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Retrograde Amnesia and the "Reminder Effect"

Retrograde amnesia produced by such treatments as electroconvulsive shock is often temporary. Retention of an avoidance response, for example, can be restored by subjecting amnesic animals to a noncontingent footshock (NCFS) (*1*). These data have led some (*2*) to theorize that the amnesic treatments interfere with retrieval of stored information and that NCFS reactivates the retrieval process. Recently, Gold *et al.* (*3*) advanced an alternative explanation. They argued that NCFS provides a learning experience and predicted that for the learning experience to restore retention it must add to weak retention. Consistent with this prediction they reported that NCFS restores retention in animals that are either partially amnesic or weakly trained (animals showing weak retention), but that NCFS does not restore retention in animals that are either completely amnesic or untrained. While the results of this study are clear, the interpretation is not, and the logic connecting the effects of NCFS on partially amnesic and weakly trained animals is tenuous.

In the first phase of their experiment, Gold *et al.* determined the extent to which NCFS restores retention in partially and completely amnesic animals. Animals were trained, subjected to an amnesic agent, and then tested. During the test, the behavior was variable, some animals showing partial and others complete amnesia. After the test, the animals were given NCFS, and the next day they were given a second retention test. Behavior on the second test also varied; the NCFS restored retention in those animals that had shown partial amnesia on the first test, but did not restore retention in those animals that had shown complete amnesia. On this basis, Gold *et al.* concluded that NCFS restores retention because it summates with weak retention shown by the partially amnesic animals. This may be true, but, in my opinion, indeterminable from their experiment.

Gold *et al.* did not include a basic control group. It is clear that partially amnesic animals show recovery of retention after NCFS and that completely amnesic animals do not. It is not clear, however, that the NCFS is necessary to initiate recovery. It is possible that partially amnesic animals would recover retention even if they were not given NCFS. What is needed is a control group that receives no NCFS: the control animals in this case must of course be partially amnesic since completely amnesic animals show no recovery even with NCFS. Gold *et al.* presented data for a control group that received no NCFS and, indeed, showed no signs of recovery. The problem is that the animals in this control group, judging from the median and interquartile range of their behavior during the first test, appear completely amnesic.

Even if the experiment had contained the appropriate controls, the data would still be difficult to interpret because of the ex post facto experimental design. It seems clear from their report (*3*) that it was not the experimenter who, by manipulating a variable, determined which animals would be in the partially and which in the completely amnesic groups. Rather, the experimenter gave the animals in each group the same treatment and then constructed the two groups on the basis of individual differences in reaction to the amnesic agent. However, individual differences in this case can be due to any number of variables, including strength of initial learning, susceptibility to the disruptive effects of the amnesic agent, or motivation to drink. Gold *et al.* failed to establish whether these uncontrolled variables, rather than strength of retention, were instrumental in determining the ultimate reaction to NCFS.

In a second phase of the experiment, to cross-validate the relation between strength of retention and effectiveness of NCFS, Gold *et al.* included two additional groups distinguished by different training conditions rather than by individual differences in reaction to the amnesic agent. One group received weak training, a second group received no training, and neither group received an amnesic agent. The next day the groups behaved as expected: the weakly trained group showed weak retention, the other group of course showed no retention. After the test, both groups were given NCFS and the next day were given a second test; the NCFS improved retention in the weakly trained but not in the untrained group. In contrast to the amnesic data, the training data are interpretable since the groups, including appropriate con-

trols, were constructed on the basis of manipulation rather than individual differences. As Gold *et al.* concluded, for NCFS to increase retention it indeed must add to weak retention produced by weak training.

Problems arise, however, when Gold *et al.* suggest that the training results are supported by the amnesic results, and both results in turn affirm that a weak memory trace is necessary for NCFS to restore retention. This strategy requires the assumption that weak retention following weak training and weak retention operating during partial amnesia reflect the same underlying process (for example, as Gold *et al.* suggest, a weak memory trace). There appears to be no basis for such an assumption. Some (*2*) would argue that amnesia, whether complete or partial, reflects individual differences in performance or retrieval rather than storage decrements. Therefore, although it is possible that NCFS improves retention in both the weakly trained and the partially amnesic animals for the same reason (that is, it adds to a weak memory trace), it is equally plausible that NCFS improves retention in the two groups for entirely different reasons. NCFS may cancel a performance or retrieval decrement in partially amnesic animals, but may add to a weak memory trace in weakly trained animals. In summary, it is quite possible that Gold *et al.*'s learning interpretation of the NCFS effect is correct, but their experiment fails to provide unequivocal support for that notion.

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In general, we agree with Schneider's comments regarding our findings that noncontingent footshock (NCFS) improves the retention of animals which have poor retention either because they were partially amnesic or because they were poorly trained. On the basis of these findings, we concluded that amnesic animals are not unique in their response to NCFS, and, therefore, one need not invoke a "reminder effect" interpretation of these studies. Of course, as Schneider reiterates for us (*1*), this is an argument by analogy. Although he is correct in stating that there is no a priori reason to assume that the poor retention performance following either weak training or partial amnesia reflects the same underlying process or processes, there is, of course, no a priori reason to assume that the poor performance in either condition reflects different underlying processes. We feel strongly that our data do suggest a reasonable and parsimonious alternative interpretation to that previously offered for "reminder" studies (*2*).

We do not, however, agree with some of Schneider's specific comments. First, Schneider suggests that our amnesia control group, which did not receive NCFS, is inadequate because spontaneous recovery might have occurred in partially amnesic animals. We have not previously observed improved retention performance over time under similar conditions (*3*). A reexamination of the data for the group in question shows that four of the six animals had partial amnesia on the first test trial (*4*). All of these animals, in fact, had latencies below 30 seconds on the second test trial. Furthermore, similar results have been reported in studies with chicks and mice (*5*). But more importantly, this argument ignores the major finding that the effectiveness of the noncontingent punishment for improving later retention performance varied directly with the initial retention performance. Specifically, NCFS did not alter the retention performance of those animals we judged to be "completely" amnesic. Retrieval block hypotheses are simply silent on this issue, whereas our alternative interpretation readily incorporates these findings.

Second, Schneider is obviously correct in indicating that there are many variables which produce individual differences in retention performance. However, this problem is certainly not limited to our study. It is a basic conceptual issue in all studies of learning and memory. Retention performance may not always accurately reflect memory. Furthermore, we believe that, to the extent that retention performance does reflect memory, NCFS will improve retention performance of any animal which has at least some weak retention of the avoidance training. Therefore, we do not share Schneider's feeling that sorting groups according to retention performance is inappropriate; retention test latencies are, after all, the measure of memory used in this task.

Finally, Schneider ends his comment with a fair summary of the alternative interpretation we offered and restates our view (*1*) that it is clearly an argument by analogy. We must restate, however, that the analogy seems quite reasonable—though not unequivocal—and that our interpretation of these results is far more parsimonious than either that offered previously (*2*) or the two hypotheses which Schneider must postulate to explain our data.

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