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SHORT PAPER

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No evidence of association between autism spectrum quotient and spontaneous mental time travel in a general adult sample performing an online vigilance task

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Abstract

Evidence supports the dissociation of voluntary and spontaneous routes to past and future thinking, collectively referred to as mental time travel (MTT). If the diminished voluntary MTT ability found in autism spectrum disorders (ASD) is attributable to a deficit in constructive/generative processes not necessary for spontaneous MTT, ASD traits (*Autism Spectrum Quotient* score) in a general adult sample should *not* be related to total spontaneous thoughts, probability of past or future thoughts, or probability of specific thoughts during an undemanding vigilance task. Results supported this hypothesis: AQ was not associated with total spontaneous thoughts and did not significantly predict the other measures. This is the first study to explore spontaneous MTT in relation to ASD traits, further supporting the argument that voluntary MTT may be compromised in ASD due to reliance on constructive/generative processes and reinforcing the notion of dissociable cognitive routes to MTT.

KEYWORDS

autism spectrum, autism spectrum quotient, episodic future thinking, episodic memory, mental time travel, spontaneous cognition

1 | INTRODUCTION

Mental time travel (MTT) refers to the complex cognitive ability to mentally relive past experiences (i.e., episodic autobiographical memory) and 'pre-live' potential future experiences (*episodic future thinking*; Atance & O'Neill, 2001). Episodic memory retrieval and future simulation are intimately related, both drawing on information stored in long-term memory (i.e., episodic details) and relying on overlapping cognitive processes (Atance & O'Neill, 2001; Schacter & Addis, 2007). A plethora of literature supports this link; for example, amnesic patients unable to recall their personal past also have difficultly imagining possible future events (Klein et al., 2002). Additionally, Williams et al. (1996) found participants who recalled general rather than specific memories were also less specific when generating future events. However, this approach has recently been questioned as it fails to account for *spontaneous* future thinking (SFT; Cole & Kvavilashvili, 2019). Spontaneous cognitive phenomena, including SFT, have received little attention in comparison to their voluntary counterparts (but see Cole et al., 2016; Plimpton et al., 2015; Schlagman & Kvavilashvili, 2008).

In their *dual process account*, Cole and Kvavilashvili (2021) propose that future thoughts occur via two alternate routes, each associated with distinct cognitive processes and functions. Voluntary MTT relies on deliberate, constructive, and effortful processes (Schacter & Addis, 2007); while spontaneous MTT relies on automatic processes, enabling thoughts to come to mind freely, often triggered by internal or external cues (Cole & Kvavilashvili, 2019, 2021). Cole and Kvavilashvili

(2021) further suggest that most SFTs consist of previously constructed event representations, or 'memories of the future', retrieved according to well-established memory processes—thereby explaining their rapid and subjectively effortless occurrence (see also Berntsen, 2019).

Correspondingly, theoretical approaches to autobiographical memory converge upon the existence of alternate cognitive routes. Conway and Pleydell-Pearce (2000), for instance, distinguish between *generative* and *direct* retrieval. Generative retrieval is a top-down process involving search, evaluation, and elaboration; whereas direct retrieval begins with an internal or external cue initiating a relatively fast, bottom-up process (Conway & Pleydell-Pearce, 2000). Berntsen (1996) more explicitly contrasts voluntary and involuntary autobiographical memory, the distinction resting on the presence/absence of deliberate retrieval attempts. Supporting evidence includes higher proportions of *spatiotemporally specific* involuntary than voluntary memories (Berntsen & Hall, 2004; Berntsen & Jacobsen, 2008); and shorter report latencies for involuntary memories, suggesting less effort in the retrieval process (Schlagman & Kvavilashvili, 2008; see also Uzer et al., 2012). Overall, as for future MTT, we can distinguish between voluntary (intentional, constructive, effortful) and involuntary (unintended, automatic, relatively effortless) routes to retrieving personal memories.

MTT research has expanded into clinical populations such as those with depression, anxiety disorders and OCD (Cole & Tubbs, 2022; Gamble et al., 2019; Wu et al., 2015). For example, individuals with Generalised Anxiety Disorder both struggle to imagine positive future events and rate imagined negative events as more likely to occur (Wu et al., 2015). On the other hand, MTT in neurodevelopmental disorders such as autistic spectrum disorders (ASD) has received less attention. ASD is defined on the basis of social, interaction and communication difficulties, and the presence of repetitive and restrictive behaviours (*DSM-5-TR*; American Psychiatric Association, 2022), varying along a continuum of severity (Lord et al., 2018).

A variety of experimental methods have been utilised to explore voluntary MTT, including autobiographical memory tests, interviews, and sentence completion tasks (e.g., Levine & Safer, 2002; Raes et al., 2007; Williams et al., 1996). These methods converge to show significant impairments in both past and future MTT in adults and children with ASD, characterised by lower retrieval rates, longer latencies and lower specificity/detail (Anger et al., 2019; Chaput et al., 2013; Ciaramelli et al., 2018; Crane et al., 2012; Goddard et al., 2007; Lind, Williams, et al., 2014; Marini et al., 2019; Robinson et al., 2017; Tanweer et al., 2010; Terrett et al., 2013).[1] A recent meta-analysis examined the extent of MTT ability in ASD across variations in participant characteristics (e.g., language ability) and the specific tasks/measures used (Ye et al., 2021). The authors concluded that individuals with ASD exhibited significant reductions in MTT ability (e.g., lower event specificity) with a medium-to-large effect size across 31 studies, and extraneous variables did not account for the observed differences (Ye et al., 2021).

A recent meta-analysis looking at episodic recollection more generally showed that difficulties in free recall in individuals with ASD are frequently not present in cued recall or recognition (Desaunay et al., 2020). This evidence is consistent with the Task Support Hypothesis (Bowler et al., 1997, 2004), which posits that individuals with ASD can recall just as much information as neurotypicals given an appropriate task context. The benefit of such 'task support' in episodic memory retrieval (i.e., use of cued and/or recognition tasks) may result from greater overlap between these tasks and semantic long-term representations (Bowler et al., 1997, 2004). Conversely, difficulties in free recall may stem from the additional cognitive operations and executive demands involved (Desaunay et al., 2020).

Arguably, a typical autobiographical memory or future thinking task is especially demanding, in its reliance on processes of scene construction (i.e., combining disparate sensory-perceptual elements into a coherent scene; Hassabis & Maguire, 2007), self-projection (Buckner & Carroll, 2007), and event elaboration (Schacter & Addis, 2007). Thus, as with episodic recollection more generally (Desaunay et al., 2020), apparent MTT differences between ASD and neurotypical groups (Ye et al., 2021) could be a product of demanding task contexts that do not enable individuals with autism to demonstrate their underlying capacity to experience past/future autobiographical events (see also Cooper & Simons, 2019). Given that access to autobiographical memories and future events also necessitates use of self-referential information (Cabeza & St Jacques, 2007), specific ASD-related deficits in self-referential cognition (i.e., relating information from the external world to oneself) could also be relevant in explaining such differences (Lind & Bowler, 2010).

Despite substantial evidence on voluntary MTT differences in ASD, to our knowledge no study has yet explored whether these extend to *spontaneous* MTT. Perhaps the most relevant existing study used an 'eyes-closed rest' condition to stimulate mind-wandering in adults with ASD and neurotypical controls, quantifying participants' thought content and characteristics using rating scales (Simpraga et al., 2021). While this study did not explicitly target MTT ability or event specificity, the ASD group reported less control over their thoughts, fewer thoughts about others, and lower feelings of comfort.

In summary, the reviewed literature supports the notion that individuals with ASD experience difficulties in deliberately (re)constructing past and future events; and that this is not simply a function of extraneous variables (Ciaramelli et al., 2018; Ye et al., 2021), but of specific difficulties with the necessary constructive/generative processes (Ye et al., 2021). Given the proposed dissociation between voluntary and spontaneous MTT, with spontaneous not reliant on constructive processes (Cole & Kvavilashvili, 2021), it is possible that these differences would not hold for spontaneous thoughts. As a first step towards combining research on spontaneous MTT and ASD, we investigated this possibility in a general adult sample self-reporting continuous trait likelihood of autism using the *Autism Spectrum Quotient* (AQ; Baron-Cohen et al., 2001).[2] To our knowledge, this is the first study to explore MTT according to autistic traits in a non-clinical sample.

To formalise our hypothesis, there should be no association between AQ score and either total spontaneous thought frequency, or the probability of past/future thoughts, in an online vigilance task (Cole et al., 2016). We also examined the spatiotemporal specificity of spontaneous thoughts (cf. Tanweer et al., 2010). Again, if the typical MTT deficit in autism reflects problems with effortful constructive processes, we should find no association between AQ score and specific thought probability.

2 | METHOD

2.1 | Participants

Participants comprised psychology undergraduates at York St John University alongside respondents to social media (e.g., Twitter) adverts. Students received course credits for participation; others participated voluntarily without incentives. The total sample of 80 individuals comprised 57 females, 16 males, and 6 reporting other gender identities (one participant's gender was not recorded), with a mean age of 21.4 ($SD = 6.49$) years. There were no a priori exclusion criteria.

2.2 | Design

The study utilised a mixed models design, with variables defined at item (i.e., thought) and cluster (i.e., participant) levels. Besides age and gender, participant-level variables were total AQ score (Baron-Cohen et al., 2001) and total spontaneous thoughts captured during an online vigilance task (see Materials). Thought-level variables comprised two dummy variables representing temporal orientation (past vs. all others, future vs. all others) and one representing specificity (specific, not specific). In this context, *past* and *future* categories distinguish involuntary memories and SFTs, respectively (Berntsen & Jacobsen, 2008); *specificity* distinguishes thoughts referring to specific, episodic events from more general/semantic thoughts (Berntsen & Hall, 2004).

2.3 | Materials

2.3.1 | Autism spectrum quotient

The AQ (Baron-Cohen et al., 2001) is a self-report instrument assessing trait likelihood of ASD in the general adult population. It consists of 50 statements, rated on a 4-point Likert scale (*definitely agree*, *slightly agree*, *slightly disagree*, *and definitely disagree*). The statements cover five areas: social skills, communication skills, imagination, attention to detail, and attention switching/tolerance of change. Half the items (e.g., 'I prefer to do things the same way over and over again') are positively scored, with slightly/definitely agree to add one point (and 'disagree' responses disregarded). The other half (e.g., 'It does not upset me if my daily routine is disturbed') are reverse scored so that 'disagree' responses add one point ('agree' responses are disregarded). Total scores therefore range from 0 (minimal trait likelihood) to 50 (highest trait likelihood). Psychometric evaluation has shown good test/re-test reliability and internal consistency ($\alpha > .80$, Baron-Cohen et al., 2001; Stevenson & Hart, 2017). For the present study, AQ score was treated as a continuum to maximise statistical robustness.

2.3.2 | Vigilance task

The paradigm used here was originally developed by Schlagman and Kvavilashvili (2008) to capture involuntary memories and subsequently adapted for SFTs (Cole et al., 2016). As in Cole et al. (2016), the present study elicited spontaneous thoughts via the *self-caught* method where participants are encouraged to pause the task whenever a spontaneous thought comes to mind.[3] The task consisted of 30 practice trials and 600 main trials, each of 1.5 s duration, displaying either horizontal or vertical lines. Participants were tasked with detecting occasional (vertical) target stimuli among a monotonous stream of (horizontal) non-target stimuli, pressing 'spacebar' on their computer keyboard in response (21 times, pseudo-randomly throughout the task; every 25–30 trials). Task duration was around 20 min.

During the main experimental block, participants were asked to press 'S', pausing the task, whenever a spontaneous thought came to mind. On each occasion, they were asked to write a brief description of the thought and determine whether it related to the past, future, present, or was atemporal (i.e., not located in time). Finally, participants indicated whether the thought was specific: 'Does this thought refer to a particular situation on a particular day in your past or future?' (yes/no).[4] They then pressed spacebar to return to the task.

2.4 | Procedure

Participants completed the study online via the Gorilla platform (www.gorilla.sc; Anwyl-Irvine et al., 2020). After providing informed consent, participants completed the AQ questionnaire before moving onto the vigilance task. After this, the experiment ended and participants were presented with a debriefing sheet outlining full study aims.

3 | RESULTS

3.1 | Descriptive statistics and preliminary analysis

Mean total AQ score was 23.8 ($SD = 8.5$, range 4–42), with scores on this variable being normally distributed ($S = 0.004$, $SE = 0.27$, $z = 0.01$, $p > .50$). Participants reported an average of 6.9 spontaneous thoughts ($SD = 11.3$); this distribution was positively skewed ($S = 5.32$, $SE = 0.27$, $z = 19.4$, $p < .001$), motivating the use of a non-parametric correlation coefficient (Kendall's τ) below. Table 1 gives a breakdown of spontaneous thought frequency for the whole sample,

TABLE 1 Spontaneous thought frequency by temporal orientation and specificity.

	Past	Present/atemporal	Future	Total
Specific	86	95	115	296
Not Specific	29	192	35	256
Total	115	287	150	552

according to temporal orientation (past, present/atemporal, future) and specificity (specific, not specific).

First, we computed Kendall's τ between total AQ score and overall spontaneous thoughts and used Bayesian inference to test the directional hypothesis of a negative association. Results showed a near-zero positive correlation ($\tau_{(80)} = .06$) and strong evidence for the null hypothesis (no association) over the possibility of a negative association ($BF_{01} = 11.8$, 95% credible interval [−.130, −.002]).

3.2 | Mixed logistic regression analyses

We next computed three mixed logistic regression analyses on different outcome probabilities at the thought level. Since the odds of a given thought being past, specific, and so forth were indeterminate for participants reporting zero spontaneous thoughts ($n = 19$), these individuals were excluded. Importantly, however, they did not differ from included participants ($n = 61$) in total AQ score ($t_{(78)} = 0.743$, $p = .46$), age ($t_{(77)} = -1.16$, $p = .25$), or gender ($\chi^2_{(2)} = 2.51$, $p = .29$).

The first analysis predicted the odds of 'past' responses (regardless of specificity) based on total AQ score (with random intercepts per participant). This yielded a non-significant effect of AQ score ($\chi^2_{(1)} = 0.24$, $p = .63$), with the accompanying odds ratio (exp(B) = 0.991, 95% CI [0.957, 1.027]) equating to an average reduction of <1% in the relative probability of past spontaneous thoughts per point increase in AQ score. An equivalent analysis predicting the odds of future spontaneous thoughts (regardless of specificity) also yielded a non-significant effect of AQ score ($\chi^2_{(1)} = 0.58$, $p = .45$), with the odds ratio (exp(B) = 0.987, 95% CI [0.954, 1.021]) suggesting an average reduction of ∼1% in relative probability per point increase in AQ. Thus, the odds of engaging in spontaneous *mental time travel* (as opposed to present/atemporal thinking) were not significantly related to participants' AQ score.

Finally, we analysed the odds of *specific* spontaneous thoughts. Predictors comprised AQ score, past orientation, future orientation, and the interaction effects AQ*past and AQ*future (plus a random intercept term). Results showed a non-significant effect of AQ score ($\chi^2_{(1)} = 0.11$, $p = .74$), with the odds ratio (exp(B) = 1.008, 95% CI [0.962, 1.060]) indicating that higher-AQ participants were no less likely to report specific thoughts. There were also significant effects of past ($\chi^2_{(1)} = 55.96$, $p < .001$) and future orientation ($\chi^2_{(1)} = 64.21$, $p < .001$), indicating that these were much more likely to be tagged as specific than were present/atemporal thoughts (unsurprising given the provided definition of specificity; see *Method*). Finally, both interaction effects were non-significant ($\chi^2_{(1)} < 0.20$, $p > .60$), indicating that the high level of specificity among past/future thoughts was not dependent on AQ score.

4 | DISCUSSION

The present study aimed to contribute to understanding of spontaneous MTT by exploring the effects of autistic trait likelihood (AQ; Baron-Cohen et al., 2001) on spontaneous thoughts during an online vigilance task (Cole et al., 2016; Plimpton et al., 2015; Vannucci et al., 2017). In combining two areas of research with little existing overlap, we aimed to stimulate further, focussed research on different forms of MTT across the autistic spectrum, including in those with a formal diagnosis.

Existing literature argues for a dissociation between voluntary and spontaneous processes in MTT (Berntsen & Jacobsen, 2008; Cole & Kvavilashvili, 2021). The diminished capacity for voluntary MTT seen in individuals with autism (e.g., Ciaramelli et al., 2018; Tanweer et al., 2010; meta-analysis by Ye et al., 2021) has been ascribed to difficulties with constructive processing required to deliberately generate past and, perhaps especially, future events (Addis et al., 2007; Schacter & Addis, 2007). Hence, given the lack of constructive processes involved in spontaneous MTT, we expected to find no significant associations between AQ score and spontaneous thought frequency, past/future probability, or thought specificity, in the vigilance task.

Results from a general adult sample supported the dissociated-processes view articulated above. Bayesian inference provided strong evidence against a negative association between AQ score and spontaneous thought frequency, indicating that the negative relationship between autistic characteristics and the extent/quality of MTT documented in clinical samples (Ciaramelli et al., 2018; Ye et al., 2021) may be limited to voluntary task contexts. Moreover, logistic regression produced no evidence that AQ score predicted the occurrence of past/future (as opposed to present/atemporal) thoughts. This indicates that individuals with a high trait likelihood of autism were no less likely than others to experience spontaneous thoughts of a particular temporal orientation. Finally, we found no evidence that AQ score predicted the probability of specific thoughts. Overall, then, findings align closely with our a priori hypothesis: There should be no evidence of diminished *spontaneous* MTT ability according to autistic trait likelihood.

The lack of differences in spontaneous MTT according to AQ score complements the established notion that a deficit in constructive/generative processes underlies diminished voluntary MTT ability in the context of autistic characteristics (including in diagnosed individuals; Ciaramelli et al., 2018; Ye et al., 2021). We agree that the distinction does not lie in encoding or maintenance (Berntsen, 2010), as if it did, participants would struggle to produce episodic events through either route as the relevant information would not be available. Rather, the increased facility and faster latencies generally observed for involuntary memories (e.g., Berntsen & Hall, 2004; Berntsen & Jacobsen, 2008; Uzer et al., 2012) reflect a difference in retrieval processes; hence, autism-related difficulties in voluntary MTT are attributable to a limited ability to *access* episodic information when it is called upon deliberately (i.e., a generative retrieval process; Conway & Pleydell-Pearce, 2000). In contrast, a task in which thoughts are sampled as they spontaneously occur requires no deliberate retrieval attempts (Berntsen, 1996, 2019) and is consequently insensitive to the presence of autistic traits, as demonstrated here. Thus, the present results make an important contribution to the broader literature on MTT in autism by reinforcing the importance of task context when drawing inferences about underlying MTT experience in specific populations.

Interestingly, at least two studies using ostensibly 'voluntary' tasks with autistic and non-autistic participants have found results comparable with the present study (Coutelle et al., 2021; Crane et al., 2013). Crane et al. (2013) found no significant differences in the number of episodic memories and future thoughts produced between groups using a sentence completion task. This is pertinent to the present argument as this type of task is often treated as more implicit, or even 'spontaneous', compared to traditional cue-word paradigms (Anderson et al., 2016; Anderson & Dewhurst, 2009). Potentially, providing a sentence stem decreases reliance on effortful constructive processes such that individuals with ASD can produce past and future events with equal fluency and specificity as controls (Crane et al., 2013), which would support the Task Support Hypothesis (Bowler et al., 1997). Interestingly, Anger et al. (2019) found providing visual cues increased the production of both past and future episodic autobiographical events in ASD. Therefore, the present study could be followed up in a multi-method study, with either a clinical or broader population sample, to compare sentence completion directly with traditional voluntary and spontaneous (e.g., vigilance task) elicitation of MTT, and incorporate the use of visual cues, offering new methodological opportunities for research within ASD.

Of course, the study is not without limitations. First, the sample was taken from a non-clinical population. It is plausible that replication in a sample of ASD-diagnosed individuals would yield different results, and this is a direction we would be keen to see followed in subsequent literature (cf. suggestions by Skewes et al., 2020). Given the present findings and theoretical context, however, we would anticipate similar null results (see also discussion of Crane et al., 2013).

Second, we did not screen for existing developmental disorders like attention deficit hyperactivity disorder (ADHD), which is a common comorbidity in those with autism (Hours et al., 2022) and also prevalent in the general population (Asherson et al., 2022). There is a possibility that such factors could have influenced results, given the attentional control dynamics involved in dual-task studies (see Randall et al., 2014). This is particularly relevant in a non-controlled environment (i.e., online studies conducted outside the lab; Clayton McClure, 2022). As expected, given the freedom to complete the study in a location and context of their choosing, participants often reported *external distractions* (Unsworth & McMillan, 2014) rather than 'true' spontaneous thoughts. Despite the option to categorise these as 'present' thoughts, it is possible that our results do not reflect the full range of spontaneous MTT observed in a laboratory setting.

Finally, different versions of the vigilance task paradigm could be explored in the context of ASD/autistic traits. For instance, instead of having participants freely report their spontaneous thoughts, they could be periodically stopped and prompted to report any momentary task-unrelated thoughts (i.e., the *probe-caught* method; Smallwood & Schooler, 2015). This is thought to rely less on meta-awareness of one's own mental contents (Schooler et al., 2011) and has been found to produce quantitative and qualitative differences in the resulting mix of responses compared with having participants monitor their ongoing thoughts (Barzykowski & Staugaard, 2018). It is possible that, lacking the requirement to self-monitor, the probe-caught vigilance task would be preferable for use in non-neurotypical populations where this might itself pose a barrier (e.g., those with a diagnosis of ASD, ADHD, etc.).

In conclusion, the present study aimed to contribute to our understanding of spontaneous MTT through examining its relationship with autism spectrum traits. In an online vigilance task, we found no evidence that autistic trait likelihood was associated either with total spontaneous thought frequency or the odds of past, future, or spatiotemporally specific instances of MTT. This is in contrast with the voluntary MTT literature, which indicates lower frequency and reduced event specificity in cases of diagnosed ASD. Beyond their applied value, these findings support the existence of two dissociable routes involved in MTT (Cole & Kvavilashvili, 2021). We hope that our research ignites further exploration of voluntary/spontaneous MTT in relation to autistic traits, as well as in formally diagnosed clinical populations.

CONFLICT OF INTEREST STATEMENT

The authors have no conflict of interest to declare.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available from the corresponding author upon reasonable request.

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ENDNOTES

[1] Two papers, by Crane et al. (2013) and Coutelle et al. (2021), failed to replicate these typical findings.

[2] Some authors have reasonably questioned the assumption that high-AQ individuals adequately approximate formally diagnosed samples (e.g., Lord et al., 2018). We are therefore careful not to overgeneralise our findings. It is worth noting that recent studies have profitably used the AQ to reveal cognitive differences, for example, in visual attention skills, which could then be examined in clinically defined samples (Skewes et al., 2020; Zhang et al., 2020).

[3] Instruction text used: 'Spontaneous thoughts refer to events in your future or memories/events in your past, near or distant, that come to mind involuntarily without you choosing to bring them to mind'.

[4] Typical examples from the data include 'remembering a conversation from earlier today' (specific past) and 'I have to do laundry tomorrow' (specific future).

REFERENCES

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), 1363–1377. https://doi.org/10.1016/j.neuropsychologia.2006.10.016

American Psychiatric Association. (2022). *Diagnostic and statistical manual of mental disorders* (5th ed., text rev.). American Psychiatric Association.

Anderson, R. J., Boland, J., & Garner, S. R. (2016). Overgeneral past and future thinking in dysphoria: The role of emotional cues and cueing methodology. *Memory*, *24*(5), 708–719. https://doi.org/10.1080/09658211.2015.1046134

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), 367–373. https://doi.org/10.1080/09658210902751669

Anger, M., Wantzen, P., Le Vaillant, J., Malvy, J., Bon, L., Guénolé, F., Moussaoui, E., Barthelemy, C., Bonnet-Brilhault, F., Eustache, F., Baleyte, J.-M., & Guillery-Girard, B. (2019). Positive effect of visual cuing in episodic memory and episodic future thinking in adolescents with autism spectrum disorder. *Frontiers in Psychology*, *10*, 1513–1525. https://doi.org/10.3389/fpsyg.2019.01513

Anwyl-Irvine, A. L., Massonnié, J., Flitton, A., Kirkham, N., & Evershed, J. K. (2020). Gorilla in our midst: An online behavioral experiment builder. *Behavior Research Methods*, *52*(1), 388–407. https://doi.org/10.3758/s13428-019-01237-x

Asherson, P., Leaver, L., Adamou, M., Arif, M., Askey, G., Butler, M., Cubbin, S., Newlove-Delgado, T., Kustow, J., Lanham-Cook, J., Findlay, J., Maxwell, J., Mason, P., Read, H., van Rensburg, K., Müller-Sedgwick, U., Sedgwick-Müller, J., & Skirrow, C. (2022). Mainstreaming adult ADHD into primary care in the UK: Guidance, practice, and best practice recommendations. *BMC Psychiatry*, *22*, 640. https://doi.org/10.1186/s12888-022-04290-7

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

Baron-Cohen, S., Wheelwright, S., Skinner, R., Martin, J., & Clubley, E. (2001). The autism-spectrum quotient (AQ): Evidence from Asperger syndrome/high-functioning autism, males and females, scientists and mathematicians. *Journal of Autism and Developmental Disorders*, *31*(1), 5–17. https://doi.org/10.1023/A:1005653411471

Barzykowski, K., & Staugaard, S. R. (2018). How intention and monitoring your thoughts influence characteristics of autobiographical memories. *British Journal of Psychology*, *109*(2), 321–340. https://doi.org/10.1111/bjop.12259

Berntsen, D. (1996). Involuntary autobiographical memories. *Applied Cognitive Psychology*, *10*(5), 435–454. https://doi.org/10.1002/(SICI)1099-0720(199610)10:5%3C435::AID-ACP408%3E3.0.CO;2-L

Berntsen, D. (2010). The unbidden past: Involuntary autobiographical memories as a basic mode of remembering. *Current Directions in Psychological Science*, *19*(3), 138–142. https://doi.org/10.1177/0963721410370301

Berntsen, D. (2019). Spontaneous future cognitions: An integrative review. *Psychological Research*, *83*(4), 651–665. https://doi.org/10.1007/s00426-018-1127-z

Berntsen, D., & Hall, N. M. (2004). The episodic nature of involuntary autobiographical memories. *Memory & Cognition*, *32*(5), 789–803. https://doi.org/10.3758/BF03195869

Berntsen, D., & Jacobsen, A. S. (2008). Involuntary (spontaneous) mental time travel into the past and future. *Consciousness and Cognition*, *17*(4), 1093–1104. https://doi.org/10.1016/j.concog.2008.03.001

Bowler, D. M., Gardiner, J. M., & Berthollier, N. (2004). Source memory in adolescents and adults with Asperger's syndrome. *Journal of Autism and Developmental Disorders*, *34*(5), 533–542. https://doi.org/10.1007/s10803-004-2548-7

Bowler, D. M., Matthews, N. J., & Gardiner, J. M. (1997). Asperger|s syndrome and memory: Similarity to autism but not amnesia. *Neuropsychologia*, *35*(1), 65–70. https://doi.org/10.1016/S0028-3932(96)00054-1

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

Cabeza, R., & St Jacques, P. (2007). Functional neuroimaging of autobiographical memory. *Trends in Cognitive Sciences*, *11*(5), 219–227. https://doi.org/10.1016/j.tics.2007.02.005

Chaput, V., Amsellem, F., Urdapilleta, I., Chaste, P., Leboyer, M., Delorme, R., & Goussé, V. (2013). Episodic memory and self-awareness in Asperger syndrome: Analysis of memory narratives. *Research in Autism Spectrum Disorders*, *7*(9), 1062–1067. https://doi.org/10.1016/j.rasd.2013.05.005

Ciaramelli, E., Spoglianti, S., Bertossi, E., Generali, N., Telarucci, F., Tancredi, R., Muratoni, F., & Igliozzi, R. (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), 2995–3009. https://doi.org/10.1007/s10803-018-3577-y

Clayton McClure, H. (2022). *Spontaneous future cognition: Cognitive mechanisms and goal-directed functions* (Doctoral dissertation, York St John University). https://ray.yorksj.ac.uk/id/eprint/6532/

Cole, S., & Kvavilashvili, L. (2019). Spontaneous future cognition: The past, present and future of an emerging topic. *Psychological Research*, *83*(4), 631–650. https://doi.org/10.1007/s00426-019-01193-3

Cole, S., & Kvavilashvili, L. (2021). Spontaneous and deliberate future thinking: A dual process account. *Psychological Research*, *85*(2), 464–479. https://doi.org/10.1007/s00426-019-01262-7

Cole, S. N., Staugaard, S. R., & Berntsen, D. (2016). Inducing involuntary and voluntary mental time travel using a laboratory paradigm. *Memory & Cognition*, *44*(3), 376–389. https://doi.org/10.3758/s13421-015-0564-9

Cole, S. N., & Tubbs, P. M. (2022). Predictors of obsessive–compulsive symptomology: Mind wandering about the past and future. *Psychological Research*, *86*, 1518–1534. https://doi.org/10.1007/s00426-021-01585-4

Conway, M. A., & Pleydell-Pearce, C. W. (2000). The construction of autobiographical memories in the self-memory system. *Psychological Review*, *107*(2), 261–288. https://doi.org/10.1037/0033-295X.107.2.261

Cooper, R. A., & Simons, J. S. (2019). Exploring the neurocognitive basis of episodic recollection in autism. *Psychonomic Bulletin and Review*, *26*(1), 163–181. https://doi.org/10.3758/s13423-018-1504-z

Coutelle, R., Goltzene, M. A., Canton, M., Campiglia-Sabourin, M., Rabot, J., Bizet, É., Schoenberger, M., Berna, F., & Danion, J. M. (2021). Episodic autobiographical memory in adults with autism spectrum disorder: An exploration with the autobiographical interview. *Frontiers in Psychiatry*, *11*, 593855. https://doi.org/10.3389/fpsyt.2020.593855

Crane, L., Lind, S. E., & Bowler, D. M. (2013). Remembering the past and imagining the future in autism spectrum disorder. *Memory*, *21*, 157–166. https://doi.org/10.1080/09658211.2012.712976

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*, 2100–2112. https://doi.org/10.1007/s10803-012-1459-2

Desaunay, P., Briant, A. R., Bowler, D. M., Ring, M., Gerardin, P., Baylete, J.-M., Guénolé, F., Eustache, F., & Parienti, J.-J. (2020). Memory in autism spectrum disorder: A meta-analysis of experimental studies. *Psychological Bulletin*, *146*(5), 377–410. https://doi.org/10.1037/bul0000225

Gamble, B., Moreau, D., Tippett, L. J., & Addis, D. R. (2019). Specificity of future thinking in depression: A meta-analysis. *Perspectives on Psychological Science*, *14*(5), 816–834. https://doi.org/10.1177/1745691619851784

Goddard, L., Howlin, P., Dritschel, B., & Patel, T. (2007). Autobiographical memory and social problem-solving in young adults with ASD. *Journal of Autism and Developmental Disorders*, *37*, 291–300. https://doi.org/10.1007/s10803-006-0168-0

Hassabis, D., & Maguire, E. A. (2007). Deconstructing episodic memory with construction. *Trends in Cognitive Sciences*, *11*(7), 299–306. https://doi.org/10.1016/j.tics.2007.05.001

Hours, C., Recasens, C., & Baleyte, J. M. (2022). ASD and ADHD comorbidity: What are we talking about? *Frontiers in Psychiatry*, *13*, 154–159. https://doi.org/10.3389/fpsyt.2022.837424

Klein, S. B., Loftus, J., & Kihlstrom, J. F. (2002). Memory and temporal experience: The effects of episodic memory loss on an amnesic patient's ability to remember the past and imagine the future. *Social Cognition*, *20*(5), 353–379. https://doi.org/10.1521/soco.20.5.353.21125

Levine, L. J., & Safer, M. A. (2002). Sources of bias in memory for emotions. *Current Directions in Psychological Science*, *11*(5), 169–173. https://doi.org/10.1111/1467-8721.00193

Lind, S. E., & Bowler, D. M. (2010). Episodic memory and episodic future thinking in adults with autism. *Journal of Abnormal Psychology*, *119*(4), 896–905. https://doi.org/10.1037/a0020631

Lind, S. E., Williams, D. M., Bowler, D. M., & Peel, A. (2014). Episodic memory and episodic future thinking impairments in high-functioning autism spectrum disorder: An underlying difficulty with scene construction or self-projection? *Neuropsychology*, *28*, 55–67. https://doi.org/10.1037/neu0000005

Lord, C., Elsabbagh, M., Baird, G., & Veenstra-Vanderweele, J. (2018). Autism spectrum disorder. *The Lancet*, *392*(10146), 508–520. https://doi.org/10.1016/S0140-6736(18)31129-2

Marini, A., Ferretti, F., Chiera, A., Magni, R., Adornetti, I., Nicchiarelli, S., Vicari, S., & Valeri, G. (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

Plimpton, B., Patel, P., & Kvavilashvili, L. (2015). Role of triggers and dysphoria in mind-wandering about past, present and future: A laboratory study. *Consciousness and Cognition*, *33*, 261–276. https://doi.org/10.1016/j.concog.2015.01.014

Raes, F., Hermans, D., Williams, J. M. G., & Eelen, P. (2007). A sentence completion procedure as an alternative to the autobiographical memory test for assessing overgeneral memory in non-clinical populations. *Memory*, *15*(5), 495–507. https://doi.org/10.1080/09658210701390982

Randall, J. G., Oswald, F. L., & Beier, M. E. (2014). Mind-wandering, cognition, and performance: A theory-driven meta-analysis of attention regulation. *Psychological Bulletin*, *140*(6), 1411–1431. https://doi.org/10.1037/a0037428

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*, *21*, 357–367. https://doi.org/10.1177/1362361316645429

Schacter, D. L., & Addis, D. R. (2007). The cognitive neuroscience of constructive memory: Remembering the past and imagining the future. *Philosophical Transactions of the Royal Society, B: Biological Sciences*, *362*(1481), 773–786. https://doi.org/10.1098/rstb.2007.2087

Schlagman, S., & Kvavilashvili, L. (2008). Involuntary autobiographical memories in and outside the laboratory: How different are they from voluntary autobiographical memories? *Memory & Cognition*, *36*(5), 920–932. https://doi.org/10.3758/MC.36.5.920

Schooler, J. W., Smallwood, J., Christoff, K., Handy, T. C., Reichle, E. D., & Sayette, M. A. (2011). Meta-awareness, perceptual decoupling and the wandering mind. *Trends in Cognitive Sciences*, *15*(7), 319–326. https://doi.org/10.1016/j.tics.2011.05.006

Simpraga, S., Weiland, R. F., Mansvelder, H. D., Polderman, T. J., Begeer, S., Smit, D. J., & Linkenkaer-Hansen, K. (2021). Adults with autism spectrum disorder show atypical patterns of thoughts and feelings during rest. *Autism*, *25*(5), 1433–1443. https://doi.org/10.1177/1362361321990928

Skewes, J. C., Kemp, T., Paton, B., & Hohwy, J. (2020). How are attention, learning, and social cognition related on the non-clinical autistic spectrum? *Acta Psychologica*, *210*, 103157. https://doi.org/10.1016/j.actpsy.2020.103157

Smallwood, J., & Schooler, J. W. (2015). The science of mind wandering: Empirically navigating the stream of consciousness. *Annual Review of Psychology*, *66*, 487–518. https://doi.org/10.1146/annurev-psych-010814-015331

Stevenson, J. L., & Hart, K. R. (2017). Psychometric properties of the autism-spectrum quotient for assessing low and high levels of autistic traits in college students. *Journal of Autism and Developmental Disorders*, *47*(6), 1838–1853. https://doi.org/10.1007/s10803-017-3109-1

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), 2558–2568. https://doi.org/10.1007/s10803-013-1806-y

Unsworth, N., & McMillan, B. D. (2014). Similarities and differences between mind-wandering and external distraction: A latent variable analysis of lapses of attention and their relation to cognitive abilities. *Acta Psychologica*, *150*, 14–25. https://doi.org/10.1016/j.actpsy.2014.04.001

Uzer, T., Lee, P. J., & Brown, N. R. (2012). On the prevalence of directly retrieved autobiographical memories. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *38*(5), 1296–1308. https://doi.org/10.1037/a0028142

Vannucci, M., Pelagatti, C., & Marchetti, I. (2017). Manipulating cues in mind wandering: Verbal cues affect the frequency and the temporal focus of mind wandering. *Consciousness and Cognition*, *53*, 61–69. https://doi.org/10.1016/j.concog.2017.06.004

Williams, J. M. G., Ellis, N. C., Tyers, C., Healy, H., Rose, G., & Macleod, A. K. (1996). The specificity of autobiographical memory and imageability of the future. *Memory & Cognition*, *24*(1), 116–125. https://doi.org/10.3758/BF03197278

Wu, J. Q., Szpunar, K. K., Godovich, S. A., Schacter, D. L., & Hofmann, S. G. (2015). Episodic future thinking in generalized anxiety disorder. *Journal of Anxiety Disorders*, *36*, 1–8. https://doi.org/10.1016/j.janxdis.2015.09.005

Ye, J. Y., Qin, X. J., Cui, J. F., Ren, Q., Jia, L. X., Wang, Y., Pantelis, C., & Chan, R. C. (2021). A meta-analysis of mental time travel in individuals with autism Spectrum disorders. *Journal of Autism and Developmental Disorders*, *1-20*, 1509–1528. https://doi.org/10.1007/s10803-021-05375-0

Zhang, M., Jiao, J., Hu, X., Yang, P., Huang, Y., Situ, M., Guo, K., Cai, J., & Huang, Y. (2020). Exploring the spatial working memory and visual perception in children with autism spectrum disorder and general population with high autism-like traits. *PLoS One*, *15*(7), e0235552. https://doi.org/10.1371/journal.pone.0235552

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