Bulletin of the Psychonomic Society
1993, 31 (4), 261-264

Water and NaCl consumption in Long-Evans rats and Egyptian spiny mice

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Water and NaCl consumption in Long-Evans rats (*Rattus norvegicus*) and Egyptian spiny mice (*Acomys cahirinus*) was examined after periods of acute water deprivation (0-100 h) and NaCl deprivation (via 0-10 mg/kg furosemide i.p.). Rats' intake of water was monotonically related to the length of the deprivation period, with only nominal changes in water intake observed for spiny mice. NaCl intake for rats was also monotonically related to furosemide dose, again with only nominal changes in NaCl intake observed for spiny mice. The patterns of water and NaCl consumption for rats were in agreement with those reported previously, whereas similar observations have not been described for spiny mice. Differences in adaptation to deprivation states were attributed to the desert heritage and physiological characteristics of the spiny mouse.

Taste function in animals is typically assessed using preference tests (see, e.g., Mook, 1969), operant tasks (see Brosvic & Slotnick, 1986; Carr, 1952; Koh & Teitelbaum, 1961; Morrison & Norrison, 1967), conditioned taste aversions (see Garcia, Hankins, & Rusiniak, 1974), and neural recording studies (see Contreras, Kosten, & Frank, 1984; Pfaffmann & Bare, 1950). The subject most commonly employed in such studies is the laboratory rat (*Rattus norvegicus*), and since the earliest studies, changes in water intake (see Stellar & Hill, 1952) and salt intake (see Richter, 1936) have been examined.

Stellar and Hill (1952) examined the amount and rate of water intake in rats (descendants of the Lashley strain) during 2-h test sessions when water-deprivation schedules ranging from 6 h to 7 days were in effect. Stellar and Hill reported that rats steadily increased water intake following brief periods of deprivation; they reported asymptotic consumption for longer periods. In his seminal studies, Richter (1936) reported that adrenalectomy enhanced the rat's taste responsivity to NaCl, as measured by the lowering of its preference threshold. These changes, Richter hypothesized, resulted from changes in oral gustatory processes that increased the adrenalectomized rat's ability to detect NaCl, rather than from a compensatory increase in the consumption of NaCl caused by the bodily loss of sodium.

Typically, most studies assessing water and NaCl consumption have used laboratory rats, and substantial differences in sensitivity to NaCl have been demonstrated between several species of Murinae (Old World rats and mice), for example, Long-Evans rats versus Fischer-344 rats (see Midkiff, Fitts, Simpson, & Bernstein, 1987). It is of interest, therefore, to examine water and NaCl intake in a rather unusual member of Murinae: the Egyptian spiny mouse (*Acomys cahirinus*). Although the spiny mouse has been the subject of considerable research (see Brunjes, 1990), its taste behavior has been the topic of only one publication (Harriman, 1980).

Unlike many members of Murinae, spiny mice are precocial, fully formed and active at birth, possess tremendous survival abilities, demonstrate a life span of up to 6 years, and inhabit arid and rocky environments. It is reasonable to conclude that such a heritage would enable the spiny mouse to adapt readily to rapid changes in the availability of water and bodily sodium content.

EXPERIMENT 1

Water Intake During Acute Water Deprivation

Method

Subjects. Five adult male and 5 adult inbred female Long-Evans hooded rats and an equal number of inbred Egyptian spiny mice served as subjects. The animals were housed in pairs in stainless steel cages with ad lib access to Purina Laboratory Chow in a temperature- and humidity-controlled vivarium with houselights on from 0700-1900 h.

Procedure. Water intake was assessed for each animal following water deprivation for 0, 20, 40, 60, 80, and 100 h, in accordance with a Latin-square design. At the end of the deprivation period, a 500-ml glass bottle containing water was presented and fluid intake (in milliliters) was monitored for 2 h; each animal was then rehydrated via ad lib access to water for 48 h. Results of these tests are expressed in terms of percent of change in water intake from baseline (0 h of water deprivation).

Results

No difference in water intake was observed as a function of sex, so the data were combined across sexes for subsequent analyses (all *p*s $>$ .05). The median percent change in water intake from baseline as a function of the length of water deprivation is presented in Figure 1.

Preliminary results of these studies were presented at the 1992 Annual Meeting of the Eastern Psychological Association. Correspondence should be addressed to Gary M. Brosvic, Department of Psychology, Biopsychology Laboratory, Rider College, 2083 Lawrenceville Road, Lawrenceville, NJ 08648-3099.

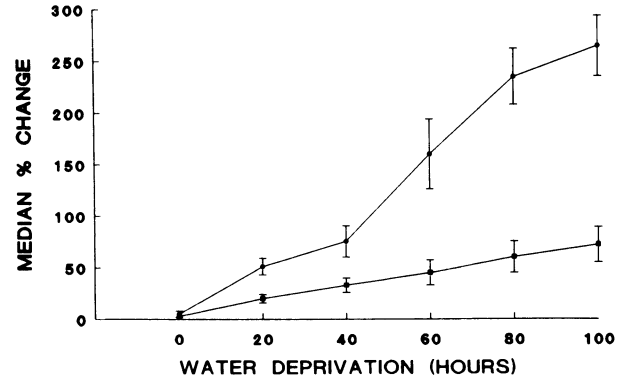

Figure 1. Median percent change from baseline (with standard error bars) water consumption for Long-Evans rats (closed circles) and Egyptian spiny mice (closed squares) as a function of the length of water deprivation.

As can be seen in Figure 1, the median percent change in water intake for Long-Evans rats was monotonically related to the length of water deprivation, and water intake increased as a function of the length of deprivation for all rats ($F = 34.5, p < .05, r_S = +.76, p < .05$). In contrast, the median percent change in water intake for spiny mice differed significantly from baseline only when water deprivation exceeded 40 h ($F = 5.53, p < .05, r_S = +.18, p > .05$), and no changes from baseline values were observed for 2 spiny mice. The median percent change in water intake was significantly greater for rats than for spiny mice at the 20-h through 100-h deprivation periods (all ts $> 7.3, p < .05$).

EXPERIMENT 2
NaCl Intake During Acute NaCl Deprivation

Method

Subjects. Five adult male and 5 adult female inbred Long-Evans hooded rats and an equal number of inbred Egyptian spiny mice served as subjects. The animals were housed in pairs in stainless steel cages with ad lib access to Purina Laboratory Chow in a temperature- and humidity-controlled vivarium with houselights on from 0700-1900 h.

Procedure. Taste preferences for reagent-grade aqueous solutions of NaCl, KCl, MSG, and sucrose at concentrations ranging from 0-0.4 M were examined prior to and after treatment with furosemide, a sodium-depleting drug. Furosemide was injected (i.p.) in a saline vehicle at doses ranging from 0-10 mg/kg in accordance with a Latin-square design—doses that have reliably produced acute sodium deficiency in pilot tests conducted in our laboratory and in prior studies using Wistar and Fischer-344 rats (see, e.g., Bernstein & Hennessy, 1987; Midkiff et al., 1987). Thirty minutes after injection, two bottles were mounted on each cage, with one bottle containing water and the second containing a test solution at a concentration ranging from 0-0.4 M. The two bottles remained on each cage for 2 h, after which each animal had 48 h ad lib access to water. Results of these tests are expressed in terms of median percent change in taste-preference behavior from baseline.

Results

No differences in any dependent measure were observed as a function of sex, so the data were combined across sexes for subsequent analyses (all ps $> .05$). The median percent change in taste-preference behavior is presented in Figures 2-7.

As can be seen in Figure 2, the median percent change in the rat's NaCl preference was monotonically related to furosemide dose ($F = 16.7, p < .05, r_S = +.57, p < .05$). The rat's preference for NaCl was significantly greater following treatment with 10 mg/kg than with either 0 or 1 mg/kg, with an intermediate change in the preference for NaCl observed following treatment with 5 mg/kg ($F = 16.72, p < .05$). As can be seen in Figure 3, the median percent change in the spiny mouse's NaCl preference increased only after the furosemide dose was incremented to 10 mg/kg ($F = 6.7, p < .05, r_S = +.15, p > .05$). Surprisingly, the preference for NaCl demonstrated by 2 spiny mice was not influenced by any furosemide dose. The median percent change in NaCl preference was significantly greater for the rat than for the spiny mouse at the 1-10 mg/kg doses (all ts $> 15.3, p < .05$).

Preferences for MSG (see Figure 4 for rats and Figure 5 for spiny mice), KCl (see Figure 6), and sucrose (see Figure 7) were determined for control purposes prior to and after treatment with furosemide. As expected,

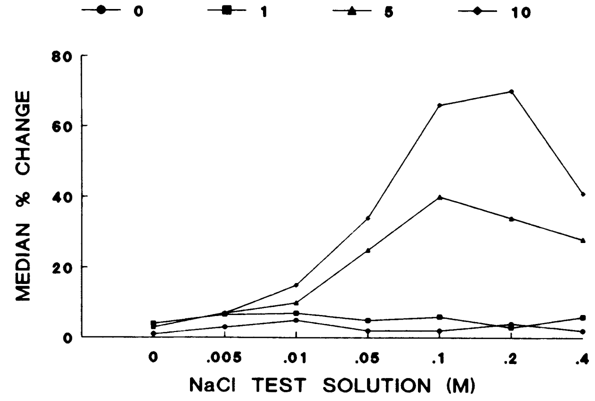

Figure 2. Median percent change from baseline NaCl preference for Long-Evans rats as a function of furosemide dose (mg/kg; see legend) and concentration (M) of NaCl test stimulus.

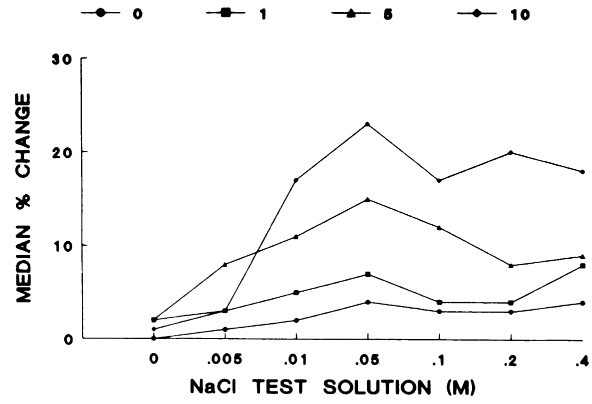

Figure 3. Median percent change from baseline NaCl preference for Egyptian spiny mice as a function of furosemide dose (mg/kg; see legend) and concentration (M) of NaCl test stimulus.

preferences for these tastants were influenced by test-stimulus concentration (all Fs $> 16.5, p < .05$, median $r_S = +.6, p < .05$). The rats' preference for the stronger concentrations of MSG, a sodium salt, was influenced by furosemide dose, with similar changes observed for most spiny mice (all Fs $> 19.53, p < .05$). Preferences for KCl and for sucrose were not influenced by any furosemide dose, and at hedonic concentrations, preferences observed for the rats exceeded those observed for the spiny mice for each tastant (all ts $> 12.34, p < .05$).

DISCUSSION

Egyptian spiny mice demonstrated significantly smaller responses to acute water and NaCl deficiency than did Long-Evans rats. In Experiment 1, the rat's pattern of water consumption was similar to that described by Stellar and Hill (1952). Although not reported here, the rat's water consumption was relatively asymptotic when the deprivation period was extended beyond 100 h (in subsequent studies)—the point at which water consumption also increased for the 2 spiny mice unresponsive to less severe periods of water deprivation. In Experiment 2, spiny mice demonstrated significantly smaller changes in NaCl preference than did Long-Evans rats. The rat's preference for NaCl was similar to that described after treatment with furosemide (see, e.g., Bernstein & Hennessy, 1987; Midkiff et al., 1987), adrenalectomy (see, e.g., Brosvic, Risser, & Doty, 1989; Richter, 1936; Sakai & Epstein, 1990), and dietary sodium deprivation (see, e.g., Brosvic & Hoey, 1990). In the control tests, preferences for a second sodium salt (MSG), but not for a potassium salt (KCl) or for sucrose, were also enhanced, suggesting that furosemide's effects were specific to reducing bodily sodium content in both spiny mice and Long-Evans rats, although this effect was less apparently pronounced in the mice—a phenomenon deserving of future study.

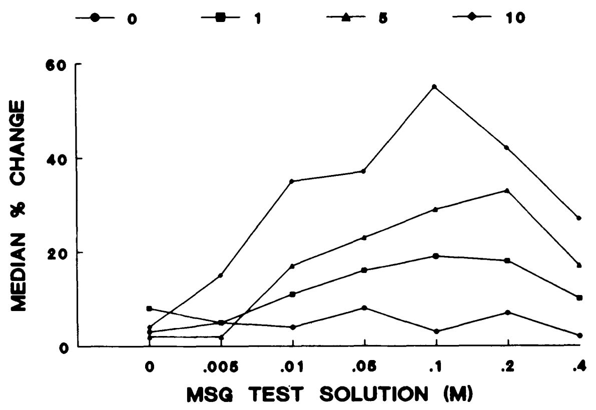

Figure 4. Median percent change from baseline MSG preference for Long-Evans rats as a function of furosemide dose (mg/kg; see legend) and concentration (M) of MSG test stimulus.

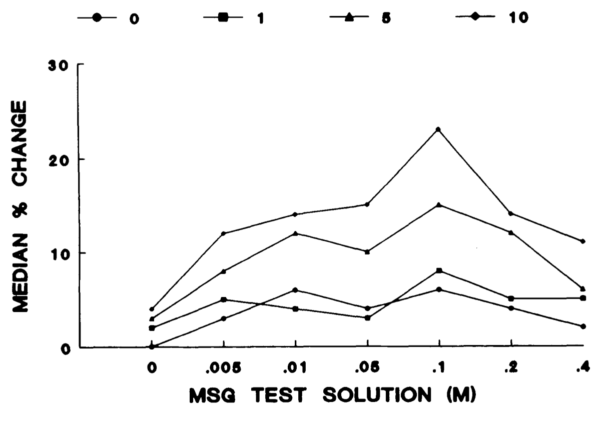

Figure 5. Median percent change from baseline MSG preference for Egyptian spiny mice as a function of furosemide dose (mg/kg; see legend) and concentration (M) of MSG test stimulus.

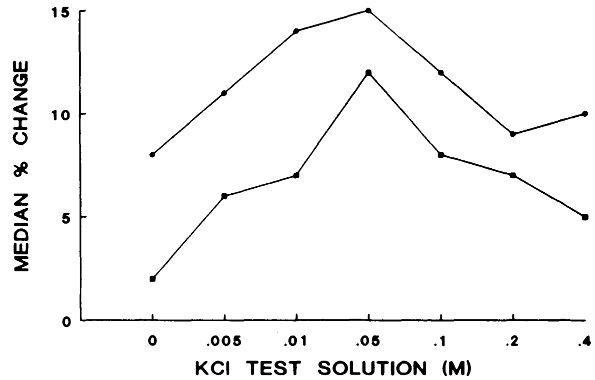

Figure 6. Median percent change from baseline KCl preference for Long-Evans rats (closed circles) and Egyptian spiny mice (closed squares) as a function of concentration (M) of KCl test stimulus. Preference values were combined across furosemide dose.

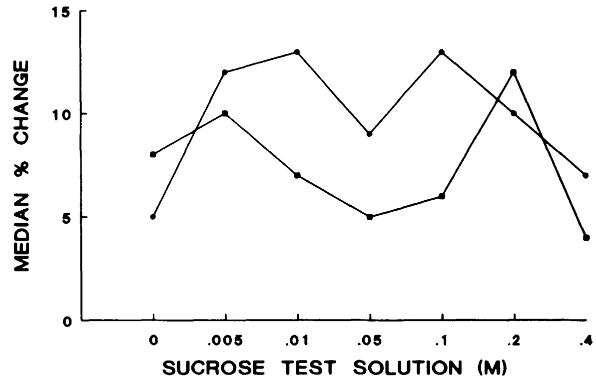

Figure 7. Median percent change from baseline sucrose preference for Long-Evans rats (closed circles) and Egyptian spiny mice (closed squares) as a function of concentration (M) of sucrose test stimulus. Preference values were combined across furosemide dose.

In the present study, several new characteristics of the spiny mouse's taste behavior were described, suggesting unique regulatory processes by which water and sodium balance are controlled. In part, these differences may be attributed to the spiny mouse's biological processes by which urine formation and vascular permeability are decreased and evaporative water loss is minimized. It would be of interest in future studies to examine the spiny mouse's preferences for a wider range of tastants as well as potential differences in regulatory behavior within the *Acomys* genus. These studies and others examining potential hormonal mechanisms for such behavior are currently in progress in our laboratory.

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(Manuscript received January 22, 1993.)