Immediate acceptance of sodium salts by sodium deficient rats[1]

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Abstract

Rats were depleted of body sodium and presented with solutions of either sodium or non-sodium salts. Patterns of licking were monitored with a drinkometer. The rats given the sodium salts drank at a high rate throughout a 100 sec. observation period. The rats given the non-sodium salts stopped drinking after the first few licks. The difference between the groups was statistically significant within 5 sec. after ingestion began.

Problem

The observation that sodium deficient rats select and ingest sodium salts but reject non-sodium salts is well established. Recent studies suggest that this preferential ingestion of sodium salts does not depend upon post-ingestional factors but that, in the sodium deficient rat, the mere taste of sodium is sufficient to activate the mechanisms which motivate its ingestion (Nachman, 1962).

However, there also exists evidence against the importance of taste in the mediation of sodium ingestion. Thomson & Porter (1953) presented evidence that sodium deprived rats made relatively ageustic by section of the gustatory nerves can learn and perform an instrumental response in order to obtain a weak saline solution which they cannot discriminate by taste. The investigators concluded that the taste of sodium is not a necessary condition for the maintenance of its ingestion. Smith, Pool, & Weinberg (1958) obtained evidence that the taste of sodium is not a *sufficient* condition for the maintenance of its ingestion by showing that the ingestion of a saline solution is not enhanced by sodium deficiency in esophagostomized rats.

The purpose of the present study was to determine precisely the sodium deficient rat's immediate response to various salt solutions by monitoring its licking pattern with a drinkometer. This allowed a much more accurate and detailed analysis of the initial ingestion patterns than has previously been possible. Also special precautions were taken to insure that the rat had no opportunity to taste salt between the time of induction of sodium deficiency and the time of testing salt intake. Rats deprived of various minerals have been reported to eat their feces (Orent-Keiles & McCollum, 1941), and repeatedly lick their genitals (Steinberg & Bindra, 1962). It has been observed in this laboratory that sodium deprived rats also lick the floors and walls of their cages. Presumably rats engage in this behavior in order to ingest the salts excreted in their feces or remaining on their genitals or their cages after evaporation of the urine. This experience might be important in determining their behavior during subsequent testing and certainly would preclude any conclusions about the rat's first responses.

Method

Eighteen male Holtzman Sprague Dawley rats approximately three months of age were used. On each of two days preceding experimental treatments the rats were deprived of water for 23 1/2 hr. in their home cages (Purina chow was available ad lib). They were allowed to drink distilled water for 1/2 hr. in a 4 in x 4 in x 8 in lucite chamber with a wire mesh floor. The water was given in an inverted graduated test tube with a standard metal drinking nozzle from which the rat could drink by protruding its tongue through a one centimeter diameter hole in the lucite wall.

After the 1/2-hr. drinking period of the second day 15 of the rats were randomly selected and injected subcutaneously with 2 ml of 1.5% formalin to produce sodium depletion (Wolf & Steinbaum, 1965) and the remaining three were injected subcutaneously with 2 ml of the water vehicle. Immediately after the injection all rats were bathed in warm water to remove all salts from their body surfaces. At this time the home cages of the rats were carefully washed to remove any traces of salt. Alternate strands of the wire mesh floors of the home cages were removed so that the remaining strands were two centimeters apart, thus allowing feces to immediately fall through the floor of the cages out of reach of the rats. It should be noted that the urine of salt deprived formalin treated rats is essentially devoid of sodium (Wolf & Steinbaum, 1965) so that ingestion of any urine during this time would provide no sodium to the rats. All animals were given distilled water and sodium-free food ad lib.

Each of the 15 formalin treated rats was randomly assigned to one of five groups. Approximately 16 hr. after the injection each of the five groups was given access to one of the following salt solutions in the drinking chamber: .15 M NaCl, .50 M NaCl, .15 M $NaHCO_3$, .15 M KCl, .15 M $CaCl_2$. The three vehicle injected rats were given .50 M NaCl. An exact record of the salt ingestion patterns of the rats was obtained via a Grayson Stadler drinkometer coupled to a Gerbrands Event Recorder.

Preliminary self-selection experiments with normal rats showed that .50 M NaCl was clearly rejected in favor of .15 M KCl, or .15 M $CaCl_2$. Thus the use of the .50 M NaCl solution in the present experiment pro-

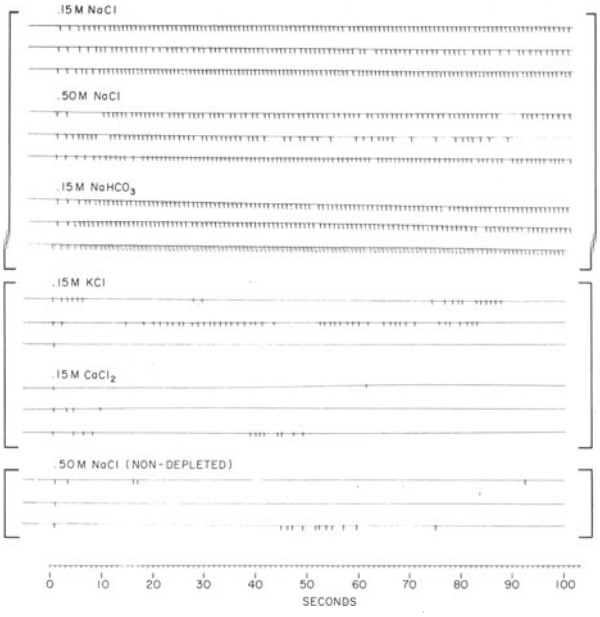

Fig. 1. Licking patterns of individual rats in the various groups during the first 100 sec. after commencement of licking. Every fifth lick is represented by a vertical mark.

vided a control for differential palatability of the sodium and non-sodium salts. Furthermore, the vehicle injected group was included to demonstrate that the ingestion of this unpalatable solution was dependent upon sodium deficiency.

Results

The latency to begin licking was approximately 130 sec. for all formalin injected groups, and considerably longer (approximately 1100 sec.) for the vehicle injected group ($p < .05$ t-test). This finding suggests that sodium deficiency activates searching and sampling behavior.

Figure 1 shows the patterns of licking for individual rats in the various groups during the first 100 sec. following the commencement of licking. In some animals the licking was preceded by contact with the drinking nozzle by the nose. Such contacts were not included in the analysis of the data. The three formalin treated groups given sodium salts manifested very similar behavior. They ingested the solutions continuously and at a high rate (approximately five licks per second) throughout the 100 sec. period. In contrast the two formalin treated groups given non-sodium salts and the vehicle injected group given the sodium salt generally stopped ingesting the solutions after the first few licks. By 5 sec. after the beginning of licking the formalin treated groups given the sodium salts had made significantly more licks than those given the non-sodium salts ($p < .05$ t-test) and this difference increased rapidly in magnitude and statistical significance during the remainder of the testing period.

Discussion

The results strongly support the hypothesis that the detection and ingestion of sodium salts by sodium deficient rats is mediated by gustatory information. The rate of ingestion of sodium salts exceeds that of non-sodium salts within a few seconds after drinking begins. Although it is possible that gastric chemo-receptors (Kassil, 1959) rather than taste receptors are mediating this behavior, it is difficult to imagine how they could so rapidly provide the necessary information about the nature of the substance being ingested. On the other hand, the results do not rule out the possibility that post-ingestional factors are necessary for the maintenance of sodium consumption over extended periods of time.

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Notes

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