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ABSTRACT

The optimal stimulaton theory (which proposes that hyperactive children are more readily underaroused than nonhyperactive children and should thus derive greater gains from stimulation added to repetitive copying tasks than comparisons) was tested with 16 adolescents, rating high on attention and behavior problems, and 16 controls. Matched pairs were randomly assigned to treatment order (high stimulation colored letters followed in two weeks by low stimulation black letters or the reverse order) and to level of information (stimulation added to difficult letter parts or added to random letters), counterbalanced for treatment order and level of information within each order. In support of the theory and analogous to stimulant drug effects, the major findings indicated that hyperactive adolescents performed better with high stimulation task stimuli than with low stimulation stimuli relative to the opposite performance pattern of controls. Differential responding was significant for experimental but not control children. (Author/SW)

Effects of Color Stimulation and Information on the Copying Performance of Attention-Problem Adolescents

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Running Head: COLOR STIMULATION EFFECTS ON ATTENTION PROBLEM ADOLESCENTS

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Abstract

The optimal stimulation theory proposes that hyperactive children are more readily underaroused than nonhyperactive children and should thus derive greater gains from stimulation added to repetitive copying tasks than comparisons. To test this hypothesis 16 adolescents, rating high on attention and behavior problems, were matched on the basis of age and poor handwriting performance to 16 controls. Matched pairs were randomly assigned to treatment order (high stimulation colored letters followed in two weeks by low stimulation black letters or the reverse order) and to level of information (stimulation added to difficult letter parts or added to random letters), counterbalanced for treatment order and level of information within each order.

Errors and activity were subjected to a mixed design analysis of covariance, with IQ the covariate. In support of theory and analogous to stimulant drug effects, the major findings indicated that hyperactive adolescents performed better with high stimulation task stimuli than with low relative to the opposite performance pattern of controls. Differential responding was significant for experimental but not control children.

Effects of Color Stimulation and Information

on the Copying Performance of Attention-Problem Adolescents

Optimal stimulation theory (Zentall, 1975) makes the assumption that there exists for all organisms a biological need for an optimal level of arousal. Arousal can be defined as a physiological representation of environmental stimulation that is assessed by such indicators as skin resistance and cardiovascular response. Because of the difficulties associated with the assessment of arousal (for review see Zentall & Zentall, 1983) we have selected to examine the relation between the stimulus determinants of arousal (e.g., color; Berlyne, 1960) and instrumental response. When an optimal level of arousal is not present, shifts in attention and activity can serve as instrumental responses (e.g., sensation seeking activity) functioning to optimize stimulation. Hyperactive children are viewed as being more readily underaroused or less tolerant of situations involving minimal stimulation, thus explaining their exacerbated symptomology in overly familiar contexts, that is, increased activity and attraction to novel stimuli (for reviews see Zentall, 1975, and Zentall & Zentall, 1983).

According to an underarousal theory, one would predict that added stimulation would be most beneficial for hyperactive children during those tasks that involve considerable repetition and monotony (e.g., sustained attention tasks). For example, a laboratory sustained attention task (vigilance performance) is hypothesized to present problems especially for hyperactive children because of its rote, repetitive nature, engendering reduced arousal levels (Olmedo, Kirk, & Suarez, 1973; Rugel, Cheatam, & Mitchell, 1978). Consistent with theory, color stimulation added to this task has been observed to result in improved performance for hyperactive children relative to no stimulation (Barlow, 1977) and to comparisons (Zentall, 1982).

In the present investigation we sought to determine the generality of these stimulation effects observed during vigilance performance and thus we selected a handwriting task. This task was considered analogous to the vigilance task by its requirement for sustained attention. While differences between hyperactive and control children in the quality or rate of handwriting have not previously been investigated, hyperactive children have been assessed as performing worse than controls on a number of fine motor tasks (Douglas, 1974). Furthermore, it has been personally observed that teachers often make written comments on an unscored item of the Rating Scales for Hyperkinesis (i.e., "poor school work," Davids, 1971); for example, they circle the specific learning problem "irregular handwriting" or they write in the word "messy". It is possible that the difficulty hyperactive children experience with 'boring' handwriting tasks is the requirement to sustain attention to repetitive task stimuli. In this case, messiness could simply be an attempt to hurry and complete the task. If this line of reasoning were correct, novelty added to handwriting materials could facilitate performance.

Additional related evidence has demonstrated that added psychotropic stimulation results in performance gains for hyperactive children on both vigilance tasks (see Aman, 1980; Barkley, 1977, for reviews) and handwriting tasks (Lerer, Artner, & Lerer, 1979; Lerer, Lerer, & Artner, 1977; Shain & Reynard, 1975; Whalen, Henker, & Finck, 1981). However, both stimulant drugs and intratask stimulation have been less consistent in improving complex task performance (see Barkley, 1977; Zentall & Zentall, 1983, for reviews). Drug dependent gains observed during the performance of simple attentional tasks (e.g., vigilance or handwriting), but less consistently during complex tasks, (e.g., language or intelligence tests), suggests that the drug's main effect is on attentional factors. Other investigators have also concluded that the ability to attend, rather than motor speed, was influenced by the drug (Knights & Hinton, 1979). Schain and Reynard (1979) noticed that medicated hyperactive children were better able to focus attention and demonstrated improved speech clarity and handwriting legibility. Similarly Lerer and his colleagues (1977; 1979) found that when hyperactive children were given methylphenidate, letter reversals and inversions were reduced within a few days.

Psychotropic stimulants are, however, typically used only with children up to adolescence, at which time excesses in motor activity are infrequently observed. Instead of motor activity, hyperactive teenagers are characterized by problems in attention and impulse control (Hoy, Weiss, Minde, & Cohen, 1978). For the purposes of the present study, we wished to determine whether color stimulation would produce gains for adolescents on an applied attention task, comparable to stimulant-produced gains observed for elementary level children on attentional tasks.

A secondary purpose of the investigation was related to the information produced by the added stimulation. Intratask stimulation could be added not only to increase arousal and improve attentional focus (see Hockey, 1970, for review) but could also be added to provide information to children whose previously inadequate attentional responses may have contributed to poor initial learning. Thus, in the present investigation stimulation was also added to provide information by emphasizing difficult parts of letters in order to increase attention to relevant letter detail

Method

Subjects

The subjects were 32 boys, ages 14 to 18 years, selected from a pool of 59 boys, each of whom had been administered a 20 min copying task (Brown, 1977), and for whom a behavioral rating had been obtained (the Abbreviated Teacher

Rating Scale; Conners, 1973, demonstrating good reliability, concurrent and predictive validity, see Zentall & Barack, 1979; Zentall, Gohs, & Culatta, 1983). Of those selected, 16 were active, attention problem boys, selected on the basis of high scores (9-18 out of 18 points possible, $M = 13.5$[1]) on the first six items of the Conners scale (i.e., discarding items 7-10 that were age-inappropriate and retaining items that primarily described attentional problems), and on the basis of poor handwriting ("blind" ratings of 6 or below using the Test of Written Language criteria, TOWL, Hammill & Larsen, 1978).[2] Raters met TOWL criterion scoring (i.e., within one rating point on 80% of the TOWL test samples), and demonstrated reliable interrater coding on a rerating of 15% of the experimental samples. TOWL ratings demonstrated good correspondence to individual error analyses ($r = .51$).

Controls were 16 boys with low Conners scores (0 to 3, $M = .9$) and matched to each experimental child on the basis of equivalent handwriting scores and age. This procedure formed 16 pairs of high Conners hyperactive (HA) children matched to low active (LA) children. Statistical differences between groups in age ($M_{HA} = 16.2$, $M_{LA} = 15.6$) and TOWL ratings ($M_{HA} = 3.8$, $M_{LA} = 3.6$) were not demonstrated; although differences were observed in IQ ($M_{HA} = 103.4$, $M_{LA} = 110.6$, $F(1, 15) = 8.17$, $p < .05$) and Conners ratings, $F(1, 15) = 263.14$, $p < .001$.

Experimental Area

Pairs were randomly assigned to one of two swivel-stool desks (2.4 m apart) facing a blank wall in a 3.0 by 5.5 m room. An observer sat behind the students at a table at the back of the room.

Design

Subjects were tested in pairs in a repeated measures crossover design, such that approximately half of the pairs experienced high stimulation handwriting tasks for the 30 min first session and the low stimulation tasks two weeks later. The remaining pairs received level of stimulation in the reverse order. Approximately half of the pairs in each treatment order were randomly assigned to either added information or to no information across both levels of stimulation. This resulted in a mixed design with stimulation and matched pairs within subject factors and information a between subject factor.

Two orders of booklet forms (A to B or B to A) were counterbalanced across treatment order and level of information. Booklet A (2497 letters) and booklet B (2490 letters) each consisted of four word lists, two city and state lists, and six paragraph stories (Townsend, 1978) of equivalent letters and paragraph story contents (i.e., animals, farms, pollution). These lists were presented six lines to a page with space for the student to write under each line.

Treatment Conditions

Two levels (high vs. low) of two treatment variables (stimulation and information) were developed from four treatment booklets in each of two booklet-forms. Low stimulation (LS) booklets, A and B, were black letters on white paper. Color was added randomly to 50% of the letters on a page producing the high stimulation (HS) condition. Lines of color were alternated (two colors per page to include red, blue, green, pink, purple, or orange). Information was added to both stimulation conditions by increasing the width of specific parts of letters in black for the LS condition or in color for the HS condition. Emphasis was added to the detailed parts of letters that should be closed or opened and to emphasize straight-up strokes, crossing _t_'s and dotting _i_'s. Information emphasis was added to parts of all 26 letters. This amount was visually equivalent to the 50% of whole letters randomly selected per page and colored in the noninformation color condition, as judged by 13 of 20 independent raters in four replications of a matching-to-sample task.

Measures

Performance. The first, middle, and last page completed in the 17 page booklets were reliably scored (intrarater agreement, r = .85), using a total error score per page summed across 37 types of errors. Errors included omission of whole and parts of letters, substitution errors (Hopkins, Schutte, & Gorton, 1971), spacing, erasures (Lerer et al., 1979), failure to close or open specific letters, failure to use straight or rounded strokes, and unrecognizable letters (Newland, 1932). Also included were varying slant, capitalization errors, and writing off the line.[3] Lines of sample "treatment" print were covered with black tape, and pages were coded and shuffled; thus each handwriting sample could be scored blind to group and condition. The number of pages that a child completed was included as a measure of productivity.

Behavior. Movements included sliding movements of the buttocks and 45 Degree torso movements forwards or backwards (not to include arm or shoulder movements involved in working). Observers alternated their observations between members of a pair at 2 min intervals signaled through earphones. Interrater agreement was established at .87 by a second observer, also blind to groups and conditions, from a one-way mirror (110 x 110 cm) on the wall behind the students and the observer.

Results and Discussion

A mixed design analysis of covariance (ANCOVA) was used to evaluate the between subjects effects of information (emphasis added to difficult letter parts or added randomly), and of order (color first followed by black-white or the reverse order), and the repeated factors of (a) stimulation (black-white vs. colored letters), (b) group (matched pairs of hyperactive, HA, and low active, LA, adolescents, and (c) time (first, middle, and last page completed).

The data were analyzed using the ANCOVA procedure, due to the observed differences between groups in IQ.

Handwriting Performance

Errors. IQ differences between the HA and LA groups contributed enough to the variation in number of errors ($F(1, 11) = 4.40$, $p = .06$) to justify using the covariate analysis as suggested by Douglas and Peters (1979). If the students were above average in IQ, they made somewhat more errors, so their mean was adjusted downward; while the mean for the below-average students was adjusted upward. This suggests that the rote nature of the task was somewhat problematic for the brighter students.

Hyperactive adolescents did not differ from controls in the number of handwriting errors, $F(1, 11) = 1.80$, $p > .05$. This finding is not surprising as pairs were matched on initial ratings of handwriting. The task does, however, appear to be a valid index of sustained attention for adolescent boys since errors increased over time: first page errors, $M = 23.1$; middle, $M = 29.7$; and last page completed, $M = 33.0$, $F(2, 24) = 11.20$, $p < .001$.

A three-way stimulation by order by information interaction was significant, $F(1, 12) = 5.40$, $p < .05$. This interaction is most easily interpreted as a change in performance from the first to the second session, because any stimulation by order interaction in this design is equivalent to a session effect. The data from this interaction have been rearranged and plotted in Figure 1 to demonstrate this effect. The interaction results from the fact that only one of the groups (no info-color first) failed to demonstrate a significant increase in errors from the first to the second session, as determined by Tukey's test: no info-color first, diff = 3.3, N.S.; no info-black first, diff = 4.0: info-black first, diff = 4.3; info-color first, diff = 11.0, all ps $< .05$.

Insert Figure 1 about here

A similar session effect was also produced by a significant two-way interaction between stimulation and order, $F(1, 12) = 42.74$, $p < .001$. Main effects of stimulation ($F(1, 12) = 3.05$) and order ($F(1, 11) = 4.45$) as well as a stimulation by information interaction ($F(1, 11) = 4.45$) may have contributed to the three-way interaction described above, but none of these trends was statistically significant.

The main finding of theoretical interest in this analysis was that the error rate for the hyperactive and low active groups was differentially affected by color stimulation and time on task, as indicated by a significant group by stimulation by time interaction, $F(2, 24) = 3.63$, $p < .05$ (see Figure 2).

Insert Figure 2 about here

Post hoc comparisons indicated that HA adolescents made more errors on the first page with black letters (b) than with color-added (c) letters ($M_b = 27.4^4$, $M_c = 20.4$, diff = 7.0, $p < .01$). Similar differences were observed in mid performance for HA adolescents ($M_b = 33.1$, $M_c = 25.9$, diff = 7.1, $p < .01$); but by the last page, the novelty effects of color stimulation had washed out ($M_b = 33.6$, $M_c = 34.1$, diff = .6, $p > .05$). No differences in error rate for controls attributable to color stimulation were observed at any of the three time periods (all ps $> .05$).

The order that stimulation was presented affected HA adolescents differently from LA adolescents, $F(1, 11) = 5.42$, $p < .05$. The group of HA

adolescents that had color first session and black second (c-b) made more errors ($\underline{M}$ = 36.9) than the HA group that had black letters first and color second (b-c) ($\underline{M}$ = 21.3) relative to the performance pattern of the controls ($\underline{M}_{c-b}$ = 28.3, $\underline{M}_{b-c}$ = 27.9). Post hoc analyses found no significant differences among any of these means (all $\underline{p}$s > .05). The difference in errors pooled across information conditions between the HA students who received black first and color second and those that received color first and black second was the largest of the mean differences (diff = 15.6). Although this difference was not significant, it may indicate a carryover effect for the HA children that did not occur for the control children.

Productivity. The number of pages that each child completed was analyzed using a four-way mixed design ANCOVA with information and order the between subject factors and with group (matched pairs of HA or LA children) and stimulation (color vs. black letters) the within-subject factors. This analysis also demonstrated an effect of the covariate, $\underline{F}(1, 11) = 6.69$, $\underline{p} < .05$.

The main finding in this analysis was a stimulation by order interaction, $\underline{F}(1, 12) = 15.54$, $\underline{p} < .01$. As previously indicated, a stimulation by order interaction can be interpreted in this design as a session main effect. An increase in productivity was observed from the first to the second session for all students, which is similar to the increase in the number of errors observed from the first to second session. Overall, productivity was a relatively insensitive measure, probably because of ceiling effects (i.e., several children completed all of the pages with as much as 5 min remaining).

Correlational analyses suggested that handwriting productivity was positively related to IQ ($\underline{r}(32) = .47$, $\underline{p} < .01$); that is, children with higher

IQ scores completed more pages. Additionally a low moderate negative correlation ($r(32) = -.38$, $p < .05$) between written productivity and activity demonstrated that children who exhibited more gross body-movement completed less work on the handwriting tasks requiring fine motor skills. Thus these two types of motor behavior were somewhat incompatible. Increases in gross motor activity and productivity were not, however, related to quality of the work completed as indicated by the lack of a significant association on this task between errors and activity ($r(32) = -.03$) and between errors and productivity, $r(32) = .27$.

Activity. A relation between IQ and torso activity was not demonstrated ($r(32) = -.20$, $p > .05$), thus the covariate was dropped from this analysis. Activity was analyzed using a five-way mixed ANOVA (Info x Order x Group x Stimulation x Time). The stimulation by information interaction was significant, $F(1, 12) = 11.03$, $p < .01$. For both groups the effects of added color stimulation on activity depended on whether information was added. Follow-up analyses suggested that color-added information resulted in significantly less movement ($M_c = 3.4$) than when information was added in black ($M_b = 5.1$, diff = 1.7, $p < .01$). Mean activity differences in the noninformation condition were not demonstrated ($M_c = 4.2$, $M_b = 3.9$, $p > .05$). The increase in torso movements for all students observed in the black information condition relative to color can be attributed to the fact that emphasis added in black to black letters may have actually changed the relevant features of some of the letters (see Figure 3). Whereas emphasis added in color highlighted the relevant features. Thus, the children in the black emphasized condition were reported by observers to lean back, speculatively in order to examine the letters from a different vantage point.

Insert Figure 3 about here

Although there were no overall group differences in the amount of this type of activity, a group by information interaction suggested that the level of information affected HA adolescents differently from controls, $F(1, 12) = 6.25$, $p < .05$. Follow-up mean comparisons indicated no significant activity differences between the HA adolescents ($M = 4.6$) and the LA adolescents ($M = 3.9$) in the high information condition. However, in the low information condition pooled across color and black conditions, there was significantly less activity for the HA adolescents than for the LA adolescents ($M_{HA} = 3.2$, $M_{LA} = 5.0$, diff = 1.8, $p < .05$). It may be that in responding to the physical, noninformational aspects of stimuli, HA children inhibit activity relative to controls.

Differences between groups were also influenced by the order in which they received color and black letters, as indicated by a significant group by order interaction, $F(1, 12) = 5.07$, $p < .05$. Post hoc analyses suggested that this effect was produced by the excessive activity of the LA adolescents across the color-first black-second condition. The LA adolescents were significantly more active in this condition than the HA adolescents ($M_{LA} = 5.5$, $M_{HA} = 3.8$, diff = 1.7, $p < .05$).

Conclusions

Added intratask color stimulation has been found to improve the performance of hyperactive children but not controls during laboratory sustained attention tasks, similar to the effects observed for hyperactive children from stimulant drugs. The present study tested the generality of these findings to a copying task and to attention problem adolescents. The advantages of using color stimulation over psychotropic stimulants included the possibility of (a) including a normal control group, (b) determining an educational treatment for older students, (c) adding information to stimulation, and (d) using a noninvasive treatment. Stimulation could be added not only to temporarily increase arousal and thus focus attention but also could be added to increase attentional scanning of relevant task cues.

Group differences in errors, productivity, and activity were not found. These findings were attributed to the baseline performance matching procedure used in the present study and to the fact that attention problem adolescents are not characterized by activity excesses. Additionally it may have been that testing adolescents in pairs provided social stimulation, competition, or increased motivation that modulated overall differences. Even though groups were equated on a number of performance variables, differential group performance responses to added color stimulation were observed.

The main findings of this investigation that support theoretical predictions were that color-added stimulation reduced errors for attention-problem adolescents but had little effect on the performance of handwriting-matched controls. These findings are consistent with those examining color effects on laboratory types of sustained attention tasks. Evidence that the copying task in the present study was assessing sustained attention was indicated by an overall increase in errors over time and session. This is similar to performance on sustained attention tasks (Douglas, 1974; Zentall, 1982) and different from tasks assessing learning (i.e., in which deceases in errors occur over time, see for example, Zentall, Zentall, & Booth, 1978). The order that students experienced their colored tasks (first or second) was also a moderating variable. The attention-problem children made more errors and the controls were more active when the first task was colored and the second was black than in the color-second order. The better response in the color second order may be attributable to the fact that the color stimulation offset the decline in task and context novelty that naturally occurs in a second session. Why one group initially responded with increased activity and the other with increased errors is not readily interpretable unless the type of activity assessed in this study and demonstrated by controls was not disruptive (i.e., was an attempt to more carefully inspect the letters by leaning back).

Effects of added information on performance were not demonstrated, due perhaps to the fact that (a) this was already an overlearned skill for this age group or (b) the students were not verbally cued that the parts of the letters that were emphasized were important for legibility. Information effects were observed on activity scores. All of the children were more active when the emphasis was black rather than colored, and the attention-problem adolescents were less active than controls in the absence of any letter emphasis. Thus it is possible that the activity observed was in response to task-difficulty, occurring (a) for both groups when the black detailed parts may have altered the overall letter shape, and (b) for the attention-problem children relative to controls with any detailed emphasis on parts of letters.

In summary, these data do not support the use of stimulation to emphasize relevant detail in rote copying tasks. The use of color to emphasize relevant cues may be useful with tasks that involve new learning rather than sustained attention. The data do, however, provide support for the use of intratask stimulation to reduce errors for hyperactive but not control adolescents. This treatment is especially useful during the performance of attentional tasks and tasks that are not selectively more difficult for this group (i.e., when groups are matched on baseline measures).

Author Notes

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Footnotes

1. For the 69 adolescent boys the Conners mean score was 4.9, SD = 5.9, and the high Conners group was 1 SD above this mean.

2. A raw score of 6 was equivalent to a scaled score of 9 out of 20 for students 14 to 14.5 years of age.

3. Copies of each type of error can be obtained from the first author and include the ten most common cursive writing errors made by students (Newland, 1932)

4. Means of the nonrepeated factors and group factor were adjusted by the covariate.

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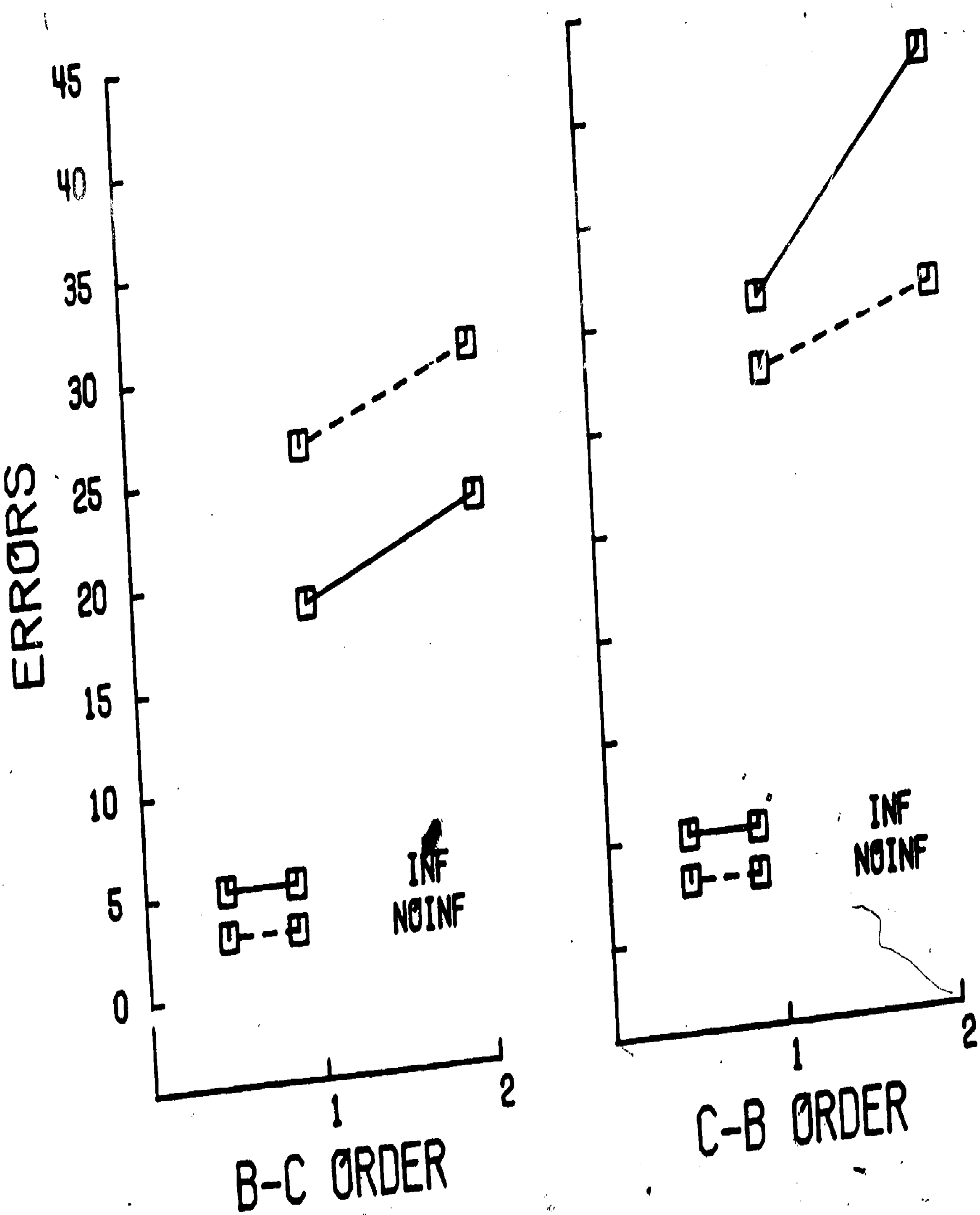
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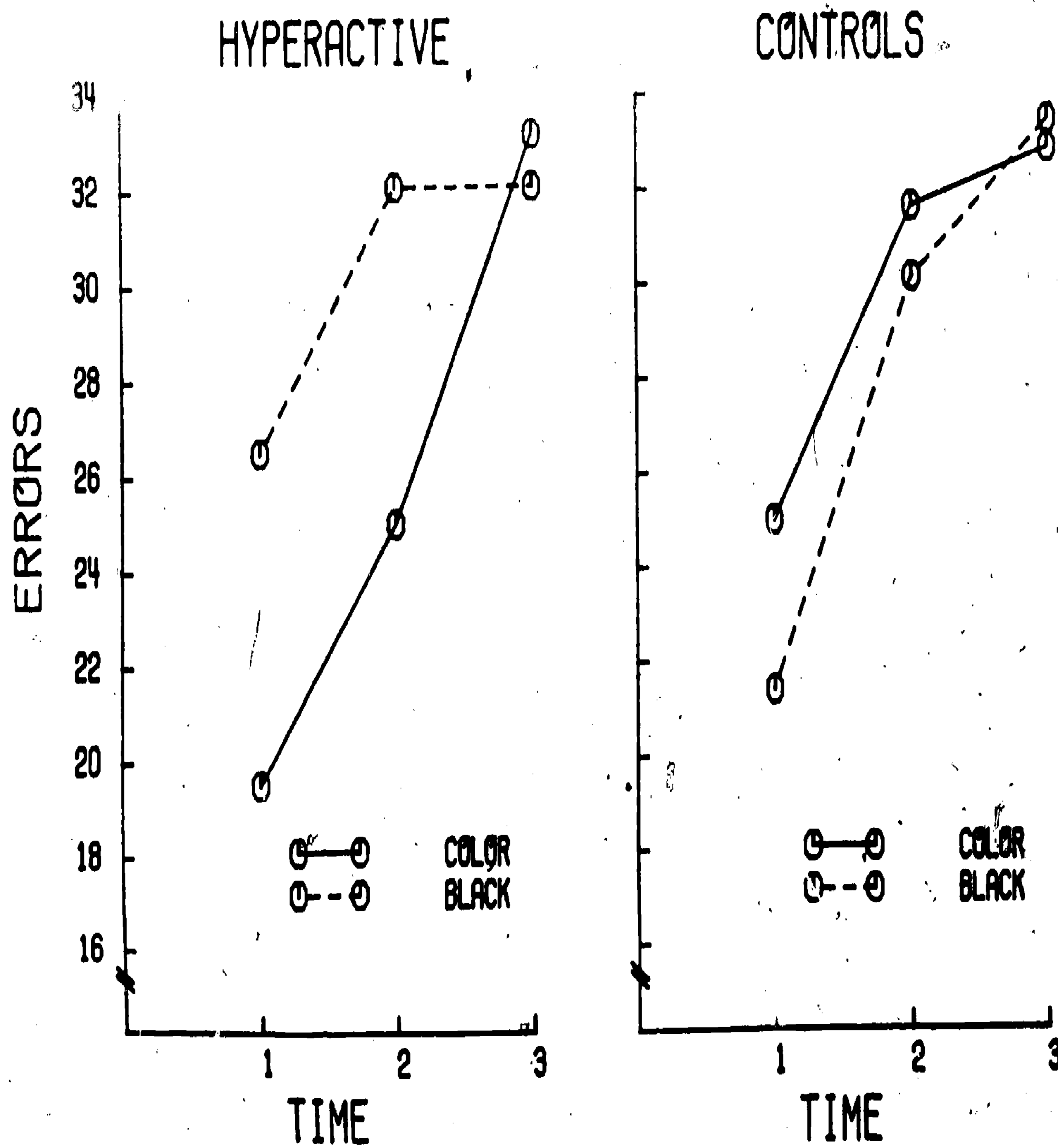
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Figure 2

Figure 3

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