Adaptation and persistence of adaptation to a cold stressor in mice¹

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To determine their ability to adapt to a cold stressor, C3H mice were immersed to the neck daily in a 45°F water bath from 36-42 days of age. Following this adaptation procedure, the mice were divided into four groups and again immersed at either 1, 7, 14, or 21 days later. The results indicate that mice adapt very rapidly to cold and maintain an increased tolerance to cold for at least 21 days.

In recent years, an increasing number of studies have been concerned with the effects of early stress on later resistance to stress. Some of these studies have interpreted their results as showing that early stimulation alters later resistance to stress (Levine & Otis, 1958; Denenberg & Karas, 1960; Schaefer, Weingarten, & Towne, 1962), while others have reported no change in later resistance (Ader, 1959; McMichael, 1961). Campbell & Riccio (in press) have suggested that a possible source of these divergent findings may be the inability to adequately specify and control the stimuli used as stressors in these studies. Consequently, they developed a new technique for studying the effects of cold exposure upon later resistance to cold which allowed them to better specify and control the stressor stimuli, in this case, cold. Their results showed that both 25 and 100 day old rats are able to rapidly adapt to cold and maintain an increased resistance to cold for some time afterwards.

This purpose of the present study was to determine whether this technique is useful for studying adaptation and persistence of adaptation to cold in another species, the mouse (*Mus Musculus*).

Method

The Ss were 90 male and 90 female C3H mice from 26 litters.

The apparatus consisted of a Forma Temp water bath; differential sensitivity $\pm .02^{\circ}\text{C}$. Plexiglas containers, scaled to the size of the mice, were used to restrain Ss during immersion in the water bath. Each container was perforated with a number of holes to allow water to circulate freely around the Ss. An Ellab Universal Thermocouple Thermometer (type TE3; differential sensitivity $\pm 0.1^{\circ}\text{C}$) with a type RM6 probe was used to measure colonic temperatures.

At 36 days of age, 40 males and 40 females, selected according to a modified split-litter design, were removed from their cages, placed in the restraining tubes, and immersed to the neck in the 45°F water bath for 2 min. 47 sec. This immersion interval was one which was easily survived by all Ss, and was 1/4 of the immersion interval which 50% of Ss could survive at this water temperature (Nagy, 1965). Following removal from the water bath, Ss were placed in individual

semi-enclosed plastic cages (5 x 3-1/2 x 3 in.) at room temperature (74°F) for a 2-hr. period. Ss were then returned to their home cages. This procedure was followed daily through 42 days of age. On the first, third, fifth, and last day of adaptation, colonic temperatures were recorded immediately after removal from the water bath, 5, 15, and every 15 min. thereafter until S returned to 35°C colonic temperature. On the last day of adaptation, 10 male and 10 female littermate controls received the same treatment as the experimental Ss.

Following immersion on the final day of adaptation, the 80 adapted Ss were assigned to one of four retention groups consisting of 10 males and 10 females on the basis of their colonic temperature immediately following removal from the water bath on that day, so that the mean temperatures were nearly the same for all groups. Persistence of adaptation was tested 1, 7, 14, and 21 days following original adaptation, with each group being immersed on only one of the retention days. Correspondingly, Ss were 44, 50, 57, and 64 days of age at testing. Separate control groups of 10 male and 10 females, littermates of the adapted Ss, were immersed on each retention day. Colonic temperatures were recorded for all groups on all retention days.

Results and Discussion

The two measures of adaptation which were used were colonic temperature of Ss immediately upon

Fig. 1. Mean post-immersion and recovery temperature of Ss during adaptation between 36-42 days of age.

Fig. 2. Mean post-immersion and recovery temperatures of Ss after 1, 7, 14, and 21 day retention intervals following adaptation at 36-42 days of age.

removal from the water (post-immersion temperature) and the time required for Ss to return to 35°C colonic temperature (recovery time).

Figure 1. shows the mean colonic temperatures of Ss following immersion for every other day of the 7 day adaptation period. On the final day of adaptation, adapted Ss had higher post-immersion temperatures ($F=48.56$; $df=1,96$; $p<.001$) and faster recovery times ($F=117.95$; $df=1,96$; $p<.001$) than controls. There were no sex differences for either post-immersion temperature ($F=0.52$; $df=1,96$) or recovery times ($F=1.88$; $df=1,96$) on day 42. However, over the course of the adaptation period, females recovered faster than males ($F=14.87$; $df=1,312$; $p<.001$) but showed no difference in post-immersion temperatures ($F=2.86$; $df=1,312$).

Prior to the retention tests, the four adapted groups were analyzed for both post-immersion temperatures and recovery times on the last day of adaptation. Analyses of variance revealed no differences between any of the groups on either measure, suggesting that each group had adapted equally well to the cold.

Figure 2. presents the mean colonic temperatures of both experimental and control Ss following removal from the water bath on their respective retention days. Overall analyses of variance showed that previously adapted Ss had higher post-immersion temperatures ($F=170.92$; $df=1,144$; $p<.001$) and faster recovery times ($F=195.95$; $df=1,144$; $p<.001$) than controls. T-tests showed that at all retention intervals, adapted male and female Ss had higher post-immersion temperatures (all $p<.001$) and faster recovery times (all $p<.01$) than their respective controls. T-tests also revealed that at the 21 day interval, male adapted Ss had higher

post-immersion temperatures than adapted females ($p<.01$), while the control males had higher post-immersion temperatures ($p<.001$) and faster recovery times ($p<.001$) than control females.

It is clear from this experiment that mice at 36-42 days of age adapt very quickly to cold immersions, as reflected by higher post-immersion temperatures and faster recovery times. This finding is in agreement with cold adaptation obtained with young rats (Riccio & Campbell, in press). The retention data demonstrate that adaptation to cold persists for at least 3 weeks following original adaptation in mice, again in agreement with results reported for young rats (Riccio & Campbell, in press).

The present results show a difference in tolerance to cold between the sexes as Ss increase in age. At 64 days of age, the previously adapted females have significantly lower post-immersion temperatures and longer recovery times than the adapted males. At all other ages, females were equal to or better than the males in both measures. Evidence that this decrease in tolerance to cold is due to age and not merely to poorer persistence of adaptation after 21 days in females than males, is provided by examination of the control groups at the various ages. Like the adapted females, control females are equal to or better than control males except at 64 days of age, where the males are significantly more tolerant to cold than the females.

The results of the present experiment should also serve as a caution to experimenters who vary water temperature as a differential source of motivation in water mazes. The present study shows that upon repeated exposure to cold water, mice can adapt within a few days, being not nearly as affected by the cold as on the first day or as controls are.

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Note

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