ON KEEPING TRACK OF THE PRESENT STATUS OF PEOPLE AND THINGS

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ABSTRACT

In order to function with reasonable efficiency in everyday life, one needs to differentiate current information from out-of-date information in one's memory. In the present paper, we first illustrate the importance of such updating processes in everyday and applied contexts. We then show that encoding processes that are effective in terms of the long-term accumulation of information in memory are not necessarily effective in keeping one's memory current. Finally, we report an experiment on "mate updating"--that is, on keeping track of who is currently married to whom--designed to explore several aspects of the updating process.

INTRODUCTION

The common-sense measure of human memory ability seems to be based on a kind of accumulation notion. People with good memories are people who retain or accumulate more information in memory than do other people. Many of the memory tasks we face, however, require not that we remember everything, but, rather, that we remember only the current or most recent exemplar of information of a certain type. We need to remember our *current* phone number, we need to remember where we left the car *today*, we need to remember what the trump suit is on the *current* hand, we need to remember who is *now* in charge of some administrative function, we need to remember where the emergency brake is on our *present* automobile, we need to remember the name of a friend's *current* spouse, we need to remember the *new* procedure for accomplishing something on a computer, and so on. There is no particular value in remembering our old phone number, for example, or where we left the car yesterday, or what the trump suit was on the preceding hand. In fact, accumulating such out-of-date information in memory creates the potential for errors and confusion.

In a number of applied job contexts as well, efficient updating is far more important than (maybe even inconsistent with) the long-term accumulation of information. Short-order cooks, air-traffic controllers, intelligence analysts, people in various command and management positions who need to keep track of the present status of personnel, supplies, or equipment, and many others must not get confused between current and out-of-date information.

It is important to distinguish between the ability to remember the most recent of a series of inputs to memory and the ability to remember as much of the total input series (not necessarily in the right order) as possible. For one thing, people who are good at keeping current may not be so good at total recall, and vice-versa. Similarly, encoding processes that are efficient in updating one's memory may not yield good total recall, and vice versa.

To illustrate the latter point, consider the results of an experiment by Bjork and McClure (1974). In Bjork and McClure's experiment, subjects were required to keep track of the current response word associated with each of four different stimulus words. On each trial of the experiment, one of the four stimulus words was presented and subjects were asked to give the last response word that had been paired with that stimulus. As soon as the subjects responded, they were shown a new response word for that stimulus. Thus, subjects went through a long series of trials on each of which one of the four stimulus words was first presented as a probe-test of the subject's memory for the most recent response word paired with that stimulus and then a new response word was presented together with the stimulus. This task, which is sometimes referred to as the maximal PI (proactive interference) task, goes back at least as far as a study by Yntema and Mueser (1960) and has been used by a number of investigators.

Bjork and McClure (1974) added two new wrinkles to the basic task. First, each subject was asked to use one of several different encoding strategies during the series of trials. Second, at the end of the experiment, without forewarning, subjects were asked to recall as many of the response words presented during the experiment as possible.

Two of the three encoding strategies used by Bjork and McClure (1974) yielded an instructive interaction. One of the strategies (Ordered Rehearsal) consisted of trying to keep the current four response words available in an active rehearsal set. When the response word paired with a given stimulus was replaced by a new response word, the new word was to be inserted into the rehearsal set in place of the old (out-of-date) word. The other strategy (Image Replacement) consisted of forming a new interactive image incorporating a given stimulus word and any new response word paired with that stimulus.

It is certainly no surprise to students of human memory that Bjork and McClure (1974) found that final-recall performance in the Image-Replacement Condition was a great deal better than final-recall in the Ordered-Rehearsal Condition. In terms of keeping track of the current response associated with a given stimulus, however, the Ordered-Rehearsal Condition was considerably better than the Image-Replacement Condition. It appears that the Image-Replacement Condition resulted in a much stronger representation in long-term memory of the responses paired with a given stimulus than did the Ordered-Rehearsal Condition, but in terms of giving the current response at any one point in time, that advantage was more than offset by the difficulty in discriminating which of the responses paired with a given stimulus was the most recent response.

Bjork and McClure (1974) contend that the Ordered-Rehearsal Condition more closely approximates a "destructive" updating process than do conditions such as the Image-Replacement Condition. Destructive updating is a process where the act of storing new information destroys or makes inaccessible the old information. A good example of purely destructive updating is the way the memory in a computer is updated: When new-information is stored at a given location, the old information at that location is obliterated. Another example of destructive updating is the displacement notion of how items are lost from short-term memory.

In terms of effective updating, a destructive updating process clearly has the advantage that out-of-date information is no longer around to compete with current information. It should be pointed out, however, that good long-term retention of all of a series of inputs to memory is not necessarily inconsistent with remembering well which of those inputs is the most recent. Provided that there is some underlying structure that orders the inputs ("structural" updating in Bjork and McClure's, 1974, terms), both updating and total recall can be very good indeed. In fact, the third encoding strategy used by Bjork and McClure (1974), Story Construction, which was designed to be such a structural updating bering our old phone number, for example, or where we left the car yesterday, or what the trump suit was on the preceding hand. In fact, accumulating such out-of-date information in memory creates the potential for errors and confusion.

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METHOD

Subjects, Apparatus, and Procedure

The subjects were 335 undergraduates at Bowling Green State University in Bowling Green, Ohio. They participated in the experiment as one part of a demonstration lecture given by a visiting lecturer (experimenter) to two different classes.

Each subject was given a deck of computer cards. The experiment consisted of three phases. During the first (practice) phase, the experimenter explained the mate updating task and had subjects turn over the first few cards in the deck, which were practice cards involving the marriages or divorces of well-known celebrities. Subjects turned over one card every 9 sec in response to a buzz from a metronome. After subjects were familiarized with the task and the procedure, they went through the second (study) phase. Each card during the study phase said either "A and B are married" or "A and B are divorced," where A and B were the first names of a hypothetical man (woman) and woman (man), respectively. The study phase consisted of 23 cards, two cards that served as a primacy buffer, 18 cards that comprised the experimental conditions of interest, and 3 recency cards. At the end of the study phase, subjects were asked to put away their decks, and the experimenter gave a 30 min demonstration lecture on another topic.

Finally, in the third (test) phase, the subjects were tested for their memory of the final marital status of every stimulus (left-hand) name presented during the study phase. On each test card a given stimulus name was shown together with a horizontal line to its right for the subject's response. If, in the subject's judgement, that person ended up divorced, the subject was to write "divorced." If, on the other hand, the subject thought that person ended up married, the subject was asked to try to write down the first name of that person's current (i.e., final) spouse. Subjects were not, however, required to guess if they did not know.

Design

The study phase contained exactly one stimulus person corresponding to each of the following eight conditions.

(1) Control: A + B. This condition consisted of one study card stating that "A and B are married."

(2) Massed Updating: A + B, A + C. This condition consisted of two study cards, the first stating "A and B are mar-

condition, yielded updating and total-recall performance levels that were higher than the best of the other two conditions. In the Story-Construction Condition, subjects were asked to develop a simple story corresponding to each stimulus word in which each new response word would provide the basis for extending the story; the story narrative, then, is the structure that orders the successive response words in memory.

The principal goal of the present study was to ascertain whether there is any evidence that people can actually destroy or erase information in updating their memories. The Ordered-Rehearsal Condition in Bjork and McClure's (1974) experiment may not demonstrate destructive updating, but, rather, that such rote rehearsal can keep items available in short-term memory indefinitely with little or no increment in the representation of those items in long-term memory (see, e.g., Craik & Watkins, 1973; Woodward, Bjork, & Jongeward, 1973).

The task employed in the present experiment is formally similar to that used by Bjork and McClure (1974), but has a somewhat different flavor. Using common male and female first names, subjects were asked to keep track of who a given hypothetical person was married to, if anybody.

The destructive updating question was approached in two ways. One way was to see whether subjects could take advantage of negative information. For example, if subjects are first told that persons A and B are married, and are later told that A is now married to C, does an intervening statement that A and B are divorced help subjects' delayed retention of the fact that A is now married to C?

The other approach to the destructive updating question was via a spacing manipulation. One might expect that "destruction" of the memory trace corresponding to the fact that A is married to B would be easier to accomplish the "fresher" or less consolidated that trace. For example, when subjects are first told that A and B are married and then, after a variable interval, are told that A and C are married, destructive updating would be expected to yield better long-term retention of the A-C pairing the shorter the interval between the A-B pairing and the A-C pairing. Given that updating is not destructive in nature, one might expect the opposite result since, from the standpoint of the final test, the closer in time the original A-B and A-C pairings, the more difficult they would be to distinguish from each other.

ried," the second (presented after only two intervening cards) stating "A and C are married."

(3) Spaced Updating: A + B, ---, A + C. This condition is the same as Massed Updating, except that five cards intervened between the A + B and A + C study cards.

(4) Multiple Updating: A + B, A + C, A + D. This condition consisted of three study cards stating that A is married to B, then C, and finally D. Two cards intervened between both the A + B and A + C cards and the A + C and A + D cards.

(5) Positive Repetition: A + B, A + B. Similar to the Control Condition except that the statement "A and B are married" was repeated on two cards, with two cards intervening.

(6) Negated Repetition: A + B, A - B. The same as the Positive Repetition Condition, except that the second card stated "A and B are divorced."

(7) Repeated Competition: A + B, A + B, A + C. The same as the Multiple Updating Condition except that the first and second study cards both state that "A and B are married."

(8) Negated Competition: A + B, A - B, A + C. The same as the Repeated Competition Condition, except that the second study card states "A and B are divorced."

Complex counterbalancing procedures insured that, across subjects, particular name pairs occurred approximately equally often in the different conditions, that the average serial input position of the final card in a given condition during the study phase was roughly equal for all conditions, and that a given name was used approximately equally often as a stimulus name and as a response name. In a given deck, for a given subject, half the pairs shown during the study phase were male, female pairs and half were female, male pairs. Finally, four non-overlapping sets of names were used for different subjects.

RESULTS

The results of the mate updating experiment are shown in Table 1. The proportions of all responses that were correct, that were intrusions of the name of a former spouse (updating intrusions), that were intrusions of some other name (other intrusions), that were incorrect "divorced" responses (erroneous divorce), and that were omitted (omissions) are shown for each of the eight conditions. The results are marred somewhat by a low rate of correct responding coupled with a high rate of omissions. The correct response proportions are generally well above chance, however, and updating intrusions, which are also clearly above chance, also demonstrate retention of study-phase information on the subjects' part.

Table 1

Proportions of All Responses that were of Certain Types

Condition	Response Type: Correct	Updating Intrusion	Other Intrusion	Erroneous Divorce	Omission
Control A+B	.126	----	.356	.015	.503
Massed Updating A+B,A+C	.093	.101	.346	.024	.436
Spaced Updating A+B,--,A+C	.116	.110	.391	.033	.349
Multiple Updating A+B,A+C,A+D	.096	.126[a]	.395	.030	.353
Positive Repetition A+B,A+B	.283	----	.319	.012	.386
Negated Repetition A+B,A-B	.084	.176	.349	----	.391
Repeated Competition A+B,A+B,A+C	.054	.140	.394	.045	.367
Negated Competition A+B,A-B,A+C	.097	.164	.382	.066	.290

[a] The proportions of all responses that were intrusions of the B and C responses were .060 and .066, respectively.

The Multiple Updating, Positive Repetition, and Repeated Competition Conditions, though not of primary interest, were included in the design to check whether certain sensible results obtained. As one would expect, there was a substantial repetition effect. Compared to the Control Condition, repeating the A + B pairing (the Positive Repetition Condition) more than doubled the proportion of correct responses, and repeating the pairing of A with a former spouse (the Repeated Competition Condition) decreased the proportion of correct responses to less than half the proportion in the Control Condition. Increasing the number of former spouses from one to two (A + B, A + C, A + D vs. A + B, A + C) did not, however, decrease the proportion of correct responses.

The comparisons of principal interest are between the Massed Updating and Spaced Updating Conditions, and between the Negated Competition and the Spaced Updating Conditions. Neither comparison supports the notion that subjects' updating processes are destructive in nature. To the degree that subjects were able to update destructively, one might have expected better performance in the Massed Updating Condition than in the Spaced Updating Condition. In fact, the proportion correct is higher in the Spaced Updating Condition, though that difference is not significant. Subjects were also not able to take advantage of the "cancellation" information in the Negative Competition Condition (A+B,A-B,A+C) in contrast to an apparent implication of the destructive updating notion. The Negated Competition Condition in fact yielded slightly worse performance than the Spaced Updating Condition, though again the difference was not significant.

In general, consistent with the comparison of the Spaced Updating and Negated Competition Conditions, it appears from the data in Table 1 that the A-B divorce event in the Negated Repetition and Negated Competition Conditions did more to reinstate the A + B pairing than to cancel that pairing. Looking at the Updating Intrusion column in Table 1, the frequency with which B was given as an intrusion in the Negated Repetition and Negated Competition Conditions is as high as the frequency with which B is given as an intrusion in the Repeated Competition Condition, and all three conditions yield a higher proportion of updating intrusions than the conditions (Massed Updating, Spaced Updating, and Multiple Updating) in which the name of a former spouse is not repeated.

DISCUSSION

Taken at face value, the present results suggest that human updating is not destructive in nature. We certainly do not contend, however, that the present results are conclusive. With a higher rate of correct responding, for example, or with a greater range of intervals in the massed versus spaced updating question, the results might well have been different. It is even possible that changing the divorce statement in the Negated Competition Condition from "A and B are divorced" to

"A is divorced" might have improved performance substantially in that condition, since such a statement would not reinstate the A, B pairing. In short, the present study was intended as an initial exploration of an important component of the updating problem. For a discussion of other aspects of the updating problem, see Bjork (1978).

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