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# Episodic elaboration: Investigating the structure of retrieved past events and imagined future events.

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Abstract

Five experiments investigated the cognitive processes involved in the elaboration of past and future events. A production listing procedure was used, in which participants listed details of each event in forwards chronological order, backwards chronological order, or free order. For both past and future events, forwards and free ordering conditions were reliably faster than backwards order. Production rates between past and future temporal directions did not differ in Experiments 1a, 1b, and 3. However, in Experiment 2, the elaboration of future events was faster than the elaboration of past events. This pattern can be explained by the findings of Experiment 4, in which production rates were faster for likely events than for unlikely events but only in the future condition. Overall, the findings suggest that the elaboration of future, but not past, events, is facilitated when constructed around current goals.

Keywords; mental time travel; episodic memory, future simulation, executive resources, event likelihood, goals.

Episodic Elaboration: Investigating the structure of retrieved past events and imagined future events.

## 1. Introduction

Episodic memory constitutes the ‘system that receives and stores information about temporally dated episodes or events’ (Tulving, 1983, p. 21). It incorporates autonoetic consciousness, whereby individuals mentally time travel into a past event through sensory and perceptual re-experiencing and identification of the event as a part of their personal existence (Wheeler, Stuss, & Tulving, 1997). Episodic memories, together with personal semantic information, create a system of autobiographical knowledge structures that maintain information on the progress of personal goals and provide a coherent sense of self identity (Conway, 2001, 2005). Recently, a growing body of literature has explored the notion that the mental time travel system used for episodic recall is also used to imagine events in the future. It has been posited that individuals use their memory as a database of information through a process of flexible reconstruction to generate descriptions of novel future scenarios (Schacter & Addis, 2007a, 2007b; e.g. Schacter, Addis, & Buckner, 2007, 2008). This constructive episodic simulation hypothesis, therefore, suggests that similar cognitive and neural structures and processes should be engaged in both episodic memory retrieval and future episodic simulation.

The retrieval of an episode from memory is thought to constitute a two-stage process (see S. J. Anderson & Conway, 1993; Conway, 2001). The first stage, *construction*, involves the retrieval of a memory of a particular event from the large database of information held about one’s personal past. This process can require an effortful top-down search, termed generative retrieval, which ensues voluntarily in response to a particular cue. However, in some cases, it can occur via a non-effortful and involuntary pathway, termed direct retrieval, whereby the representation is automatically generated through a bottom-up process without the need for executive resources. The second stage of retrieval, *elaboration*, occurs as the individual holds the constructed event within working memory and pieces together the disparate details to provide a coherent description of the event (Conway & Pleydell-Pearce, 2000; Conway, Pleydell-Pearce, & Whitecross, 2001; Conway & Rubin, 1993). To date, a growing body of literature has compared the cognitive processes involved in constructing past and future episodes. In contrast, there has been relatively little research specifically comparing the elaboration phase of past and future episodic thinking. To date, the only direct comparison between the elaboration phase of past and future thinking is a neuroimaging study by Addis, Wong, and Schacter (2007). As Addis et al. noted, previous studies have typically collapsed across the construction and elaboration phases. The aim of the current study was to compare the cognitive processes involved in the elaboration of past and future episodes.

Research exploring the construction phase of episodic memories and future thoughts provides support for the notion that the same cognitive and neural substrates are involved in both processes. Work by D'Argembeau and colleagues (D'Argembeau & Demblon, 2012; D'Argembeau & Mathy, 2011) suggests that autobiographical knowledge structures provide a framework for organising future events, with personal goals acting as key anchors within this organisational framework. This work, alongside other behavioural studies, suggest that future event simulation often involves a search through these hierarchically organised information structures, and makes use of similar generative and direct pathways to access episodic information as are evidenced in memory retrieval (R. J. Anderson, Dewhurst, & Nash, 2012; Berntsen & Bohn, 2010; D'Argembeau & Mathy, 2011). Furthermore, neuroimaging work has demonstrated that past and future thinking engage the same core autobiographical memory network (See Schacter et al., 2012 for a review).

Alongside these similarities, however, a number of differences have emerged with respect to the mental construction of past and future episodes. For instance, behavioural findings suggest that spontaneous future thinking is more abstract (R. J. Anderson & Dewhurst, 2009) and generation of specific events in response to cue words is slower for future compared with past events (R. J. Anderson et al., 2012). Furthermore, neuroimaging data demonstrate increased neural activity and a number of differentially recruited areas when an individual is constructing future, compared with past, events (e.g. Addis et al., 2007). It has been argued that, whilst both processes source details from the same autobiographical memory information system, future thinking is a more effortful process. Future episodic simulation, unlike memory retrieval, involves flexible recombination of episodic details and it is this additional activity that places increased demands on the underlying cognitive, particularly executive, resources. This is illustrated by the finding of D'Argembeau, Ortoleva, Jumentier, & van der Linden (2010) that the specificity of future events was positively correlated with executive processes but the specificity of past events was not. Similarly, a neuropsychological study by de Vito, Gamboz, Brandimonte, Baroni, Amboni, and Dalla Salla (2012) found that impaired future thinking in Parkinson's Disease was associated with poor executive control. Taken together, these studies support the notion that the construction of future episodes is often an effortful process and that, in comparison to retrieval of past events, can place increased demands upon executive resources.

As noted above, there has been relatively little research explicitly comparing the elaboration stage of past and future episodic thought. The neuroimaging study by

Addis et al. (2007) investigated the neural activity associated with the construction and elaboration of past and future events. Differences were observed between past and future thinking during the construction phase, with both the right hippocampus and frontopolar aspects of the right medial prefrontal cortex being uniquely recruited during the construction of future events. In contrast, they found extensive overlap in neuronal activity when comparing past and future elaboration, particularly in areas known to respond to self-referential material such as the left medial pre-frontal cortex. They did, however, evidence activation in the posterior right middle temporal gyrus and the left parietal lobule when an individual elaborated upon a future, compared with past, event. The latter of these areas is thought to be involved in the selective retrieval of information from within memory. Addis et al argued that future event simulation is likely to place heavier demands on selective retrieval processes than episodic memory retrieval due to the need to combine disparate details from numerous episodic events within memory in order to create a novel future scenario.

Previous behavioural research into the elaboration phase has primarily focused on the descriptions of past and future events. For instance, when individuals are asked to freely describe future episodes they contain significantly less episodic and sensory detail compared with their memory counterparts. However, to date, there is little work exploring the organisation of information within, and the cognitive processes underlying, the elaboration stage of future event simulation. In order to elucidate the role of memory in imagining future events, it is important to establish not only how we construct future events, but also how we elaborate upon them and the processes used in piecing together, structuring and organising the individual episodic details into a coherent description.

S. J. Anderson and Conway (1993) developed a production listing procedure to examine the process of elaboration when retrieving episodes from memory. They asked participants to recall autobiographical events and write a list of the distinctive details of the event. The dependent variable varied across experiments, and was either the number of details listed within a set timeframe (10 and 30 seconds) or the time taken to list 10 details. By manipulating task demands, whereby detailing instructions varied so that events were described in one of four different orders (forwards chronological, backwards chronological, order of interest or free recall), they examined the role of temporal and thematic structures in the organisation of information within specific events. They argued that the free recall condition would engage the participants' spontaneous production strategies and, thus, would have the fastest production rates. They argued that the other conditions required participants to organise their knowledge prior to responding; therefore, if temporal (forwards and backwards chronological ordering) and/or thematic (order of interest) knowledge represented the underlying organisation structure of autobiographical elaboration then production rates would closely resemble those seen in the free recall condition. S.J. Anderson and Conway found that production rates were fastest in the free recall and forward chronological conditions, suggesting that temporal knowledge guides the organisation of information during the elaboration process. Slower responses within the order of interest condition suggested that thematic knowledge may not be important in the ordering of details within memory reconstruction; however, the role of thematic structures was clarified in a further experiment where, through use of a memory verification procedure in which participants indicated whether or not a presented detail was part of a previously retrieved memory, the authors demonstrated that accessing a distinctive chunk of memory details often acts a first step to memory construction.

The current study reports a series of experiments investigating the organisation of information during the elaboration of simulated future events and retrieved memories. This allowed a direct comparison of the organisational structures guiding, and cognitive effort involved in, the elaboration of future simulations and memories. Experiments 1a and 1b employed production listing procedures identical to those used by S.J. Anderson and Conway (1993), with the additional manipulation of temporal direction. Participants were asked to elaborate on past/future events that were retrieved or simulated in response to cue words; temporal direction of events and elaboration order instructions were manipulated within-subjects. In experiment 1a the number of details generated after 10 and 30 seconds was recorded, whilst experiment 1b measured the time taken to list 10 distinctive details. These experiments investigated the hypothesis that, in line with the constructive episodic simulation hypothesis, past and future elaboration would make use of similar underlying processes. Specifically, we investigated whether elaborating upon future events would make use of temporal knowledge structures to organise information in a similar way to memory retrieval.

These initial studies also investigated whether the elaboration of future events is more or less effortful than the elaboration of memories. It was more difficult to predict how elaboration of future simulations and memories would compare with respect to effortful processing. Given the need to selectively retrieve information from disparate memory traces in order to elaborate on future episodes, it is feasible to suggest that this process may place greater demand on executive resources than the elaboration of episodes from memory. Piecing together disparate details to make a coherent future event may be a more time-consuming process that requires effort to manipulate and choose from the wide variety of available episodic details. If this is the case, the time taken to record episodic details would be longer for future, compared with past, episodes.

## 2. Experiment 1a

### *2.1. Method*

#### *2.1.1. Design*

A 2x4 within subjects design, with independent variables of temporal direction (past vs. future) and elaboration order (forwards vs. backwards vs. interest vs. free recall), was used. The dependent variables were number of details recorded after 10 and 30 seconds.

#### *2.1.2. Participants*

Twenty participants (14 females) completed the study. Ages ranged from 18 to 40 years ($M$ = 22.20, $SD$ = 5.77). All were undergraduate students and received course credit in exchange for participation.

#### *2.1.3. Materials & Procedure*

Participants completed a past recall and a future imagination task, with the order of the two tasks counterbalanced across participants. In each task they were presented with a series of cue words on a computer screen. The cue words, presented using E-prime, consisted of 32 high imagery nouns drawn from Rubin & Friendly (1986). Four practice and twelve experimental cues were presented for each of the past and future tasks; thus participants recalled and simulated three events in each of the elaboration orders.

For each cue word participants were asked to recall/imagine a specific event that happened (or could feasibly happen) on one particular day in the past/future. As soon as they had an event in mind they were to press the space bar and give a brief verbal title of the event to the researcher; then one of four possible listing protocols appeared on the screen (forwards chronological, backwards chronological, order of interest, or free recall in the order in which they come to mind). For forwards chronological order participants were instructed to list the details from the first to the last detail as they occurred (or would occur) temporally, whilst backwards chronological order was the reversal of this with details listed from the last to the first detail. The order of interest listing protocol was described as how they might order the information in conversation with a friend, when they would discuss the most interesting details first and move onto the less interesting details afterwards. Equal numbers of cues were assigned to each listing protocol, with cue word and listing protocol presentation randomised. Participants were instructed to provide a description of the event, writing down individual episodic details (3-5 words), as quickly as possible, whilst adhering to the listing protocol specified. Each detail was to be recorded on a separate line of the response sheet and could consist of any episodic information pertaining to the event that they regarded as a distinct detail, such as other people present, actions, feelings, thoughts, emotions, perceptual details, locations, or time information. Two examples are provided of the memories and future events constructed and elaborated upon in response to the cue word "magazine". One participant recalled "reading a funny story about a squirrel in the newspaper" with the following episodic details provided in a forwards listing protocol: "At the top of my street"; "waiting for Steph"; "she texts me"; "I go into shop"; "buy newspaper"; "walk outside"; "Steph arrives"; "get in car"; laugh at newspaper". Another participant simulated "reading about my friend in a magazine" in order of interest protocol: "feeling shocked"; "recognising friend in picture";

“feeling confused”; ringing another friend”; “reading headline”; “upset”; “picking up magazine from doormat”.

After 10 seconds, the experimenter recorded which detail the participant was currently working on and after 30 seconds the participant was instructed to stop as soon as they had finished the current detail.

*2.2. Results*

Two separate repeated measures 2x4 ANOVAs assessed the impact of temporal direction (past vs. future) and elaboration order (forwards vs. backwards vs. interest vs. free recall) on the number of details generated after 10 and 30 seconds (Table 1). In both cases, main effects of elaboration order emerged: details after 10 seconds, $F(3,54)=21.41$, $p<.001$, $\eta_p^2=.82$; details after 30 seconds, $F(3,57)=15.91$, $p<.001$, $\eta_p^2=.76$. Bonferroni-adjusted pairwise comparisons revealed that in both cases the number of details did not differ between the free and forwards listing protocols ($p>.05$), nor between the backwards and interest conditions ($p>.05$). The number of details produced after 10 and 30 seconds were, however, significantly faster in both free and forwards conditions compared with the backwards and interest conditions (all $p$s < .01). With respect to both the number of details generated after 10, and after 30, seconds, neither the main effect of temporal direction nor the temporal direction x elaboration order interaction were significant (all $p$s>.14).

**3. Experiment 1b**

*3.1. Method*

*3.1.1. Design*

Identical to Experiment 1a, a 2 (temporal direction) x4 (elaboration order) within subjects design was used. The only modification was with respect to the dependent variable, which in this instance was the response latency to produce ten distinctive episodic event details.

*3.1.2. Participants*

Nineteen participants (14 females) completed the study. Ages ranged from 18 to 27 years ($M$ = 19.74, $SD$ = 2.21). All were undergraduate students and received course credit in exchange for participation.

*3.1.3. Materials & Procedure*

The procedure for the past recall and future imagination tasks was identical to those used in Experiment 1a. The only difference was that participants, in this instance, were instructed to write down ten individual episodic details, as quickly as possible, for each event. The response time to generate ten details was recorded; as soon as the participant completed the tenth detail the experimenter pressed the space bar and Eprime recorded the time lag between presentation of listing protocol on the screen and completion of the tenth detail. In each case, participants were able to list 10 details for events retrieved/simulated.

*3.2. Results*

A repeated measures 2x4 ANOVA assessed the impact of temporal direction (past vs. future) and elaboration order (forwards vs. backwards vs. interest vs. free recall) on mean response times to list ten episodic details (Table 2). A main effect of elaboration order emerged, $F(3,54)=20.41$, $p<.001$, $\eta_p^2=.88$. Bonferroni-adjusted pairwise comparisons revealed an identical pattern to that seen in Experiment 1a, with listing response times not differing between the free and forwards listing protocols ($p>.05$), nor between the backwards and interest conditions ($p>.05$). Listing response times were, however, significantly faster in both free and forwards conditions compared with the backwards and interest conditions (all $p$s $< .01$). Neither the main effect of temporal direction, F(1,18)=0.12, p=.73, nor the temporal direction x elaboration order interaction, F (3,54)=0.22, p=.88, were significant.

**3.3. Discussion**

Experiments 1a and b examined the role of temporal and thematic knowledge in the organisation of information during event elaboration, comparing simulation of future episodes with the retrieval of past episodes. It also examined whether future event elaboration was a more effortful, and thus slower, task than elaboration of remembered episodes. The findings, irrespective of the dependent variable used, found that production rates did not differ across past and future episodes. They did, however, differ as a function of ordering method. Forwards chronological and free ordering conditions did not differ from each other, but both were significantly faster than the backwards chronological and order of interest conditions.

Our findings support those of S. J. Anderson and Conway (1993) who demonstrated that temporal organisation in a forwards chronological order guides the elaboration process within episodic memory recall. Furthermore, it extends these findings to suggest that temporal organisation is equally important when elaborating upon simulations of future events. However, no evidence was found to suggest that elaborating upon a possible future scenario was more effortful than recalling the details of a past event. This is consistent with the findings of Addis et al (2007) of extensive overlap of neural activity when comparing the elaboration phase of past and future episodes. However, Addis et al also found selective activation in the posterior right middle temporal gyrus and the left parietal lobule associated with the elaboration of future events. These subtle differences were not, however, picked up by the behavioural measures used in the current study.

Replicating and extending the paradigm used by S. J. Anderson and Conway (1993), whereby participants were cued to recall and simulate events using nouns, provided a useful starting point to investigate the organisation of information within simulated future episodes. There are, however, limitations to this cue-word methodology that may have contributed to the null effect of temporal direction. It is feasible that ease of elaboration is related to the temporal distance of an event from the present, as previous research has suggested that close events are rated as more vivid and rich in sensory detail than distant events (D'Argembeau & van der Linden, 2004). It is possible that, in the present investigation, future events were closer in time and past events further away, resulting in events that could be described with similar ease. Whilst participants in the current research were not asked to report the temporal distance of the events they recalled and simulated, such a pattern was reported in our previous work that made use of a similar cue word methodology (R.J. Anderson et al.,2012).Other factors that may have contributed to the null effect of temporal direction relate specifically to the elaboration of future events. It is possible that participants rely heavily on schemas to generate future events; for instance, the cue word *restaurant* may cue a script for what someone does in a restaurant, without any preliving of a specific event (see Alba & Hasher, 1983, for a review of schema theory). Alternatively, participants may simply be recasting entire memories into the future.

The remaining experiments reported here were designed to overcome the alternative explanations that hindered interpretation the findings of experiments 1a and 1b. Modifications include methods to control the temporal distance of past and future events and ensuring that the events elaborated upon, particularly those in the future, were novel.

In Experiment 2 we modified the paradigm used in Experiments 1a and 1b, with the aim of controlling the temporal distance of recalled and simulated events . The cue word technique makes it difficult to control for differences in temporal distance. Instructions can include temporal constraints, such as asking participants to recall/simulate events from the last/next month. However, previous work suggests that the construction of events, particularly memories, is made more difficult by such constraints (e.g. R. J. Anderson et al., 2012); this would, potentially, significantly reduce the number of events available for elaboration. Thus, in Experiment 2, participants were asked in an initial testing session to outline forty brief titles of events, with 20 event titles pertaining to memories of events that happened in either the distant or near past and 20 event titles pertaining to specific future events that could feasibly happen in the near or distant future. By asking participants to self generate events in Experiment 2 we also began to investigate the role that schematic representations play in the elaboration of past and future events. In particular, we investigated the extent to which the events generated comprised cultural life scripts events; such events represent occurrences that are culturally expected within a typical adult lifespan and, thus, they represent events for which individuals are likely to hold schematic representations within semantic memory. Previous research has suggested that cultural life script events provide a thematic structure that can guide both retrieval and simulation processes (Berntsen & Bohn, 2010; Berntsen & Rubin, 2004).

A random selection of the event titles generated in the first part of the experiment were then used in a second testing session, where participants were asked to elaborate on the events using a paradigm similar to that employed in Experiment 1b. The only modification was the exclusion of the ‘interest’ listing protocol. This was because participants in first experiment, and in the previous work of S. J.

Anderson and Conway (1993), expressed difficulty understanding the instructions for this particular listing protocol and it evidenced similar response times to the backwards chronological listing procedure. Furthermore, the increased complexity of this study meant that the inclusion of sufficient trials in each condition extended the duration of the recall and imagination tasks, risking participant fatigue.

## 4. Experiment 2

### *4.1. Method*

#### *4.1.1. Design*

A 2x2x3 within subjects design was employed, with independent variables of temporal direction (past vs. future), temporal distance (near vs. distant) and elaboration order (forwards vs. backwards vs. free recall). As in Experiment 1b, the dependent variable was the response latency to produce ten distinctive episodic event details.

#### *4.1.2. Participants*

Twenty-one participants (17 females) took part in this study. All were undergraduate students at the University of Hull and received course credit for their participation. Ages ranged from 18 to 37 years ($M$ = 19.00; $SD$ = 4.80).

#### *4.1.3. Materials & Procedure*

This study was conducted in across two testing sessions. In the first session, participants were instructed to provide 40 brief titles of events that had happened in the past or could feasibly happen in the future. Participants were informed that they each event needed to be a specific event, defined as an event that happened, or would happen, on one particular day and were given an example of an appropriate response. They were asked to provide titles for ten events that had happened over a year ago (distant past), ten events that had happened in the past month (near past), ten events that could happen feasibly in the next month (near future), and ten events that could feasibly happen over one year from now (distant future). For each event they were asked to provide sufficient detail that it was clear the event happened (or would happen) on one particular day and to give an approximate date for the event. Thematic analyses were conducted to ascertain the types of events generated within this first part of the study using categories of life script events developed by Berntsen and Rubin (2004); RJA coded all 40 events generated by each participants, assessing whether or not each represented a life script events. A second, independent, rater coded all events, with the two raters agreeing on 98% of all events. Any disagreements were discussed between the two raters and resolved.

The second session took place exactly one week later. This time lag was chosen for two reasons; the experimenters required time to prepare the materials for the second session and it fitted most appropriately with the participants' timetables whilst ensuring that the time-lag between sessions was identical for all participants. Twenty four event titles from session one, six from each time period (near past, distant past, near future, distant future), were used as cues for recall and imagination tasks similar to those employed in Experiments 1a and 1b. The two tasks were counterbalanced across participants, and within each task the near and distant events were blocked with presentation order of these blocks randomised. Both recall and imagination tasks were preceded by three practice trials. The event title, along with instructions to list details in one of three possible listing protocols (forwards chronological, backwards chronological or order in which they came to mind), were presented together on the screen. As in Experiment 1b, participants listed 10 episodic details, as quickly as possible, with response time to list the 10 details being recorded. In each case, participants were able to list 10 details for each of the event titles provided. After completing the experiment participants were given a list of all events and asked to indicate if any had occurred during the past week (the period between testing sessions); this was not the case for any of the distant past, near future, or distant future events.

*4.2. Results*

Thematic analyses established the mean percentage of events generated in the first part of the experiment that constituted cultural life script events. For recalled events, 10.38% (SD=9.44) of near, and 42.24% (SD=19.50) of distant, events referred to life script events. For simulated future events, 4.29% (SD=5.98) of near, and 42.33% (SD=11.10) of distant, events were coded as life script events. A 2x2 repeated measures ANOVA ascertained whether differences existed in the proportion of events that constituted cultural life script events as a function of temporal direction (past vs. future) and temporal distance (near vs. distant). The main effect of temporal distance was significant, $F(1,20)=149.57$, $p<.001$, $\eta p2 = .88$. Temporally distant, compared with temporally near, events were more likely to refer to a cultural life script event. The main effect of temporal direction, $F(1,20)=1.49$, $p=.24$, and the interaction effect, $F(1,20)=1.36$, $p=.26$, were not significant.

A 2x2x3 repeated measures ANOVA examined the effects of temporal direction (past vs. future), temporal distance (near vs. distant) and elaboration order (free vs. forwards vs. backwards) on mean response latency to list 10 episodic details (Table 3). The main effects of temporal direction, $F(1,20)=4.96$, $p<.05$, $\eta p2=.20$, and temporal distance, $F(1,20)=8.85$, $p<.01$, $\eta p2=.31$, were both significant. Future events took less time to be elaborated on compared to past events, while elaborating on temporally close events was quicker than elaborating on distant events. A main effect of elaboration order also emerged, $F(2,40) = 9.61$, $p < .001$, $\eta p2 = .32$. Bonferroni-adjusted pairwise comparisons revealed that, similar to Experiment 1, no significant difference existed in elaboration response times in the free and forwards listing protocols ($p>.05$). However, both of these elaboration orders were significantly faster than when participants listed details in a backwards order ($ps<.01$). The temporal direction x temporal distance, ($F(1,20) =.13$, $p=.73$, $\eta p2=.01$), temporal direction x elaboration order ($F(2,40) = 1.08$, $p = .35$, $\eta p2 = .05$), and the temporal distance x elaboration order ($F(2,40) = .36$, $p = .70$, $\eta p2 = .02$) all failed to reach significance.

*4.3. Discussion*

Experiment 2 used a modified methodology designed to limit the effect of potential differences in temporal distance on the ease of event elaboration. The findings, in line with those from Experiments 1a and 1b, suggested that temporal organisation of information is used when elaborating on both past and future events. Additionally, there was no support for the notion that future elaboration is a more effortful process. In fact, production rates were faster when elaborating on future, compared with past, events. This finding is consistent with recent theoretical models proposing that one of the adaptive functions of memory is its role in future planning (e.g. Klein, Cosmides, Tooby, & Chance, 2002; Klein, Robertson, & Delton, 2010). As Klein (2007) argues, complex and effortful cognitive systems do not evolve by chance. Instead, their functional organisation exists in its current form because it has positively influenced the ability to survive and reproduce. By this reasoning, the reconstructive nature of episodic memory exists because it serves an adaptive function by providing a database of episodic details for simulating potential future events. If this is the case, the underlying systems will have evolved to ensure that creating descriptions of future events does not represent a more effortful process than memory retrieval. This may become particularly pertinent when the simulated event is highly likely to occur in the future because it fits closely with an individual's overarching working goals.

The current experimental design ensured that the temporal distance of events were comparable for past and future events. However, it is feasible that the modifications to the experimental procedure did not prevent participants from recasting memories or from using schemas when elaborating on future events. Recently, research has begun to consider the extent to which it is possible to imagine future episodes without relying wholly on details drawn from episodic memories (e.g. R. J. Anderson, 2012; D'Argembeau & Mathy, 2011; Rubin, 2014; Szpunar, 2010). Specifically, Rubin (2014) has argued that future events might be created from schema, which serve as general principles abstracted from specific past experiences; the details that are added could then come from a range of sources and, again, may not necessarily tied to specific past experiences. Furthermore, Szpunar (2010) argued that as individuals experience repeated similar events the details become more abstracted from individual episodic memories. Thematic analyses suggested that approximately 25% of all events represented cultural life script events, which arguably constitute schematic representations of culturally expected events held within semantic memory. However, the percentage of cultural life script events did not differ as a function of temporal direction; thus, the faster elaboration of future events does not seem to have been a function of these events representing schematised life script events. Nevertheless, if participants were describing highly familiar scenarios containing little novelty then, within the context of the arguments presented by Rubin and Szpunar, it is still feasible that the details reported were not being drawn from episodic memory; instead, they may have formed abstracted representations within schemas created from repeated past experiences. In this context it is unsurprising that elaborative details for future events were produced at a faster rate.

The final two experiments aimed to elucidate further on the potential role of memory recasting and schemas by investigating the roles of prior experience and event likelihood on the elaboration of past and future events. Experiment 3 made use of a life events inventory, adapted from Garry, Manning and Loftus (1996), whereby participants rated their prior experience of 40 episodic events. These events then served as cues for event elaboration. The events were chosen on the basis of being unusual, and therefore unlikely, occurrences that people might experience once or twice in a lifetime (e.g. go on a hot air balloon ride). It was anticipated that participants would have prior experience of some, but not all, events. The use of unlikely events meant that even those that had been previously experienced were unlikely to have happened to participants on repeated occasions; thus the potential for information to have been abstracted from such experiences was controlled. In short, we manipulated participants' prior experience of similar events (old vs. new events) whilst controlling for event likelihood (all events were unlikely). Specifically, we were interested in whether the elaboration of *novel* future events, whereby the individual has no prior experience of similar events, is a more effortful process as would be indicated by longer production rates for episodic details. If the elaboration of novel future events proved to be a more effortful process then this would suggest that the findings in the first two experiments occurred as a result of memory recasting and/or the use of schemas during the elaboration of future events.

## 5. Experiment 3

### *5.1. Method*

#### *5.1.1. Design*

A within subjects design was employed, with independent variables of temporal direction (past vs. future), prior experience (old vs. new) and elaboration order (forwards vs. backwards vs. free recall). Due to the nature of the temporal direction and prior experience variables, it was not feasible to ask participants to recall events that were 'new' (where they had no prior experience). Therefore, participants recalled events for which they had prior experience (past-old) and imagined events for which they did (future-old) and did not (future-new) have prior experience. This allowed the effects of temporal direction (past-old vs. future-old) and prior experience (future-old vs. future-new) to be assessed separately. The dependent variable was identical to those in Experiments 1b and 2.

*5.1.2. Participants*

Twenty-one University of Hull undergraduates (16 females) received course credit in return for participation. Ages ranged from 18 to 53 ($M = 24.14$; $SD = 9.96$).

*5.1.3. Materials & Procedure*

As in Experiment 2, participants attended two testing sessions one week apart. In the first session, participants completed a life events inventory comprising 40 event titles. Some items were taken from Garry et al (1996) with the remaining items developed specifically for this investigation. Each event was chosen for its potential novelty, with any prior occurrences likely to have been a single occurrence happening on one particular day in the past (e.g. watch a house burn down; go on a hot air balloon ride; get lost in a city you don't know). For each event, participants indicated if the event had, or had not, happened to them previously.

In the second session, participants completed recall and imagination tasks, similar to those in our earlier experiments. The cues for these tasks were selected from the life events inventory and were based on the ratings made in the first session.

Eighteen events were selected as cues for the recall and imagination tasks. Six events had never previously happened to the participant and were used as cues for the imagination task (future-new). The other twelve events had been experienced previously, with six being used as cues for the recall task (past-old) and six for the imagination task (future-old). Future-old and future-new event titles were combined into a single imagination task, in which they were presented at random. The order of presenting the recall and imagination tasks was counterbalanced over participants, with each being preceded by three practice trials. As in Experiment 2, all participants were able to list 10 details for each of the event titles provided and on completion of the experiment we checked that no participants had experienced any of the listed events in the week between the two testing sessions.

*5.2. Results*

A 2x3 ANOVA was used to explore the effect of temporal direction (past-old vs. future-old) and elaboration order (backwards vs. forwards vs. free recall) on mean response times to generate ten episodic details (Table 4). A main effect of elaboration order emerged, ($F(2,40)=3.97$, $p<.05$, $\eta_p^2=.17$). Consistent with earlier studies, the backwards listing protocol resulted in significantly slower response times to produce ten episodic details compared with the free and forwards listing protocols (*p*s<.01), which did not differ from each other (*p*>.05). Neither the main effect of temporal direction, $F(1,20)=1.49$, $p=.24$, nor the temporal direction x elaboration order interaction, $F(2,40)=2.35$, $p=.11$, were significant.

A further 2x3 ANOVA examined the effects of prior experience (future-old vs. future-new) and elaboration order (backwards vs. forwards vs. free recall). The main effect of prior experience was not significant, $F(1,20)=0.38$, $p=.55$. A main effect of elaboration order did, however, emerge, $F(2,40)=16.24$, $p<.01$, $\eta_p^2=.46$. As in previous analyses, listing in backwards order was significantly slower than listing in forwards order ($p$<.01), yet the free listing order did not differ significantly from either of these ($p$s>.05). This was qualified by a trend towards a significant prior experience x elaboration order interaction ($F(2,40) = 2.99$, $p=.06$). Bonferroni adjusted pairwise comparisons revealed that, for future-new events, both forwards and free ordering protocols produced significantly faster detailing than the backwards order ($p$s<.01). In contrast, in the future-old condition, the forward ordering protocol was significantly faster than both the backwards and free listing protocols ($p$<.05), which did not reliably differ from each other ($p$>.05).

*5.3. Discussion*

The findings of Experiment 3 provide further support for the role of temporal organisation in the elaboration of both past and future events. The main aim of Experiment 3, however, was to explore the role of novelty, as a function of prior experience, on the elaboration production rates for future episodic events. No significant differences emerged with respect to the manipulation of temporal direction (past vs. future-old) or prior experience (future-old vs. future-new). This suggests that the requirement to simulate a completely novel event did not slow down the elaboration process when imagining future events. Thus, the observed similarities in production rates between memories and future simulations are highly unlikely to be a function of memory recasting. Furthermore, given that we chose unlikely events that individuals would not have experienced multiple times before it is also difficult to argue that the findings reflect greater reliance on schematic information in the simulation of future relative to past events. Note that we are using schematic information in the sense of knowledge extracted from multiple experienced events in the form of scripts (Schank & Abelson, 1977) or frames (Minsky, 1975). Previous research has shown that future events can be constructed from conceptual knowledge from third party sources such as the media (see R.J. Anderson, 2012). This distinction is considered further in the General Discussion.

In light of the findings from Experiment 3, the final study sought to test our alternative proposition that the evolution of a memory system designed to serve adaptive functions, such as future planning, underlies the similarities in effort required to produce elaborative content of memories and future event simulations. Experiment 4 enlisted a similar method to Experiment 3, with participants' responses on a life events inventory determining cues for event elaboration. In this instance, however, we manipulated the role of event likelihood whilst controlling for the role of past experience. Thus, we specifically investigated whether events that are perceived as likely to occur, indicating that they are active within an individual's working goal framework, lead to faster production rates during the elaboration process.

## 6. Experiment 4

### *6.1. Method*

#### *6.1.1. Design*

A 2x2x3 within subjects design with independent variables of temporal direction (past vs. future), likelihood of occurrence (likely vs. unlikely) and elaboration order (forwards vs. backwards vs. free recall). The dependent variable was the same as in the Experiments 1b, 2 and 3.

#### *6.1.2. Participants*

Twenty-one University of Hull undergraduates (16 female) received course credit for their participation in this study. Ages ranged from 18 and 47 years ($M$ = 21.57; $SD$ = 6.48).

#### *6.1.3. Materials & Procedure*

This experiment was conducted in two sessions, one week apart. In session one, participants completed a 40-item life events inventory. In this study all 40 events were common events that participants were likely to have experienced previously (e.g. getting a hair cut; going shopping in a big city; baking cookies). Participants were asked to indicate whether they had experienced the event before (yes/no) and to rate the likelihood of the event happening in the next month on a 5-point scale (1 = very unlikely; 5 = very likely). This allowed the investigation of event likelihood distinct from prior experience, with only previously experienced (old) events being used in the second session.

The second session involved recall and imagination tasks similar to those employed in the previous experiments. For each participant, the 12 events with the highest and lowest likelihood scores were used as cues, split evenly among the past and future tasks. Again, past and future tasks were counterbalanced across participants. The likely and unlikely events were blocked within the past/future tasks, with presentation order of likely and unlikely blocks randomised. As in the earlier studies, all participants were able to list 10 details for each of the event titles provided and on completion of the second session we ensured that participants had not experienced any of the events in the intervening week.

*6.2. Results*

A 2x2x3 repeated measures ANOVA investigated the effects of temporal direction (past vs. future), likelihood of occurrence (likely vs. unlikely) and elaboration order (backwards vs. forwards vs. free recall) on mean response times to produce ten episodic details (Table 5). As in the previous experiments, the main effect of elaboration order, $F(2,40)=12.70$, $p<.01$, $\eta_p^2=.39$, was significant. Bonferroni adjusted pairwise comparisons revealed the same pattern as previously: the free and forwards listing protocols did not differ from each other ($p$>.05), and both were significantly faster than listing in a backwards order (both $p$s<.01). The main effects of temporal direction (F(1,20)=.004, p=.95 and likelihood of occurrence (F(1,20)=2.44, p=.13) were not significant. However, the interaction effect between temporal direction x likelihood was significant (F(1,20)=4.47, p<.05, $\eta_p^2$=.18). For future events, participants were significantly faster in their elaboration of likely, compared with unlikely, events ($p$<.05). No such difference was found for past events ($p$>.05). Neither the temporal direction x elaboration order, F(2,40) =1.44, p=.25, nor the likelihood of occurrence x elaboration order, (F(2,40)=1.57, p=.22, interactions were significant.

*6.3. Discussion*

Consistent with Experiments 1 to 3, the findings of Experiment 4 indicate that information is organised temporally when elaborating on both past and future events. The key aim of this final experiment, however, was to investigate the role of event likelihood on the elaboration of past and future events. Specifically, we investigated whether events that are perceived as likely to occur, indicating that they are active within an individual's working goal framework, lead to faster production rates during the elaboration process. Results indicated that greater likelihood speeded the production rate of events, but only when the events were being simulated in the future and not when they were being reconstructed from memory.

The significant interaction evidenced in Experiment 4 lends support to our belief that likelihood of events may underlie the finding from Experiment 2, which evidenced faster production rates for future compared with past events. When an event is likely to occur in the future, perhaps because it is intended and planned by the individual to fit with their working goals, then the provision of a detailed elaboration of that event becomes easier. This, does not, however, appear to be a mere function of the frequency of event occurrence, with more frequent events being closely related to schemas and/or containing details that are more readily accessible. If this was the case then a similar increase in production speed would be observed when elaborating upon likely events in the past.

The likelihood of events is, however, not the only possible mechanism for explaining the findings in Experiment 2. The current experiment only asked participants about events that were likely to occur within the next month (i.e. the near future); in Experiment 2, participants elaborated upon events in both the near and distant future. Arguably, the effect of planning and goals on speeding elaboration is more fitting with temporally near, rather than distant, events; this, therefore, raises the question as to whether planning and goals drive temporally distant, as well as near, future thinking. Unfortunately, the event descriptions provided in Experiment 2 do not allow us to ascertain whether the events had already been explicitly planned by participants. However, the findings of Experiment 2 were supportive of previous work showing that temporally distant events often represent cultural life script events (e.g. wedding day; having children; graduation day). Such events represent occurrences that are culturally expected within a typical adult lifespan; thus, whilst they may not have been explicitly planned by the participants, they are still events that may have been regularly envisioned or discussed. Future research could attempt to tease apart the different roles of future planning, personal goals, and cultural life scripts in the elaboration of future events.

## 7. General Discussion

The series of five experiments reported here directly compared the organisational structures guiding, and cognitive effort involved in, the elaboration of future simulations and memory retrieval. Previous research has investigated the neural and cognitive processes involved in the *construction* of future episodes, but there has been little consideration of the processes involved in the *elaboration* stage, when details of a future event are pieced together in order to provide a coherent description of the event (see S. J. Anderson & Conway, 1993). With respect to the organisation of information within episodes, the results of all five experiments suggested that temporal knowledge structures guide the elaboration of future events. Furthermore, the results of Experiments 1a and 1b suggested that information is not organised around thematic structures, such as importance or centrality of details. This pattern of findings was also evident for past events, which is in line with the findings of S. J. Anderson and Conway (1993).

Our findings do, however, suggest that thematic structures such as an individual's current goals may have a role to play in the elaboration of future events. Experiment 4 found that production rates were faster for likely, compared with unlikely, events, and that this effect only occurred for the elaboration of future episodes. D'Argembeau and Van der Linden (2012) found that a significant relationship between ratings for likelihood of future events and their importance with respect to personal goals. Thus, we argue that events that are considered likely to occur are already active within an individual's working goals and this speeds the elaboration process. This argument fits with other recent work by D'Argembeau and colleagues (e.g. D'Argembeau & Demblon, 2012; D'Argembeau, Lardi, & Van der Linden, 2012), who proposed that autobiographical knowledge structures provide a framework for organising future events and that personal goals act as key anchors within this organisational framework.

The current study also investigated whether the elaboration of future events is more or less effortful in comparison to the elaboration of memories. We speculated that, given the need to selectively retrieve information from disparate memory traces in order to elaborate on future episodes, this process might involve more executive resources than the elaboration of episodes from memory. Therefore, the time taken to record episodic details would be longer for future, compared with past, episodes. However, we found no evidence to support this hypothesis in any of the studies. As discussed above, Addis et al (2007) found activation in the posterior right middle temporal gyrus and the left parietal lobule associated with the elaboration of future, but not of past, events, which they attributed to the greater demand on executive resources for future events. Despite these differences at the neural level, the current study found no difference in the time taken to elaborate on past and future events. It is possible that, whilst the elaboration of past and future events make use of the same organisation framework, they may engage different cognitive processes that are similarly effortful. Whereas the task of future episodic simulation involves the selective retrieval and manipulation of details from memory, the task of memory recall has its own constraints. For example, the retrieval of memories involves an accuracy requirement that is not present when imagining future scenarios. Therefore, the necessary inhibition of inaccurate details from alternative memories may require cognitive effort. This proposition is one that requires further investigation. To date, our understanding of the elaboration phase of future episodic simulation is limited to the study by Addis et al and the data presented here. It is crucial, therefore, that further studies explore both the neural and cognitive underpinnings of this process, in particular the roles of selective retrieval in future thinking and the need for inhibition of inaccurate details in memory retrieval.

One explanation for why we did not find future elaboration to be a more effortful process lies in the possibility that simulation of future episodes does not wholly rely on the recombination of episodic details from memory (e.g. Rubin, 2014; Szpunar, 2010). Arguably, future thinking is more heavily reliant on abstracted information stored within memory schemas. Hierarchical models of autobiographical memory (e.g. Conway & Pleydell-Pearce, 2000) suggest that such abstracted information is stored at a higher level within the hierarchy, and is thus requires less of an effortful search to retrieve, than episodic details. The current findings lend some support to this notion as highly familiar events were simulated quicker than they were recalled (Experiment 2). Furthermore, recent work has shown that, when situations are truly novel, individuals draw on information from a range of sources beyond their episodic memory to build future simulations (R. J. Anderson, 2012). However, Experiment 3 found that simulations and recollections of unusual events, for which participants were unlikely to have schemas, were elaborated upon at a similar rate; this suggests that schemas cannot wholly explain the lack of evidenced differences in the past and future elaboration processes. Although individuals can draw on conceptual knowledge when constructing future events, it is unlikely that participants in Experiment 3 had schematic knowledge of the unusual events that could simply be recast into a future scenario. The separate roles of conceptual knowledge and schemas derived from personally experienced events might be a fruitful topic for future research. The current findings, together with those of R.J. Anderson (2012), suggest that individuals can draw on a diverse range of sources when constructing future events (see Szpunar, 2010), and do not rely solely on personally experienced events.

The current findings are consistent with the view that episodic memory evolved to serve adaptive functions, such as future planning. If episodic memory evolved with the sole purpose of providing an accurate record of the past then we would not expect an effortful and error-prone reconstructive process. Thus, the reconstructive nature of episodic memory must exist because it serves an adaptive function and, therefore, we argue that the underlying systems will have evolved to ensure that creating descriptions of future events does not represent a more effortful process than memory retrieval. The fact that the process of elaborating on novel future events, of which the individual has no direct prior experience, can occur just as quickly as memory retrieval is supportive of this argument.

Furthermore, the findings that likelihood of events speeds the elaboration of future, but not past, events lends support to the role of overarching personal goals in guiding this adaptive process. As noted above, D'Argembeau and colleagues have argued that the planning of future events is constructed around personal goals (D'Argembeau & Demblon, 2012; D'Argembeau & Mathy, 2011) Although the studies presented here did not specifically investigate the role of personal goals, work by D'Argembeau and Van der Linden (2012) suggests that individuals' ratings of likelihood are closely related to importance of events with respect to current goals; therefore, we argue that the manipulation of event likelihood provide an indirect measure of events that are in line with the individuals' working goals. The importance of personal goals in the elaboration of future events is also consistent with the proposal by Klein et al (2002) that episodic memory evolved to serve future planning. However, future work needs to clearly elucidate on the role of personal goals in the elaboration of future episodes.

The current series of experiments set out to systematically compare the process of *elaboration*, distinct from the process of *construction,* for past and future events.  However, Experiment 2-4 required participants to construct events in the first testing session and then elaborate upon them in the second testing session, one week later. Arguably, this long time-lag meant that when participants were presented with the cues at the second session they had to construct the event again before elaborating upon it; thus, our attempt to exclusively examine the process of elaboration may be contaminated by elements of the construction process. However, the reaction time data collected within these experiments allows us to examine the time taken for participants to record episodic details 2-10 (assuming that the construction phase occurred before they listed the first episodic detail). Reanalysis of responses from Experiment 2-4 revealed an identical pattern to those reported for all 10 details. Thus, we are confident that any interference from the need to *re*construct events generated at an earlier session has minimal impact on the findings.

In conclusion, the work presented here represents the first behavioural investigation into whether elaborating upon potential future events relies on similar processes to memory elaboration. We found support for the role of both temporal and thematic knowledge structures in organising the elaboration of future events. However, we found little evidence to suggest that elaboration on future events was a more effortful process compared with memory elaboration. Whilst a number of explanations for this finding have been discussed, more work is needed to fully elucidate on the mechanisms and knowledge structures involved in the elaboration stage of future episodic thinking.

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Table 1 – Mean number of details produced after 10 and 30 seconds, with standard deviations in parentheses, as a function of temporal direction and elaboration order (Experiment 1a)

| | Elaboration Order | Temporal Direction | |
|---|---|---|---|
| | | Past | Future |
| 10 Seconds | Free | 1.66 (0.39) | 1.76 (0.42) |
| | Forward | 1.66 (0.37) | 1.54 (0.42) |
| | Backward | 1.23 (0.26) | 1.23 (0.32) |
| | Interest | 1.38 (0.31) | 1.31 (0.34) |
| 30 Seconds | Free | 4.33 (0.95) | 4.38 (0.81) |
| | Forward | 4.29 (0.79) | 4.22 (0.89) |
| | Backward | 3.80 (0.77) | 3.74 (0.83) |
| | Interest | 3.80 (0.85) | 3.69 (0.74) |

Table 2 – Mean response latency to produce 10 episodic details (secs), with standard deviations in parentheses, as a function of temporal direction and elaboration order (Experiment 1b)

| Elaboration Order | Temporal Direction | |
|---|---|---|
| | Past | Future |
| Free | 88.80 (24.31) | 88.77 (27.27) |
| Forward | 84.64 (21.76) | 88.38 (23.02) |
| Backward | 104.88 (27.47) | 105.47 (31.04) |
| Interest | 102.20 (27.38) | 102.65 (27.72) |

Table 3 - Mean response latency to produce 10 episodic details (secs), with standard deviations in parentheses, as a function of temporal direction, temporal distance, and elaboration order (Experiment 2)

| | Temporal Direction and Distance | | | |
|---|---|---|---|---|
| | Past | | Future | |
| Elaboration Order | Near | Far | Near | Far |
| Free | 117.37 (39.98) | 130.71 (38.41) | 107.58 (31.19) | 114.62 (26.74) |
| Forwards | 113.70 (34.21) | 121.19 (40.34) | 109.24 (34.15) | 114.40 (34.01) |
| Backwards | 129.76 (42.69) | 133.99 (38.67) | 116.88 (26.73) | 125.41 (31.38) |

Table 4 – Mean response latency to produce 10 episodic details (secs), with standard deviations in parentheses, as a function of temporal direction, prior experience and elaboration order (Experiment 3)

| | Temporal Direction and Prior Experience | | |
|---|---|---|---|
| Elaboration Order | Past | Future-Old | Future-New |
| Free | 119.58 (42.66) | 122.54 (54.36) | 108.33 (35.86) |
| Forwards | 123.98 (46.46) | 112.28 (38.23) | 113.08 (48.21) |
| Backwards | 132.04 (60.41) | 123.52 (39.36) | 132. 05 (57.31) |

Table 5 – Mean response latency to produce 10 episodic details (secs), with standard deviations in parentheses, as a function of temporal direction, event likelihood and elaboration order (Experiment 4)

| | Temporal Direction and Event Likelihood | | | |
|---|---|---|---|---|
| | Past | | Future | |
| Elaboration Order | Likely | Unlikely | Likely | Unlikely |
| Free | 98.84 (29.17) | 102.28 (34.61) | 99.65 (39.59) | 108.37 (35.17) |
| Forwards | 104.40 (32.42) | 101.76 (34.50) | 96.99 (30.96) | 106.56 (34.81) |
| Backwards | 115.52 (36.56) | 110.05 (34.97) | 108.65 (32.76) | 111.91 (38.96) |