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The Self as a Memory System: Powerful, but Ordinary

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This article provides a research model of the process by which personal and social knowledge serves as a nucleus around which new knowledge is easily accumulated. In 4 experiments, Ss produced friends' names and then constructed sentences, each including a name together with an assigned (target) noun. Unexpected recall tests showed greatly superior memory for target nouns used in sentences with own friends' (self-generated) names vs. nouns used in sentences with others' friends' (other-generated) names. This "self-generation" effect was robustly observed across several procedural variations. Computer simulations of Experiments 3 and 4 supported the assumption that the self-generation procedure's effect on free recall of target nouns is mediated by retrieval of the self-generated names with which the nouns are sentence-paired. Together with other recent findings, these results indicate that powerful mnemonic effects associated with the self can be understood in terms of familiar, ordinary memory processes.

Traditionally, the self has been regarded as an object of some mystery. Philosophical discussions of a "transcendental ego" (cf. James, 1890, who criticizes that usage) have implied that the self is beyond scientific study. However, the research and scholarship of the past decade have justified interpretation of the self as an *organization of knowledge,* and thus as an object within the scope of empirical psychology. Greenwald and Pratkanis (1984) and Kihlstrom and Cantor (1984) described the self as a knowledge structure that combines declarative and procedural components, favoring structural characterizations of the self as a complex attitudinal schema (Greenwald & Pratkanis) or a memory network (Kihlstrom & Cantor).

Self and Memory

Historical reviews of theory and research on the self reveal a long tradition of viewing the self and memory as two sides of the same coin (see Greenwald, 1981; Greenwald & Pratkanis, 1984; Kihlstrom et al., 1988, for reviews). However, it is only in the past 10 years, beginning with the demonstration of the self-reference effect in memory (Rogers, Kuiper, & Kirker, 1977), that empirical studies of the role of the self in memory have been actively pursued. The extensive recent research on self and memory is the major empirical arm of the movement to bring the study of the self within the sphere of empirical science.

Research on self and memory has proceeded as a dialogue between works that demonstrate exceptional mnemonic capabilities associated with self-knowledge (e.g., Bellezza, 1984; Kuiper & Rogers, 1979; Rogers et al., 1977) and works that credit such "exceptional" findings to ordinary processes (e.g., Bower & Gilligan, 1979; Ferguson, Rule, & Carlson, 1983; Keenan & Baillet, 1980; Klein & Kihlstrom, 1986). There appear to be three options for interpreting this evolving body of evidence: (a) the self is a unique cognitive structure, having extraordinary mnemonic capabilities; (b) the self is built on the model of other knowledge structures, although it may have some memory-favoring properties in especially great degree; or (c) there is no distinct structure associated with the self—mnemonic effects attributed to the self are readily interpreted as artifacts of other structures and processes.

The recent burst of research activity on self and memory provides the major context for the present research, which establishes procedures for a new self/memory effect. However, this research has additional contexts in three other domains of memory research, which converge in their focus on processes by which a structure of existing knowledge facilitates the acquisition of new knowledge: (a) the study of strategies for improving memory, or mnemonic devices (Bellezza, 1981; Bower, 1970; Yates, 1966), (b) the empirical study of item content variations, such as meaningfulness and imageability, that reliably affect memorability (Paivio, 1965; Rubin, 1980; Underwood & Schulz, 1960), and (c) the study of experts' mnemonic abilities versus those of novices (Charness, 1976; Chiesi, Spilich, & Voss, 1979).

Self-Generation Procedure

Following the lead of Rogers et al. (1977), most self/memory research has used variants of the *levels-of-processing* procedure introduced by Craik and Tulving (1975). The essence of the levels-of-processing procedure is to give subjects a variety of judgment tasks in relation to a series of items, with no memory test expected. The tasks oblige qualitative variations in encoding and result in different levels of incidental memory for the items. As one such encoding task, *self-reference* is typically achieved by asking subjects to judge the accuracy of each of a series of

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trait adjectives as self-descriptions. The levels-of-processing procedure has been remarkably successful both in documenting the superiority of self-reference over many other encoding tasks and in permitting variations that test alternative interpretations.

This article introduces a new experimental procedure for examining self/memory relations. This procedure, *self-generation,* is based on two previous studies that used sentence-construction encoding tasks (Breckler, Banaji, Greenwald, & Pratkanis, 1981; Greenwald, Banaji, Pratkanis, & Breckler, 1981). The subject's task is to construct a sentence that contains both a to-be-remembered target item (generally a concrete-object-name noun) and a friend's name. This task overlaps little with the familiar self-reference task and provides an opportunity for a non-self-relevant item (the noun) to become associated with an existing item of self-relevant (i.e., idiosyncratic, personal) knowledge. Such sentence-construction procedures (see also Bobrow & Bower, 1969; Bower & Gilligan, 1979; Friedman & Pullyblank, 1982) avoid a problem of the self-reference procedure, namely that it is limited to use with materials (such as trait names and body parts) that have existing associations with the self. Breckler et al. (1981) showed that target nouns that had been used in sentences with self-generated names were much better recalled on incidental recall tests than were nouns used in sentences with unfamiliar names. Greenwald et al. (1981) showed also that this self-generation effect was observed for cued recall of target nouns (cued by the self-generated names).

Like the self-reference-effect procedure, that for the self-generation effect provides opportunities for variants that can test a range of interpretations. The present experiments establish the basic properties of the self-generation procedure. In addition, computer simulations of Experiments 3 and 4 establish the feasibility of suggested interpretations.

Experiment 1: A Self-Generation Effect

Method

Overview of Procedure

The experiment was presented in a series of short booklets, through which subjects proceeded at their own pace. The first booklet started by describing a task that was ostensibly the major focus of the research: learning and remembering miscellaneous minor facts (trivia). Actually, the trivia learning served as a filler task that permitted a delay before unexpected memory tests for target nouns. Before doing the trivia task, subjects were asked to generate the names of 10 college friends. They were then asked to construct 20 sentences, each of which was to include a person's name and an assigned (target) noun. Half the sentences used subjects' own generated (friends') names; the remainder used comparable but unfamiliar names, which were provided in the booklet. Next, subjects studied the answers to 20 trivia questions, for which they knew they would receive a recall test later in the session. Before that anticipated test, however, three unexpected recall tests were administered: (a) target free recall—free recall of the target nouns that had been used in the sentence-construction task, (b) name recall—free recall of all names used in the 20 sentences, and (c) cued recall—recall of target nouns, cued by presentation of the 20 names that had been used in the sentence-construction task.

Subjects

Thirty-six Ohio State University undergraduates participated in partial fulfillment of a requirement of their introductory psychology course. The subjects participated in small groups and were seated around a table.

Procedure

Name generation. After reading a description of the trivia task that was presumably the focus of the experiment (see Filler task section), subjects were told that they would be performing other tasks that had not previously been used in research. The first of these was to write the last names of 10 college friends onto numbered blank spaces and to copy 10 other names from a separate sheet onto other numbered spaces. (Subjects were asked to copy the other-generated names in order to match the physical response aspect of producing self-generated friends' names.) Across subjects, 10 different lists of other-generated names were used, each a different selection of names generated by subjects in a previous study by Greenwald et al. (1981).

Sentence-pairing task. The next task was to write a series of 20 sentences, for which the only instruction was that each sentence include (a) a person's name and (b) an assigned (target) noun. Each person's name was identified by number on the sheet that had been used for writing self-generated names and copying other-generated names. Nouns were selected from the Battig and Montague (1969) study of 56 noun categories. All nouns were the names of concrete objects (examples: *candle, brush, ring, truck*). These target nouns were selected with two constraints: (a) no 2 came from the same category and (b) no 2 had the same initial letter.

Subjects wrote sentences on sheets of paper on which the space for each sentence was headed by (a) the number used to index a person's name and (b) the target noun, which was printed in all uppercase letters. Of the 20 sentences, 10 paired a target noun with a self-generated name, whereas the remaining 10 paired nouns with other-generated names. These two types of sentences were requested in a random order. This task was self-paced in order to ensure that the encoding activity of constructing a sentence would be completed for each item, without at the same time obliging subjects to be idle for a substantial fraction of their time. The following instructions preceded the first requested sentence:

> If the task is "Create a sentence using name #4 and the word REFRIGERATOR," you should turn to the previous page and look up name #4. If name #4 happens to be "Jones," then a suitable sentence might be:
>
> Jones spent all Saturday morning repairing the refrigerator.
>
> The sentence should be constructed so that the person and object are actively involved with one another.

Filler task. On completing the sentence-construction task, subjects returned their first booklets to the experimenter. They then received a second booklet containing 20 items, each of which consisted of a question about an obscure fact and its answer. Subjects studied these trivia items as long as they wished. The following is an example:

> Q: In 1941, RCA presented the first commercial television program. What was it, and who sponsored it?
>
> A: A report giving time and weather, sponsored by the Bulova Watch Company.

Subjects were informed that there would later be a test in which these questions would appear again, at which time it would be necessary to produce the answers. As noted previously, subjects had been instructed that the anticipated test for the trivia answers was the main focus of the experiment.[1]

[1] We thank our colleague, Anthony R. Pratkanis, for developing the materials for this task, which proved to be an involving diversion for subjects in this series of experiments.

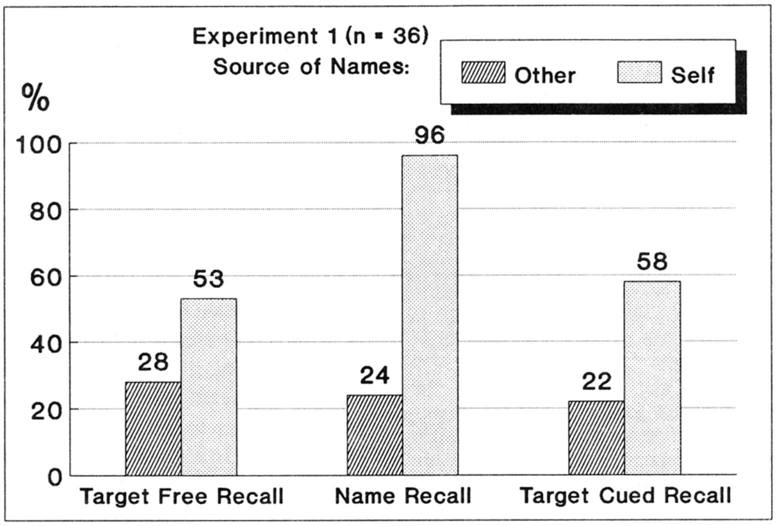

Figure 1. Free and cued recall of nouns linked to self-generated and other-generated names and to free recall of names. (Measures obtained in this order: free recall, name recall, cued recall.)

Free recall. On completing study of the trivia items, subjects were given a sheet that contained an unexpected test for recall of the nouns that had been used in the sentence-construction task. The sheet contained 20 blank spaces, in which subjects were asked to write as many as they could of the "object words" (target nouns) that they had been asked to use in their sentences.

Name recall and cued recall. On turning in the sheet containing the target free-recall data, subjects received a sheet on which they were asked to recall the self-generated names ("your friends' names") and the other-generated names ("names we provided"). After turning in that sheet, subjects were given back the sheet on which they had originally produced the self-generated names and had copied the other-generated names. They were asked to write, next to each name, the object word (noun) that had been associated with it in the sentence-construction task.

Finally, subjects were given the expected quiz for recall of the answers to the trivia questions, after which the purposes of the experiment were explained and questions about the experiment were invited and answered.

Results

Findings for the three recall measures are shown in Figure 1. As expected on the basis of previous findings, free recall of target nouns was considerably better when the nouns had been used in sentences with self-generated, as compared with other-generated, names (53% vs. 28%), $F(1, 35) = 43.61$, $p < .001$, root $MS_e = 15.5\%$. An even larger effect was observed on the cued-recall measure (58% vs. 22%), $F(1, 35) = 99.13$, $p < .001$, root $MS_e = 15.5\%$. In addition, and not surprisingly, self-generated names were recalled much better than other-generated names (96% vs. 24%), $F(1, 35) = 603.76$, $p < .001$, root $MS_e = 12.2\%$.

Discussion

Self-Generation Effect

When sentences were constructed using other-generated names, only about half as many target nouns were recalled (28% vs. 53%). Using the **d** metric for effect magnitudes suggested by Cohen (1977), this difference constitutes a strong effect, one for which **d** equals 1.56. The strength of this self-generation effect indicates the operation of a mnemonically powerful process.[2]

Unexpected Cued-Recall Inferiority

For targets associated with other-generated names, cued recall was, surprisingly, lower than free recall at a marginally significant level (22% vs. 28%), $F(1, 35) = 2.95$; $p < .10$, two-tailed; root $MS_e = 16.5\%$. This occurred even though cued recalls were scored using a lenient criterion, by which recalled target nouns were counted as correct even on the (rare) occasions when they were not in correct association with names. One expects routinely that cued recall should be at least at the level of free recall, because the major difference between free- and cued-recall tests is that subjects have an *extra* aid to recall in the latter. Possibly, either (a) there was some forgetting between the first memory test (free recall) and the third (cued recall), or (b) subjects were inhibited in producing target-noun responses on the cued-recall test because of the request that they link these nouns with names, a difficult task in the case of other-generated names.

Experiment 2: Varied Order of Recall Tasks

The three recall measures of Experiment 1 were obtained in the order: (a) free recall of target nouns, (b) free recall of names, and (c) cued recall of targets. The tests were conducted in this order so as not to give subjects information during one test that

[2] For comparison, Cohen (1977) characterized **d** values of 0.2, 0.5, and 0.8 as, respectively, weak, moderate, and strong effects. Some other well-established effects on free recall and their effect sizes are the effect of levels of processing on incidental free recall (**d** = 2.29; Hyde & Jenkins, 1969, average of Experiments 1–3); the effect of elaboration distinctiveness on incidental cued recall (**d** = 1.38; Stein & Bransford, 1979); and the generation effect on intentional free recall (**d** = 1.29; Slamecka & Graf, 1978, Experiment 4).

Table 1
Recall Measures (%) as a Function of Six Order-of-Presentation Conditions: Experiment 2

Recall order condition	n	Free recall Self	Free recall Other	Name recall Self	Name recall Other	Cued recall Self	Cued recall Other
Free, name, cued	13	58.5	41.5	95.4	—	62.3	25.3
Free, name, cued	13	66.9	47.7	—	37.7	68.5	23.1
Cued, name, free	13	74.6	39.2	98.6	—	73.8	23.8
Cued, name, free	14	60.0	39.3	—	56.4	62.9	22.1
Free, cued, name	9	55.6	38.9	—	53.3	63.3	21.1
Cued, free, name	11	71.8	40.9	—	62.3	68.2	36.4

Note. Free- and cued-recall data in Self and Other columns are for nouns linked in sentences to self- and other-generated names, respectively. Name-recall data are for self- and other-generated names. Subjects were asked to recall only self-generated names or only other-generated names, as indicated by the column in which name-recall data appear.

could improve their performance on a later test. Nevertheless, there are several ways in which recall performance could have been affected by the order of the three tests (see discussion by Srull, 1984). For example, there could have been forgetting between tests or—just the reverse—one test might have provided rehearsal that aided performance on a second one. Experiment 2 was a replication of Experiment 1 in which the order of recall tests was varied among six groups of subjects.

Method

Subjects

Seventy-three undergraduates from the same population used in Experiment 1 provided data. (Data were not analyzed for 2 other subjects who did not properly follow instructions.)

Design and Procedure

With the exception of varying the order of recall tasks and making a change in the name-recall task, the procedure was the same as that of Experiment 1. The first recall test was always either for free or cued recall of targets. In four of the six recall-order treatments, name recall was the second task. The name-recall instructions were changed from those in Experiment 1 by asking that subjects report either just the self-generated names or just the other-generated names. For the remaining two treatments, the name-recall task was last. The full design, along with results of all recall tests for each order of tests, is shown in Table 1.

Results

Averaged results for name recall and for free and cued recall of target nouns are shown in Figure 2. These results are similar to those of Experiment 1. Free recall was substantially better for targets associated with self-generated names as compared with other-generated names (65% vs. 41%), $F(1, 72) = 63.74$, $p < .001$, root $MS_e = 17.7\%$; and a similar but larger difference was obtained for cued recall (66% vs. 26%), $F(1, 72) = 215.19$, $p < .001$, root $MS_e = 16.6\%$. Also, free recall of names was considerably better for self-generated names than for other-generated names (97% vs. 47%), $F(1, 51) = 141.70$, $p < .001$, root $MS_e = 15.0\%$. Experiment 1's surprising result—the inferiority of cued recall to free recall for targets associated with other-generated names—was again obtained; this unexpected difference was highly significant (26% vs. 41%), $F(1, 72) = 47.48$, $p < .001$, root $MS_e = 13.7\%$, and the direction of this difference was the same for all six order-of-testing treatments (cf. second and sixth data columns of Table 1).

As can be seen in Figure 2, the magnitude of the self-generation effect (free-recall differences between self- and other-generated conditions) was little affected by the order of recall tests. There was a slight tendency for recall to be greater when cued-recall tests came first, suggesting that the cued-recall test might provide some useful rehearsal. Nevertheless, with one expectable exception, differences as a function of test order were not statistically significant. The exception was that subjects recalled more other-generated names when they had a chance to observe those names in a cued-recall test before taking the name-recall test (38% vs. 57%), $t(67) = 3.72$, $p < .001$.

Discussion

Experiment 2 confirmed Experiment 1's finding of superior free and cued recall for words that had been sentence-paired with self-generated names. Furthermore, Experiment 2 provided assurance that the order of free- and cued-recall measures used in Experiment 1—an order selected because it appeared least likely to produce mutual contamination among the tests—reasonably estimated the results to be expected for each measure when it came first.

Experiment 1's unexpected result—that of cued recall being inferior to free recall for targets sentence-paired with other-generated names—was obtained even more strongly in Experiment 2, and was obtained for the comparison of free- and cued-recall tests when each was the first test administered (see Table 1). It cannot yet be judged whether this effect is of theoretical interest or is only an inconsequential by-product of novel procedures.

Experiment 3: Between-Subjects Replication

In Experiment 3, a between-subjects variation of self- versus other-generated names was used, both to extend the range of conditions under which the mnemonic impact of self-generated names was observed and to obtain reference data for a planned computer modeling of this effect (see General Discussion section). In Experiment 3, then, half the subjects constructed sentences exclusively with self-generated names; the remainder constructed sentences exclusively with experimenter-provided names. In an attempt to examine further the unexpected cued-recall inferiority effect, a liberalized procedure for testing cued recall was used. Another extension of the preceding experiments was the addition of a final test for recognition of target nouns.

Method

Subjects

Thirty-two students from Ohio State University's introductory psychology course participated in several small groups.

Procedure

To implement self-generation versus other-generation as a between-subjects variable, 16 of the subjects (randomly chosen) were asked to generate 20 friends' names as their first task, whereas the other 16 were to copy 20 names provided by the experimenter as their first task. Correspondingly, half the subjects then performed the sentence-construction task with all 20 sentences using self-generated names. The remainder performed this task with all 20 sentences using other-generated names. The recall tests were conducted as in Experiment 1; that is, free recall first, name recall second, and cued recall third.

In light of the possibility that cued recall for other-generated names might have been suppressed by the difficulty of producing correct name–target linkages, the cued-recall procedure of Experiments 1 and 2 was modified. Subjects were asked to recall target nouns in the presence of the full list of name cues, but were not initially asked to match recalled targets with names. The cued-recall test was therefore virtually a second free-recall test, but with the list of 20 names provided as a source of possibly helpful cues. A recognition test was added at the end of the procedure, that is, after the cued-recall test. For the recognition test, the 20 target nouns were randomly intermixed with 20 foils, which were selected from the Battig and Montague (1969) norms in the same manner as the 20 targets (see Experiment 1, Procedure section). Subjects responded to each of these items on a 4-point scale, ranging from *Sure I did not see it* to *Sure I did see it*. Because the two middle response categories (*Think I did not see it* and *Think I saw it*) were almost never used, responses were scored simply as *old* or *new*.

Results

The findings are summarized in Figure 3. The results confirmed those of Experiments 1 and 2 in all particulars: (a) Free recall of targets was better for self- than for other-generated names (72% vs. 49%), $F(1, 30) = 12.28$, $p < .001$, root MS_e = 18.2%; (b) a slightly larger difference of the same sort was obtained for cued recall of targets (70% vs. 42%), $F(1, 30) = 11.22$, $p < .01$, root MS_e = 23.5%; (c) free recall of names was much better for self-generated names (94% vs. 29%), $F(1, 30) = 316.20$, $p < .001$, root MS_e = 10.5%; and (d) cued recall was again inferior to free recall for targets associated with other-generated names, although this effect was not statistically significant (42% vs. 49%), $F(1, 15) = 2.95$, $p < .11$, root MS_e = 11.3%. (The marginal significance of the cued-recall inferiority effect level is plausibly a consequence of the reduced power of Experiment 3's between-subjects design, relative to the within-subjects designs of Experiments 1 and 2.)

Recognition performance was nearly perfect (better than 98% correct) for target nouns associated with both self- and other-generated names. The very high level of recognition in the other-generated-names condition may have obscured a possible self-generation effect on target recognition. Nevertheless, the recognition data provided an informative contrast with the data for free and cued recall. The generally high recognition level indicated that virtually all target nouns received an initial encoding that was sufficient to establish a retrievable episodic trace. At the same time, the recall findings showed that the self-generation and other-generation conditions differed sharply in the success of this encoding in supporting either free recall or cued recall.

Experiment 4: Self-Generated Names Mediate Recall of Targets

The theoretical analysis that guided development of the self-generation procedure (Greenwald, 1981, pp. 228) assumed that (a) cue items generated by the subject play a critical mediating role in recall, and (b) these mediating cues could be "any . . . easily remembered set of items." These two hypotheses, which can be labeled *cue mediation* and *cue variety*, are described more completely here.

> *Cue mediation hypothesis.* It is hypothesized that self-generated cues (friends' names in Experiments 1–3) are essential *mediators* of free recall in the self-generation experiment. If this hypothesis is correct, then in order to recall a target noun subjects should first retrieve, at least covertly, the self-generated name associated with it.
>
> *Cue variety hypothesis.* It is hypothesized that any reliably reproducible set of self-generated cues can mediate target recall. In Experiments 1–3, friends' names were used because they had the desirable properties of being easily generated and reproduced by all subjects while also differing from subject to subject (i.e., being idiosyncratic). Other sets of producible–reproducible cues should also work as effective mediators.

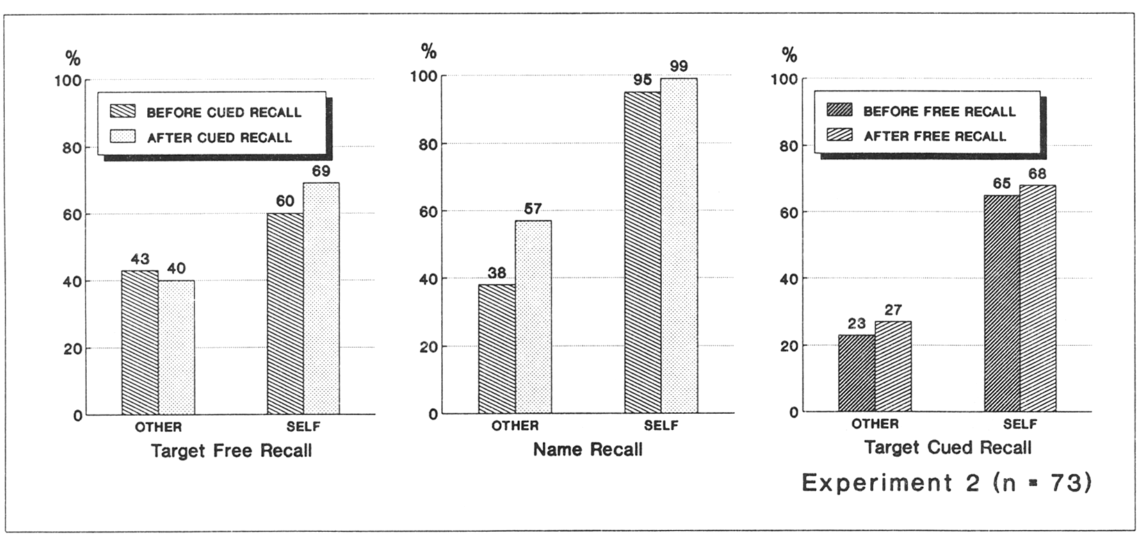

Figure 2. Recall as a function of test order. (Data combine conditions given in Table 1.)

The first 3 experiments repeatedly demonstrated superior free and cued recall for targets associated with self-generated names, as compared with targets associated with other-generated names. However, there have as yet been no direct tests of the cue mediation and cue variety hypotheses.

In Experiment 4, the cue mediation hypothesis was tested in two ways. First, a manipulation of associative interference with name retrieval was used. There was no reason to expect this manipulation to interfere *directly* with target free recall. Accordingly, an observed reduction of target free recall in association with a reduction in name recall would support the hypothesis that target free recall is mediated by recall of name cues. Second, the recall task was revised to allow observation of the spontaneous order-of-recall relation between self-generated names and target nouns. The cue mediation hypothesis predicts that recall of names should precede recall of their associated target nouns.

The cue variety hypothesis was tested by using entertainers' names as a second type of cue that had the properties of being easily producible and reproducible. High levels of target recall with this second category of self-generated cues would indicate that the present results are not dependent on the specific category of self-generated cues (friends' names) used in Experiments 1–3.

Method

Overview

All subjects constructed 20 sentences, each of which included a self-generated name. For half the subjects, the names for the first set of 10 sentences were those of friends; for the other half, the names were those of favorite entertainers. For half the subjects (interference condition), the second set of 10 sentences used names from the same category as the first 10, whereas for the remaining subjects (noninterference condition), the second set of names came from the category not used for the first set. This procedure was designed to provide an uncontaminated test of the effect of interference for the target nouns used in the first 10 sentences. That is, for the first 10 sentences, the encoding task was identical for the interference and noninterference conditions. For the second 10 sentences, however, interference condition subjects were obliged to use names that were only 11th to 20th in prominence in the assigned category, whereas noninterference subjects used—as they had for the first 10 sentences—the most prominent 10 names in the assigned category.

Subjects

Students from University of Washington's introductory psychology course participated in groups of at most 6 at a time. Subjects were assigned at random to the four conditions of the factorial design. Data for 14 of the 62 participants were unusable because of various failures to follow instructions ($n = 9$) or inability to generate sufficient numbers of entertainers' names ($n = 5$). This relatively high rate of subject loss was associated with the presence, in the University of Washington student population, of a sizable proportion of non-native speakers of English (chiefly Asian Americans). The greatest subject loss was in a condition that required production of 20 entertainers' names; some subjects were not sufficiently acquainted with popular culture to produce the needed number of entertainers' names.

Procedure

In contrast to the self-paced procedures of Experiments 1–3, Experiment 4 was under the timed control of the experimenter. This was done chiefly to ensure that the time spent constructing the second 10 sentences did not vary between interference and noninterference conditions.

First 10 sentences. After the usual initial instructions describing the trivia task, subjects generated 10 names, which for half the subjects were names of friends and for the other half were names of entertainers (defined as "movie stars, TV stars, comedians, musicians, etc."). Subjects wrote each name on an index card and then thoroughly shuffled the 10 cards. Next subjects constructed sentences by taking the top index card, reading the name on it, then turning it over to find a word (one of the 20 target nouns) printed in the upper left corner. A 30-s period was allowed for construction of each sentence. After completing the 10 sentences using these cards, subjects were given the trivia questions and answers, which they were permitted to study for 5 min, in anticipation of a later test.

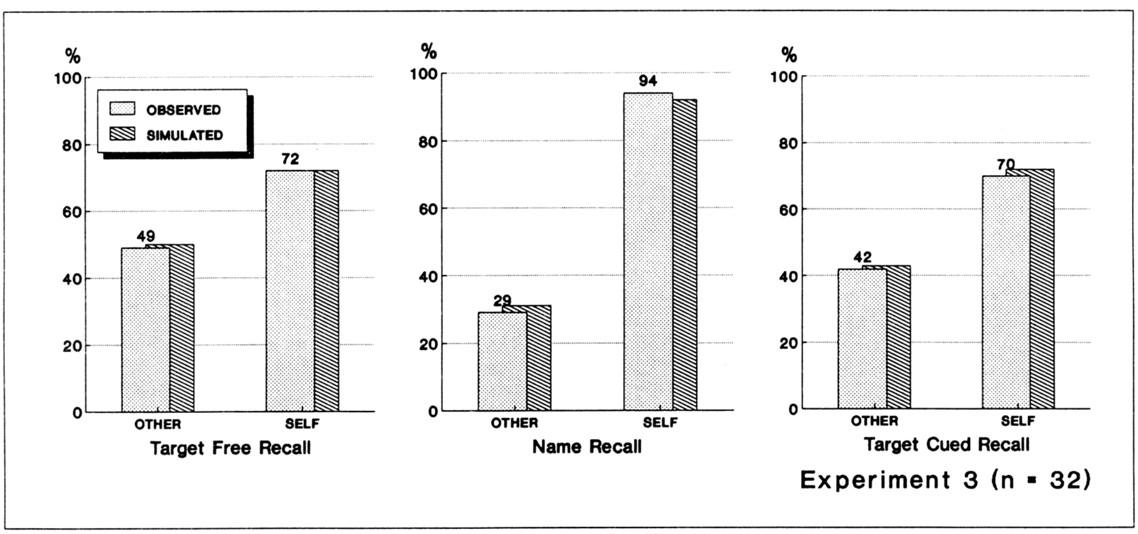

Figure 3. Recall measures for targets associated with self- and other-generated names. (Simulated data were produced in the computer simulation that is described following Experiment 4.)

Interference and noninterference treatments. The second set of 10 sentences used the same procedure as the first set: subjects generated 10 names on separate cards, shuffled the cards, and then constructed a sentence for each. As the critical experimental variation, half the subjects were instructed to generate 10 more names from the same category used for their first 10 (interference condition), whereas the remainder generated 10 names from the category not used for the first 10 (noninterference condition). After completing the second set of 10 sentences, subjects were again provided with the trivia questions and given a 4-min period for written recall of the answers.

Free recall. Next, each subject was given a small 40-sheet pad, which was to be used for recall of the 20 friends' and/or entertainers' names and the 20 target words. Subjects were allowed 6 min to recall as many names and nouns as possible, in whatever order they came to mind. They were instructed, further, to use the sheets of the pad in order and to write no more than 1 name or noun on each sheet. This procedure (a) permitted collection of data on the sequence in which names and target nouns were recalled and (b) removed already-recalled items from visibility.

Cued recall. After the free-recall test, cued recall was tested separately for the first and second sets of 10 items. The first set of 10 index cards was returned to each subject, with the subject's generated names facing up. Subjects were given 10 s per card to write their recall of the word that was printed on the card's reverse side, that is, to recall the target noun that had been sentence-paired with the name. Subjects were asked not to turn the cards over during this procedure and therefore received no feedback on the success of their cued-recall efforts. The same procedure was then used for the second set of 10 index cards.

Results

The associative interference variation did not succeed: The first 10 generated names were remembered equally well regardless of whether the second 10 names were from the same or a different category, $F(1, 44) = 1.21$, *ns*. As a consequence, it was not possible to pursue the test of the cue mediation hypothesis that depended on the occurrence of the interference treatment effect.

Cue Variety: Between-Subjects Test

Half the subjects (those in interference treatments) generated sentences with only a single type of name, either friends' or entertainers' names. Their data allowed a between-subjects test of the effect of type of generated name. If the self-generation effect does not require using friends' names for the sentence-generation task, then performance on the target free- and cued-recall measures should be similar, regardless of whether subjects produced sentences with friends' or entertainers' names. Analyses indicated no significant effects of name type used for the self-generation task on any of the three recall measures, all $Fs(1, 21) < 2.9$, $p > .10$. Although friends' names were slightly better recalled than entertainers' names (90.0% vs. 81.0%), target free recall (52.5% vs. 63.5%) and cued recall (53.3% vs. 68.5%) were actually better for entertainers' names.

Cue Variety: Within-Subjects Test

Half of the subjects (those in noninterference treatments) generated sentences with both friends' and entertainers' names, permitting a within-subjects test of the cue variety hypothesis. Analyses indicated the same pattern as was found in the between-subjects tests reported in the preceding section. Friends' names were better recalled than entertainers' names (90.0% vs. 82.2%), $F(1, 24) = 6.93$, $p < .05$. However, there were no differences as a function of friends' versus entertainers' names in either target free recall (57.0% vs. 55.9%) or target cued recall (58.2% vs. 63.8%), both $Fs(1, 24) < 1.52$, *ns*. In sum, all tests indicated that free and cued recall for targets used in sentences with self-generated entertainers' names were at a level equivalent to recall for targets in sentences with friends' names. The cue variety hypothesis was supported.

Recall-Order Test of Cue Mediation

For the free-recall test, subjects were permitted to recall names and nouns in any order. If recall of target nouns is mediated by recall of the names with which they are sentence-paired, then recall of each target noun should often come immediately *after* (rather than before or separated from) recall of its sentence-paired name. Examination of the recall-order data revealed that the majority of subjects (27 of 48) had, as instructed, freely intermixed nouns and names in their recalls (mixed-recalls strategy), whereas the remainder showed a pattern of recalling first a block of names, then a block of nouns, perhaps followed by smaller blocks of names or nouns (separated-recalls strategy).[3] The data (see Figure 4) can be summarized by observing that, for the mixed-recall subjects, there was an average of 11.66 (of the possible 20) name–target pairs for which both items of the pair were recalled; for 9.70 of these pairs (83.2%) the recalls were immediately adjacent, and 90.1% of these adjacent recalls were in the expected order of name followed immediately by target noun.[4] These recall-order data are strongly in accord with the cue mediation interpretation of the self-generation effect. Further discussion of these data, as well as of the other data in Figure 4, is given later with the results from associative modeling of Experiment 4.

Discussion

Experiment 4 was intended to provide direct tests of the hypotheses of cue mediation (recall of target nouns is mediated by recall of their sentence-paired names) and cue variety (any easily generated and remembered type of item can serve in the role played by friends' names in Experiments 1–3). Because the interference manipulation did not succeed, one of the planned tests of cue mediation was unavailable. However, consistent with the cue mediation hypothesis, order-of-recall analysis of the mixed-recall strategy subjects (top panel of Figure 4) showed a strong occurrence of the expected name-followed-by-

[3] The separated-recalls group included all subjects who either (a) started their recalls with a homogeneous block of at least four names, or (b) no more than two times gave adjacent recalls of a noun and a name from the same sentence (such pairs are likely to occur in switching between a block of name recalls and a block of noun recalls).

[4] Data had not been analyzed for 4 subjects who did not follow the instruction of reporting only a single word on each sheet of the recall booklet. For 3 of these subjects the improper recalls consisted of recalling the two items of each sentence pair on the same sheet, with name first; the 4th subject recalled the previously generated sentences (including both name and noun) on single sheets. Thus, these discarded subjects add to the evidence that recall of target nouns is mediated by recall of their sentence-paired names.

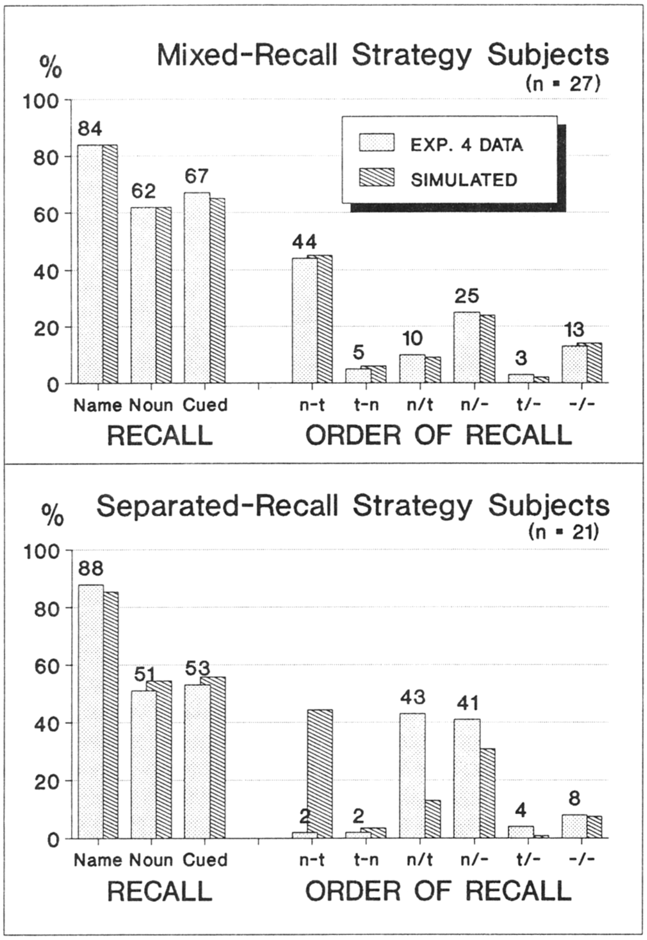

Figure 4. Results of Experiment 4. (n = name; t = target; n–t = pair recalled with name just before target; t–n = pair recalled with target just before name; n/t = name and target both recalled, but not adjacent; n/– = name only recalled; t/– = target only recalled; –/– = neither recalled.)

paired-noun sequence. (The bearing of Figure 4's data on cue mediation is considered further in the associative modeling analysis that follows.) The cue variety hypothesis was clearly supported by the equivalence of recall levels for target nouns that were sentence-paired with friends' and entertainers' names, in both between-subjects and within-subjects tests of this comparison.

Associative Modeling of the Self-Generation Effect

In the familiar terms of paired-associate learning, the self-generation experiment consists of a series of cue–response pairs (cue = generated name; response = target noun). The cue mediation interpretation of the self-generation effect of Experiments 1–3 can be translated into paired-associate terms by assuming that two types of associations are stronger when the cue term is a self-generated, rather than an other-generated, name. These two types of associations are (a) names with sentence-paired target nouns (cue–response associations) and (b) general cues of the experimental situation with names (context–cue associations—these permit retrieval of names during recall attempts). Because of the possibility of identifying some of its parameters with strengths of these associations, Shiffrin's SAM model (search of associative memory; Gillund & Shiffrin, 1984; Raaijmakers & Shiffrin, 1981) was used in an attempt to model the present findings. In particular, SAM was used to model the major findings of Experiments 3 and 4.[5]

Model of Experiment 3

Experiment 3's between-subjects variation of self- versus other-generated names provided data that were more easily used for model fitting than were data from the within-subjects designs of Experiments 1 and 2. SAM was used to fit parameters that would simultaneously model the data of Experiment 3's three recall measures (free recall of names, free recall of targets, and cued recall of targets).[6] In modeling Experiment 3, only two parameters of the SAM model, those corresponding to the two types of associations hypothesized (by the cue mediation interpretation) to be affected by the self-generation procedure, were permitted to vary between the (simulated) self-generated and other-generated names conditions. These two parameters were (a) one representing the strength of associations between names and target nouns and (b) one representing the strength of associations between nonspecific cues (context) and names. Results of a successful model, which was used for 500 simulated subjects (enough to provide very stable simulated data), are included in Figure 3. As can be seen in that figure, the simulation produced a very close fit to the observed data. The success of this fit indicates the feasibility of the cue mediation interpretation, that is, the feasibility of explaining the self-generation effect in terms of the mediation of target–noun recall by retrieval of self-generated names.

Model of Experiment 4

The goal of simulating Experiment 4 was to model not only the findings for the three recall measures, but also the detailed order-of-recall patterns shown in Figure 4. Other than the three associative strength parameters that were permitted to vary in modeling Experiment 3 (associative strengths of context to generated names, names to target nouns, and context to targets; see Appendix), all SAM parameters were fixed at the same values used for Experiment 3's simulation.

The initial attempt to model Experiment 4's order-of-recall data combined the data from all subjects into a single simulation. After repeated failed attempts to model the order-of-recall data, close examination of protocols revealed the two order-of-recall strategies (previously identified as mixed and separated

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[5] The authors are grateful to Gary Gillund for providing a FORTRAN version of SAM and to Richard Shiffrin for some suggestions regarding the use of SAM to model the results of the present research. The Gillund and Shiffrin program was revised by the authors (see Appendix) to run interactively and to model a paired-associate procedure (rather than the list learning procedure of the original).

[6] The SAM simulation did encounter a problem in attempting to fit the recognition data of Experiment 3. It was not possible to find a single value for SAM's recognition criterion parameter that would produce the high (near 100%) level of recognition accuracy that was obtained in both conditions of Experiment 3, while also successfully modeling the data for the three recall measures.

recall). It was possible to produce a very close fit to the order-of-recall data for the mixed-recall subjects, but it was not possible to find SAM parameters that came even close to fitting the order-of-recall data for the separated-recall subjects. (This simulation failure provides some justification for concluding that the separated-recall subjects had actively avoided the suggested strategy of recalling generated names and target nouns freely in any order.)

The modeling exercise for Experiment 4 was continued as an attempt to find two sets of SAM parameters, one set to fit the overall recall and order-of-recall data for the mixed-recall subjects, and another set to fit only the overall recall data for the separated-recall subjects. The resulting fits are shown in Figure 4. The parameter values that provided these fits (see the Appendix for details) were smaller than those for the self-generated names condition of Experiment 3, but were similarly proportioned in that the largest associative-strength parameter was that for name–noun associations, the next largest was that for nonspecific (context) cues to names, and the weakest was that for context cues to target nouns. The simulated order-of-recall data, shown on the right side of the lower panel of Figure 4, were generated as if subjects had used the mixed-recall strategy. As can be seen, these simulated results were very discrepant from the observed data. Remarkably, the simulation suggested that, had the subjects who used the separated-recall strategy instead used the mixed-recall strategy, they would have recalled an extra 6% of names and an extra 7% of nouns.

Free Parameters and Number of Data Points Fit

As is detailed in the Appendix, the SAM model for Experiment 3 included 10 parameters, 2 of which were allowed to have different values in the self- and other-generated names conditions. This model, with a total of 12 parameters, was used to fit 6 data points (three recall measures for each of the two conditions). It is apparent that, with more free parameters than data points being fit, the SAM model was not strenuously tested. (The test was, however, more strenuous than is suggested by this comparison of number of free parameters with number of data points, because there was an a priori specification of the two parameters that were permitted to have different values in the two conditions.) The value of the SAM simulation was more clearly apparent from its application to Experiment 4, in which a model that permitted only 4 parameters to vary was used to fit two sets of three recall measures, together with the six order-of-recall means (one of which is constrained by the remaining data) for the mixed-recall subjects. Consequently, 11 independent data points were economically fit with only 4 free parameters.

Modeling the Cued-Recall Inferiority Effect

It was surprising that subjects in Experiments 1–3 showed weaker cued recall than free recall of targets that had been sentence-paired with other-generated names. (Experiment 4 did not test this comparison.) Because cued-recall tests differ from free-recall tests only in having an extra cue for recall, this effect was puzzling. One explanation was evaluated by determining whether a model based on it could simulate Experiment 3's cued-recall inferiority finding.

The explanation that was modeled assumes that cued-recall inferiority results from subjects' attempts to use, as a retrieval aid, a cue that is only weakly associated with the to-be-retrieved target item. To model this interpretation, two sets of parameter values were used—one set corresponding to each condition of Experiment 3—with all but one parameter in each set fixed at the values previously used to simulate the recall data of Experiment 3. The one parameter allowed to vary was that specifying the strength of association between names and target nouns, that is, the parameter that represents the effectiveness of names as retrieval cues for targets. Figure 5 displays the simulated results that were obtained when this name–target strength parameter was varied through a wide range of values. It is apparent that cued-recall inferiority is predicted (by the SAM model) when the name–target association strength parameter drops to a sufficiently low value. An approximate description of the conditions that produce (simulated) cued-recall inferiority is that the strength of name–target associations is weaker than that of context–target associations; that is, cued-recall inferiority occurs when the cue (i.e., the name) is less effective as a retrieval cue than are other, nonspecific (i.e., context) cues. Conceivably, this process could be involved in some significant everyday failures of memory. That is, one may fail to retrieve an item by attempting to recall it with the aid of a salient cue with which it is only weakly associated (cf. Winograd & Soloway, 1986).

General Discussion

Relation to Other Memory Phenomena

The key ingredients of the self-generation effect are (a) the production of a set of items of personal, idiosyncratic knowledge, (b) strong association of each of these items with an arbitrary target item, and (c) later recall of the target items, mediated by covert retrieval of the self-generated cues. Other well-known memory procedures incorporate these three ingredients in varying degrees.

Formal mnemonic techniques have the most obvious similarity to the self-generation procedure. For example, in the *pegword* method (cf. Bower, 1970) the ordinal numbers (one, two, three, . . .) are linked in rhyming fashion to a set of objects (bun, shoe, tree, . . .), each of which is then imaged in association with consecutive items on a target list. The series of object-cues is later easily regenerated and the target items are then retrieved by virtue of the image associations. The *method of loci* is similar, except that the series of cues is a familiar sequence of locations, and the target items are imaged in these locations. These formal mnemonic devices differ from the self-generation procedure by virtue of their using the same cues for each subject; that is, the cues are items of common, rather than personal, knowledge.

The self-generation and mnemonic device procedures involve subject production of item-specific cues. In many other procedures, item-specific cues are provided by the experimenter. These cues may be some form of the target item itself (e.g., reading, hearing, or making judgments for each of a list of target items) or some cue that enables production of the target item (e.g., presenting an initial letter plus a rhyming word or a synonym, as for the generation effect; Slamecka & Graf, 1978). It is possible that, in response to each item-specific cue, the sub-

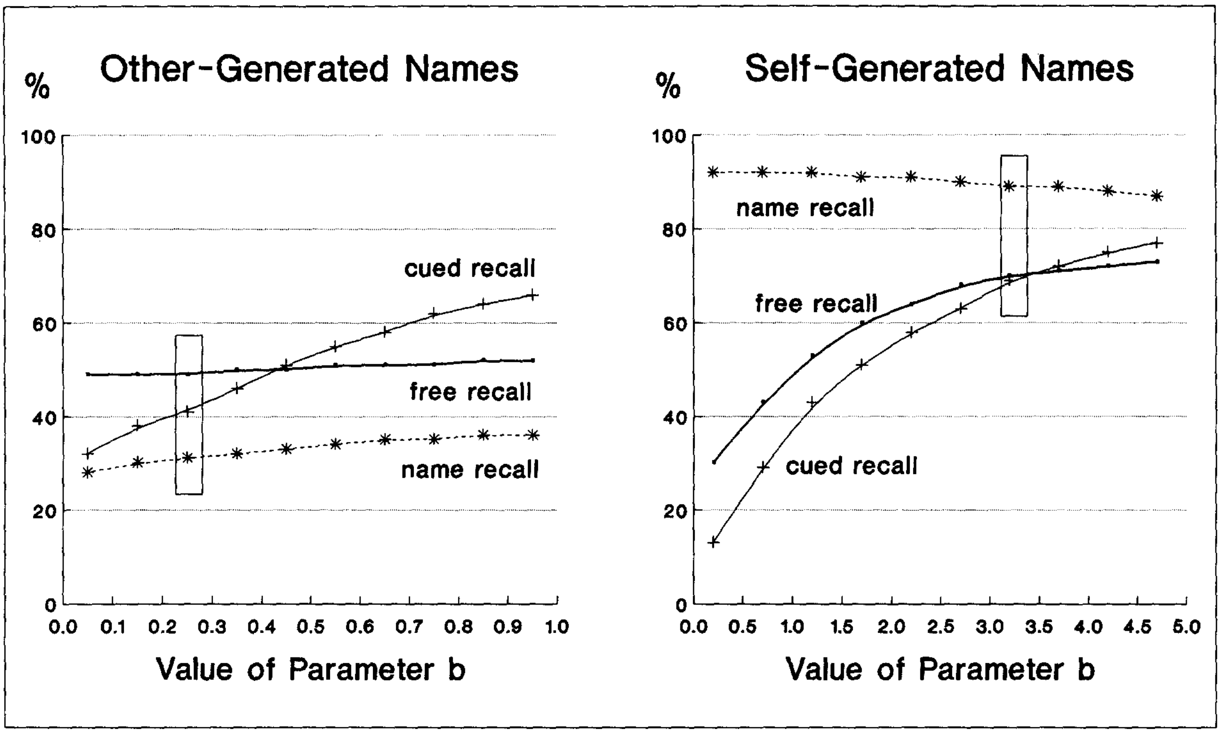

Figure 5. Simulation of Experiment 3's recall measures, varying SAM's name–target (interitem) associative strength (*b*) parameter (see Appendix for details). (Rectangles cover the value of *b* for each condition that best fit the actual results; cf. Figure 3.)

ject produces not only the target item, but also some covert response that may provide a cue useful in later retrieval. To the extent that item-stimulated covert cues are idiosyncratic and are retrievable in the absence of the target item, the theoretical analysis of memory tasks with experimenter-provided item-specific cues can resemble that of the self-generation effect.

For many experimental procedures, any idiosyncratic cues that are produced in response to each item remain covert and unobservable. However, for a variety of procedures item-stimulated cues can be made observable by instructing subjects to generate and report them. These include studies in which subjects are asked to generate (a) overt item elaborations, (b) item-relevant images or personal episodes, and (c) semantic, self-reference, or other item-relevant judgments. These procedures resemble the self-generation procedure to the extent that cues produced in response to items are idiosyncratic, easily retrievable without reexposure to the items, and effective in retrieval of target items.

Is the Self Unique as a Memory System? (No)

The introduction described three options for interpreting the literature on self and memory. In order of decreasing grandiosity, these are (a) the self is a unique cognitive structure that has *extraordinary* mnemonic capabilities; (b) the self is an *ordinary* knowledge structure, although it may have some memory-favoring properties in large degree; and (c) memory phenomena credited to the self can instead be credited to various sources of *artifact.*

The initial finding that self-reference led to higher levels of incidental recall than other encoding tasks (Rogers et al., 1977) gave some encouragement to the extraordinary view. However, subsequent research has been generally successful in making plausible the two less grandiose (ordinary and artifact) views. Follow-up studies have shown, for example, that the mnemonic benefit for self-reference judgments is no greater than those for judgments on other evaluated dimensions (Ferguson, Rule, & Carlson, 1983; Keenan & Baillet, 1980), for judgments concerning highly familiar persons (Bower & Gilligan, 1979; Friedman & Pullyblank, 1982; Keenan & Baillet, 1980), or for judgments that oblige a high level of organization of the judged items (Klein & Kihlstrom, 1986). Collectively, these findings suggest that the mnemonic benefit of encoding items in relation to self can be explained by the self's being a highly familiar and well-organized body of evaluatively polarized knowledge; these properties predispose events encoded in relation to self to be both effectively encoded and easily retrieved.

The present findings add to the existing evidence that the self's mnemonic effectiveness is explainable in terms of ordinary memory processes. First, as already noted, the self-generation procedure is a close analog of familiar mnemonic devices, such as the pegword method; its effectiveness can therefore be understood in terms of established principles for interpreting mnemonic devices (especially the properties of cue constructibility and associability, as described by Bellezza, 1981). Second, effective fits for the results of Experiments 3 and 4 were achieved using a simulation program that was developed to model a variety of familiar memory phenomena (SAM; Raiijmakers &

Shiffrin, 1981). Third, the high levels of free recall repeatedly obtained without instructions to remember indicate that the self-generation effect models a system that is effortlessly effective in episodic memory, as the self is assumed to be in some treatments (Greenwald, 1981).

Limiting Conditions for the Self-Generation Effect

The present experiments have consisted exclusively of positive demonstrations of the self-generation effect. Such unmixed success is a mixed blessing. Theoretical interpretation is made easier by being able to point to empirical variations that weaken or eliminate the effect (Greenwald, Pratkanis, Leippe, & Baumgardner, 1986). Fortunately, some preliminary studies included conditions that either failed to produce the effect or produced it at a substantially weaker level than in the present experiments.

An initial failed attempt, preliminary to Breckler et al. (1981), used as mediating cues a set of items that are commonly found in a desk drawer (paper clip, stapler, ruler, pencil, etc.), and used as target items object–name nouns that were printed on index cards. The (actual) desk items were presented one by one, and subjects were asked to pick out an index card containing the word "that goes best with" each object. The observed level of incidental free recall was so low with the first several subjects that the experiment was simply abandoned. This failed procedure differed in several ways from the present experiments. The two most likely to be critical were that (a) subjects did not themselves generate the mediating cues from memory, and (b) the encoding task was likely ineffective in establishing strong associations between cue items and their paired target words.

Breckler et al. (1981), Experiment 2

Self- and other-generated names were used with two encoding tasks: (a) sentence construction with target nouns, as in the present research, and (b) anagram construction, producing a four-letter word using two letters each from the name and the target noun. The sentence-construction task with self-generated names yielded more than three times as much free recall (50%) as the anagram task (14%), a difference that was highly significant statistically. This indicates the importance, in production of the self-generation effect, of using an encoding task, such as sentence construction, that establishes a strong association between each cue name and paired target noun.

Greenwald et al. (1981)

Three categories of self- and other-generated names were used with the sentence-construction task: (a) college friends' last names, (b) male and female first names (*not* the first names of friends), and (c) full names of celebrities (film stars and writers). For college friends' last names, the experiment was virtually identical to the present ones; the effect on free recall of targets for self- versus other-generation of names was even stronger than in the present experiments (78% vs. 16%). The results for the other two categories of items are particularly informative because the self- and other-generated names should have been approximately comparable in familiarity to subjects. For male and female first names, 38% of target nouns used in sentences with self-generated names were recalled, compared with 33% for other-generated names. For celebrities' full names, the corresponding self- versus other-generated comparison for free recall was 53% versus 36%. These results led to choosing friends' names, which showed the strongest self-generation effect, as the major category of items to be used in the present self-generation experiments.

The findings just reviewed identify empirical limiting conditions that prompt the following theoretical interpretations: (a) The encoding task must establish strong cue–target associations (the sentence-generation task appears to do this very effectively, whereas the object–word matching task used in the abandoned preliminary experiment and the anagram task used by Breckler et al, 1981, do not); and (b) the self-generated cues must participate in an existing rich knowledge structure (friends' names and celebrities' names appear to have this characteristic, whereas the desk objects used in the abandoned preliminary experiment and the generic first names used by Greenwald et al, 1981, do not).

If, as suggested, the self-generation effect depends on self-generated cues participating in a rich knowledge structure, how does that structure play its role in the effect? One possibility is that sentences constructed with associatively rich cues such as friends' names might be qualitatively different from ones constructed with associatively weak cues such as unfamiliar names. To assess this possibility, the authors examined a large sample of sentences of each type (one of each type generated by each of 100 subjects). Those generated with friends' names were not distinguishable from those generated with unfamiliar names on any of the criteria examined, including affective content, use of action verbs or imagery, and meaningfulness of content. There was thus no obvious content difference that might explain the superior name–target associations that result from constructing sentences with friends' names. Perhaps friends' names (and other richly connected cues) should be thought of as fostering covert associative structures that help to secure the associative bridge represented by the sentence's superficial content. It is more plausibly the existing rich cognitive structure, rather than the positive affective value of friends' names, that produces this effect—a speculation that could easily be tested by repeating the experiment with self-generated names of enemies. A still more interesting experiment would be one that attempts to vary richness of cognitive structure independently of or in the absence of either positive or negative affect. However, it is difficult to identify cognitively rich mental objects that are not invested with affect.

Developing View of the Self as an Organization of Knowledge

The preceding discussion suggests that an effective memory system should be capable of (a) producing cues that are available for association with novel target items, (b) forming strong associations between these cues and the target items, (c) reproducing the cues in the absence of the targets, and (d) retrieving the targets via the previously established cue–target associations. Formal mnemonic devices obviously have these properties (cf. Bellezza's 1981 discussion of the mnemonic properties of constructibility, associability, and reversibility).

The self is a particularly rich knowledge structure, the properties of which match the four just-mentioned requirements of an effective memory system. As a source of cues, the self can yield idiosyncratic lists of people (e.g., friends, relatives, acquaintances), likes or dislikes (e.g., foods, films), activities, traits, physical features, and familiar places (cf. McGuire & McGuire, 1982; McGuire & Padawer-Singer, 1976). The present experiments confirm that such self-generated items are easily associated with novel targets, are readily reproduced after a delay (see also Greenwald, Bellezza, & Banaji, 1988), and are effective as retrieval cues.

Outward manifestations of the self as a knowledge structure can be likened to the visible portion of an iceberg. Many aspects of this knowledge structure may not be as easily verbalized as, say, one's friends' names. However, personal knowledge need not be verbalized for it to function mnemonically in mediating retrieval. That is, the self's knowledge can function as "internal cues," in the fashion described by Bellezza (1984).

Although evidence consistent with the view of the self as an ordinary but highly organized knowledge structure continues to accumulate, there still remain significant gaps in the evidence for this interpretation. One gap is that the self's structure has not yet been well described. Various suggested structural descriptions (see Greenwald & Pratkanis, 1984; Kihlstrom & Cantor, 1984 for reviews) are not currently discriminable by available empirical procedures. Furthermore, empirical criteria for deciding whether given cognitive elements participate in the self's structure (however that structure is conceived) are not yet established. Also, disturbingly, one imaginative experiment designed to determine whether self is an automatically deployed schematic structure failed to support that conclusion (McDaniel, Lapsley, & Milstead, 1987). Clearly, much of the work of delineating the self as a knowledge structure remains to be done.

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Appendix

Technical Notes on the Simulations of Experiments 3 and 4

The search of associative memory (SAM) computer simulation has been used to model recall and recognition results of laboratory verbal learning investigations (e.g., Gillund & Shiffrin, 1984; Raaijmakers & Shiffrin, 1981). The SAM simulation models separate phases of acquisition (storage) and retrieval. During the storage phase, presented items enter a limited-capacity buffer (working memory) in which they establish levels of associative strength both to context (non-item-specific cues considered as a single set) and to any items that are co-resident in the buffer. When the buffer reaches its capacity, the oldest resident item is lost as each new item is encountered.

During the retrieval phase, "images" of items are sampled by virtue of their associations with a set of search cues consisting either of (a) context alone or (b) context plus an already-retrieved item. Whether a sampled image is retrieved depends on the strengths of its associations to the search cues. The retrieval process is also governed by parameters that determine the number of failures-to-retrieve before the set of search cues is changed and the total number of failures-to-retrieve before efforts at retrieval are abandoned. The SAM simulation uses one structural parameter, four associative strengthening parameters, and three retrieval strategy parameters in its simulations of recall experiments. In the following descriptions of these eight parameters, the values of six that were set at fixed values in the present simulations are given in boldface.

Structural Parameter

r = size of association buffer (number of items that are co-resident in short-term memory). **r = 2** (corresponding to a name and target noun being in the buffer as each sentence is constructed; these items enter and leave the buffer simultaneously)

Acquisition (Storage) Parameters

a = associative strength of item to context (established while item is buffer resident).

b = associative strength of buffer-resident item to co-resident item.

c = associative strength of item to itself (established while it is buffer resident). **c = .1**

d = residual interitem strength (associative strengths between items that are never buffer co-resident). **d = .017**

Free Recall Retrieval Parameters

L_{MAX} = number of failed attempts to use context or context plus a specific item as a search cue before switching to another search cue. $\mathbf{L_{MAX} = 2}$

K_{MAX} = total number of failed retrieval attempts before ending attempts at free recall. $\mathbf{K_{MAX} = 4.0 \times}$ **Number of items being retrieved**

Cued Recall Retrieval Parameter

M_{MAX} = number of failed attempts to use the provided cue as a search cue for another item before ending an attempt at cued recall. $\mathbf{M_{MAX} = 2}$

Added Parameters

In using SAM to model Experiments 3 and 4, it was necessary to give parameter a (associative strength of item to context) two values, one for strengths of name items to context (a_n) and one for strengths of target items to context (a_t). One other modification of SAM was needed for the present simulations. In the retrieval phase of previous versions of SAM, an item could be sampled only once in response to any search cue. With this restriction it was difficult to achieve 90 + percent rates of recall for self-generated names without using values for associative strength parameters that seemed inordinately high (in comparison with values in previously published SAM simulations). Accordingly, a parameter (identified as S_{MAX}) was added to SAM's free-recall retrieval process to govern the number of times that retrieval could be attempted for any item in relation to a given search cue set. (S_{MAX} is a free-recall analog of the M_{MAX} parameter for cued recall. Accordingly, it was set to the same value used for M_{MAX} viz. $\mathbf{S_{MAX} = 2}$.)

Fitting the Three Recall Measures of Experiment 3

The constraint adopted in fitting Experiment 3's three recall measures (see Figure 3) was that the value of a_n and b were free to vary separately for the two conditions in seeking a good fit to the obtained data. In effect, these constraints meant that six data points (i.e., means for three recall measures in each of two conditions) were fit with five variable parameters. The selected parameter values that produced the fits shown in Figure 3 are given in Table 1-A. The values of the a_n and b parameters are much higher for the self-generated names condition than for the other-generated names condition. This is consistent with the interpretation that the second-generation effect depends on the differences between the two conditions in the strengths of just these two categories of associations.

Fitting the Recall Measures and the Order-of-Recall Data of Experiment 4

In addition to simulating the overall recall data of Experiment 4, SAM was used to model the detailed order-of-free-recall data for the 27 subjects who freely intermixed names and nouns in their recalls (top panel of Figure 4). Constraints adopted in this modeling exercise were that (a) the two sets of recall means (for the mixed-recall and separated-recall subjects) should be fit, if possible, while allowing only one parameter value to be different for the two groups of subjects, and (b) all parameters other than a_n, a_t, and b (which were adjusted in order to fit the observed data) be set at the values given in the initial list of SAM's parameters (the same ones used in modeling Experiment 3). Thus, there were two differences in the models for the two sets of subjects in Experiment 4: (a) the two groups were assumed to differ in their recall strategies (mixed name and noun recall for the larger group and separated recall for the smaller group), and (b) the a_n parameter, which represented strength of context–name associations, was larger for the group of subjects who used the separated strategy.

Table 1-A
Simulated Conditions of Experiment 3

Parameter	Other-generated names		Self-generated names
a_n	0.25		2.40
a_t	0.43	=	0.43
b	0.25		3.20

Note. a_n = associative strength of name items to context, a_t = associative strength of target items to context, b = associative strength of buffer-resident item to co-resident item.

Table 2-A
Simulated Strategies of Experiment 4

Parameter	Mixed-recalls strategy		Separated-recalls strategy
a_n	1.10		1.70
a_t	0.23	=	0.23
b	2.40	=	2.40

Note. a_n = associative strength of name items to context, a_t = associative strength of target items to context, b = associative strength of buffer-resident item to co-resident item.

The values for the variable parameters that produced the fits shown in the two panels of Figure 4 are given in Table 2-A. For both conditions, all three parameters were low in comparison to their values for the self-generated names condition of Experiment 3. This difference may be due to the greater delay between acquisition and recall in the procedure of Experiment 4. Possibly, however, the difference is an indirect effect of another procedural difference between Experiments 3 and 4—the use of a recall task in which names and target nouns were recalled together, rather than separate recall tasks for the two categories of items.

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