Journal of Abnormal Child Psychology, Vol. 3, No. 3, 1975

The Effects of Reward and Punishment on Reaction Times and Autonomic Activity in Hyperactive and Normal Children[1]

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The performance of hyperactive and control children was compared on a delayed reaction time task under three reinforcement conditions: reward, punishment, and reward plus punishment. Hyperactives had slower and more variable reaction times, suggesting an attentional deficit. Although each of the three reinforcement conditions was successful in improving reaction times for both subject groups, reward led to a significant increase in impulsive responses in the hyperactive children. Autonomic data revealed that reward also increased arousal to a greater extent than punishment or reward plus punishment. Although resting skin conductance was not different in the two groups of subjects, hyperactives produced fewer specific autonomic responses to signal stimuli.

Hyperactivity, one of the most common behavior management problems in childhood, has been estimated to affect up to 5% of all school-age children (Chess, 1960; Werry & Sprague, 1969). Although activity level is most frequently stressed in clinical descriptions of the syndrome, there are several other deficits including the inability to sustain attention and to inhibit impulses that appear to be central to the disorder (Douglas, 1974; Keough, 1971).

Recent years have seen numerous investigations into the deficits and treatment of hyperactive children (see Conners, 1972; Douglas, 1972, 1974; Keough, 1971; Werry & Sprague, 1969). Of particular interest have been those studies

Manuscript received in final form August 26, 1975.

[1] This study was conducted in partial fulfillment of the Ph.D. while the first author was at McGill University. The research was supported by Canada Council grant number S72-1389 to Dr. V. I. Douglas, and by a grant from the Social Science Research Fund, McGill University (No. 943-03-69).

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investigating the effects of contingency management with hyperactives. Several investigators (Christensen & Sprague, 1973; Patterson, Jones, Whittier, & Wright, 1965; Pihl, 1967; Quay, Sprague, Werry, & McQueen, 1966) have demonstrated that rewards (tokens or pennies) contingent on appropriate behaviors are effective in reducing undesirable and increasing desirable behaviors in hyperactive children. There are, however, some critical issues in the use of reward with hyperactive children that require further clarification. For example, Freibergs and Douglas (1969) compared the effects of continuous and partial reinforcement schedules on concept learning with hyperactive children. The task consisted of pairs of pictures and the *S* had to learn to respond to the correct concept. There were three reinforcement conditions; a continuous reinforcement condition, in which each correct response was reinforced by a marble; a 50% partial reinforcement condition, in which every other correct response was rewarded; and a delay condition, in which the interval between presentation of stimuli was increased from 4 to 8 seconds. They found that performance of the hyperactives was significantly below that of controls in the partial schedule, whereas there was no difference in performance when rewards were given on a continuous basis or in the delay condition.

By using marbles of different colors, one of which signified only correctness while the other signified correctness and was of value in "purchasing" rewards, Parry and Douglas (1975) were able to separate the effects of motivation and information on the same task. They found that the hyperactive group receiving 100% feedback and 50% rewards (partial reinforcement condition) performed more poorly than a group receiving 100% feedback and 100% rewards (continuous reinforcement). Thus they were able to conclude that a motivational-frustration explanation, rather than an information hypothesis, best explained the poor performance of the hyperactives in the partial reward condition.

Cohen (1970) studied the effect of reward on the performance of hyperactive and normal children on a delayed reaction time task (DRT) which is sensitive to attentional processes. There were three conditions: a baseline condition, in which the child released a button in response to a reaction signal; a reinforcement condition, in which the child was verbally rewarded (good) for reaction times (RTs) that were faster than those in the baseline condition; and an extinction condition, in which no feedback was given. Cohen found that praise for quick responding improved mean RTs and decreased response variability of both hyperactives and controls. However, in the extinction condition the RTs of hyperactives returned to baseline speeds, whereas normal controls maintained some improvement.

Parry and Douglas (1975) expanded on the work of Cohen (1970) using the same DRT task. They had three reinforcement groups: a continuous reward group, in which children were verbally rewarded for each response that was faster than their mean baseline; a partial reward group, in which the children were rewarded every other time they exceeded this criterion; and a noncontingent group, which was rewarded with the same frequency as the partial group but on a random preset basis. Each group also experienced an extinction condition in which no feedback was given. Their results replicated those of Cohen (1970): The RTs of hyperactives were slower and more variable than those of controls and continuous social reward, contingent upon good performance, improved mean RTs and reduced variability. In the partial reinforcement condition mean RTs of both groups improved but a significant decrease in response variability was not obtained for the hyperactive subjects. The data from extinction trials following continuous reinforcement supported the hyperactive–normal differences found by Cohen (1970). Normal controls retained improved performance while hyperactives returned to baseline level. Following withdrawal of partial reinforcement, however, both groups returned to their baseline levels of performance. The reactions of the hyperactive children to noncontingent reward are of particular interest. Whereas the reaction times of the normal control subjects improved, the hyperactive children performed reliably more poorly under noncontingent reinforcement.

These studies suggest that hyperactives respond differently from normal controls to partial and noncontingent reinforcement schedules. To date, however, there have been no studies investigating the effectiveness of disapproval (e.g., punishment, response cost) with hyperactive children. The present investigation compared the effects of verbal rewards and punishers on the performance of hyperactive and normal control children.

Another purpose of the study was to study the effects of reward and punishment on autonomic activity. This was of interest since evidence has indicated that subjects who exhibit deficits in attention, as do hyperactives, have autonomic responses which deviate from the norm (Boydstun, Ackerman, Stevens, Clements, Peters, & Dykman, 1968; Luria, 1963). Some have speculated that hyperactive children are autonomically overaroused (Laufer, Denhoff, & Solomons, 1957; Wender, 1972), while others have suggested they are underaroused (Satterfield & Dawson, 1971). Boydstun et al. (1968), Cohen and Douglas (1972), and more recently, Spring, Greenberg, Scott, and Hopwood (1974) have found no differences between hyperactives and normals on resting skin conductance, suggesting no differences in general arousal levels. However, Cohen and Douglas (1972) have shown that while performing on a DRT, normal control children showed an increase in tonic skin conductance (SC) levels to increased task demands but hyperactives did not. In addition, when *S*s were rewarded for faster reaction times, both groups showed an increase in SC which was maintained when reward was withdrawn. Another autonomic response that was monitored, the orienting response (OR), differentiated between the groups. The OR is the phasic skin conductance response to the warning signal in the DRT and is indicative of a *S*'s ability to attend to the task and prepare for further action (Boydstun et al, 1968; Luria, 1963). It was found that normal control children showed more ORs to the warning signal when rewarded and maintained this increase when reward was withdrawn. Hyperactives, on the other hand, showed no changes in ORs over experimental conditions.

The DRT also made it possible to study the skin conductance response in anticipation of the reaction signal, which is assumed to be a conditioned response. Cohen and Douglas (1972) report that the normal control children and hyperactives increased the frequency of anticipatory skin conductance responses (ASR) when reward was introduced but only controls maintained this increase when reward was terminated. The present study will extend this line of research by comparing the effects of reward and punishment on autonomic activity in hyperactive and normal control children.

METHOD

Subjects

Prior to the study teachers and principals were given a brief verbal description of the symptomatology characteristic of hyperactive children. This description focused mainly on three traits — overactivity, inability to sustain attention, and impulsivity. The teachers were then asked to fill out Conners' (1969) behavior rating scale for teachers. Those male children whose average score on the hyperactivity factor of the scale was 1.5 or greater were considered as candidates for the hyperactive sample. Further selection was based on an interview with the parents regarding the child's behavior at home. For the child to be included, his hyperactivity had to be chronic and present since early childhood. Twenty-seven experimental *S*s were selected.

Each teacher of a hyperactive child was asked to choose from the class register the next male child on the list who was of approximately the same age and intelligence as the experimental subject. Subsequently, the teacher was required to fill out the rating scale on the control child.

Children with a history of brain damage, epilepsy, or psychosis were not acceptable as experimental or control *S*s. All *S*s were living at home with at least one parent and none were taking psychotropic medication.

Rating Scale and Apparatus

Conners' Rating Scale. Conners (1969) has developed a widely used rating scale for teachers. This scale of 39 items has been factor analyzed to give 5 factors: (1) conduct–problem, (2) inattentive–passive, (3) tension–anxiety, (4) hyperactivity, and (5) sociability. The score for each factor is based upon the mean of the items within the factor (a 4-point scale, 0–3, is used).

Physiological Recording Apparatus. A Grass Model 7 polygraph was used to make continuous recordings of skin conductance as well as releases and depressions of the reaction time button. Skin conductance was measured directly (Lykken, 1965) by connecting a constant voltage of .5 volts in series with the *S* and a 500-ohm potentiometer, and feeding the signal into a polygraph amplifier. Skin conductance electrodes were Beckman silver-silver chloride (No. 653418). Beckman electrode paste (No. 201210) was used in the prescribed manner to treat the skin prior to securing the electrodes to the S with Beckman collars (No. 650429) as mounts. The electrodes were placed on the center of the fingerprints on the first and third fingers of the left hand and secured there with surgical tape.

Reaction Time Apparatus. The RT apparatus was triggered by auditory stimuli which had been preprogrammed. Stimuli were recorded on separate channels of a stereophonic tape recorder. The first tone was fed directly from the first channel of the tape recorder to the *S*'s earphone and acted as the warning signal (WS). This was a 500-cps tone of 70-db intensity and 1-second duration. Onset of the WS marked the beginning of a 10-second preparatory interval at the end of which another tone recorded on the second channel of the tape recorder activated the reaction signal (RS). This consisted of a 7.5-watt light bulb enclosed in a small grey metal container which was situated along with the response button on the right arm of the *S*'s chair. Trials were separated by a 5-second interval. The circuit was constructed so that the RS would not appear unless the response button was depressed. Simultaneous with the appearance of the RS a Standard Electrical Clock Timer started and ran until the *S* removed his finger from the response button. The onset and termination of the warning and reaction signals and the *S*s responses were automatically marked on the polygraph chart record.

Procedure

Experimental Task. The physical setting consisted of a small windowless room isolated in the basement of an elementary school. The room was kept at a temperature of approximately 70 degrees and was divided by a large plywood screen in which there was a one-way mirror. The *S* was seated alone on one side of the screen. The polygraph, tape recorder, and programming equipment was operated by the *E* on the other side of the screen, out of the *S*'s view.

The *S* was seated in a semireclining chair and told that the *E* was interested in how well he could pay attention to things. The electrodes were put on, the content of the experiments was explained, and the earphones were put on the *S*. The *E* then left the room and a 10-minute relaxation period ensued. The last 5 minutes of this period were used to assess resting levels of the galvanic skin conductance (SC).

The Delayed Reaction Time Task: Manipulation of Reinforcement. Directly following the relaxation period *E* repeated the instructions via earphones. The *S* was told to press the response button and keep it down until the light (RS) came on. He was told not to let go when the tone (WS) came through the earphones.

A series of 15 baseline trials with no feedback to the *S* was administered first and the base RT was determined by computing the mean of the last 12 of these trials. The *S* was urged to respond as quickly as possible to the RS. One group of *S*s was then put into the reward condition, another the punishment condition, and a third the reward plus punishment condition. In the reward condition *S*s were asked to respond as quickly as possible and *E* explained they would be told every time they were as fast as or faster than the mean baseline RT (that's good, that's fine, and other encouragements). No feedback was given for responses slower than this mean. *S*s in the punishment group were also asked to respond as quickly as possible and *E* explained that they would be told when they were responding too slowly (that's not good, that's poor, for instance). No feedback was given if responses were as fast as or faster than the mean in the baseline condition. The reward–punishment group was rewarded or punished after every trial. After the reinforcement trials *S*s were given a 1-minute break and told that this time no feedback would be given, but that they should respond as quickly as possible. In both the reinforcement and extinction conditions the first three trials were regarded as practice and not included in the analyses.

Skin Conductance Data. SC readings were taken at 30-second intervals during the last five minutes of the 10-minute relaxation period. SC readings also were taken at the onset of the WS.

Skin conductance changes were expressed as the difference between the logarithms of the prestimulus and stimulus values and changes in excess of .30 micromhos were counted as phasic responses. A skin conductance was scored if it occured within .5–4.0 seconds of the WS onset. On the same trials skin conductance responses which occurred 2.5 or fewer seconds prior to the RS were considered as anticipatory skin conductance responses (ASR).

Three kinds of "impulsive" responses were studied in relation to the DRT. False starts refer to those button releases that occurred between the onset of the WS and up to 2.5 seconds following its occurrence. Intertrial responses were those that occured from 2.5 seconds after the WS up to the onset of the reaction signal. Responses after the button release to the reaction signal which occurred before the warning signal of the next trial were designated redundant responses.

Data Analysis. Whenever an analysis of variance resulted in a statistically significant interaction it was further analyzed by a test of simple effects followed by a multiple comparison of means (Neuman Keuls).

The OR in the present study was defined as the skin conductance response to the WS. However, as noted previously, there were a large number of "false-

Table I. Mean Ages and IQs of Hyperactives and Controls

Group	Variable (mean ± *SD*) Age (months)	Peabody Picture Vocabulary Test IQ
Hyperactive children	110.96 ± 23.65	104.52 ± 10.8
Normal controls	112.4 ± 22.84	104.56 ± 12.2

start" responses. Since it has been demonstrated experimentally (Germana & Chernault, 1968) that skin conductance responses accompanied by overt responses are larger than those that are not so accompanied, the ORs which occurred in temporal proximity to a false start (up to 2.5 seconds after the WS) were not included in the analyses. To control for this, each experimental subject was paired with a control *S* and the deletions were "yoked" between the *S*s.

RESULTS

Statistical comparisons revealed that there were no significant differences between the ages and IQs of the experimental and control groups (Table I).

The means of the factor scores from Conners's teacher rating scale (Table II) revealed that the hyperactive children were rated significantly higher than controls on all five factors.

Reaction Times

The means and standard deviations of the RTs (Table III) were subjected to a three-way analysis of variance. The factors were subject group, type of reinforcement, and trial condition. The analysis of the mean scores revealed a significant main effect for subject ($p < .05$), indicating that hyperactive *S*s responded

Table II. Mean Factor Scores of Hyperactives and Controls on Conners' Rating Scale for Teachers

Factor	Hyperactives	Controls
I Conduct problem	1.50	.14[a]
II Inattentive–passive	1.48	.43[a]
III Tension–anxiety	.88	.49[b]
IV Hyperactivity	2.13	.42[a]
V Sociability	.82	.12[a]

[a] $p < .001$.
[b] $p < .01$.

Table III. Mean Reaction Times of Hyperactives and Controls During Reward, Punishment, and Reward plus Punishment Conditions

Group and reinforcement condition	Reaction time (mean ± *SD*) during experimental condition:		
	Baseline	Reinforcement	Extinction
Hyperactives			
Reward	50.68 ± 32.80	45.69 ± 29.26	51.36 ± 34.30
Punishment	50.95 ± 33.62	41.55 ± 26.76	46.12 ± 31.19
Reward plus punishment	50.18 ± 31.40	42.12 ± 26.57	51.57 ± 39.63
Controls			
Reward	41.30 ± 29.62	38.55 ± 26.58	41.87 ± 29.30
Punishment	39.36 ± 24.78	35.59 ± 22.42	40.86 ± 25.99
Reward plus punishment	38.99 ± 25.44	32.89 ± 20.23	38.69 ± 25.57

more slowly than control *S*s. A significant trial effect ($p < .05$) showed that there was a significant improvement in speed from baseline to reinforcement ($p < .01$), indicating that all three reinforcement conditions were effective in improving RTs. Also, when reinforcement was terminated, RTs decreased ($p < .01$) to baseline levels.

The analysis of the standard deviations of the RTs showed that the responses of hyperactives were more variable than those of controls ($p < .05$). A significant trial condition effect ($p < .01$) reflects a significant decrease in variability when reinforcement was administered ($p < .01$) and a significant increase ($p < .01$) back to baseline level when reinforcement was withdrawn.

A two-way analysis of variance on the frequency of reinforcement revealed that, as expected, the number of reward statements (8.8) was significantly higher than the frequency of punishment statements (2.4, $p < .001$).

Impulsive Responses. The analysis of variance on the interstimulus responses disclosed that hyperactives made more of these than controls (1.72 vs. .27, $p < .01$). A significant trial condition effect ($p < .001$) indicated that the frequency of interstimulus responses increased from baseline to reinforcement conditions ($p < .01$) and decreased ($p < .01$) to baseline levels when reinforcement was terminated. A significant reinforcement effect ($p < .001$) showed that there were more interstimulus responses during the reward than punishment condition ($p < .05$) and a trend for more of these responses to occur with reward than with reward plus punishment ($p < .10$). There was no difference in frequency of interstimulus responses between the punishment and the reward plus punishment groups.

Four significant interactions were also revealed by the analysis: reinforcement X trial condition ($p < .001$); subject group X trial condition ($p < .05$); subject group X reinforcement ($p < .01$); and the more inclusive subject group X trial condition × reinforcement interaction ($p < .01$). Since *E*'s emphasis is on hyperactive/control comparisons, accounts of detailed analyses are given only on the more interesting reward schedule by trial condition within subject group. The other two-way interactions are discussed only where they contribute to a fuller understanding of the data.

Multiple comparisons on the means within the hyperactive sample (Figure 1) showed that only in the reward condition did interstimulus responses increase over baseline levels ($p < .01$). When reward was terminated, interstimulus responses decreased ($p < .01$) to baseline level. In addition, the only other significant differences were found within the reinforcement condition. Reward led to significantly more interstimulus responses than punishment ($p < .01$) or reward plus punishment ($p < .01$). These latter two conditions did not differ from each other. Data from the three two-way interactions suggest that, although interstimulus responses were generally more frequent for hyperactives than controls, this difference reached statistical significance *only* when subjects were given rewards. During baseline and extinction conditions the differences between hyperactive and control subjects did not reach significance.

Within the control sample (Figure 2) there were no significant differences between trial conditions or reinforcement groups. This suggested that, unlike hyperactives, control *S*s performed equally well in reward, punishment, and reward–punishment contingencies.

Redundant responses. The analysis of variance on redundant responses produced subject group ($p < .001$) and reinforcement condition main effects ($p < .001$). These results show that hyperactives made more redundant responses than controls (1.46 vs. .42), and the frequency of redundant responses in re-

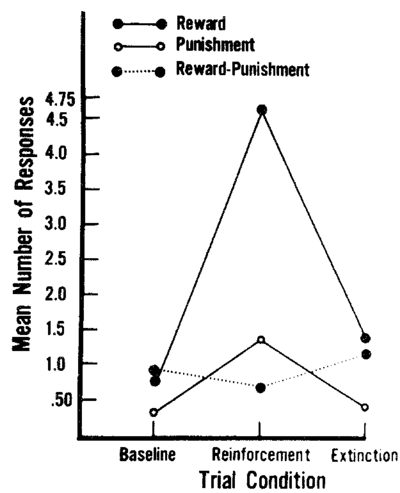

Fig. 1. Mean number of interstimulus responses in the three reinforcement contingencies for hyperactive subjects.

warded Ss was higher than in the punishment group ($p < .025$) or the reward plus punishment group ($p < .025$), which did not differ from each other.

There were three reliable interactions: reinforcement × trial condition ($p < .001$); subject group × reinforcement ($p < .01$); and the subject group × trial condition × reinforcement interaction ($p < .05$). The three-way interaction for hyperactive children revealed a pattern similar to that found for interstimulus responses. The frequency of redundant responses increased when reward was introduced ($p < .01$) and decreased during extinction ($p < .01$) to baseline level. During reinforcement reward led to more redundant responses than either punishment ($p < .01$) or reward plus punishment ($p < .01$), which did not differ from each other. As with the interstimulus responses, although hyperactives seemed to make more redundant responses than controls, a statistical difference was found only when the Ss were being rewarded.

Once again, there were no significant differences between reinforcement groups or trial conditions within the control sample.

The analysis of variance on false starts resulted only in a significant main effect for groups ($p < .001$). Hyperactives made more false starts than controls (1.49 and .73).

Autonomic Activity

Tonic Skin Conductance. An analysis of variance on the tonic skin conductance data revealed a significant trial condition effect ($p < .01$) and a trend for a reinforcement × trial condition interaction ($p < .01$). The trial condition effect was due to a significant increase in tonic skin conductance from the rest period to baseline ($p < .01$), from baseline to the reinforcement condition ($p < .01$), and from reinforcement to extinction ($p < .01$).

As Figure 3 suggests, the three reinforcement groups in the interaction reacted somewhat differently over trial conditions. Although all reinforcement groups showed a significant increase from rest to baseline, only the reward group continued with an increase from baseline to reinforcement ($p < .01$) and from rein-

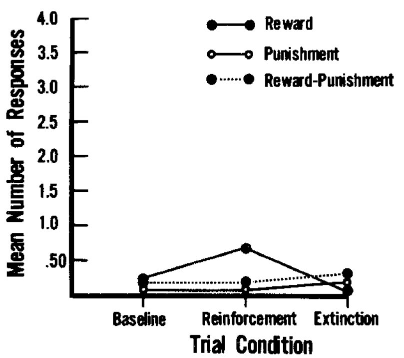

Fig. 2. Mean number of interstimulus responses in the three reinforcement contingencies for normal controls.

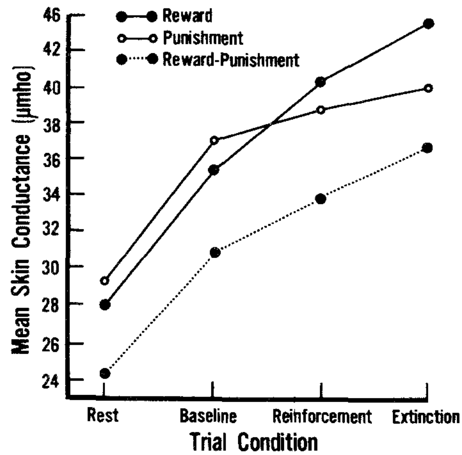

Fig. 3. Mean tonic skin conductance across experimental conditions in the three reinforcement contingencies.

forcement to extinction ($p < .01$). The reward plus punishment group showed only a slight increase over trial conditions; the only significant difference was between baseline and extinction ($p < .01$). Within the punishment group there was no significant increase in tonic skin conductance following the baseline condition.

Phasic Skin Conductance Responses. The analyses of variance yielded no significant differences on the amplitude of the skin conductance measure to either the warning or response stimuli. The frequency measure, on the other hand, yielded several significant results. An analysis of variance on the frequency of the ORs revealed that control *S*s produced more ORs than the hyperactives ($p < .01$).

The analysis of the frequency data of the ASRs gave a significant trial condition effect ($p < .001$). The frequencies of ASRs were lower in extinction than during baseline ($p < .01$) or reinforcement ($p < .01$). ASR frequencies during baseline and reinforcement did not differ.

DISCUSSION

Although hyperactives and normal controls were chosen on the basis of the hyperactivity factor of Conners' rating scale for teachers, they were rated higher on all five factors. One might expect that hyperactives would score higher on the conduct–problem, inattentive, and sociability factors. Less to be expected, perhaps, is their higher rating on the anxiety factor. It is possible that a "halo effect" was operating to cause more maladjusted ratings throughout the scale. In any case, the ratings received by experimental and control *S*s in the present investigation were quite comparable to *S*s used by at least one other research group (Sprague, Christenson, & Werry, 1975).

The results from the delayed reaction time task partially replicated previous studies (Cohen, 1970; Cohen & Douglas, 1972; Parry & Douglas, 1975). In comparison to normal controls, hyperactives demonstrated slower and more variable reaction times, suggesting an attentional deficit. With reinforcement, mean reaction time and variability decreased for both groups. In the present study, however, reaction times of hyperactives and normals returned to baseline levels during extinction. In the previously reported studies this was the case only with hyperactives, while controls maintained some improvement in the extinction phase.

One of the major aims of the present study was to investigate the relative effectiveness of reward (R), punishment (P), and reward plus punishment (R-P) on the performance of hyperactive and normal control children. Although the mean reaction times of both groups were somewhat slower in the R than in the P or R-P condition, these differences were not statistically significant. It was evident, however, that variability in performance decreased more during R-P and P than during R, suggesting that R leads to less stable performance than the other conditions.

The lack of statistical significance between means in these reinforcement conditions may be due to the fact that R, P, and R-P are equally effective in motivating behavior, or it may be that the DRT, as used in the present study, is not sufficiently sensitive to measure subtle differences. The short duration and the relative simplicity of the DRT may also have made it difficult to demonstrate differences in performance due to reinforcement procedures. It is also possible that the reinforcers used were not sufficiently potent. More pleasing positive comments and harsher negative comments might have produced differences among the three conditions.

Another well-known feature of hyperactive children, their inability to inhibit responses, became evident in the three types of responses labeled impulsive. The high frequency of "false starts" suggests that the hyperactives were "geared up" to respond as quickly as possible to the reaction signal. However, in their eagerness to respond these children would erroneously remove their finger when the warning signal occurred; typically, they would become aware of their error, and almost immediately place their finger back on the button. This behavior is somewhat reminiscent of the errors of commission Sykes, Douglas, and Morgenstern (1972) reported on the continuous performance task. These responses also resemble the tendency of hyperactives to respond too quickly on the Matching Familiar Figures Test (Campbell, Douglas, & Morgenstern, 1971).

The interstimulus responses, which are also indicators of a breakdown in inhibitory control, appeared in the absence of any obvious stimulation, in the period between the warning signal and the reaction signal. Again, this behavior was produced significantly more frequently by the hyperactive *S*s. Both hyperactive and control children tended to make more of these responses when rewarded. However, the only significant increase in interstimulus responses occurred in the hyperactive group that received reward. With both punishment and reward plus punishment contingencies there were no significant differences between hyperactive and control *S*s.

The hyperactives also produced more redundant responses, a finding which replicates the results of Cohen (1970). Although Cohen did not find an increase in redundant responses when reward was introduced, she did find an increase in the frequency of concordant motor responses (finger movements in the left index finger concomitant with the required right finger response to the reaction signal). Cohen found, as in the present study, that, although both groups increased excessive responses during reward, the increase was significantly greater for the hyperactive than for the control groups.

It could be argued that the increased impulsivity during the reward condition is due to a higher frequency of feedback and hence more distraction (Spence, 1970). This explanation, however, is not tenable since, if distraction were responsible, impulsive responding should be most evident in the reward plus punishment condition, since here *S*s received feedback on each trial. The data clearly show that impulsive responses occur less frequently with the reward plus punishment contingency than in the reward group.

A possible breakdown of inhibitory control resulting in increased irrelevant and disruptive behavior in response to reward has also been found by Ferritor, Buckholdt, Hamblin, and Smith (1972). In their study a group of children in a classroom were rewarded during an initial phase for attending and nondisruptive behavior, followed by a period when they were rewarded for good performance on mathematics tasks, and finally they were rewarded for both attending and performing well on mathematics tasks. The results showed that only the target behaviors improved with reward. When children were being rewarded only for improvements in mathematics, there was actually an increase in disruptive behaviors. Thus, as in the present study, reward improved performance on the task but also produced a concomitant increase in irrelevant behavior.

The autonomic skin conductance data seem to favor an arousal hypothesis to explain the increased incidence of impulsive responses in the reward condition. Tonic skin conductance may be viewed as an indication of overall arousal as well as a sign that the organism is prepared to take in and act on new information. Tonic levels increased throughout the task, from the rest period to baseline, reinforcement, and extinction conditions. A finer analysis, however, shows that this increase was not uniform for all reinforcement conditions. In fact, reward led to the greatest increase across trial conditions, punishment the least, with reward plus punishment falling between the two. This parallels the increased frequency of impulsive responses found in the R condition. We might speculate, therefore, that the observed increase in impulsive responses was due to the influence of arousal on performance (Hebb, 1968). Hebb suggests that there is an optimal level of arousal; too little or too much leads to poor performance. Apparently normal children can cope with this increased arousal and keep their impulsive responses to a minimum. Hyperactives, however, seem unable to maintain the required inhibitory control.

In agreement with the findings of other researchers (Boydstun et al., 1968; Cohen and Douglas, 1972; Spring et al., 1974) the hyperactive and normal control children, in the present study, did not differ on resting skin conductance levels and demonstrated similar increases across trial conditions. Thus these results lend no support to the hypothesis that hyperactive children are either overaroused or underaroused. On the other hand, although the hyperactives seemed to be generally alerted to task demands (as evidenced by tonic skin conductance levels), they showed fewer reactions than controls in autonomic responses to specific stimuli. This lower level of specific responsivity in hyperactive children has also been found in previous research (Boydstun et al., 1968; Cohen and Douglas, 1972; Spring et al., 1974).

The lower frequency of orienting responses in the hyperactive group suggests that these children were not using the warning signal effectively. This low autonomic responsivity to the finer demands of the task is probably related to their poorer performance on the DRT. The fact that there was not a significant difference between hyperactives and normals in the anticipatory skin conductance response is rather puzzling. The lack of a significant difference suggest that both hyperactive and control *S*s realized that the reaction signal appeared at a particular point during the sequence of events on the DRT. Cohen's (1970) control *S*s were more sensitive to particular demands of the DRT than the control *S*s in this study. She found that controls increased their frequency of both orienting and anticipatory responses from baseline to reward and maintained this increase into the extinction phase. However, differences in experimental procedures preclude a direct comparison of the results from the two studies. Cohen's *S*s took part in the reward study after completing over 90 reaction time trials and other psychological tests, whereas in the present study *S*s came into the experimental setting fresh and the DRT lasted for only 45 trials. Cohen's DRT task also differed slightly from the one used in the present study. Cohen required her *S*s to depress the reaction time button to the WS and release to the RS; in the present study the DRT was modified so that *S*s kept the button down, and released only momentarily to the RS.

The findings suggest that improved performance by hyperactives in reward conditions may be obtained at the cost of increased impulsivity, due perhaps to increased arousal levels. On some tasks and in some conditions they may be too high a price to pay. In other situations parents and teachers might be well advised to put up with this "overflow effect." We, unfortunately, know little about the extent to which impulsive responses of various kinds interfere with performance on different kinds of tasks. In the present study, although the *S*s had been told that impulsive responses were undesirable, no attempt was made to control them. Possibly the DRT was simple enough so that the *S*s could maintain relatively fast reaction times while also making several of these responses. Conceivably, however, performance on a more complex task could be seriously hampered by an increase in impulsivity. In situations where these behaviors are undesirable the judicious use of punishment or negative feedback techniques may help to control them.

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