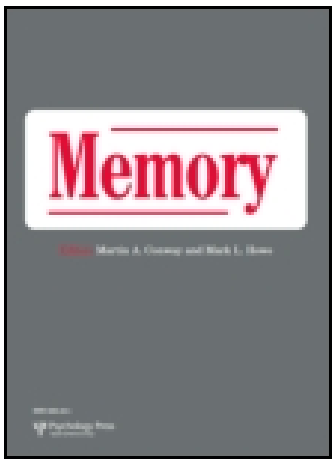

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Strategic search from long-term memory: An examination of semantic and autobiographical recall

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Strategic search from long-term memory: An examination of semantic and autobiographical recall

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Searching long-term memory is theoretically driven by both directed (search strategies) and random components. In the current study we conducted four experiments evaluating strategic search in semantic and autobiographical memory. Participants were required to generate either exemplars from the category of animals or the names of their friends for several minutes. Self-reported strategies suggested that participants typically relied on visualization strategies for both tasks and were less likely to rely on ordered strategies (e.g., alphabetic search). When participants were instructed to use particular strategies, the visualization strategy resulted in the highest levels of performance and the most efficient search, whereas ordered strategies resulted in the lowest levels of performance and fairly inefficient search. These results are consistent with the notion that retrieval from long-term memory is driven, in part, by search strategies employed by the individual, and that one particularly efficient strategy is to visualize various situational contexts that one has experienced in the past in order to constrain the search and generate the desired information.

Keyword: Strategic search.

Our ability to retrieve information from memory, whether it be information about general facts, a specific instance in our life, or people we know, is one of the most fundamental components of our cognitive system. Typically, this information comes from the distant past, and thus can be considered to be recalled from long-term memory. Given the importance of such a system to a wide range of tasks and situations, research on how information is recalled from long-term memory has spanned nearly all of the subdisciplines of psychology. In the current study, we examined strategic aspects of recall from both semantic and autobiographical long-term memory (LTM) in order better to understand strategic recall processes and their implications for how individuals recall information from LTM.

STRATEGIC SEARCH PROCESSES

If asked to recall a fact from memory or to recall what you had for your birthday last year, one must typically probe LTM to access the desired information. Intuitively, probing feels like a search of the memory system to find the desired information. The notion that retrieval from LTM is, at least partially, due to search mechanisms has long been an important component of many models of memory. In fact, several contemporary models of recall from LTM assume that a search process is used to select target information from LTM (e.g., Howard & Kahana, 2002; Polyn, Norman, & Kahana, 2009; Raaijmakers & Shiffrin, 1980; Shiffrin, 1970; Williams & Hollan, 1981; Wixted & Rohrer, 1994). Importantly, these models can account for a wide range of recall phenomena,

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suggesting that the memory search notion not only matches our intuitive notions of retrieval but also accounts for much of the known data.

In these views, searching for desired information typically involves a cyclical search process in which the generated information is used as an additional cue to probe the memory system (e.g., Raaijmakers & Shiffrin, 1980; Williams & Hollan, 1981). For instance, in the Search of Associative Memory model (SAM; Raaijmakers & Shiffrin, 1980), it is assumed that the search process first relies on context information (such as the retrieval question) present at the time of retrieval to probe the memory system. Information (i.e., a target item) generated by the search process is then combined with the overall global cue to search for the next item. Thus, the search process begins with an overarching general cue and then proceeds by utilizing information generated by this cue to further cue the memory system (Burgess & Shallice, 1996; Conway & Pleydell-Pearce, 2000; Graesser & Mandler, 1978; Gruenewald & Lockhead, 1980; Herrmann & Pearle, 1981; Mandler, 1967, 1975; Norman & Bobrow, 1979; Reiser, Black, & Abelson, 1985; Whitten & Leonard, 1981; Williams & Hollan, 1981; Wixted & Rohrer, 1994). Recent work by Hills, Jones, and Todd (2012) and Hills and Pachur (2012) has expanded on these ideas by suggesting that searching for information in memory also relies on two-stage search processes in which individuals first search using a global cue and then switch to using a more local cue. Importantly, Hills and colleagues (2012) suggest that participants search using local cues until the ability of the cue to activate additional items is depleted, at which point individuals switch back to using a more global cue. This suggests that search is a dynamic process in which individuals are constantly transitioning between global and local search policies.

An important aspect of search frameworks is that it is assumed that there are both directed and random components to the overall search process (Shiffrin, 1970; Shiffrin & Atkinson, 1969). The directed component refers to those strategic processes that are under direct control of the individual. These strategic control processes include setting up an overall retrieval plan, selecting appropriate retrieval strategies, selecting and generating appropriate cues to search memory with, as well as various monitoring strategies and decisions to continue searching or not. The random component refers to the probabilistic nature of the search process in which a subset of information is activated by the cues (i.e., the search set), and representations are subsequently sampled (probabilistically with replacement) and recovered from this subset (Raaijmakers & Shiffrin, 1980; Shiffrin, 1970). Thus, recall from LTM is dictated not only by various strategies that individuals bring to bear on the task, but also by the probabilistic nature of recall from LTM.

To investigate the directed component more thoroughly, researchers have specifically examined the role of various search strategies used by participants to generate information during recall. Typically, to investigate search strategies researchers either have participants report which strategies they are using via think-aloud procedures or researchers will directly manipulate search strategies. Both methods provide evidence for the notion that search strategies are an important component of recall from LTM.

For example, Williams and Hollan (1981) had participants name individuals they went to high school with while utilizing a think-aloud procedure in which participants were instructed to say everything that came to mind during recall. Williams and Hollan (see also Williams & Santos-Williams, 1980) found that participants utilized a number of different strategies to generate names. These included thinking of different activities individuals participated in (activity strategy), thinking of different locations individuals were associated with (location strategy), thinking of names that began with each letter of the alphabet (letter sets strategy), generating and mentally scanning pictures from yearbooks (picture strategy), and starting with a given individual and thinking of people associated with that individual (general association strategy). Williams and Hollan suggested that these search strategies allowed individuals to generate different contexts (or subcontexts) to search, resulting in more systematic means for focusing the search on the desired information. Thus, rather than being merely a random sampling of information from the search set, search strategies allow individuals to search LTM dynamically via multiple different routes. Furthermore, Williams and Hollan noted that participants typically adopted strategies for some time and then shifted to other strategies when the current strategy was no longer generating usable information. For example, a detailed examination of one individual's recall protocol suggested that early in recall this participant tended to switch between the activity and location

strategies. Later, this participant shifted to the letter sets strategy, presumably after the activity and location search strategies no longer provided new information. Clearly, then participants are not only utilizing search strategies to generate items from LTM, but they also seem to utilize several strategies over the course of the recall period.

Similar evidence for the utilization of search strategies was provided by Whitten and Leonard (1981), who had participants name teachers from each grade. In their first experiment, participants were instructed to recall their teachers in a forward order (Grades 1–12), a backward order (Grades 12–1), or in a random order. Whitten and Leonard found that a backward order search was most effective in generating names from LTM. In their second experiment, Whitten and Leonard used a think-aloud procedure to better examine the variety of strategies participants used to generate names from LTM. Similar to Williams and Hollan (1981), Whitten and Leonard found that participants used a variety of strategies (including enumeration and locations strategies) to generate the names of their teachers. Importantly, the strategies utilized were largely task specific, suggesting that participants tended to use strategies that were effective in getting the requested information out of LTM.

Additional evidence for the use of large and varied retrieval strategies has been provided by Walker and Kintsch (1985), who had participants generate items from various semantic categories (automobiles, soups, detergents) while using a think-aloud procedure. Similar to the preceding studies, Walker and Kintsch found that participants reported using a number of different strategies. One strategy in particular seemed to be used frequently when generating items from the various categories, namely a location strategy. Specifically, Walker and Kintsch noted that participants seemed to generate different locations where one would encounter automobiles, soups, or detergents and then participants would search within that context for the desired information. Thus, regardless of whether one is searching for names of people from one's past or for various items from semantic categories, it seems that generally people will use something like a location strategy to generate various contexts and then search within those contexts.

These studies provide evidence for the notion that participants spontaneously use various search strategies that are tailored to the task at hand and can change throughout the recall period. Additional evidence for the role of search strategies comes from studies that have specifically required participants to use one strategy or another during recall. As noted earlier, Whitten and Leonard (1981) found that requiring participants to use a backward ordered search resulted in better performance than a forward ordered or random search. Likewise, Gronlund and Shiffrin (1986) had participants recall items from semantic or episodic memory using different strategies. For example, some participants were required to recall animals from semantic memory using no strategy in particular (free recall), an alphabetic strategy, or a size strategy. Gronlund and Shiffrin found that the free recall group performed much better than either the alphabetic or size strategy groups. These results suggest that some search strategies can actually be detrimental to the retrieval process, leading to poorer overall performance. When participants are allowed to spontaneously use their own idiosyncratic search strategies, performance tends to be better than some experimenter-provided strategies. This suggests that participants tailor their search strategies to the particular task at hand and tend to use normatively effective search strategies in order to generate different contexts to search. These findings point to the importance in understanding search strategies in retrieval from LTM.

THE PRESENT STUDY

The work reviewed previously suggests that, when searching, LTM participants likely utilize strategic control processes to probe LTM. Despite prior work suggesting these basic notions, additional work is needed to better examine these notions and answer more detailed questions of interest. For instance, assuming that we use various strategies to search LTM, we can ask: What strategies we actually use to probe LTM? Are some strategies more effective than others? Likewise, what are the similarities and differences across various tasks? It is likely that, if asked to retrieve names of animals from memory, one will use different strategies and different contexts than if one is asked to retrieve names of one's friends from memory. Yet, at the same time, it seems likely that some strategies should cut across tasks. As noted previously, visual-location strategies seemed to be reported frequently in a number of studies regardless of the type of information that one is asked to

recall from memory. Thus, it is possible that although there are differences across various tasks, there will also be important similarities. Our goal in the present study was to better examine the strategic nature of LTM memory search by examining the different types of strategies that participants use during search. Furthermore, to examine possible similarities and differences across tasks, we examined how participants retrieve information from both semantic memory and autobiographical memory. In the semantic memory experiments, participants were required to recall names of animals for several minutes. In the autobiographical memory experiments, participants were required to recall the names of their friends for several minutes. The same experiments were done for both semantic and autobiographical recall in order to better examine the extent to which similar strategies were used to recall information. By examining how participants recall information from LTM, we hope to shed light on the strategic nature of LTM search.

EXPERIMENT 1

The purpose of Experiment 1 was to examine the nature of the different search strategies that participants are likely to use when searching for animal names. Participants were asked to generate exemplars from the category of animals for five minutes. After attempting to generate animal names, participants were required to fill out a questionnaire regarding the various search strategies they used to perform the fluency task.

Method

Participants. Participants were 31 undergraduate students recruited from the subject pool at the University of Georgia. Participants received course credit for their participation.

Procedure. Participants were tested individually. Participants were instructed that they would be recalling as many exemplars from the category of animals as possible in five minutes. Participants were informed that they could recall the names of animals in any order they wished. Participants were required to type in each animal name and then press ENTER to record the response. Participants were instructed that they needed to keep trying to recall animal names throughout the entire five minute recall period.

Following the recall task, participants also completed a brief questionnaire regarding any search strategies that they used during the animal fluency task. Specifically, participants indicated whether they had used a visualization strategy, a personal importance strategy, a semantic strategy, a rhyme strategy, an alphabetic strategy, or no strategy was used and the results were based on random responding.[1] The participants could indicate that they used more than one strategy during the course of retrieval. Additionally, participants also indicated whether they had intentionally used the previous response as cue for the next response.

Results

Participants recalled on average 52.32 ($SE = 2.30$) animals. Shown in Figure 1 are the cumulative numbers of animals recalled as a function of time. As can be seen, the rate of recall slows towards the end of the recall period despite the fact that individuals are still recalling items. That is, the rate of recall is a negatively accelerating function suggesting that recall was more efficient early in the recall period than later in the recall period (Bousfield & Sedgewick, 1944; see Wixted & Rohrer, 1994, for a review). Examining first recall latency suggested that participants began recalling items on average 4.2 s ($SE = 0.34$) into the recall period. Thereafter, the average interresponse times (IRTs) were 6.93 s ($SE = 0.31$).

Next, we examined responses in the questionnaires regarding the strategies they used. Specifically, participants indicated whether they had used a visualization strategy, a personal importance strategy, a semantic strategy, a rhyme strategy, an alphabetic strategy, or no strategy was used and the results were based on random responding. Participants could indicate that they used more than one strategy during the course of retrieval. Shown in Table 1 are the proportions of strategies reported for each strategy. As can be seen, the most frequently reported strategies were

[1] Strategies for Experiments 1 and 3 came from prior studies where we specifically asked participants what strategies they used to generate items in fluency tasks (e.g., Unsworth, Brewer, & Spillers, 2013), as well as pilot testing where participants were further asked to describe the various strategies they used to generate both animals (Experiment 1) and friends (Experiment 3).

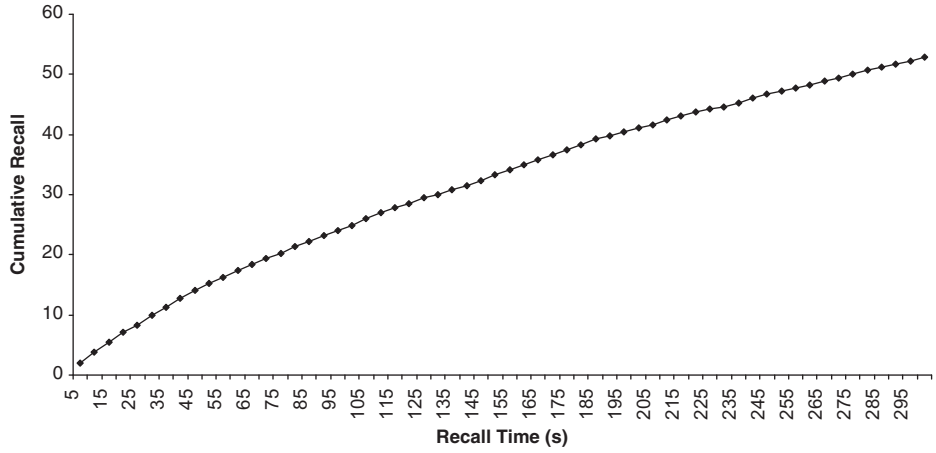

Figure 1. Mean cumulative number of animals recalled as a function of recall time in seconds for Experiment 1.

the visual, semantic, and random/no strategy, followed by a strategy based on personal importance, an alphabetic strategy, and finally a rhyme strategy. On average, participants reported using 2.19 ($SE = 0.16$) strategies while performing the animal fluency task. Furthermore, 90% ($SE = 5$) reported intentionally using the previously recalled item as a cue to generate subsequent items. Thus, participants reported using some strategies more frequently than others as well as reporting that sometimes they recalled items based on random responding.

Discussion

The results from Experiment 1 demonstrated a number of novel and interesting findings regarding strategy use. Specifically, it was found that participants reported using a variety of search strategies to perform the animal fluency task with the most common strategies being a visualization strategy (e.g., participants imagined walking around a zoo and looking at animals) and a semantic strategy (e.g., participants listed animals based on common characteristics such as belonging to a particular family or genus). On average, participants reported using two or more strategies during the recall period and 90% of participants reported that while recalling animals they intentionally tried to use the previously recalled item as a cue to generate subsequent items. Participants also frequently reported that they simply relied on random responding and no strategy to generate animals. Collectively, these results are very much in line with search frameworks discussed previously where it is suggested that participants use a variety of search strategies to generate different contexts to search. Furthermore, as discussed previously, in these models it is assumed that participants utilize just-recalled information as a cue to generate additional items, and the current subjective reports provide evidence for this notion. Finally, the fact that participants reported using both search strategies and relying on random responding provides evidence for the notion that during a prolonged search task both directed (strategic) and random components are important for search.

TABLE 1
Proportions of reported strategy use as a function of strategy for Experiment 1

Strategy					
Visual	*Personal*	*Semantic*	*Rhyme*	*Alphabetic*	*Random*
.74 (.08)	.45 (.09)	.71 (.08)	.06 (.04)	.23 (.08)	.81 (.07)

Proportions of strategies sum to greater than 1.0 because the participants could report using more than one strategy. Standard errors are shown in parentheses.

EXPERIMENT 2

The purpose of Experiment 2 was to examine the nature of the different search strategies by instructing participants to use a particular search strategy and determining how that influenced performance relative to other search strategies and to a free recall condition similar to Experiment 1. Participants performed the same animal fluency task as Experiment 1 but they were instructed to use one of four different strategies or no strategy was suggested. The strategies were an alphabetic strategy, a semantic strategy, a size strategy, or a visualization strategy. These strategies were selected because prior work by Gronlund and Shiffrin (1984) suggested that both an alphabetic strategy and a size strategy actually resulted in worse performance compared to free recall. Likewise, the strategy reports from Experiment 1 suggested that only 23% of participants report using an alphabetic strategy. Based on prior work, one could conclude that requiring participants to use a particular strategy will result in lower recall levels. However, the strategy reports from Experiment 1 suggest that participants frequently report using both a visualization strategy and a semantic strategy; thus, instructing participants to use these strategies should lead to overall similar levels of recall as when no particular strategy is required.

Method

Participants. Participants were 95 undergraduate students recruited from the subject pool at the University of Georgia. Participants received course credit for their participation. Participants were randomly assigned to one of five conditions.

Procedure. Participants were tested individually. Participants performed the exact same animal fluency task as the prior experiment. Participants in the alphabetic strategy condition ($n = 18$) were instructed to recall animals in alphabetic order starting with A and working through to Z. They were told that if they found themselves back at A, then they needed to cycle back through the alphabet. Participants in the semantic condition ($n = 21$) were instructed to recall animals based on shared semantic characteristics or features such as sharing a family or genus or overall semantic relatedness. Participants in the size condition ($n = 16$) were instructed to recall animals in order from smallest to largest. They were told to start with the physically smallest animals and gradually generate animals of increasing size. Participants in the visualization strategy condition ($n = 20$) were instructed to recall animals by trying to visualize different places where they may have encountered animals in the past (e.g., zoos). Finally, participants in the free recall condition ($n = 20$) were simply told to recall as many animals as possible in the time allowed. This represents the same recall conditions as Experiment 1.

Results

The overall results in the form of cumulative recall functions are shown in Figure 2. As can be seen, despite the fact that all strategy conditions started off recalling similar numbers of animals, by the end of the recall period the visualization strategy condition and the free recall condition demonstrated the highest levels of recall, whereas the alphabetic and size strategy conditions demonstrated the lowest levels of recall, and the semantic strategy condition demonstrated intermediate levels of recall. These results were supported by an ANOVA examining the total number of animals recalled as a function of strategy condition. There was a main effect of strategy condition, $F(4, 90) = 25.98$, $MSE = 120.28$, $p < .01$, partial $\eta^2 = .54$. Bonferroni follow-up comparisons suggested significant differences between all conditions (all ts > 3.5, all ps $< .01$) except between the alphabetic and size strategy conditions and the visualization strategy condition and the free recall condition (both ts < 1, both ps $> .90$).[2]

[2] Given differences in the cumulative recall functions, we also examined recall latency and IRTs in Experiments 2 and 4. Examining first recall latencies in both experiments suggested no differences between any of the strategy groups with the different groups initiating recall 5 s into the recall period. Turning to IRTs in Experiment 2, there were differences between the groups, with the alphabetic and size strategy conditions demonstrating much longer IRTs than any of the other conditions which did not seem to differ. Similarly, in Experiment 4 there were differences between the groups, with the alphabetic and backward chronological conditions demonstrating much longer IRTs than any of the other conditions, which did not seem to differ.

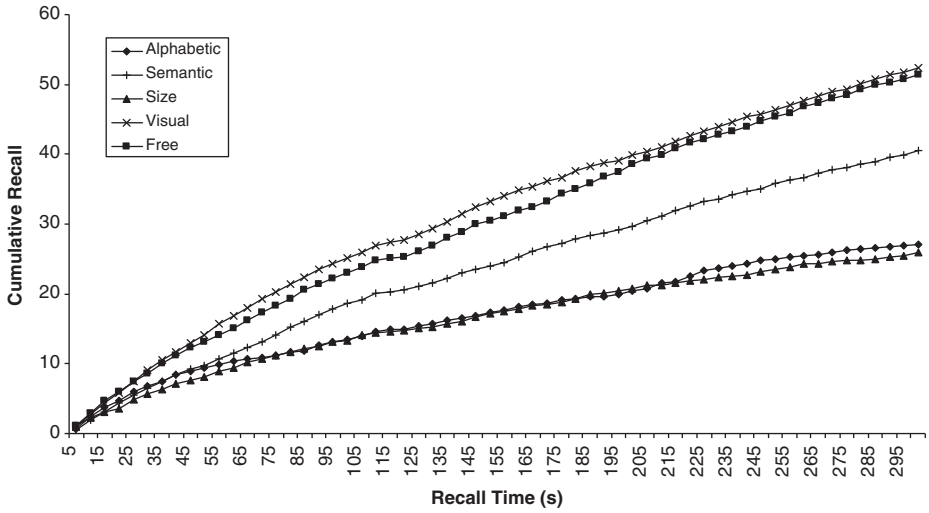

Figure 2. Mean cumulative number of animals recalled as a function of recall time in seconds and strategy condition for Experiment 2.

Discussion

The results from Experiment 2 suggested that, similar to prior research, alphabetic and size strategies led to overall lower levels of performance compared to the free recall condition (Gronlund & Shiffrin, 1986). However, instructing participants to use a visualization strategy led to similar levels of performance as the free recall condition. Likewise, the semantic strategy condition led to overall higher levels of recall than either the size or alphabetic conditions, but slightly lower levels than the free recall and visualization strategy conditions. Examination of the cumulative recall functions suggested that, although participants started off recalling at a similar rate in all conditions, searching for animals with an ordered strategy (alphabetic or size search strategy) resulted in a less efficient search with long gaps between successively recalled items. Overall, these results suggest that when searching for animals from semantic memory participants likely rely on something like a visualization strategy and to a lesser extent a semantic strategy. Relying on other ordered strategies resulted in a less efficient search leading to overall lower levels of recall.

EXPERIMENT 3

The prior experiments examined strategic search processes in a common semantic retrieval task. In order to examine the generality of strategic search processes, we next examined these same issues in an autobiographical retrieval task. Specifically, rather than retrieving animals for several minutes, participants were now instructed to retrieve the names of their friends (e.g., Bahrick, Bahrick, & Wittlinger, 1975; Bond & Brockett, 1987; Brewer, Rinaldi, Mogoutov, & Valente, 2005). The purpose of Experiment 3 was to examine the nature of the different search strategies that participants are likely to use when searching for their friends. Participants were asked to generate the names of their friends for eight minutes. After attempting to generate their friend's names, participants were required to fill out a questionnaire regarding the various search strategies they used to perform the fluency task.

Method

Participants. Participants were 34 new undergraduate students recruited from the subject pool at the University of Georgia. Participants received course credit for their participation.

Procedure. Participants were instructed that they would be recalling as many of friends as possible in eight minutes (Bahrick et al., 1975). Participants were informed that they could recall the names in any order they wished. Participants were required to type in each name (first and last) and then press ENTER to record the name. Participants were instructed that they needed to keep trying to recall names throughout the entire eight minute recall period.

Following the recall task, participants also completed a brief questionnaire regarding any search strategies that they used during the friend fluency task. Specifically, participants indicated whether they had used a location visualization strategy, an activity visualization strategy, a forward chronological strategy, a backward chronological strategy, a personal importance strategy, a rhyme strategy, an alphabetic strategy, or no strategy was used and the results were based on random responding. The participants could indicate that they used more than one strategy during the course of retrieval. Additionally, participants also indicated whether they had intentionally used the previous response as cue for the next response.

Results

Participants recalled on average 75.88 ($SE = 3.13$) friends. As shown in Figure 3, cumulative recall functions were similar to prior research demonstrating a negatively accelerating function in which friends were retrieved rapidly at first, but the time between retrievals increased throughout the recall period. Furthermore, participants tended to initiate recall 4.7 s ($SE = 0.28$) into the recall period. Thereafter, the average IRTs were 7.86 s ($SE = 0.53$). Next, we examined responses in the questionnaires regarding the strategies they used. Specifically, participants indicated whether they had used a location visualization strategy, an activity visualization strategy, a forward chronological strategy, a backward chronological strategy, a personal importance strategy, a rhyme strategy, an alphabetic strategy, or no strategy was used and the results were based on random responding. Shown in Table 2 are the proportions of strategies reported for each strategy. As can be seen, the most frequently reported strategies were the location visual, location activity, personal importance, and random/no strategy, followed by forward chronological, backward chronological, an alphabetic strategy, and finally a rhyme strategy. On average, participants reported using 2.56 ($SE = 0.18$) strategies while performing the friend fluency task. Furthermore, 88% ($SE = 6$) reported intentionally using the previously recalled item as cue to generate subsequent items. Thus, participants reported using some strategies more frequently than others as well as reporting that sometimes they recalled items based on random responding.

Discussion

The results from Experiment 3 demonstrated that participants reported using a variety of search strategies to perform the friend fluency task, with the most common strategies being some form of visualization strategy (e.g., participants generated their friends based off of different locations where they saw them or based off of different activities they participated in) and a personal importance strategy (e.g., participants listed friends based on how important they were to them). On average, participants reported using two or more strategies during the recall period, and 88% of participants reported that while recalling their friends they intentionally tried to use the previously recalled

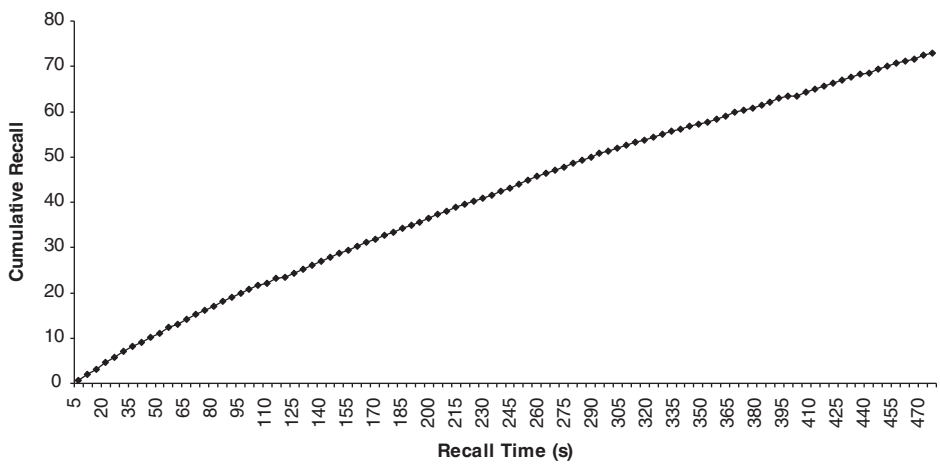

Figure 3. Mean cumulative number of friends recalled as a function of recall time in seconds for Experiment 3.

TABLE 2
Proportions of reported strategy use as a function of strategy for Experiment 3

Strategy							
Location	*Activity*	*Forward*	*Backward*	*Personal*	*Rhyme*	*Alphabetic*	*Random*
.68 (.08)	.59 (.09)	.29 (.08)	.21 (.07)	.59 (.09)	.06 (.04)	.15 (.06)	.65 (.08)

Proportions of strategies sum to greater than 1.0 because the participants could report using more than one strategy. Standard errors are shown in parentheses.

item as a cue to generate subsequent items. Participants also frequently reported that they simply relied on random responding and no strategy to recall the names of their friends.

EXPERIMENT 4

The purpose of Experiment 4 was to examine the nature of the different search strategies by instructing participants to use a particular search strategy and determining how that influenced performance relative to other search strategies and to a free recall condition similar to the prior experiments. Participants performed the same friend fluency task as Experiment 3 but they were instructed to use one of five different strategies or no strategy was suggested. The strategies were location visualization strategy, activity visualization, a forward chronological strategy, a backward chronological strategy, or an alphabetical strategy. Similar to Experiment 2, instructing participants to use some search strategies (e.g., alphabetic strategy) should result in poorer performance relative to the free recall condition, whereas instructing participants to use other strategies (e.g., visualization strategies) should result in similar performance compared to the free recall condition.

Method

Participants. Participants were 129 new undergraduate students recruited from the subject pool at the University of Georgia. Participants received course credit for their participation. Participants were randomly assigned to one of five conditions.

Procedure. Participants were tested individually. Participants performed the exact same friend fluency task as Experiment 3. Participants in the activity visualization strategy condition ($n = 21$) were instructed to recall their friends by trying to visualize different activities they engage in with their friends (e.g., watching sports). Participants in the alphabetic strategy condition ($n = 23$) were instructed to recall their friends in alphabetic order based on their first names starting with A and working through to Z. They were told that if they found themselves back at A, then they needed cycle back through the alphabet. Participants in the backward chronological condition ($n = 18$) were instructed to recall their friends in backward chronological order starting with their most recent friends and working backwards towards their oldest friends. Participants in the forward chronological condition ($n = 21$) were instructed to recall their friends in forward chronological order starting with their oldest friends and working forwards towards their most recent friends. Participants in the location visualization strategy condition ($n = 23$) were instructed to recall their friends by trying to visualize different locations where they encounter their friends (e.g., at school). Finally, participants in the free recall condition ($n = 23$) were simply told to recall as many of their friends as possible in the time allowed. This represents the same recall conditions as Experiment 3.

Results

The overall results in the form of cumulative recall functions are shown in Figure 4. As can be seen, despite the fact that all strategy conditions started off recalling similar numbers of friends, by the end of the recall period the activity and location visualization conditions and the free recall condition demonstrated the highest levels of recall, whereas the alphabetic condition demonstrated the lowest levels of recall and the two chronological strategy conditions demonstrated intermediate levels of recall. These results were supported by an ANOVA examining the total

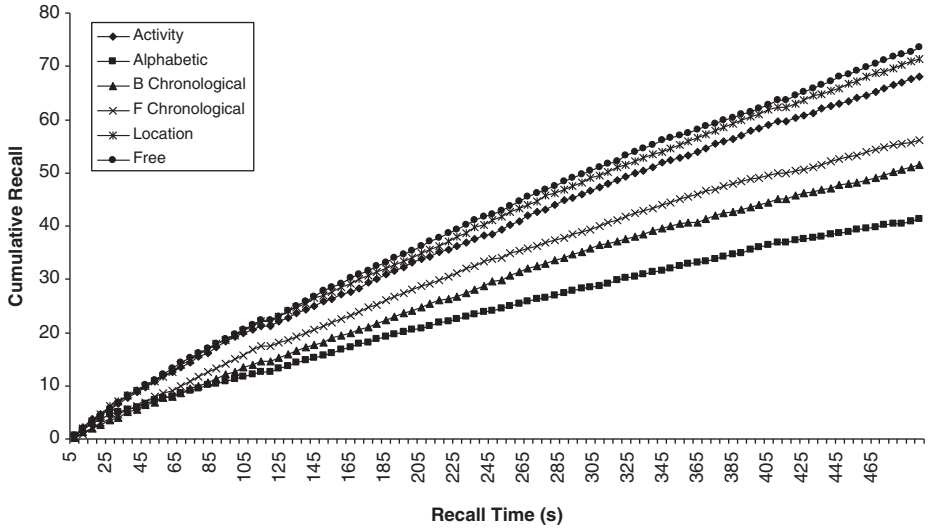

Figure 4. Mean cumulative number of friends recalled as a function of recall time in seconds and strategy condition for Experiment 4.

number of friends recalled as a function of strategy condition. There was a main effect of strategy condition, $F(5, 123) = 12.14$, $MSE = 307.45$, $p < .01$, partial $\eta^2 = .33$. Bonferroni follow-up comparisons suggested that both visualization conditions were not significantly different from one another and were not significantly different from the free recall condition (all ts < 1, all ps $> .90$). However, the number of friends recalled in the free recall condition was significantly higher than all other conditions (all ts > 3.4, all ps $< .01$).

Discussion

The results from Experiment 4 demonstrated that instructing participants to use a visualization strategy (either an activity or location visualization strategy) led to similar levels of performance as the free recall condition. Instructing participants to use an alphabetic recall strategy resulted in the lowest recall levels, whereas instructing participants to use a chronological strategy resulted in intermediate levels of recall. Examination of the cumulative recall functions suggested that, although participants started off recalling at a similar rate in all conditions, searching for friends with an ordered strategy (alphabetic or chronological) resulted in a less efficient search with long gaps between successively recalled items. These results suggest that, when searching for friends from autobiographical memory, participants likely rely on visualization strategies and rely less on ordered strategies.

GENERAL DISCUSSION

In four experiments we examined strategic search processes in tasks that required recall of information from semantic and autobiographical memory. In the first two experiments, we examined strategic search processes in semantic memory by having participants recall animals for an extended period of time. In Experiment 1, it was found that participants report using a variety of different strategies to recall animals, mostly relying on a visualization strategy and using the prior retrieved item as a cue for additional items. Furthermore, participants reported that many times their recall was based on no strategy at all. Consistent with prior work, this suggests that participants are quite strategic when searching their semantic memories, but that random components also dictate retrieval at times. In Experiment 2, participants were instructed to use various strategies and it was found that being instructed to use a visualization strategy resulted in similar overall performance as when participants were allowed to recall using what strategy they wished, but being instructed to use an ordered strategy (i.e., alphabetic or size) resulted in much worse performance. This suggests that participants have a strong tendency to rely on a visualization strategy when searching semantic

memory and that other search strategies (such as ordered strategies) do not adequately access the stored information.

Examining autobiographical recall in Experiments 3 and 4 in terms of recalling personal friends suggested very similar results as when recalling animal names. Specifically, Experiment 3 demonstrated that when participants are asked about the types of strategies, if any, they use when recalling their friends, participants report using a variety of different strategies and in particular report using a visualization strategy and using the just retrieved item as cue for additional items. Likewise, participants also reported that many times they relied on no strategy to retrieve the names of their friends. Furthermore, Experiment 4 demonstrated that, when instructed to use a visualization strategy, performance was similar to free recall, but, when instructed to use an ordered strategy (such as alphabetic or chronological strategies), performance tended to be worse than free recall. This suggests that, when recalling the names of friends from autobiographical memory, participants tend to rely on something like a visualization strategy (location or activity based) and more ordered strategies are not as efficient. Note that prior work has suggested that the search for friends is largely dictated by social proximity factors (how well two individuals know each other; Brewer et al., 2005; Hills & Pachur, 2012). It is likely that several of the strategies indicated in the present study are partially based on social proximity factors. For example, when visualizing different locations it is likely that the friends retrieved from those locations all know one another (i.e., they all work together). Future work is needed to better examine how these factors are related and uniquely or jointly account for retrieval.

Across the semantic and autobiographical retrieval tasks a number of similarities arose. Specifically, participants reported using a variety of search strategies while recalling. Importantly across both types of tasks participants primarily reported using a visualization strategy, no strategy, and using the prior retrieved item as a cue. When instructed to use particular strategies, participants in the visualization conditions performed equivalently to participants in the free recall condition, whereas participants in various ordered strategy conditions performed far worse. These results suggest that there are strong similarities between semantic and autobiographical recall in the current tasks.

Collectively, these results are consistent with the idea that LTM search relies on both directed (strategic) and random components. Across both tasks, participants indicated that they used a variety of strategies and, at the same time, frequently relied on no particular strategy. Thus, word generation was driven by both strategic factors and as well as the probabilistic nature of the search process. These findings coincide nicely with Nickerson's (1981) claim that retrieval from LTM (or what he called archival memory) is a balance between automatic/passive retrievals and more strategic/motivated search. Thus, the current results, as well as prior research which has examined the nature of retrieval strategies (Gronlund & Shiffrin, 1986; Walker & Kintsch, 1985; Whitten & Leonard, 1981; Williams & Hollan, 1981), suggests that search from LTM is not just a probabilistic search process, but rather that the individual brings a number of different strategies to the table in an attempt to retrieve the desired information. The ability to generate and utilize particular search strategies is likely reliant on working memory control processes that allow one to self-generate various cues to search LTM with, and to dynamically change search strategies when a particular search strategy is no longer working within a given retrieval task or across tasks (Hills & Pachur, 2012; Rosen & Engle, 1997; Schelble, Therriault, & Miller, 2012; Unsworth et al., 2013). In order to understand the nature of LTM search, we must not only understand the probabilistic nature of search, but also understand the strategic components that participants use to retrieve target information.

The current results are also consistent with prior research which suggests that when searching for information in fluency tasks participants frequently rely on episodic/experiential information to generate various situational contexts to search (e.g., Reiser et al., 1985; Williams & Hollan, 1981). For example, Walker and Kintsch (1985) found that, when participants search for information in semantic fluency tasks, they typically relied on aspects of episodic memory (e.g., a visualization strategy) to guide their search of LTM. Likewise, prior research has demonstrated that the hippocampus is active while generating exemplars in semantic fluency tasks and that similar activations are found while searching for information in semantic and episodic memory tasks (Ryan, Cox, Hayes, & Nadel, 2008). Furthermore, patients with medial temporal lobe lesions demonstrate deficits on semantic fluency

tasks (Greenberg, Keane, Ryan, & Verfaellie, 2009). The fact that participants relied on visualization strategies while searching both semantic and autobiographical memory in the current study is consistent with this prior work in suggesting that a key component of strategic search processes is the ability to utilize past experiences to generate situational contexts to search. Thus, an efficient search strategy is one that allows participants to use prior experiences to constrain the search to particular contexts. Furthermore, the current results suggests that most participants appear to naturally use strategies that perform well, which may indicate that strategies are adapted to the structure of the environment (Hills et al., 2012).

These results can be interpreted within prior models of controlled search that suggest that first participants select a retrieval strategy and then participants use that retrieval strategy to switch between global and local cues while searching LTM (Burgess & Shallice, 1996; Hills et al., 2012; Norman & Bobrow, 1979; Reiser et al., 1985; Whitten & Leonard, 1981; Williams & Hollan, 1981). Specifically, it is suggested that individuals likely start out recalling high frequency exemplars based on fairly spontaneous passive recall (Nickerson, 1981). However, given the prolonged nature of the task, random/passive recall will cease to produce many results and participants will likely switch to a more strategic/active approach. In this case, participants will select various retrieval strategies throughout the task that allow them to effectively search within a particular domain (e.g., search for animals or search for friends). Although we have primarily focused on the overall strategies that participants use, it would be remiss not to note that it is likely that participants are dynamically switching strategies throughout the task and switching from using passive/random retrieval versus more effortful/directed retrieval. Indeed, while using a specific conscious strategy it is likely that information will also be activated automatically that is associated with the information generated by the strategy, so that both strategic and automatic processes are working together. Thus, it is not the case that conscious strategies are always dictating retrieval, but that these strategies generally facilitate retrieval by consciously generating various contexts to search and via automatic associations that are activated within the different contexts. Future research is needed to better examine the dynamic nature of strategic search processes.

Overall, the current results suggest that examining strategic aspects of the search processes is necessary in order to fully understand how we retrieve information from LTM. Future work is needed to better examine the dynamic nature of strategic search by examining how participants switch search strategies within and between tasks and to examine when participants are likely relying on more automatic/passive components of search and when they switch to more controlled/strategic components. By examining the dynamic nature of LTM search, we should be able to better characterize the retrieval process.

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