# Reports

## Memory for Verbal Material: Effects of Sensory Deprivation

*Abstract.* Memory retention of a short verbal passage did not change significantly in subjects who were isolated in a dark and soundproof room for 24 hours between the immediate recall test and the terminal recall test. A significant decrease in performance was noted in the control subjects who went about their everyday activities during the 24-hour period after acquisition.

The discovery that sleep in man (*1*) and inactivity in the cockroach (*2*) facilitate retention favors the interference theory of forgetting over the disuse theory. Nevertheless, the sleeping or inactive groups in these studies showed retention losses during the first hour or two after acquisition.

Hunter (*3*), in accordance with the interference theory, predicted that almost perfect retention would result if the subject could be held in quiescence during the entire learning-relearning interval. Minami and Dallenbach (*2*) also expected perfect retention if a subject could be shielded from new experience immediately after learning; however, they noted that the dangers inherent in the use of drugs and anesthetics prevent the establishment of such a state in man. McGeoch and Irion (*4*) called for the interpolation of a period of inactivity or "psychological vacuum," stretching from the moment of learning to the moment of measuring retention.

On the basis of the interference theory of forgetting, we felt that a long undisturbed postacquisition period would facilitate retention of verbal material.

Twenty Princeton University students who volunteered for paid participation in a 24-hour isolation experiment served as subjects. They were randomly assigned to an experimental or a control group.

All subjects were instructed to get their normal amount of sleep on the night prior to the experiment. They were isolated individually in a soundproof, dark room and they were restricted to their beds. They were told to defecate before entering the room so that they would not have to leave the bed to use the emergency chemical toilet in the room. Food, water, and urinal tubes were at the bedside.

As they entered the room the subjects were told to remain relatively still and totally silent during their confinement. They were warned that they would be monitored for violations of the quiescence restrictions and that forfeiture of payment would be the penalty for any violations.

After 1 minute of confinement, the subjects were aurally presented with a 182-word passage adapted from Tolstoy's *War and Peace*. They were told to listen carefully and to pay strict attention to all the details of the passage, because they would be asked to repeat the passage after its presentation.

Immediately upon termination of the passage the subjects were asked to attempt a *verbatim* retelling of the story. When they had finished this task the control subjects were released from the chamber and told to go about their everyday affairs, but to return to the laboratory 24 hours later for 15 minutes of "further work." They were promised payment for their efforts only if they returned at the specified time. Experimental subjects were left undisturbed in the chamber for 24 hours and then were asked to repeat the passage *verbatim* prior to their release. The control subjects were returned briefly to the chamber for the same purpose.

After the experiment the subjects were asked if, during the test-retest interval, they had thought about the passage or had anticipated a retest. Only one subject (experimental) reported having thought about the passage after the immediate recall test with the expectation that there might soon be another recall test. It should be noted that all subjects complied with the activity restrictions which had been imposed on them and none left the bed during confinement.

Responses were scored for the number of correctly reproduced words from the passage, irrespective of correspondence of sequence, each word being valued at one point. This method was adapted from that of King (*5*), who found that it yielded scores which were highly correlated with a count of retained ideas, scaled scores based on judges' rankings, and other retention measures.

The percentage retroaction (the percentage interference effect during the test-retest interval) was computed for each subject by means of the formula where $RC$ is the recall score:

$$\text{Retroaction } \% = \frac{RC_{\text{immediate}} - RC_{\text{terminal}}}{RC_{\text{immediate}}} \times 100$$

Mean retroaction for the sensorially deprived group was $-1.8$ percent, while that for the control group was $+12.6$ percent. The difference between these means is significant ($p < .01$ in a two-tailed $t$ test). Utilizing the $t$ test for correlated samples, we also determined that the difference between the mean immediate and the mean terminal score was not significant for the experimental subjects ($p > .8$, two-tailed). The same statistical procedure revealed a very significant decrease during this interval from the first to the terminal test for the control subjects ($p < .005$, one-tailed). The difference between the two groups on the immediate recall test was not significant ($p > .4$ in a two-tailed $t$ test).

We concluded that sensory deprivation as the intervening experience in a retroaction design facilitates retention of verbal material. These results seem to confirm earlier predictions that learning followed immediately by quiescence and the cessation of new experience is perfectly retained (*6*).

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*Instructions for preparing reports.* Begin the report with an abstract of from 45 to 55 words. The abstract should *not* repeat phrases employed in the title. It should work with the title to give the reader a summary of the results presented in the report proper.

Type manuscripts double-spaced and submit one ribbon copy and two carbon copies.

Limit the report proper to the equivalent of 1200 words. This space includes that occupied by illustrative material as well as by the references and notes.

Limit illustrative material to *one* 2-column figure (that is, a figure whose width equals two columns of text) or to *one* 2-column table or to *two* 1-column illustrations, which may consist of two figures or two tables or one of each. Submit three copies of illustrative material.

For further details see "Suggestions to contributors" [*Science* **125**, 16 (1957)].

#### References and Notes


1. J. G. Jenkins and K. M. Dallenbach, *Am. J. Psychol.* **35**, 605 (1924); E. B. van Ormer, *Arch. Psychol. N.Y.* **21** (137), 5 (1932).
2. H. Minami and K. M. Dallenbach, *Am. J. Psychol.* **59**, 1 (1946).
3. W. S. Hunter, *J. Genet. Psychol.* **41**, 254 (1932).
4. J. A. McGeoch and A. L. Irion, *The Psychology of Human Learning* (Longmans, Green, New York, ed. 2, 1952).
5. D. J. King, *Psychol. Rec.* **10**, 113 (1960).


6. This research was supported by the U.S. Army, Office of the Surgeon General (contract DA-49-007-MO-671).

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## Minimal Dosage of Iodide Required To Suppress Uptake of Iodine-131 by Normal Thyroid


*Abstract*. Sodium iodide was given in increasing doses to mentally defective children with normal thyroid function. Maximal suppression of iodine-131 uptake was achieved with 1500 to 2000 micrograms of iodide per square meter of body surface per day, but quickly rebounded when iodide was discontinued. This minimal effective dose is important if countermeasures against fallout are employed.


The release of radioactivity into the atmosphere from nuclear explosions in the recent past has created an acute awareness of the problem of human protection from such radiation. Radioactive iodine ($I^{131}$) is one of the principal contaminants in fallout (*1*). Government health agencies and others have considered several countermeasures for reducing the hazard of such radiation in humans. One of the most practical methods considered has been the suppression of thyroid function to prevent the retention by the thyroid of radioactive iodine regardless of the route by which it gains entrance into the blood stream. The use of iodide added to milk or other vehicles is obviously a first line of defense, but to employ this as a prophylactic measure it is desirable to know the minimal effective daily dosage of iodide. Surprisingly, a search of the literature as well as consultation with the subcommittee on countermeasures of the National Advisory Committee on Radiation (*2*) revealed the stark fact that the minimal effective oral dose of iodide for suppression of radioactive iodine uptake by the normal thyroid was unknown.

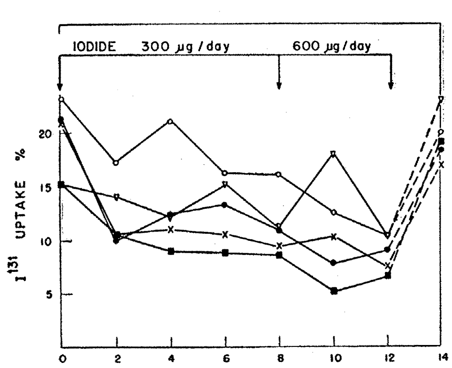


Fig. 1. Iodine-131 uptake by the thyroids of 2-year-old children given sodium iodide, 300 μg/day over an 8-week period, followed by 4 weeks of 600 μg daily, and the uptakes 2 weeks after discontinuation of iodide.

It is the purpose of this paper to present data acquired from observations on children, which define this minimal effective dosage of iodide required to suppress the avidity of the normal thyroid for radioactive iodine, and the time required to achieve such suppression.

The studies were carried out between 14 December 1961 and 14 April 1962 on children at the Wrentham (Massachusetts) State School, which is a hospital for long-term care of mentally defective children. We chose this population of children because it was desirable to secure children living under constant conditions of environment, diet, and iodide uptake. Their salt supply was found to be free of iodine.

The children were selected in three age groups (see Table 1) for study only if their thyroid function was normal clinically, and as judged by protein-bound iodine and radioactive iodine uptake ($I^{131}$ uptake). None of the children had an enlarged thyroid. Iodide was administered orally as sodium iodide in aqueous solution, pipetted from a stock solution.

The effect of a single dose of 1500 μg/m$^2$ of iodide was studied on a separate group of seven children to see how soon one can get suppression of $I^{131}$ uptake. Table 1 shows the age groups studied and the doses of iodide administered daily.

The protein-bound iodine was determined at the beginning and end of the experiment in all children. Twenty-four-hour urinary excretion of iodide was measured in eight children at the beginning and end of the observations. Measurements of 24-hour $I^{131}$ uptakes were done before the administration of iodide and repeated every 2 weeks during iodide administration until either the uptakes decreased to approximately 5 percent or until there was no demonstrable change in successive uptakes.

Table 1. Number of children in each age group and their daily dose of iodide.

| Sub-group | Dose (μg) | Children (No.) Group I (1–3 yr) | Group II (4–6 yr) | Group III (9–11 yr) |
|---|---|---|---|---|
| A | 100 | 5 | 5 | 4 |
| B | 300 | 5 | 5 | 5 |
| C | 600 | 5 | 10 | 5 |
| D | 1000 | 5 | 4 | 5 |

The iodide was then discontinued and one or more measurements of $I^{131}$ uptakes were made during subsequent weeks. In subgroup B of groups I and II, when the $I^{131}$ uptake had become stabilized on 300 μg of iodide daily, the dose was increased to 600 μg daily before discontinuation.

The tracer doses of 1 μc of $I^{131}$ were given orally. Standard and patient background counts were done before each tracer, and corrections were made in the calculations.

The mean protein-bound iodine was 5.5 μg per 100 ml before and 5.9 μg per 100 ml after iodide administration; the corresponding values for total iodine were 6.4 and 7.4 μg per 100 ml. At the end of the investigation 24-hour urinary excretion of iodine was considerably increased from the pretreatment mean value of 176 μg, depending upon the dose of iodide given.

The $I^{131}$ uptakes by the thyroids of 2-year-old children given 300 μg of iodide daily are shown in Fig. 1. The maximum change occurred at 2 weeks with some further fall during the next 2 to 4 weeks when the uptakes levelled

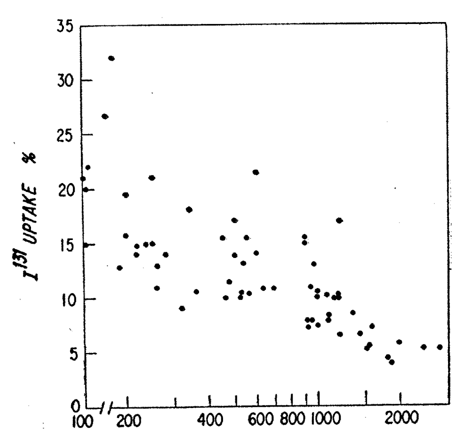


Fig. 2. Each dot represents from the ordinate the uptake of radioactive iodine by one child at the end of 2 weeks administration of iodide. The abscissa gives the dose in micrograms of iodide per square meter of body surface per day.