EPISODIC FUTURE THOUGHT: CONTRIBUTIONS FROM WORKING MEMORY

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PAUL FAXON HILL

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APPROVED BY:

Lisa J. Emery
Chair, Thesis Committee

Douglas A. Waring
Member, Thesis Committee

Mark C. Zrull
Member, Thesis Committee

James C. Denniston
Chair, Department of Psychology

Edelma D. Huntley
Dean, Research and Graduate Studies

FOREWORD

This thesis is written in accordance with the style of the *Publication Manual of the American Psychological Association (6th Edition)* as required by the Department of Psychology at Appalachian State University.

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Episodic Future Thought: Contributions from Working Memory

Paul F. Hill

Appalachian State University

Abstract

Increasing evidence from several domains of research indicates that similar neurocognitive mechanisms underlie both the ability to remember the past and the ability to imagine novel future events. An emerging hypothesis accounting for these similarities suggests that the contents of episodic memory are retrieved and then recombined to provide the source material when mentally simulating future events. Accordingly, executive processes may play a key role in the strategic retrieval and binding of past episodes into a unitary future event representation. In the current study, I investigated the extent to which individual differences in working memory capacity contributed to the ability to imagine future autobiographical events. College students completed measures of working and short-term memory and were cued to recall autobiographical memories and imagine future autobiographical events consisting of varying levels of specificity (i.e., ranging from generic to increasingly specific and detailed events). The results indicated that future thought was related to performance on measures of autobiographical memory, which likely reflects similar retrieval demands associated with both past and future oriented autobiographical tasks. In addition, after controlling for autobiographical memory, residual working memory variance only independently predicted future specificity. I suggest that working memory provides the attentional and inhibitory resources necessary in order to imagine specific future episodic events.

Episodic Future Thought: Contributions from Working Memory

The ability to disengage from the present environment and shift one's perspective across space and time is thought to be a uniquely human characteristic (Suddendorf & Corballis, 2007). The concept of mental time travel, in which we can mentally project ourselves both backward into the past and forward into the future, may provide an adaptive advantage aiding in flexible problem solving and decision making by allowing one to use the lessons learned in the past in approaching present and future situations (Suddendorf & Corballis, 2007; Wheeler, Stuss, & Tulving, 1997). Likewise, memories of past events and foresight into the future become fundamental in creating the phenomenological representation of a self-concept that is consistent across space and time, conceptually referred to as autonoetic consciousness (Tulving, 1985). A growing body of research is therefore beginning to approach episodic memory as not only a cognitive mechanism for recalling past events but as a broader vehicle allowing for the projection of oneself into both the experienced past and imagined future (Addis, Wong, & Schacter, 2007; Busby & Suddendorf, 2005; D'Argembeau & Van der Linden, 2004; Okuda et al., 2003; Suddendorf & Corballis, 2007). Conceptualizing episodic memory in this broader context suggests similar or shared neurocognitive mechanisms underlying both episodic memory and the ability to imagine events in the future, alternatively referred to as *episodic future thought* (Atance & O'Neill, 2001).

The adaptive advantage of using past experiences to aid future oriented behavior suggests that executive processes may be used to access lessons learned in the past in order to shape present and future behavior. Generative models of autobiographical memory propose that semantic autobiographical information (including goals and life events) is used to guide strategic access to contents stored within long-term memory (Conway & Pleydell-Pearce, 2000). Research has suggested similar generative processes at work when imagining future events (D'Argembeau & Mathy, 2011). The strategic retrieval mechanisms supporting both past and future mental time travel may therefore be mediated by similar executive processes (D'Argembeau, Ortoleva, Jumentier, & Van der Linden, 2010).

Though autobiographical memory and future thought are believed to share underlying mechanisms, additional executive resources may be necessary to support the increased demands of constructing a novel future event (D'Argembeau & Mathy, 2011; D'Argembeau et al., 2010). Expanding on this idea, in the current study I took an individual differences approach to examine the relationship between episodic future thought and working memory (WM), a widely studied measure of executive attention that has been implicated in a number of higher order cognitive processes (Engle, Tuholski, Laughlin, & Conway, 1999; Kane et al., 2004). Though WM has previously been suggested to contribute to the ability to imagine the future (Schacter & Addis, 2007a; Suddendorf & Corballis, 2007), and evidence has indicated a potential functional relationship between WM and measures of future directed behavior (Bickel, Yi, Landes, Hill, & Baxter, 2011), the direct contributions of WM capacity on future thought have not been systematically investigated. In the following sections, I will first review evidence which indicates overlapping mechanisms underlying episodic memory and future thought. I will then discuss models of WM accounting for a functional relationship with long-term memory, while framing the potential role of WM capacity in contributing to episodic future thought.

Evidence for Shared Mechanisms Supporting Past and Future Autobiographical Events

Evidence from several domains of research support the idea of similar neurocognitive mechanisms underlying both episodic memory and future thought. Case studies of amnesiac patients indicate that the loss of episodic memory corresponds with similar deficits in the ability to imagine the future (Klein, Loftus, & Kihsltrom, 2002; Tulving, 1985). For example, Tulving (1985) reported on patient N. N. who suffered from severe amnesia for personal events occurring both before and after the onset of his condition. When asked to imagine events in the future, N. N. was unable to do so; it was only after further probing that the patient described his attempts at imaging the future as consisting of blankness, similar to that of being asleep. Klein and colleagues (2002) reported similar observations of patient D. B. whose severe amnesia corresponded to a related inability to imagine himself in the future. However, D. B.'s deficits were noted to be restricted to personally relevant events. In contrast, his ability to recall semantic events from the past and to contemplate future events occurring within the public domain remained relatively intact, indicating a dissociation between autobiographical and semantic mental time travel.

Similar to those suffering from amnesia, research has identified additional patient populations displaying similar patterns of memory deficits extending into the ability to contemplate the future. For example, Williams and colleagues (1996) reported that suicidally depressed individuals displayed reduced specificity when recalling past events – that is, they tended to recall generic or categorical events rather than events corresponding to a particular episode – and this correlated with their reduced specificity when imagining future events. Likewise, Lind and Bowler (2010) reported that, relative to comparison populations, autistic adults had trouble generating specific past and future events, indicating marked impairments in both episodic memory and future thinking. Schizophrenic patients were found to show similar patterns, reporting significantly fewer specific past and future events compared to controls, with the future condition exhibiting more pronounced group disparity (D'Argembeau, Raffard, & Van der Linden, 2008). Interestingly, the deficits in generating specific past and future events exhibited by autistic and schizophrenic patients were unrelated to performance on measures of general fluency in both populations, indicating that the impairments observed in episodic memory and future thought cannot be solely accounted for by retrieval difficulties (D'Argembeau et al., 2008; Lind & Bowler, 2010).

Developmental research provides further evidence for overlap between recalling the past and imagining the future. Although children may begin to successfully recall previously experienced events at a younger age, it is generally believed that it is not until the age of about four that children begin to generate contextually rich and personally significant episodic memories (Levine, 2004; Suddendorf & Busby, 2005; Wheeler et al., 1997). It is also around this age that children begin to demonstrate more sophisticated planning and anticipatory behaviors related to the future (Atance & O'Neill, 2001). In a study in which young children were asked to report an event from yesterday and an event to take place tomorrow, Busby and Suddendorf (2005) found that episodic memory and future thought emerged in tandem in 3-5 year olds.

On the other end of the developmental spectrum, age related declines in episodic memory have been observed to correspond with similar impairments in future oriented thought (Addis, Wong, & Schacter, 2008). Though semantic knowledge shows little change and is perhaps facilitated across the lifespan, aging is accompanied by reduced production of contextual and temporally specific autobiographical details (Levine, Svoboda, Hay, Winocur,

& Moscovich, 2002). Addis et al. (2008) extended these findings to reveal that age related impairments in recalling past autobiographical events correspond to similar specificity deficits when attempting to imagine future events.

In addition to the extensive evidence of parallel deficits observed in a variety of populations, similarities in the phenomenological characteristics of recalling the past and imagining the future lend further support for a shared mechanism underlying both episodic memory and future thought. Specifically, many of the subjective aspects of recalling the past and imagining the future appear to be bound by similar constraints. The valence and temporal distance of both past and future events similarly affects the subjective aspects of our mental representations of those events, with positive and temporally close events being more richly remembered or imagined (D'Argembeau & Van der Linden, 2004). A bias to maintain a positive self-concept, driven by personal goals and motives, may explain the impact of positive valence on the contextual details of past and future simulations (Conway & Pleydell-Pearce, 2000; D'Argembeau & Van der Linden, 2004, 2008). Autobiographical memory has often been shown to exhibit a strong positivity bias, whereby positive events are more richly recollected than negative events (D'Argembeau & Van der Linden, 2008). Likewise, simulations of future events typically involve more positive and idyllic representations (Bernsten & Jacobsen, 2008), likely indicating similar self-enhancement strategies.

Brain imaging studies have also indicated a core neural network underlying episodic memory and future thought, including areas of the medial prefrontal cortex (mPFC), medial temporal lobes (MTL), and extending posteriorly into the parietal and occipital lobes (Addis, Pan, Vu, Laiser, & Schacter, 2009; Addis et al., 2007; Botzung, Denkova, & Manning, 2008; Okuda et al., 2003; Szpunar, Watson, & McDermott, 2007). These regions are widely regarded as comprising the autobiographical memory network (Svoboda, McKinnon, & Levine, 2006), and their engagement during both past and future oriented tasks has been hypothesized to reflect the shared contributions of self-referential, retrieval, and contextual binding processes inherent in both recalling an autobiographical past and imagining a personally relevant future (Addis et al., 2007; Botzung et al., 2008).

Activation of posterior neural regions, including bilateral parahippocampal, retrosplenial, and posterior cingulate cortices, extending into the precuneus and occipital areas has also been reported during both past and future episodic thinking (Addis et al., 2007; Botzung et al., 2008; Okuda et al., 2003; Szpunar et al., 2007). These regions likely support the integration of contextual and visuo-spatial information into a coherent episodic representation (Botzung et al., 2008; Szpunar et al., 2007). Furthermore, preferential engagement of parahippocampal and posterior cingulate cortices and superior occipital regions has been observed during tasks which involve thinking about an event in a familiar versus unfamiliar context, suggesting a tendency to place ourselves within familiar contexts when imagining future events (Szpunar, Chan, & McDermott, 2009).

Addis et al. (2007) incorporated an event-related functional magnetic resonance imaging design to investigate the neural substrates of episodic memory and future thought. This method allowed the authors to distinguish between the initial construction and subsequent elaboration phases of past and future thought. As expected, their results indicated extensive neural overlap during the elaboration phase of both episodic memory and future thought, which they attributed to similar demands placed on autobiographical retrieval mechanisms related to self-referential, contextual, and episodic imagery processes. The construction phase, however, was marked by considerable neural differentiation between the two temporal directions. Of particular note during this phase was the lateralized hippocampal function corresponding with past and future event construction. Though the left hippocampal activity was observed during both past and future events, the right hippocampus was found to be preferentially engaged during the future oriented tasks, a surprising finding given this structure's widely regarded role in memory retrieval (Svoboda et al., 2006). The authors noted that, whereas recalling a past event involves the *reintegration* of previously bound information into a coherent mental event simulation, imagining a future event involves the *novel* integration of information. This fundamental difference between past and future event construction may account for the differential hippocampal involvement. Specifically, Addis and colleagues (2007) suggested that left hippocampal activity observed early during the construction phase likely reflects the interaction between event cues and stored memory traces, which would be necessary for both past and future event construction. Further activation of the right hippocampus during future oriented tasks likely supports the novel integration of distinct component episodes into a coherent future event. Investigations of amnesiac patients with hippocampal damage have similarly implicated this regions role supporting the novel integration of disparate details into a unified event (Hassabis, Kumaran, Vann, & Maguire, 2007). Specifically, when asked to imagine novel events, Hassabis and colleagues found that, relative to control subjects, responses made by the amnesiac patients were fragmented and lacking in spatial coherence, leading to an overall lack of a unified episodic representation.

Okuda and colleagues (2003) were among the first to observe overlapping patterns of regional cerebral blood flow as subjects recalled events from their past and imagined events in their future. Notably, the authors reported less bilateral *deactivation* in anterior portions of the mPFC during past and future autobiographical tasks relative to a semantic control task. Szpunar et al. (2007) reported similar patterns of attenuated mPFC deactivation during tasks requiring participants to elaborate on past and future autobiographical events, relative to a control task in which a semantically known 3rd person was imagined (Bill Clinton). These patterns of mPFC deactivation in response to autobiographical demands are consistent with this region's hypothesized role in supporting self-referential mental activity (D'Argembeau et al., 2007; Gusnard, Akbudak, Shulman, & Raichle, 2001; Raichle et al., 2001; Wicker, Ruby, Royet, & Fonlupt, 2003). The mPFC has also been hypothesized to underlie the ability to dissociate from the present experience and direct our attention to a temporally distinct event, thus allowing us to mentally travel through time (Botzung et al., 2008; Okuda et al., 2003), an idea supported by regional overlap with Theory of Mind tasks, which similarly require shifting focus away from the immediate environment (Spreng & Grady, 2010; Spreng, Mar, & Kim, 2009). The mPFC has thus been suggested to serve as the neural seat of autonoetic consciousness (Wheeler et al., 1997).

In addition to the mPFC, episodic past and future tasks have also been observed to engage left ventrolateral (Addis et al., 2007) and left dorsolateral (Botzung et al., 2008) prefrontal cortex, which may reflect executive retrieval operations. Specifically, ventrolateral and dorsolateral frontal areas may correspond to the cueing and monitoring of memory search, respectively, with anterior areas playing more of an executive role in switching between these processes (Fletcher & Henson, 2001).

Overlapping activation patterns observed between both episodic past and future oriented thought could indicate that our memories of past events are similarly recruited both when recalling the past and imagining novel future episodes. According to the *constructive* *episodic simulation* hypothesis proposed by Schacter and Addis (2007b), the contents of our episodic memories are recruited as source material and flexibly recombined in order to produce novel mental representations of future events. The notion that our episodic memories are utilized in generating representations of a novel event is supported by neuroimaging research indicating that, within the core neural network underlying both past and future episodic thought, future oriented thought tends to elicit increased neural activity relative to recalling the past, potentially indicating the increased cognitive demands of flexibly recombining multiple past episodes in generating a novel simulation of a future event (Addis et al., 2007; Okuda et al., 2003; Szpunar et al., 2007).

Proposed Role of WM in Constructing Novel Future Events

Though extensive attention has been focused on the neural correlates of episodic past and future directed thought, the cognitive components that support the construction of episodic mental representations remain less clear. One aspect of mental time travel that remains to be thoroughly explored is the role of WM in integrating elements from our experienced past to form novel mental representations of future events. WM capacity is a widely used measure of controlled attention, which serves to hold important information in a readily accessible state which is subsequently capable of being processed and manipulated in support of various cognitive demands (Miyake & Shah, 1999). Accordingly, WM capacity has been linked to a range of higher order cognitive abilities, such as general fluid intelligence, reading and language comprehension, among others (Engle et al., 1999). With respect to episodic future thought, WM may play a role in the strategic retrieval and active maintenance of relevant episodic memories, providing the cognitive structure on which these episodes may be flexibly recombined to create a coherent, novel simulation of a future event.

If WM does indeed play a role in flexibly recombining contents from our episodic memories to construct novel representations, the cognitive mechanisms and neural substrates underlying WM would need to exhibit at least partial overlap with long-term memory (LTM). Indeed, investigations of amnesiac patients (Baddeley & Wilson, 2002), as well as examinations into the constructive validity of WM and LTM tasks (Unsworth, 2010), does seem to indicate cognitive overlap. Evidence from behavioral research also supports the interaction between WM and LTM processes. For example, the typical span for the recall of a sequence of unrelated words is about five; however, when recalling a meaningful sentence, this span increases to roughly 16 words (Baddeley, 2000; Baddeley & Wilson, 2002). This increased span likely indicates a process known as *chunking*, in which semantic associations between words, made possible by the retrieval of semantic knowledge stored within LTM, results in the partitioning of conceptual units within a sentence into a more manageable number of component ideas, which are then more easily recalled (Baddeley, 2000).

Neuroimaging investigations of WM indicate neural activity in brain regions corresponding to those that contribute to the core network underlying episodic past and future thinking, notably prefrontal and medial temporal cortices, further suggesting a relationship between WM and LTM. (Addis et al., 2007; Botzung et al., 2008; Cabeza, Dolcos, Graham, & Nyberg, 2002; Chein, Moore, & Conway, 2011). Such neural overlap is particularly evident with respect to WM tasks that require the reconstruction of displaced memories rather than simple short-term storage and retrieval processes (Chein et al., 2011). For example, WM and episodic retrieval tasks have both been shown to produce overlapping activation in left dorsolateral prefrontal and MTL regions (Cabeza et al., 2002). Left lateralized activation of dorsolateral PFC regions has been suggested to play a role in monitoring information within the focus of attention, whether the information is being transiently stored for WM tasks or the subject of episodic retrieval from LTM (Cabeza et al., 2002; Faraco et al., 2011). Overlapping MTL activations, including bilateral hippocampal and parahippocampal areas, may indicate this region's role in mediating indexing operations for the retrieval of task relevant information. Preferential engagement of dorsolateral PFC (Addis et al., 2007) and MTL (Addis et al., 2007; Okuda et al., 2003) regions during the construction of future episodic events, relative to past events, may suggest the increased demands of maintaining multiple episodes retrieved from LTM in order to mentally simulate a detailed future event (Addis et al., 2007).

Numerous theoretical frameworks have been proposed attempting to account for the relationship between WM and LTM. These theories often take different approaches in explaining how contents stored in LTM are retrieved and subsequently monitored in order to provide the information maintained in WM. Structural approaches tend to focus on describing the executive and storage components underlying WM, and how they interact in order to encode, retrieve, and maintain information (e.g., Baddeley, 2000; Logie, 2003). Functional approaches tend to focus on the underlying purpose of the WM system, typically viewing WM capacity as the ability to direct controlled attention to task relevant resources in order to complete complex cognitive tasks (e.g., Engle et al., 1999).

Structural approaches to the WM-LTM relationship. Baddeley and Hitch (1974) proposed a three component, limited capacity model of WM in order to conceptualize the role of the temporary storage of multimodal information in cognitive performance. This model consists of two domain specific subsidiary storage systems, the phonological loop and the visuo-spatial sketchpad, which are capable of storing verbal and visual information, respectively, and the domain general central executive, which controls the selective access and manipulation of information stored within the temporary subsidiary systems. This original model has since been modified in an attempt to better account for the WM-LTM relationship. Baddeley (2000) introduced the concept of the episodic buffer to provide limited capacity storage of multimodal information, which is capable of binding information retrieved from the subsidiary short term storage systems and LTM into a coherent episodic representation (Baddeley, 2000). The episodic buffer is assumed to provide a modeling space for producing novel scenarios that can guide future action (Baddeley & Wilson, 2002). Investigating the ability of amnesiac patients to recall the basic gist of a prose passage consisting of about 15-20 idea units, Baddeley and Wilson (2002) observed that patients who were uniformly bad at recalling a passage after a delay often were within the normative range when recalling the passage immediately after the initial presentation. These results were interpreted as being consistent with the functional role of the episodic buffer. Specifically, the authors suggested that the preservation of immediate prose recall involves the temporary activation of representations held in LTM, ranging from individual words and phrases to more general conceptual schemas. This activated information is then held in temporary storage via the episodic buffer.

Logie (2003) proposed a model of WM as a mental workspace, in which a semantic knowledge base held in LTM is activated in response to perceptual stimuli. For example, when viewing an object such as a stapler, the perceived visual elements of the stapler (lines, edges, color, etc.) activate associated meanings based on our previous experiences with staplers. When viewing a stapler, one can imagine what it would feel like to hold it, or what would happen if it was thrown at someone. It is possible to imagine these particular details despite the fact that they are not a part of the immediate visual perception of the stapler. It is these activated representations that are then held in temporary storage and are capable of manipulation, which ultimately allows for mental discovery and the generation of new knowledge (Logie, 2003).

Cowan (1995, 1999) takes a similar approach in functionally defining WM by proposing a unitary system of activated memory. According to Cowan's Embedded-Processes Model, WM does not entail a distinct mechanism; rather, WM is more accurately viewed as a subset of activated memory embedded within LTM. The contents of WM consist of accessed task specific information within the current focus of attention, or information that is readily accessible with sufficiently pertinent retrieval cues, with attention allocated by both the central executive and by sufficient external cues (Cowan, 1999).

Functional approaches to the WM-LTM relationship. Functional frameworks focus on how working memory may be recruited in service of cognitive demands. For example, Ericsson and colleagues (Ericsson & Delaney, 1999; Ericsson & Kintsch, 1995) conceptualized a model of long-term working memory, in which expert task performance involves the use of specialized encoding strategies. According to this model, task specific information is encoded in association with preexisting semantic knowledge in anticipation of future retrieval demands. Information stored in this way is subsequently capable of being easily and efficiently accessed upon exposure to appropriate retrieval cues (Ericsson & Delaney, 1999).

A second group of functional theories conceptualize WM as a domain-general executive attention mechanism, which functions to keep task relevant information in a readily accessible state (Kane et al., 2004). These theories emphasize the difference between complex working memory span (CWMS) tasks and short-term memory (STM) span tasks in predicting complex cognitive functions like reasoning and language comprehension. Whereas STM tasks encompass the storage and recall of information, CWMS tasks focus on the storage and recall of information in the face of cognitively engaging processing demands (Unsworth & Engle, 2007). The processing demands of a typical CWMS task serve to displace to-be-remembered items from the current focus of attention such that successful completion of the recall task requires that this displaced information be retrieved from secondary storage systems (LTM). Executively controlled retrieval operations are thought to be mediated by task-relevant contextual cues and function to reactivate displaced information stored in LTM (Chein et al., 2011; Unsworth & Engle, 2007). WM capacity, therefore, entails the ability to actively maintain information within the current focus of attention while also efficiently retrieving and maintaining displaced information. Such a theoretical framework extends Cowan's embedded process model to explain why WM tasks are powerful predictors of other complex cognitive tasks and may explain the shared variance between WM and LTM measures (Unsworth, 2010).

Chein et al. (2011) investigated whether brain regions implicated in CWMS tasks underlie domain-general functions for both verbal and spatial WM tasks, utilizing a novel WM imaging paradigm. Lateral prefrontal, anterior cingulate, and parietal cortices were activated during the encoding, maintenance, and coordination phase of the task, suggesting their role as attentional control and selection mechanisms. Anterior PFC and MTL (including posterior hippocampus and inferior portions of the parahippocampal gyrus) were activated during the recall phase of the WM task. This latter pattern of activation is consistent with the previously mentioned framework proposed by Unsworth and Engle

(2007), suggesting that the interaction between anterior PFC and MTL may indicate a "controlled search mechanism…critically involved in reactivating information from LTM" (Chein et al., 2011, p. 557) previously displaced by the CWMS task, suggesting the involvement of LTM mechanisms in mediating the relationship between WM and cognitive performance (Chein et al., 2011; Faraco et al., 2011; Unsworth & Engle, 2007). Notably, these neural regions, which correspond with the aforementioned autobiographical network underlying both episodic memory and future thought, have been observed to be preferentially engaged during future, relative to past, oriented-tasks (Addis et al., 2007; Okuda et al., 2003).

Recent studies have found that executive processes play an important role supporting episodic future thought. For example, D'Argembeau and colleagues (2010) examined the influence of individual differences in eight component processes across four autobiographical past and future measures. In this study, participants completed a series of basic cognitive tests and questionnaires in order to determine which factors predicted people's fluency and clarity of their future imaginings. An exploratory principal components analysis of the eight component measures yielded three factors (tasks with highest factor loadings, >.70, in parentheses): visual-spatial processing (Block Design Test, Visual Patterns Test), executive processes (Phonemic and Semantic Fluency), and verbal relational memory (Verbal Paired Associates).

The results from the D'Argembeau et al. (2010) study indicated that executive processes significantly predicted several facets of both past and future autobiographical event generation. The authors interpreted this as reflecting a general executive role supporting retrieval, monitoring, and selection of autobiographical knowledge necessary when constructing past and future events. In addition, visuo-spatial processes contributed to the number of sensory details included in future event narratives, likely attributable to the increased demands of constructing a novel event rich in visual imagery. Verbal relational memory was not related to any of the autobiographical measures, possibly attributable to the low ecological validity of the Verbal Paired Associates task which loaded most heavily on this factor (McDermott, Szpunar, & Christ, 2009). Notably, this study included the Letter-Number Sequencing subtest as a measure of WM; however, when collapsing each of the measures across the three aforementioned factors, Letter-Number Sequencing performance exhibited moderate loadings on each. Any direct observation of WM contributions to episodic future thought was, therefore, not possible.

Overview of the Present Study

In the current study, I took an individual differences approach to investigate the hypothesis that WM provides the cognitive structure on which disparate episodes stored in LTM are accessed and then integrated to form a mental representation of a novel future event. The methods and measures used in this study were adapted from the aforementioned study by D'Argembeau and colleagues (2010), which similarly focused on the component processes uniquely contributing to episodic future thought. The primary question was whether individual differences in WM differentially predict measures of episodic past and future oriented tasks, and the extent to which WM serves a domain-general role in supporting episodic future thought. Based on the increased neural activations of brain regions while imagining the future relative to recalling the past, taken with the relationship between executive processes and future directed thought (D'Argembeau et al., 2010), the primary hypothesis was that WM would correlate with episodic future thought over and above autobiographical memory. Due to the speculated domain generality of WM and specificity of STM tasks (Chein et al., 2011; Kane et al., 2004), I also expected verbal and visuo-spatial WM to similarly predict performance on the past and future autobiographical tasks, and visuo-spatial STM to be more closely related to past and future autobiographical performance than verbal STM.

Method

Participants

Participants were 109 college students (71 women, 38 men; mean age 19.3 years old, *SD* = 3.0) enrolled in introductory and intermediate psychology classes at Appalachian State University who elected to enter the psychology subject pool in order to fulfill an experiential learning credit for their course. All study procedures adhered to the ethical standards outlined by the institutional review board (IRB). This study received exempt status from the IRB on August 31, 2011 (see Appendix A); therefore, signatures were not required during the consent process. Verbal informed consent was obtained prior to the study procedures (see Appendix B). Data from the operation span and episodic details task were missing for one participant who was unable to complete all study procedures due to time constraints.

Materials

Participants completed three measures of episodic memory and future thinking borrowed from D’Argembeau et al. (2010): autobiographical fluency, episodic specificity, and number of episodic details. Participants also completed verbal and visuo-spatial CWMS tasks, and verbal and visuo-spatial STM tasks. All measures were administered on a desktop computer using E-Prime software (Schneider, Eschman, & Zuccolotto, 2002).

Autobiographical fluency. The autobiographical fluency task assessed the ability to generate multiple generic representations of past and future events. Participants were instructed to think about two time periods from their past (within the past year and within the past 5-10 years) and two time periods in their future (within the next year and within the next 5-10 years). Participants were given 60 seconds to generate as many events as possible that occurred or may occur within the specified time frame. Instructions indicated that the events could be trivial or important. Participants were also instructed that responses were not required to be detailed. The order of cue presentation was counterbalanced across temporal direction (past or future), with the one-year time period presented first, regardless of temporal direction. Scores were based on the total number of events generated for each time period. Following D’Argembeau et al. (2010), the two time periods from each temporal direction were subsequently combined to produce a total past and total future fluency score.

Episodic specificity. The episodic specificity task assessed the ability to generate specific autobiographical past and future events. Participants were cued to recall specific events occurring in their personal past and specific events that might reasonably occur in their personal future. Participants were instructed to identify unique events that take place in a specific place at a specific time, lasting a few minutes to hours, but not more than a day. Two sets of five cue words were used, matched for imageablitity, frequency of use, and word length (Tse & Altarriba, 2007; see Appendix C), and counterbalanced across past and future conditions. The order in which the participants completed the two time conditions was also counterbalanced.

For scoring purposes, responses were counted as specific when occurring at a specific place and time, lasting a few minutes or hours, but less than one day (e.g., “I am going camping near Wilson Creek next weekend; I can imagine arriving at the trailhead in the afternoon and hiking to the river to find a nice spot”). The total number of specific events generated for each temporal condition was computed, yielding a past and future specificity score. The highest possible score for either temporal condition was 5.

Episodic details. The episodic details task, adapted from Hassabis et al. (2007), assessed the number of details participants were able to generate when recalling or imagining specific episodic events. Participants were cued to think about a past or future episodic event and then were instructed to elaborate on the details of that event, providing as many sensory and introspective details as possible. Instructions specified that the events should be unique, occurring at a specific place and time, lasting a few minutes or hours, but less than one day. Future events were additionally required to be both plausible and novel. The past and future event cues were adopted from D'Argembeau et al. (2010) and the assignment of each cue to a particular temporal direction was counterbalanced across participants (e.g., "recall the last time you met a friend; imagine something you will do on your next vacation" or "recall something you did on your last vacation; imagine the next time you will meet a friend").

For scoring purposes, each event description was broken into a set of statements, roughly constituting a single idea unit. These statements were then classified into six categories: spatial reference, entity presence, sensory description, thoughts and emotions, actions, or temporal reference. Spatial references included aspects related to the position or direction of entities relative to the participant's vantage point (e.g., "she sat to my left"), references to explicit measurements (e.g., "about 50 feet from the water"), as well as distinct locations (e.g., "Florida"). Any reference to a distinct, concrete object was categorized as an entity (objects, people, animals, etc.). The sensory description category consisted of references to the qualitative properties of entities or of the environment (e.g., "the water is dark blue," "it is very humid"). The thoughts and emotions category included introspective thoughts and emotions of the participant or any other entities in the scene. Likewise, actions constituted any action initiated by an entity within the scene. The temporal category was adopted by D'Argembeau et al. (2010) and included references to the temporal context of an event (e.g., "last winter") as well as time measurements (e.g., "four hours later").

Operation span. The operation span (OSPAN) is a measure of verbal WM (Engle et al., 1999; Kane et al., 2004) in which participants must recall a string of letters while simultaneously completing an algebraic processing task. The algebraic operation consists of a parenthetical multiplication or division problem, followed by a number which must be added or subtracted from the previous product or dividend. In this automated version of the task, participants must decide whether a given response correctly answers the algebraic operation, and they are then presented with a letter to be recalled at the end of the sequence (Unsworth, Heitz, Schrock, & Engle, 2005).

The OSPAN is a widely used measure of verbal WM, generally showing high internal consistency (Chronbach's α = .80, Kane et al., 2004). In the automated version, participants completed three trials each of spans ranging from 3-7 operation-letter pairs per set (Figure 1). Set sizes randomly varied across trials so participants were unaware of the sequence length to be recalled before being cued. Throughout the task, participants received feedback on their performance on the algebraic processing task. In order to ensure that attention was adequately focused on the processing tasks, participants were instructed to keep their scores at or above 85%. Scores were determined based on the total number of letters recalled in the correct ordinal position.

Symmetry span. The symmetry span is a measure of visuo-spatial WM exhibiting high internal consistency (Chronbach's α = .80, Kane et al., 2004). This automated version of the task requires participants to recall the spatial locations of a sequence of shaded squares within a 4 x 4 matrix while simultaneously completing a symmetry judgment processing task (Unsworth et al., 2005). The symmetry judgment consisted of an 8 x 8 matrix with some of the squares filled in black. The participants were required to determine whether the black squares were symmetrical along the vertical axis. Participants completed three trials each of spans ranging from 3-7 memory matrices and symmetry judgments per set (Figure 1). Scores were determined based on the total number of locations recalled in the correct ordinal position.

Letter span. The letter span is a measure of verbal STM in which participants recalled sequences of letters presented visually on a computer screen for one second with a 500 millisecond (ms) blank screen between each letter (Kane et al., 2004). At the end of each trial, participants were required to recall the letters in their correct ordinal positions. Participants completed three trials each of randomly ordered spans ranging from 3-8 letters per set (18 sets total). Scores were based on the total number of letters recalled in the correct ordinal position.

Matrix span. The matrix span is a measure of visuo-spatial STM in which participants recalled the location of a shaded square within a sequence of visually presented 4 x 4 matrices (Kane et al., 2004). Each matrix was presented for 650-ms with a 500-ms blank screen between each presentation. At the end of a trial, participants indicated the locations of the shaded boxes in the order in which they were presented. Participants completed three trials each of randomly ordered spans ranging from 2-7 matrices per set (18 sets total). Scores were based on the total number of locations recalled in the correct ordinal position.

Procedure

After obtaining informed consent (Appendix B), participants completed the measures in the following order: letter and matrix span, autobiographical fluency, OSPAN or symmetry span, episodic specificity, OSPAN or symmetry span, episodic details. The WM and STM span tasks were counterbalanced across participants, with the STM tasks completed first and the WM tasks separating the autobiographical measures. Borrowing from D'Argembeau et al. (2010), the autobiographical tasks were presented in a fixed order due to the increasingly explicit instructions for generating episodic events. The total time to complete all experimental procedures was approximately one hour.

Results

WM Tasks

Correlations between verbal and visuo-spatial WM and STM as well as descriptive statistics and reliability estimates are shown in Table 1. Reliability estimates (Cronbach's α) were generally high and consistent with previously reported values (Kane et al., 2004). As described above, previous research (e.g., Kane et al., 2004) suggested that the WM tasks should tap both domain general and domain specific abilities; whereas, the STM tasks should primarily be domain specific. If this was true, I would expect to observe the following patterns: (a) moderate to strong correlations between verbal and visuo-spatial WM; (b) moderate to strong correlations between same-domain WM and STM tasks (e.g., verbal WM and verbal STM); (c) weak correlations between cross-domain measures of WM and STM (e.g., verbal WM and visuo-spatial STM); and (d) weak correlations between verbal and visuo-spatial STM.

As may be seen in Table 1, both measures of WM were strongly correlated, whereas the STM measures were not significantly related, consistent with expectations. However, the cross-domain correlations between WM and STM were inconsistent with those reported by Kane et al. (2004). In particular, visuo-spatial WM was significantly more related to verbal STM than to visuo-spatial STM, $t(106) = 2.80$, $p < .01$, though the inverse pattern was expected. Furthermore, though verbal WM and the two STM tasks exhibited correlation patterns consistent with what I expected (i.e., strongest relationship observed between verbal WM and verbal STM), the correlations were not statistically different, $t(106) = .43$, $p > .05$.

To further examine the domain generality and specificity issue, I performed an exploratory principal components analysis to determine whether the WM and STM measures could be reduced into domain general and domain specific component constructs. This analysis yielded only one factor with an eigenvalue greater than 1.0 and accounting for 52% of the total variance, which can be characterized as a general measure of WM capacity. Factor loadings are shown in Table 2. I used the resulting factor score as a composite measure of WM capacity in all subsequent analyses. Because the WM data was not consistent with separable domain general and domain specific WM components, the remaining analyses will focus on the primary hypothesis that WM contributes to episodic future thought independently of past autobiographical performance.

Future Thought Tasks

Each of the autobiographical measures was scored by three independent raters trained using the previously mentioned scoring procedures. Intraclass correlation coefficients (ICC) indicated that there was generally strong agreement between the raters with respect to the number of autobiographical events generated in the fluency task (past ICC = .98, future ICC

= .99), the number of specific events produced in the episodic specificity task (past ICC = .77, future ICC = .79), and the total content scores in the episodic details task (past ICC = .98, future ICC = .98).

Bivariate correlations and descriptive statistics for the past and future autobiographical measures and WM composite are shown in Table 3. Scores for autobiographical fluency and episodic specificity were higher for past events than for future events [$t_{fluency}$ (108) = 2.12, p = .036; $t_{specificity}$ (108) = 6.40, p < .001], which is consistent with previous research (Addis et al., 2008; D'Argembeau et al., 2010). The total number of episodic details, however, did not significantly differ between past and future events, $t_{details}$ (103) = 1.53, p = .129. Each measure of future thought was also correlated with its past counterpart. Among the autobiographical measures, past and future fluency exhibited the most striking relationship, as 64% of the variance in future fluency performance could be accounted for by past fluency. Conversely, a much smaller percentage of shared variance was observed between past and future measures of episodic specificity (18%) and details (25%). Composite WM capacity correlated with future specificity but none of the other autobiographical tasks.

Hierarchical multiple regression analyses were used to test the independent contributions of WM on future thought, over and above autobiographical memory. For each future measure, the corresponding autobiographical memory task was entered as a predictor of future thought in Step 1; WM was entered in Step 2 to determine any unique shared variance not accounted for by the corresponding autobiographical memory task. Results from these analyses are shown in Table 4. As can be seen, past fluency was a significant predictor of future fluency, whereas WM capacity did not independently contribute to future fluency. Past episodic specificity contributed to performance on the future specificity task; when controlling for past specificity, residual WM capacity independently predicted an additional 5% of the variance in future specificity. The total amount of details included in past narratives predicted the total content scores of future narratives; WM capacity did not independently contribute to future content scores when controlling for past details.

Discussion

In this study, I took an individual differences approach to investigate the role WM plays in the ability to generate future episodic events. Participants completed measures of episodic memory and future thought, as well as verbal and visuo-spatial WM and STM tasks. Using a composite score of WM capacity, I was able to examine the extent to which residual WM variance contributed to future thought while controlling for autobiographical memory. However, because the relationships between the measures of WM and STM were inconsistent with previous values, I was unable to explore the extent to which domain general and domain specific components of WM capacity contributed to various facets of episodic future thought. The results indicated that: (a) the ability to imagine personally relevant events in the future was strongly related to autobiographical memory; and (b) even when controlling for autobiographical memory, WM capacity uniquely predicted the ability to imagine future events within a distinct spatio-temporal context.

Measures of autobiographical memory were correlated with corresponding measures of future thought, which is consistent with the hypothesis that autobiographical memory and episodic future thought are supported by largely overlapping neurocognitive mechanisms (Buckner & Carroll, 2007; Suddendorf & Corballis, 2007). The similarities between the autobiographical measures were particularly evident in the highly correlated fluency tasks.

Notably, the fluency tasks were the least demanding of the autobiographical measures in terms of generating episodic details, with no criteria to elaborate on the specificity or details of that event. Additionally, events were not required to be episodic in the sense that they occur at a distinct time and place. The strong correlation between past and future autobiographical fluency thus suggests that accessing autobiographical information – regardless of temporal direction – appears to load on largely overlapping retrieval mechanisms. Each of the six autobiographical tasks used in the present study likely rely on similar retrieval operations (D'Argembeau et al., 2010), which may account for the moderate to strong correlations observed among each of the corresponding past and future measures. However, additional cognitive mechanisms are required as the demands associated with each task become increasingly explicit (i.e., required to recall and imagine increasingly unique and detailed events). This would account for the attenuated relationships observed among the specificity and detail tasks, which no longer rely chiefly on retrieval mechanisms. Instead, additional cognitive mechanisms are likely necessary when elaborating on vivid episodic events.

WM capacity correlated with performance on the future specificity task, though a similar relationship was not observed between WM and past specificity. WM was not related to any of the other past or future autobiographical measures. Results from a regression analysis further showed that even when controlling for past specificity, residual WM variance uniquely predicted the ability to imagine a specific future event, replicating D'Argembeau and colleagues (2010). These results may reflect the increased cognitive demands of imagining a future event occurring within a specific context. Recent models have conceptualized episodic future thought as a protracted generative process

(D'Argembeau & Mathy, 2011). Semantic knowledge corresponding to an autobiographical narrative, consisting of personal goals (e.g., obtaining a PhD) and temporally extended life events (e.g., tenure as a graduate student), provides the contextual framework for the retrieval of progressively explicit levels of specificity and episodic details (e.g., imagining the date of my thesis defense including the location, committee members in attendance, and Dr. Zrull's sweater vest and jeans). WM likely represents the attentional resources necessary to maintain increasingly specific and disparate information, which is subsequently bound into a unitary and coherent mental simulation of a future event. This interpretation suggests a functional role similar to that of Baddeley's episodic buffer (2000).

Controlled attention becomes particularly important when information must be kept in an active state in the face of other competing information (Engle et al., 1999). Research has indicated that increasingly specific levels of autobiographical memory are largely mediated by inhibitory processes (Piolino et al., 2010). Imagining a specific future event likely places even greater demands on similar strategic executive mechanisms. Specifically, whereas previously experienced events are restricted in time and place, future events have the potential of occurring within any number of possible contexts. When imagining a plausible future event, information inconsistent with that event's particular context must be suppressed during the constructive process. Therefore, the greater demands likely placed on inhibitory mechanisms when imagining a realistic future event may account for the unique contributions of WM to future specificity.

If WM does in fact provide the mental workspace necessary to actively maintain and integrate disparate information into a coherent future event, future event narratives rich in sensory-perceptual details should similarly load on the same attentional resources hypothesized to aid future specificity. However, this was not the case in the present study as I failed to observe a relationship between WM capacity and the measure of future details. One explanation may lie in the procedure used to score the amount of details included in past and future event narratives. Specifically, all unique details were counted towards an event's total content score; no distinction was made between general semantic and contextually specific episodic aspects of that event. Relative to the retrieval of episodic information, accessing semantic personal knowledge places fewer demands on inhibitory processes (Piolino et al., 2010). It is therefore possible that the inclusion of semantic details in an event's total content score may have veiled any potential contributions of WM when elaborating on future events.

Another explanation may be related to differences in the prompts used to cue episodic events in the specificity and details tasks. Whereas the episodic specificity tasks used an open-ended cue-word technique to elicit an episodic event, the details task prompted participants to provide a narrative corresponding to a particular episode (e.g., imagine your next vacation). Because the inherent specificity of this kind of cue limits the potential details that may be associated with an imagined future event, it is likely that fewer demands are placed on inhibitory processes relative to those required during the open-ended specificity task. Additional research is necessary to further explore the potential link between WM capacity and detailed future event narratives.

Notably, the results from this study deviated somewhat from those reported by D'Argembeau and colleagues (2010) who observed much more robust relationships between executive processes and the past and future autobiographical measures. Specifically, whereas both studies indicated a relationship between executive measures and future specificity, D'Argembeau noted additional relationships between executive processes and both past and future autobiographical fluency and episodic details. These differences likely stem from the distinct executive constructs being explored in each study. In the D'Argembeau study, executive processes consisted of measures of phonemic and semantic fluency, tasks which load heavily on strategic retrieval operations. Accordingly, their results indicated broad executive involvement in both past and future autobiographical event knowledge, which was interpreted as reflecting a general executive role in the retrieval and monitoring of autobiographical information in support of episodic recollection and prospection. In the present study, I was primarily interested in the relationship between future thought and WM capacity, a widely used measure of executive attention. The inherently distinct constructs explored in each study likely support different facets of future thought. Whereas retrieval operations seem to play a general role in access to autobiographical thought, the unique demands of imagining a specific future event likely place higher demands on attentional resources which mediate the active maintenance and integration of disparate information into a unitary future event.

The results of this study are generally consistent with neuroimaging research reporting extensive neural overlap among past and future autobiographical processes (Addis et al., 2007; Botzung et al., 2008; Okuda et al., 2003; Szpunar et al., 2007). Notably, differences in the magnitude of activation patterns elicited by past and future oriented tasks have been observed in regions within this neural overlap, particularly in portions of lateral and medial PFC and medial temporal lobes, including the hippocampus (Addis et al., 2007; Okuda et al., 2003). Among the studies reporting asymmetries in the scale of neural activation across temporal directions, increased activity is reported exclusively in response to future oriented tasks and is likely attributable to the increased cognitive demands of flexibly recombining multiple past episodes into a unitary future event representation (Addis et al., 2007).

One of the primary objectives of this study was to explore whether WM capacity may partially account for the increased cognitive demands hypothesized to support future thought. Indeed, the regions in which increased activity is seen in response to future thought correspond with regions believed to support the controlled attention and retrieval operations underlying WM capacity. Specifically, functional interactions between lateral and medial PFC and the hippocampus have been suggested to assist in the temporary storage of information within WM as well as the selective reactivation of content which has been displaced by competing information (Chein et al., 2011; Yoon, Okada, Jung, & Kim, 2008).

One potential limitation with the present results may stem from the observed specificity scores that were lower than those reported by D'Argembeau et al. (2010). Furthermore, the distribution of the future specificity scores was positively skewed as nearly 50% of participants failed to generate a single specific future event. This may be due to time constraints associated with the specificity task in the current study. When constructing a specific future narrative, semantic information is frequently provided before a specific event is produced (D'Argembeau & Mathy, 2011). Accordingly, 30 seconds for each cue may not have been an adequate amount of time to mentally construct and then convey a specific novel event. Though this may be viewed as a potential limitation, it is worth noting that the correlations between WM capacity and past and future specificity in the present study were nearly identical to those between executive processes and the specificity measures reported by D'Argembeau and colleagues (2010). Though future research should address this, the similar correlational patterns observed in both studies suggests that imagining specific future events does appear to tap executive mechanisms not similarly recruited when recalling specific past events.

Another potential limitation with the present study was the large standard deviations observed on the past and future episodic details tasks (Table 3), which were much larger than previously reported values (D'Argembeau et al., 2010; Hassabis et al., 2007). Because this was the final task in the experiment, and was the only task to be unconstrained by a time requirement, the large variability in total content scores may reflect individual differences in participants' conscientious engagement with experimental procedures. Taken with the aforementioned scoring procedures which failed to distinguish between semantic and episodic information, future research using alternative paradigms is necessary to further explore the relationship between WM capacity and episodically vivid future event narratives.

The use of college students, as well as prompts that restricted potential future episodes to events occurring within the next 10 years, may further affect the generalizability of the present results. Specifically, among college students, the next 10 years typically represent the emergence into young adulthood. Likewise, the events imagined as taking place during this period have a greater tendency of corresponding with cultural life-script events such as starting a career, getting married, the birth of a child, etc. (Bernsten & Jacobsen, 2008), which are qualitatively different from similar events not falling within the same temporal realm (Rubin & Bernsten, 2003). Future research requiring the generation of events within a broad temporal range, as well as the inclusion of various age groups and demographics, is therefore necessary to further elucidate executive contributions to future thought.

Though recent studies have begun to explore the cognitive processes supporting episodic future thought, a broad and thorough understanding of the executive mechanisms underlying the constructive mental simulation of novel future events remains to be thoroughly explored. Though previous research on this subject has indicated executive contributions to a range of future oriented autobiographical tasks (D’Argembeau et al., 2010), it is important to consider that executive functions encompass a broad range of functionally specialized processes. In the present study, I focused on the relationship between future thought and WM capacity, a widely used measure of executive attention. When imagining a specific future episodic event, WM appears to provide the attentional and inhibitory mechanisms necessary to strategically retrieve and manipulate disparate information into a unitary event simulation. Therefore, this study was an important step in gaining a clearer and more nuanced understanding of how a range of executive processes contribute to episodic future thought.

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Table 1

Bivariate Correlations and Descriptive Statistics for WM and STM Tasks

Measure	1	2	3	4	*M*	*SD*	*α*
1. Verbal WM	-				55.04	15.23	.84
2. Visuo-spatial WM	.49**	-			26.39	8.00	.77
3. Verbal STM	.38**	.52**	-		38.85	10.78	.60
4. Visuo-spatial STM	.33**	.21*	.14	-	76.61	10.24	.76

Note. WM = Working Memory; STM = Short-Term Memory

*p < .05; **p < .01.

Table 2

WM and STM Factor Loadings

Measure	Factor Loading
Visuo-spatial WM	.81
Verbal WM	.79
Verbal STM	.73
Visuo-spatial STM	.52

Note. WM = Working Memory; STM = Short-Term Memory.

Table 3

Bivariate Correlations and Descriptive Statistics for Autobiographical Measures and Composite WM Scores

Measure	1	2	3	4	5	6	7	*M*	*SD*
1. Past Fluency	-							16.61	5.73
2. Future Fluency	.80**	-						15.79	6.76
3. Past Specificity	.21*	.11	-					2.22	1.57
4. Future Specificity	.18	.16	.42**	-				1.20	1.54
5. Past Details	.36**	.26**	.25*	.18	-			17.17	11.83
6. Future Details	.31**	.24*	.21*	.24*	.50**	-		15.61	11.62
7. WM Composite	.06	.15	.01	.22*	.19	.09	-	-	-

Note. WM = Working Memory

*p < .05; **p < .01.

Table 4

R^2 Statistics from Multiple Regression Analyses

Dependent Variable	Predictor(s)	R^2	ΔR^2	$F(\Delta R^2)$	*df*
Future Fluency	Past Fluency	.64	.64**	176.30	1, 98
Future Fluency	Past Fluency, WM	.65	.01	2.83	1, 97
Future Specificity	Past Specificity	.18	.18**	21.18	1, 98
Future Specificity	Past Specificity, WM	.23	.05*	6.00	1, 97
Future Details	Past Details	.25	.25**	31.66	1, 97
Future Details	Past Details, WM	.25	.00	.01	1, 96

Note. WM = Working Memory Composite.

*$p < .05$; **$p < .01$.

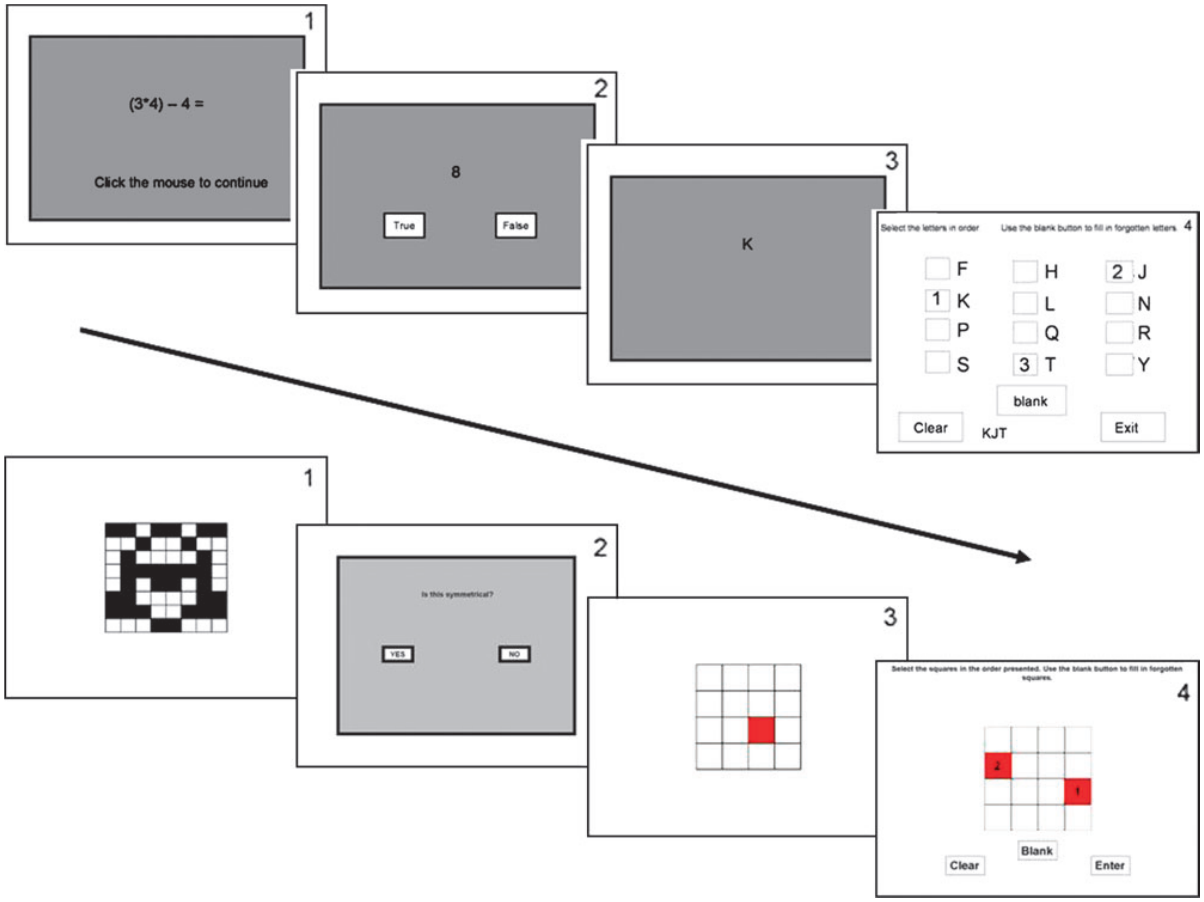

Figure 1. Automated Working Memory Tasks. The Automated Operation Span task (upper) is a measure of verbal working memory in which participants must perform an arithmetic operation while simultaneously storing a sequence of to-be-recalled letters. The Automated Symmetry Span task (lower) is a measure of visuo-spatial working memory in which participants must judge whether a pattern is symmetrical along the vertical axis while simultaneously storing the sequential locations of to-be-recalled squares within a 4 x 4 grid. The numbers in the top right corners indicate the order in which each screen is presented and are not visible to participants. This image was reprinted from Barch et al. (2009).

Appendix A

IRB Approval

To: Paul Hill

CAMPUS MAIL

From: Jessica Yandow, Office of Research and Sponsored Programs
Date: 8/31/2011
RE: Notice of IRB Exemption
Study #: 12-0036

Study Title: Episodic Future Thought: The Modulating Role of Working Memory
Exemption Category: (2) Anonymous Educational Tests; Surveys, Interviews or Observations

This submission has been reviewed by the IRB Office and was determined to be exempt from further review according to the regulatory category cited above under 45 CFR 46.101(b). Should you change any aspect of the proposal, you must contact the IRB before implementing the changes to make sure the exempt status continues to apply. Otherwise, you do not need to request an annual renewal of IRB approval. Please notify the IRB Office when you have completed the study.

Best wishes with your research!

CC:
Lisa Emery, Psychology

Appendix B

Informed Consent

Consent to Participate in Research

Information to Consider About this Research

Episodic Future Thought

Principal Investigator: Paul F. Hill
Department: Psychology
Contact Information: Lisa Emery, 112B Smith-Wright Hall, 828-262-7667

What is the purpose of this research?

You are being invited to take part in a research study about how we remember past events, and how this may be related to how we imagine future events. If you take part in this study, you will be one of about 100 people to do so. By doing this study we hope to learn more about the cognitive mechanisms that underlie memory.

What will I be asked to do?

The research procedures will be conducted in room 201c of Smith-Wright Hall on the Appalachian State University campus. You will need to come here one time during the study. Each of those visits will take about one hour. The total amount of time you will be asked to volunteer for this study is one hour over one day.

You will be asked to complete a series of tasks on the computer. Some of these tasks will measure your ability to recall sequences of information that have previously been presented to you. You will also be asked to recall and elaborate on events from your past, and to imagine and describe events that are likely to take place in your future.

What are possible harms or discomforts that I might experience during the research?

To the best of our knowledge, the risk of harm for participating in this research study is no more than you would experience in everyday life.

What are the possible benefits of this research?.

There may be no personal benefit from your participation but the information gained by doing this research may help others in the future.

This study should help us learn more about how our memory functions.

Will I be paid for taking part in the research?

We will not pay you for the time you volunteer while being in this study. For your participation in this study you will earn two Experiential Learning Credits (ELCs) for your course.

How will you keep my private information confidential?

Your information will be combined with information from other people taking part in the study. When we write up the study to share it with other researchers, we will write about the combined information. You will not be identified in any published or presented materials.

This study is anonymous. That means that no one, not even members of the research team, will know that the information you gave came from you.

We will make every effort to prevent anyone who is not on the research from knowing that you gave us information or what that information is.

We will not keep any record of your name indicating that you have participated in our study. All of your data will be identified by a random ID number and kept in a filing cabinet in a locked office.

Records will be kept for 5 years after publication of the results, and then destroyed as specified by the American Psychological Association. Your information will not be identified by your name.

Who can I contact if I have questions?

The people conducting this study will be available to answer any questions concerning this research, now or in the future. You may contact the Principal Investigator at hillpf@appstate.edu. If you have questions about your rights as someone taking part in research, contact the Appalachian Institutional Review Board Administrator at 828-262-2130 (days), through email at irb@appstate.edu or at Appalachian State University, Office of Research and Sponsored Programs, IRB Administrator, Boone, NC 28608.

Do I have to participate? What else should I know?

Your participation in this research is completely voluntary. If you choose not to volunteer, there will be no penalty and you will not lose any benefits or rights you would normally have. If you decide to take part in the study you still have the right to decide at any time that you no longer want to continue. There will be no penalty and no loss of benefits or rights if you decide at any time to stop participating in the study.

You may choose to write a research paper for credit in lieu of participating in this study.

This submission has been reviewed by the IRB Office and was determined to be exempt from further review.

I have decided I want to take part in this research. What should I do now?

The person obtaining informed consent will ask you to read the following and if you agree, you should indicate your agreement:

- I have read (or had read to me) all of the above information.
- I have had an opportunity to ask questions about things in this research I did not understand and have received satisfactory answers.
- I understand that I can stop taking part in this study at any time.
- I understand I am not giving up any of my rights.
- I have been given a copy of this consent document, and it is mine to keep.

Appendix C
Cue-words for the episodic specificity task

<u>List A</u>
Money
Art
Health
Police
Gender

<u>List B</u>
Father
Death
School
Culture
Science

Vita

Paul F. Hill was born in Russellville, AR to Don and Carol Hill. He attended school in Russellville, graduating with highest honors from Russellville High School in May 2002. The following autumn, he enrolled at Hendrix College in Conway, AR, where he studied psychology and philosophy. Upon being awarded a Bachelor of Arts degree from Hendrix College in May 2006, Paul moved to Little Rock, AR where he began working as a research assistant with the Center for Addiction Research at the University of Arkansas for Medical Sciences in the spring of 2007. He moved to Boone, NC in 2010 to begin study towards a Master of Arts degree in Experimental Psychology from Appalachian State University. Upon receiving his Master of Arts degree in May 2012, Paul sought employment before continuing his academic studies towards a PhD in neuroscience.