Pharmacology Biochemistry & Behavior, Vol. 13, pp. 305–306. Printed in the U.S.A.

Effect of S-Adenosylhomocystein on Color Avoidance Behavior

NOBUHIRO SATAKE[1]

Bekesy Laboratory of Neurobiology, University of Hawaii, Honolulu, HI 96822

Received 28 March 1980

SATAKE, N. *Effect of S-adenosylhomocystein on color avoidance behavior*. PHARMAC. BIOCHEM. BEHAV. 13(2) 305–306, 1980.—The intracranial injection of an inhibitor of the enzyme hydroxyindole-O-methyltransferase (S-adenosylhomocystein: SAH) in goldfish prior to color avoidance training caused delay in responding to either white or green conditioned stimulus in the shuttlebox. Latency of the responses to red or blue conditioned stimulus was not affected by an injection of SAH. The results suggested that an injection of SAH increased the preference to white and green color, but did not increase the general brightness preference.

S-adenosylhomocystein Color avoidance conditioning

RECENTLY, the involvement of N-acetylserotonin (NAS) (one of the products of serotonin) was implicated in the control of brightness preference in goldfish [4]. In that study, the importance of the pineal gland was also suggested for the maintenance of that behavior. In view of the findings of Smith and Weber [5] in which color environment influenced the activity of the enzyme hydroxyindole-O-methyltransferase (HIOMT) and of Dodt [1] where the fish pineal gland was shown to be sensitive to green-blue color, there is also, then, the possibility of interaction between the green-blue preference behavior and the HIOMT-activity in the pineal gland. In fact, my own research showed that an injection of S-adenosylhomocystein (SAH), which has been shown to increase light preference [4], caused green preference in goldfish when the color was contrasted with blue, red or darkness without any training. Blue and red color preference behaviors, on the other hand, were not affected by an injection of SAH when each was contrasted with darkness.

In this report, I have examined the effect of SAH in a signaled shock avoidance situation in order to analyze whether the effect of SAH on color preference could be manifested. Since SAH was implicated in increasing the sensitivity to electric shock, it was conceivable that a possible enhancement of shock sensitivity would increase the light avoidance learning and overcome the effect on color preference.

METHOD

Subjects were sixteen 8 cm common goldfish (*Carassius auratus*), supplied locally, kept in a large home tank divided into individual compartments, illuminated from 6 a.m. to 6 p.m. Fish were fed daily and the temperature of the tank was regulated at about 21°C. The chemical used was SAH (Sigma Chemical Co.) dissolved in 0.9% NaCl solution to 15 μg SAH per 10 μl saline for intracranial injection.

The apparatus was six black Plexiglas shuttleboxes [2], water circulated. The interiors of three boxes were illuminated from each end of the shuttleboxes with white or blue Christmas tree lights and the others with green or red light of equal intensity. The use of specific color wavelength was not needed in this experiment. If the injection of SAH caused preference to each color which was paired with darkness, brightness preference effect of SAH could be implicated. If, on the other hand, it caused preference to some of the colors, color preference effect could be implicated.

Each trial of avoidance training was started with a 65 sec dark intertrial interval (ITI) followed by a 10 sec conditioned stimulus (CS) in the compartment where the fish was located. During CS period, if the fish moved away from light into the dark compartment, CS was terminated and no electric shock (7 volts at the source) was delivered. One shock was delivered, through stainless steel plates covering two side-walls, when the subject failed to respond within the CS period. The light was then terminated as the ITI began. This sequence was repeated for 1 hour with white and blue light alternating as CSs for one group (8 fist) and green and red light alternating for the others. The response measured was the latency of response to CS and recorded every 10 min for 1 hr. All operations of the experiment were automated.

All the fish were, at first, trained in this schedule for 3 days. On Day 4, half of the white-blue avoidance group and half of the green-red avoidance group were injected with SAH and the other fish were injected with 10 μl saline. Immediately after the injection, they were tested in the avoidance schedule as previously described.

RESULTS

Mean avoidance latency per trial for SAH-injected groups and control groups are plotted in Fig. 1A and 1B. Figure 1A shows that an injection of SAH caused an increase in avoidance latency to white color CS without affecting the

[1]I thank Dr. M. E. Bitterman for providing the laboratory facilities for this experiment.

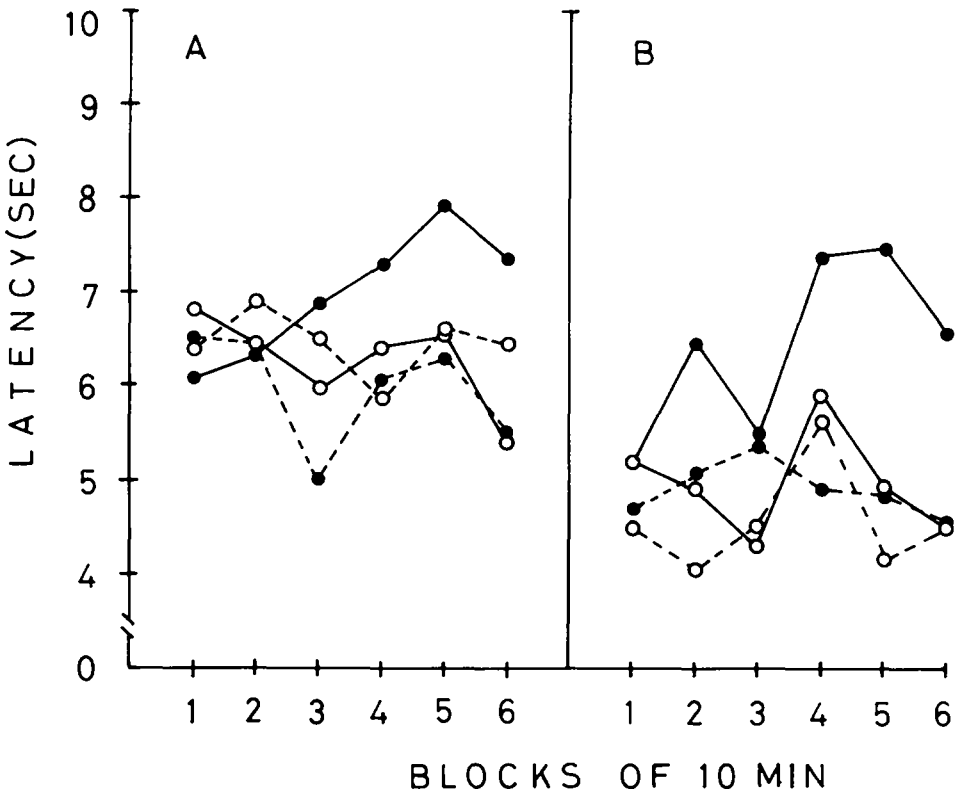

FIG. 1. Mean latency of responses during color avoidance conditioning was plotted in blocks of 10 min immediately following an intracranial injection of 15 μg SAH per 10 μl saline or 10 μl saline alone. Solid lines represent SAH-injected groups and broken lines represent control groups. (A) Closed circle represents latency responses to white light and open circle represents responses to blue light. (B) Closed circle represents responses to green light and open circle represents responses to red light.

latency to blue CS compared to the saline injected group. Figure 1B shows that an injection of SAH caused a delay in green color avoidance without affecting red color avoidance compared to the control group. An analysis of variance, incorporating two drug groups (SAH and saline) as the between-subject factor and time-after-injection and stimuli (white vs blue or green vs red) as the two within-subject factors, showed a significant drug×stimuli interaction, $F(1,6)=42.0$, $p<0.05$, for the white-blue avoidance groups and a significant stimuli effect, $F(1,6)=10.5$, $p<0.05$, and drug×stimuli interaction, $F(1,6)=6.1$, $p<0.05$, for the green-red avoidance groups. There were no other significant effects ($p<0.05$). It can be seen that the effect of SAH continued to increase until 50 min after injection and the last 10 min of the experiment shows decreased effectiveness of the drug.

DISCUSSION

The results presented here showed the expected white light preference effect of SAH and also green light preference by an injection of SAH. These effects of SAH may not be due to the brightness preference effect of SAH. If it caused brightness preference, it should have delayed all the color avoidance responses, since all the colors used had the same intensity. This study also shows that the color preference effect of SAH can be seen even with electric shock present. It is possible that with lower level of shock the effect of SAH in increased sensitivity may facilitate the conditioning and may interfere with the manifestation of delayed avoidance responses caused by SAH.

It is interesting to note that chromodiopsin G and B [6,7] were isolated from goldfish trained in a similar situation where fish were to avoid shock by swimming out of green (or blue) into blue (or green) compartment. It is conceivable that chromodiopsins may act similarly to SAH in increasing green preference behavior, just as scotophobin A [4] inhibited HIOMT, causing light preference behavior.

REFERENCES

1. Dodt, E. Photosensitivity of the pineal organ in the teleost, *Salmo irideus* (Gibbons). *Experientia* **19:** 642–643, 1963.
2. Potts, A. and M. E. Bitterman. Puromycin and retention in the goldfish. *Science* **158:** 1594–1596, 1967.
3. Satake, N. and B. Morton. Scotophobin A causes several responses in goldfish if the pineal gland is present. *Pharmac. Biochem. Behav.* **10:** 183–188, 1979.
4. Satake, N. and B. Morton. Scotophobin A causes dark avoidance in goldfish by elevating pineal N-acetylserotonin. *Pharmac. Biochem. Behav.* **10:** 449–456, 1979.
5. Smith, J. R. and L. J. Weber. Alternation in diurnal pineal hydroxyindole-O-methyltransferase (HIOMT) activity in steelhead trout (*Salmo gairdneri*) associated with changes in environmental background color. *Comp. Biochem. Physiol.* **53C:** 33–35, 1976.
6. Tate, D. F., L. Galvan and C. Ungar. Isolation and identification of two learning-induced brain peptides. *Pharmac. Biochem. Behav.* **5:** 441–448, 1976.
7. Ungar, G., L. Galvan and G. Vhapouthier. Evidence for chemical coding of color discrimination in goldfish. *Experientia* **28:** 1026–1027, 1972.