

Testosterone Administration in Chicks Affects Responding in the Presence of Task Irrelevant Stimulus Changes¹

ROBERT D. OADES^{2,3} AND PETER R. MESSENT^{4†}

School of Biological Sciences, University of Sussex, Brighton, England

In their first week of life 62 chicks were trained on a continuous reinforcement color discrimination (CRF). Then 20 males were injected with testosterone enanthate (12.5 mg, im), 19 with sesame oil: 8 males and 15 females received no injection. There were no effects of treatment on CRF performance. In the second week there were four test conditions: the color of the reinforced, the nonreinforced, both keys, or of the overhead illumination was changed. All birds decreased their response rate when the color of the reinforced key changed. The testosterone-treated birds did not decrease their response rate like the other groups after color changes on the nonreinforced key. They also showed a shorter latency to their first response after the change on the reinforced key. The results support a role for testosterone in the discrimination between relevant and irrelevant stimulus changes. The involvement of testosterone in the persistence of using learned sets is discussed.

A number of studies have reported that circulating testosterone increases the persistence for selecting a preferred visual cue and the perseveration of the associated behavioral response on a variety of tasks in birds (Andrew, 1972a, 1972b, 1976; Andrew & Rogers, 1972; Archer, 1974a, 1974b; Oades, 1978; Young & Rogers, 1978), and mammals (Archer, 1976; Earley & Leonard, 1978; Chambers & Sengstake, 1979; Thompson & Wright, 1979).

Some studies are suggestive of an effect of testosterone on a memorial mechanism. Earley and Leonard (1978) conditioned a taste aversion response in rats by adding lithium to a sucrose solution. On an extinction test intact animals retained their aversion whereas castrated animals showed a preference for the sucrose solution. Adult (Rogers, 1974) and

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² Present address: Max-Planck-Institut für Hirnforschung, Deutschordenstr. 46, D-6000 Frankfurt a.M 71, Germany.

³ To whom correspondence should be sent.

⁴ Present address: 75 Redwood Ave., Melton Mowbray, Leicester, England.

† Present address: White Lodge Stables, Main St., Wissendine, Rutland, England.

young chickens (Andrew, 1976; Young & Rogers, 1978) with circulating testosterone make longer runs of pecks to the trained, preferred food color on a colored food choice (in the presence of food-shaped stones) compared to controls. Quail with circulating androgens continue with a particular pattern of stimulus choice (right or wrong) on a match-to-sample task longer than that of castrates (Oades, 1978).

But these studies, like other reports, could be interpreted in terms of an hormonal effect on attentional mechanisms. Testosterone-treated chicks show a more sustained gaze on a localized (Archer, 1974) or novel stimulus (Andrew & Clayton, 1979). Archer trained chicks to run on a runway leading to a food dish. When distracting panels were hung on the side of the runway controls showed a latency to reach the food dish longer than that of testosterone-treated birds. He also reported that testosterone-treated chicks show longer latencies if changes are made near the goal stimulus (e.g., color of food dish). The effect of testosterone apparently can depend on the distinction between task-relevant and -irrelevant changes. The ability to make such a distinction is crucial to an attentional mechanism (e.g., James, 1890; Solomon, 1979; Oades, 1979). Thompson and Wright (1979) have suggested that testosterone affects the ability to make extradimensional shifts of attention. Testosterone treatment affected the ability of rats to shift from a light to a position cue (and vice versa) on a discrimination task. Anti-androgen treatment improved performance.

These studies show that animals change their preferred responses (or strategy) less when testosterone circulates. This suggests that it is not so much the retrieval process that is affected but the holding of information for comparison with sensory input once it has been retrieved. In *this* process conventionally conceived memorial and attentional processes meet. We describe this as an *attention-related* process. In order to say that testosterone exerts an effect on an "attention-related" mechanism it is important to show that it affects the ability to distinguish between relevant and irrelevant stimuli. We report the results of an experiment where intradimensional changes of the colors relevant and irrelevant to an operant discrimination were made. These show that circulating testosterone is important for the ability to ignore irrelevant stimulus change.

METHODS

Preparation of Animals

Warren, sex-linked chicks were obtained from the Southdown hatchery on their first day of life (Day 1). They were maintained visually isolated in chambers (20 × 20 × 30 cm high) on a 12 × 12-hr light/dark cycle.

Both male (47) and female (15) chicks learned a CRF color discrimi-

nation task in a Skinner box (30 × 30 × 40 cm high; Messent, 1973) where the operant task consisted of pecking one of two randomly alternating colored keys (3 × 3 cm). The positive key was illuminated from behind (Kodak carousel S) with a pale blue Wratten filter (§75) and the negative key with a pale red Wratten filter (§72B). Illumination of the chamber was provided from a 60-W bulb 70 cm above the floor. Each training and test session started after the chicks had been deprived of food for 3 hr. A correct response was rewarded by access to a food cup for 4 sec. With a 1-sec delay after feeding the CRF presentation of the colored keys continued. Two 9-min training sessions were given on Days 3, 4, and 5. If an 85% discrimination criterion was achieved on the training session on Day 6, the test procedure was started.

Test Procedure

Twenty male chicks received 12.5 mg testosterone enanthate in 0.05 ml sesame oil (im) on Day 6 after training (T group). The enanthate is a long-acting ester from which testosterone is released over 2 to 3 weeks (Junkman, 1952). This dose is half that used in the studies of Archer (1973a, 1973b, 1973c, 1974a, 1974b) and is the same as that which produced a maximal increase in copulation, attack, and persistence in food searching (Andrew, 1972a). Andrew (1972b) has discussed the relationship of doses of this ester to adult physiological levels. Nineteen male chicks received the sesame oil alone (M group). There were eight un-injected male chicks (C group). Fifteen females (F group) that came in the same batch were also tested alongside the male groups.

On Day 9 all chicks received two more CRF sessions. Two test sessions were carried out on Day 10 and two on Day 11. The test sessions consisted of 2 min on the trained program and 5 min on the test program, followed by 2 min on the trained program. The four test programs were as follows: (1) Negative key color changed from red (§72B) to deep blue (§95), (2) positive key color changed from pale blue (§75) to green (§74), (3) both negative and positive key colors changed as above, and (4) the overhead illumination was changed with the introduction of a pale red filter.

Test programs were run in a random sequence. Program records were taken on an Esterline Angus event recorder and the behavior was recorded on videotape. The data obtained from the limited group of subjects in each group did not show a normal distribution, therefore nonparametric statistics were applied (Siegel, 1956). Where a Kruskal-Wallis analysis of variance showed there to be significant changes further intergroup comparisons were made with the Mann-Whitney *U* test and intragroup comparisons were made with the Wilcoxon matched pairs test. Comparisons are for two-tailed tests unless otherwise stated.

RESULTS

All groups of chicks rapidly acquired the CRF discrimination in the first week and showed similar rates of response. The discrimination performance was not significantly affected by testosterone or oil treatment (Fig. 1a).

When the color on the positive key was changed either alone (Fig. 1b) or together with the negative key color (Fig. 1c) all groups showed a depressed response rate ($p < .02$). There were no differences between the groups. When only the negative cue changed the testosterone-treated group showed a significantly attenuated depression of response rate with respect to injected (M, $p < .002$) and noninjected (C, $p < .05$) control groups (Fig. 1d). The testosterone-treated group maintained a response rate higher than that of either male control group when the background illumination changed ($p < .05$, Fig. 1e). The female group did not differ from either of the male control groups.

A comparison of the response rates of the testosterone-treated group between test regimes shows that responding was higher when the negative cue (1d) or the background illumination (1e) changed than when the positive cue was changed (1b, $p < .02$). When the CRF program was reintroduced after the test program in which the positive cues changed (1b), the response rates of the control groups were higher than after the reintroduction of CRF following the negative cue (1d, $p < .05$) or the background illumination (1e, $.002 < p < .02$). Although the response rate varied with the cue manipulation the discrimination levels did not fall below criterion except for the female group when the positive cue alone was changed (70%).

The latency to the first peck after the positive cue changed was shorter for the testosterone-treated group than for the other control groups (Table 1a, $p < .05$). After the return to the CRF program the latency of the testosterone-treated group was longer than for the controls (Table 1b, $p < 0.04$, one tail). When the changes concerned the negative cues or background illumination all groups showed similar latencies. These were shorter than when the positive cues changed. These latencies remained unchanged when the CRF program was reintroduced.

CONCLUSIONS

The rate of responding on a CRF schedule was depressed by a change of the relevant (positive) cues in male chicks, with and without testosterone. When there was a change in the negative cue alone or in the background illumination, most chicks were distracted and showed a depressed response rate. However, the testosterone-treated group continued to respond at a rate significantly higher than that of the controls. This rate was higher than when the relevant cues were changed.

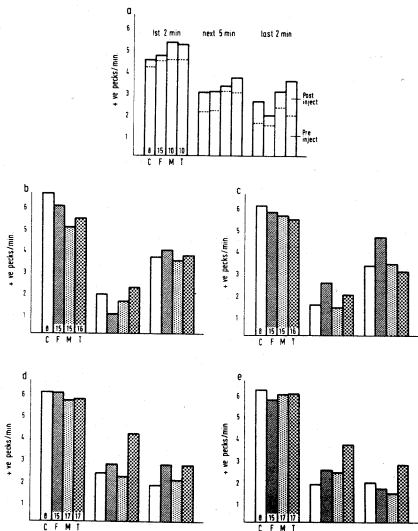


FIG. 1. These diagrams show the mean response rate (min^{-1}) on the positive key for four groups of chicks on a CRF color discrimination. The horizontal axis is divided into the first 2 min (CRF training program), the middle 5 min (stimulus change, test program), and the last 2 min (CRF training program) of a session. (a) The pre- and (superimposed) postinjection control levels of responding; time segments are shown for comparison, although there was no stimulus change. (b-e) The response rate change after a cue change. (b) Positive cue change (all groups show a decrease, $p < .02$). (c) both cues change (all groups show a decrease, $p < .02$). (d) negative cue change (T's respond more than other groups, $p < .05$). (e) overhead illumination changes (T's respond more than other groups, $p < 0.05$). The number of subjects is shown in the left hand columns. C, male chicks, no injection; F, female chicks, no injection; M, male chicks + sesame oil; T, male chicks + testosterone enanthate.

TABLE 1
Median Latencies to First Peck (sec)

Experimental group	Test change			Background
	Positive cue	Negative cue	Both cues	
(a) After stimulus change				
T	62 (22)*	16 (3.6)	37 (23)	34 (6.6)
M	110 (29)	12 (15)	60 (33)	32 (13)
C	127 (42)	12 (36)	38 (51)	32 (34)
F	300 (33)	18 (23)	55 (33)	34 (30)
(b) After return to normal condition				
T	19 (8.3)**	14 (4.8)	19 (5.7)	27 (8.6)
M	6 (7.9)	26 (9.6)	15 (8.2)	32 (8.1)
C	4 (6.8)	42 (13)	9 (14)	33 (13)
F	6 (5.7)	19 (14)	6 (11)	47 (12)

Note. T, male chick + testosterone, M, male chick + sesame oil, C, male chick, no injection, F, female chick, no injection. Standard error in parentheses.

* $p < 0.05$, two tail;

** $p < 0.05$, one tail.

The result that testosterone-treated chicks were less distracted by irrelevant changes on a CRF discrimination supports the evidence obtained from the introduction of side panels to a runway task (Archer, 1974a). However, there were no differences of response rate when the relevant cue was changed. This appears to contradict the report from the runway task. In the treatment of external stimuli, when these were relevant, the presence of testosterone in chicks of this experiment did not alter response rates on a CRF discrimination. When the changes were irrelevant, the testosterone-treated group showed a persistence that was observed in terms of a lack of distraction from the performance of the learned task.

Nevertheless the response latency data suggest that there can be an effect if the stimulus change is relevant. With the introduction of the positive cue change the testosterone-treated group first pecked with a latency shorter than that of controls. This shows a short-term "persistence" of the ongoing strategy or set just at the start of the new segment of the task. The chicks rapidly modified their behavior so that overall response rates during the test segment did not differ from those of controls. The test circumstances were rapidly acquired because on return to the previous CRF condition the initial latency to peck proved longer than for the controls. This "persistence," seen after both changes, can be contrasted with the latency of the testosterone-treated birds when there was an irrelevant cue change. Here the latency was shorter.

The specificity of these responses argues against a testosterone-induced

perceptual deficit. No deficit of discrimination performance was recorded. Elsewhere it has been argued that testosterone has no influence on long-term learning (Gibb, Messent, Clifton, & Andrew, in preparation).

In conclusion, an effect of testosterone on response rate and response latency in the presence of irrelevant/relevant stimulus changes has been shown. Such effects on response patterns could affect the strategy of choice between stimuli and thus the persistence in use of a learned set. Thus the effect, shown here, may be the same as that which underlies the long runs of pecks on food of a preferred color in the presence of other colored foods shown by birds with circulating testosterone (Rogers, 1974; Young & Rogers, 1978). The ability to distinguish relevant from irrelevant stimuli has been described as one characteristic of the operation of an attention mechanism (James, 1890; Solomon, 1979; Oades, 1979). It is suggested that these results show an effect of testosterone on an *attention-related* mechanism and as such may help to explain the effects of this hormone on the performance of other tasks (e.g., Andrew, 1976; Oades, 1978; Thompson & Wright, 1979).

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