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Causality and Similarity in Autobiographical Event Structure: An Investigation Using Event Cueing and Latent Semantic Analysis

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A thesis submitted in partial fulfillment of the requirements for the Doctor of Philosophy degree in Psychology

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Abstract

The influence of similarity- and causally-based relations on the organization of autobiographical events was investigated using extended strings of related event memories. These strings were elicited using an event cueing paradigm in which participants generated descriptions of memories from their life, which were then presented as cues to subsequent event memories. In Experiment 1, similarity between generated events was investigated using participants' similarity ratings, Latent Semantic Analysis, and experimenter judgements of shared event properties. For events close together in a string, event owners' similarity ratings were higher than non-owners', and non-owners' ratings were comparable to similarity calculated using LSA. In Experiment 2, the influence of causal connectivity of events on perceived event similarity was investigated using causality ratings by event owners and non-owners. Results indicated that many events cued other events based on causal relations, owners' causal ratings were highly consistent, and the ownership advantage in Experiment 1 could in part be explained by causal connections among events. It is concluded that both event similarity and causality are important aspects of the organization of autobiographical memory.

Keywords: Autobiographical memory, event memory, autobiographical, memory, event, cueing, event cueing, LSA, Latent Semantic Analysis, similar, similarity, causal, causality.

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Causality and Similarity in Autobiographical Event Structure:
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When we recollect a set of events from our own life, there are a number of ways that we might retrieve them from autobiographical memory. On some occasions, we might think of a collection of stories involving our college roommates, or a set of childhood memories from our grandparents' cottage. We might reminisce about various camping trips with our family, or road trips in a beat up car we bought when we were 16. Thus, similarity in terms of shared event components, such as people, locations, activities, and even objects, appears to influence the manner in which memories are connected. In addition, we also may remember personal events in terms of their causal connections, regardless of event similarity. For instance, the memory of getting your wisdom teeth out at the dentist might cue the memory of your mother making you pudding for lunch because you were unable to chew, even though those two events include different people, locations, activities, and objects. In other words, similarity and causality seem to be two important factors around which autobiographical events are organized. In fact, with respect to cognitive processes in general, the idea that similarity and causality are factors that have a prominent influence plays a role in a number of theories. These constructs permeate multiple sub-disciplines of cognitive science, such as conceptual representation (Ahn, Marsh, Luhmann, & Lee, 2002; Jones & Love, 2007), analogical reasoning (Lee & Holyoak, 2008), decision making (Garcia-Retamero & Hoffrage, 2006; Osman & Shanks, 2005), and perception (Kushnir & Gopnik, 2007; Newman, Choi, Wynn & Scholl, 2008).

The primary goal of this thesis is to investigate similarity and causality as they pertain to the cognitive structure of autobiographical memory. The present studies make use of participant similarity ratings, corpus-based measures of similarity derived from Latent Semantic Analysis (LSA: Landauer, Foltz, & Laham, 1998), and participant ratings of the causal connectivity of events. Specifically, I investigate what role similarity plays in leading one personal event memory to cue another. I also use LSA to assess the degree to which similarity ratings between pairs of events are determined by the surface similarity and meaning of the words used to describe those events. These lexical factors are contrasted with the additional knowledge that human raters could bring to bear, particularly when rating their own memories. Furthermore, I investigate what role causality plays, over and above similarity, in connecting events in people's autobiographical memory.

Similarity

There has been extensive research investigating the similarity structure among specific personal event memories (Brown & Schopflocher, 1998a; 1998b; Dijsktra & Misirlisoy, 2006; Wright & Nunn, 2000; Odegard, Lampinen & Wirth-Beaumont, 2004), as well as experimenter-generated event descriptions (Lancaster & Barsalou, 1998). A popular contention is that event memories are organized according to the (in many cases, perceptual) properties associated with them, such as the activity, participants, location, objects, time, and emotional aspects of an event. Under this framework, previous research investigated the types of shared event properties that have the strongest influence on event similarity. Initially it was postulated that the activity associated with an event memory was the dominant property for indexing an event within the larger context of autobiographical memories (Kolodner, 1983; Reiser, Black & Abelson, 1985; Shank, 1982). Events were thought to be further subclassified according to other properties, such as participants and location, within each activity. However, although activity continues to play a central role in theories of the organization of personal memories, these theories have been expanded such that other properties are now also viewed as important (Barsalou, 1988).

Lancaster and Barsalou (1997) investigated the role of participants, location and time, in addition to activity, on event memory organization. Participants were presented with descriptions of sets of fictitious events that included the above properties, but varied the number of overlapping properties within each set (low vs. high similarity). They were subsequently asked to recall these descriptions. Across all sets of remembered descriptions, participants and activity were reported with equal frequency, which were correctly recalled more often than location and time. In addition, events that shared an activity or participant with other events in the set were recalled with similar frequency, but more so than those that shared location or time. Sets of events that shared both activity and participant were recalled most often, while sets that shared neither of these elicited the worst recall. Critically, when the similarity among a set of events was increased from one shared non-activity property to two, events were more often recalled in sequence, suggesting that increased property-based similarity led to a stronger connection between events in memory. These results support the contention that similarity, in terms shared event properties, plays an important role in the organization of a person's memory for events.

Lancaster and Barsalou (1997) demonstrated that the organization of autobiographical memories is concurrently determined by similarity in terms of participants, activity and, to a lesser degree, location. Recent studies indicate that location

(Dijsktra & Misirlisoy, 2006; Knez, 2006) and even climate (Knez, 2005) can be particularly relevant factors, not only for autobiographical memories, but for self-concept and identity (Knez, 2005) – memory and self-concept are widely believed to be tightly bound (Conway, 2005; Pasupathi, Mansour, & Brubaker, 2007). The emotionality, happiness, vividness, and importance of remembered personal events have also been implicated in determining similarity (Wright & Nunn, 2000). However, studies have also shown that events can be organized according to information other than similarity of event properties between events, most notably causality and temporal order.

Causality and Temporal Order

Similarity and Time

The joint influence of similarity and chronology in structuring autobiographical event memories was highlighted in a diary study by Linton (1982). She recorded descriptions and dates of multiple autobiographical events every day over the course of six years, along with a number of measures of the events' salience, such as emotionality and importance. Every month she tested her ability to remember and chronologically order random pairs of event descriptions (as well as other tasks that I will not discuss). Linton (1986) provides an interesting account of her retrieval strategies. She noted that recent memories were best recalled using a chronological search strategy, whereas remembering remote events required categorical or thematic information. However, for remote events, a chronological strategy was still most efficient within the category or theme. For example, one might search chronologically through 'working at the law firm' memories, possibly even searching within a particular 1-year time frame, such as 'the Pensky account'.

Anderson and Conway (1993) experimentally confirmed these results, finding that although sometimes thematic or distinctive information is used initially (leading to faster recall for a set of events; Burt, Kemp, Grady, & Conway, 2000), recall typically proceeds in forward order, despite the fact that time serves as a poor retrieval cue. Most recently, Burt, Conway, and colleagues (Burt, Watt, Mitchell, & Conway, 1998; Burt, Kemp, & Conway, 2008) replicated Linton's interaction between retention interval and temporal order. In their studies, participants took a sequence of photos at prescribed locations and were later asked to put a shuffled stack of photos back into chronological order. Burt et al. (1998) found that ordering performance was poor when the interval between sessions was long (a mean of 175 days), but was better for participants that conducted the recall task within about a week of taking the photos (mean of 4 days); thus, recent events elicited greater chronological/sequential structure than remote events. Interestingly, participants' ability to order events was poor even for recent events, although their ordering performance was improved by an increase in their ability to remember event details. An intriguing question, then, is *why* one remembers that certain, often remote, event memories are connected in time, while many other temporal connections are lost.

Causal Connectivity

Many recent memories appear to be retained, to a large degree, according to temporal order without necessitating thematic or categorical information, and this temporal information decays rapidly (Conway, Williams, & Baddeley, 2005). However, a small subset of these temporal connections remains intact over time. This occurs because some temporally contiguous events are meaningfully related. Similarity obviously plays a role in this process, as events that occur very close in time are likely to share multiple properties. However, people also remember events as temporally connected if they also share a causal relationship, that is, if the outcome of one event *caused* a second to occur. For example, if you broke your leg, you would then get a cast put on it.

Many researchers have suggested that autobiographical memory is similar, in many respects, to memory for narratives (Brown, 1990; Bruner, 1991); often one's compendium of life memories is described as a "life narrative" or "life story". Theories of narrative comprehension include the assumption that causal connections formed among events in a narrative text are crucial in forming a mental model, and result in the construction of a causal network (Johnson-Laird, 1983) or situation model (Van Dijk & Kintsch, 1983) for the events that a narrative describes (Trabasso, Secco & van den Broeck, 1984; Trabasso, van den Broeck & Suh, 1989). In addition, the causal network of events in a story is better remembered than event properties, such as the setting, objects, or details of certain actions (Graesser & Clark, 1985; Trabasso & van den Broeck, 1985). Statements with greater causal connections are rated as more important and are easier to remember (Trabasso & Sperry, 1985), and narratives that are more conceptually coherent include a greater number of causal connections (Trabasso, Suh & Payton, 1994). Thus, causality appears to play a vital role in the maintenance and retrieval of event memories.

Radvansky, Copeland and colleagues (Copeland, Radvansky, & Goodwin, 2009; Radvansky, Copeland, & Zwaan, 2005) investigated similarities and differences between memories for narrative and autobiographical events using participants' memory of a novel that describes the entire life of a protagonist. Participants read a ten chapter novel one sentence at a time on a computer screen, one or two chapters per session. At least one week later, they performed a series of memory tests, such as generating descriptions of events from the novel in response to cue words (e.g., names and places), generating details of specific episodes (in response to questions such as “What happened on Daisy and Harold’s honeymoon?”) in forward order, backward order, or in order of detail importance, and performing a recognition test on descriptions of events from the novel. Radvansky et al. compared these results to those on the same tasks when testing participants’ recall and recognition of events from their own lives. Consistent with past studies of autobiographical memory (Anderson & Conway, 1993), participants were fastest to recall event details in forward temporal order. Most critically, a causal connectivity analysis indicated that causality has a stronger influence on autobiographical memory recall than on narrative recall. Whereas causal connectivity did not influence participants’ ability to recognize event descriptions, personal event memories (which Radvansky et al. term event details) that were more strongly causally connected were more likely to be important autobiographical events. In contrast, causal connectivity had no influence on narrative detail importance. Furthermore, while the number of causal connections among event memories for a given narrative event was the same regardless of the way events were recalled, autobiographical events recalled in forward order elicited more causal connections between details than in backward or importance-based recall order. These results indicate not only that a forward temporal order of autobiographical events is more memorable and more easily recalled, but that causal connections play an important role in remembering this temporal order, and in structuring our memory for autobiographical events.

Radvansky et al.’s (2005) results dovetail nicely with previous findings. Most notably, in studies in which participants recall autobiographical memories as a life narrative (Fromholt et al., 2003), they do not show the recency effect observed in studies of cued autobiographical recall (Rubin, Wetzler & Nebes, 1986). That is, although people's memory for recent events is better than for remote events – in terms of the number of remembered personal events and the number of temporal connections among them – memory for causal connections among recent events is equivalent in number to those among remote events. This suggests that the rate of decay of causal connections is much lower than that of temporal connections, accounting for their import in structuring autobiographical memory, and the importance of incorporating this factor into models of autobiographical memory.

Structure of Autobiographical Memories

Arguably the most influential model of autobiographical memory, the self memory system, originally proposed in full by Conway and Pleydell-Pearce (2000) and also described in Conway (2005; 2009), emphasizes the interaction of two primary systems: the autobiographical knowledge base and the working self. In this general framework, it is assumed that autobiographical memories are "transitory dynamic mental constructions generated from an underlying knowledge base" (p. 261, Conway & Pleydell-Pearce). Thus, formation of a person's specific episodic representations, and their ability to recollect those episodes, is dependent on the structure of this underlying autobiographical knowledge base, and further modulated by one's recent goal processing (Conway & Pleydell-Pearce; Conway, 2009). Conway (2009) argues that "one of the main functions of episodic memories might be to keep a highly specific record of aspects of experience relevant to recent goal processing" (p. 2306).

In the present thesis, however, I focus on the structure of the underlying autobiographical knowledge base, upon which the control processes of the working self operate. The autobiographical knowledge base has been described as having three levels of autobiographical knowledge: lifetime periods, general events, and specific episodic memories (Conway, 2005; Conway & Pleydell-Pearce, 2000). These structures are hypothesized to be organized hierarchically with partonomic relations between levels (Barsalou, 1988). Abstract life themes and lifetime periods, such as “living with Molly” or “working at the car dealership”, are stored at the highest level. These, in turn, are sub-classified into general events at the next level, such as “the day I sold my first car”, and specific episodic memories comprise the lowest level of the hierarchy, such as “prepping during the morning for the client’s arrival” or “going out for dinner with the boss after the paperwork was done”.

At present, the self memory system does not address direct similarity relations or causal relations among events at the lowest level of the putative hierarchy. Instead, it emphasizes connections between a specific event and its associated superordinate general event. Conway (2009) does, however, describe specific episodic events as having a sequential structure, based on the temporal order in which the events were experienced and encoded, at least initially. When this temporal information is forgotten – typically quite quickly, as reported above – he hypothesizes that an episodic memory is represented due to the integration of the episodic elements of each simple event with an event frame. For example, one’s simple episodic memory for a company meeting on a given project is formed through an integration of brief moments of episodic experience (i.e., recollections of visual imagery) and one's conceptual interpretation of the elements (e.g., what was discussed, in what order, who were the participants, etc).

While this provides a preliminary framework for the formation of memories for extended temporal sequences of events, the types of relations that are maintained once this temporal information is lost is not well understood, and it is not clear how these relations might operate outside the context of general events. Many studies have described sequences of episodic memories that were recalled as part of a general event as being temporally and/or thematically related. However, research that investigates the direct connections among these individual episodic memories outside the context of larger general events is underrepresented in the literature.

The present thesis augments Conway and colleagues' theory (Conway, 2009; Conway & Pleydell-Pearce, 2000) by investigating the role of direct similarity and causal relations between and among episodic memories in the organization of the autobiographical knowledge base. Studies that have investigated similarity relations among event memories have used artificial memories (Lancaster & Barsalou, 1997) and other studies that have investigated autobiographical episodic memories have imposed retrieval constraints that may have influenced results systematically (Anderson & Conway, 1993; Radvansky et al., 2005). In the present thesis, I use a less constraining procedure, event cueing, to address whether both causality and similarity play a role in the organization and recollection of events at the lowest level of the self memory system hierarchy.

Event Cueing

Brown and Schopflocher (1998a,b, see Brown, 2005) propose that connections are drawn among autobiographical event memories as a result of the goals, plans, or themes that produce coherence in our daily lives. The basic unit is the event cluster, which is "a memory structure that organizes information about a set of causally and thematically related events" (Brown & Schopflocher, 1998a, p. 470). They investigated this structure using a modification of the traditional autobiographical event cueing procedure (Crovitz & Schiffman, 1974; Crovitz & Quina-Holland, 1976; Galton, 1883; Wagenaar, 1986; 1988). In their study, participants were asked to recall a personal event in response to a cue word, such as “car”, and that event description was then used as a cue to an additional personal event, resulting in a pair of cueing and cued events. The investigation of event pairs is an important evolution of the event cueing procedure because previous studies had only looked at event memories in isolation. Previously, events were each recalled in response to a cue word, and inferences were made with regards to the distribution of events across the lifespan based on the dates that participants provided. While informative in its own right, this procedure does not provide insight into the cognitive architecture or structure of autobiographical memories because it does not speak to the connections among events. To understand how event memories are organized, one must measure how events relate to each other.

Brown and Schopflocher (1998b) had participants assess pairs of cueing and retrieved events along a number of dimensions, including activity (whether the same activity was involved), location and participants (whether the two events took place in the same location or involved the same participants), causality (whether the first event caused the second to occur), whether one event was part of the other, and whether both were part of a larger event. The underlying rationale was that when one memory representation activates or cues another, those representations are connected in some way. Therefore, if one event memory cues another, knowing how those events are related is informative of autobiographical memory structure. This rationale has often been applied in psychological theories of, for example, semantic memory, perception, attention, and even event memory (Shank, 1982; 1999).

Brown and Schopflocher (1998a, 1998b) experimentally defined a pair of events as clustered if participants rated them as causally related, part of one another, or parts of a larger event, and did not consider shared properties (similarity) as a defining feature of a cluster. Sixty-eight percent of event pairs were clustered by Brown and Schopflocher's definition. They were more temporally proximate (2 days) than non-clustered pairs (317 days), and were more likely to share activities, participants, and locations – although, consistent with Lancaster and Barsalou (1997), no single shared event property dominated. In addition, 52% of all event pairs, and 77% of clustered pairs, were causally related.

Brown and Schopflocher's (1998a, 1998b) *theoretical* definition of event clusters, however, included both causal *and* thematic relations, highlighting the importance of both causality and similarity. However, their empirical definition appears biased toward the former, and does not address the influence of similarity (i.e., thematic relations) on leading one event to cue another because participants' ratings of whether a pair shared participants or locations were not used to define that pair as clustered. In addition, although they used the term "event cluster", their task investigated event pairs only. This leads to two interesting questions. First, do clusters exist for longer strings of cueing and cued events and, second, is within-string similarity greater than similarity for events from different strings?

Recent studies have iterated the event cueing paradigm to develop strings or chains of autobiographical event memories (Odegard et al., 2004; Wright & Nunn, 2000). This is useful because it allows sets of related events to be generated without strong constraints on recall, such as having participants recall strings of events in a prescribed temporal order. In Wright and Nunn (2000), participants generated strings of personal events by using a recalled event (generated in response to a cue word) as a cue to an additional event, which was then used as a cue in its own right, and so on until a string of six events were produced. They assessed whether these strings of events held together as unitary event clusters, focusing on similarity. Using hierarchical modeling, they demonstrated that events within a string are more similar in terms of participant-rated clarity, emotionality, importance, and happiness, than are events between strings. Wright and Nunn concluded that that their data support Brown and Schopflocher's (1998a, 1998b) contention that event clusters are an organizational construct in autobiographical memory, and that a single string of cueing and cued events can be viewed as one cluster. However, similarity within a cluster was not predictive of the time it took for events within a cluster to cue each other. An important consideration, therefore, is that each string of events might not represent a single unitary cluster, but instead represents a chain of clustered event pairs.

Odegard et al. (2004) investigated this possibility in two experiments by assessing how event-pair similarity changed when the distance between pairs of events in a string differed. Their hypothesis was that if a string of events is not a unitary cluster, then they should find "event clusters which contain events that are *only similar to those events directly adjacent* to them in the [string]" (p.687, emphasis added). Participants generated a string of four events to each of four cue words using a procedure similar to Wright and Nunn (2000). Six weeks later, the same participants were presented with the 16 event descriptions they had produced and asked to "sort them into four piles, each containing four events" (p. 688). They then performed the same task for 16 events produced by another participant. Sorting performance acted as an indirect measure of event-pair similarity.

Overall, participants were more likely to sort an event pair into the same grouping when the events were closer to one another in the original string. Participants were also more likely to sort events describing their own experiences back into the appropriate strings compared to other people sorting those events, an effect henceforth referred to as an ownership advantage. There was no interaction between the distance between events and ownership. Moreover, event sorting was above chance even for non-owners.

These results are problematic because they partially disconfirm both an event-chain theory proposed by Odegard et al. (2004) and Wright and Nunn's (2000) theory that a string represented a single event cluster. They partially support Odegard et al.'s hypothesis because overall sorting was best for adjacent pairs. However, the sorting performance of other participants' events was above baseline for events two apart in a string. In addition, the magnitude of the ownership advantage was equivalent for all event distances, which is not predicted by a theory of chains of clustered pairs. If only adjacent events are relevant for clustering, then the structural connections unique to them should result in an ownership advantage that is greatest for, or exclusive to, adjacent events, resulting in an ownership by distance interaction.

The results partially support Wright and Nunn's (2000) argument for a string as a single cluster because by event owners eliciting an advantage for all pairs in a string, it suggests that they use information over and above the similarity obvious to other participants rating the events, information that would allow all of the pairs to be connected in autobiographical memory in the same way. If, however, the ownership advantage had been present for some event distances but not others, it would strongly refute the hypothesis that an entire string is a cluster. Such a result would suggest that only a subset of event pairs are connected in autobiographical memory. The difficulty in interpreting Odegard et al.'s (2004) results is that, without a measure of the similarity between pairs of events from different strings, it is impossible to know whether the ownership advantage occurs within strings only (supporting Wright & Nunn's theory) or is simply a bias for event owners to call their own event pairs more similar than others, whether they are related in any way or not. A third possibility, proposed by Odegard et al. is that, when participants sort their own events, they have the original retrieval strategy and retrieval context available to them (which another participant could not), and this additional information might result in superior sorting performance, rendering the results uninformative of autobiographical memory structure.

In a second experiment, Odegard et al. (2004) investigated the influence of retrieval context. Recall that in their Experiment 1, four initial event memories were cued in response to four cue words, and each event then elicited an event string. In their Experiment 2, participants generated two strings of five events from each initial event –

one string on the first session, and another during a second session – so that each string of a pair had a separate retrieval context, but putatively originated from a single autobiographical memory structure, a construct termed a “supracluster”. In this way, Odegard et al. hypothesized that structure and context could be teased apart. After a multiple-week delay, participants sorted their generated event descriptions (44 in total) into 4 groups, only now each group contained 11 events (one source event, plus two strings of five additional events). They also sorted another participant’s memories. For events generated as part of the same five-event string (i.e., during the same session), Experiment 1 was replicated with main effects of ownership and event distance. However, event pairs from the same supracluster that were generated on different sessions were not sorted together more consistently by event owners than by non-owners. These results appear to suggest that the ownership effect in Odegard et al.’s (2004) Experiment 1 may simply have been caused by a bias for event owners to remember the initial session in which the events were generated (information non-owners could not access).

Present Thesis

In the present thesis, I contend that the ownership advantage, the tendency for event owners to rate pairs of descriptions as more similar than do naïve participants, reflects autobiographical memory structure. It does not reflect a bias for event owners to remember that, in the initial event generation session, two events were in the same string of cueing and cued events, or a bias for event owners simply to rate their own events as more similar. When event owners access a memory in response to an event description as a cue, they use information about, as well as over and above, shared event properties between those cueing and cued events. Using a new more direct measure of similarity and a more controlled event generation design, I first provide evidence against Odegard et al.'s (2004) hypothesis that event owners' elevated sense of similarity is due solely to their memory for the initial generation context, or an event owner bias. Second, I provide insight into the type of similarity information that participants might be using in evaluating event pairs by comparing patterns of rated similarity to an automated measure of passage similarity, LSA. I then demonstrate that the ownership advantage is due to a key piece of information that participants are missing when rating other people's event descriptions, causal relations.

In Experiment 1, I focus primarily on similarity between event pairs collected using an extended cueing technique (Odegard et al., 2004; Wright & Nunn, 2000). Rather than using indirect measures of similarity such as sorting, I collected participants' similarity ratings of their own event pairs, and other naïve participants' ratings of them as well. I also calculated similarity derived from LSA, a model of the meaning of English words and passages that is based entirely on the co-occurrence of words and phrases in large electronic text corpora. The assumption underlying the LSA analyses is that the similarity of two event descriptions as determined by LSA indexes solely the semantic and textual similarity of those passages. Therefore, LSA similarity can be thought of as a baseline, in terms of similarity rating, that might be provided if participants relied on textual and semantic content only. I conducted three sets of analyses. I first investigated event owners and non-owners' similarity ratings and introduce a baseline measure using events from different supraclusters (i.e., from strings originating from different cue words). In contrast to previous results, I demonstrate that some event pairs in a string are no more similar than baseline, and that the ownership advantage is not present for all pairs in a string. In the second analysis, I used LSA to determine the degree to which event similarity, in terms of common words in the descriptions, influences rated similarity. Using these data, I provide insight into the conditions under which individuals use information over and above basic similarity.

In Experiment 2, I investigated how causal connectivity within a string influences event pair similarity. The specific issue concerns whether causal connectivity can account for the ownership advantage. I asked event owners and non-owners whether event pairs are causally related, and had them rate similarity as well. I investigated similarity ratings for causally connected and non-causally connected pairs, for participants rating their own events, for other participants rating them, and for LSA similarity. By accounting for the causal connectivity of events in a string, I provide insight into the interaction between causal connectivity and similarity in the structure of events in autobiographical memory. In addition, I demonstrate that the heightened similarity ratings observed in previous studies are in large part determined by the causal structure of those events, indicating that causal connectivity and similarity are two prominent determinants of autobiographical memory structure.

Experiment 1: Event Generation and Similarity Ratings

The purpose was to demonstrate that when participants rate their own event pairs as more similar than do other participants, the reason is not that event owners are simply recalling the experimental context in which those events were generated. Instead, they are bringing to bear additional information about how a pair of events are related that may not be entirely explicated in the event descriptions that they produce. I used pairwise event similarity ratings rather than sorting to investigate the similarity structure of strings of cueing and cued autobiographical events. The primary reason was that similarity ratings are less constrained than sorting tasks in which the number of clusters or groups is pre-defined by the experimenter. Participants generated strings of cueing and cued events in session one, and returned three weeks later to rate pairwise similarity. A second set of participants who were naïve to the elicitation task also rated the pairs. The use of a direct similarity measure is an important advancement in the event-cueing literature because it is relatively transparent in its interpretation and free of task-related confounds. Past experiments have assessed similarity using ratings of event properties (i.e., clarity, emotionality, importance, etc.) or sorting procedures. Although these ratings provided important information, in the former, overall similarity between events was inferred from similarity on the experimenter-chosen attributes, which introduces potential biases. With sorting, interpretation appears more transparent. Although a sorting task is straightforward to measure as a dependent variable, the apparent interpretability of the data can be misleading because of numerous confounds that a sorting paradigm can introduce.

Odegard et al. (2004) asked participants to sort event descriptions into four groups. However, constraining participants to sort event descriptions into a predetermined number of groups can force events that are not otherwise related autobiographically – and are therefore not considered by participants to be similar – to be sorted together. For instance, two initial events might be sorted together based on pair-wise similarity. By the same logic, a third event might then be sorted into that group because of a pair-wise similarity to *only one* of the previously grouped events (regardless of similarity to the other event). Another possibility is that three main event groupings might be salient whereas a fourth “miscellaneous” cluster is produced only because of task demands. Thus, the sorting task may provide an illusion of similarity. Another issue is that instructing participants to sort their own events biases them to consider groupings that were inherent in the format of the event-generation procedure on the initial session. Finally, a sorting task may make the experimenters’ motivations too obvious. Pair-wise similarity ratings avoid these problems because they do not force participants to hone in on experimenter-determined event properties, they allow participants to evaluate event pairs without considering other events in the experiment, and the relation of the ratings to the event generation procedure is not obvious.

The initial event generation procedure employed by Odegard et al. (2004) was altered to further minimize (or eliminate) cues that participants in Odegard et al.’s experiments might have used during the second session to remember event groupings generated in the first session, leading to higher performance for event owners. Odegard et al. utilized a block design. For the first block, a participant saw each cue word and generated an autobiographical (source) event. In the next block, each of the generated events were then used as cues to another set of events, and this blocked procedure was employed again and again until six blocks had been completed. Arguably, a trial block could by itself act as a retrieval cue, as has been proposed in other contexts (Bahrick, 1971), and might have facilitated sorting. For instance, a person might remember that two or more events had been generated in the same block, and consequently should not be sorted together. The use of two sessions could have had similar effects. To address these concerns, in the present Experiment 1, presentation was random and all events were generated in the same session.

Using similarity ratings also allows for the calculation of a baseline measure of similarity using unrelated events. Odegard et al. (2004) computed chance sorting performance using simulations of 5000 participants by randomly placing event descriptions into groups, and used this as a baseline. However, as they acknowledge, participants performed above chance even when the sorted events were not their own, a finding I investigate further using LSA. They attributed this effect to organizational properties among events at the “surface level”. This begs the question of what is an appropriate baseline. To address this issue, for each participant, I computed the average similarity between event pairs from different supraclusters. This is appropriate because, in theory, these events are unrelated in terms of autobiographical memory structure and in terms of original retrieval context because these pairs of events are generated in strings with different source cue words. This baseline provides the opportunity to verify that the autobiographical advantage is not simply an artifact of a bias for participants to rate their own events as more similar than do other participants by demonstrating that event owners and non-owners perform comparably on baseline items , but differently on events within a string.

There are three possible outcomes for Experiment 1. First, if the ownership advantage reported by Odegard et al. (2004) is simply the result of a bias for event owners to rate all of their memories as more similar than non-owners, then every distance condition will elicit an ownership advantage; both events within a string (no matter the distance between events) as well as unrelated (baseline) events will be rated more similar by owners. Second, if Odegard et al. are correct in their hypothesis that the ownership advantage is simply due to participants' memory for the original event generation session then, due to the random presentation of event generation cues, only adjacent pairs of events within a string (D1s) will be rated as more similar by event owners than by non-owners. However, if the ownership advantage is observed for event pairs beyond adjacent events within a string (i.e., D2s and/or D3s), this indicates that the ownership advantage is due to owners' use of autobiographical knowledge relating each pair of events beyond what can be gleaned from the event descriptions, information to which non-owners are not privy.

Method

Participants

Thirty-eight University of Western Ontario undergraduates participated for course credit. Half of the participants generated and rated their own events, whereas the other half rated another participant's events only.

Procedure

Participants performed all experimental sessions individually. Instructions were given verbally and appeared on a computer screen, as did all experimental trials. Responses were typed on a keyboard. The experiment was implemented using E-prime (Psychology Software Tools, Inc.) on an AMD Athlon 64 Processor 3200+ computer.

There were two sessions. In the first, event chains were generated and, in the second, participants rated similarity. Participants generated six event strings, each originating from one of three cue words (car, shoe, and birthday) that were used by both Wright and Nunn (2000) and Odegard et al. (2004). On each event generation trial, an

“*” (fixation point) appeared on the computer screen for 1000 ms, followed by a cue word. Participants were instructed to type a description of the first event memory that came to mind after reading that cue word. They pressed the spacebar when their event memory came to mind, and typed their description in a box that appeared in place of the word. The text box held a maximum of 168 characters. The fixation point for the subsequent trial immediately followed.

An event memory was described to participants as an event from the participant’s own life, lasting no longer than a few hours, that happened on a specific day at a specific time. Participants were told that an acceptable event description should include enough detail that if another person read it they would be able to understand the context of the event. This definition was similar to that of Odegard et al. (2004). This resulted in three source event descriptions (one in response to each cue word), that were used to elicit six strings of four events (five including the source event) by generating two strings from each source event. Figure 1 depicts the nine event descriptions (i.e., a supracluster) derived from a single cue word.

Event descriptions were presented to participants as cues in random order until all 27 descriptions had been generated. The only exception to the random presentation was that an event description was never presented as a cue on the trial after it had been generated, and, as is relevant only for the source events, the same event was never presented as a cue in adjacent trials. All event descriptions were generated in a single session.

In the second session, which occurred three weeks later, participants rated similarity for every possible pairing of generated events (351 trials). On each trial, an event pair was presented on the computer screen. Participants were asked to read both descriptions carefully and rate their similarity on a 9-point scale, where 9 means the two events are “very similar” and 1 means they are “very dissimilar”. Ratings were provided by pressing the appropriate number on the keyboard. Participants were told that, to be considered similar, the events needed to “relate to one another in some fashion” (as in Odegard et al., 2004; p. 688). The 9-point scale remained on the computer screen for all trials. Participants who generated event descriptions in the first session performed similarity ratings on their own events only, whereas another set of 19 participants that were naïve to the initial session also rated those event descriptions.

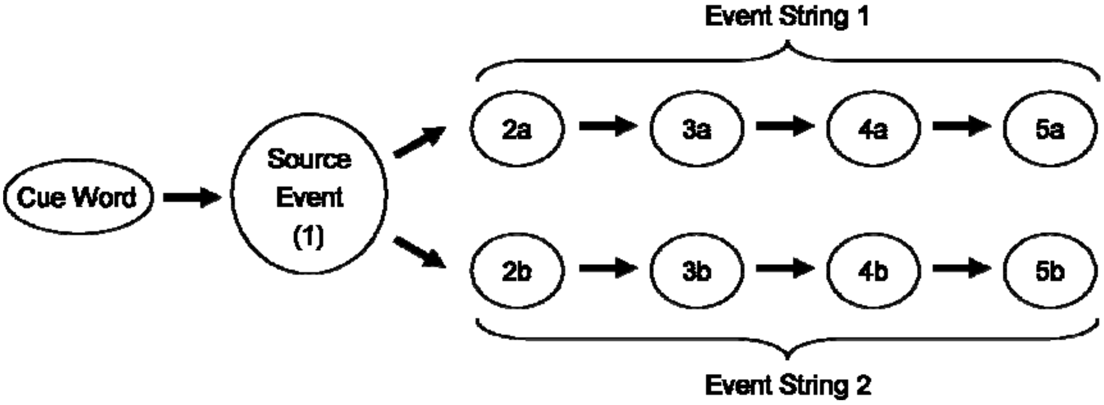

Figure 1. Depiction of the nine events that originated from a given cue word in the event generation task of Experiments 1 & 2. A source event is generated from a cue word and two strings of four events are elicited from that source event. The composite of nine events is termed a supracluster (Odegard et al., 2004).

Similarity Analyses

Overall Similarity Analysis

The dependent variable was the rated similarity between an event pair. The independent variables were ownership (event owners vs. non-owners) and distance, which was the distance between two events within a string of events, and included four levels: D1, D2, D3 and the baseline measure, between strings. D1 event pairs were adjacent in a generated string (i.e., one event cued the other), D2s had one intervening event, and D3s had two intervening event descriptions. The between strings mean rating was computed as the average similarity between each event pair that did not share the same source event.

A two by four repeated measures analysis of variance was performed on the similarity data, with ownership and distance as within-participants variables. The mean similarity ratings for each condition appear in Figure 2. Event pairs that included source events were excluded (as per Odegard et al., 2004); however the pattern of results was the same when the source events were included. Note also that I did not distinguish between the two separate strings that were generated from each source event (i.e., within a supracluster) because of the random presentation of the events in the event generation task in session one. In Odegard et al. each string was produced in a different session, which allowed them to include 'Time' as a variable. In the present case, only some events from one string preceded events in the other string and vice versa because of random presentation; thus, there was no meaningful way to distinguish the strings except that one string's initial event (2a in Figure 1) was cued by the source event on a previous trial to the other string's initial event (2b in Figure 1).

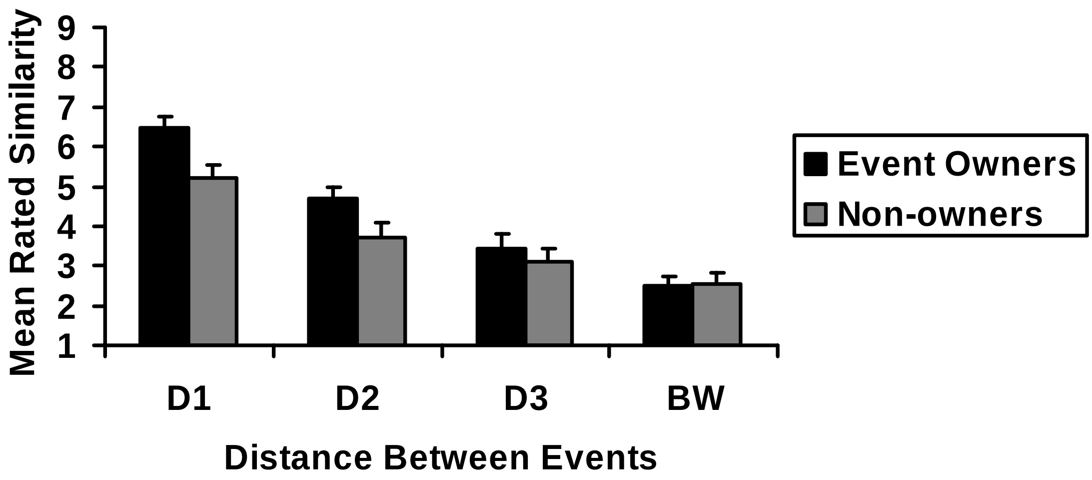

Figure 2. Mean rated similarity of event pairs in Experiment 1. D1 refers to adjacent events, D2 to events two apart, D3 to events three apart, and BW (Between strings) to event pairs originating from different source events (and hence different cue words). Error bars depict standard errors.

Consistent with Odegard et al. (2004), there was a main effect of distance, $F(2, 48) = 92.18$, $p < .001$. To assess this main effect, all possible pairwise comparisons between distance levels were evaluated (6 in total) and, as such, a Bonferroni adjustment of observed significance values was conducted to adjust the family-wise alpha to .05. Adjacent events (D1s; $M = 5.85$) were more similar than events two apart (D2s: $M = 4.20$), $t(18) = 9.31$, $p < .001$, three apart (D3s: $M = 3.28$), $t(18) = 11.52$, $p < .001$, and between strings ($M = 2.52$), $t(18) = 14.52$, $p < .001$. Events that were two apart were more similar than events three apart, $t(18) = 5.37$, $p < .001$, and between strings, $t(18) = 7.47$, $p < .001$, and events three apart were more similar than those between strings, $t(18) = 3.28$, $p < .05$. There was also a marginally significant main effect of ownership, $F(1, 18) = 4.08$, $p < .06$, such that event owners ($M = 4.27$) rated events as more similar than did non-owners ($M = 3.65$).

Critically, in contrast to Odegard et al. (2004), ownership and distance interacted, $F(1, 32) = 7.82$, $p = .002$. To investigate the interaction, planned comparisons were computed between the two levels of ownership at each level of distance. Event owners rated events as more similar than did non-owners for adjacent events (D1s), $t(18) = 3.33$, $p < .01$, and events two apart (D2s), $t(18) = 2.79$, $p = .01$. This was not the case for events three apart in the strings (D3s), $t(18) = 0.81$, $p > .4$, or between strings, $t(18) = -0.26$, $p > .7$.

Three aspects of these results are particularly informative. First, an ownership effect was found despite limited cues to retrieval context. These results counter Wright and Nunn’s (2000) hypothesis that a string of cueing and cued autobiographical events are part of a single organizational unit or cluster in autobiographical memory because rated D3 similarity was comparable for event owners and non-owners. Thus, there is nothing idiosyncratic for event owners that relates these event pairs, at least no more so than for between string pairs. The results are also problematic for Odegard et al.'s (2004) contention that the ownership advantage is caused by event-owners' privileged access to the event generation context. By using random presentation of items within a single session, the only contextual cue available to participants concerns what event pairs co-occurred on a trial; that is, they might remember that some events cued each other. That said, if the ownership advantage is caused *only* by experimental contextual information, then the ownership advantage should be limited to adjacent events, but it persisted for D2s. This leaves Odegard et al.'s alternate hypothesis remaining, that an event string consists of a chain of related (clustered) pairs. That events two apart elicited an autobiographical advantage suggests that event owners use information over and above what other participants are able to see, leading event owners to rate these events as more similar.

The second aspect of these results that warrants note is that non-owners' ratings are above baseline for events within a string, in line with previous findings (Odegard et al., 2004). This raises the question of what information non-owners are using when they rate event-pair similarity, a finding I address in the LSA analysis below. The third relevant aspect is that baseline performance for event owners is the same as for non-owners. This demonstrates that the ownership advantage is not simply due to a bias produced by event owners rating their own events as more similar, a conclusion that could not be drawn from previous studies because the ownership advantage had been observed with similar magnitude in every condition[1].

Order Effects of Similarity Within an Event String

It could be argued that computing averages across relative positions in a string (e.g., all D1s or D2s) obscures important information regarding absolute position. That is, there might be an order effect such that events are more similar at the beginning than at the end of a string, regardless of their relative distance. Therefore, I analyzed pairwise similarity ratings at ordinal positions within each level of distance. For example, for all D2s, I compared rated similarity for the first and third, second and fourth, and third and fifth event pairs (see Table 1). For each level of distance, an analysis of variance was conducted with order and ownership as within participants variables. All analyses within this section include source events for completeness, despite their omission in the previous analyses (as per Odegard et al., 2004). Note, however, that the overall pattern of results is the same with these pairs removed. I present the data for each distance pair separately.

D1. A repeated measures analysis of variance was conducted with pair (1/2, 2/3, 3/4, 4/5) and ownership (event owners, non-owners) as independent variables. There was no main effect of pair, $F(2, 44) = 1.05$, $p > .3$, and no interaction, F<1. Event owners ($M = 6.37$) rated D1 pairs as more similar than did non-owners ($M = 5.23$), $F(1, 18) = 9.80$, $p < .006$.

D2. With pair (1/3, 2/4, 3/5) and ownership as independent variables, there was no main effect of pair, $F<1$, and no interaction, $F<1$. Event owners ($M = 4.54$) rated D2 pairs

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[1] A simulation of Odegard et al.'s (2004) sorting procedure was conducted by performing a multidimensional scaling and cluster analysis of the similarity data. This simulation elicited a replication of Odegard et al.'s sorting results whereby an ownership advantage was observed for D1s, D2s, and D3s. See Appendix A for a detailed description of the methodology and results of the simulation.

Table 1

Mean Rated Similarity of Event Pairs Within Event Strings at Each Level of Distance Between Events in Experiment 1

Distance and Ownership	Pair 1	Pair 2	Pair 3	Pair 4
D1	(1/2)	(2/3)	(3/4)	(4/5)
Owner	6.2	6.4	6.5	6.4
Non-owner	4.9	5.4	4.7	5.2
D2	(1/3)	(2/4)	(3/5)	
Owner	4.1	4.9	4.3	
Non-owner	3.6	3.8	3.3	
D3	(1/4)	(2/5)		
Owner	3.4	3.4		
Non-owner	3.0	3.2		

as more similar than did non-owners (*M* = 3.72), *F*(1, 18) = 6.73, *p* < .02.

D3. With pair (1/4, 2/5) and ownership as independent variables, there was no main effect of pair, *F*<1, or ownership, *F*(1, 18) = 1.47, *p* < .3, and no interaction, *F*<1.

Taken together, these data indicate that the effects of relative distance hold regardless of an event's ordinal position in a string. That is, the main effects of distance for these analyses replicate the results of the overarching similarity analysis such that an ownership advantage is only elicited for D1s and D2s. More importantly, there are no effects of event order that confound these ownership effects. This is important because if, for example, rated similarity was greater at earlier positions, it might indicate that participants were assessing similarity of events based on their distance from the source event, which, in turn, might indicate use of their event generation context. This was clearly not the case.

To conclude, the ownership advantage observed for the similarity ratings, whereby event owners rate events as more similar than do non-owners, suggests that in cueing one autobiographical memory with another, event owners use important information over and above the surface similarity of the words constituting the event descriptions. Furthermore, non-owners, perhaps surprisingly, rate events within a string as more similar than expected by chance. An important question, then, is what information participants are using to compare events. I investigate this issue next.

Similarity Analyses Using LSA

Latent Semantic Analysis is a mathematical technique for capturing the similarity of words and/or passages, based on analyses of large bodies of electronic text. The algorithm captures similarity by first creating a matrix of the co-occurrence of words and passages (e.g., sentences, paragraphs, or essays, depending on the specifications of the researcher) in a corpus of text. Each row represents a word, each column represents a passage, and each cell represents the frequency of a word in a given passage. Singular value decomposition is applied to this matrix (after some preprocessing) so that each word and passage can be described as a vector in a high-dimensional space, where each latent semantic factor is a dimension. The similarity of a given word or passage to another word or passage is then computed as the cosine between two vectors.

I created a passage vector for each event description. To compute a passage vector, LSA takes the vectors for all the words in the passage and computes their sum. All resulting event description vectors were then compared using the cosine metric. These LSA similarities provide a measure of the semantic and textual similarity of event pairs. Therefore, if two words occur in similar contexts (i.e., in passages with similar overall meaning), they elicit a higher degree of similarity (a higher cosine) than two words that occur in passages with completely different meaning. Conversely, if two passages contain words with similar meaning, then they will have a higher degree of similarity than two passages that contain words with different meaning. Note that the passages need not have the same words, necessarily, to be considered similar because each passage vector is made up of word vectors, and similar words have similar vectors. However, the greater the number of words with similar meaning between passages, the greater is passage similarity. Therefore, LSA's cosine similarity can be thought of as a baseline similarity rating that might be provided if participants were to rely solely on textual and semantic content. LSA similarity might provide interesting insights with regard to the ownership advantage. The ownership effect presumably reflects autobiographical information available only to event owners. That is, when rating similarity, event owners may have brought to bear additional background personal knowledge that is not explicitly contained in the event description and therefore that another person or LSA would not possess.

There is a curious finding in Odegard et al. (2004) and replicated in the present experiment: non-owners considered events within a string to be more related than they should be according to chance. More specifically, Odegard et al.’s participants successfully sorted events together, even in cases in which event pairs were rather distant in a string (e.g., D3s) and participants’ ratings of similarity for events within a string were above baseline in the present study. Therefore, another motivation for the use of LSA is to empirically determine the contribution of semantic and textual factors in the perception of event descriptions by non-owners. An additional reason is that presumably this textual information was available to, and used by, event owners as well. This is interesting because all of the generated event descriptions have some autobiographical basis; they were provided by participants because they were autobiographical memories. It is informative, therefore, to determine whether participants rate some pairs of personally experienced autobiographical events using non-autobiographical information only.

I hypothesized that LSA similarity might pattern like that of non-owners, whereas owners’ ratings would pattern differently due to autobiographical knowledge that is not contained in the actual descriptions that those descriptions may have activated or cued. That is, the purpose of these analyses is to use an objective measure of the similarity of semantic content in pairs of event descriptions to provide insight into the contribution of non-autobiographical semantic factors in participants’ similarity ratings.

Method

Procedure. The text-based similarity among each participant's 27 event descriptions was computed using the Matrix Comparison interface on the LSA website (http://lsa.colorado.edu; Latham, 1998), which allows the user to compute the similarity of multiple texts. For all computations, the General-Reading-up-to-1st-year-college corpus was used with a document-to-document comparison type and 300 dimensions (the default setting). The analysis produced a matrix of cosines (similarities) for each participant's event descriptions. These similarities were then compared to the human-generated similarity ratings from Experiment 1.

Results and Discussion

To equate the scales generated by LSA and by humans, all three datasets were mathematically transformed in a similar fashion to *z*-scores, except that the between strings condition was used as a reference in computing means and standard deviations. It is plausible that the human similarity ratings and LSA ratings would use similar sources of information in this condition, but might use different sources of information for other conditions where participants (even non-owners) might use information over and above textual semantic similarity. Note that the pattern of results for this analysis was the same when standardizing the data using the mean and standard deviations of humans and LSA across all distance levels, however, the between strings scaling method was necessary for Experiment 2, and therefore was used to maintain consistency.

The LSA data were scaled using the between strings mean for each dataset as an item in computing the mean and standard deviation. For the human data, mean between strings similarity within each dataset and each ownership level was an item in computing the mean and standard deviation. Event owners and non-owners were scaled together because they used the same scale, and doing so maintained the relative differences among the conditions observed in the absolute similarity ratings described above. The scaled similarity scores appear in Figure 3.

A repeated measures analysis of variance was performed with ownership (event owners, non-owners, LSA) and distance (D1, D2, D3, between strings) as within participants factors. A main effect of distance was found, $F(2, 41) = 95.89$, $p < .001$, such that adjacent events (D1s; $M = 2.73$) were more similar than events two apart (D2s; $M = 1.35$), three apart (D3s; $M = 0.56$), and between strings ($M = 0.00$), all ts(18) > 10.08, all ps < .001. Events two apart were more similar than those three apart or between strings, all ts(18) > 6.92, all ps < .001, and events three apart were more similar than between strings, $t(18) = 3.10$, $p < .05$. Thus, event pairs that are closer together in a string were always rated as more similar than those farther apart. All six post hoc contrasts underwent a Bonferroni adjustment of the significance values to make the family-wise error rate .05, for six total comparisons. There was a marginally significant main effect of ownership, $F(1, 34) = 3.14$, $p < .09$, however, none of the post hoc contrasts reached significance.

As in the similarity data, ownership interacted with distance, $F(2, 47) = 6.69$, $p < .003$. Planned comparisons were conducted between owners, non-owners, and LSA at each level of distance. Each set of these three contrasts at each distance level was considered a family; all significance values were adjusted using a Bonferroni procedure

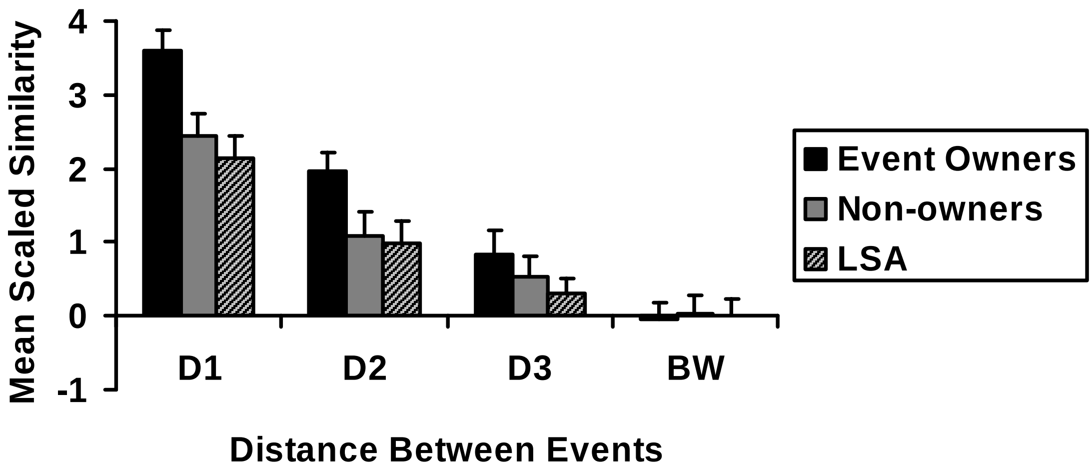

Figure 3. Scaled similarity scores for Experiment 1 including LSA similarity.

as such.[2] Event owners rated adjacent (D1) events as significantly more similar than did non-owners, $t(18) = 3.33$, $p = .01$, and LSA, $t(18) = 3.98$, $p < .01$; but LSA similarity and Non-Owners' ratings did not differ, $t(18) = 0.87$, $p > .9$. Event owners rated D2 events as more similar than did non-owners, $t(18) = 2.80$, $p < .05$, and LSA, $t(18) = 2.83$, $p < .05$, and LSA similarity and non-owners' ratings again did not differ, $t(18) = 0.27$, $p > .9$. For events three apart, and between string events, there were no significant differences between any pair of ownership conditions, all ts(18)<±1.35.

These results demonstrate that when a participant rates the similarity of event pairs that are not their own, they rely heavily on semantic and textual similarity. The overall pattern of LSA similarity is comparable to non-owners. For all four distance conditions, the difference in similarity between non-owners and LSA was non-significant. This provides an explanation for the greater than chance event sorting by non-owners in Odegard et al. (2004) and both of the present experiments. Depending on the properties from one event that are used to cue another, similar event properties might, at least some of the time, extend to events three apart, resulting in elevated ratings of similarity relative to the baseline between strings condition.

LSA similarity also is interesting theoretically when compared to event owners. For events three apart (D3s) and from different strings, owners' ratings did not differ significantly from LSA and non-owners. That is, when two events do not elicit an autobiographical advantage (as with D3 and between strings events), both owners and non-owners rely heavily on semantic and textual similarity between descriptions. Thus,

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[2] This adjustment did not, however, affect the pattern of results; all contrasts that were or were not significant before the adjustment, remained so after the adjustment. This is relevant in this case because the analogous contrasts between owners and non-owners in the previous similarity analyses did not undergo an adjustment, and the only difference between these and the previous contrasts (other than scaling by a constant) is the addition of the LSA condition.

even though event owners have an autobiographical memory for each of two event descriptions, if those events are not related over and above shared semantic content, they did not rate them as more similar than did a non-owner or a text-based corpus measure. The next section provides analyses of this shared semantic content.

Sources of Similarity: Shared Event Characteristics

To examine potential sources of similarity, a qualitative analysis was performed using the event components discussed by Dijkstra and Misirlisoy (2006): activity, location, participant and temporal information, and because of the large number of objects reported, object information.

D1. To assess characteristics between adjacent events (D1s), I scored the frequency with which a property described in event *n* was also mentioned in event *n+1*, omitting pairs containing source events. These ratings were also performed by an independent scorer. All scores were agreed upon after short discussion of discrepancies. For the 18 D1's per participant, shared activity was mentioned 45% of the time (*SE* = 4%), a shared participant 30% of the time (*SE* = 4%; the event owner was never considered a shared participant), a shared object 19% of the time (*SE* = 3%), and a shared location 14% of the time (*SE* = 4%). A shared time period was mentioned even less frequently (*M* = 9%, *SE* = 2%). These proportions are comparable to those found for pairs of sequentially remembered events in Lancaster and Barsalou (1997), considering only their incidental recall items (averaged across low & high similarity items; see Figure 4). The results corresponded despite the fact that they used artificial event descriptions followed by a recall task.

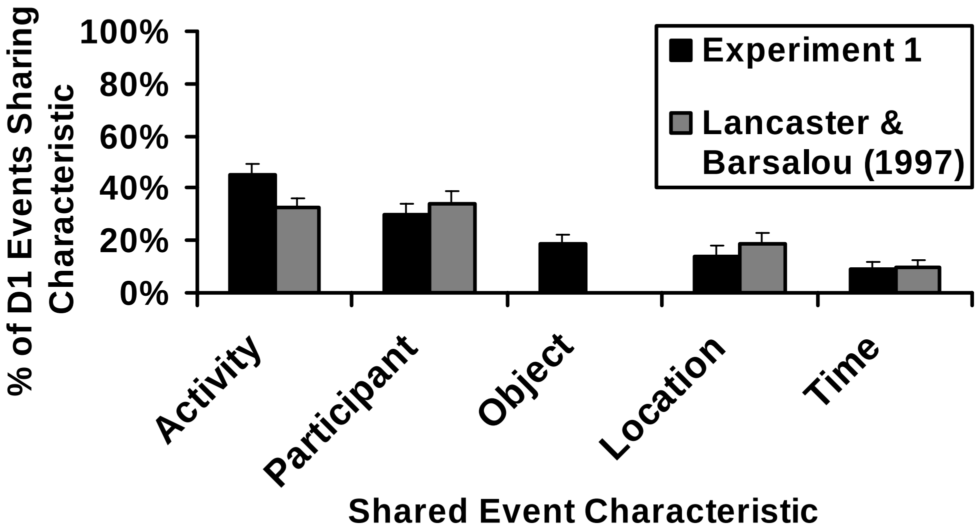

Figure 4. Percentage of adjacent items within a string (D1s) that share a given type of event characteristic in the present Experiment 1, and in Lancaster & Barsalou (1997). Error bars represent standard errors.

D2. For all D2s (12 per participant), shared activity was mentioned 32% of the time (SE = 4%), shared participant 25% of the time (SE = 4%), shared object 13% of the time (SE = 3%) and shared location 11% of the time (SE = 2%). As with D1s, and shared time period (*M* = 3%, *SE* = 1%) occurred least often. Thus, proportion of shared event characteristics appears to have decreased relatively proportionally for D2s relative to D1s.

D3. For all D3s (6 per participant), shared activity was mentioned 11% of the time (SE = 4%), shared participant 13% of the time (SE = 4%), shared object 4% of the time (SE = 2%) and shared location 6% of the time (SE = 2%). Again, shared time period (*M* = 1%, *SE* = 1%) occurred least often. Again, proportions of event characteristics are reduced proportionally relative to D1 and D2 except that the proportion of shared events sharing activities appears to have dropped more sharply to be in line with proportions for shared participants. These data indicate that, from trial to trial, different aspects of events are salient for cueing a related memory, with activity and participants being particularly important. However, time period information does not seem to be playing a prominent role.

Two main conclusions emerge from these analyses. First, the rated similarity between two events is based, at least in part, on semantic and textual aspects of the descriptions of these events. The proportions of shared event characteristics appear to elicit a graded structure that falls in line with the similarity results above. Events become less similar and share fewer event characteristics as they get farther apart in a string. Second, the higher similarity ratings produced by event owners, relative to LSA or non-owners, can be more confidently attributed to additional relations among autobiographical memories that are not captured by the similarity ratings. In Experiment 2, I investigated whether the ownership advantage is due, at least in part, to causal relations between pairs of events.

Experiment 2: Similarity, Causality and General Events

In Experiment 1, I demonstrated that shared semantic information between two events, such as shared participants, activities, locations, or objects, connects memories in such a way that one event can cue the memory of a similar event. However, the shared semantic content does not entirely explain how pairs of cueing and cued events are related because event owners indicated, through elevated ratings of similarity relative to non-owners and LSA, that there are additional factors that lead one event to cue another. This means that the representations for these two episodes must have some additional organizational relation that makes the thought of one event lead to the other.

In a recent paper, Conway (2009) asserts that individual episodic memories have nine essential properties (see Table 2). For example, episodic memories are highly specific autobiographical recollections (properties 8 and 9), remembered either from the perspective of the rememberer (field) or as a third party observing the rememberer (observer; property 3), and that are rapidly forgotten (property 7). While the properties that Conway discusses pertain to singular episodes, they provide a framework for describing how relations between and among episodic memories might be formed, an important facet of autobiographical memory.

Although similarity and causality are never mentioned as part of Conway's (2009) comprehensive account, some of the types of knowledge and properties of episodic memories that he describes provide a basis with which to connect pairs or sets of episodic

Table 2

Conway's (2009) Nine Properties of Episodic Memories

1. Contain summary records of sensory-perceptual-conceptual-affective processing.
2. Retain patterns of activation/inhibition over long periods.
3. Often represented in the form of (visual) images.
4. They always have a perspective (field or observer).
5. Represent short time slices of experience.
6. They are represented on a temporal dimension.
7. They are subject to rapid forgetting.
8. They make autobiographical remembering specific.
9. They are recollectively experienced when accessed.

memories using these relations. For example, the first through third properties state that episodic memories are summary records of sensory-perceptual-conceptual-affective processing (often highly visual) that are represented as patterns of activation/inhibition. These three characteristics are also true of semantic memories (Barsalou, 1999) and similarity has been shown to play a significant role in semantic memory organization, representation and processing (O'Connor, Cree, & McRae, 2009; Smith, Shoben, & Rips, 1974). This provides support for the findings in Experiment 1 that indicate similarity as a prominent organizational construct in connecting episodic memories in the autobiographical knowledge base.

Properties five and six state that an episodic memory captures a short time slice that is represented on a temporal dimension (typically in forward order), an aspect of episodic memory that is distinct from semantic memory. However, these temporal connections have been shown to decay rapidly, and it is not well understood how or why a subset of these connections remain intact as the connections become remote. One way that meaningful temporal connections between events are captured is through narratives and, by extension, causal relations.

Autobiographical memory has often been studied experimentally using narrative style experiments where participants are asked to recall a set of related episodes in a prescribed order (Anderson & Conway, 1993). Typically events recalled in forward order, or in order of importance, are recalled faster than in backward order. This has been used to support the notion that memories are generally represented in the same order as they were experienced. More recently, Radvansky and colleagues (Copeland, Radvansky & Goodwin, 2009; Radvansky, Copeland & Zwaan, 2005) have used the narrative paradigm to demonstrate the considerable commonality between autobiographical memory and one's memory for fictional narratives. While the idea that autobiographical memory is structured according to a narrative or life script is not new (Bruner, 1991; Burt et al., 1998; Fivush, 1991; Schank & Abelson, 1995), there are few experimental demonstrations of this relationship (although research by Nelson & Fivush suggests a connection between a child's development of narrative skills and the emergence of autobiographical memory; Fivush & Nelson, 2004; Nelson, 2003; Nelson & Fivush, 2004).

More importantly in the present context, Radvansky et al. (2005) show that causal connectivity plays a role in the formation of people's memories for both narrative structure and autobiographical memory, and that events with greater causal connectivity are recalled faster than those with fewer causal connections. However, Radvansky and colleagues (Radvansky et al., Copeland et al., 2009) were primarily interested in higher level (arguably, general event) structures that form the basis of narratives and structure autobiographical memory, as opposed to the individual connections among episodic memories in isolation per se. By design, studies that use a narrative paradigm necessitate that participants' retrieval strategy be constrained in some way, making it extremely difficult to determine whether the elicited relations exist in the structure of the autobiographical knowledge base or merely reflect a retrieval bias as a result of the task instructions. In contrast, traditional studies that used cue words (Galton, 1883; Crovitz & Schiffman, 1974) elicit memories for episodes without imposing retrieval constraints, but these tasks only allow for the generation of isolated singular events and do not provide insights into the connectivity or organization of events.

In Experiment 2, I investigated how causal connectivity within a string of cueing and cued events influence similarity. More specifically, I was interested in whether event owners were privy to causal connections between events that non-owners were not, and whether these causal connections account for the ownership advantage. In addition to rating similarity, both owners and non-owners answered a series of questions (derived from Brown & Schopflocher, 1998b) to determine whether event pairs are causally related or related by a general event. I investigated similarity ratings for causally connected and non-causally connected event pairs for event owners, non-owners, and LSA. There were three primary findings. First, event owners generated extended strings of causally connected events and rated these causal connections in a consistent manner. Second, despite random presentation of cues, similarity varied with causality to the extent that the ownership advantage was accounted for, at least in part. Third, participants' judgements of whether event pairs were part of the same general event provided insight into the similarity and causality results. These three findings provide insights into the formation of event representations, suggesting that causal connectivity and similarity are two prominent determinants of autobiographical memory structure.

Method

Participants

Thirty-seven University of Western Ontario undergraduates participated either for $25 as event owners (2 sessions), $10 as non-owners (1 session) or for course credit. Nineteen generated and rated their own events, whereas the other 18 rated another participant's events only. One participant (an event owner) was dropped because their mean between strings similarity ratings were greater than three standard deviations above the mean for that condition, indicating that their similarity ratings were extremely positively biased.

Procedure

Participants performed all experimental sessions individually during two sessions that were approximately three weeks apart. During the first session, they generated event descriptions as in Experiment 1, and in the second session, they rated event pairs for similarity as in Experiment 1, as well as answered three questions pertaining to the causal and event-based relations. The procedure for the first session was identical to that of Experiment 1, except that four cue words were used (*car*, *shoe*, and *birthday* as in Experiment 1, and *restaurant*). These words cued four source events that each led to two strings of four subsequent events (nine events per cue word) for a total of 36 event descriptions and four supraclusters containing nine events (see Figure 1).

In the second session, participants first rated event pair similarity, and then answered three questions regarding causal and general-event relations. The procedure for the similarity ratings was identical to Experiment 1, except that fewer between strings trials were conducted[3]. All event pairs within strings including source events were included (80 = 10 x 8 strings), as were all pairs between strings within a supracluster (64 = 16 x 4 supraclusters). Only a pseudorandom 18 out of a possible 486 (~4%) event pairs in the between strings condition were included, such that all 36 events were presented once. This was deemed to be a sufficient number of items, given that 24, 16 and 8 items were included in the D1, D2, and D3 conditions of the overall analysis, respectively. This resulted in 162 event pairs to each be presented on individual trials.

[3] Every pair of event descriptions was rated for similarity in Experiment 1 for the MDS in the sorting simulation (see Appendix A), which was not conducted in Experiment 2.

For the second half of session two, participants judged relations between event pairs. The same 162 event pairs were used, presented in a new random order. For each trial, two event descriptions appeared on the computer screen. Participants answered three questions. The first was: “Did one of the events cause the other?” If the top event caused the bottom event, participants were instructed to press the down arrow, if the bottom event caused the top event, to press the up arrow, and if neither event caused the other, to press the ‘n’ key. The second and third questions were: “Is one of the events part of the other?” and “Are both events part of a single broader event?” Participants responded yes or no using the ‘y’ or ‘n’ keys.

Participants who generated event descriptions in the first session rated similarity and answered the three questions for their own events only, and another set of participants who were naïve to the initial session did the same for another participant’s memories. LSA similarity between event pairs was computed using the same procedure as in Experiment 1.

Results and Discussion

The first analysis ignores the causal ratings to determine whether the pattern of similarity ratings observed in Experiment 1 was replicated. The second investigates the frequency with which event pairs across distances within strings and between strings were considered causally related by owners and non-owners. Third, I considered the consistency of participants’ causal ratings by testing whether non-adjacent pairs of causally related events were connected by a series of causally related adjacent events, and whether ratings by owners and non-owners differed in this regard. Last and most importantly is whether the patterns of similarity ratings differ when event pairs are causally related, and how this might provide insight into the ownership advantage, and more generally the organization of episodes in autobiographical memory.

Replication of Experiment 1 (Ignoring Causal Ratings)

Analyses of absolute similarity ratings without LSA will not be presented here as they were in Experiment 1, although they are presented in Appendix B. The primary reason for omitting these analyses is that the results are the same as in Experiment 1, and the pattern of results is represented in the analyses of scaled similarity ratings using LSA.

Similarity and LSA. The dependent variable was scaled similarity, transformed as in Experiment 1. A mixed model analysis of variance was required for all causal analyses in the following section. Therefore, to maintain consistency, a three (ownership: owner, non-owner, LSA) by four (Distance: D1, D2, D3, between strings) analysis of variance using GLM, and a three by four Mixed Model analysis of variance are reported, with the GLM results always appearing first. In both cases, ownership and distance were treated as within-participants variables. For all Mixed Model ANOVAs, analysis was performed using the Linear Mixed Function in SPSS. Covariance structure was based on sequential comparisons of model fit (such as -2log likelihood and AIC) starting with an unstructured covariance structure, and simplifying the model sequentially using Toeplitz, compound symmetry, or scaled identity covariance structures respectively, until the simplest model that could adequately describe the data was found. The present analysis used a Toeplitz covariance structure.

The scaled similarity scores are presented in Figure 5. There was a main effect of distance, $F(1, 25) = 71.47$, $p < .001$; $F(3, 3) = 56.65$, $p = .003$. To assess it, all six

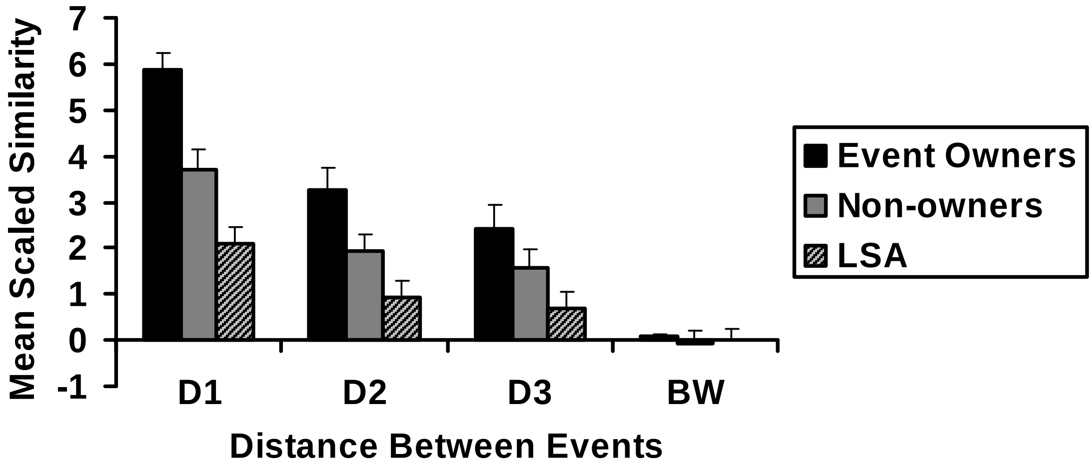

Figure 5. Scaled similarity scores, including LSA, for Experiment 2, ignoring causal ratings.

pairwise comparisons were evaluated, with Bonferroni correction. Adjacent events (M = 3.90) were rated as more similar than events two apart (*M* = 2.04), $t(17) = 12.97$, $p < .001$; $t(24) = 9.19$, $p < .001$, three apart (*M* = 1.56), $t(17) = 12.32$, $p < .001$; $t(34) = 7.09$, $p < .001$, and between strings (*M* = 0.00), $t(17) = 11.08$, $p < .001$; $t(49) = 9.41$, $p < .001$. Events two apart were significantly more similar than those three apart according to the GLM ANOVA, $t(17) = 4.36$, p < .01, but not according to the mixed model ANOVA, $t(24) = 2.37$, $p < .16$, and significantly more similar than between strings events according to both analyses, $t(17) = 5.68$, $p < .001$; $t(34) = 6.16$, $p < .001$. Events three apart were more similar than those between strings, $t(17) = 4.64$, $p = .001$; $t(24) = 7.67$, $p < .001$. There was also a significant main effect of ownership, $F(1, 28) = 14.89$, $p < .001$; $F(2, 36) = 10.67$, $p = .007$. A Bonerroni adjustment was conducted to adjust the family-wise Type I error rate to .05 for the three contrasts. Event owners' ratings (*M* = 2.91) were more similar than non-owners' (*M* = 1.79), $t(17) = 2.62$, $p = .05$; $t(35) = 3.50$, $p < .01$, and LSA, $t(38) = 5.51$, $p < .001$; $t(38) = 5.97$, $p < .001$. Non-owners rated events as more similar than did LSA, $t(17) = 2.93$, $p < .05$; $t(35) = 2.69$, $p < .05$.

Consistent with Experiment 1, ownership interacted with distance, $F(3, 58) = 21.64$, $p < .001$; $F(6, 5) = 10.67$, $p < .008$. Planned comparisons were conducted between owners, non-owners, and LSA at each level of distance. Each set of three contrasts comparing event owners, non-owners, and LSA at a distance level was considered a family; all significance values were adjusted using a Bonferroni procedure as such[4]. For adjacent events (D1s), owners' ratings were higher than non-owners', $t(17) = 4.66$, $p < .001$; $t(92) = 5.54$, $p < .001$, or LSA, $t(17) = 10.69$, $p < .001$; $t(92) = 9.25$, $p < .001$, and

[4] As in Experiment 1, the Bonferroni adjustment had no effect on the pattern of results. See footnote 2 above for further discussion.

non-owners' were higher than LSA, $t(17) = 4.66$, $p < .001$; $t(92) = 4.09$, $p < .001$. Events two apart were considered more similar by owners than by non-owners, $t(17) = 2.67$, $p < .05$; $t(92) = 3.37$, $p < .01$, or LSA, $t(17) = 5.08$, $p < .001$; $t(92) = 5.66$, $p < .001$, and more similar by non-owners than by LSA, $t(17) = 3.00$, $p < .05$; $t(92) = 2.53$, $p < .05$. For events three apart, there was no ownership advantage, $t(17) = 1.38$, $p > .5$; $t(92) = 2.12$, $p > .1$, but event owners' ratings were higher than those from LSA, $t(17) = 3.35$, $p < .02$; $t(92) = 4.24$, $p < .001$. Non-owners' rating did not differ significantly from LSA in the GLM ANOVA, $t(17) = 0.67$, $p > .1$, but were marginally more similar than LSA in the MM ANOVA, $t(92) = 2.29$, $p < .08$. For events between strings, similarity ratings did not significantly differ for any pairwise comparison, all *t*s < |1|; all *t*s < |1|.

The principal difference between Experiments 1 and 2 for the scaled similarity analysis with LSA is that, relative to the ratings provided by owners and non-owners, LSA similarity is lower across all distances within strings. The reason for this difference is that participants' ratings of similarity (on the 9-point scale, presented in Appendix B) for the between strings condition are lower in Experiment 2 than Experiment 1, but LSA similarity is not. Mean between strings similarity was 2.48 (*SE* = .23) for owners and 2.56 (*SE* = .28) for non-owners in Experiment 1, but 1.93 (*SE* = .17) and 1.82 (*SE* = .20) in Experiment 2, while the ratings in the same condition for LSA remained relatively constant – 0.37 (*SE* = .01) in Experiment 1 and 0.36 (*SE* = .01) in Experiment 2. Therefore, when similarity ratings were scaled in Experiment 1, the relative differences between the between strings condition and the D1, D2, and D3 conditions was larger for participants than it was for LSA in Experiment 2, because the between strings condition was used as a reference.

Thus, from Experiment 1 to Experiment 2, participants' perception of the similarity of between strings events became lower despite comparable (textual and semantic) LSA similarity. The number of between string trials was reduced from 486 in Experiment 1 to 18 in Experiment 2 and the number of within-strings trials was actually greater in Experiment 2. Therefore, the proportion of unrelated between strings trials was much higher in Experiment 1. Faced with all of these unrelated event pairs in Experiment 1, participants may have searched for any similarities between events. That is, any perceived relation between events may have lead participants to generate slightly inflated between-strings similarity ratings in Experiment 1. Conversely, in Experiment 2, the small number of between strings trials probably made them stand out in terms of their dissimilarity, engendering low ratings.

Given that the proportion of trials in each distance condition was more balanced in Experiment 2, the mean ratings in this condition are probably more veridical. In addition, the general pattern of similarity ratings was comparable between Experiments 1 and 2 for participants' ratings of similarity within a string (D1s, D2s, & D3s). In any event, in terms of interpreting similarity for this experiment, I am primarily interested in relative differences in similarity that occur as a result of causal relations, and how these differences may have resulted in the ownership advantage of Experiment 1 and 2.

Causal Analyses

There were three main goals of the following analyses. The first was to determine whether causal relations connect events in autobiographical memory (regardless of similarity), and whether these relations lead participants to produce one event memory given another, at least part of the time. The second was to determine the stability of causal relations across strings of related events, and whether these relations lead to complex causal structures. The third goal was to determine how these causal relations relate to similarity among autobiographical event memories, and to what degree they can account for the ownership advantage.

Design. For all subsequent analyses, group and distance were independent variables. Furthermore, each event pair was assigned to one of four conditions depending on event owners' and non-owners' evaluation of causality. If both considered a pair to be causally related, it was part of the Both Causal condition. If both indicated no causal relation, it was included in the Neither Causal condition. If owners indicated a causal relation but non-owners did not, the event pair was Owner Causal only, and conversely, it was Non-owner Causal only. The result is four sets of items each having the same design as the dataset in Experiment 1. Each data point was the mean similarity produced in each group (owners, non-owners and, in the LSA analysis, LSA) within each level of distance and causal condition, for each of the 18 datasets.

Frequency data. The frequency with which event pairs were assigned to various conditions is quite informative. Because, by design, the number of event pairs within each of the distance levels was different, I looked at the percent of event pairs, across all 36 participants, that were assigned to each causal condition within each distance level (see Table 3).

For events owners, 28% of D1s were considered causally related (Both Causal + Own Causal), as were 14% of D2s and 10% of D3s. That more than a quarter of adjacent events are causally related implies that causality is a relevant aspect of autobiographical memory structure because causal information was used quickly in retrieving event

Table 3

Mean Percent of Event Pairs at Each Level of Distance Between Events in a Pair

Ownership	D1	D2	D3	Between Strings
Both Causal	15	9	6	0.3
Owner Causal Only	13	5	3	0.6
Non-owner Causal Only	10	7	6	0.3
Neither Causal	62	78	84	98.8
Total Own Causal (Both+Owner Only)	28	14	10	0.9
Total Non-owner Causal (Both+Non-owner Only)	25	16	13	0.6

memories, and event cues were presented in random order. This proportion is comparable to that observed for shared event characteristics for adjacent events described in Experiment 1, where 45% of events involved the same activity, 30% the same participant, 19% had the same object, and 14% were at the same location. Interestingly, the proportion of causally-related event pairs for non-owners was relatively comparable: 25% of D1s, 16% of D2s, and 13% of D3s. Thus, the proportion of causally related events at each distance level was generally within about 3% between owners and non-owners.

The proportions across the distance levels are just as telling as the differences between causal conditions discussed above. Generally speaking, for both owners and non-owners, the proportion of causally related events was largest for events that were closer in a string, and this held for every condition in which owners and/or non-owners rated events as causally related. Events that came from different strings (between strings condition) were agreed upon not to be causally related (Neither Causal) almost 99% of the time. This should not come as a surprise because each pair of between-strings events was derived from different cue words and, in theory, completely unrelated sets of cueing and cued events. Apparently, by chance, about one percent of these items appeared to have some causal relation that led participants to consider them causally connected.

These findings taken together suggest that, to a large degree, non-owners are able to pick up on many of the causal relations based on the event descriptions. This is supported by the finding that, of the three conditions where items are rated as causally connected, the Both Causal condition had the largest proportion at each distance level within a string. That owners judge slightly more event pairs as causally related is not surprising. It is surprising, however, that event owners do not elicit a markedly higher proportion of causal events, especially because they should have more privileged access to causal information relating pairs of events. This is especially surprising when we consider that the perceived event similarity is higher for event owners than non-owners. One possibility is that non-owners believed that they needed to judge a certain proportion of the event pairs as causal (given that this was the task), so that this expectation caused them to see causality where it perhaps did not exist. Participants' confidence in their causality ratings might have provided insight here, but I did not measure this variable.

Causal consistency data. Whereas the frequency data indicate that a substantial proportion of the event pairs were considered causally related, the internal consistency of these relations is also quite telling. That is, for causally related events that were either two apart (D2s) or three apart (D3s), I investigated whether the adjacent events (D1s) that connected them were also rated as causally connected, and how this differed between owners and non-owners. For example, if a pair of causally related events are two apart in a string, call them events 'a' and 'c', are a–b and b-c also rated as causally connected? If all three event pairs are causally connected, then this set of events could be considered to have high causal consistency. If only one of the adjacent pairs (e.g., b-c) was rated as causally connected, then the set of event pairs has medium causal consistency, and if no D1s are causally connected, the set of event pairs has no causal consistency. For all D2s that were rated as causally connected, the causal consistency is reported in Table 4 broken down by causal condition. The same data are reported for D3s in Table 5.

For event owner D2s, not a single set of causally related events had no causal consistency and approximately two thirds were completely causally connected. When one

Table 4

Consistency in Causal Ratings for D2s, Illustrated by the Number of Event Pairs in Each Causal Condition for Which Both, One, or Zero of the Connecting D1s Were Also Rated As Causal.

Causal Condition	Both	One	Zero	Total
Both Causal				
Owner	17 (65%)	9 (35%)	0	26
Non-owner	13 (50%)	10 (38%)	3 (12%)	26
Owner Causal Only	10 (66%)	5 (33%)	0	15
Non-owner Causal Only	5 (24%)	9 (43%)	7 (33%)	21
Total Owner Causal (Both + Owner Only)	27 (66%)	14 (34%)	0	41
Total Non-owner Causal (Both + Non-owner Only)	18 (38%)	19 (40%)	10 (21%)	47

Table 5

Consistency in Causal Ratings for D3s, Illustrated by the Number of Event Pairs in Each Causal Condition for Which Three, Two, One of the Connecting D1s Were Also Rated As Causal.

Causal Condition	Three	Two	One	Total
Both Causal				
Owner	5 (56%)	3 (33%)	1 (11%)	9 (100%)
Non-owner	3 (33%)	5 (56%)	1 (11%)	9 (100%)
Owner Causal Only				
Owner	1 (20%)	2 (40%)	2 (40%)	5 (100%)
Non-owner Causal Only				
Non-owner	1 (11%)	3 (33%)	3 + 2 zeros (33% + 22%)	9 (100%)
Total Owner Causal (Both + Owner Only)	6 (43%)	5 (36%)	3 (21%)	14 (100%)
Total Non-owner Causal (Both + Non-owner Only)	4 (22%)	8 (44%)	4 (22 %)+ 2 zeros	18 (100%)

considers that each pair of event descriptions was presented randomly within a set of 162 trials, it is impressive that owners were able to perform so consistently. Surprisingly, even individuals rating other participants' event descriptions generally correctly detected causality, judging sets of events as causal although they had no causal consistency only 21% of the time, while the remaining trials were equally split between high and medium causal consistency. Thus, non-owners certainly picked up on causal information, but were not as consistent as event owners. That said, the consistency of non-owners was markedly better for events in the Both Causal than for the Non-owner Causal Only condition. Half of the Both Causal D2s had high causal consistency, and only 12% had none, while in the Non-owner Causal Only condition, only about a quarter of D2s had high causal consistency, and about a third had no causal consistency.

Unfortunately, for D3s the number of causally related events is quite small because events that are far apart in a string were rarely directly causally related. Therefore, any conclusions should be made with caution. However, there are still some notable and reasonable patterns in the data. Event owners were generally more consistent. Forty-three percent of event owners' causal D3s had high causal consistency, whereas only 22% were highly consistent for non-owners, and event owners did not have any causal D3s with no causal consistency. For Both Causal D3s, event owners were somewhat more consistent in their ratings of causality, in that 56% of items were of high causal consistency with all three D1s considered causality related, whereas non-owners reported only 33% as highly causally consistent. That said, for both owners and non-owners, 89% of Both Causal event pairs had two or more causally related D1s. The primary difference between the groups comes from the fact that non-owners reported a greater number of D3s with one or fewer causally connected D1s in the Non-owner Causal Only condition than did event owners in the Owner Causal Only condition. That is, in this condition, they were incorrectly attributing causality.

Thus, while the overall frequency data indicate that there is little difference between owners and non-owners with regard to the proportion of events considered causally related, the consistency data paint a different picture. It appears as though event owners are effectively recovering their causal chains. In contrast, whereas non-owners rate almost as many events as causally related as do owners, they do so in a much less internally consistent manner. In the next section, we see the effects of these differences on participants' perceived similarity.

Causality and Similarity using LSA. As in the replication of Experiment 1 (ignoring causal ratings), an analysis of absolute similarity ratings by causal condition without LSA is not presented here, but can be found in Appendix C.

The inclusion of LSA provides a baseline measure of similarity where no causal information was present. To equate the scale generated by LSA and by humans, both datasets were transformed in the same fashion as in Experiment 1, using the between strings events within the Neither Causal condition as a reference. The Neither Causal between-strings condition was used because neither the human data nor LSA similarity should be influenced by causal information, given that it was judged to be absent.

A 4 (causal condition: Both Causal, Neither Causal, Only Causal Only, Non-owner Causal Only) by 4 (distance: D1, D2, D3, between strings) by 3 (Group: owners, non-owners, LSA) Mixed Model ANOVA was conducted using a compound symmetry covariance structure with all three independent variables treated as within participants fixed factors. Causal condition was again treated as one variable with four levels. The dependent variable was scaled similarity. All reported means are raw unweighted means (see Figure 6), however, the estimated marginal means from the model appear in Appendix E.

A main effect of group was observed, $F(2, 488) = 49.61$, $p < .001$. To assess it, all three pairwise comparisons among the groups were evaluated, with Bonferroni correction. Owners ($M = 5.67$) rated events as more similar than did non-owners ($M = 3.74$), $t(488) = 5.49$, $p < 0.001$, or LSA ($M = 2.17$), $t(488) = 9.94$, $p < 0.001$. Non-owners also rated events as more similar than did LSA, $t(488) = 4.46$, $p < 0.001$. A main effect of distance was also observed, $F(3, 497) = 13.48$, $p < .001$, and, again, a Bonferroni adjustment was conducted for the set of six contrasts. D1s ($M = 4.91$) were more similar than D2s ($M = 4.10$), $t(491) = 3.82$, $p < 0.001$, D3s ($M = 3.57$), $t(495) = 5.81$, $p < 0.001$, and between string events ($M = 2.88$), $t(505) = 2.93$, $p < 0.05$. However, D2s did not differ from D3s, $t(495) = 2.45$, $p < .09$, or between string events, $t(506) = 1.37$, $p > .9$. Events three apart also did not significantly differ from those between strings, $t(505) = 0.17$, $p > .9$. There was also a main effect of causal condition, $F(3, 500) = 72.32$, $p < .001$. Both Causal event pairs ($M = 6.38$) were more similar than Owner Causal Only events ($M = 3.98$), $t(491) = 4.74$, $p < .001$, Non-owner Causal Only events ($M = 3.67$), $t(502) = 5.19$, $p < .001$, and Neither Causal events ($M = 1.43$), $t(501) = 13.34$, $p < 0.001$. Neither Causal events were rated as less similar than Non-owner Causal Only events, $t(499) = 6.50$, $p < .001$, and Owner Causal Only events, $t(504) = 7.00$, $p < .001$. There was no significant difference in similarity ratings of the Owner Causal Only and Non-owner Causal Only conditions, $t(505) = -0.59$, $p > .9$.

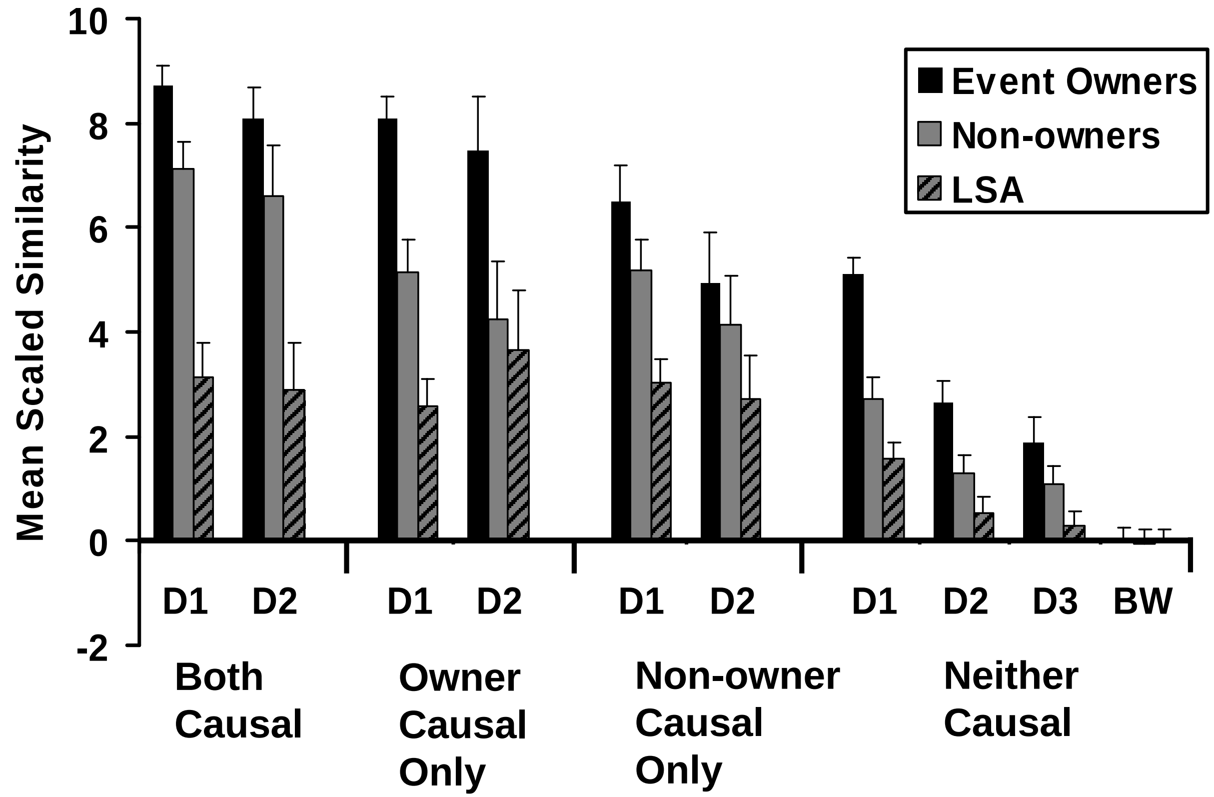

Figure 6. Scaled similarity including LSA, for Experiment 2 for D1s & D2s in all causal conditions, and D3s and Between strings pairs for the Neither Causal condition only.

Causal condition interacted with group, $F(6, 488) = 5.06$, $p < .001$, and with distance, $F(9, 495) = 2.62$, $p < .007$. However, group and distance did not interact, $F(6, 488) = 1.35$, $p > .2$. There was no three-way interaction, $F(18, 488) = 1.05$, $p > .3$. The means and standard errors for D1s and D2s in the Both Causal Only, Owner Causal Only, and Non-owner Causal Only conditions appear in Figure 6, along with the means and standard errors for all distances in the Neither Causal condition. The data from the D3 and between strings conditions should be interpreted with caution (except for the Neither Causal condition) because sample size was so low.[5] These means and standard errors appear in Appendix F along with the relevant multiple comparisons and a brief interpretation. They are omitted here for the sake of clarity and continuity. Given that the primary interest was in the patterns of similarity among the causal conditions, planned comparisons were conducted among the three groups within each level of distance for each causal condition. Significance values were adjusted using a Bonferroni correction, treating each set of three contrasts as a family, similar to the previous analysis. The results of these comparisons appear in Table 6.

Consider, first, the patterns of similarity in the Neither Causal condition (see Figure 6). This is the condition in which both event owners and non-owners rated pairs of events as having no causal connection. Thus, the pattern of similarity ratings in this condition should be indicative of how similarity between pairs of events operates when causal relations are absent. For between strings events there were no differences between owners, non-owners or LSA. For D3s there were no differences between owners and non-owners, or between non-owners and LSA, but there was a significant difference between

[5] A separate ANOVA omitting the D3s and Between Strings distance levels resulted in the same pattern of results for the D1s and D2s as when D3s and Between Strings events were included in the overall analysis.

owners and LSA. Thus, relative to the replication of Experiment 1 above, the results of the D3 and between strings condition are the same, which is perhaps unsurprising given that the Neither Causal condition accounted for 85% of D3s and almost 99% of between string events (which were also used as a reference for standardizing).

For Neither Causal D2s, group differences were reduced. In the analyses excluding causal relations, D2 similarity significantly differed for event owners, non-owners, and LSA. In the Neither Causal condition, the difference between owners and LSA remained significant, but those between owners and non-owners and between non-owners and LSA were non-significant. For D1s, all three groups differed significantly when ignoring causal relation, but in the Neither Causal condition the difference between non-owners and LSA was non-significant, whereas owners' similarity was still higher than the other two groups.

Thus, when events rated as causally connected were removed from the analysis (i.e., considering only events in the Neither Causal Condition), significant differences between non-owners' ratings and LSA disappeared (although non-owners' ratings remained numerically larger). Note that these differences between LSA and non-owners were not present in Experiment 1, and I suggested that they were due in Experiment 2 to a much lower proportion of between strings event pairs. This suggests that the differences between non-owners and LSA observed in the Experiment 1 replication were due in part to non-owners' perception of causal relations given that removing event pairs in which causal relations were present muted differences between non-owners and LSA. Thus, elevated ratings by non-owners relative to LSA are in part due to the fact that non-owners are able to perceive causal relations between events, which of course LSA is not privy to.

Table 6
Multiple Comparisons Among The Three Ownership Conditions at Each Level of Distance For Each Causal Condition.

	Distance	Group1	Group2	*t*(488)	*p* <
Both Causal					
	D1	Owner	Non-owner	2.04	*ns*
		Owner	LSA	7.05	.001
		Non-owner	LSA	5.01	.001
	D2	Owner	Non-owner	1.72	*ns*
		Owner	LSA	6.00	.001
		Non-owner	LSA	4.28	.001
Owner Causal Only					
	D1	Owner	Non-owner	4.02	.001
		Owner	LSA	7.50	.001
		Non-owner	LSA	3.48	.002
	D2	Owner	Non-owner	3.74	.001
		Owner	LSA	4.42	.001
		Non-owner	LSA	0.68	*ns*
Non-owner Causal Only					
	D1	Owner	Non-owner	1.97	*ns*
		Owner	LSA	5.25	.001
		Non-owner	LSA	3.28	.005
	D2	Owner	Non-owner	1.02	*ns*
		Owner	LSA	2.83	.02
		Non-owner	LSA	1.81	*ns*
Neither Causal					
	D1	Owner	Non-owner	3.67	.001
		Owner	LSA	5.48	.001
		Non-owner	LSA	1.82	*ns*
	D2	Owner	Non-owner	2.09	*ns*
		Owner	LSA	3.25	.01
		Non-owner	LSA	1.16	*ns*
	D3	Owner	Non-owner	1.20	*ns*
		Owner	LSA	2.48	.05
		Non-owner	LSA	1.28	*ns*
	BW	Owner	Non-owner	0.17	*ns*
		Owner	LSA	0.09	*ns*
		Non-owner	LSA	-0.09	*ns*

Also of interest was the finding that the ownership advantage observed in Experiment 1 (and in the Experiment 2 analysis ignoring causality) was reduced, and for D2s, so much so that the difference between owners and non-owners became non-significant. Thus, for both D1s and D2s, the ownership advantage was impacted by causal relations because when causality was absent, this advantage was reduced. That the ownership advantage remains for adjacent events could perhaps be driven by owners having access to information regarding additional shared people, places, activities or objects that did not appear in the event descriptions. It is also possible that the D1 residual ownership advantage after removing causality was due in part to owners' privileged access to the event generation task. When two events shared no causal relation, and if both non-owners and owners were aware of the shared event properties between events, perhaps event owners recollected that one event memory cued another in the original event generation task (and perhaps even how or why this was the case) leading to artificially heightened ratings of similarity.

The results differ considerably for the condition in which both owners and non-owners judged the events to be causally related (Both Causal). D1s and D2s show a similar pattern. Owners' and non-owners' similarity ratings are not significantly different, but both are higher than LSA. Thus, when owners and non-owners have access to shared event properties and causal relations, similarity ratings are comparable (although numerically, owners' ratings are slightly larger) and are greater than LSA similarity. This suggests that similarity and causality are two primary components connecting autobiographical events. In the Both Causal condition, non-owners see the causal connection between pairs in addition to the shared event characteristics in the event descriptions that event owners also see, and both groups produced extremely high similarity ratings.

In Experiment 1, I hypothesized that at least some of the ownership advantage was due to causal relations that only an event owner might have. The Owner Causal Only condition corresponds precisely to this case. Importantly, unlike the Both Causal condition, in which non-owners also noticed a causal relation, the ownership advantage in the Owner Causal Only condition was significant for both D1s and D2s. Furthermore, non-owners' similarity ratings did not differ significantly from LSA for D2s. However, for D1s, non-owners rated event pairs as more similar than did LSA, which is somewhat puzzling given that they indicated that they were not aware of a causal relation between these events. Presumably, shared event components that resulted from a true causal relation (as judged by the event owners) influenced even non-owners' ratings.

In the Non-owner Causal Only condition, one might expect that non-owners would have higher similarity ratings than owners given that they believed there was a causal relation, but owners did not. Instead, the ownership advantage was muted in that there was no difference between owners and non-owners for either D1s or D2s, although ratings were numerically larger for owners. This difference showed itself in significantly higher similarity for owners versus LSA for D1s and D2s, whereas non-owners were significantly higher than LSA for D1s, but not D2s. These results are surprising because in this condition event owners did not rate the events as causally related and it was therefore expected that they would pattern with LSA. Instead, event owners rated the events as more similar than LSA, and appear to treat these events similarly to non-owners, who rated the events as causally related.

To provide further insight, I compared the four causal conditions at each distance for each group (e.g., comparing all four D1 conditions). Significance values were adjusted using a Bonferroni correction, treating each set of six contrasts as a family. For the sake of clarity and brevity, each contrast will not be described in the text, but all comparisons appear in Table 7.

LSA similarity for D1s and D2s did not differ among the three conditions in which either (or both) the owner or non-owner judged an event as causally related. For D1s, the only differences were between Neither and Non-owner Causal Only, and only before the Bonferroni adjustment, and a marginally significant difference between Neither and Both Causal, and again only before the Bonferroni adjustment. Neither Causal D2s were less similar than D2s in all three of the causal conditions. Given that LSA is not privy to causal information or general event knowledge, this suggests that, perhaps because causally related events are often temporally contiguous, these events often share numerous properties. For example, if two events occur close in time, they will often occur at the same location, with the same people, the same objects, or even the same activities. Thus, some aspects of causally related events are reflected in LSA similarity. It is also possible that some degree of causality is encoded in LSA vectors because causes and effects may appear close together in text (or as part of the same passage), and therefore are deemed somewhat similar by LSA.

For event owners, similarity ratings did not differ between Both Causal and Owner Causal Only events for either D1s or D2s. That is, when owners judged events as causally related, their similarity ratings did not differ. In addition, owners rated

Table 7
Multiple Comparisons among the Four Distance Conditions at Each Level of Distance in the Three Groups in Experiment 2 (after Bonferroni adjustment).

Distance	Group1	Group2	*t*(488)	*p* <
LSA				
D1	Both Causal	Owner Causal Only	-0.35	*ns*
	Both Causal	Non-Owner Causal Only	0.15	0.001
	Both Causal	Neither Causal	-1.82	0.001
	Owner Causal Only	Non-Owner Causal Only	0.54	*ns*
	Owner Causal Only	Neither Causal	-1.52	0.001
	Non-owner Causal Only	Neither Causal	-2.18	0.001
D2	Both Causal	Owner Causal Only	0.91	*ns*
	Both Causal	Non-Owner Causal Only	0.01	*ns*
	Both Causal	Neither Causal	-2.79	.05
	Owner Causal Only	Non-Owner Causal Only	-0.94	*ns*
	Owner Causal Only	Neither Causal	-3.83	.001
	Non-owner Causal Only	Neither Causal	-2.97	.02
Owners				
D1	Both Causal	Owner Causal Only	-0.46	*ns*
	Both Causal	Non-Owner Causal Only	-2.69	.05
	Both Causal	Neither Causal	-4.63	.001
	Owner Causal Only	Non-Owner Causal Only	-2.32	*ns*
	Owner Causal Only	Neither Causal	-4.34	.001
	Non-owner Causal Only	Neither Causal	-2.10	*ns*
D2	Both Causal	Owner Causal Only	-0.65	*ns*
	Both Causal	Non-Owner Causal Only	-3.53	.01
	Both Causal	Neither Causal	-6.82	.001
	Owner Causal Only	Non-Owner Causal Only	-2.84	.05
	Owner Causal Only	Neither Causal	-6.09	.001
	Non-owner Causal Only	Neither Causal	-3.17	.01
Non-Owners				
D1	Both Causal	Owner Causal Only	-2.19	*ns*
	Both Causal	Non-Owner Causal Only	-2.78	*ns*
	Both Causal	Neither Causal	-5.67	.001
	Owner Causal Only	Non-Owner Causal Only	0.01	*ns*
	Owner Causal Only	Neither Causal	-3.51	.01
	Non-owner Causal Only	Neither Causal	-3.72	.001
D2	Both Causal	Owner Causal Only	-2.66	.05
	Both Causal	Non-Owner Causal Only	-2.71	.05
	Both Causal	Neither Causal	-6.65	.001
	Owner Causal Only	Non-Owner Causal Only	0.07	*ns*
	Owner Causal Only	Neither Causal	-3.62	.002
	Non-owner Causal Only	Neither Causal	-3.92	.001

Non-owner Causal Only and Neither Causal events as significantly less similar than those in the Both Causal and Owner Causal Only conditions. Thus, they rated events that they judged as causally related to be more similar than those they judged as causally unrelated (regardless of non-owners' causal ratings). In addition, owners' similarity ratings of Non-owner Causal Only events were significantly higher than Neither Causal events. This supports the contention that Non-owner Causal Only event pairs, while not considered causally related by owners, share content, perhaps due to temporal or thematic relations, that lead both to elevated owners' similarity ratings, and also to non-owners judging them as causally related.

Non-owners' ratings of Owner Causal Only events (which non-owners did not judge as causally related) were much lower than those of Both Causal events, for both D1s and D2s. In contrast, there were no differences between these conditions for owners (and for LSA). This suggests that a large component of the ownership advantage comes from events that have causal relations that the owners know about, but non-owners do not detect. The failure to detect these causal relations results in a substantial drop in similarity rating by non-owners.

The remaining non-owner contrasts provide insights into the results of the two conditions in which participants disagreed in their causality judgements, Owner Causal Only and Non-owner Causal Only. Ratings for both D1s and D2s in these two conditions did not significantly differ, and were higher than those in the Neither Causal condition. This also was found for LSA. However, non-owners rated events as more similar than LSA in both the Owner Causal Only and Non-owner Causal Only conditions in all cases except one, Owner Causal Only D2s. Thus, the data suggest that, in these conditions, non-owners noticed that there was information over and above simple co-occurrence of event properties. This additional (possibly temporal) information was sufficient to trigger a causal judgement in some cases, but not others.

Recall that event owners and non-owners elicited comparable frequencies with regard to the number of causally related events within each condition, but that non-owners were much less consistent. Thus, the consistency data indicate that owners are indeed recalling chains of causal events and these causal influences are reflected in the similarity ratings. However, for non-owners, causal chains are much less consistent and there appears to be a bias such that they rate some pairs of events as causally related for which even event owners do not. Given that non-owners' similarity was comparable in the Owner Causal Only and Non-owner Causal Only conditions, this may reflect an experimental bias. Participants were asked to decide whether pairs of events were causally related. It is likely that non-owners assumed that at least a reasonable proportion of event pairs were causally related, and therefore it would be odd to make very few causal relatedness judgements. The comparable causal frequencies between owners and non-owners, and the existence of the Non-owner Causal Only event pairs likely result partly from this experimental expectation. Furthermore, non-owners' incorrect attributions of causality were not completely random. Rather, they (mis)judged events as causally related when those events had similar non-causal content. On the other hand, it is not entirely clear why non-owners judged some, but not other, events as causally-related even though they had previously given them equivalent similarity ratings (i.e., in the Owner Causal and Non-owner Causal Only conditions).

These results show that causal relations between events are a relevant factor in leading one episodic memory to cue another. However, an interesting question is whether these causal connections coincide with higher order general events. Radvansky et al.'s (2005) novel study indicates that causal connections among episodic memories play a role in the recall of general events. However, in the present study individual episodic memories were cued in a random order with an unconstrained retrieval task and, if results herein shed some light on the link between causal relations and general events, it may provide additional insight to Radvansky et al.'s (2005) results, and into the formation of general event representations.

General event ratings. In addition to judging whether a pair of events was causally related, participants were asked whether each pair of events was part of the same larger event. Although these ratings are not of primary interest, they provide additional insight. For each causal by distance condition (e.g., Owner Causal Only D2), I broke down the proportion of events according to whether event owners and non-owners rated the pair as being part of the same general event. This resulted in four general event conditions similar to the causal conditions: Both General, Own General Only, Other General Only, and Neither General events. These proportions appear in Table 8.

In the Both Causal condition, general event ratings were largely consistent with causal ratings. In cases where a causal relation was indicated by both owners and non-owners, 79% of the time for D1s and 85% of the time for D2s, both participants rated both events as part of the same overarching general event. Also, when both groups agreed that a pair of events were causally related, 94% of the time for D1s and 96% of the time

Table 8

Percent of Events Rated as Part of the Same General Event at Each Level of Distance for Each Causal Condition in Experiment 2.

Causal Condition	General Event Condition	D1	D2	D3	BW
Both Causal					
	Both General	79	85	78	0
	Owner General Only	6	4	11	0
	Non-owner General Only	15	12	11	0
	Neither General Only	0	0	0	100
Owner Causal Only					
	Both General	46	33	29	0
	Owner General Only	39	53	29	50
	Non-owner General Only	6	0	14	0
	Neither General Only	9	13	0	50
Non-owner Causal Only					
	Both General	47	38	44	0
	Owner General Only	12	0	0	0
	Non-owner General Only	42	48	56	0
	Neither General Only	0	10	0	100
Neither Causal					
	Both General	17	7	5	0
	Owner General Only	22	12	8	5
	Non-owner General Only	18	12	12	4
	Neither General Only	42	70	75	91

Note: Each set of four proportions within each distance for each causation condition should sum to 1.00 (with rounding it may not be exactly 1.00).

for D2s, non-owners rated the pair as part of the same general event, and never was a pair in this condition not part of the same general event for both participants.

Perhaps of greatest interest were the Owner Causal Only and Non-owner Causal Only conditions. In both cases, when one group considered a D1 event pair to be causally related, over half of the time the participant in the other group considered the pair to be part of the same general event. For example, in the Owner Causal Only D1 condition, 52% (46% Both General + 6% Non-owner General Only) of event pairs were rated as part of the same general event by non-owners and in the Non-owner Causal Only group, 59% of event owners (47% Both General + 12% Owner Causal Only) rated event pairs as part of the same general event. However, these numbers drop to 33% (Owner Causal Only) and 38% (Non-owner Causal Only) for D2s.

The Neither Causal condition provides some additional insights into the experimental bias referred to previously. I suggested that the ownership advantage in the D1 condition might be a result of participants recalling that a pair of events occurred on the same trial as cueing and cued events. However, if this were the case, the proportion of events that were rated as part of the same general event would have been higher for event owners than for non-owners in this condition. However, there was only a difference of 4%, with 22% of event owners in the Own General Only condition of D1s and 18% in the Other General Only condition. For D2s the proportions are identical at 12%.

Conclusions. The results of Experiment 2 indicate that causal and similarity based relations between events are significant factors in connecting events in autobiographical memory. By accounting for participants' perceptions of the causal relations between events, the ratings of similarity provided in Experiment 1 were made much clearer.

Generally speaking, the ownership advantage appears to be due, in large part, to event pairs in which only event owners were aware of a causal connection between events, and they therefore rate those events as more similar than do non-owners. In contrast, when owners and non-owners agree that both events are causally related, similarity ratings are comparable, but when participants agree that event pairs are not causally related, event owners appear to have had access to additional information for D1s that led them to rate them as more similar. All other events in the Neither Causal condition were rated comparably by owners and non-owners. Interestingly, the similarity of these events decreased as they became farther apart in a string, and event pairs rated as causally connected were considered more similar than Neither Causal events, no matter if they were rated as causal by event owners, non-owners, or both. In addition, the pattern of general event ratings suggests that causal connections may be an important component in forming general event memories given their patterns of co-occurrence. However, the results of the present study indicate that causal and general event relations also operate independently to some degree.

General Discussion

This thesis makes two sets of contributions. In Experiment 1, I demonstrated that when event owners rate an event pair as more similar than do non-owners, it reflects that event owners have additional autobiographical information at their disposal, over and above what appears in the descriptions. This contrasts with Odegard et al.’s (2004) proposal that the ownership advantage is due simply to a reinstatement of the experimental retrieval context from the initial event generation session. Using LSA as a baseline, I showed that, to a large extent, non-owners base their similarity ratings on the meaning of the words and the properties of the event descriptions. This suggests that, in many cases, event owners were aware of additional information over and above the physical characteristics of the individual passages that connected each pair of events, and that this information influences their similarity judgements. In Experiment 2, I investigated one possible source of this ownership advantage, causal relations. When non-owners perceive the same property-based similarity and causal relations as do owners, similarity ratings are comparable. In addition, the causal connections within extended strings of causally connected events are internally consistent (much more so for event owners), even though events were generated and subsequently rated in isolated pairs. However, comparisons of human ratings to LSA similarity also suggest that individuals make use of information over and above textual similarity and causality in a subset of the event pairs, and in many cases this additional information pertains to the higher order event structures to which an event pair belongs. As a whole, these findings suggest that individual autobiographical memories are connected, not only in terms of *what* is shared between them, but also according to the causal ties between events that tell us how they might unfold over time.

Property-based Similarity

The results suggest that the shared content between events is a significant factor in connecting autobiographical memories. This is consistent with the findings of numerous previous studies. This influence is perhaps most clear in the Neither Causal condition of Experiment 2 in which events eliciting causal connectivity are excluded. In this case, similarity varies with distance between events, and this is evident for owners, non-owners, and most importantly, LSA. Thus, in the absence of causal connections, similarity in terms of shared event properties plays a prominent role in leading one event memory to cue another. One explanation that has been provided for similar results in past experiments is that participants engage in pivoting (Lancaster & Barsalou, 1997; Odegard et al., 2004). Participants may focus on one shared event property (or a type of property) in leading one event to cue a second, but switch to other properties to cue a third event. Thus, event one and three would have substantially less in common than events one and two, or two and three. This is consistent with the results of the qualitative analysis of the shared event properties in Experiment 1, in which fewer properties (i.e., participants, activity, location, objects, and time) were shared between events as distance increased.

Similarity computed using LSA was critical for understanding what makes two events similar, and the present study was the first study of autobiographical memory to make use of corpus-based similarity. In Experiment 1, the disparity between owners' and non-owners' ratings appeared to be driven by owners' privileged access to information over and above the shared content. In addition, the same analysis in Experiment 2 indicated that, because of a slight modification in the design of the experiment, non-owners rated events using more than shared content between event descriptions. This was an unexpected result because the results of the two experiments were the same when LSA was ignored (i.e., when looking at human similarity ratings only). Thus, the use of LSA not only made it possible to learn more about the ownership advantage, it also gave an indication of what information non-owners were (or were not) attending to. This baseline similarity measure also was useful for understanding the role that causal relations play in autobiographical memory.

Causal Relations

When a participant was cued with an autobiographical event description, 28% of the time the generated event memory was causally related, as judged by the event owner. This supports previous findings that causal connections play a role in the organization of autobiographical events. Of greater interest, however, was that these causal connections led to extended strings of causally connected events that elicited a high degree of internal consistency. Almost 60% of non-adjacent events in a string (D2s and D3s) that were rated as causally connected by event owners were fully connected by causally related cueing and cued events (D1s). This number jumps to almost 80% if D3s are included for which two of three D1s are judged as causal. These statistics provide an added degree of confidence to the conclusions regarding the importance of causality, particularly because pairs were rated in random order and intermixed with event pairs that were completely unrelated (between strings), or from different strings originating from the same source event (i.e., between strings, but within a supracluster). Recall also that event descriptions were generated using random presentation of event cues, and that causal relatedness was judged three weeks after events were generated.

Similarity and Causality

Experiment 2 demonstrates that similarity and causality interact in interesting ways, even though they do not appear to be inextricably tied. Similarity and causality can be considered to be separable organizational constructs in autobiographical memory. For example, more than 60% of adjacent event pairs in a string had no causal relation (Neither Causal), suggesting that property-based similarity alone led one event to cue another in many cases. Conversely, there were certainly events for which similarity was not high; approximately 20% of D1s rated as causally connected by event owners were given a similarity rating of 4 or less by non-owners (on a scale of 1 to 9). Thus, the use of causal relations as a means of cueing event memories may be a complement strategy to pivoting. That is, participants may use shared content to cue additional events by default until an event with a strong causal connection to another (set of) event(s) is activated. At that point perhaps causality dominates until a causal dead end is reached, at which point property-based similarity dominates again.

Interestingly, causally connected event pairs often elicit common content. Event pairs in the three causal conditions had higher ratings of similarity than events in the Neither Causal condition, and events that were agreed upon to be causally related (Both Causal events) were more similar than events rated as causally connected by event owners or non-owners only. This could simply reflect that causally related events often occur in close temporal proximity and therefore usually have similar participants, locations, activities or objects involved. However, it could also be that similarity and causality together are greater than the sum of their parts, such that causal events that are highly similar are more easily remembered than those that are highly similar but not causally related, or events that are causally related but not highly similar. Given the design of the present study, these are both possibilities.

Causality and Time

One potential argument that could be made is that causality, as it has been measured here, is confounded by time; this is undoubtedly true. For one event to cause another, the second event naturally must occur after the first. Radvansky et al. (2005) found that events that were recalled in forward order elicited more causal connections, on average, than events recalled backward or in order of event importance. That said, a temporal relation need not imply a causal relation because one event that follows another event in time need not be caused by the earlier event; for example, having breakfast does not cause one to go to work. Radvansky et al. demonstrated that causal connectivity of events accounted for a significant proportion of variance in recall latency regardless of whether events were recalled forward, backwards or by importance. However, the order in which events were originally experienced was not predictive of recall speed in any condition. Because participants were not asked to assess the order of events, provide dates, or assess any temporal relations, there is no way to determine the degree to which time confounded participants' decisions regarding causality or their subjective ratings of similarity in the present Experiment 2.

Interestingly, participants' recognition latency for events in Radvansky et al.'s (2005) study was unaffected by either the order of the events as they were experienced in the original episode or by the causal connectivity of the events. The results of the present experiments speak to this seemingly counterintuitive result. In this thesis, events were recalled in the context of event pairs, whereas in Radvansky et al.'s recall task, events were presented in the context of a number of related events and the recognition task involved events in isolation. Thus causal connectivity only plays a role when an event representation is being accessed within the context of other events, and the present experiments suggest that this causal influence even plays a role when the an event is not being constrained to be recalled within the context of a larger event. When an event is being recognized in isolation, however, the relations between that event and other causally or temporally contiguous events do not aid retrieval.

Task-based Considerations

In the present thesis, I implemented an event cueing paradigm (Brown & Schopflocher, 1998a, b), which I modified and extended in important ways. There are two considerations regarding the task that I used. First, the use of an event cueing paradigm itself was especially important because it allowed me to investigate direct relations between memories for real autobiographical events without instantiating a larger context. Past studies have investigated organizational properties of autobiographical memory using tasks in which participants are constrained to recall events in a specified order (Anderson & Conway, 1993; Radvansky, Copeland & Zwaan, 2005), or asked to describe only events related to the cue (Brown & Schopflocher, 1998X), making it difficult to conclude that observed relations between events are not tied to the constraints of the event generation paradigm. The event cueing paradigm used herein obfuscates this issue. Recall that each event description that was presented as a cue (randomly from a pool of event descriptions) was never seen by participants on a trial preceding or following a trial where an event description from the same string was also presented. Not only does this eliminate the use of any constraints on the possible relations between cueing and cued events, but it drastically reduces possible cues to the connections between events (in a string) from the initial event generation task. One possible limitation was the choice of words utilized to cue the initial events in the strings. Cue words were taken from past event cueing experiments (Odegard et al., 2004; Wright & Nunn, 2000). One potential argument is that limiting cues to four cue words may have skewed the results. Anecdotally, having rated each pair of related event descriptions in Experiment 1, most of the event descriptions in a chain of related events diverged from the initial cue very quickly. For example, if an initial cue word was car, the source event might be related to a car or driving experience, which then might cue a second car-related event, but more often than not this is where the theme ends. Given that each source event was omitted from similarity analyses, this means that in most cases the initial cue word was rarely one of the event properties that connected a pair of events, and primarily for D1s (D2s would extend beyond the pair once the source event was removed). That said, in future experiments, it would be wise to vary the initial cue words to verify that these particular words did not significantly influence the results herein.

Additional Relations

In utilizing ratings of similarity to assess relations between events it is likely that numerous factors that determine the organization of episodes in the autobiographical knowledge based simply were not captured. While similarity and causality are prevalent constructs in the literature, there are many other ways in which events might become connected that similarity and causality cannot capture. The results of the present thesis suggest that other sources of information, over and above shared content and causal relations, are necessary to connect autobiographical events in memory. Event owners elicited numerically higher ratings of similarity throughout Experiment 2, even in cases where the difference was non-significant. This suggests that event owners are aware of some details of event pairs that might make them seem more similar to them, but there is no way to know what this information might be, except to say that these events are often part of the same general event. It could be as simple as event owners' privileged access to the specific sensory details of the memory (and the vividness of those details; Wright & Nunn, 2000), or it could be shared emotional content that was not obvious from the descriptions of the events, for example. Perhaps temporal proximity led one event to cue another in this condition, and non-owners used this information to incorrectly infer a causal relation.

Modeling Autobiographical Memories

There are also interesting implications for models of autobiographical memory. The results herein suggest that the direct connections among specific episodic events, regardless of their connectivity to superordinate level respresentations in the autobiographical knowledge base, play a role in the cognitive structure of autobiographical memory. To the best of my knowledge, this is the first study to elicit strings of related episodic memories using a random-presentation cueing procedure. In the present thesis, events were iteratively presented as random cues, allowing participants to generate pairs of cueing and cued events in isolation, so that the focus was on retrieving a single event. Thus, events were generated without reference to larger "top-down" information, such as general events, or an overall narrative or story, or a life period. Given that internally consistent causal event strings resulted from this paradigm, it may be the case that direct relations between pairs of specific episodic memories operate independently from general event representations.

If the relations among episodic events in terms of, for example, similarity and causality operate directly at the lowest level of the Self Memory System's putative hierarchy (Conway, 2005; Conway, 2009; Conway & Pleydell-Pearce, 2000), then perhaps these relations are responsible for the formation of general events and life themes. For example, life themes may be an emergent property of similarity relations among numerous episodic memories. A set of events that occurred at a common workplace, or involved the same significant other, might be linked in autobiographical memory. Along the same lines, causal and temporal relations among specific memories might lead to general event representations. That is, it could be that you remember a certain series of events in a story-like fashion *because* of the strong causal connectivity among the specific episodes within that set of events. Initially a set of recent events might be remembered as a temporal sequence of autobiographical events and lead to a general event representation. As time passes and memory for temporal information decays, if a string has few causal connections, the sequence will become fragmented and the associated general event will be forgotten or broken up into multiple temporally-shorter general events. This conceptualization of autobiographical memory structure also allows that single isolated episodic memories can be maintained in autobiographical memory, without following a strict hierarchy. For example, a set of episodic memories might be indexed according to a life theme based on similar people, places, activities or objects, but not be conceptualized within a general event.

Finally, focusing on the relations among specific episodic events provides a framework for the creation of general event memories and life themes. However, it suggests that perhaps a hierarchy need not exist as a structure in memory per se, but instead explains how these representational constructs are formed, as emergent properties of a system that relies on simple relations among perceived experiences. Moving forward, rather than envisioning episodic memories as organized in terms of general events or themes, an alternate conceptualization is that direct connections are formed between events based on causal and similarity-based relations, and general events or themes are an effective way to describe our processes in retrieving these memories through these connections.

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Appendix A

Sorting Simulation using Experiment 1 Similarity Data

It could perhaps be argued that in emphasizing event pairs by asking participants to rate pairwise similarity, the results of Experiment 1might not be comparable to a sorting procedure. I addressed this concern using a sorting simulation, in which participants' similarity ratings were used to create a similarity space using multidimensional scaling, and then events were sorted into groups using cluster analysis, based on the similarity of various events from resultant prototypes (cluster centers).

Method

Each participant's similarity ratings were used in a multidimensional scaling analysis, resulting in a separate 3-dimensional event space for each person's data, which was then subjected to a cluster analysis. This process resulted in three "prototypes" or cluster centers that were used to assign event descriptions into groupings.

Multidimensional Scaling. The similarity matrices for the 27 event descriptions from each participant (i.e., 26 separate matrices) were converted to dissimilarity matrices by subtracting each rating from 9 (so that 0 = very similar, 9 = very dissimilar). Each matrix was used to generate a separate multidimensional event space because each event description was presented to only two participants, making inappropriate an aggregate dataset or a multi-mode MDS analysis (e.g., INDSCAL, Carroll & Chang, 1970; PARAFAC, Harshman, 1970). Multidimensional scaling was performed using the PROXSCAL model (PROXimity SCALing) available in SPSS (SPSS, v.15). A metric MDS analysis (Torgeson, 1965) for each dissimilarity matrix was computed with default settings, using a simplex initial configuration, and no restrictions on the common space, to import as few assumptions into the analysis as possible. After MDS, the average correlation between MDS distances and original similarity ratings was -.73 (*SE* = .02) for event owners and -.70 (*SE* = .02) for non-owners, and these did not differ, $t(18) = 1.19$, $p = .25$. The overall pattern of results reported for the similarity ratings above also held for the distance data form the MDS. Thus the statistical regularities in the similarity data appear to have reliably transferred to the distances in the MDS solution.

Cluster Analysis. In Odegard et al.'s (2004) sorting task, participants were instructed to sort all the event descriptions they had generated into a number of piles equal to the number of source events. To replicate this procedure, we performed a k-means cluster analysis on each participant's 3-dimensional MDS solution, with three clusters specified to derive three cluster centers (recall that our participants generated three source events) that served as cluster prototypes for simulating Odegard et al.'s sorting task. Each event for the cluster analysis was represented as a vector of scores on the 3-dimensions from the MDS above.

To accomplish this, a k-means clustering algorithm initially generated three random 3-dimensional points that served as cluster centers. The (Euclidean) distance between each event and each cluster center was then computed, and each event was assigned to the cluster to which it was closest. This was repeated for every event (the number of events in each cluster was not fixed). The cluster centers were then re-computed as the average (i.e., the center) of the events that were assigned to that cluster. All events were then reassigned based on these new centers, and the process was repeated until cluster centers, and the membership of the events with those clusters, stabilized. This process was conducted on each of the 26 MDS solutions described above, derived from each participant's similarity data. The number of events in each cluster for the final solution was never the same across the three clusters.

Sorting simulation. The actual sorting of the event descriptions into groups specified by the cluster centers above was simulated using three steps. First, for each cluster center, the nine closest events (27 total ÷ 3 clusters) were assigned to that group, allowing events to be assigned to multiple groups. Second, if an event was assigned to more than one group, it was sorted into the group with the closest cluster center. Third, for the alternate cluster(s) that lost that event (i.e., the non-closest cluster[s]), I assigned the next closest event to that group (if it had not already been assigned to that group), whether it had already been assigned to another group or not, so that every cluster again had nine events. Steps two and three were repeated until every event was sorted into a single group only, and every group had nine events.

Results

I assessed simulated sorting using a procedure identical to Odegard et al. (2004), that is, by considering the probability that each pair of events in a string was sorted into the same group given their distance apart (D1, D2, & D3). These results appear in Figure 7 A 2 X 3 repeated measures analysis of variance was conducted with ownership and distance as independent variables, and sorting performance as the dependent variable.

I replicated Odegard et al. (2004) in that there was no interaction between ownership and distance, $F < 1$. A main effect of ownership obtained with event owners ($M = 0.52$) being significantly better at sorting the events than were non-owners ($M = 0.43$), $F(1, 18) = 4.79$, $p < .05$. A main effect of distance was also observed, $F(1, 31) = 24.71$, $p < .001$, such that events one apart in the original event string (D1; $M = 0.58$)

were sorted together with higher probability than events two apart (D2; $M = 0.46$), $t(18) = 5.17$, $p < .001$, and three apart (D3; $M = 0.39$), $t(18) = 6.06$, $p < .001$. D2s were significantly more likely to be sorted together than D3s, $t(18) = 2.59$, $p < .02$. The results of the sorting simulation appear in Figure 7.

The results of the simulation suggest that the statistical regularities in the similarity data obtained here would lead to the same sorting results as in Odegard et al. had participants performed a sorting task instead of similarity ratings. This supports the notion that the similarity ratings tap valid relations among event descriptions.

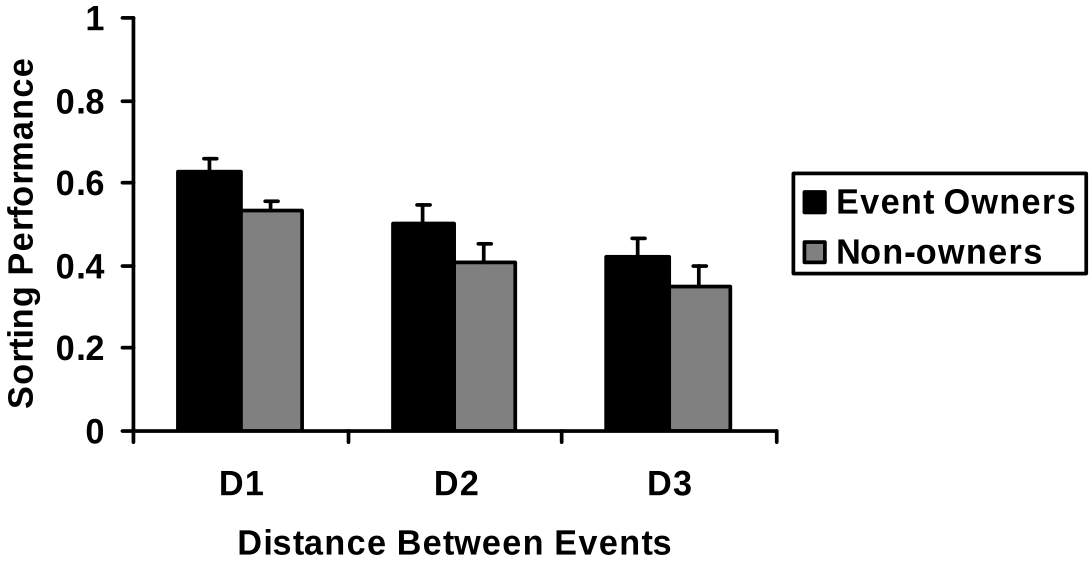

Figure 7. Sorting performance in the simulation of Odegard et al.'s (2004) sorting task using the Experiment 1 similarity ratings. Sorting performance was measured as the probability that each pair of events in a string was sorted into the same group given their distance (D1, D2, & D3).

Appendix B

Similarity Results from Experiment 2 Ignoring Causality

The dependent variable was event similarity. A mixed model analysis of variance was required for the causal analyses presented in the main text. To maintain consistency, a two (ownership: owner, non-owner) by four (Distance: D1, D2, D3, between strings) analysis of variance using GLM, and a two by four Mixed Model analysis of variance are reported, with the GLM results always appearing first. In both cases, ownership and distance were treated as within-participants variables (see Figure 8 for means and standard errors). For all Mixed Model ANOVAs, analysis was performed using the Linear Mixed Function in SPSS. Covariance structure was based on sequential comparisons of model fit (such as -2log likelihood and AIC) starting with an unstructured covariance structure, and simplifying the model sequentially using Toeplitz, compound symmetry, or scaled identity covariance structures respectively, until the simplest model that could adequately describe the data was found. The present analysis used a Toeplitz covariance structure.

As in Experiment 1, event owners ($M = 4.10$) rated event pairs as more similar than did non-owners ($M = 3.24$), $F(1, 17) = 6.88$, $p < .02$; $F(1, 41) = 8.38$, $p < .01$. There was also a main effect of distance, $F(1, 27) = 85.36$, $p < .001$; $F(3, 18) = 49.37$, $p < .001$. To assess this main effect, all six pairwise comparisons were evaluated, with Bonferroni correction. Adjacent events ($M = 5.55$) were rated as more similar than those that were two apart ($M = 3.86$), $t(17) = 11.25$, $p < .001$; $t(32) = 8.98$, $p < .001$, three apart ($M = 3.40$), $t(17) = 12.80$, $p < .001$; $t(38) = 7.36$, $p < .001$, and between strings ($M = 1.88$), $t(17) = 13.13$, $p < .001$; $t(52) = 10.02$, $p < .001$. Events two apart were rated as more similar than those three apart in the GLM ANOVA, $t(17) = 4.45$, $p < .01$; but not in the mixed-model ANOVA, $t(32) = 2.41$, $p < .13$, and between strings in both analyses, $t(17) = 6.38$, $p < .001$; $t(38) = 56.79$, $p < .001$. Events three apart were more similar than those between strings, $t(17) = 5.23$, $p < .001$; $t(32) = 8.11$, $p < .001$. Thus, events closer together in a string are generally rated as more similar. These results are consistent with Experiment 1 in which events closer in a string were always rated as more similar.

As in Experiment 1, an interaction between ownership and distance obtained, $F(2, 38) = 10.50$, $p < .001$; $F(3, 7) = 6.12$, $p < .02$. Owners rated events as more similar than non-owners for adjacent events, $t(17) = 4.66$, $p < .001$; $t(75) = 4.69$, $p < .001$, and events two apart, $t(17) = 2.67$, $p < .02$; $t(75) = 2.86$, $p < .01$. There was no significant difference between owners and non-owners for events three apart in the GLM ANOVA, $t(17) = 1.38$, $p > .5$; but owners' ratings were marginally higher in the MM ANOVA, $t(75) = 1.80$, $p < .08$. Furthermore, owners and non-owners did not differ signficantly when rating events between strings, $t(17) = 0.41$, $p > .9$; $t(75) = 0.29$, $p > .9$. This pattern of simple main effects is almost identical to Experiment 1, although there appears to be a slightly greater difference between owners and non-owners for events that were three apart.

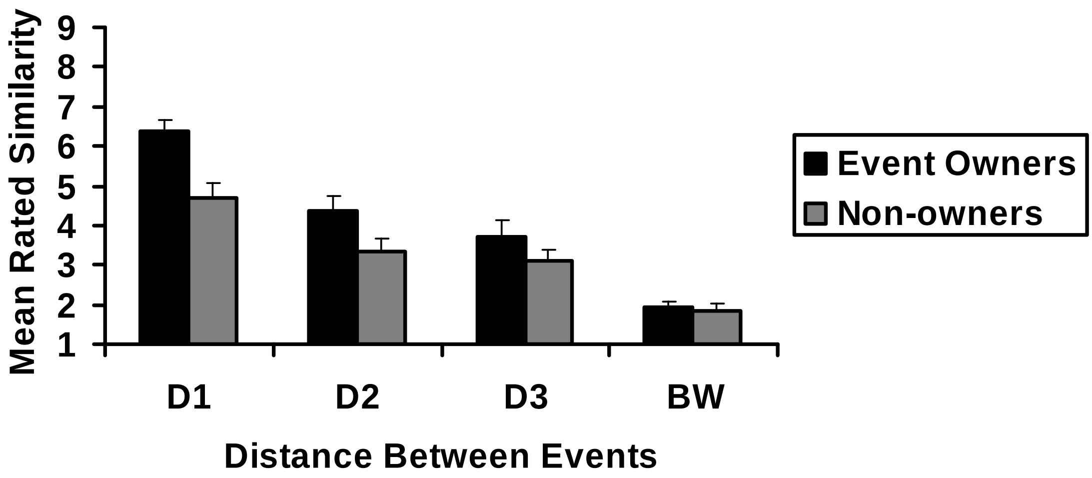

Figure 8. Similarity ratings for Experiment 2 ignoring causality.

Appendix C

Similarity by Causality Results from Experiment 2 Ignoring LSA

The primary purpose was to determine the extent to which similarity varied as a function of event owners and non-owners' perceived causal relations between events. The dependent variable was similarity. A 4 (causal condition: Both Causal, Neither Causal, Only Causal Only, Non-owner Causal Only) X 4 (distance: D1, D2, D3, between strings) X 2 (ownership: event owners, non-owners) Mixed Model ANOVA was conducted using a compound symmetry covariance structure and independent variables treated as fixed within participants factors. Causal Condition was treated as one causal variable with four levels, as opposed to two causal variables (one for each person's ratings) with two levels each because I was primarily interested in whether distance and ownership might interact with causal condition in general. However, an analysis treating causal condition as two variables indicated that each variable interacted with the same other variables, the two causal variables did not interact with each other, and the pattern of multiple comparisons was the same as with one four-level causal variable.

The analysis was performed using the Linear Mixed Function in SPSS. A compound symmetry covariance structure was used because, based on sequential comparisons of model fit (such as -2log likelihood and AIC) starting with an unstructured and Toeplitz covariance structures respectively, compound symmetry was the simplest model that could adequately describe the data. All reported means are raw unweighted means (see Figures 9 through 12). The estimated marginal means from the model appear in Appendix D.

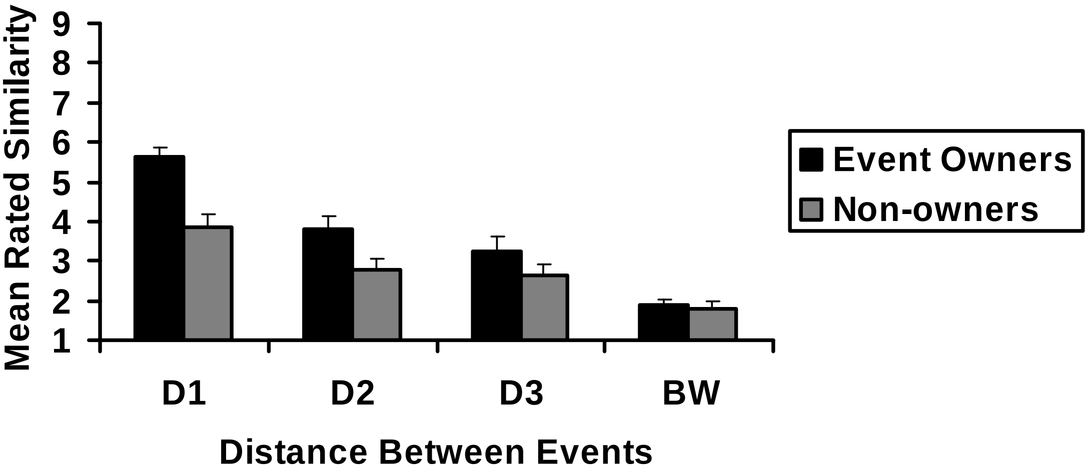

Figure 9. Similarity ratings for Experiment 2 within the Neither Causal Condition.

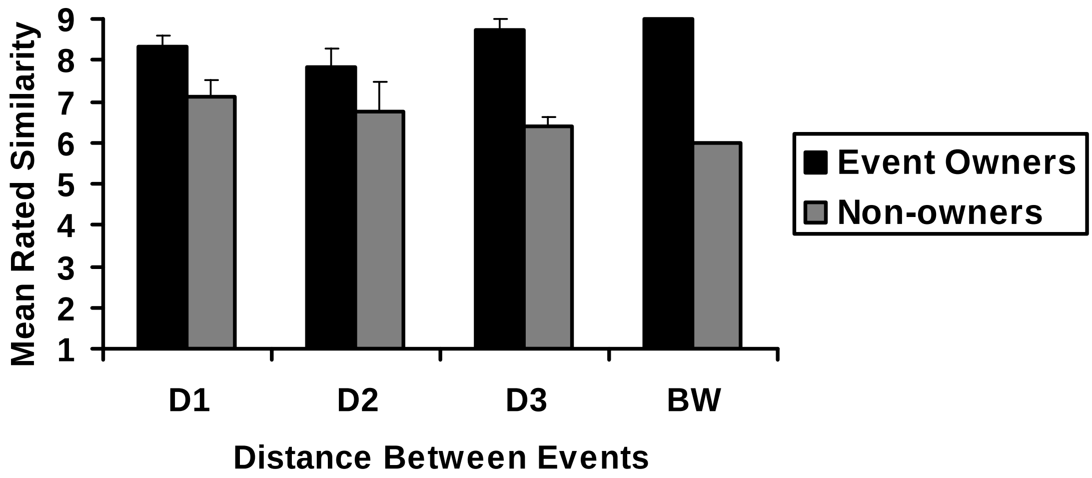

Figure 10. Similarity ratings for Experiment 2 within the Both Causal Condition.

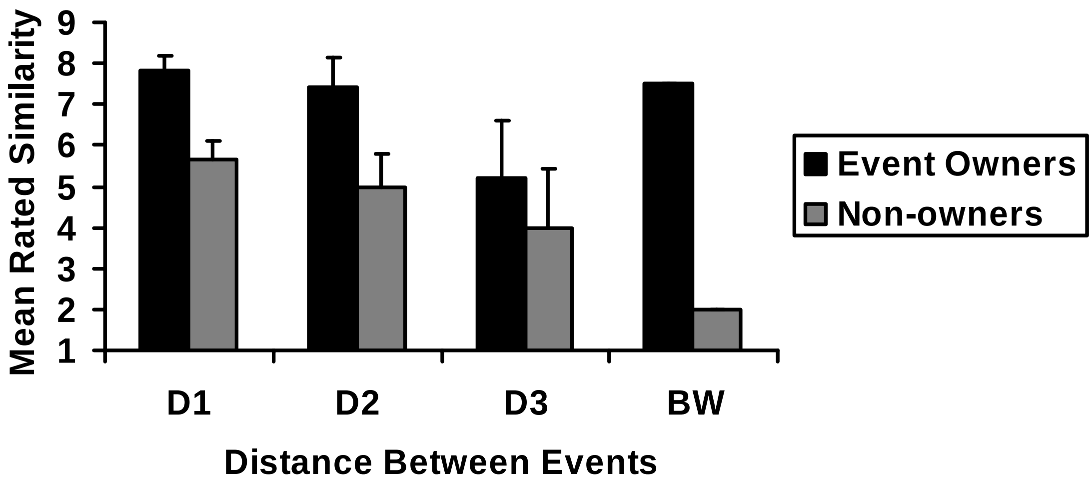

Figure 11. Similarity ratings for Experiment 2 within the Owner Causal Only Condition.

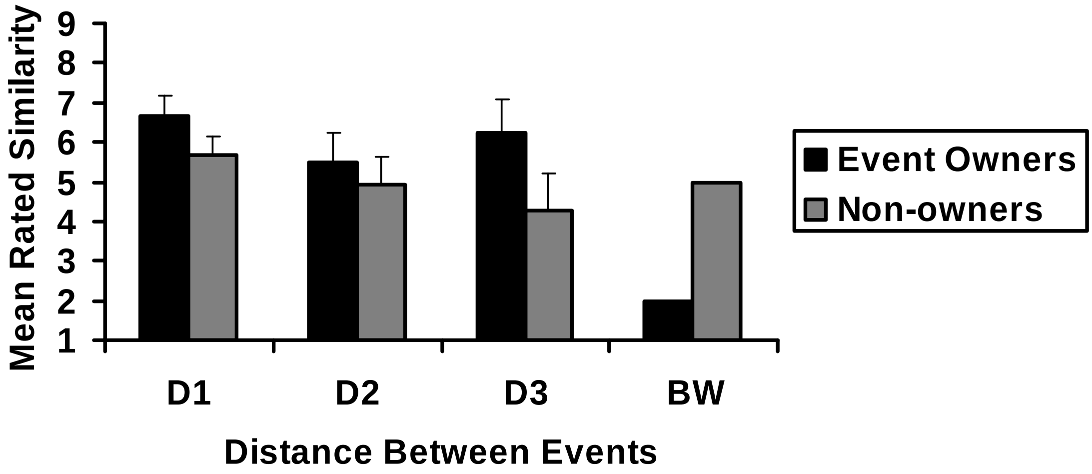

Figure 12. Similarity ratings for Experiment 2 within the Non-owner Causal Only Condition.

Event owners (M = 6.05) rated events as more similar than did non-owners (M = 4.61), $F(1, 319) = 30.24$, $p < .001$. There was a main effect of distance, $F(3, 327)$ = 14.30, $p < .001$. All six pairwise comparisons were evaluated, with Bonferroni correction. Adjacent events (D1s; M = 4.40) were more similar than all other distances, all ts > 3.36, all ps < 0.01. However, D2s (M = 3.83) were not more similar than D3s (M = 3.55), $t(326) = 1.96$, $p > .3$, or between string events (M = 3.08), $t(326) = 1.61$, $p > .6$, and D3s were not more similar than were between string events, $t(326) = 0.64$, $p > .9$. There was also a main effect of causal condition, $F(3, 330) = 68.09$, $p < .001$. Again, to assess this main effect, all six pairwise comparisons were evaluated, with Bonferroni correction. Both Causal events (M = 7.52) were significantly more similar than all other causal conditions, all ts > 6.06, all ps < .001. Neither Causal events (M = 3.20) were significantly less similar than all other causal conditions, all ts > 4.32, all ps < .001. Non-owner Causal Only events (M = 5.04) were not significantly different from Owner Causal Only Events (M = 5.57), $t(326) = -0.99$, $p > .3$. Causal condition and ownership interacted, $F(3, 319) = 4.70$, $p = .003$, as did causal condition and distance, $F(9, 325)$ = 1.87, $p < .06$. In contrast to Experiment 1, ownership and distance did not interact, F<1. These interactions were qualified by a marginally significant interaction among causal condition, ownership and distance, $F(9, 319) = 1.75$, $p < .08$. To investigate this three-way interaction, planned comparisons were conducted between event owners and non-owners at each level of distance and causal condition. Each set of three contrasts between event owners, non- event owners and LSA at each distance level within each causal condition was considered a family. All significance values were adjusted using a Bonferroni procedure as such to make alpha equal to .05 for each family. For the purposes of interpreting the results, the data from the D3 and between strings conditions should be interpreted with caution for Both Causal, Owner Causal Only and Non-owner Causal Only events because the sample size was so low.[6]

In the Neither Causal condition (see Figure 9 for means and standard errors), owners considered D1 event pairs to be more similar than did non-owners, $t(319) = 3.68$, $p < 0.001$, and D2 event pairs to be more similar than did non-owners, $t(319) = 2.09$, $p < 0.05$, but there were no further differences between groups across any other distance levels in this condition, all $ts(319) < 1.20$, all $ps > .1$. For the Both Causal condition (see Figure 10), there were no significant ownership effects for D1, D2, or between string events, all $ts(319) < 2.06$, all $ps > .1$. However, owners rated D3 events as more similar than did non-owners, $t(319) = 3.30$, $p < 0.004$. For the Owner Causal Only condition (see Figure 11), events were rated as more similar by owners than by non-owners for D1s, $t(319) = 4.03$, $p < 0.001$, D2s, $t(319) = 3.75$, $p < 0.001$, and between string events, $t(319) = 2.70$, $p < 0.05$. However, this was not the case for D3s, $t(319) = 1.32$, $p > .5$. Lastly, for the Non-owner Causal Only condition (see Figure 12), there were no ownership effects for D1s, D2s, or between string events, all $ts(319) < 1.97$, all $ps > .14$. However there was an ownership advantage for D3s, $t(319) = 2.38$, $p < 0.06$.

[6] A separate ANOVA omitting the D3s and Between Strings distance levels resulted in the same pattern of results for the D1s and D2s as when D3s and Between Strings events were included in the overall analysis.

Appendix D

Estimated Marginal Means for Experiment 2: Causal Analysis of Similarity Rating Data Ignoring LSA

Causal Condition	Distance	Group	Mean	SE
Neither Causal	D1	Event Owner	5.63	0.37
		Non-owner	3.86	0.37
	D2	Event Owner	3.79	0.37
		Non-owner	2.79	0.37
	D3	Event Owner	3.23	0.37
		Non-owner	2.65	0.37
	Between Strings	Event Owner	1.87	0.37
		Non-owner	1.79	0.37
Both Causal	D1	Event Owner	8.15	0.45
		Non-owner	6.95	0.45
	D2	Event Owner	7.73	0.49
		Non-owner	6.62	0.49
	D3	Event Owner	8.38	0.54
		Non-owner	6.00	0.54
	Between Strings	Event Owner	9.23	1.48
		Non-owner	6.23	1.48
Owner Causal Only	D1	Event Owner	7.87	0.42
		Non-owner	5.67	0.42
	D2	Event Owner	7.29	0.49
		Non-owner	4.87	0.49
	D3	Event Owner	5.17	0.67
		Non-owner	3.97	0.67
	Between Strings	Event Owner	7.73	1.48
		Non-owner	2.23	1.48
Non-owner Causal Only	D1	Event Owner	6.66	0.38
		Non-owner	5.68	0.38
	D2	Event Owner	5.57	0.45
		Non-owner	4.97	0.45
	D3	Event Owner	6.19	0.62
		Non-owner	4.20	0.62
	Between Strings	Event Owner	2.54	1.48
		Non-owner	5.54	1.48

Appendix E

Estimated Marginal Means for Experiment 2: Causal Analysis of Scaled Similarity Data using LSA.

Causal Condition	Distance	Group	Mean	SE
Neither Causal	D1	Event Owner	5.10	0.50
		Non-owner	2.73	0.50
		LSA	1.56	0.50
	D2	Event Owner	2.63	0.50
		Non-owner	1.28	0.50
		LSA	0.53	0.50
	D3	Event Owner	1.88	0.50
		Non-owner	1.10	0.50
		LSA	0.28	0.50
	Between Strings	Event Owner	0.06	0.50
		Non-owner	-0.06	0.50
		LSA	0.00	0.50
Both Causal Only	D1	Event Owner	8.46	0.60
		Non-owner	6.85	0.60
		LSA	2.88	0.60
	D2	Event Owner	7.88	0.65
		Non-owner	6.39	0.65
		LSA	2.68	0.65
	D3	Event Owner	8.73	0.72
		Non-owner	5.54	0.72
		LSA	2.67	0.72
	Between Strings	Event Owner	10.04	1.98
		Non-owner	6.00	1.98
		LSA	6.52	1.98
Owner Causal Only	D1	Event Owner	8.11	0.56
		Non-owner	5.16	0.56
		LSA	2.61	0.56
	D2	Event Owner	7.32	0.65
		Non-owner	4.07	0.65
		LSA	3.48	0.65
	D3	Event Owner	4.51	0.90
		Non-owner	2.89	0.90
		LSA	1.49	0.90
	Between Strings	Event Owner	8.02	1.98

		Non-owner	0.63	1.98
		LSA	0.13	1.98
Non-owner Causal Only	D1	Event Owner	6.48	0.51
		Non-owner	5.17	0.51
		LSA	2.99	0.51
	D2	Event Owner	4.93	0.60
		Non-owner	4.13	0.60
		LSA	2.69	0.60
	D3	Event Owner	5.63	0.83
		Non-owner	2.97	0.83
		LSA	2.42	0.83
	Between Strings	Event Owner	0.91	1.98
		Non-owner	4.94	1.98
		LSA	1.76	1.98

Appendix F

Results of the Scaled Similarity by Causality Analysis from Experiment 2 for D3s and the Between Groups Conditions in the Three Causal Groups

The frequency analysis showed that a maximum of 6.25% of D3s and 0.62% of between strings events were placed in any one condition where an owner and/or non-owner participant rated a pair as causal. When one considers that each participant rates only 8 D3s and 18 Between String events, this means that, on average, each participant would provide less than one event pair any given D3 condition and less than two event pairs for any given Between Strings condition. In fact, ratings of similarity for the Between Strings distance in the Both Causal, Owner Causal Only and Non-owner Causal Only conditions each resulted from a single dataset (but not all from the same one).

Many of the patterns of similarity for the events that were provided in these conditions are fairly intuitive numerically. For example, between string events in the Owner Causal Only condition were rated as markedly higher for event owners than for non-owners, whose ratings were in line with those of LSA. Thus, when non-owners see a pair of events as causally unrelated, their similarity rating is based on the similar words between the two event descriptions, whereas event owners' ratings are heightened because they perceive a causal relation. The same is true for the between string condition of the Non-owner Causal Only condition, in which non-owners' similarity ratings were much higher than those of owners and LSA, with the latter two being comparable. For the Both Causal Condition, non-owners' and LSA similarities were much larger than that reported in the other distances within this causal condition, which indicates that between string events were only found to be causally related by both groups if the similarity between the pair of otherwise unrelated events was unusually high. However, many of these numerical differences were not significant due to the large standard errors resulting from the small sample within this condition. Unfortunately, because these data rely on participants to put items into various conditions, adding participants is not guaranteed to improve power. Nonetheless, the sample size in the other conditions was sufficient to make interpretation possible.

Appendix G

Psychology Research Ethics Board Ethical Approval

Western

Department of Psychology The University of Western Ontario
Room 7418 Social Sciences Centre,
London, ON, Canada N6A 5C1
Telephone: (519) 661-2067Fax: (519) 661-3961

Use of Human Subjects - Ethics Approval Notice

Review Number	**09 02 08**	**Approval Date**	**09 02 24**
Principal Investigator	**Albert Katz/Chris O'Connor**	**End Date**	**09 11 30**
Protocol Title	**Investigating autobiographical memories**		
Sponsor	**n/a**		

This is to notify you that The University of Western Ontario Department of Psychology Research Ethics Board (PREB) has granted expedited ethics approval to the above named research study on the date noted above.

The PREB is a sub-REB of The University of Western Ontario's Research Ethics Board for Non-Medical Research Involving Human Subjects (NMREB) which is organized and operates according to the Tri-Council Policy Statement and the applicable laws and regulations of Ontario. (See Office of Research Ethics web site: http://www.uwo.ca/research/ethics/)

This approval shall remain valid until end date noted above assuming timely and acceptable responses to the University's periodic requests for surveillance and monitoring information.

During the course of the research, no deviations from, or changes to, the protocol or consent form may be initiated without prior written approval from the PREB except when necessary to eliminate immediate hazards to the subject or when the change(s) involve only logistical or administrative aspects of the study (e.g. change of research assistant, telephone number etc). Subjects must receive a copy of the information/consent documentation.

Investigators must promptly also report to the PREB:
a) changes increasing the risk to the participant(s) and or affecting significantly the conduct of the study;
b) all adverse and unexpected experiences or events that are both serious and unexpected;
c) new information that may adversely affect the safety of the subjects or the conduct of the study.

If these changes/adverse events require a change to the information/consent documentation, and/or recruitment advertisement, the newly revised information/consent documentation, and/or advertisement, must be submitted to the PREB for approval.

Members of the PREB who are named as investigators in research studies, or declare a conflict of interest, do not participate in discussion related to, nor vote on, such studies when they are presented to the PREB.

Clive Seligman Ph.D.

Chair, Psychology Expedited Research Ethics Board (PREB)

The other members of the 2008-2009 PREB are: David Dozois, Bill Fisher, Riley Hinson and Steve Lupker

CC: UWO Office of Research Ethics

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Use of Human Subjects - Ethics Approval Notice

Review Number	09 02 07	**Approval Date**	09 02 24
Principal Investigator	Albert Katz/Chris O'Connor	**End Date**	09 11 30
Protocol Title	Investigating event memories		
Sponsor	n/a		

This is to notify you that The University of Western Ontario Department of Psychology Research Ethics Board (PREB) has granted expedited ethics approval to the above named research study on the date noted above.

The PREB is a sub-REB of The University of Western Ontario's Research Ethics Board for Non-Medical Research Involving Human Subjects (NMREB) which is organized and operates according to the Tri-Council Policy Statement and the applicable laws and regulations of Ontario. (See Office of Research Ethics web site: http://www.uwo.ca/research/ethics/)

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Clive Seligman Ph.D.

Chair. Psychology Expedited Research Ethics Board (PREB)

The other members of the 2008-2009 PREB are: David Dozois, Bill Fisher, Riley Hinson and Steve Lupker

CC: UWO Office of Research Ethics

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Curriculum Vitae

CHRISTOPHER MARK O'CONNOR

Department of Psychology, University of Western Ontario

Education:

2010 (Expected)	PhD	Department of Psychology, University of Western Ontario Thesis Title: Causality and Similarity in Autobiographical Event Structure: An Investigation Using Event Cueing and Latent Semantic Analysis
2006	MSc	Department of Psychology, University of Western Ontario Thesis Title: Conceptual Hierarchies Arise from the Dynamics of Learning and Processing: Insights from a Flat Attractor Network
2004	BA	Department of Psychology, University of Western Ontario Thesis Title: A Connectionist Approach to the Etiology of the Tip-of-the-Tongue Phenomenon
2002	BMus	The Don Wright Faculty of Music, University of Western Ontario (Music Theory)

Scholarship & Awards:

2009-2010 Ontario Graduate Scholarship

2007-2008 Graduate Student Teaching Award

2006-2007 Graduate Student Teaching Award

2005-2006 Graduate Student Teaching Award – Nominated

Teaching Experience:

2009-2010 Research Design (Advanced Statistics for Graduate Students), Teaching Assistant

2007-2009 Honors Thesis (4th Year Honors Thesis Course), Teaching Assistant

2005-2007 Psychological Statistics Using Computers, Lab Instructor/Teaching Assistant

2004-2005 Research Methods in Psychology, Lab Instructor/Teaching Assistant

Professional Activities:

2009-2010 UWO Language and Concepts Research Group Seminars, Organizer/Coordinator

2006-2008 UWO Psychology Graduate Affairs Committee (Student Representative)

2007-2008 The 18th Annual Meeting of the Canadian Society for Brain, Behaviour and Cognitive Science, Conference Volunteer

2005-2006 Councilor, Society of Graduate Students (Student Representative)

2004-2005 The 34th Annual Lake Ontario Visionary Establishment Conference, Volunteer

Publications:

Peer reviewed journal articles:

O'Connor, C.M., Cree, G.S., & McRae, K. (2009). Conceptual Hierarchies in a Flat Attractor Network: Dynamics of Learning and Computations. *Cognitive Science, 33,* 665-708.

Conference Presentations:

O'Connor, C. M., & Katz, A. (2008). Event Clusters in Autobiographical Memory: A Multidimensional Scaling of Autobiographical Events. Poster presented at the *Eighteenth Annual Meeting of the Canadian Society for Brain, Behaviour and Cognitive Science*, London, Ontario, Canada.

McRae, K. & **O'Connor, C. M.**, & Cree, G. S. (2007, August). Emergent conceptual hierarchies and the dynamics of similarity. Invited Talk in P. Li (Chair), Rumelhart Symposium: Language as a Dynamical System: In Honor of Jeff Elman. *Twenty-Ninth Annual Conference of the Cognitive Science Society*, Nashville, TN.

O'Connor, C. M., McRae, K., & Cree, G. S. (2006, July). Conceptual hierarchies arise from the dynamics of learning and processing: Insights from a flat attractor network. Poster presented at the *Twenty-Eighth Annual Conference of the Cognitive Science Society*, Vancouver, B.C., Canada.