Indexing Events in Memory: Evidence for Index Dominance

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Research on narrative comprehension and autobiographical memory converge on three hypotheses which make different predictions about event organisation. The availability of different event components as indexes may explain the convergence on three hypotheses rather than one. In this paper, three experiments assessed event indexing in narratives with different available indexes. In Experiment 1, participants read event descriptions organised by character or time. In Experiment 2, event descriptions were organised by character or location. In Experiment 3, participants read event descriptions where events were grouped by activity. In each experiment, memory could be organised by any of the available components alone, by both components, or by using the organisation imposed by the discourse. Participants indexed events by character in Experiment 1, re-indexing information when necessary. Results of Experiment 2 indicated equal use of character and location indexes. In this case, participants used the discourse organisation. In Experiment 3, participants indexed events using activity groupings, again re-indexing events when necessary. Results are interpreted as indicating reliance on a single organising index with flexibility in the selection of different event components as indexes.

INTRODUCTION

Although life presents us with continuous activity, we tend to perceive it as discrete events (Newson, 1976). Events are perceived as discrete whether real

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or imaginary, experienced directly or vicariously, emotionally charged or ordinary. Events are rich with information, including the people they involve, the places in which they occur, and the times that they happen. The basic tenets of journalism define the essential components of events: *who, what, where, when, why, and how.* With so many possible events and so many kinds of associated information, how do people organise events in memory?

Two primary areas of research have addressed organisation of events in memory: autobiographical memory and narrative comprehension. In autobiographical memory, events typically include visual, auditory, kinaesthetic, olfactory, and/or tactile information. Autobiographical events are typically personal and spontaneous. Narrative events, in contrast, are often orchestrated and limited to written or spoken text, or perhaps slides or movies. The act of reading a description of events can itself become an event in autobiographical memory, including the colour of the book, the size and style of the type, and the feel of the paper as well as the meaning of the prose. Despite essential differences, many of the same issues and hypotheses about organisation of events have been raised by both research areas. The current studies address narrative events, and generalise only to this domain, but the discussion draws on both literatures.

**Two Elements of Organisation: Sequencing and Indexing**

Event organisation occurs on two levels: *sequencing* and *indexing*. Sequencing refers to the order in which memories are recalled. Indexing refers to the system of tags or cues, based on the event components, used to access memories. Therefore, indexes can cue sequences. A clear discussion of organisation needs the level of organisation to be specified. Although many studies have clearly distinguished between sequencing and indexing (e.g. Anderson & Conway, 1993; Barsalou, 1988; Conway, 1992; Kolodner, 1984), failure to do so can lead to confusion.

Organisational level is particularly relevant to the time component of events. For sequencing autobiographical events, most studies find evidence supporting a chronological order (Tulving, 1983; Whitten & Leonard, 1981). Anderson and Conway (1993) found faster retrieval of autobiographical events when participants recalled in chronological order, compared to other possible orders including reverse order, order of decreasing centrality, or order of decreasing interest. Friedman (1987; Friedman & Wilkins, 1985) found evidence that events cue other temporally close events. Similarly, Conway (1992) cites neurological evidence of amnesics indicating that temporally contiguous memories are stored close together. Others argue that although a strict chronological ordering is not always possible, events are arranged chronologically within groupings (Barsalou, 1988; Schooler & Hermann, 1992). Still others propose that temporal information may not be stored in memory at all, but may be reconstructed when needed. Larsen and Thompson and their colleagues (Larsen & Thompson, 1995; Larsen, Thompson, & Hansen, 1996; Thompson, Skowronski, Larsen, & Beitz, 1996) suggest that temporal information is entirely reconstructed based on a number of strategies. One reconstruction strategy uses a week schema whereby information about the day of the week on which an event occurred helps in estimating the correct date (Huttenlocher, Hedges, & Prohaska, 1992; Thompson et al., 1996). Other strategies rely on information recalled about the event, about the event's relation to other events, or incorporated from world knowledge.

The role of temporal links to sequence events in both scripts and narrative events is less clear. Some work strongly supports temporal order sequences (Abbott, Black, & Smith, 1985; Barsalou & Sewell, 1983; Schank & Abelson, 1977). For scripted events, randomly ordering sentences (or paragraphs) at presentation decreases recall (Kintsch, Mandel, & Kozminsky, 1977; Stein & Nezworski, 1978; Thorndyke, 1977). Additionally, events presented in nontemporal order are often recalled in temporal order (Bower, Black, & Turner, 1979; Kintsch et al., 1977; Mandler, 1978; Stein & Glenn, 1978), perhaps because the temporal order can be reconstructed from long-term memory (Bower et al., 1979; Galambos & Rips, 1982; Schank & Abelson, 1977). However, even using model-based events, the order of which can only be ascertained from the text, Ohtsuka and Brewer (1992) found improved comprehension when text order matched event order.

Others argue that temporal order is only weakly maintained in memory and that causality or centrality plays a greater role in sequencing (e.g. Galambos & Rips, 1982; Nottenham & Shoben, 1980). Van den Broek, Risden, Fletcher, and Thurlow (1996) found that causal relations in a story predicted recall order better than temporal relations. Other recent work on retrieval of text memory has found similar results (e.g. Fletcher, van den Broek, & Arthur, 1996). Galambos and Rips (1982) found priming based on centrality, but no evidence of priming based on temporal proximity. Similarly, Reder and Abelson (described in Abelson, 1981) found no comprehension deficit when events that were temporally distant, but central to a script, were juxtaposed in a passage.

How people index events in memory, the central question here, is even less clear. Different measures have been used to determine effectiveness of index or cue use, including speed of access, success of retrieval number of items retrieved, and subjective reports of organisation. From this set of previously used methodologies, we are concentrating on speed and accuracy of retrieval and subjective reports of organisation as the primary indicators of index effectiveness.

Evidence addressing event indexing can be summarised by three hypotheses. In the first, the Combined Index Hypothesis, two or more event components meaningfully combine into a single index. The combination leads to faster and
more accurate access. The other two hypotheses focus on single components as indexes. According to the Index Dominance Hypothesis, some components are differentially more effective than others in organising events in memory. The most effective component available will be used as the index. According to the Equitopential Index Hypothesis, all components serve equally well as indexes, although only one component is used for any given retrieval.

Combined Index Hypothesis

Extended event time lines accurately cue autobiographical events (Barsalou, 1988; Conway & Bekerian, 1987; Schooter & Hermann, 1992). Extended event time lines are defined as lifetime periods designated by two or more event components, an effective combination for summarising events (Barsalou, 1988). For example, "when I was in college", is defined by a location (college) and a time (approximately a four-year period); or "when I travelled in Europe with Aunt Mae," is defined by a location (Europe), a participant (Aunt Mae), and a time (a two-month period). Time is an important element in the extended event time lines, as the time embedded in these higher-order periods is linear and may help to keep track of consecutive time cycles (Thompson et al., 1996). Additionally, the time boundaries between time lines are well remembered (Robinson, 1992), serving as temporal landmarks (Loftus & Marburger, 1983). Conway and Bekerian (1987) found that extended event time lines primed autobiographical memory, whereas other potential primes, such as semantic categories or emotion terms, did not. Memory for public events, although it lacks the same degree of informativeness and salience as autobiographical memory (Brown, 1990; Friedman, 1987; Friedman & Wilkins, 1985; Larsen, 1988), also organises around extended event time lines (Larsen, 1988). These time lines relate either to personal life history or to public history, such as presidential administrations (Brown, 1990; Friedman, 1987; Friedman & Wilkins, 1985; Larsen, 1988).

The Combined Index Hypothesis is important for an overall understanding of the structure of event memory. Consensus on use of extended event time lines comes from both autobiographical and narrative research. For several reasons, however, this hypothesis will not be relevant to the present research. First, extended event time lines incorporate events spanning long time frames. Events in short narratives only span a short time. Second, extended event time lines group many events. However, the event structure used in this study is such that the combination of two event components cues just a single event.

Index Dominance Hypothesis

Some work on autobiographical memory indicates that certain individual components serve as better indexes than others. Although any of the six components (who, what, where, when, why, and how) is a potential index, the uniqueness of the component, i.e., how well it distinguishes one event from another, influences its effectiveness as an index (Burt, Mitchell, & Cowan, 1995). Time is an exception to the uniqueness idea, as the exact time that an event occurs is unique, yet exact times are rarely remembered (Bradburn, Rips, & Shavell, 1987; Huttenlocher, Hedges, & Prohsaka, 1988; Larsen, 1993; Linton, 1975; Loftus & Marburger, 1983; Thompson, Skowronski, & Betz, 1993; Thompson, Skowronski, & Lee, 1988; Wagenaar, 1986). Instead, people remember time relatively, either based on recency (Linton, 1975; Yutema & Trask, 1963), by comparison to temporal landmarks (Loftus & Marburger, 1983), or by reconstruction based on temporal schemata (Larsen, 1993; Larsen & Thompson, 1995; Larsen et al., 1995; Thompson et al., 1995). The salience of the relative nature of time may arise due to the dual nature of time. Time is both linear and cyclic. Larsen and Thompson and their colleagues (Larsen, 1993; Larsen & Thompson, 1995; Larsen et al., 1996; Thompson et al., 1996) find that dating errors may have more to do with the linear than the cyclic nature of time. Individuals’ dating errors tend to follow a seven-day scalloped function, indicating accuracy with respect to the day of the week, but not with respect to the specific week. Similar findings have been shown by Huttenlocher, Hedges, and Prohsaka (1992). The cyclic aspect of time is not unique. For example, many events could occur on a Tuesday. Furthermore, the information provided by day of the week knowledge only provides information about the nature of an event for regularly scheduled events (e.g., my cognitive lab class only meets on Tuesdays) and does not exclude other events that occurred on the same day. Two components, why and how, have not been investigated within the autobiographical domain.

With the remaining components, uniqueness should predict the order what, where, then who (Burt et al., 1995). What refers to the type of event and as only a subset of events fits into any event category, it provides a relatively unique cue to individual events. Research supports the effectiveness of activities as indexes (Kolodner, 1983a; Reiser, Black, & Abelson, 1985; Reiser, Black, & Kalamarides, 1986); although in some cases (Reiser et al., 1985) the support is questionable, as stimuli were confounded with other components, such as temporal order. For the where dimension, because different events occur in the same place, the uniqueness value decreases. Similarly, we participate in different activities with the same people. Place, however, is somewhat more restrictive than character and consequently closer to being unique. Studies examining the relative effectiveness of these three components as cues support the uniqueness ordering (Burt, 1992; Burt et al., 1995; Wagenaar, 1986).

Basing an index dominance ordering on uniqueness leaves open the possibility of context effects. The context in which events occur will define the uniqueness of the components. For example, if one character carries out multiple events in multiple locations, where is more unique than who for each particular event, as predicted by the typical uniqueness ordering. But, if multiple
characters carry out multiple events in a single location, then who is more unique than where for any particular event. Consequently, although there is a typical predicted index dominance order, this order is not immune to the effects that context has on uniqueness.

Within narrative research, the work on scripted events supports the Index Dominance Hypothesis. The nature of scripts assumes organisation around an activity, such as going to a restaurant or attending a lecture. Using the activities as a cue, people generally agree on the constituent actions and their order (Bower et al., 1979; Galambos & Rips, 1982), make inferences about the main actions comprising the activity (Abbott et al., 1985), and easily retrieve actions central to the activity (Barsalou & Sewell, 1985; Nottenburg & Shoben, 1980).

Other narrative work supports how and why as dominant indexes. These studies show better memory for events related to goals and when the causal structure is strong (e.g. Bower, 1978; Mandler & Johnson, 1977; Rumelhart, 1977; Stein & Nezworski, 1978; Thorndyke, 1977; Trabasso & van den Broek, 1985; van den Broek, 1988).

**Equipotential Index Hypothesis**

Other work indicates that all event components can be used to access autobiographical memory, implying the existence of multiple retrieval pathways. Barsalou (1988) found no difference in cue effectiveness for recalling using people, activities, locations, and times as cues. Robinson (1976) found no difference between object and activity cues. While Kolodner's (1983a,b, 1984) model CYRUS assumes activities are the primary organisers in the form of E-MOPS, it incorporates a hierarchical system of indexes, related to participants, locations, actions, and times, for retrieval of specific events. Index reorganisation occurs after the addition of any new item, and specific events can be cross-indexed, allowing different retrieval paths. Although Kolodner's theory and work are based on computer modelling, not empirical findings, the models successfully retrieve event information in a memory system based on Cyrus Vance's memory of political events.

The research in narrative shifts also supports the Equipotential Index Hypothesis. Gernsbacher (1990) proposes that people build knowledge structures while comprehending narratives. New textual information is incorporated into the current knowledge structure whenever possible. If, however, new information cannot be incorporated, a new knowledge structure is created. A shift can move the narrative from one character to another, from one time to another, from one place to another, from one activity to another, or from one goal to another, corresponding to the different event components. Narrative shifts necessitate the creation of new knowledge structures. The work of Zwaan and his colleagues indicates that people keep track of all types of narrative shifts, updating the appropriate indexes following shifts (Zwaan, Langston, & Graesser, 1995; Zwaan & van Oostendorp, 1993).

The Equipotential Index Hypothesis may have an alternate interpretation—that different indexes work for different situations, rather than simply that all indexes are equally effective in accessing memory. This alternate interpretation fits the supporting data, as main effects of index type would disappear given different contexts. It seems clear that different elements of events carry differential importance. Take for example, two events with the same character. In one event a friend helps you study for an important test at school. In the other, you go out and have an amazing dinner with this same friend at your favourite restaurant. Between these two events, the school event may be better accessed using your friend as a cue, whereas the restaurant event may be better accessed using the location as a cue. Recall of both of these events together would indicate that both characters and locations serve as effective cues. Based on this interpretation, support for the Equipotential Index hypothesis should account for context.

In summary, three hypotheses emerge from the literature on both narrative and autobiographical memory regarding the organisation of events. Two of these hypotheses will be examined in the current research, the Index Dominance Hypothesis and the Equipotential Index Hypothesis. Work supporting the Index Dominance Hypothesis indicates that some event components make better indexes than others (Bower et al., 1979; Burt, 1992; Burt et al., 1995; Reiser et al., 1985; Reiser et al., 1986; Schank & Abelson, 1977; Wagenar, 1986). Research supporting the Equipotential Index Hypothesis, shows that all components can serve as effective avenues of access (Barsalou, 1988; Kolodner, 1983a, 1984; Robinson, 1976; Zwaan et al., 1995; Zwaan & van Oostendorp, 1993).

**Current Research**

Our current research examines event components two-by-two to determine how the availability of different event components influences indexing. Events, defined by two event components, were presented to participants through narratives. Experiment 1 examines who and when. Experiment 2 examines who and where. Experiment 3 groups events by what and relates groupings to either who or when. Components not under investigation were controlled, making their use as indexes unlikely.

With only two components available as indexes, the hypotheses make different predictions. The Index Dominance Hypothesis predicts that some components serve as better indexes than others and will consequently receive greater use. The Equipotential Index Hypothesis predicts that participants use both components as indexes, creating something akin to a matrix. Access with
one component should be undistinguishable from access with the other. The use of narratives to present events raises another possibility. By necessity, narratives can only present one event at a time and the relationship between events is established linguistically. The ordering or structure of the events within the narrative is determined prior to narrative presentation. Given a structure, participants may simply rely on the narrative organisation in indexing the events in memory. This is particularly true for the relatively simple narrative structure used in these experiments. In this case, the index used for retrieval would match that used in the narrative presentation. We shall call this the Narrative Index Hypothesis.

EXPERIMENT 1: WHO VS. WHEN

In this experiment, characters and times served as possible indexes. Either component could potentially be used as an index. Supporting character as the dominant index is the fact that characters are concrete, vivid, and perceived as causal agents of events. Supporting time is the fact that temporal categories are familiar, widely used, and often associated with specific activities (Nelson, 1993). Tulving (1983), among others, has claimed that time is the basic means of organising episodic memory. However, the organising capacity served by time may be more related to sequencing than to indexing. Working against time as the dominant index is the argument that temporal elements are rarely stored in memory directly and are, instead, reconstructed from other available event details, including the people taking part in the event (Larsen & Thompson, 1995; Larsen et al., 1996; Thompson et al., 1996).

According to the Equipotential Index Hypothesis, both components should have equal access to memory. Finally, according to the Narrative Index Hypothesis, a hypothesis only relevant to discourse events, the component serving as an index is determined by the narrative organisation. This hypothesis only pertains to discourse events. When actually experiencing events, who, what, where, and when occur simultaneously. When relating events, these components must be presented linearly, as language is linear. Thus, certain event components have a necessary priority over others, which is determined by the narrator. The components could, realistically, be described in any order. As reorganising information takes time and effort (Black, Turner, & Bower, 1979), reliance on the narrative organisation may reduce cognitive load.

In summary, there are three possible outcomes. Participants could use a single index determined either by index dominance (Index Dominance Hypothesis) or by the narrative presentation order (Narrative Index Hypothesis). Finally, participants could use both components as indexes, cross-referencing information (Equipotential Index Hypothesis).

To investigate how character and time are used in organising memory for events, we wrote descriptions of simple event scenarios where the events were not related to character, to time, or to each other, except through the narrative. In this way, we can investigate the core features of events. Who, where, and when define individual events. What and why define events in relation to other events. We were initially interested in how these core features are used to index events. Several measures were used to assess how participants indexed the descriptions: reading time, reaction time and accuracy to test items, and post-experiment diagrams. Reading time indicates how difficult narrative information is to integrate into memory and is commonly used in research on narrative comprehension (e.g., Rumelhart, 1984). Reaction time and accuracy to test items indicates ease of access from memory. The post-experiment diagrams provide subjective assessments of memory organisation. When producing diagrams, participants use metacognitive insights into their memory performance. Although meta cognitive information may not be a perfect indicator of memory processes, it has been shown to be a good predictor of performance on tasks requiring event knowledge, such as dating error and probability of recall (Thompson et al., 1996). The diagrams also provided some information about order of recall, another measure sometimes used to indicate memory organisation (e.g., Tulving, 1962).

Method

Participants

A total of 47 undergraduates from Stanford University participated in groups of three either in partial fulfilment of a course requirement or for pay.

Materials

Descriptions. We wrote pairs of descriptions relating the events of two scenarios, The Stakeout and The Retirement Centre. Each scenario relates events with respect to two elements—characters and times of day (see Fig. 1 for matrix depicting Retirement Centre scenario). All characters within a scenario were the same gender, females in The Stakeout and males in The Retirement Centre. Events within scenarios were independent of one another, of specific times, and of specific characters. Individual events only occurred in one scenario.

Description pairs presented a scenario's events in different orders. One grouped events by character (character description), presenting all of one character's events in chronological order before moving on to the next character. The other description grouped events by time of day (time description), presenting events occurring during one time period and then moving chronologically to the next time period. A sentence in the description introduction indicated the presentation organisation.

Filler information made the descriptions more story-like. An introductory paragraph provided a setting, introduced the characters and times, and
presented a basic plot. A descriptive sentence followed the mention of each event. Characters were referred to by first names, times of day using common terms such as morning and afternoon, and events using two-word phrases consisting of an action and an object of the action. See Table 1 for an example description.

Descriptions were equated for repetition of character names and time labels. All character names had two syllables and were of approximately equal familiarity. Frequency of mention of character names and time labels was equated as follows. The description orders required different sentence structures to match an event unambiguously with a character and a time. In character descriptions, the time label preceded the event; in time descriptions, the character name preceded the event. Thus, initially character descriptions repeated time labels more often and time descriptions repeated character names more often. To rectify this imbalance, character names were repeated twice in character descriptions, resulting in three mentions of character names; time labels were repeated twice in time descriptions, resulting in three mentions of time labels.

Test Items. The test items consisted of pairs of event descriptions, the same two-word phrases used in the event descriptions. Three types of pairs were possible: two events that occurred at the same time (time pairs), two events done by the same character (character pairs), and two events that occurred at different times and by different characters (both-feature pairs).

Postexperiment Diagram. The postexperiment diagram included the instructions: “Please draw a diagram representing the way you remembered the information in the second story you studied”, printed on an otherwise blank sheet of paper.

Design and Procedure

Participants sat at an IBM AT controlled by Micro Experimental Lab (MEL) software (Schneider, 1988) and read instructions stating that the experiment consisted of two descriptions, each followed by a memory test. The nature of the memory test was not stated. Participants studied one time description and one character description, in counterbalanced order. Descriptions appeared approximately 23 lines at a time, requiring three screens for a complete presentation. Study time for each screen was recorded. Participants were told to study until they felt they were capable of taking an unspecified memory test. Participants studied at their own pace, cycling through a story a maximum of four times. This self-paced and self-terminating study procedure was used rather than one using learning-to-criteria so as not to bias performance on the later memory tests. Note-taking was not allowed. Tasks for one description were completed before presentation of the second.

Two blocked memory tests accompanied each description, one focusing on characters (character focus test) and the other focusing on times (time focus test). The character focus test asked participants to assess whether pairs of events were done by the same character or by different characters. The time focus test asked whether pairs of events occurred at the same time or at different times. Test order was randomised for each description and instructions

<table>
<thead>
<tr>
<th></th>
<th>Arnold</th>
<th>Conrad</th>
<th>Marvin</th>
<th>Jerry</th>
</tr>
</thead>
<tbody>
<tr>
<td>morning</td>
<td>wrote letter</td>
<td>painted picture</td>
<td>sang ballads</td>
<td>baked cookies</td>
</tr>
<tr>
<td>after lunch</td>
<td>made ceramics</td>
<td>called friend</td>
<td>played bingo</td>
<td>watched TV</td>
</tr>
<tr>
<td>before dinner</td>
<td>took walk</td>
<td>read novel</td>
<td>talked polities</td>
<td>practised piano</td>
</tr>
<tr>
<td>evening</td>
<td>met attorney</td>
<td>petted cats</td>
<td>did aerobics</td>
<td>delivered mail</td>
</tr>
</tbody>
</table>

FIG. 1. Matrix of events for The Retirement Centre scenario, Experiment 1.

<p>| | | | |</p>
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| Cedar Village is a retirement community designed for senior citizens who still enjoy an active lifestyle. The grounds in the community have many walking trails, tennis courts, and even a golf course. Planned activities go on all day in the many different recreation areas. Not too long ago, the planning staff noticed differences in the attendance at planned activities. Some had extremely low attendance while others attracted almost everyone. So the staff decided to overhaul the recreation program so that planned activities occurred when the residents wanted them. To determine when residents preferred to do what, the staff decided to note which activities four of their newest residents chose on a specific day. The planned recreational activities occurred in the morning, after lunch, before dinner, and in the evening. The residents they chose to follow were Arnold, Conrad, Marvin, and Jerry. The staff noted these residents' activities for one day and then gave their notes to the planning staff. To best determine when residents preferred to do what, the staff organised their notes on their residents' activities by time of day. First they looked at the schedule of morning activities. Arnold wrote a letter to his son. His son is stationed in South Korea with the Air Force. During the morning, Conrad painted a picture of a bird. This particular bird regularly perches on a tree outside the cafeteria. Marvin sang ballads at a group sing-a-long. A different resident organises the sing-a-ongs each week. That morning, Jerry baked cookies in one of the kitchens. Although the residents eat meals in the dining hall, the kitchenettes are available when a snack attack hits.

[Description continues with remaining time periods]
immediately preceded each memory test. Participants responded using keys marked “SAME” and “DIFF”.

For both tests, 60 event pairs (e.g. swam laps, played bingo) appeared side by side, vertically and horizontally centred. One event was randomly assigned to the right side of the screen. Each participant received the pairs in a different random order. The test pairs selected depended on the test focus. Character focus tests consisted of 12 time pairs (correct response is DIFF), 24 character pairs (correct response is SAME), and 24 both-feature pairs (correct response is DIFF). This combination results in approximately equal numbers of SAME and DIFF pairs (24 SAME and 36 DIFF). All possible character pairs were used. One-half and one-third of the time and both-feature pairs, respectively, were used. When all possible pairs were not used, pairs selected represented an equal distribution in terms of distance of mention in the event descriptions. This criteria was selected to assure testing of conceptual indexing rather than recency of mention in the descriptions. The same criteria applied to time focus tests resulted in use of 24 time pairs, 12 character pairs, and 24 both-feature pairs. Reaction time and accuracy for each pair were recorded. After completing tasks for both descriptions, participants drew their postexperiment diagram.

Results

Based on the error rate analysis, six participants were eliminated from all analyses. Two participants had errors indicating chance performance. Error patterns of four additional participants indicated that they did not follow the test instructions. Because correct responses to test pairs interact with the test foci, this pattern was easy to identify. For time pairs, the correct response is same for time focus tests and different for character focus tests. The opposite is true for character pairs. Therefore, few errors on time and character pairs for one test focus and many errors for the other indicated that a subject did not completely follow instructions.

Study Time

Descriptions ranged in length from 1007 to 1051 syllables. The analyses consisted of a repeated measures design with within-subject factor of description organisation and between-subject factor of order of descriptions. As analyses of study time and study time per syllable yielded similar results, only study time per syllable results will be reported. Participants spent longer studying time descriptions ($M = 0.167$ s/syllable) than character descriptions ($M = 0.156$ s/syllable), $F(1,39) = 3.90, p = .055, MSE = 0.0782$. Analyses showed a significant interaction between description organisation and order of description, $F(1,39) = 16.21, p < .0005, MSE = 0.0782$. Simple effects indicated that when participants studied a time description first ($M = 0.149$), $F(1,39) = 17.59, p < .0005, MSE = 0.0782$. When participants studied a character description first ($M = 0.161$), study time did not decrease for the second (time) description ($M = 0.150$), $F(1,39) = 2.15, n.s., MSE = 0.0782$.

Test Items

The analyses consisted of repeated measures designs using within-subject factors of description organisation, test focus, and test pair. Data for test items were trimmed, based on a criteria of mean plus 2.5 standard deviations, to eliminate outlier reaction times. The trimming procedure eliminated 3.27% of the data. The analyses for both dependent measures, error rate and RT, showed similar patterns, indicating no speed/accuracy trade-off. Analyses of RT included only correct responses.

Although the two dependent measures showed similar patterns, they differed in significance level for other different within-subject factors. The results generally indicate use of a character index. The error rate analyses showed a main effect of description organisation. Participants made more errors after studying a time description ($M = 0.10$) than after studying a character description ($M = 0.06$), $F(1,40) = 4.27, p < .05, MSE = 0.0282$. RT results showed no effect of description organisation. RT results showed a significant main effect of test focus. Participants responded faster when focused on characters ($M = 3426ms$) than when focused on times ($M = 3701ms$), $F(1,40) = 6.54, p < .05, MSE = 1424118$. The error rate results showed no effect of test focus.

Results also showed a significant interaction of description organisation and test focus for RT, $F(1,40) = 7.18, p < .05, MSE = 1143672$. Simple effects analyses indicated that participants showed no effect of test focus after studying a time description, $F(1,40) = 0.01, n.s., MSE = 967095$. However, differences were observed only during character focus tests than during time focus tests after studying a character description, $F(1,40) = 18.11, p < .0005, MSE = 967095$.

As a preliminary means of assessing the generality of these results, analyses were performed on the scenario separately to assess consistency. In these analyses, description organisation served as a between-subject factor. The analyses indicated that, although not always significant, results for the individual scenarios were generally consistent with the overall results, with one exception. The exception arose for one factor in one scenario for the error rate results. Although the overall analyses did not show a test focus effect for error rate, analyses of the Stakeout scenario showed a significant effect of test focus, $F(1,39) = 6.11, p < .05, MSE = 0.0064$, where participants made more errors during character focus tests ($M = 0.08$) than during time focus tests ($M = 0.06$). Although this exception is counter to use of a character index, all other factors in the analysis of The Stakeout scenario supported use of a character index.

Other results indicated that participants responded faster and more accurately to correct different responses than to correct same responses. Error rate results
showed a significant main effect of test pair, $F(2,80) = 7.43$, $P < .005$, $MSe = 0.0049$. Participants responded more accurately to both-feature pairs ($M = 0.06$) than to either character ($M = 0.09$) or character pairs ($M = 0.09$) (see Fig. 2 for error rate results). The correct response to a both-feature pair is different, regardless of the test focus. Correct responses to the other test pairs depends on the test focus. Following this up, the analyses showed a significant interaction between test focus and test pair, $F(2,80) = 52.23$, $P < .0001$, $MSe = 0.005$ for errors and $F(2,80) = 21.63$, $P < .0001$, $MSe = 260215$ for RT. Tukey’s multiple comparisons showed that for time focus tests, participants responded faster and more accurately to both character pairs ($q(3,80) = 7.30$, $P < .01$ for errors and $q(3,80) = 4.9$, $P < .05$ for RT) and both-feature pairs ($q(3,80) = 5.42$, $P < .01$ for errors and $q(3,80) = 4.43$, $P < .05$ for RT) than to time pairs. Similarly, for character focus tests, participants responded faster and more accurately to both time pairs ($q(3,80) = 6.68$, $P < .01$ for errors and $q(3,80) = 4.19$, $P < .05$ for RT) and both-feature pairs ($q(3,80) = 6.43$, $P < .01$ for errors, but not significant for RT) than to character pairs.

**Postexperiment Diagram**

Diagram coding required two steps: determining the diagram organisation and assessing whether the diagram organisation followed the description organisation. Diagram organisations fell into three categories: character, time, and both dimensions. Diagram types fell into two main formats, lists or matrices. For lists, the type of heading dictated the organisation. For example, a list would include a header, such as Conrad and then list all of Conrad’s events, making no explicit indication to time labels. This format would be coded as a character diagram. For matrices, participants often emphasised one dimension, using arrows or boxes. Examples of matrix diagrams with a single organisation include events presented in a matrix configuration with only one dimension labelled or events presented in a matrix configuration with arrows or boxes grouping events along one dimension. If participants did not emphasise one dimension, the matrix was coded as using both dimensions. Two codes scored the diagrams, agreeing on 95% of diagrams. Consensus was reached where disagreement existed. A chi-square analysis showed that diagram organisations differed from description organisations more often for time descriptions, $\chi^2(2, N=16.64, P < .001$ (see Table 2).

**Discussion**

For this experiment, participants had to keep track of multiple events that could be indexed by character, time, or both. The dependent measures converged in support of the *Index Dominance Hypothesis*, with character as the dominant index. This meant that for time descriptions, the information had to be re-indexed. Longer study times for time descriptions give some evidence of re-
TABLE 2
Experiment 1: Postexperiment Diagram Organisation

<table>
<thead>
<tr>
<th>Number of diagrams of each type</th>
<th>Matching Description</th>
<th>Opposite description</th>
<th>Both Features</th>
</tr>
</thead>
<tbody>
<tr>
<td>Character descriptions</td>
<td>17</td>
<td>0</td>
<td>4</td>
</tr>
<tr>
<td>Time descriptions</td>
<td>5</td>
<td>10</td>
<td>5</td>
</tr>
</tbody>
</table>

indexing. Once the events had been learned, participants responded faster to test items when focusing on characters. This was especially true after studying a character description. Finally, a majority of participants drew diagrams emphasising the character component. Some participants who had studied time descriptions drew character diagrams, but no participants who had studied character descriptions drew time diagrams.

Although the majority of participants drew character diagrams, some included both dimensions in their diagrams. If the diagrams indicate memory organisation, then these participants may show a greater likelihood to cross-index information from the descriptions. There was weak evidence that this may have occurred. A post-hoc division of participants into groups based on their diagram organisation and subsequent analyses showed some differences between these groups. In particular this analysis indicated that the effects pointing to indexing by character were stronger for participants who drew character diagrams than for participants who emphasised both features in their diagrams. We are, however, hesitant to claim much from this finding, as the group who emphasised both dimensions was small.

One possible argument that would lessen the strength of these findings involves adoption of study strategies during the experiment. Although participants did not know the nature of the memory test prior to the test for their first description, they knew its exact nature for the second description and could have, as a result, adopted a different study strategy. Separate analyses using data only from the first description, however, mirrored the overall pattern of results, diminishing the likelihood that strategy differences for the second description may account for the overall results.

A finding unrelated to indexing also emerged. Participants responded faster to a correct response of different than to a correct response of same. This finding is contrary to same/different response patterns for perceptual matching, which generally find faster responses for same (Kreuger, 1978). A two-step procedure has been proposed to explain this more common pattern. Participants first search for a match and, if that fails, check for a difference (Kreuger, 1978; Tversky, 1969). Memory search may use a different strategy where a single difference allows a different response and more comparisons are needed to assure no differences. In fact, different search mechanisms have been attributed to different types of perceptual search, accounting for some findings of faster responses to same pairs (Bindra, Bonderi, & Nishisato, 1968; Sekular & Abrams, 1968). Relatively fast different responses have been noted in some semantic memory experiments, such as when responding to statements like A Chevrolet is a vegetable.

Two related explanations may account for the use of who as the dominant index. First, as suggested by Larsen and Thompson and their colleagues (Larsen & Thompson, 1995; Larsen et al., 1996; Thompson et al., 1996) for autobiographical memory, temporal information may not be coded directly. In the case of our descriptions, time could be reconstructed from order information. There is evidence from the postexperiment diagrams that participants maintained order information. Even in diagrams where the time dimension was not labelled, participants generally listed events in chronological order, a fact also relevant to the second explanation. Second, participants may use time primarily for sequencing events, leaving character for indexing. In this case, only ordinal temporal properties are needed. As stated earlier, participants’ diagrams support this explanation. This explanation also supports the idea that the components available dictate the indexing strategy.

Experiment 2 examines event indexing when the time component is unavailable. Without time, both characters and locations may be used as either indexes or sequences.

EXPERIMENT 2: WHO VS. WHERE

In comparing indexing by location or character, both components could arguably serve as dominant indexes. As stated before, characters serve as the causative agents of events. However, locations are well remembered, making location appropriate for indexing. Locations serve as good cues for remembering other things, harking back to the Method of Loci (Bower, 1970; Naveh-Benjamin, 1987; Radavsky & Zacks, 1991). Work on mental models shows that a single model can be created around a location, thereby decreasing memory load (Franklin & Tversky, 1990; Radavsky & Zacks, 1991). Just as either component could serve as an index, either could also serve as a sequencer. Arguments for the Equipotential Index Hypothesis and the Narrative Index Hypothesis remain the same.

Method

Participants

A total of 58 participants from Stanford University participated in groups of three either in partial fulfillment of a course requirement (undergraduates) or for pay (graduates and undergraduates). Graduate students were not psychology students.
Materials

Descriptions. As in Experiment 1, we wrote pairs of descriptions relating to events of two scenarios, The Stakeout (revised) and Election Time. Each scenario related events with respect to two elements, locations and characters. Descriptions grouped events either around locations (location description) or around characters (character description). Other aspects of description construction followed conventions discussed in Experiment 1.

Test Items. The test items consisted of pairs of events of three types: two events that occurred at the same location (location pairs), two events done by the same character (character pairs), and two events that occurred at different locations and were done by different characters (both-feature pairs). Selection of pairs for tests followed procedures described in Experiment 1.

Postexperiment Diagram. The diagram task was identical to that used in Experiment 1.

Design and Procedure

Participants followed the procedure outlined in Experiment 1, substituting the location components for comparable time components.

Results

Analyses used in Experiment 1 were repeated here. The data for seven participants were lost due to problems in logging data. Based on error rate analysis and criteria described in Experiment 1, five additional participants were eliminated from all analyses. Two participants had errors indicating chance performance. The error patterns for three additional participants indicated failure to follow instructions.

Study Time

Descriptions ranged in length for 942 to 1102 syllables. Total study time and study time per syllable analyses showed similar patterns; thus, only study time per syllable will be reported. Participants spent an average of 0.153 s/syllable on location descriptions and 0.147 s/syllable on character descriptions, a difference that was not significant. Analyses showed a significant interaction between description organisation and order of descriptions, $F(1,43) = 6.77, P < .05, MSe = 0.126$. Simple effects analyses showed that when participants studied a location description first ($M = 0.165$), study time for the second (character) description decreased ($M = 0.139$), $F(1,43) = 5.92, P < .05, MSe = 0.126$. When participants studied a character description first ($M = 0.152$), study time for the second description (location) did not decrease ($M = 0.140$), $F(1,43) = 1.52, P = n.s., MSe = 0.126$.

Test Items

The data were trimmed to eliminate outlier RT using a criteria of mean plus 2.5 standard deviations. This procedure eliminated 4.2% of the data. Error and RT results showed similar patterns, indicating no speed/accuracy trade-off. Error results showed a main effect of description organisation, $F(1,45) = 7.27, P < .01, MSe = 0.0303$. Participants made fewer errors after studying a location description ($M = 0.122$) than after studying a character description ($M = 0.162$). The RT data showed a similar trend, but it did not reach significance. Both measures showed a mean effect of test focus, $F(1,45) = 4.09, P < .05, MSe = 0.0162$ for errors and $F(1,45) = 3.85, P = .06, MSe = 998088$ for RT. Participants responded faster and more accurately to a location focus test ($M = 0.131$ errors, $M = 3607$ms for RT) than to a character focus test ($M = 0.153$ errors, $M = 3774$ms for RT).

As in Experiment 1, separate analyses were performed on the individual scenarios. Description organisation served as a between-subjects factor. Results of both dependent variables followed the same patterns as the overall analyses.

Results again showed faster and more accurate responses for correct different responses than for correct same responses. Error results showed a main effect of test pair, $F(2,90) = 13.45, P < .0001, MSe = 0.0095$. Participants made the fewest errors on both-feature pairs ($M = 0.114$) followed by location pairs ($M = 0.148$) followed by character pairs ($M = 0.165$). Additionally, a significant interaction between test focus and test pair emerged, $F(2,90) = 42.28, P < .0001, MSe = 0.0144$. Tukey's multiple comparisons showed that for location focus tests, participants responded more accurately to both character pairs ($g(3,80) = 7.33, P < .01$) and both-feature pairs ($g(3,80) = 6.42, P < .05$) than to location pairs. For character focus tests, participants responded more accurately to both location pairs ($g(3,80) = 7.14, P < .01$) and both-feature pairs ($g(3,80) = 6.23, P < .05$) than to character pairs. This interaction was also insignificant for the RT results, $F(2,90) = 5.76, P < .005, MSe = 395952$.

Postexperiment Diagrams

Diagram scoring proceeded as in Experiment 1, substituting locations for times. Four participants did not draw diagrams due to an experimenter oversight, so results are based on 42 diagrams. The two coders agreed on 93% of diagrams. Consensus was reached where disagreement existed. Results indicated that diagram organisation matched description organisation with no organisation strategy predominating, $\chi^2(2, N = 42) = 1.823, P = n.s.$ (see Table 3).
**TABLE 3**

<table>
<thead>
<tr>
<th>Number of diagrams of each type</th>
<th>Matching Description</th>
<th>Opposite description</th>
<th>Both Features</th>
</tr>
</thead>
<tbody>
<tr>
<td>Character descriptions</td>
<td>11</td>
<td>6</td>
<td>4</td>
</tr>
<tr>
<td>Time descriptions</td>
<td>12</td>
<td>2</td>
<td>4</td>
</tr>
</tbody>
</table>

**Discussion**

Results of this experiment were mixed, with most support for the *Narrative Index Hypothesis*. Study time favoured a character index. As in Experiment 1, reading time favoured character descriptions. Participants showed a practice effect only if they received the character description second. Responses to test items favoured a location index. Participants made fewer errors after studying location descriptions. Additionally, participants were faster and more accurate to location focused tests. Finally, diagram organisations matched the organisation presented in the descriptions. Participants drew character diagrams after studying character descriptions and drew location diagrams after studying location descriptions. An equal, but small, number of participants with each description type emphasised both components by drawing matrices.

Experiment 1 showed support for the *Index Dominance Hypothesis*, with indexing by character and sequencing by time. In Experiment 2, when character and location served as possible indexes, participants relied more on the index provided by the description. This supports the *Narrative Index Hypothesis*.

An alternative argument suggests that the different dependent measures used in these experiments—study time, reaction time and error rate to test items, and diagram organisation—have differential reliability in assessing indexing. These measures, however, make up the core techniques used to assess situation model structure in the domain of narrative comprehension research, and are sometimes used independently in studies and sometimes together to provide converging evidence. For example, Zwaan and his colleagues (see Zwaan, Langston, & Graesser, 1995; Zwaan, Magliano, & Graesser, 1995; Zwaan & Van Oostendorp, 1993) used either reading time or a subjective organisation measure (verb grouping) to examine the effects of different event components on narrative comprehension and recall. These measures may differ in sensitivity, but are assumed to tap similar underlying constructs.

Experiment 3 attempts to extend the results of Experiment 1 by examining the flexibility of components used for indexing and for sequencing. We examine whether participants will use character for indexing and time for sequencing when events are grouped into activities.

**EXPERIMENT 3: INDEXING FLEXIBILITY**

As Experiment 1 indicated indexing by character and sequencing by time, these components were used in this experiment to examine organisation flexibility. In Experiments 1 and 2 the events were unrelated to the characters, to the times or locations, or to each other. In this experiment we created scenarios with events interrelated on the basis of activities. Activities could be correlated with either characters or times. As in Experiment 1, stories were presented either organised around characters or around times.

**Method**

**Participants**

A total of 45 undergraduates from Stanford University participated in groups of three in partial fulfilment of a course requirement. Due to difficulty in logging data, results from one subject were lost.

**Materials**

**Descriptions.** For this experiment, we wrote descriptions relating the events of each of two scenarios, *The Halloween Party* and *Summer Camp*. As in Experiment 1, characters and times served as possible indexes. These descriptions differed from those in Experiment 1 with respect to the relationship between events. In Experiment 1, individual events within scenarios were independent of one another, of specific times, and of specific characters. In this experiment, groups of four events were interrelated by a common activity (e.g. *making food*). The events were still independent with respect to specific times and characters. The activities grouping the four events were associated with characters (*character activities*) for half of the descriptions and with times (*time activities*) for the other half (see Fig. 3 for example matrices).

As in Experiment 1, the descriptions could be organised by presenting each characters’ activities (*character description*) in turn or by presenting the activities of each time period in order (*time description*). Because activity association and description organisation could vary independently, four descriptions were needed for each scenario. The four descriptions included all combinations of the two activity associations (*character activities or time activities*) and the two description organisations (*character descriptions or time descriptions*). Consequently, for two descriptions, the activity association and description organisation matched (activities associated with characters in a description organised by character or activities associated with times in a description organised by time) and for two descriptions they did not match (activities associated with characters in a description organised by time or activities associated with times in a description organised by characters). The match between activity association and description organisation has interesting
The Halloween Party: Time Activities

<table>
<thead>
<tr>
<th>Time</th>
<th>Kristen</th>
<th>Bridget</th>
<th>Janie</th>
<th>Laura</th>
</tr>
</thead>
<tbody>
<tr>
<td>morning</td>
<td>wired</td>
<td>set-up</td>
<td>hung</td>
<td>painted</td>
</tr>
<tr>
<td></td>
<td>lights</td>
<td>speakers</td>
<td>masks</td>
<td>walls</td>
</tr>
<tr>
<td>lunchtime</td>
<td>mopped</td>
<td>dusted</td>
<td>vacuumed</td>
<td>scrubbed</td>
</tr>
<tr>
<td></td>
<td>floors</td>
<td>shelves</td>
<td>rugs</td>
<td>bathroom</td>
</tr>
<tr>
<td>afternoon</td>
<td>carved</td>
<td>pumpkin</td>
<td>blew up</td>
<td>made props</td>
</tr>
<tr>
<td></td>
<td>streamers</td>
<td></td>
<td>balloons</td>
<td></td>
</tr>
<tr>
<td>evening</td>
<td>mixed</td>
<td>arranged</td>
<td>prepared</td>
<td>baked</td>
</tr>
<tr>
<td></td>
<td>punch</td>
<td>candy</td>
<td>pizzas</td>
<td>cakes</td>
</tr>
</tbody>
</table>

Activities

- Haunted House
- Cleaning
- Decorations
- Prepare food

The Halloween Party: Character Activities

<table>
<thead>
<tr>
<th>Time</th>
<th>Kristen</th>
<th>Bridget</th>
<th>Janie</th>
<th>Laura</th>
</tr>
</thead>
<tbody>
<tr>
<td>morning</td>
<td>mopped</td>
<td>wired</td>
<td>mixed</td>
<td>strung</td>
</tr>
<tr>
<td></td>
<td>floors</td>
<td>lights</td>
<td>punch</td>
<td>streamers</td>
</tr>
<tr>
<td>lunchtime</td>
<td>dusted</td>
<td>set-up</td>
<td>arranged</td>
<td>carved</td>
</tr>
<tr>
<td></td>
<td>shelves</td>
<td>speakers</td>
<td>candy</td>
<td>pumpkin</td>
</tr>
<tr>
<td>afternoon</td>
<td>vacuumed</td>
<td>hung</td>
<td>prepared</td>
<td>blew up</td>
</tr>
<tr>
<td></td>
<td>rugs</td>
<td>masks</td>
<td>pizzas</td>
<td>balloons</td>
</tr>
<tr>
<td>evening</td>
<td>scrubbed</td>
<td>painted</td>
<td>baked</td>
<td>made props</td>
</tr>
<tr>
<td></td>
<td>bathroom</td>
<td>walls</td>
<td>cakes</td>
<td></td>
</tr>
</tbody>
</table>

Activities

- Cleaning
- Haunted House
- Prepare food
- Decorations

FIG. 3. Matrices of events for The Halloween Party scenario, Experiment 3.

Implications for indexing and will be used as an independent variable called description match.

As in the previous experiments, filler information made the descriptions more story-like. For these descriptions, in addition to providing a setting, a basic plot, and an introduction to characters and times, the introductory paragraph also presented the activities and explained how they were associated with either times or characters. See Table 4 for example introductory paragraphs for the Halloween Party scenario.

Test items and Postexperiment Diagram. Both the test item and postexperiment diagram construction followed that used in Experiments 1 and 2.

### Table 4

<table>
<thead>
<tr>
<th>Description Introductions for Different Activity Organisations</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>A. Introduction common to both activity organisations</strong></td>
</tr>
<tr>
<td>The feeling of fall was in the air and Halloween was just around the corner. For four roommates, Kristen, Bridget, Janie, and Margo, Halloween was their favorite holiday. Although they no longer waited excitedly all day to go trick-or-treating after dinner, they all still enjoyed the craziness that accompanied the holiday. This year, instead of waiting to be invited to a Halloween party, these four decided to throw their own party. After all, it was their senior year and they were determined to make the year memorable. As usual, there was a lot of debate over the details of the party. They finally decided all they needed was lots of people, tons of food, and a Haunted House. Of course, in their usual way of procrastinating, work for the party got left until the last day. Planning the day carefully was the only way to get everything done. They divided the work into four categories: preparing food, building the Haunted House, cleaning the house, and setting up decorations. The party was supposed to start around nine o’clock, so they would have quite a bit of time. The night before the party, they all got together to plan how to get everything done. [continue with activity specific parts of introduction]</td>
</tr>
<tr>
<td><strong>B. Character Activities Introduction</strong></td>
</tr>
<tr>
<td>Kristen volunteered to prepare all the rest of the food. Bridget wanted to set up the Haunted House. Janie, although she wasn’t pleased with the idea, said she would clean the house. Margo volunteered to put up the decorations. They figured they could do one job for each project first thing in the morning, a second one during lunchtime, a third in the afternoon, and a fourth one in the early evening, right before the party. The main catch to getting everything done in time was going to be getting out of bed pretty early the next morning.</td>
</tr>
<tr>
<td><strong>C. Time Activities Introduction</strong></td>
</tr>
<tr>
<td>They decided that each person, Kristen, Bridget, Janie, and Margo, would work on the projects together, each doing a separate job for the project. In the morning, they would set up the Haunted House. During lunchtime, everyone would split up cleaning the house. In the afternoon, they would work on putting up the decorations. Finally, in the evening, before the party, they would all prepare the food. The main catch to getting everything done in time was going to be getting out of bed pretty early the next day.</td>
</tr>
</tbody>
</table>

### Design and Procedure

Each participant received two descriptions, one from each scenario. Activity association was a between-subjects factor and description match was a within-subject factor. Thus, for an individual, both descriptions had activities associated with either time or with character, but not with both. All participants read one description where activity association and description organisation matched and one where they did not match. All other aspects of the procedure followed those used in Experiments 1 and 2.

### Results

As there are several variables of interest, we will reiterate the variables and the possible values of each. Activity association (character or time) refers to the
grouping of related events by time or by character. Description match (matched or unmatched) refers to whether activity association and description organisation grouped events using the same dimension or using different dimensions. Test focus (character or time) refers to whether the memory test asked about characters or time. Finally, test pairs (time, character, or both-features) refers to the relationship between two events presented in the memory tests, as defined by the description.

Data from eight participants were eliminated from all analyses for not following instructions, as described in Experiment 1.

**Study Time**

The descriptions ranged in length from 1247 to 1366 syllables. As in previous experiments only study time per syllable will be reported. A repeated measures analysis investigated the between-subjects effect of activity association and the within subject effect of description match. No main effects or interactions were significant.

A separate analysis investigated the between-subjects effect of description order (matched description first or second) and the within-subject effect of description match. Although not significant, the results showed a similar trend to that seen in Experiments 1 and 2. The trend suggests an interaction between description order and description match. Simple effects analyses indicated that when participants studied a mismatched description first, they spent less time on the subsequent matched description, $F(1,35) = 3.29, P = .08, MSe = .038$. When participants studied a matched description first, there was no difference in study time for the subsequent mismatched description, $F(1,35) = 0.09, P = n.s., MSe = .038$.

**Test Items**

The analyses consisted of repeated measures designs using the between-subjects factor of activity association and within-subject factors of description match, test focus, and test pair. The data were trimmed to eliminate outlier RT using a criteria of mean plus 2.5 standard deviations. This procedure eliminated 3.6% of the data. The analyses for both dependent measures showed similar patterns, indicating no speed/accuracy trade-off.

Several significant interactions indicated that participants remembered events based on the activity association. The activity association and test focus interacted, $F(1,35) = 20.10, P < .0005, MSe = .014$, for errors and $F(1,35) = 141.22, P < .0001, MSe = .947092$, for RT (see Fig. 4). Participants studying character activities performed better on character focus tests. Participants studying time activities performed better on time focus tests (see Table 5). The activity association also interacted with the test pairs, $F(2,70) = 19.37, P < .0001, MSe = .004$ for errors and $F(2,70) = 14.54$, for
TABLE 5
Experiment 3: Responses to Test Foci Based on Activity Association Studied

<table>
<thead>
<tr>
<th>Time Focus</th>
<th>Character Focus</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>RT</td>
<td>Error</td>
<td>RT</td>
</tr>
<tr>
<td>Time activity</td>
<td>2982</td>
<td>0.06</td>
<td>4318</td>
</tr>
<tr>
<td>Character activity</td>
<td>4569</td>
<td>0.11</td>
<td>2969</td>
</tr>
</tbody>
</table>

P < .0001, MSE = 177691 for RT. Character activities led to better performance on character pairs than on the other two types. Time activities led to better performance on time pairs than on the other two types. No main significant main effects emerged from the analyses.

As in the previous experiments, separate analyses were performed on the individual scenarios. Organisation match served as a between-subjects factor. Results of both dependent variables followed the same pattern as the overall analyses.

As in Experiment 2, the analyses also showed an interaction between test focus and test pairs, F(2,70) = 22.62, P < .0001, MSE = 0.006, for errors and F(2,70) = 23.34, P < .0001, MSE = 164468, for RT. Participants responded faster and more accurately to different responses than to same responses.

Finally, for RT, responses showed a significant interaction between activity association, test focus, and test pairs, F(2,70) = 5.99, P < .01, MSE = 164468 (see Fig. 4). Tukey’s multiple comparisons indicated that when the test focus matched the activity association, i.e., both time or both character, responses to test pairs did not differ. When the test focus did not match the activity organisation, responses to test pairs differed, showing faster responses to test pairs not matching the test focus. After studying time activities and when the test focused on characters, participants responded faster to time pairs than to character pairs, q(3,70) = 8.32, P < .01. Conversely, after studying character activities and when the test focused on time, participants responded faster to character pairs than to time pairs, q(3,70) = 8.94, P < .01.

Postexperiment Diagram

Diagram scoring proceeded as before, except that diagram organisation was compared to activity association rather than to description organisation. Five participants did not follow directions and were eliminated from this analysis. Coders agreed on 98% of diagrams. Consensus was reached where disagreement existed. Results indicated that activity association affected diagram organisation, χ²(2, N = 32) = 10.165, P < .01. Participants studying character activities organised diagrams around characters, while participants studying time activities used a variety of diagram organisations (see Table 6).

TABLE 6
Experiment 3: Postexperiment Diagram Organisation

<table>
<thead>
<tr>
<th>Number of diagrams of each type</th>
<th>Matching Activity</th>
<th>Opposite Activity</th>
<th>Both Features</th>
</tr>
</thead>
<tbody>
<tr>
<td>Character activity</td>
<td>13</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>Time activity</td>
<td>4</td>
<td>8</td>
<td>4</td>
</tr>
</tbody>
</table>

DISCUSSION

This experiment again supported the Index Dominance Hypothesis, using what as the dominant index. Results also indicated flexibility in using core event components. Unlike Experiment 1, participants in this experiment sometimes used time to index events. The activity association dictated indexing as indicated by the test statement and the diagram results. For the test statements, participants responded faster and more accurately on the test focus that corresponded with the activity association. Studying character activities led to better performance on character focus tests; studying time activities led to better performance on time focus tests. Additionally, participants responded faster and more accurately to test pairs that corresponded to the activity association. Finally, the three-way interaction between activity association, test focus, and test pair also lends support. When the test focus corresponded to the activity association, participants responded to all test pairs with equal speed and accuracy. When it did not, participants differentially responded depending on the correct response.

Between the core components of character and time, one component serves as a dominant index. All other things being equal, participants use character as an index and time as a sequence. However, this experiment shows that the nature of the events and how they are related can change this organisation strategy. Event indexing is flexible, depending on context. When the theme relating events correlates with time, the activities and related times serve as an index. In this situation, however, time cannot serve as a sequencer.

GENERAL DISCUSSION

Events we read in discourse, whether they are relating news of increased terrorist activity in the Middle East or a fictitious tale of mystery and intrigue, get organised in memory. While significantly different in character from autobiographical events, both narrative and autobiographical memory research supports three different hypotheses related to event organisation. The goal of the present research was to determine whether the availability of different event components influences indexing in memory. Examining event components two-
by-two, we found primary support for the Index Dominance Hypothesis. Participants indexed events in all three experiments using a single index, rather than using both components by cross-referencing. Different factors contributed to the index used in each experiment. In Experiment 1, participants indexed by character, perhaps because time was reserved to sequence events. In Experiment 2, the index presented in the narrative dictated the index adopted by participants, indicating no natural dominance between who and where. In Experiment 3, the activity association dictated index use. Taken together, the use of different indexes in context of different available components indicates flexibility in organising event memory.

The fact that different types of cues, who, what, where, and when, can all be used to retrieve events from memory has been taken as evidence that several indexes or even cross-indexing is possible (Barsalou, 1988; Wagenaar, 1986). Such flexibility seems essential, given that no all event components are either present or readily apparent. Our results indicate that single indexes are used despite the possibility of cross-indexing by creating a matrix-like organisation. Although a few participants may have used this strategy, as suggested by their postexperiment diagrams, the majority did not.

With use of a single index as opposed to cross-indexing, there is a trade-off between cognitive load and accessing time. Maintaining both indexes for every event creates a cognitive load. However, using a single index increases access time for information not directly associated with that index. As participants can still access all information through one index, the cognitive load created by cross-indexing does not seem worthwhile. The use, in these experiments, of a single index lends credence to this position.

Additionally, our results show that some components naturally dominate over others as indexes. This relative dominance of different indexes makes intuitive sense, fits with what is known about memory, and conforms to predictions based on uniqueness (Durt et al., 1995). Characters provide motivation for events. Characters are vivid, animate, and typically the prime actors in events. We are used to watching people in activities and talking to them to determine their motivations and goals. As people are seen as the agents of activities, it is easy to predict events based on the people involved. In social psychology, the primary role of characters in events is an assumption rather than an empirical question. Sedikides and Ostrom (1988), in a meta-analysis of literature related to person categories, found that participants group traits around specific characters, even unfamiliar characters. Although the events in Experiment 1 did not relate to characters, times, or themselves, participants often reported building scenarios around each character, constructing character traits based on the events, and linking events to them. In other words, they spontaneously invented character traits based on unrelated events.

Locations, like characters, also make good indexes. They are concrete, and memorable. Using locations as cues to memory dates back to the ancient Romans’ use of the method of loci to remember their orations (Yates, 1966), and extends to contemporary mnemonic devices (Bower, 1970). People are able to build unified mental models including several objects or people in a single location (Franklin & Tversky, 1990; Radavsky & Zacks, 1991). People can even represent the different perspectives of two characters in the same environment (de Vega, 1995).

Time is the least used index, perhaps because it serves a different role, that of a sequencer (Bower et al., 1979; Kintsch et al., 1977; Mandler, 1978; Ohtsuka & Brewer, 1992; Stein & Glenn, 1978). The aspect of time that is most memorable, the ordinal aspect, is useful for sequencing events (Linton, 1975; Loftus & Marburger, 1983; Yntema & Trask, 1963). In contrast, people are not generally good at remembering the absolute aspects of time, such as specific dates and times that would allow time to serve as a useful index to memories (Baddley, Lewis, & Nimmo-Smith, 1978; Brown, Rips, & Shleve, 1983; Friedman, 1993). Another reason why time may not be used as an index is that temporal information may not be coded directly in memory (Larsen & Thompson, 1995; Larsen et al., 1996; Thompson et al., 1996). Instead, temporal information may be reconstructed from other available information or from temporal schemas.

However, the index dominance for the core components of events is situationally limited, depending on the other components available and on the absence of strong relational ties between events. Therefore, it seems more plausible to argue that index dominance is situationally determined. This position is supported by Experiments 2 and 3. Experiment 2 indicated that character indexes were not dominant compared to location indexes. Experiment 3 indicated that time could become a dominant index when based on the relationship between events.

The fact that participants used single indexes brings up another interesting issue, that of reorganisation. Use of some components as indexes over others means that with memory for narratives, information must sometimes be reorganised from the way it was presented in Experiment 1, time descriptions needed to be reorganised to character indexes. In Experiment 3, some descriptions needed to be reorganised to match the activity association. Reorganisation requires time and cognitive effort. Again a trade-off exists, here between the cognitive effort of reorganisation and that of using a less effective organisation system. With a component serving as a dominant index, as in Experiments 1 and 3, the effort of a less effective organisation system seems to outweigh that of reorganisation. With no dominant component, as in Experiment 2, reorganisation is not necessary. Kolodner (1983a,b) suggests that reorganisation occurs each time information is updated. Other work has also supported reorganisation. Conway and Bekerian (1987) failed to replicate the priming effect of Reiser, Black, and Abelson (1985) using shorter ISIs, suggesting insufficient time for reorganisation. In our experiments several pieces of evidence supported reorganisation. Response patterns to test items reflected
the same memory organisation for both description organisations. Participants organised diagrams around the more effective index component. Only when the components worked equally well as indexes did participants simply use the index available to them.

As stated earlier, our work examines events presented through discourse. Although we have discussed the autobiographical memory literature, we cannot say that our results generalise to autobiographical memory. Instead, some of the findings within that literature guided our thinking about narrative events. With autobiographical memory, the richer assortment of available cues as well as the simultaneous presentation of multiple cues makes use of combined cues, such as extended event time lines, more likely. Additionally, from our own lives the personal importance of specific people, such as a significant other, places, and even times, such as our own birthday, may differentially weight use of these specific retrieval cues in autobiographical memory. Finally, other types of cues such as emotions and self-constructs (Strauman, 1990) may also play a strong role in retrieving memories from our own lives.

Although these experiments have focused on memory retrieval, they have implications for forgetting as well. One common cause of forgetting is failure of source monitoring (Johnson, Hashtroudi, & Lindsay, 1993). That is, an event may be remembered per se, but its source may be misremembered. For example, an imagined event may be thought to have actually happened, or a read or heard event may be thought to have been witnessed. In these cases, the event seems to be disembodied, stripped of context. Context in turn consists of who, what, where, when, and why. Our findings suggest that all other things being equal, the what, who, and where ties to context are stronger than the when ties to context. Put differently, source monitoring should be more reliable for activities, participants, and locations, than for time.

An alternative explanation for our results is that these findings merely mirror conventions for producing and therefore processing narratives rather than having any implication for memory. This alternative would stipulate that activities should be presented first in discourse, followed by characters (or locations), followed by times. Work in progress by the first author (Taylor & Rich, 1995) suggests that the indexes used in memory do not simply reflect the order in which information is presented in discourse. In these studies, participants produced narratives to include particular events. In these narratives, participants first mentioned locations, providing the setting. After the initial mention, locations were infrequently mentioned. Activities and characters came next, associated directly with the events and often repeated throughout the discourse. Finally participants used time to sequence the events. In order for our results to mirror the order of discourse presentation, locations indexes would predominate, followed by activities and character, which would be equal, followed by time.

Who, where, when, and what only cover four possible ways to organise events. In this research, participants used what to index more than who and where. This makes sense, as what indicates the relationship between events while the other two components define individual events. Furthermore, these three components were used more than when. Although reasonably all three could be organisers, the results attest to the ease with which each can be used. With some effort by the subject, namely building character traits from unrelated events, who serves as a good index. For where, like who, participants could imagine traits based on the events occurring in the location. When, however, is more difficult to link to the events, especially those that have no stereotypic time of occurrence. Other variables also help define events, like what and why or combinations of these components, such as those that make up extended event time lines.

Our current work, an extension of that presented here, is examining where in the organisation puzzle other variables fit. These variables, like the others, have compelling reasons for being good organisers. Why relates causally to goals for carrying out events. Combined cues allow either, as well as the combination, to be used as retrieval cues. The question of interest is how events will be organised given different possibilities.

REFERENCES


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**EVENT MEMORY ORGANISATION**


