The Neurocognitive Development of Episodic Prospection and Its Implications for Academic Achievement

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ABSTRACT— Episodic prospection is the ability to mentally simulate personal future events that are rich in contextual detail and plausible for the individual. It therefore incorporates episodic information (who, what, where, and when of a particular event), as well as details about one's self (e.g., knowledge, goals, motivations and desires). The ability to mentally simulate personal future events is thought to serve an adaptive purpose as it allows the individual to plan actions that align with his or her future goals and challenges. This review seeks to integrate research exploring how changes in episodic memory and self-concept, and their associated neural mechanisms, contribute to the development of episodic prospection between childhood and adolescence. Elucidating the mechanisms contributing to this development is critical for understanding its potential influence on learning, goal achievement, and pedagogy between childhood and adolescence.

People spend considerable time reflecting on who they once were, who they are in the present, and who they will become in the near or distant future. Our ability to envision a possible future for ourselves is particularly intriguing. On the one hand, mental representations about the future are strongly grounded in and constrained by our knowledge of the world and our perceived place in it. On the other hand, these representations capture something that is necessarily novel and uncertain, and thus require the capacity to push our minds beyond the boundaries of current reality to the realm of prediction and imagination. Critically, our capacity to prospect has long been attributed an important adaptive value because it might afford the unique opportunity to mentally pre-experience what the future might bring, which would allow us to anticipate possible challenges, motivate anticipatory actions, or consider alternative plans (Suddendorf, Addis, & Corballis, 2009).

The goal of the present review is twofold. First, we are interested in the critical cognitive and neural mechanisms that build the foundations of the mental capacity to envision the future. Although multiple neurocognitive mechanisms have been implicated as important for episodic prospection (Suddendorf & Corballis, 2007), this review highlights the roles of episodic memory and self-related processes in episodic prospection specifically. Prior literature indicates that these two constructs exhibit age-related improvements across childhood and adolescence (Coughlin, Robins, & Ghetti, 2016; Ghetti & Bunge, 2012; Harter, 2006), demonstrating significant overlap with the developmental trajectory of episodic prospection (Coughlin, Lyons, & Ghetti, 2014). In addition, they play critical mechanistic roles in episodic prospection in adults (Conway & Loveday, 2015; Newby-Clark & Ross, 2003; Schacter & Addis, 2007; Wang, Gould, & Hou, 2015). While episodic memory helps inform the content of episodic future thoughts (i.e., the specific contextual aspects of the scene), self-related processes help organize future possibilities based on plausibility (i.e., how likely it is to happen to one's self). Thus, we start with a discussion

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of the adult literature to situate research regarding the role of episodic memory and self-related processes on episodic prospection, and then focus on the development of episodic prospection. Second, given our interest in the adaptive value of episodic prospection, we introduce a potential connection between the developing capacity to pre-experience the future and positive academic achievement. Importantly, as children get older, their social interactions and academic environment begin to play a larger role in their life, affording more opportunities for autonomous choices and independent self-regulation (Trommsdorff, Lamm, & Schmidt, 1979). Thus, examining how children's past experiences and developing sense of self contribute to their ability to envision their future may not only increase our understanding of episodic prospection, but also provide an opportunity to observe the potential benefits of episodic prospection on critical aspects of their lives, including, but not limited to, academic achievement.

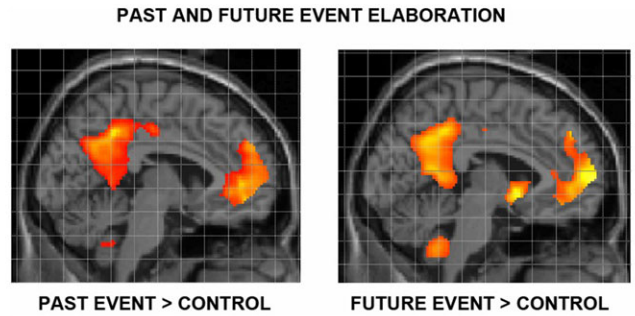

Fig. 1. Common areas of activation during mentalization of past (left) and future (right) personal events, including the left hippocampus, left temporal pole, retrosplenial cortex, medial prefrontal, parietal and bilateral parietal lobule. Additional activation during mentalization of future events was found in the hippocampus and frontal pole. Adapted from Addis, Wong, and Schacter (2007).

THE BUILDING BLOCKS OF EPISODIC PROSPECTION: EVIDENCE FROM RESEARCH IN ADULTHOOD

Episodic prospection refers to the ability to form a contextually rich mental representation of a future event that is personal and plausible. It has been proposed that episodic prospection may be achieved through two phases: a construction phase, which involves retrieving relevant episodic details from memories of past events, and an elaboration phase, which involves elaborating these details to create a coherent and meaningful representation of future events (D'Argembeau & Mathy, 2011). Similar mechanisms have been proposed to explain autobiographical memory functioning (Conway & Pleydell-Pearce, 2000), but unlike autobiographical memory, prospection requires a capacity to simulate novel events, as reflected by Schacter and Addis's (2007) description of this process in their *constructive episodic simulation hypothesis*.

A large body of empirical work corroborates a relation between episodic memory and episodic prospection in adults. For example, Madore, Gaesser, and Schacter (2014) demonstrated a role of episodic processing on both episodic memory and episodic prospection in adults using an episodic specificity induction. During this induction, individuals were asked to generate mental pictures of scenes viewed in a video and to later report all of the details they remembered from the scenes. Following their report, individuals were asked to remember a past event, to imagine a possible future event, or to simply describe a scene. Results showed an effect of the episodic specificity induction that was specific only to the generation of past and future events, such that it related to greater internal details (i.e., contextual details specific to the event) versus external details (i.e., general facts, elaborations, knowledge, or references to other events) for these events, but not for scene descriptions.

Support for similarities between episodic memory and episodic prospection has also been garnered from studies showing that patients with acquired neurological insult exhibit similar deficits in reports of past and future events with regard to episodic detail (D'Argembeau, Raffard, & Van der Linden, 2008; Klein, Loftus, & Kihlstrom, 2002) and phenomenological experiences (D'Argembeau & van der Linden, 2004, 2006; Spreng & Levine, 2006; Szpunar & McDermott, 2008). In addition, neuroimaging research suggests that a common neural network supports mentalizing about both past and future personal events (Figure 1; Addis, Wong, & Schacter, 2007; Botzung, Denkova, & Manning, 2008; Hassabis, Kumaran, & Maguire, 2007a; Okuda et al., 2003; Schacter, Addis, & Buckner, 2008; Szpunar, Watson, & McDermott, 2007). Together, the evidence reviewed thus far underscores a central role of episodic memory in supporting the capacity to prospect.

But, how do individuals select which information to retrieve from memory when constructing a future event? It has been proposed that self-related processes may play such an organizational role. Since there are several self-related processes, it is important to distinguish between processes that reflect a continuous sense of self-awareness and processes that reflect a stable mental representation of the self (Robins, Tracy, & Trzesniewski, 2008). Although all of these processes likely contribute to episodic prospection, this review focuses on the role of a stable mental representation of the self, and *self-concept* in particular. An individual's self-concept is a set of mental representations (e.g., thoughts, feelings, goals, knowledge, and beliefs) that reflect a characterization of one's personal identity (Conway, 2005). During autobiographical memory retrieval, the individual's self-concept is thought to serve as a basis for selecting memories that align with their current self (Conway & Pleydell-Pearce, 2000). It has been proposed that a similar process may support the selection of episodic details during the construction of personal future events (cf. Conway & Loveday, 2015). Although empirical work directly testing this proposal is needed, a growing body of literature provides general support, suggesting an important relation between self-concept and episodic prospection.

Recent research has corroborated the role of self-concept in episodic prospection by showing that individuals appeal to schematic and abstract knowledge related to the self when generating personal future events (D'Argembeau & Mathy, 2011; Demblon, Bahri, & D'Argembeau, 2016; Demblon & D'Argembeau, 2014; Rubin, 2014). For example, D'Argembeau and Mathy (2011) found that participants used episodic details to elaborate and enrich narratives about personal past and future events that were built around representations reflecting self-concepts and personal goals. Similarly, Rathbone, Conway, and Moulin (2011) found that adults generated personal future events based on representations of their future selves. These results indicate that self-concept representations provide the foundations upon which personal past and future events are generated. Further, Anderson, Peters, and Dewhurst (2015) have shown that future events are elaborated upon faster than past events when the content of future events contains abstract, self-related representations. These results support the notion that the generation of future events may be constrained and organized by one's goals, as well as informed by personally relevant information. Taken together, these findings suggest that the self-concept plays an important organizational role in selecting plausible personal future events. In addition to this behavioral work, results from neuroimaging studies have provided compelling support for an important role of episodic memory and self-concept in episodic prospection.

NEURAL SUBSTRATES UNDERLYING EPISODIC MEMORY AND SELF-CONCEPT IN EPISODIC PROSPECTION

Prior research, reviewed above, suggests that episodic memory and self-concept support the ability to mentally simulate contextually rich future events that are personal and plausible (Conway & Pleydell-Pearce, 2000; Schacter et al., 2008). Additional research suggests that these constructs rely on different neural substrates in the frontal and medial temporal lobes (Addis, Cheng, Roberts, & Schacter, 2011; D'Argembeau et al., 2010; Kurczek et al., 2015). For example, Kurczek et al. (2015) found that involvement of the hippocampus was more strongly associated with the inclusion of episodic details in future event narratives, whereas involvement of the medial prefrontal cortex (mPFC) was associated with the incorporation of the self in these narratives. In addition, studies with clinical populations have shown that amnesic patients with adult-acquired medial temporal lobe damage exhibit difficulty imagining personal future events (D'Argembeau et al., 2008; Hassabis, Kumaran, Vann & Maguire, 2007b; Klein et al., 2002), and that individuals with frontal lobe damage or deficits exhibit rigidity when generating personal future plans in new environments and from new perspectives (Kwan, Kurczek, & Rosenbaum, 2015; Unterrainer & Owen, 2006).

While these studies support a critical role of the medial temporal lobe (MTL) and mPFC regions in episodic prospection, it should be noted that preserved prospection abilities have been reported in child and adult patients with bilateral hippocampal damage and developmental amnesia (Cooper, Vargha-Khadem, Gadian, & Maguire, 2011; Maguire, Vargha-Khadem, & Hassabis, 2010; Hurley, Maguire, & Vargha-Khadem, 2011). However, it has been suggested that the presence of residual hippocampal tissue in these patients may support intact prospective abilities, and that patients may rely on strategies and semantic knowledge to construct fictitious future events. In fact, some studies have reported that patients who utilize semantic knowledge to construct fictitious future scenes are not able to generate episodic and self-related details to imagine personal future events (Kwan et al., 2015; Race, Keane, & Verfaellie, 2011), suggesting that the types of future events constructed by patients with developmental amnesia may be qualitatively different from those of healthy controls.

The role of frontal and medial temporal lobe regions in episodic prospection has been further investigated using intrinsic functional connectivity. With this method, Andrews-Hanna, Reidler, Sepulcre, Poulin, and Buckner (2010) divided the default mode network into two subsystems: the dorsal medial prefrontal cortex (dMPFC) subsystem and the MTL subsystem (Figure 2). The dMPFC subsystem includes the dMPFC, temporoparietal junction (TPJ), lateral temporal cortex, and temporal pole. The MTL subsystem consists of the ventral medial prefrontal cortex, posterior inferior parietal lobule, retrosplenial cortex, the parahippocampal cortex, and the hippocampal formation. After asking participants to either make future self-related decisions or decisions about current personal situations, the authors found that the MTL subsystem overlapped with regions activated when one was asked to think about their personal future, and the dMPFC subsystem overlapped with regions activated when one was asked to think about themselves in the present. This suggests that recall of personally relevant information involves a prefrontal system which can work in conjunction with the MTL system to help individuals recombine episodic details to construct a personally relevant future event.

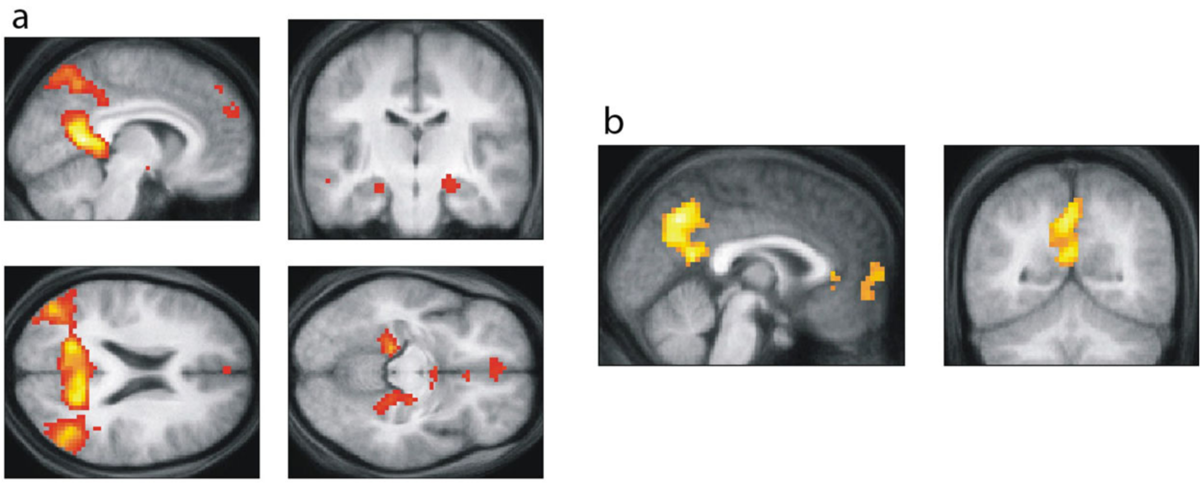

Fig. 2. These figures show differential activation during construction of imagined past or future events (a) and recall of personally relevant past events (b). In (a), regions associated with construction of scenes versus objects include bilateral hippocampus, parahippocampal gyrus, retrosplenial cortex, posterior parietal cortex, medial temporal cortex, and medial prefrontal cortex. In (b), brain regions associated with real versus imagined events include precuneus, the anterior medial prefrontal cortex, and posterior cingulate cortex. Adapted from Hassabis et al. (2007a).

This process-driven explanation for these neural findings align with other findings suggesting that multiple processes, including those supporting working memory, allow individuals to retrieve, recombine and bind information to construct a coherent personal future scene (e.g., Abram, Picard, Navarro, & Piolino, 2014). Therefore, it is important to note that, although distinguishing between self-relevant and episodic processes (and their supporting neural substrates) may promote a better conceptual understanding of episodic prospection, these processes likely interact with numerous other processes and associated neural substrates to support the construction and elaboration of personal future events.

EPISODIC PROSPECTION IN CHILDHOOD AND ADOLESCENCE: BEHAVIORAL DEVELOPMENT AND NEURAL UNDERPINNINGS

In recent years, a growing body of research has helped us to better understand the development of episodic prospection in childhood and adolescence. This research indicates that episodic prospection emerges alongside episodic memory during early childhood (Atance & O'Neill, 2001; Prabhakar & Hudson, 2014, 2016; see Hudson, Mayhew, & Prabhakar, 2010 for a review). However, both episodic prospection and episodic memory continue to improve over the course of middle and late childhood (Coughlin et al., 2014; Ghetti & Angelini, 2008; Ghetti, DeMaster, Yonelinas, & Bunge, 2010; Ghetti, Mirandola, Angelini, Cornoldi, & Ciaramelli, 2011; Ofen et al., 2007). Research also suggests that the self-concept becomes more complex during childhood and adolescence (Harter, 2006). Episodic memory and self-concept have been shown to be important components of episodic prospection in adults (Andrews-Hanna et al., 2010), but how their developmental trajectories interact with one another to support the development of episodic prospection is an open question.

Given the theoretical and empirical support for a relation between episodic memory and episodic prospection, several studies have compared the development of these two abilities. The majority of these studies have focused on early childhood, showing significant age-related changes in both abilities between the ages of three and five years, as well as a functional relation between the two abilities during this period (e.g., Quon & Atance, 2010). Extending this work on early childhood, Coughlin et al. (2014) compared the relation between episodic memory and episodic prospection from early to late childhood by asking 5–9-year-olds to introspect about personal past and future events, and then coding resulting narratives for episodic content. Results showed that individual differences in the episodic content of past events predicted the episodic content of future events, providing support for a relation between these abilities during middle to late childhood. However, age-related improvements in the ability to incorporate episodic details were more protracted for future event narratives compared to past event narratives (Figure 3), suggesting that factors beyond episodic memory contribute to the development of episodic prospection.

Neuroimaging studies complement behavioral work on the development of both episodic prospection and episodic memory during childhood. These studies provide evidence

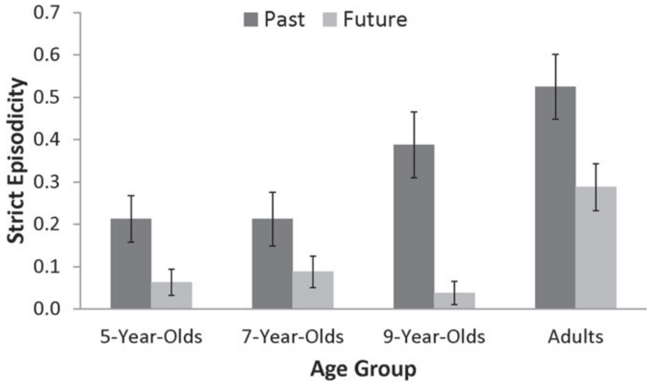

Fig. 3. This figure presents the episodic content of narratives provided by participants in a task that required them to reflect upon personal past and future events. Narratives were strictly coded strictly for whether (score = 1) or not (score = 0) they described an isolated event in episodic detail (i.e., including information about the spatio-temporal context, as well as the individuals' sensorial experience during the event). Adapted from Coughlin et al. (2014).

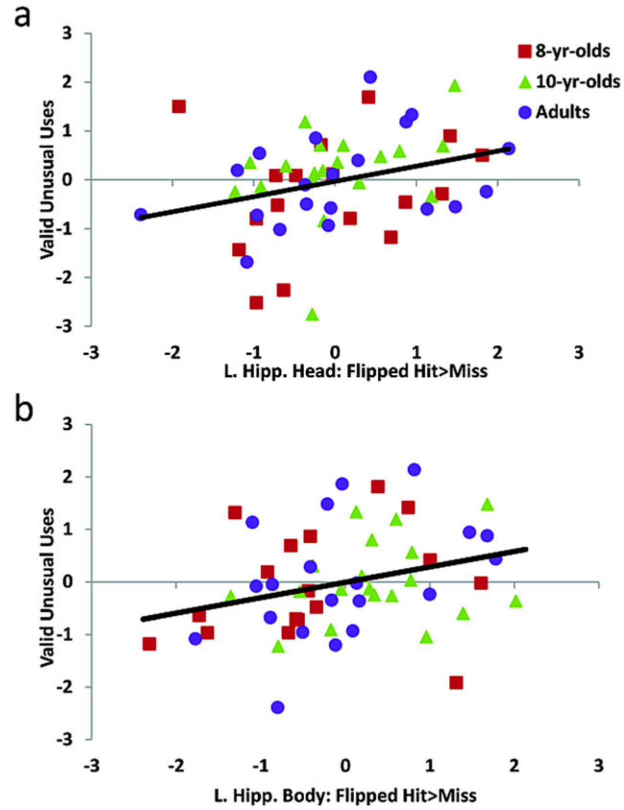

Fig. 4. Significant positive correlation between left hippocampal head (a) and body (b) activation associated with Hit > Miss under high flexibility demands and the number of unusual uses generated for a distinct object in a divergent thinking task. Adapted from DeMaster et al. (2016).

of rapid changes in memory-related mechanisms supported by the MTL between middle to late childhood (Ghetti et al., 2010; Gogtay et al., 2006). For example, structural changes in the hippocampus relate to episodic memory development across childhood (DeMaster, Pathman, Lee, & Ghetti, 2014; Gogtay et al., 2006; Lee, Ekstrom, & Ghetti, 2014; see Ghetti & Bunge, 2012 for a review). Furthermore, age-related differences have been found in neural activity in these regions in association with episodic encoding (Ghetti et al., 2010) and retrieval (DeMaster et al., 2014). More recently, DeMaster, Coughlin, and Ghetti (2016) further showed that retrieval flexibility demands may play a role in age differences in hippocampal activation during retrieval, with 8-year-olds engaging the hippocampus more strongly when flexibility demands were low, adults engaging the hippocampus more strongly when flexibility demands were high, and 10-year-olds falling somewhere in between. In addition to these age differences, individual differences in hippocampal activation during flexible retrieval predicted performance in a divergent thinking task (Figure 4). These results highlight the role of the hippocampus in flexible cognition beyond episodic memory (Giovanello, Schnyer, & Verfaellie, 2009; Konkel & Cohen, 2009; Zeithamova & Preston, 2010). Because episodic prospection involves flexibly representing and binding discrete episodic details from memory (Schacter & Addis, 2007), development of this structure during middle childhood likely plays a critical role in predicting children's ability to recruit episodic details when envisioning the future.

Although this literature underscores the importance of mechanisms mediated by the hippocampus, it is important to also highlight the critical role of cortical mechanisms. For example, development of memory encoding and retrieval has been associated with developmental differences in activity in the anterior prefrontal cortex, lateral prefrontal cortex, and posterior parietal cortices (Ofen et al., 2007; see Ofen, 2012 for a review). Memory mechanisms supported by cortical structures may allow for more deliberate use of strategies to guide retrieval of episodic and self-related details relevant for personal future situations, as well as facilitate binding processes to construct a coherent personal future event (cf. Abrams et al., 2014).

Importantly, developmental research also supports a relation between self-related processes and episodic prospection. For example, Wang and Koh (2015) found that, like adults (Rathbone et al., 2011; Shao, Yao, Ceci, & Wang, 2010; Wang et al., 2015), children between 9 and 11 are able to maintain continuity in their self-concept between their personal past and future experiences. This study indicates that in childhood self-concept plays a role in allowing children to envision plausible future events by establishing continuity between their past, present, and future selves. Coughlin et al. (2016) corroborate this link between emerging self-concept and episodic prospection. In their study, 5–11-year-olds and adults were asked to provide narratives of personal past and future events, which were then coded for *semantic generation* (i.e., the generation of a plausible personal event) and *episodic elaboration* (i.e., imbuing that event with rich contextual details such as vivid imagery). In addition, participants' self-concept coherence (i.e., how coherently they view themselves across multiple psychological dimensions) was assessed. Results indicated that self-concept coherence was a significant predictor of generating a plausible future event (but not imbuing that event with rich contextual detail) when age and the ability to generate past events were taken into account. Taken together, these results suggest that by middle to late childhood, self-concept begins to play an organizing role in the mental generation of future events that are personal and plausible.

Related research has also indicated a relation between organized future thinking and the content of self-concept (e.g., self-worth, self-efficacy, and personal goal achievement) during development. For example, Wang and Koh (2015) found that children who envisioned greater upward changes (from past to future) in peer relations and lower downward changes in future academic performance exhibited greater self-worth. And research with older children (ages 12 and 13) has indicated a positive relation between achievements in future academic goals and feelings of self-worth and self-efficacy (Pajares, Britner, & Valiante, 2000). These studies indicate that the developing self-concept may not only play an organizational role in selecting plausible future events, but may also interact with future thinking to support and maintain positive self-views.

Although the reviewed behavioral evidence highlights a potentially critical role of self-concept in shaping prospective thought during childhood and adolescence, there is little research examining the neural mechanisms that might support this developmental connection. Adult literature has indicated involvement of mPFC-mediated mechanisms (Kurczek et al., 2015) as well as the broader dMPFC network described by Andrews-Hanna et al. (2010) in self-relevant processing during episodic prospection. However, research in childhood and adolescence has not directly assessed this relation. There is evidence, however, that regions that overlap with the dMPFC network described by Andrews-Hanna et al. (2010), such as the TPJ, dMPFC, and temporal poles (Frith & Frith, 2006), also support self-concept in childhood and adolescence. In addition, significant changes in the cortical thickness of mPFC and dMPFC regions between childhood and adolescence might help support changes in self-concept awareness during this time period (Shaw et al., 2008).

Thus, these regions have been implicated in establishing self-concept during childhood and adolescence (Blakemore, den Ouden, Choudhury, & Frith, 2007; Mitchell, Banaji, & MacRae, 2005). Nevertheless, several studies have indicated age-related differences in the recruitment of components of the dMPFC network during self-relevant processing may have implications for differential contribution of self-concept on episodic prospection in children and adults. For example, Pfeifer et al. (2009) found that children recruited the dMPFC to a greater extent than did adults during self-relevant processing. In contrast, adults recruited the lateral temporal cortex to a greater extent than did children. These authors suggest that these differences may reflect the use of different strategies. Whereas adults may rely on accessing established semantic knowledge about the self, children may rely on an on-line self-reflective process. If this interpretation holds, then it may provide one basis for predicting protracted developmental change in the coherency and plausibility of individuals' mentalized future events. Therefore, more research is required to determine whether children rely on different self-related processes compared to adults during episodic prospection.

Together, this literature indicates that episodic prospection follows a protracted developmental trajectory, and suggests that the neurocognitive mechanisms underlying episodic memory and self-concept contribute to this development. Importantly, episodic memory development likely contributes to age-related improvements in the ability to incorporate episodic details when mentalizing personal future events across childhood (Coughlin et al., 2014; Wang et al., 2015), whereas self-concept development may contribute to improvements in the ability to use self-knowledge to construct personal future events that are plausible, relevant, and goal-directed from early childhood into early adulthood. An important open question concerns the functional significance of these complex developmental processes. This question is addressed in the next section.

EPISODIC PROSPECTION IN CHILDHOOD AND ADOLESCENCE: ADAPTIVE BENEFITS AND RELEVANCE FOR EDUCATION

The development of episodic prospection may convey considerable adaptive benefits during childhood and adolescence, periods during which seemingly simple decisions (e.g., deciding whether one should study for an exam or go to a party) could combine to have significant long-term consequences (e.g., influencing one's academic attainment). In this section, we review literature on the adaptive benefits of episodic prospection while discussing the possible implications of these benefits from a developmental and educational perspective.

The ability to mentally pre-experience personal future events may be adaptive for several reasons.

First, envisioning personal future events likely fosters a heightened sense of connection with one's future self, which may make individuals more willing to make decisions that will benefit their future selves. Indeed, research with adults has shown that feeling psychologically closer to one's future self increases the likelihood that an individual will forgo a smaller immediate reward in favor of a greater deferred reward (Bartels & Urminsky, 2011). There is also evidence that thinking about one's future self makes individuals more apt to seek intellectual enrichment than they would normally (O'Brien, 2015). Together, this research suggests that a central adaptive function of episodic prospection is to *increase motivation* for present-day behavior that will benefit the future self.

This has significant implications for children's behavior in educational contexts across development. Specifically, developmental improvements in episodic prospection may increase children's psychological connection to their future self, subsequently increasing their motivation to engage in academically oriented behaviors that will benefit their future self. For example, young children with limited episodic prospection ability may choose to ignore their homework in order to play with a neighbor, and as a result make decisions that come at a cost to their future self. In contrast, older children may choose to do their homework because they feel more connected to their future self and the potential negative consequences they may suffer (e.g., failing the assignment, being judged negatively by one's teacher, and—if the behavior becomes habitual—potentially reducing one's chances for high academic attainment).

Other adult research has indicated that in addition to reducing negative outcomes for the future self, episodic prospection also may support increases in prosocial tendencies toward others by allowing individuals to imagine the outcomes of their own helping behavior (Gaesser, 2013; Gaesser, Horn, & Young, 2015; Gaesser & Schacter, 2014). With increasing social demands during childhood and adolescence, the impact of episodic prospection on promoting positive social relationships becomes a crucial avenue for exploring the adaptive relevance of episodic prospection. Developmental improvements in episodic prospection may thus help facilitate strong social bonds and positive self-concepts.

Another potential adaptive benefit of episodic prospection is that it allows individuals to *mentally practice* possible future events. Being able to envision a possible future event in full contextual detail affords the individual with a unique opportunity to mentally practice different actions he or she could take during the course of that event, and to mentally pre-experience the potential consequences of such actions. Although there has been very little work examining mental practice as an adaptive function of episodic prospection explicitly, a relatively large body of literature has focused on the adaptive function of mental practice in general (see Driskell, Cooper, & Moran, 1994 for a meta-analysis). Not only does mental imagery about personal goals increase students' feelings about ease and accomplishment (Burke, Shanahan, & Herlambang, 2014), it also affects behavior relevant to their academic performance. For example, Pham and Taylor (1999) found that college students who mentally simulated successful performance on a future exam changed their studying behavior in order to do well on the exam and received better scores as a result. Galyean (1980, 1982–1983) has shown that low-achieving Spanish students showed reduced disruptive behaviors and improved test scores over a 4-month period after being taught to use mental imagery in which they envisioned themselves as successful learners. These findings complement research showing that mentally simulating an event fosters participants' belief that the event will occur and, importantly, the likelihood that they will pursue actions related to the event (Gregory, Cialdini, & Carpenter, 1982). They also have important implications for age differences in academically relevant behavior. As children become better at binding episodic features to form a mental simulation of a future event, they are better equipped to practice (and thus benefit from) mental practice via episodic prospection.

Together, the reviewed literature suggests that episodic prospection may support academic motivation and action across childhood and adolescence. If true, programs to support educational achievement may benefit from utilizing time- and cost-effective episodic prospection exercises. Importantly, such programs would likely be most effective if they took into consideration the child's or adolescent's episodic prospection ability. As reviewed earlier, the development of prospection is likely supported by episodic memory and self-concept (among other constructs). Thus, considering how these constructs differentially contribute to the development of, and individual differences in, episodic prospection could provide valuable insight into the potential effectiveness of such programs across different age groups and populations.

THE FUTURE OF EPISODIC PROSPECTION RESEARCH: WHAT'S NEXT?

This review provides insight on the neurocognitive development of episodic prospection during childhood and adolescence, with a special focus on its implications for academic achievement. First, it informs our theoretical understanding of how episodic memory and self-concept processes support children's ability to envision and plan for their future. These constructs likely interact with others (e.g., executive functioning, cognitive flexibility, and goal attribution) to support episodic prospection. Thus, future research should work to integrate additional constructs to better understand their contribution to the developmental trajectory of episodic prospection. Further, this review examined MTL-mediated and prefrontal-mediated systems, and their individual roles in supporting episodic prospection development. It is important to note that, despite their individual roles, these regions likely interact in more complex ways (and with additional neural regions) than has been prescribed in the literature. Thus, future research should aim to provide a more comprehensive understanding of how changes in neural structure, function, and connectivity support the development of episodic prospection.

Second, childhood and adolescence may be arguably characterized as a time of high impulsivity and shortsighted behavior (Eaton et al., 2012), but episodic prospection might be helpful. For example, Bromberg, Wiehler, and Peters (2015) found that adolescents' delay-discounting behavior (i.e., devaluing future rewards as a function of time), which might place adolescents at risk for poor decision making, is strongly predicted by episodic prospection. However, these results are correlational in nature, and it is unclear which mechanisms contribute to the decrease of impulsivity in adolescents. Therefore, the consideration of individual differences in impulsivity and goal attribution during late childhood and adolescence may be useful for establishing targeted interventions aimed at improving academic achievement through episodic prospection. In a study about the benefits of deliberate practice, Davis, Cullen, and Suddendorf (2015) found that 4- and 5-year-old children chose to practice difficult tasks (e.g., directing a string through a wire without touching it) that yielded a future reward more often than ones that did not. Younger children did not act to prepare for the future in this way. To our knowledge, this is the only study that has explored the spontaneous use of future-thinking behavior to improve achievement of future goals in childhood, although this study did not explicitly manipulate episodic prospection or goal attribution. Adopting such tasks to explore achievement of academic and personal goals in later childhood and adolescence through both neuroimaging and behavioral methodologies could provide crucial understanding of the adaptive benefits of episodic prospection, as well as help identify the consequences of limitations in this ability.

Lastly, further exploration of the heterogeneous processes that underlie episodic prospection during childhood and adolescence can provide insight on age-specific targets for intervention. For example, Vasquez and Buehler (2007) found that when college students visualize themselves accomplishing a future task from a third-person perspective, they increase self-motivation for the task as well as successful achievement of the task. The authors argue that imagining a future goal from a third-person perspective allows for abstract, high-level construal of task demands and personal motivations. This approach capitalizing on perspective taking may not be as helpful during childhood: even though children begin to prospect spontaneously and behave in a more autonomous manner, they may not have mastered sufficient flexibility to deliberately take different perspectives and their motivation for learning is still strongly supported by environmental influences such as parents and teachers. Thus, pedagogy could benefit from a greater understanding of how and when the mental simulation of future events is most effective in motivating academic achievement. Indeed, age-specific interventions require a deeper understand of changes in prospection over time.

CONCLUSION

Episodic prospection allows individuals to regulate motivational drives, generate goals, construct plans, and evaluate the extent to which a future event may be possible by incorporating information and evidence from one's own personal and global timeline. In this review, we examined cognitive and neural mechanisms that likely support the development of episodic prospection. The studies reported here lend credence to our suggestion that memory-related mechanisms and self-related mechanisms interact to contribute to children's ability to construct future episodes that maintain personal goals and establish consistency in one's representation of self across time. In order to establish a coherent picture regarding the development of episodic prospection, future research should establish paradigms that can target both cognitive and neural changes that support episodic prospection ability between childhood and adolescence. In so doing, researchers can begin to think about how intervention can capitalize on the development of episodic prospection to facilitate learning outcomes, behavioral outcomes, and goal achievement.

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