

Retrograde Amnesia in Free Recall

Abstract. *Supervention of high-priority events in a series of events constituting a free-recall task interferes with postexposure processing of mnemonic information about immediately preceding events, with the result that recall of these preceding events is impaired. Recall of immediately following events is not affected. This retrograde interference is time dependent.*

Retrograde amnesia refers to selective impairment of memory for events preceding a critical "amnesic" event. The magnitude or the extent of such impairment varies directly with the temporal proximity between the amnesic event and the events whose retention is measured. Known and putative amnesic events or treatments include concussion, electroconvulsive shock, local brain stimulation, anesthesia, anoxia, and administration of various drugs (1). The action of amnesic events is usually interpreted in terms of the disruption of consolidation of the engrams or memory traces of events preceding the amnesic event, but alternative interpretations have also been offered (2).

Understanding of retrograde amnesia is of considerable theoretical importance. The advancement of such understanding depends on availability of appropriate methods for the production of retrograde amnesia under the laboratory conditions and for accurate specification of its characteristics. I describe here two experiments with use of a new method of demonstrating a phenomenon that resembles retrograde amnesia. The method has certain advantages over the existing

ones (3), although its applicability is limited to human subjects.

In the experiments, the events to be remembered were common words presented to the subjects sequentially, one word at a time, with the instructions to remember as many of the words in a given list as possible and to recall them at the end of the presentation of the list in any expedient order. Thus the basic experimental paradigm was that of single-trial free recall (4). It is convenient to think of the words in a free-recall list as a succession of events, and of the subject's task as one of processing mnemonic event information. Hence "word" and "event" in this context are to be treated as synonyms.

The amnesic events were names of famous people (for example, Columbus, Freud, Aristotle) that occurred in some lists and that were to be treated as high-priority events by subjects. Subjects were instructed that whenever a name of a famous person appeared in the list, he was to make sure that he remembered that name. He also had to recall the name first, before proceeding to recall other items (common words) from the list.

Two kinds of lists were used: standard lists, each containing 15 common words, and high-priority lists, each containing 14 common words and the name of one famous person (the high-priority event). The high-priority event in a given list occurred in input position 2, 8, or 14 (high-priority lists 2, 8, and 14). The subjects knew before the experiment that some lists would contain high-priority events, but they did not know before presentation of any particular list whether or not it would contain a high-priority event.

In the first experiment, each of 40

subjects (summer school students at the University of Toronto) was tested with 20 standard-test and 30 high-priority lists, ten of each of three types, the 50 lists occurring in a scrambled order. List items were presented visually on a television screen at the rate of 1 second per word. After seeing a list, subjects had 30 seconds to write down as many items as they remembered from the list. Different sets of computer-generated lists were used with different small groups of subjects, so that the findings are based on a wide sampling of relevant materials.

The second experiment was essentially a replication of the first, except that two rates of presentation were used—0.5 second per word and 2 seconds per word. Each of 20 subjects (senior high school students) was tested with 100 lists in two separate experimental sessions. One-half of the lists were seen by each subject under the fast rate and the other half under the slow rate of presentation. Lists and rate of presentation were counterbalanced across subjects and sessions.

The primary data from the experiments are provided by probabilities of recall of items from each of 15 input positions in a list (Table 1).

The data of interest concern the probabilities of recall of words from input positions immediately preceding and immediately following the high-priority events in the high-priority lists. To assess the effects of the high-priority events the data for any given high-priority list are to be compared with recall probabilities of words from corresponding input positions in standard-test lists presented at the same rate (numbers in parentheses, Table 1).

With faster rate of presentation (1

Table 1. Probabilities of recall of items from 15 input positions in different lists in experiments 1 and 2. Decimal points are omitted. *N*, number of observations (No. of subjects times No. of lists) on which probabilities in a row are based; ST, standard test; HPE, high-priority event; numbers in parentheses, data from high-priority lists compared with recall probabilities of words from corresponding input positions in standard-test lists presented at same rate; numbers in square brackets refer to high-priority events.

List	N	Input position														
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
<i>Experiment 1—1 second per item</i>																
ST	800	(37)	22	(18)	17	15	15	(20)	20	(22)	24	30	35	(53)	69	(79)
HPE 2	400	(28)	[83]	(18)	15	14	14	18	16	20	18	22	29	44	57	66
HPE 8	400	31	24	16	20	13	12	(09)	[79]	(20)	18	26	31	46	57	63
HPE 14	400	32	22	18	17	14	18	17	20	18	28	22	30	(28)	[96]	(81)
<i>Experiment 2—0.5 second per item</i>																
ST	400	(26)	19	(13)	14	11	15	(16)	18	(19)	22	26	42	(55)	72	(74)
HPE 2	200	(16)	[82]	(10)	09	12	12	12	16	16	22	24	34	50	55	62
HPE 8	200	22	18	14	08	12	09	(08)	[92]	(17)	17	28	35	44	60	62
HPE 14	200	27	23	16	14	10	17	15	20	26	22	28	32	(28)	[99]	(80)
<i>Experiment 2—2 seconds per item</i>																
ST	400	(43)	33	(31)	27	28	29	(29)	30	(31)	35	42	51	(60)	78	(84)
HPE 2	200	(40)	[88]	(28)	24	33	26	28	25	28	38	42	50	60	64	65
HPE 8	200	38	32	29	26	32	28	(26)	[92]	(38)	30	40	54	54	74	68
HPE 14	200	36	32	34	32	34	32	28	36	39	46	45	51	(49)	[100]	(81)

sec/word in the first experiment and 0.5 sec/word in the second experiment), the presence of the high-priority event appears to depress the recall of the immediately preceding words, particularly in high-priority lists 8 and 14. Recall of words from input positions 7 and 13 is approximately twice as high in standard-test lists as it is in high-priority lists 8 and 14, respectively. Thus, the supervention of a high-priority event produces a sizable decrement in recall of at least one immediately preceding event. There is also a suggestion that in high-priority lists 8 and 14 (0.5-second rate), recall of two immediately preceding words is affected.

The presence of the high-priority events in any of these lists, however, does not seem to have affected the recall of words from input positions immediately following the high-priority events, at least not to the extent anywhere near that shown for immediately preceding words. The amnesic effect of such an event thus appears to be asymmetrical: High rates of recall of high-priority events are accompanied by lowered recall of immediately preceding events without showing similar effects on the recall of immediately following events.

This phenomenon, of retrograde amnesia in free recall, depends on the rate of presentation of the words. The amnesia all but disappeared with the rate of 2 seconds per word in the sec-

ond experiment. The difference in the recall of words from input position 13 between the standard test list and the high-priority list 14 (0.60 compared to 0.49) is barely significant at $P = .05$ level (on the basis of the *t* test) but it is considerably attenuated in comparison with corresponding differences observed with faster rates of presentation. High-priority lists 2 and 8 show no evidence of retrograde amnesia in free recall at the rate of 2 seconds per word.

The most promising explanation of retrograde amnesia in free recall appears to be some version of the consolidation hypothesis. The asymmetry of the amnesic effects of the high-priority event as well as the apparent rate-sensitivity of the phenomenon rule out a number of otherwise plausible interpretations. My data suggest that the initial registration or the encoding phase of the act of remembering sometimes extends beyond the temporal interval during which the event to be remembered is physically present in the subject's field of view. It is this processing, after exposure, of rapidly occurring events that seems to be interfered with by the supervention of another event which is afforded high-priority treatment by the system.

Consolidation-like processes have frequently been postulated in theoretical accounts of human memory. Peterson (5), for instance, assumed

that consolidation of one component of the memory trace accounted for the paradoxical observation that a verbal item presented twice in the input series was recalled best when it was partially forgotten before its second presentation.

The method described here may have some value in probing the consolidation process. It may also lead to other insights into the nature of memory.

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References and Notes

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3. It affords relatively precise control over the duration of events to be remembered and the amnesic events and their temporal separation, and it includes a comparison between retrograde and anterograde effects of amnesic events.
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