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Effects of Methylphenidate (Ritalin) on Selective Attention in Hyperactive Children[1]

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This study investigated the effect of methylphenidate (Ritalin) on the selective attention of hyperactive children designated as favorable or adverse responders to stimulant medication. Using a type II incidental learning paradigm, it was found that children in the drug condition recalled more central and less incidental stimuli than those children in the placebo condition. While no differential effects on recall were found for responder type, methylphenidate did affect the spontaneous overt labeling of central stimuli by the favorable responder group. Results were interpreted in terms of the role of methylphenidate in narrowing the focus of attention. Implications for the classification of hyperactive children as favorable and adverse responders were also discussed.

Among the major characteristics of hyperactivity are those behaviors associated with inattention and distractibility (Ross & Ross, 1976; Sroufe, 1975). Several studies have examined the influence of psychostimulants, such as methylphenidate (Ritalin) upon what Berlyne (1970) has considered to be intensive phenomena, involving attention to the stimulus field as a whole. These include vigilance (Campbell, Douglas, & Morgenstern, 1971; Sykes, Douglas, & Morgenstern, 1972), distraction (Campbell et al., 1971), and orienting (Conners, 1972; Sroufe, Sonies, West, & Wright, 1973). Little research, however, has dealt directly with

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selective phenomena, even though many researchers have explicitly suggested that it is in attention of a selective or focused nature that hyperactive children demonstrate the most pronounced deficiency.

Studies have demonstrated drug-associated improvements on such tasks as coding, picture completion, and block design subtests of the WISC (Knights & Hinton, 1969), the figure ground perception subtest of the Frostig DTVP (Millichap, Aymat, Sturgis, Larsen, & Egan, 1968), Porteus maze tasks (Conners & Eisenberg, 1963; Conners, Eisenberg, & Sharpe, 1964), and on duration scores of maze and hold tasks (Knights & Hinton, 1969). Methylphenidate has also been found to improve paired associate learning (Conners et al., 1964; Swanson, Kinsbourne, Roberts, & Zuker, 1978), to improve use of learning time (Dalby, Kinsbourne, Swanson, & Sobol, 1977), and to reduce impulsivity (Campbell et al., 1971; Kinsbourne, 1977) and task-irrelevant motor responses (Cohen, Douglas, & Morgenstern, 1971). Most of these investigators have suggested that it is attentional abilities and specifically the capacity to selectively inhibit, plan, and control responses that is positively affected by stimulant treatment.

The purpose of the present study was to directly assess the effect of methylphenidate upon visual selective attention within the confines of the incidental learning paradigm (Hagen, 1972). Subjects were instructed to learn central (task-relevant) materials while simultaneously being exposed to incidental (task-irrelevant) material. Central and incidental learning were assessed through a free recall procedure. High incidental learning is assumed to reflect a high degree of attention to irrelevant stimuli, whereas low incidental learning plus high central performance indicates selectivity of attention.

In several studies (Safer & Allen, 1976; Swanson et al., 1978; Wender, 1971), hyperactive children have been differentially classified as displaying either a favorable or an adverse response to stimulant medication. If methylphenidate increases the selectivity of attention, as Kinsbourne (1977) has suggested, then hyperactive children who respond favorably to the drug ought to display higher central and lower incidental scores than would a similar group given placebo. On the other hand, hyperactive children designated as adverse responders ought to display both lowered central and lowered incidental scores, given that methylphenidate may narrow attention to an excessive degree in this group (Kinsbourne, 1977).

Dalby et al. (1977) have suggested that methylphenidate may influence the performance of positive responders by raising the decision criterion to a normal level. This would allow for a more comprehensive analysis of available information before suspending the option to continue. Thus it was predicted that positive responders, given methylphenidate, ought to take more time than a group given placebo to respond during the free recall task.

Furthermore, since verbal mediation is a mechanism postulated to underlie the development of selective attention (Maccoby & Hagen, 1965), measures of spontaneous overt verbal encoding and reported covert labeling and rehearsal

were obtained. If the drug has a normalizing effect on favorable responders, it would be expected that this group would display more task-relevant verbal behavior.

METHOD

Subjects

Fifty-four hyperactive, distractible children (46 males, 8 females), treated as outpatients at the Learning Clinic of the Hospital for Sick Children in Toronto, participated in the study. These children were initially referred for treatment because they were seriously impaired in their ability to function at home and at school. Some or all of the classical symptoms of hyperactivity (i.e., impulsivity, short attention span, distractibility, conduct disorder, and overactivity) were present in each child. Prior to participation in this study, all children were assessed in the Learning Clinic. This involved a neurological examination and extensive parent interviews conducted by a pediatric neurologist, as well as psychological and achievement testing (including WISC-R and WRAT). All children with a diagnosis of epilepsy, cerebral palsy, psychosis, or gross brain damage were excluded from the study.

Before participation in the present study, the children had been tested in the laboratory for responsiveness to methylphenidate via the time-response cognitive measure developed by Swanson et al. (1978). In this procedure, children were administered drug or placebo at 8:30 a.m. and at 12:15 p.m., the order of drug administration being counterbalanced across children. Fifteen minutes prior to receiving the capsule each child was tested on a paired associate learning task. This was used as a baseline measure. Four subsequent trials were then given at ½ hour, 2 hours, 3 hours, and 4 hours after administration. Since there is little transfer from list to list (Swanson & Kinsbourne, 1976), on each retesting a new list of six to eight items was used. The difference between the baseline test trial and the best performance on the subsequent trials served as the basis for the classification of the child as either an adverse or a favorable responder. If there was a drug-induced facilitation greater than 25% and it was at least 10% greater than any placebo effect, then the child was designated as a favorable responder. If, however, the child displayed a drug-induced impairment in performance resulting in greater than a 10% increase in errors compared to baseline, then he was classified as an adverse responder. Children showing no clear response were later retested on a higher dosage. This retesting continued until either an adverse or a favorable pattern emerged.

As a result of this classification procedure, 33 children were diagnosed as favorable responders. Of this group, 18 children (CA = 9.42, MA = 9.30) were subsequently tested under drug on the selective attention task, while the remain-

ing 15 children (CA = 10.00, MA = 10.45) were tested under placebo. Of the 21 children diagnosed as adverse responders, 11 (CA = 10.05, MA = 10.78) were tested under drug and 10 (CA = 9.37, Ma = 10.56) were tested under placebo. Analyses of variance revealed no differences between any of the four groups on either CA or MA.

Drug Schedule

Children were randomly assigned to drug or placebo groups. Of the favorable responders, 18 children received methylphenidate, while 15 received a placebo. In the adverse responder group, 11 children were given methylphenidate and 10 received a placebo. Dosages, which were determined by a pediatric neurologist, ranged between 5 and 20 mg, with an average dose of 10 mg. There were no differences between the average dosages for the favorable and adverse responder groups.

Testing took place only in the morning. Children received either methylphenidate or placebo at least an hour after breakfast to prevent interference by digestive processes of absorption of medication. Drug and placebo tablets were visually identical. Testing began between 1 and 2½ hours after medication was administered. This has been determined to be the period of optimal performance for favorable responders and of most impaired performance for adverse responders (Swanson et al., 1978). A double-blind procedure was followed.

Materials

Stimulus materials were similar to those developed by Hagen (1967). Eight stimulus cards were prepared, each bearing two black line drawings, one of an easily recognized animal and one of a common and easily recognized household object. All pictures were drawn within a 5 × 5-cm-square area and centered on a 6-cm white square. Each pair of pictures was centered on a separate sheet of 12 × 17.5-cm lightweight white cardboard with one picture placed above the other, 2 cm apart.

The pictures on top of each card were designated as the central stimuli. Central stimulus type (animals or household objects) was counterbalanced over each medication (drug/placebo) and responder type (favorable/adverse) group. Therefore, two sets of 8 cards were prepared, one set with animal pictures placed above household objects and the other set with household objects placed above the animals. The same animal was always paired with the same household object: bird-chair, cat-lamp, cow-clock, dog-stove, elephant-spoon, fish-telephone, horse-cup, snake-television.

The following materials were used for the Matching-of-Pairs task. Each of the central stimuli (i.e., all 16 pictures) were individually mounted on a 12 ×

17.5-cm card in the same position occupied on the original stimulus card, that is, the upper half of the card. The two series (animals or household objects) of the eight incidental stimuli were randomly arranged in eight different horizontal arrays. Each drawing was placed approximately 2 cm from the next and each series of eight was centered on a piece of 57 X 8-cm white cardboard.

Procedure

Each child was assessed individually. It was first determined whether the child could distinguish top from bottom. All children were able to do so. The child was then informed that he would be presented with cards bearing two pictures, one on top and one on the bottom. He was instructed to look at both pictures but to remember those that were on top for a later retention test. Instructions were repeated if necessary. Each card was exposed for 7 seconds, then placed face down in a pile. Each child was presented with a different random order of the stimulus cards.

Free Recall Task. Immediately following the exposure of the eight stimulus cards, the child was asked to recall as many pictures (that is, both central and incidental stimuli) as possible, in any order. The child was asked to inform the examiner when he had completed this task. The time in seconds taken by each child for the free recall was noted.

Matching-of-Pairs Task. Following the free recall task, the child was asked to match the central and incidental stimuli that had been seen together on the stimulus cards during initial exposure. The eight arrays of incidental stimuli were presented on at a time. Simultaneously with each array, one of the eight individually mounted central stimuli was presented, centered above the array. The child was asked to indicate which of the eight incidental stimuli had appeared with the central stimulus. After each choice, the incidental stimulus array was removed and replaced with another array and the next central stimulus cue card was presented with the same instructions. Orders for presenting the central stimulus cards and the incidental stimulus arrays were randomized for each child.

Postquestionnaire. Following presentation of experimental tasks, all children were asked a series of questions adapted from Druker and Hagen (1969). Specifically, the children were asked about which pictures they looked at most, how they went about remembering the pictures, and whether they said anything to themselves when looking at the cards or trying to remember which ones they had seen.

Dependent Measures. There were several measures of major interest: (1) number of central stimuli recalled, (2) number of incidental stimuli recalled, (3) number of correctly matched pairs, (4) proportion of central stimuli recalled to total stimuli recalled, (5) proportion of recalled central stimuli to matching of pairs total, (6) an efficiency measure (Hallahan, Kauffman, & Ball, 1974) ex-

pressed in terms of percent central minus percent incidental stimuli recalled, and (7) a second efficiency measure, percent free recall central stimuli minus percent matching of pairs. Time was measured during free recall. As well, all verbalizations were noted during the initial presentation of the materials. Those children who spontaneously overtly labeled at least two stimuli were classified as overt labelers. Covert labeling was determined from postquestionnaire responses.

RESULTS

Means and standard deviations for all free recall measures are presented in Table I.

Free Recall

A three-factor ANOVA was performed on the free recall data to assess the effect of two between-subject factors, medication (drug or placebo) and responder type (favorable or adverse), and one within-subject factor, type of recall (central or incidental). The significant main effect for type of recall indicated that more central stimuli than incidental stimuli were recalled, $F(1,50) = 156.26$, $p < .001$. The type of recall X medication interaction was also significant, $F(1, 50) = 13.97$, $p < .001$. A simple effects analysis revealed that more central stimuli were recalled in the drug condition than in the placebo condition, $F(1,50) = 7.14$, $p < .01$, but for incidental recall, the drug condition produced significantly less recall than the placebo condition, $F(1,50) = 7.86$, $p < .01$. The effect of medication was not different for the two types of subjects, favorable and adverse responders. In both cases, medication increased central recall and decreased incidental recall and resulted in a nonsignificant medication X responder-type

Table I. Cell Means and Standard Deviations for All Measures Derived from Free Recall (FR) and Matching-of-Pairs (MP) Tasks

	Favorable/drug $N = 18$		Favorable/ placebo $N = 15$		Adverse/drug $N = 11$		Adverse placebo $N = 10$	
	M	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
FR-central	4.83	1.50	4.07	1.03	5.00	1.54	3.70	1.42
FR-incidental	.78	.65	2.07	1.10	1.27	.47	1.50	1.51
MP-incidental	.83	1.04	1.73	1.16	1.09	.94	1.20	1.03
FR-proportion	.860	.12	.669	.14	.787	.08	.769	.20
MP-proportion	.877	.14	.736	.15	.826	.17	.750	.21
FR-efficiency	.507	.22	.250	.23	.466	.20	.275	.19
MP-efficiency	.500	.22	.292	.15	.489	.24	.313	.25
Time (seconds)	122.72	48.41	85.13	30.39	107.91	52.35	101.90	24.70

interaction, $F(1,50) = 2.95, p > .05$. This suggests that even though some hyperactive children have a favorable response to medication and some have an adverse response in terms of performance on a paired-associate learning task in the laboratory, both types have the same response to medication in terms of performance in a free recall task.

Free recall scores were also expressed as efficiency and proportion scores. In the analysis of the free recall efficiency scores, the only significant effect was that of medication, $F(1,50) = 13.97, p < .001$. However, using the proportion measure, both the medication effect, $F(1,50) = 7.40, p < .01$, and the medication X responder-type interaction, $F(1,50) = 5.06, p < .05$ were significant. A simple effects analysis of this interaction revealed that higher proportion scores were obtained for medicated favorable than for unmedicated favorable responders, $F(1,31) = 17.04, p < .001$.

Matching-of-Pairs. An ANOVA on the matching-of-pairs task scores yielded no significant effects. However, when these data were expressed to reflect proportion and efficiency scores, medication produced a significant effect in both cases, $F(1,50) = 5.63, p < .05$ and $F(1,50) = 10.29, p < .01$, respectively.

Time. No significant effects were found in the analysis of time taken during free recall.

Overt Labeling and Postquestionnaire

Percentage of children displaying overt and covert labeling and rehearsal may be found in Table II. Chi-square analyses, using Fisher's exact method (McNemar, 1969) were carried out on these data. Favorable responders on drug tended to overtly label the central stimuli more frequently than did those on placebo ($p < .05$). These medicated subjects also tended to overtly label central stimuli more frequently than central plus incidental stimuli ($p < .01$).

Interestingly, medication did not affect the reported covert labeling or rehearsal of favorable responders. However, both drug and placebo groups reported covert labeling and rehearsal of central stimuli more frequently than of both stimuli, $p < .001$ and $p < .05$, respectively.

Similar analyses were carried out on the data of adverse responders. No significant differences were found between drug and placebo groups on any of the measures. As found in the favorable responder group, there was more reporting of covert labeling and rehearsing of central stimili than of both stimuli ($p < .05$).

DISCUSSION

The results of the present study clearly indicate that under stimulant medication, hyperactive children show greater selectivity of learning. Two

Table II. Percentages of Children Responding to Postquestionnaire Items

	Favorable/drug $N = 18$	Favorable/placebo $N = 15$	Adverse/drug $N = 11$	Adverse/placebo $N = 10$
Overt labeling	67	27	27	50
Overt central labeling	56	13	27	40
Overt central/incidental labeling	6	7	0	10
Covert labeling and rehearsal	72	67	82	50
Covert central labeling	67	53	64	50
Covert central/incidental labeling	6	13	18	0
Covert rehearsal	39	33	64	40
Covert central rehearsal	39	27	45	40
Covert central/incidental rehearsal	0	7	18	0

hypotheses may be offered for this finding. Ross (1970), using retarded children, and Bahrick (1954, 1957), using college students, have demonstrated that an increase in incentive resulted in a decrease in acquisition of incidental cues. As Ross (1970) stated, this inverse relationship between motivational level and incidental learning was assumed to be due to a restriction of perceptual set as the incentive increased. In a similar vein Satterfield (1975) has suggested that methylphenidate increases motivation, while Kinsbourne (1977) has proposed that the action of methylphenidate is to narrow the focus of attention. This being the case, the effect of methylphenidate in the present study would be to increase motivation and decrease the range of attention more exclusively to the central stimuli. This would then decrease the opportunity to learn the incidental material.

A second hypothesis focuses upon the performance of the child during the presentation of central and incidental stimuli. It will be recalled that in the present study favorable responders who received methylphenidate overtly labeled the central stimulus more often than did favorable responders who received placebo. Studies by Dusek (1978), Traver, Hallahan, Kauffman, and Ball (1976), and Wheeler and Dusek (1973) using unmedicated normal children have found that labeling of the central stimulus has two significant effects: First, it increases central learning due to its efficiency as an encoding strategy, and second, by enhancing the focusing of attention to central stimuli, it decreases the possibility of attending to and subsequently learning the incidental stimuli. Thus methylphenidate may affect the selective learning of the favorable responder by increasing the probability of utilizing a suitable verbal behavior that might mediate such learning. Obviously, such a possibility would lead to the suggestion that remedial programs based on verbal mediation (Douglas, 1972; Meichenbaum, 1977) may be enhanced by appropriate stimulant medication.

Another important issue arising from the results of this study concerns the validity of differentiating hyperactive children into favorable and adverse responders. For both groups, medication led to an increase in free recall of central stimuli and a decrease in recall of incidental stimuli. While this finding by itself would call into question the use of distinguishing the two groups, seen in the wider context of a task X medication X responder-type interaction, the results are more clearly understood. For tasks marked by low-level processing, all groups, be they medicated normal children (Rapoport, Buchsbaum, Zahn, Weingartner, Ludlow, & Mikkelsen, 1978), medicated normal adults (Weiss & Laties, 1962), or medicated hyperactive children, show improvement. On tasks marked by higher level processing, a more complicated picture emerges. Normal adults given stimulant drugs show an impairment of performance (Burns, House, Fensch, & Miller, 1967; Smith, 1967; Smith, Weitzner, Levenson, & Beecher, 1963). The response of medicated normal children to such tasks is not known at the present time, but if they respond as normal adults, then impaired performance would also be expected. For medicated hyperactive children tested on

tasks that require higher level processing (Swanson et al., 1978), two distinct patterns have been found. For approximately 30% of the children there is impairment, while for the other 70% there is a marked improvement in performance. This favorable drug response by one group of hyperactive children may prove to be an effective means of separating hyperactive children into the two groups typically found in clinical practice (Laufer & Denhoff, 1957; Safer & Allen, 1976; Wender, 1971).

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