The Quarterly Journal of Experimental Psychology
Publication details, including instructions for authors and subscription information:
http://www.tandfonline.com/loi/pqje20

The degree of disparateness of event details modulates future simulation construction, plausibility, and recall

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Accepted author version posted online: 08 Jun 2015.Published online: 15 Jun 2015.

THE QUARTERLY JOURNAL OF EXPERIMENTAL PSYCHOLOGY, 2015
http://dx.doi.org/10.1080/17470218.2015.1051559

The degree of disparateness of event details modulates future simulation construction, plausibility, and recall

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(Received 20 September 2014; accepted 10 May 2015)

Several episodic simulation studies have suggested that the plausibility of future events may be influenced by the disparateness of the details comprising the event. However, no study had directly investigated this idea. In the current study, we designed a novel episodic combination paradigm that varied the disparateness of details through a social sphere manipulation. Participants recalled memory details from three different social spheres. Details were recombined either within spheres or across spheres to create detail sets for which participants imagined future events in a second session. Across-sphere events were rated as significantly less plausible than within-sphere events and were remembered less often. The presented paradigm, which increases control over the disparateness of details in future event simulations, may be useful for future studies concerned with the similarity of the simulations to previous events and its plausibility.

Keywords: Episodic future though; Simulation; Imagination; Autobiographical memory.

The majority of studies examining future event simulation have focused on events that are likely to occur in the near future; such imagined events are typically very similar to previous events that have occurred (e.g., Addis, Cheng, Roberts, & Schacter, 2011). However, we are also capable of imagining future events that are highly dissimilar to previous events, which allows us to prepare for a greater range of future events. This is an important adaptive feature of event simulation as we never know exactly what the future might bring (see also Bar, 2009). Surprisingly, very little research has investigated differences in unusualness of future events. One study, by Weiler, Suchan, and Daum (2010), investigated differences between imagined future events that were low or high in occurrence probability and found that lower event occurrence probability was accompanied by increases in activity in the right anterior hippocampus (independent of the amount of detail). It was suggested that low probability events are likely to involve more disparate details than high probability events, and that the enhanced hippocampal activation may reflect more extensive recombination processes for these disparate details.

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This work was supported by the Marsden Fund [grant number UOA0810], [grant number UOA1210]; Rutherford Discovery Fellowship [grant number RDF-10-UOA-024]; and the National Institutes on Aging [grant number R01 AG08441].

Indeed, future events that are dissimilar to past events probably consist of more dissimilar detail recombinations, involving disparate components gleaned from a variety of distinct episodic memories (Addis & Schacter, 2008). Importantly, whether the disparateness of the details comprising a simulation influences the construction processes or the plausibility of that simulation has not yet been investigated directly. In many studies investigating episodic simulation, such as those utilizing the "episodic recombination paradigm" (Addis, Pan, Vu, Laiser, & Schacter, 2009; Martin, Schacter, Corballis, & Addis, 2011; van Mulukom, Schacter, Corballis, & Addis, 2013), it was not possible to determine the degree of disparateness of newly recombined details. Therefore, we designed a novel version of the recombination paradigm, which incorporates a manipulation of the disparateness of details through *social spheres*. Participants imagined future events incorporating memory details extracted either from the same or from different social spheres. We expected that more extensive detail recombination processes would be required for events composed of details from different spheres than from the same sphere, and that this would be reflected in higher event construction times and lower detail and coherency ratings. In addition, we expected the events with disparate details to be rated as more implausible, following their dissimilarity to previous events. Another aim of this study was to investigate the effect of disparateness on encoding of, and later memory for, future events. We assessed whether recall differs between events with disparate or nondisparate details.

EXPERIMENTAL STUDY

Method

Participants

Twenty-five healthy young adults were recruited via on-campus advertisements and gave written consent to participate in this study, approved by The University of Auckland Human Participants Ethics Committee. All participants were fluent in English, had no history of neurologic or psychiatric conditions or use of psychotropic medications, and had not previously participated in other future simulation studies. Two participants were excluded due to failure to comply with task instructions, and thus data from 23 participants were analysed (9 males, aged 18–32 years, $M = 21.7$ years).

Procedure

We designed a new version of the recombination paradigm (Addis et al., 2009) to include social spheres. The experiment consisted of three sessions: a pre-simulation session where memory details from various social spheres were collected; a simulation session, in which participants imagined future events involving the collected memory details; and a post-simulation session, consisting of a surprise recall test and a post-simulation interview.

Session 1: Recall of memory details. Participants identified three social spheres in their lives, where social spheres were defined as "groups of people who know each other". It was indicated that the selected social spheres should have minimal overlap. Examples of possible social spheres were provided (e.g., university friends, family, work colleagues, or music/rugby friends). Participants recalled 90 episodic details (30 persons, 30 locations, 30 objects) for each of these spheres (resulting in 270 memory details in total), where none of the memory details could be duplicated. In addition, these details were required to be as sphere-specific as possible. Note that unlike previous versions of the recombination paradigm used in our laboratory (Martin et al., 2011; van Mulukom et al., 2013), participants were asked to list episodic details during the pre-simulation session, rather than recall events containing these details. During piloting, participants struggled to recall sufficient numbers of events that had social sphere-specific locations as well as objects, which is crucial for the manipulation in this study. Therefore, we decided to use this listing method for episodic detail generation introduced in a recent study also using the recombination paradigm (Szpunar, Addis, & Schacter, 2012).

The episodic details were used to create cues for two conditions of the simulation session: the *within-sphere* and *across-sphere* conditions. For the

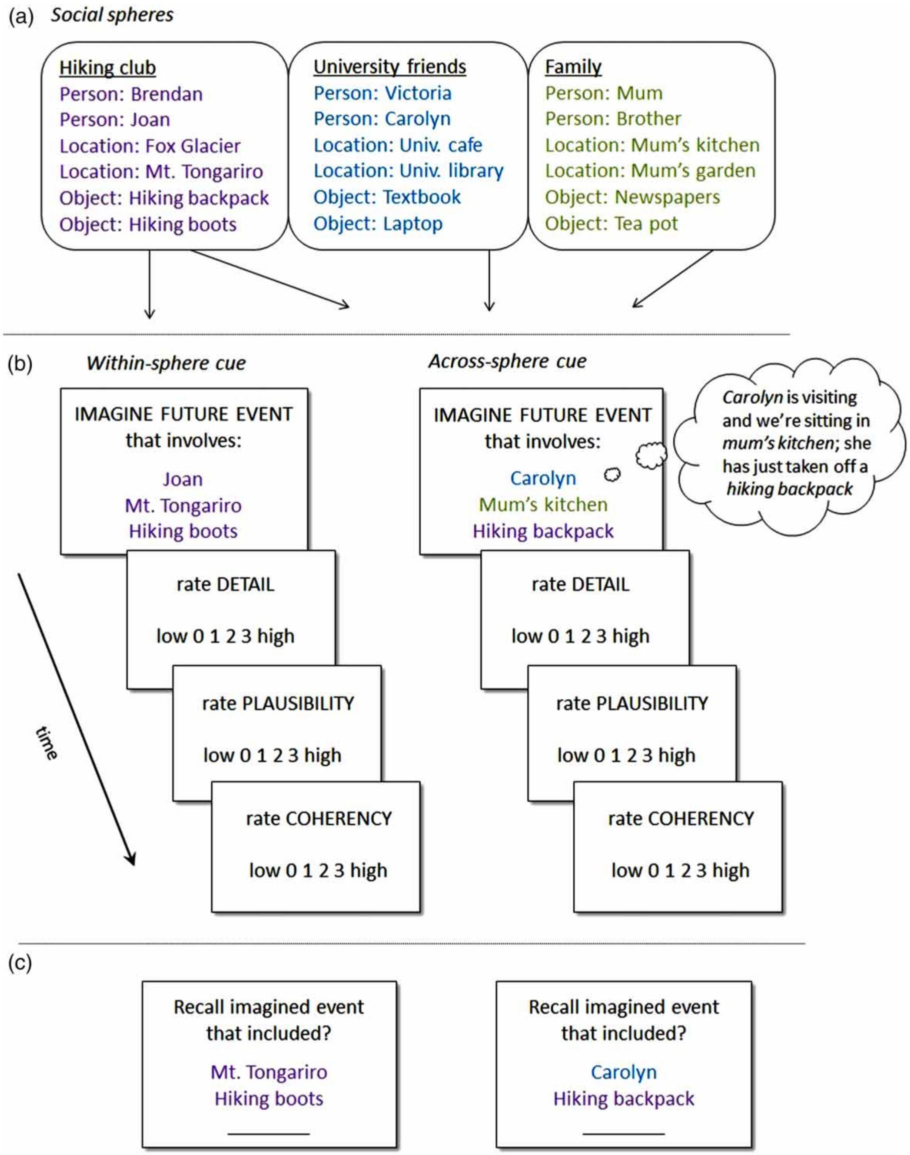

Figure 1. *Social sphere recombination paradigm. (a) The first session: the detail collection session. (b) The second session: the simulation session. Future event cues are created either by combining three memory details within one social sphere (within-sphere, cue left) or by combining three memory details across three social spheres (across-sphere, cue right). (c) The third session: the post-simulation session. Following the simulation session, a surprise cued recall memory test was completed by all participants. Participants were presented with two of the three details from each simulation trial set and were requested to provide the missing detail. In addition, participants completed a post-simulation interview (see the section on Session 3 below for more information). Please note that the colours [online version only] are used here to emphasize the difference between conditions (each colour indicates details from the same sphere) and were not utilized in the experiment. To view this figure in colour, please visit the online version of this Journal.*

within-sphere condition, three memory details (one person, one location, and one object) from the same social sphere were randomly combined. For the across-sphere condition, each memory detail was selected from a different social sphere and was combined into a set of three (see Figures 1a and 1b).

Session 2: Future simulation. Approximately one week later ($M = 7$ days, $SD = 2.4$ days, range = 4–17 days[1]), participants completed the future simulation session. After a practice session involving trials from both conditions, participants were presented 90 future event trials (45 within-sphere, 45 across-sphere), each showing a recombined set of memory details for 8 s (see Figure 1b). Participants were instructed to imagine specific and novel future events that could take place within the next five years, whilst incorporating the three episodic details presented on the screen. Participants made a button press as soon as they had an event in mind; this response, however, did not change the screen, and participants continued imagining until the end of the 8 s of the trial. During this time, participants were encouraged to elaborate and flesh out the event. The event simulation screen was followed by three rating screens, each shown for 3 s. The order of these rating screens was pseudorandomized and counterbalanced. Participants rated each event on a 4-point scale for detail ("0" vague with no or few details, "3" highly detailed and vivid), plausibility ("0" highly implausible, "3" highly plausible), and coherency ("0" a fragmented simulation, the details did not come together well; "3" a fluent simulation, the details came together well). In order to pilot the feasibility of this paradigm for functional magnetic resonance imaging (fMRI), trials were separated by periods of fixation, ranging from 2 to 10 s ($M = 4.22$, $SD = 2.08$ s).

Session 3: Cued recall and post-simulation interview. Each participant was given a 10-minute break after the simulation session, followed by a surprise memory test. In this cued recall test, participants were presented with two of the details from every detail set presented in the simulation session and were required to provide the third missing detail (Martin et al., 2011; see Figure 1c). Participants were encouraged not to guess if they did not know the answer but rather move on to the next question, to ensure that the participants were confident about their answers. Afterwards, events were classified as successfully or unsuccessfully remembered on the basis of the cued-recall test.

Next, an interview was conducted for all trials that were successfully remembered—we did not probe trials for which the simulations were subsequently forgotten as we could not be sure that these had been successfully constructed. For each trial, participants briefly described the event they had imagined, enabling us to identify trials in which a specific future event (i.e., events that were specific in time and place) was generated; only these trials were included in the analyses. Next, participants rated the likelihood of the co-occurrence of the three details presented in that detail set. This rating provided a measure of the disparateness of the detail recombination by assessing whether these three details naturally occur together in the participant's life, allowing us to test whether our sphere manipulation was successful. In addition, participants made a number of ratings for each of the simulated events. The ratings used were: the difficulty to combine the three presented details into a simulation ("0" not difficult, "3" difficult); the emotionality of the event ("0" not emotional, "3" very emotional); and the similarity of the imagined event to previous thoughts and experiences ("0" not similar at all, never happened before, and "3" very similar, I've imagined this exact event/this event actually occurred). Participants also estimated how far in the future the events might take place. Finally, all participants were asked whether they were aware there was going to be a memory test, and all responded that they were not.

Results

Trials were excluded if there was no button press (signalling lack of event construction) or a reaction time of less than 500 ms (to exclude accidental button presses). Also excluded were trials with a similarity rating of "3", indicating that the imagined

[1]The delay duration between detail recollection and future event simulations did not correlate with the percentage of future events recalled ($r = .04$, $p = .85$).

future event was identical to previously experienced or imagined events (and therefore noncompliant with task instructions to imagine novel events). These criteria resulted in 5.9% of trials being excluded.

Behavioural data for across-sphere and within-sphere events are provided in Table 1. Results in this section were analysed through a series of paired-sample *t*-tests. To correct for multiple comparisons, we computed a Bonferroni-corrected alpha threshold of $p = .004$, derived by dividing our original alpha criterion ($p = .05$) by the number of *t*-tests we ran (12 in total). Note that unadjusted *p*-values are provided.

First, to confirm that our sphere manipulation had worked, we examined post-simulation ratings to determine whether the details in the across-sphere detail sets were indeed more disparate than the details in the within-sphere set. As expected, we found that the likelihood of co-occurrence of the details comprising the details sets was significantly lower for across-sphere events than for within-sphere events, $t(22) = -12.50$, $p < .001$, $d_z = -2.61$. Furthermore, across-sphere events were rated as less similar to previous thoughts, $t(22) = -29$, $p < .001$, $d_z = -6.05$, and experiences, $t(22) = -10.58$, $p < .001$, $d_z = -2.21$, than within-sphere events (noting, though, that events from both sphere conditions were still considerably far removed from being similar to previous events). Together, these findings confirm that the sphere manipulation affected the disparateness of the details in an imagined event.

Next, we were interested in whether differences in the disparateness of the details influenced the plausibility of events. We found that, as predicted, across-sphere events were rated during simulation as significantly less plausible than within-sphere events, $t(22) = -12.43$, $p < .001$, $d_z = -2.59$. Furthermore, the disparateness of details also affected the construction of future events. A series of paired-samples *t*-tests demonstrated that within-sphere events were faster, $t(22) = 4.99$, $p < .001$, $d_z = 1.04$, and less difficult, $t(22) = 8.96$, $p < .001$, $d_z = 1.87$, to construct, and they were rated during simulation as more coherent, $t(22) = -6.47$, $p < .001$, $d_z = -1.35$, and more detailed, $t(22) = -5.65$, $p < .001$, $d_z = -1.18$, than across-sphere events. We also tested whether post-simulation ratings of emotionality and temporal distance differed between the sphere conditions. While the temporal distance exceeded the alpha level of $p = .05$, neither effect exceeded the Bonferroni-corrected alpha level of $p = .004$ [temporal distance, $t(22) = 2.23$, $p = .04$, $d_z = 0.46$; emotionality, $t(22) = -0.98$, $p = .34$, $d_z = -0.20$].[2]

Finally, we were interested in whether the disparateness of details influenced recall. We analysed whether the percentage of recalled events of total events differed between across-sphere and within-sphere conditions.[3] A paired-sample *t*-test revealed that across-sphere events ($M = 59.48\%$, $SD = 19.50\%$) were remembered significantly less often than within-sphere events ($M = 72.20\%$, $SD = 14.48\%$), $t(22) = -4.33$, $p < .001$, $d_z = -0.90$.

Discussion

The main objectives of this study were to investigate whether the disparateness of details comprising imagined future events modulates event plausibility and event recall. To this end, we designed a novel paradigm in which simulation cues incorporated details extracted from the same or from various social spheres. Consistent with the idea that the integration of disparate details requires more extensive processing, the disparateness of details affected construction-related

[2]Given that the nonsignificant difference of temporal distance between the sphere conditions was nevertheless a medium-sized effect ($d_z = 0.46$), we explored whether temporal distance correlated with key dependent variables. These correlations were generally weak (plausibility: $r = -.25$, $p = .26$; detail: $r = -.14$, $p = .54$; coherency: $r = -.22$, $p = .32$, difficulty: $r = .14$, $p = .52$; emotion: $r = .10$, $p = .64$), suggesting that differences in temporal distance on the order of a few weeks are not likely to affect phenomenology of details that were imagined to occur more than a year in the future.

[3]We calculated a percentage of the total events per sphere condition rather than comparing the number of recalled trials directly as the number of total trials could slightly differ between the sphere conditions due to the exclusion criteria (see the beginning of the *Results* section).

Table 1. *Behavioural data for across-sphere and within-sphere events*

Ratings	*Mean (SD)*	
	Across	*Within*
Simulation ratings and RT		
Coherency***	1.36 (0.47)	1.90 (0.40)
Detail***	1.67 (0.48)	2.04 (0.40)
Plausibility***	0.56 (0.41)	1.52 (0.54)
RT (s)***	4.92 (0.91)	4.41 (0.86)
Post-simulation ratings[a]		
Difficulty***	1.53 (0.47)	0.79 (0.30)
Emotionality	0.43 (0.39)	0.49 (0.37)
Likelihood of co-occurrence***	0.32 (0.21)	1.29 (0.39)
Similarity of event to previous experiences***	0.34 (0.21)	0.98 (0.38)
Similarity of event to previous thoughts***	0.14 (0.17)	0.35 (0.39)
Temporal distance of event (years)	1.71 (0.81)	1.47 (0.42)

Note: All participant ratings were made using a 4-point rating scale, ranging from 0 (low) to 3 (high), except for temporal distance (in years).
[a]These ratings were only collected for events that were successfully recalled.
***$p < .001$.

processes: Across-sphere events took significantly longer to generate, were less coherent, were rated as more difficult to construct, and contained less detail than within-sphere events. Furthermore, our analyses also confirmed previous assumptions that events containing disparate details from different social realms of one's life were rated as less plausible than events containing details that are more closely connected.

Little is known, however, about the psychological mechanisms by which people evaluate the plausibility of imagined future events (Szpunar & Schacter, 2013). If plausible and implausible future events are distinguished in the way that we also distinguish between real (i.e., past) and imagined events, then according to the *reality monitoring theory*, the distinction is made on the basis of the events' phenomenology, and more particularly on the basis of the amount of sensory and perceptual detail present (Johnson & Raye, 1981; Johnson, Suengas, Foley, & Raye, 1988), where more detailed events may be considered more plausible. This idea is supported by a number of findings that real events are typically associated with greater sensory and perceptual detail than imagined future events (e.g., Addis et al., 2009; D'Argembeau & Van der Linden, 2004; Weiler, Suchan, & Daum, 2011). From the perspective of the *availability heuristic,* on the other hand, the fluency with which the event is imagined influences plausibility estimations (Bernstein, Godfrey, & Loftus, 2009; Tversky & Kahneman, 1973; Whittlesea & Leboe, 2003). Thus an unexpected fluency of imagining for a novel event may lead individuals to mistake this fluency for familiarity with the event, thus inflating the belief that the event (or part of the event) is present in episodic memory, resulting in a higher plausibility rating (Bernstein et al., 2009). This idea is consistent with the suggestions that a crucial difference between imagined future events and recalled real past event lies in the effort that is required to construct them (Hassabis, Kumaran, & Maguire, 2007; McDonough & Gallo, 2010). Unfortunately, our data could not adjudicate between these two hypotheses because more plausible within-sphere events were both more fluently constructed and more detailed. Therefore, future studies that can differentiate the reality monitoring theory and availability heuristic are needed.

Another aim of this study was to investigate the effect of novelty (i.e., dissimilarity to past events and unusualness of event details occurring together) on the recall of future simulations. A long-held view maintains that novelty enhances encoding (Tulving, Markowitsch, Craik, Habib, & Houle, 1996), following the idea that information is encoded to the extent it is novel (see also, Knight, 1996). Consistent with this idea is the finding that anterior hippocampus supports memory for novel but not repeated stimuli (Poppenk, McIntosh, Craik, & Moscovitch, 2010) and the finding that medial temporal responses to novel stimuli are correlated with subsequent memory for these stimuli (Kirchhoff, Wagner, Maril, & Stern, 2000). Typically, these studies have examined recall effects for novel relative to repeated stimuli; however, increased rates of remembering are also evident for novel or *uncommon* stimuli over common stimuli. This encoding advantage for uncommon stimuli has been called the "bizarreness effect" and has been documented over a range of studies including bizarre images and word-pairs (for reviews see, Einstein, Lackey, & McDaniel, 1989; Hirshman, Whelley, & Palij, 1989). In contrast, a recent theory suggests that novelty may be a disadvantage for later recall, in particular with regards to episodic events. Poppenk and Norman (2012) propose in their *scaffolding hypothesis* that the similarity of novel stimuli to previous experiences facilitates the binding of new information as the previous experience provides a "scaffold" to which the new information can be attached. Consistent with this hypothesis are findings that familiarity with the stimuli enhances encoding (Klein, Robertson, Delton, & Lax, 2012; Poppenk, Köhler, & Moscovitch, 2010). Thus, it would be expected that for future events that are less similar to previous experiences, encoding may be less efficient, leading to decreased recall rates for events with more disparate details relative to events with less disparate details.

Our results demonstrated that within-sphere events were remembered significantly more often than across-sphere events. Thus, it would appear that novelty (manifested in the across-sphere condition as the inclusion of disparate details that normally do not occur together) impairs the encoding and recall of imagined future events, while heightened similarity to previous experiences (as evident for the within-sphere condition) enhances encoding. This pattern of findings therefore suggests, in line with the scaffolding hypothesis (Poppenk & Norman, 2012), that factors that scaffold the event into memory—such as preexisting memories of similar content—probably enhance encoding. This finding is in line with recent work focused on the key role played by encoding of integrated memory representations (Shohamy & Wagner, 2008). Future work that directly evaluates this prediction should provide a basis for evaluating the suggestions laid out here.

The finding that novelty does not seem to enhance encoding and may even disrupt it was somewhat surprising given previous findings that bizarre information is often better encoded than common information (Hirshman et al., 1989; McDaniel & Einstein, 1986). It may be, however, that this pattern of results is related to the type of memory test that was employed in studies that found the bizarreness effect (free recall) versus the current study (cued recall; Einstein et al., 1989). Free-recall tests measure how strong an entire memory is represented in the mind and how well this memory can be accessed. Cued recall, on the other hand, tests how strong the connections are between the components that were cued (Einstein et al., 1989). It has previously been suggested that increased remembering rates for bizarre relative to common stimuli (e.g., imagery) are due to increased access to the images rather than enhanced retrieval of the components of the images (McDaniel & Einstein, 1986). Accordingly, the bizarreness effect is found with free recall, but not with cued recall (Einstein et al., 1989). This idea can also explain why our participants frequently mentioned during the post-simulation session that they remembered the "bizarre" events in particular (i.e., an instance of free recall), even though their performance on the cued-recall test showed the contrary. For future research, it would be interesting to do an experiment with the same social sphere paradigm as that used in the present study, but using both free- and cued-recall tests to further explore this hypothesis. Although our piloting of the standard recombination paradigm (e.g., Martin et al., 2011) has demonstrated that participants remember very few events through the free-recall method, it is possible that the sphere manipulation might increase rates of free recall, and thus this may be an interesting venture for future research.

It is important to note that across-sphere events were rated as occurring slightly further into the future than within-sphere events, and this medium effect approached significance. This observation suggests that the sphere differences in temporal distance may have influenced some of the results observed in this study. Indeed, close future events (within a year) tend to contain more sensory and contextual details and be associated with stronger feelings of "preexperience" than distant events (e.g., 5–10 years into the future; D'Argembeau & Van der Linden, 2004). However, our finding that temporal distance was not significantly associated with construction difficulty and event phenomenology speaks against this interpretation and suggests that differences in temporal distance on the order of a few weeks are not likely to affect the phenomenology of events imagined to occur more than a year into the future.

In summary, this study demonstrates that future events composed of more disparate details were not only more dissimilar from previous events and less plausible but also required more extensive constructive processes. Moreover, these future events were recalled less frequently than events with similarities to preexisting memories, highlighting the importance of scaffolding in successful encoding. Further investigation of event novelty and plausibility should provide important insights in the nature and function of future simulation.

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