performed with a Wilcoxon paired-samples test (differences between T0-T1, T1-T2 and T0-T2 for the ASD group and the TD group for past AM and EFT scores) integrating a Bonferroni correction. Effect sizes were calculated using Rosenthal's r for the Wilcoxon Mann Whitney test and Kendall's W for Friedman's ANOVA. Effect sizes were interpreted as follows: 0–.3: small effect, .3–.5: moderate effect, .5 and over: strong effect (Cohen, 2013).

## 3. Results

Concerning intergroup comparison, no significant differences in past EM and EFT were observed between the TD and ASD groups at T0 (past EM: $U = 21$, $p = .115$, $r = .20$; EFT: $U = 39$, $p = 1$, $r = .16$), T1 (past EM: $U = 33$, $p = .645$, $r = 0$; EFT: $U = 36.5$, $p = .890$, $r = .27$), and T2 (past EM: $U = 10.5$, $p = .460$, $r = .21$; EFT: $U = 5.5$, $p = .093$, $r = .49$).

Intragroup comparison over T0, T1, and T2 showed a significant increase in past EM scores ($\chi2 = 6.86$; $p < .05$; $W = .57$) in the ASD group (Fig. 1), ; there was no significant change in the TD group ($\chi2 = 4.13$; $p > .05$; $W = .41$). Post-hoc analyses did not reveal any significant difference. In the ASD group, the evolution of the past component was characterized by a significant increase in content ($\chi2 = 7.6$, $p < .05$; $W = .63$) subscores but not in context ones [$\chi2$ (2, $n = 6$) = .67, $p = .716$; $W = .23$]; there was no significant change in the TD group (Table 3).

Concerning intragroup comparison over T0, T1, and T2 in EFT scores, no significant change was observed in the ASD group over the three assessment times ($\chi2 = 1.2$; $p > .05$; $W = .10$; see Fig. 2), there was a significant increase of EFT scores in the TD group ($\chi2 = 6.50$; $p < .05$; $W = .65$; see Fig. 2). The post-hoc analysis did not reveal any significant difference. Regarding EFT subscores, there was no significant change in the ASD group; in the TD group, both content ($\chi2 = 6.78$; $p < .05$; $W = .68$) and context ($\chi2 = 6.13$; $p < .05$; $W = .61$) EFT subscores significantly increased over time (Table 3).

## 4. Discussion

This first longitudinal group study showed more detailed past EM across years but no evolution in EFT in adolescents with ASD. In the TD group, results highlighted increased EFT performances but no change in past EM. The exploration of event details revealed that the evolution of past EM in the ASD group is accompanied by increased content elements only but no evolution regarding context. In comparison, the evolution of EFT in TD adolescents is associated with increased both content and context elements.

In this three-year longitudinal study, both groups show different developmental patterns of AM during adolescence. Concerning the ASD group, we report an increased performance in past EM across the three years. The evolution of past EM development in ASD is consistent with Goddard's cross-sectional results (Goddard et al., 2014) and Bon's case study (Bon et al., 2013), which describe improved performance in recalling past memories through adolescence. According to

**Table 3 – From Past to Future task scores for content and context elements for the analysis between T0, T1, and T2.**

| | | ASD ($n = 6$) | | | Friedman's ANOVA | | |
|---|---|---|---|---|---|---|---|
| | | T0 | T1 | T2 | χ2 | *p* | W |
| Past EM median (inter-quartile range) | Content | 4.5 (4–5) | 5.5 (5–6) | 5 (4.25–5.75) | **7.60** | **.022** | **.63** |
| | Context | 1 (1–1.75) | 2 (1.25–2) | 2,5 (1.25–3) | 2.78 | .249 | .23 |
| EFT median (inter-quartile range) | Content | 4 (3.25–4) | 4 (4–4.75) | 5 (5–5) | 4.10 | .129 | .34 |
| | Context | 2 (2–2.75) | 2 (1.25–2.75) | 2 (1.25–2.75) | .67 | .717 | .06 |
| | | **TD ($n = 5$)** | | | **Friedman's ANOVA** | | |
| | | **T0** | **T1** | **T2** | **χ2** | ***p*** | **W** |
| Past EM median (inter-quartile range) | Content | 4 (4–5) | 4 (4–6) | 6 (5–6) | 2.36 | .307 | .24 |
| | Context | 2 (0–3) | 3 (1–3) | 3 (3–3) | 1.73 | .420 | .17 |
| EFT median (inter-quartile range) | Content | 3 (3–4) | 5 (4–5) | 5 (5–5) | **6.78** | **.034** | **.68** |
| | Context | 2 (1–2) | 2 (2–2) | 3 (3–3) | **6.13** | **.047** | **.61** |

TD: Typically Developing participants; ASD: participants with Autism Spectrum Disorders; past EM: past episodic memory; EFT: Episodic future thinking; W: Effect size calculated with Kendall's W. χ2 value calculated using Friedman's ANOVA test. Context is scored out of 2 (One point for each of "where" and "when" details) and content is scored out of 3 (for each of "what", "who", and "how" details).

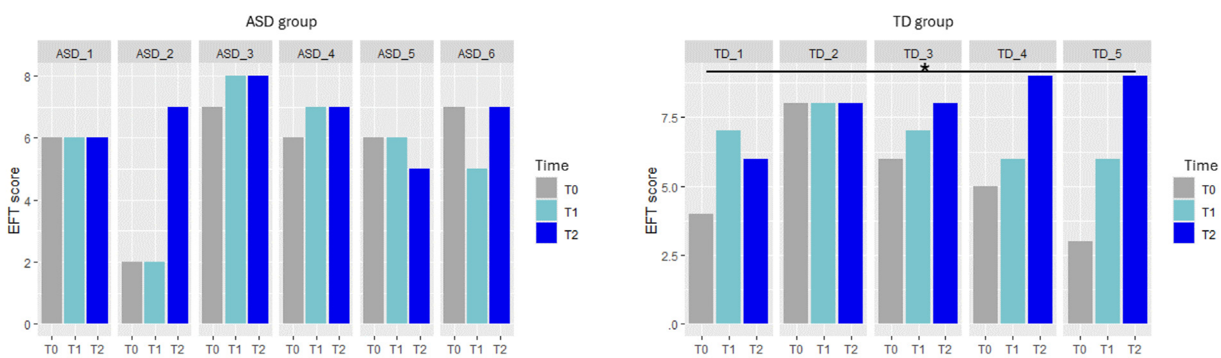


**Fig. 2 – EFT score over T0, T1, and T2 in ASD and TD groups. TD: Typically Developing participants; ASD: participants with Autism Spectrum Disorders; EFT: Episodic future thinking. **p* < .05 obtained with the Friedman's ANOVA test comparing EFT performances at the three assessment times in each group: ASD group ($n = 6$) and TD group ($n = 5$).**

Atance and O'Neill (2005), AM appears around 3-4 years old in TD and continues developing until the beginning of adolescence (Bauer, Burch, Scholin, & Güler, 2007; Cycowicz, Friedman, Snodgrass, & Duff, 2001; Guillery-Girard et al., 2013). Past EM in ASD would, therefore, seem to develop during adolescence and continue until adulthood. Indeed, adults with ASD present lower past EM skills than TD adults (Adler et al., 2010; Crane et al., 2012; Goddard et al., 2007; Tanweer et al., 2010). Given that the average age in these studies is under 40, this raises the question of whether past EM continues to evolve to match TD at a certain age or is slowed down or stopped at some point to remain under TD performances. More research is needed to confirm this hypothesis.

Concerning the future component of AM, while TD participants improved significantly their EFT across the three years, no significative evolution was shown in the ASD group. This evolution in TD is coherent with Gott and Lah's (2014) results that highlighted a more developed EFT for TD adolescents than children. The static nature of EFT through adolescence in ASD compared to its evolution in TD peers seems to point to an atypical developmental profile. Nevertheless, the absence of any significative difference between the two groups does not allow us to interpret this result further. However, it opens up a field for future research to explore the hypothesis of a developmental delay of AM.

In this line, previous studies suggest that EFT could develop later. Lind and Bowler (2010) proposed the necessity of a greater cognitive mobilization to create future projections compared to recalling past memories, regardless of the population (ASD or TD adults). Many studies showed that TD individuals produce significantly more accurate, specific, and detailed past events than future ones (Anderson & Dewhurst, 2009; Ben Malek, Berna, & D'Argembeau, 2017; Crane, Lind, & Bowler, 2013; Gott & Lah, 2014). These behavioral data are accompanied by increased hippocampal recruitment during EFT tasks compared to past EM tasks (Addis et al., 2007, 2009, 2011; Martin, Schacter, Corballis, & Addis, 2011; Okuda et al., 2003; Weiler, Suchan, & Daum, 2009). This increase could be linked to the recruitment of complex cognitive mechanisms involved in imagining new events. Indeed, according to the theory of "constructive episodic simulation" (Schacter & Addis, 2007a; 2007b), EFT requires a highly flexible system capable not only of selecting and extracting elements from the past but also of manipulating and recombining them to develop a coherent scenario in the future (Addis, Pan, Vu, Laiser, & Schacter, 2009; Schacter, Addis, & Buckner, 2007, 2008).

The ASD population presents binding problems (Bowler, Gaigg, & Lind, 2010) related to poor central coherence (Happé & Frith, 2006), which could participate in difficulty linking details from the past to construct a future projection (Maister & Plaisted-Grant, 2011). Moreover, ASD presents executive dysfunctions (Hill, 2004) that can impact the mobilizing of complex memory processes such as EFT (Bowler et al., 2000; Marcaggi, Bon, Eustache, & Guillery-Girard, 2010). Goddard et al. (2014) reported that AM difficulties in ASD were associated with executive dysfunctions. More recently, a meta-analysis (Ye et al., 2021) also highlighted the impairment of "mental time travel" in individuals with ASD of different ages (adults and children), which includes projecting the self in the past and/or the future. Other studies have reported poorer EFT skills and evoked a link with difficulties in narrative production skills in children with ASD (Ferretti et al., 2018; Marini et al., 2019), spatial navigation, and scene construction in adults with ASD (Lind, Bowler et al., 2014; Lind, Williams, et al., 2014). All these factors could contribute to more complexity in the development of EFT in autism during adolescence. An avenue worth exploring in future studies.

One other interesting finding from the study is that the improvement in past EM in the ASD group focused on content items (the "what", "who", and "how") with no evolution in context elements (the "where" and "when"). In the control group, the improvement of EFT was through both content and context details. Difficulties in recalling context have previously been described for past and future episodes in the ASD population (Goldman, 2008; Lind, Williams, et al., 2014). The lack of spatial elements observed in AM development may be associated with a spatial navigation impairment in adults with ASD (Lind, Williams, Raber, Peel, & Bowler, 2013) in relation to impaired scene construction, self-projection, and especially projection into the future in ASD (Lind, Bowler et al., 2014). Scene construction refers to the mental process that allows for generating and maintaining a multimodal spatial representation (Hassabis & Maguire, 2007). This process involves the hippocampus binding these details using relational memory (Martin et al., 2011; Piolino et al., 2008; Schacter & Addis, 2007a), a type of memory that is affected in ASD (Happé & Frith, 2006; Maister, Simons, & Plaisted-Grant, 2013). In a recent review, Agron, Martin, and Gilmore (2024) mention that beyond the social deficits widely explored in ASD, scene construction and spatial navigation difficulties are partially responsible for AM impairments and could represent new avenues for understanding ASD. Time perception is less studied in ASD but seems to be also affected. Boucher, Pons, Lind, and Williams (2007) propose the existence of atypical 'diachronic thinking' (the ability to apprehend a fact or set of facts as they evolve over time), which may be linked to the lack of binding in autism (Brock, Brown, Boucher, & Rippon, 2002).

The heterogeneous evolution of AM in adolescents with or without ASD leads us to posit the hypothesis of a developmental delay. Our preliminary results, corroborated by previous studies, highlight that past EM is still developing in ASD during adolescence, a period during which TD adolescents usually would have already developed this function and would continue to develop more elaborate mechanisms such as EFT. The idea of a developmental delay in ASD is evocated in some longitudinal studies concerning executive functions. Ozonoff and McEvoy (1994) report a slight improvement in executive functions during adolescence in an ASD group without catching up with the performances of the TD participants over the three years of their study. Likewise, Skogli, Andersen, Orm, Hovik, and Øie (2024) reported more difficulties in daily executive functions in adolescents with ASD compared to TD. These difficulties remain relatively stagnant after a 2-year longitudinal follow-up, with no evolution for the ASD group. Furthermore, the developmental delay hypothesis also appears in a longitudinal study following a group of adolescents with ASD for ten years. This study demonstrated that, over time, ASD adolescents improved in certain executive functions, such as working memory performance. However, they still displayed difficulties relative to the TD group without catching up (Fossum, Andersen, Øie, & Skogli, 2021).

Considering the inter-group comparison between the ASD and the TD groups at each time point separately, we found no significant difference in past AM and EFT between the two groups. Although this is the first longitudinal group study, our sample size remains small, and a lack of power could explain this lack of difference. Nevertheless, the study of Anger et al. (2019) using the same AM task with a transversal approach and larger samples showed that adolescents with ASD performed less than controls for past EM and EFT. These results are coherent with other studies where children with ASD usually perform worse than TD peers in the past EM and EFT (Ciaramelli et al., 2018; Lind, Williams et al., 2014; Marini et al., 2019; Terrett et al., 2013). However, another explanation could be that we combine recent and remote events to score each past and future direction. Goddard et al. (2014) found poorer past EM in the remote past but preserved recent memory in children with ASD. Future studies are needed to explore the evolution of the distant time perspective.

Understanding the developmental trajectories of AM in ASD is crucial for developing targeted interventions supporting social integration, identity formation, and future planning capabilities in this population. Thinking about a self-defining future and past event would lead participants to conceptualize themselves more regarding their psychological traits (D'Argembeau & Garcia Jimenez, 2023). As Westby (2022) mentioned, the ability to reflect on past actions and decisions to adapt to future challenges impacts self-regulation skills in ASD. Thus, according to this same review, difficulties in EFT and, more broadly, in mental time travel are accompanied by difficulties in regulating one's self, actions, and decisions. Moreover, as mentioned above, AM plays a key role in the social life of the individual (Bluck et al., 2005; Fivush, 2011). The link between social difficulties in ASD and AM has been widely discussed in the literature (Coutelle et al., 2020; Goddard et al., 2007; Goldman, 2008; Wantzen et al., 2021). A deficit or delay in acquiring AM could also contribute to the social difficulties encountered by this population.

This must allow clinicians to consider AM better in their interventions. Indeed, in previous work, we set up a psychoeducation program around AM for adolescents with ASD (Wantzen et al., 2021). We highlighted the beneficial effect of this training on social aspects. These are encouraging results that need to be pursued. The present study, suggesting a heterogenous pattern in the development of AM, emphasizes the importance of working on this cognitive skill. This is especially true for this pivotal period of adolescence/early adulthood, during which crucial decisions arise, such as the choice of socio-professional orientation and life projects that open problematic questions for people with ASD and their entourage (Cheak-Zamora, Nowell, Helterbrand, & Tait, 2021).

## 5. Limitations

Because of the small sample size, the results presented here require replication with a bigger cohort. Indeed, this restricts the power of our study to demonstrate an eventual significative difference between our groups (ASD versus TD) that limited our interpretation. On the other hand, a small sample can further reinforce intragroup variability. To consider this variability, we have opted for the graphic representation of each individual separately. Furthermore, the limited number of participants limits our results' generalizability. For example, the comparison between the two groups revealed a moderate effect size for age, which suggests a moderate difference between the two groups in terms of age, which should lead to a cautious interpretation of the results. Nevertheless, in line with the delay development hypothesis, we found a strong size effect in all significant analyses and a weak or moderate effect in all non-significant analyses which is coherent with our results. Despite these limitations, the present longitudinal approach is novel and gives a new dimension to understanding the development of AM in ASD. Although this study is only preliminary and cannot provide an exact conclusion as to the developmental profile of AM in ASD, it does open the door to interesting questions about the possibility of developmental delay. It also encourages more studies on this subject, given the role that AM plays in the development of an adolescent.

## 6. Conclusion

The present investigation aims to start the path toward a better understanding of the development of AM in adolescents with ASD. Our study provides the first longitudinal suggestion of heterogenous developmental trajectories of AM in ASD, highlighting the need for further research with larger sample sizes to validate and extend these findings. We argue this is a critical scientific endeavor due to the tight links between AM and daily life impairments in adolescents with ASD. Future studies are needed to confirm this development pattern and explore cognitive factors involved, including social impairments, executive functions, central coherence or mental time travel. Future directions should investigate the potential benefits of specific interventions to enhance past and future episodic memory. By addressing these areas, we can better support the social development of adolescents with ASD, ultimately aiding their integration and identity construction.

## Transparency and openness promotion

For reasons of confidentiality required by the ethics committee, raw data is only accessible upon request from the corresponding author through a collaboration agreement. Processed data and code are available at https://zenodo.org/records/14014622. No part of the study procedures and analyses was pre-registered prior to the research being conducted. We report all data exclusions, all inclusion/exclusion criteria, whether inclusion/exclusion criteria were established prior to data analysis, all manipulations, and all measures in the study. Given that no longitudinal study has yet been carried out on this subject and with this population, we were unable to calculate the sample size. In addition, this study is proposed as a multiple case study.

## CRediT authorship contribution statement

**Rima Touati:** Writing – original draft, Visualization, Formal analysis. **Fabian Guénolé:** Writing – review & editing, Validation, Resources. **Bérengère Guillery-Girard:** Writing – review & editing, Validation, Supervision, Project administration, Methodology, Investigation, Funding acquisition, Formal analysis, Conceptualization. **Prany Wantzen:** Writing – review & editing, Visualization, Validation, Supervision, Project administration, Investigation, Conceptualization.


## Funding

This study was supported by PHRC N∘ ID-RCB: 2014-A00481-46.


## Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that might have appeared to influence the work presented in this article.


## Acknowledgments

We are indebted to all the adolescents and their families participating in this study. We thank the team at the Calvados-Orne-Manche Autism Resource Center. We are grateful to the psychologists Lucie Raoul and Clémentine Piet. We thank David Corredor for his review.


## REFERENCES


Atance, C. M., & O'Neill, D. K. (2001). Episodic future thinking. *Trends in Cognitive Sciences, 5*(12), 533–539. https://doi.org/10.1016/S1364-6613(00)01804-0

Atance, C. M., & O'Neill, D. K. (2005). The emergence of episodic future thinking in humans. *Learning and Motivation, 36*(2), 126–144. https://doi.org/10.1016/j.lmot.2005.02.003

Anderson, R. J., & Dewhurst, S. A. (2009). Remembering the past and imagining the future : Differences in event specificity of spontaneously generated thought. *Memory, 17*(4). https://doi.org/10.1080/09658210902751669

American Psychiatric Association. (2022). *Diagnostic and statistical Manual of mental disorders (DSM-5-TR)*. American Psychiatric Association Publishing. https://doi.org/10.1176/appi.books.9780890425787
Addis, D. R., Wong, A. T., & Schacter, D. L. (2007). Remembering the past and imagining the future : Common and distinct neural substrates during event construction and elaboration. *Neuropsychologia, 45*(7). https://doi.org/10.1016/j.neuropsychologia.2006.10.016
Addis, D. R., Pan, L., Vu, M.-A., Laiser, N., & Schacter, D. L. (2009). Constructive episodic simulation of the future and the past : Distinct subsystems of a core brain network mediate imagining and remembering. *Neuropsychologia, 47*(11). https://doi.org/10.1016/j.neuropsychologia.2008.10.026
Adler, N., Nadler, B., Eviatar, Z., & Shamay-Tsoory, S. G. (2010). The relationship between theory of mind and autobiographical memory in high-functioning autism and Asperger syndrome. *Psychiatry Research, 178*(1), 214–216. https://doi.org/10.1016/j.psychres.2009.11.015
Addis, D. R., Cheng, T., Roberts, P., & Schacter, D. L. (2011). Hippocampal contributions to the episodic simulation of specific and general future events. *Hippocampus, 21*(10). https://doi.org/10.1002/hipo.20870
Anger, M., Wantzen, P., Le Vaillant, J., Malvy, J., Bon, L., Guénolé, F., et al. (2019). Positive effect of visual cuing in episodic memory and episodic future thinking in adolescents with autism spectrum disorder. *Frontiers in Psychology, 10*, 1513. https://doi.org/10.3389/fpsyg.2019.01513
Agron, A. M., Martin, A., & Gilmore, A. W. (2024). Scene construction and autobiographical memory retrieval in autism spectrum disorder. *Autism Research, 17*(2), 204–214. https://doi.org/10.1002/aur.3066
Buckner, R. L., & Carroll, D. C. (2007). Self-projection and the brain. *Trends in Cognitive Sciences, 11*(2), 49–57. https://doi.org/10.1016/j.tics.2006.11.004
Bohn, A., & Berntsen, D. (2008). Life story development in childhood : The development of life story abilities and the acquisition of cultural life scripts from late middle childhood to adolescence. *Developmental Psychology, 44*(4), 1135–1147. https://doi.org/10.1037/0012-1649.44.4.1135
Bluck, S., & Alea, N. (2011). Crafting the TALE : Construction of a measure to assess the functions of autobiographical remembering. *Memory, 19*(5), 470–486. https://doi.org/10.1080/09658211.2011.590500
Benoit, R. G., & Schacter, D. L. (2015). Specifying the core network supporting episodic simulation and episodic memory by activation likelihood estimation. *Neuropsychologia, 75*, 450–457. https://doi.org/10.1016/j.neuropsychologia.2015.06.034
Ben Malek, H., Berna, F., & D'Argembeau, A. (2017). Reconstructing the times of past and future personal events. *Memory, 25*(10). https://doi.org/10.1080/09658211.2017.1310251
Bowler, D. M., Gardiner, J. M., & Grice, S. J. (2000). Episodic memory and remembering in adults with Asperger syndrome. *Journal of Autism and Developmental Disorders, 30*(4). https://doi.org/10.1023/A:1005575216176. Article 4.
Brock, J., Brown, C. C., Boucher, J., & Rippon, G. (2002). The temporal binding deficit hypothesis of autism. *Development and Psychopathology, 14*(2), 209–224.
Bluck, S., Alea, N., Habermas, T., & Rubin, D. C. (2005). A TALE of three functions : The self–reported uses of autobiographical memory. *Social Cognition, 23*(1), 91–117. https://doi.org/10.1521/soco.23.1.91.59198
Bauer, P. J., Burch, M. M., Scholin, S. E., & Güler, O. E. (2007). Using cue words to investigate the distribution of autobiographical memories in childhood. *Psychological Science, 18*(10), 910–916. https://doi.org/10.1111/j.1467-9280.2007.01999.x
Boucher, J., Pons, F., Lind, S., & Williams, D. (2007). Temporal cognition in children with autistic spectrum disorders : Tests of diachronic thinking. *Journal of Autism and Developmental Disorders, 37*(8), 1413–1429. https://doi.org/10.1007/s10803-006-0285-9
Bruck, M., London, K., Landa, R., & Goodman, J. (2007). Autobiographical memory and suggestibility in children with autism spectrum disorder. *Development and Psychopathology, 19*(1). https://doi.org/10.1017/S0954579407070058
Bowler, D., Gaigg, S., & Lind, S. (2010). Memory in autism : Binding, self and brain. In I. Roth, & P. Rezaie (Eds.), *Researching the autism spectrum* (pp. 316–346). Cambridge University Press. https://doi.org/10.1017/CBO9780511973918.013.
Bon, L., Baleyte, J.-M., Piolino, P., Desgranges, B., Eustache, F., & Guillery-Girard, B. (2013). Growing up with asperger's syndrome : Developmental trajectory of autobiographical memory. *Frontiers in Psychology, 3*. https://doi.org/10.3389/fpsyg.2012.00605
Conway, M. A. (2005). Memory and the self. *Journal of Memory and Language, 53*(4), 594–628. https://doi.org/10.1016/j.jml.2005.08.005
Cohen, J. (2013). *Statistical power analysis for the behavioral sciences*. Routledge. https://doi.org/10.4324/9780203771587
Cycowicz, Y. M., Friedman, D., Snodgrass, J. G., & Duff, M. (2001). Recognition and source memory for pictures in children and adults. *Neuropsychologia, 39*(3), 255–267. https://doi.org/10.1016/S0028-3932(00)00108-1
Crane, L., Pring, L., Jukes, K., & Goddard, L. (2012). Patterns of autobiographical memory in adults with autism spectrum disorder. *Journal of Autism and Developmental Disorders, 42*(10), 2100–2112. https://doi.org/10.1007/s10803-012-1459-2
Crane, L., Lind, S. E., & Bowler, D. M. (2013). Remembering the past and imagining the future in autism spectrum disorder. *Memory, 21*(2). https://doi.org/10.1080/09658211.2012.712976
Cooper, R. A., Plaisted-Grant, K. C., Baron-Cohen, S., & Simons, J. S. (2016). Reality monitoring and metamemory in adults with autism spectrum conditions. *Journal of Autism and Developmental Disorders, 46*(6). https://doi.org/10.1007/s10803-016-2749-x
Ciaramelli, E., Spoglianti, S., Bertossi, E., Generali, N., Telarucci, F., Tancredi, R., et al. (2018). Construction of past and future events in children and adolescents with ASD : Role of self-relatedness and relevance to decision-making. *Journal of Autism and Developmental Disorders, 48*(9). https://doi.org/10.1007/s10803-018-3577-y. Article 9.
Coutelle, R., Goltzene, M.-A., Bizet, E., Schoenberger, M., Berna, F., & Danion, J.-M. (2020). Self-concept clarity and autobiographical memory functions in adults with autism spectrum disorder without intellectual deficiency. *Journal of Autism and Developmental Disorders, 50*(11). https://doi.org/10.1007/s10803-020-04447-x
Cheak-Zamora, N. C., Nowell, K., Helterbrand, E., & Tait, A. (2021). Investigating health-related knowledge and independence for physical and mental health conditions in young adults with autism spectrum disorder. *Research in Autism Spectrum Disorders, 85*, Article 101801. https://doi.org/10.1016/j.rasd.2021.101801
D'Argembeau, A. (2021). Memory, future thinking, and the self. In honour of martial van der linden. *Psychologica Belgica, 61*(1), 274–283. https://doi.org/10.5334/pb.1074
D'Argembeau, A., & Van der Linden, M. (2004). Phenomenal characteristics associated with projecting oneself back into the past and forward into the future : Influence of valence and temporal distance. *Consciousness and Cognition, 13*(4). https://doi.org/10.1016/j.concog.2004.07.007
D'Argembeau, A., & Garcia Jimenez, C. (2023). Effects of past and future autobiographical thinking on the working self-concept. *Memory*, 1–16. https://doi.org/10.1080/09658211.2023.2269324

Demetriou, E. A., Lampit, A., Quintana, D. S., Naismith, S. L., Song, Y. J. C., Pye, J. E., et al. (2018). Autism spectrum disorders : A meta-analysis of executive function. *Molecular Psychiatry, 23*(5), 1198–1204. https://doi.org/10.1038/mp.2017.75

Desaunay, P., Briant, A. R., Bowler, D. M., Ring, M., Gérardin, P., Baleyte, J.-M., et al. (2020). Memory in autism spectrum disorder : A meta-analysis of experimental studies. *Psychological Bulletin, 146*, 377–410. https://doi.org/10.1037/bul0000225

Fivush, R. (2011). The development of autobiographical memory. *Annual Review of Psychology, 62*(1), 559–582. https://doi.org/10.1146/annurev.psych.121208.131702

Ferretti, F., Adornetti, I., Chiera, A., Nicchiarelli, S., Valeri, G., Magni, R., et al. (2018). Time and narrative : An investigation of storytelling abilities in children with autism spectrum disorder. *Frontiers in Psychology, 9*, 944. https://doi.org/10.3389/fpsyg.2018.00944

Fossum, I. N., Andersen, P. N., Øie, M. G., & Skogli, E. W. (2021). Development of executive functioning from childhood to young adulthood in autism spectrum disorder and attention-deficit/hyperactivity disorder : A 10-year longitudinal study. *Neuropsychology, 35*(8), 809–821. https://doi.org/10.1037/neu0000768

Goldman, S. (2008). Brief report : Narratives of personal events in children with autism and developmental language disorders: Unshared memories. *Journal of Autism and Developmental Disorders, 38*(10). https://doi.org/10.1007/s10803-008-0588-0

Guillery-Girard, B., Martins, S., Deshayes, S., Hertz-Pannier, L., Chiron, C., Jambaqué, I., et al. (2013). Developmental trajectories of associative memory from childhood to adulthood : A behavioral and neuroimaging study. *Frontiers in Behavioral Neuroscience, 7*. https://doi.org/10.3389/fnbeh.2013.00126

Gott, C., & Lah, S. (2014). Episodic future thinking in children compared to adolescents. *Child Neuropsychology, 20*(5). https://doi.org/10.1080/09297049.2013.840362

Goddard, L., Howlin, P., Dritschel, B., & Patel, T. (2007). Autobiographical memory and social problem-solving in asperger syndrome. *Journal of Autism and Developmental Disorders, 37*(2). https://doi.org/10.1007/s10803-006-0168-0

Goddard, L., Dritschel, B., Robinson, S., & Howlin, P. (2014). Development of autobiographical memory in children with autism spectrum disorders : Deficits, gains, and predictors of performance. *Development and Psychopathology, 26*(1), 215–228. https://doi.org/10.1017/S0954579413000904

Hill, E. L. (2004). Executive dysfunction in autism. *Trends in Cognitive Sciences, 8*(1), 26–32. https://doi.org/10.1016/j.tics.2003.11.003

Habermas, T., & Bluck, S. (2000). Getting a life : The emergence of the life story in adolescence. *Psychological Bulletin, 126*(5), 748–769. https://doi.org/10.1037/0033-2909.126.5.748

Happé, F., & Frith, U. (2006). The weak coherence account : Detail-focused cognitive style in autism spectrum disorders. *Journal of Autism and Developmental Disorders, 36*(1), 5–25. https://doi.org/10.1007/s10803-005-0039-0

Hassabis, D., & Maguire, E. A. (2007). Deconstructing episodic memory with construction. *Trends in Cognitive Sciences, 11*(7). https://doi.org/10.1016/j.tics.2007.05.001

Habermas, T., & De Silveira, C. (2008). The development of global coherence in life narratives across adolescence : Temporal, causal, and thematic aspects. *Developmental Psychology, 44*(3), 707–721. https://doi.org/10.1037/0012-1649.44.3.707

Irish, M., & Piguet, O. (2013). The pivotal role of semantic memory in remembering the past and imagining the future. *Frontiers in Behavioral Neuroscience, 7*. https://doi.org/10.3389/fnbeh.2013.00027

La Corte, V., & Piolino, P. (2016). On the role of personal semantic memory and temporal distance in episodic future thinking : The TEDIFT model. *Frontiers in Human Neuroscience, 10*. https://doi.org/10.3389/fnhum.2016.00385

Landis, J. R., & Koch, G. G. (1977). The measurement of observer agreement for categorical data. *Biometrics, 33*(1), 159. https://doi.org/10.2307/2529310

Lord, C., Risi, S., Lambrecht, L., Cook, E. H., Leventhal, B. L., DiLavore, P. C., et al. (2000). The autism diagnostic observation schedule-generic : A standard measure of social and communication deficits associated with the spectrum of autism. *Journal of Autism and Developmental Disorders, 30*(3), 205–223.

Lind, S. E., & Bowler, D. M. (2010). Episodic memory and episodic future thinking in adults with autism. *Journal of Abnormal Psychology, 119*(4). https://doi.org/10.1037/a0020631

Lind, S. E., Williams, D. M., Raber, J., Peel, A., & Bowler, D. M. (2013). Spatial navigation impairments among intellectually high-functioning adults with autism spectrum disorder : Exploring relations with theory of mind, episodic memory, and episodic future thinking. *Journal of Abnormal Psychology, 122*(4), 1189–1199. https://doi.org/10.1037/a0034819

Lind, S. E., Bowler, D. M., & Raber, J. (2014a). Spatial navigation, episodic memory, episodic future thinking, and theory of mind in children with autism spectrum disorder : Evidence for impairments in mental simulation? *Frontiers in Psychology, 5*. https://doi.org/10.3389/fpsyg.2014.01411

Lind, S. E., Williams, D. M., Bowler, D. M., & Peel, A. (2014b). Episodic memory and episodic future thinking impairments in high-functioning autism spectrum disorder : An underlying difficulty with scene construction or self-projection? *Neuropsychology, 28*(1). https://doi.org/10.1037/neu0000005

Maister, L., & Plaisted-Grant, K. C. (2011). Time perception and its relationship to memory in autism spectrum conditions : Time perception in ASC. *Developmental Science, 14*(6). https://doi.org/10.1111/j.1467-7687.2011.01077.x

Marcaggi, G., Bon, L., Eustache, F., & Guillery-Girard, B. (2010). La mémoire dans l'autisme : 40 ans après. *Revue de neuropsychologie, 2*(4). https://doi.org/10.3917/rne.024.0310

Martin, V. C., Schacter, D. L., Corballis, M. C., & Addis, D. R. (2011). A role for the hippocampus in encoding simulations of future events. *Proceedings of the National Academy of Sciences, 108*(33). https://doi.org/10.1073/pnas.1105816108

Maister, L., Simons, J. S., & Plaisted-Grant, K. (2013). Executive functions are employed to process episodic and relational memories in children with autism spectrum disorders. *Neuropsychology, 27*(6), 615–627. https://doi.org/10.1037/a0034492

Marini, A., Ferretti, F., Chiera, A., Magni, R., Adornetti, I., Nicchiarelli, S., et al. (2016). Brief report : Self-based and mechanical-based future thinking in children with autism spectrum disorder. *Journal of Autism and Developmental Disorders, 46*(10), 3353–3360. https://doi.org/10.1007/s10803-016-2867-5

Marini, A., Ferretti, F., Chiera, A., Magni, R., Adornetti, I., Nicchiarelli, S., et al. (2019). Episodic future thinking and narrative discourse generation in children with Autism Spectrum Disorders. *Journal of Neurolinguistics, 49*, 178–188. https://doi.org/10.1016/j.jneuroling.2018.07.003

Ozonoff, S., & McEvoy, R. E. (1994). A longitudinal study of executive function and theory of mind development in autism. *Development and Psychopathology, 6*(3), 415–431. https://doi.org/10.1017/S0954579400006027

Okuda, J., Fujii, T., Ohtake, H., Tsukiura, T., Tanji, K., Suzuki, K., et al. (2003). Thinking of the future and past : The roles of the frontal pole and the medial temporal lobes. *Neuroimage, 19*(4). https://doi.org/10.1016/S1053-8119(03)00179-4

Prabhakar, J., & Ghetti, S. (2020). Connecting the dots between past and future : Constraints in episodic future thinking in early childhood. *Child Development, 91*(2). https://doi.org/10.1111/cdev.13212

Piolino, P., Desgranges, B., Hubert, V., Bernard, F. A., Matuszewski, V., Chételat, G., et al. (2008). Reliving lifelong episodic autobiographical memories via the hippocampus : A correlative resting PET study in healthy middle-aged subjects. *Hippocampus, 18*(5), 445–459. https://doi.org/10.1002/hipo.20406

Reese, E. (2009). The development of autobiographical memory : Origins and consequences. In *Advances in child development and behavior* (Vol. 37, pp. 145–200). Elsevier. https://doi.org/10.1016/S0065-2407(09)03704-5.

Reese, E. (2013). Taking the long way : Longitudinal approaches to autobiographical memory development. In P. J. Bauer, & R. Fivush (Eds.), *The wiley handbook on the development of children's memory* (1re éd, pp. 972–995). Wiley. https://doi.org/10.1002/9781118597705.ch41.

Robinson, S., Howlin, P., & Russell, A. (2017). Personality traits, autobiographical memory and knowledge of self and others : A comparative study in young people with autism spectrum disorder. *Autism: the International Journal of Research and Practice, 21*(3), 357–367. https://doi.org/10.1177/1362361316645429

Rutter, M., Le Couteur, A., & Lord, C. (2003). Autism Diagnostic Interview-Revised. Western Psychological Services.

Schacter, D. L., Addis, D. R., & Buckner, R. L. (2007). Remembering the past to imagine the future : The prospective brain. *Nature Reviews Neuroscience, 8*(9). https://doi.org/10.1038/nrn2213. Article 9.

Schacter, D. L., & Addis, D. R. (2007a). The cognitive neuroscience of constructive memory : Remembering the past and imagining the future. *Philosophical Transactions of the Royal Society B: Biological Sciences, 362*(1481). https://doi.org/10.1098/rstb.2007.2087. Article 1481.

Schacter, D. L., & Addis, D. R. (2007b). The ghosts of past and future. *Nature, 445*(7123). https://doi.org/10.1038/445027a. Article 7123.

Schacter, D. L., Addis, D. R., & Buckner, R. L. (2008). Episodic simulation of future events : Concepts, data, and applications. *Annals of the New York Academy of Sciences, 1124*(1). https://doi.org/10.1196/annals.1440.001. Article 1.

Skogli, E. W., Andersen, P. N., Orm, S., Hovik, K. T., & Øie, M. G. (2024). Executive functioning in everyday life in youth with attention-deficit/hyperactivity disorder and autism spectrum disorders : A two-year longitudinal study. *International Journal of Disability, Development and Education, 71*(3), 373–388. https://doi.org/10.1080/1034912X.2022.2095360

Tanweer, T., Rathbone, C. J., & Souchay, C. (2010). Autobiographical memory, autonoetic consciousness, and identity in Asperger syndrome. *Neuropsychologia, 48*(4), 900–908. https://doi.org/10.1016/j.neuropsychologia.2009.11.007

Terrett, G., Rendell, P. G., Raponi-Saunders, S., Henry, J. D., Bailey, P. E., & Altgassen, M. (2013). Episodic future thinking in children with autism spectrum disorder. *Journal of Autism and Developmental Disorders, 43*(11). https://doi.org/10.1007/s10803-013-1806-y. Article 11.

Westby, C. (2022). Nature and effects of autobiographical memory issues in persons with autism spectrum disorders. *Neuropsychiatric Disease and Treatment, 18*, 2279–2293. https://doi.org/10.2147/NDT.S332521

Wechsler, D. (2003). Wechsler Intelligence Scale for Children – Fourth Edition (WISC-IV). The Psychological Corporation.

Wechsler, D. (2008). *Wechsler Adult Intelligence Scale-Fourth Edition.* The Psychological Corporation.

Weiler, J. A., Suchan, B., & Daum, I. (2009). Foreseeing the future : Occurrence probability of imagined future events modulates hippocampal activation. *Hippocampus*. https://doi.org/10.1002/hipo.20695. NA-NA.

Wantzen, P., Boursette, A., Zante, E., Mioche, J., Eustache, F., Guénolé, F., et al. (2021). Autobiographical memory and social identity in autism : Preliminary results of social positioning and cognitive intervention. *Frontiers in Psychology, 12*. https://doi.org/10.3389/fpsyg.2021.641765

Ye, J., Qin, X., Cui, J., Ren, Q., Jia, L., Wang, Y., et al. (2021). A meta-analysis of mental time travel in individuals with autism spectrum disorders. *Journal of Autism and Developmental Disorders*. https://doi.org/10.1007/s10803-021-05375-0