AN ABSTRACT OF THE THESIS OF

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Title: THE EFFECT OF CONCENTRATED COLOR ON STUDENT PERFORMANCE

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A study of student performance in relation to concentrated color in the environment was conducted in an elementary school near Portland, Oregon. Third grade classrooms served as laboratories, with the total third grade student population of 83 students serving as subjects.

The project covered a four week period of time. An attempt was made to select a period as free of school extra-curricular activities, holidays and weather variability as possible.

Three colors--red, green, and grey--were rotated among three classrooms, the fourth classroom serving as a control group with no additional color. Color was introduced through smocks for the teachers to wear for all in-classroom time, folding screens, and background material for bulletin boards and fronts of teachers' desks. These colors were rotated among the three rooms, remaining a week in each of three classrooms.

Student performance was measured by scores on tests in arithmetic completion, arithmetic accuracy, spelling completion, spelling accuracy, and pencil pressure used in writing the spelling words.

Tests were administered to the students on each Monday and Friday of the four week session. The first series of tests was under normal classroom color conditions. Each classroom received a week of each of the three colors, with the students being tested under each color concentration.

Significant score differences occurred between color added and no color added in arithmetic accuracy and pencil pressure. Arithmetic accuracy was greater with no added color, compared with added color, and pencil pressure was lower with no added color, compared with pencil pressure with added color.

Further study is recommended in the area of human performance in relation to color in the environment, and the effects of extended color exposure.

The Effect of Concentrated Color on Student Performance

by

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INTRODUCTION

A glance into today's home furnishing and fashion publications provides evidence that color is part of today's living. Primary colors are being promoted for clothing and family living equipment. A stroll through department and clothing stores will furnish evidence that color is "in".

That human beings respond to color is commonly accepted, but it seems relevant to question their performance when surrounded by intense and concentrated color in the environment. Remarks, pertaining to unexpected student behavior, overheard in a school faculty lounge, have led to the thought that perhaps the dress of the teacher and the classroom decor could be influencing factors in student behavior.

Previous studies on the effects and affects of color have been reviewed by S. L. Pressey in 1921, and by Norman and Scott in 1952. Research findings on color responses have been varied and, in some cases, contradictory. Measurements of color preferences and the linking of mood associations with color names have been studied. Many of the subjects were institutionalized persons, and many of the sample numbers were small. Pressey suggested that these subjects were more responsive than non-institutionalized subjects, and

therefore, the resulting measurements would possibly be unreliable when applied to normal situations.

In 1940 Guilford pointed out that controlled chroma and tint are as important as the hue control in research design. He also suggested that for practical usefulness of a test result, a practical situation should serve as the testing laboratory, with normal people serving as subjects.

Goldstein (1942) believed that humans responded as a total organism, generally sensitive to various light rays. He classed red and yellow as warm colors, and found they had an expansive effect. Blue and green, classed as cool colors, had a reverse effect on the subjects. A more recent study by Gerard in 1958, supported Goldstein's theory and the popular assumption that red is stimulating and blue is quieting.

Louis Cheskin (1947), Assistant Director of the Color Institute of America, defines color in several ways. To the physicist color is light; to the chemist, pigment; to the artist, a potential design; to the physiologist, anatomical identification; to the psychologist, color is important as it affects man's emotions. Everyone experiences color, but many are not aware--do not actually perceive it. However, Mr. Cheskin maintains that color sensations in the form of physical reaction occur in people who are completely unaware of the presence of color.

If color does have an exciting or calming effect on the human organism, perhaps it could be used to help in reaching the under-achiever, exciting him to a higher level of achievement. Another possibility could be in using color to aid in the calming of an over-active student.

Statement of the Problem

The purpose of the study was to examine the performance of primary children in the presence of introduced color concentrations in the school environment. With no significant change in the daily school routine, performance was measured through testing in the areas of arithmetic and spelling.

Limitations of the Study

This study was limited to the use of three colors: red, green, and grey, with identification made by the Munsell Color System (1946). It dealt with third grade students only, and was limited to one elementary school in a suburb of Portland, Oregon. The study included the total third grade population, and was limited in time to a period of four weeks. Sex differences and possible color blindness were not studied.

Assumptions

The study was undertaken with the following assumptions:

1. The involved faculty members were interested in participating in the color study, and were willing to make an honest effort to eliminate as many variables as possible by following the agreed-upon schedule.
2. The available equipment necessary for accurate measurements was dependable.
3. School sessions would proceed in a normal pattern during the four week study period, with no vacation or planned school activity during the preplanned time.
4. The students were normally distributed.
5. The sampling was random over time.
6. Weekly tests were independent.

Objectives of the Study

In an attempt to relate student performance to the color concentration in the classroom environment, the following hypotheses were tested:

H_{o1}: There will be no difference in student performance with the introduction of color concentration into the classroom, as opposed to student performance with no added color.

H_{o2}: There will be no difference in student performance in the room with the cool color concentration and the student performance in the room with the warm color concentration.

H_{o3}: There will be no difference in student performance in the classroom with introduced neutral color concentration and the student performance in the classroom with warm and cool color concentrations.

H_{o4}: There will be no difference in student performance on the first day of exposure to introduced color concentration and student performance on the fifth day of exposure to the same color.

Each of the null hypotheses was tested by using the data obtained in the following tests:

1. Pencil pressure in spelling test
2. Arithmetic accuracy
3. Number of arithmetic problems completed
4. Spelling accuracy
5. Number of spelling words completed

REVIEW OF LITERATURE

Early Studies of Human Responses to Color

Man has long considered the effect of light upon the human mechanism, Wilhelm Ostwald, Nobel Prize winner and genius at organizing scattered knowledge (Taylor 1962, p. 64) was among the first to work on the aspects of color as related to human sensations. He assembled the works of previous scientists into a simple system--one that was based on three essentials of vision: light, the human eye, and sensation. He was convinced that a dimension, beyond that which is visible, should be used as the basis for another measurement of color. He spent much of his life working on the psychological factors associated with human response to color.

About the same time, around 1900, Jastrow and Ellis (1900, 1901) published articles pertaining to the psychological responses to color. Jastrow conducted a survey at the World's Columbian Exposition in Chicago in 1893. From 4,500 records he computed the preferences in color for both men and women. Of every 30 male votes, 10 placed blue first, with three votes for red. Among the female voters, of 30 decisions, first place went to red with five votes, while four were for blue. The remaining votes were distributed among the other color choices. Most frequently preferred combinations overall were red with violet, blue with red, and blue with violet.

Ellis (1900) wrote that he considered red to be the color with the most emotional tone. He pointed out that in all parts of the world red was symbolic of happy emotion, and nowhere was it used as a symbol of unhappiness.

Ellis (1900) stated that the role of red had been a fairly consistent one among all people, but yellow was not as easily categorized. Sometimes exalted, sometimes debased, it was often used symbolically with red. In primitive societies yellow was easily a second preference, sometimes very close in popularity to red. In some parts of New Guinea, according to Ellis, parrots having red tail feathers were fed a certain root that caused the tail feathers to turn yellow. The yellow materials were important for royal ornament. The ambivalence toward yellow has been evidenced through history, but, he pointed out, most primitive societies seemed to have a name for red, white, black--but none for other colors.

In the Chicago Exposition investigation of Jastrow (1900), the color yellow, along with orange, was among the least favorite. Among Asians of today, in India and Ceylon, it is held in high honor, being essential to many of their ceremonies (Ellis, 1901). With the coming of Christianity yellow became associated with jealousy, treachery, and envy.

Color Preference Studies

Various studies on the color preferences of children have associated red with the young child, as with the primitive, with yellow following closely in popularity. Katz (1922) reported a preference for blue at every age from 5 to 15. He found that poorer children preferred red, and, that green and yellow were selected more often by children from higher socio-economic families. Katz also noted a rise in the popularity of blue and green with increase in age, with a simultaneous lower interest in red. Garth (1924) found that an increase in education seemed to influence color choice with the exception of blue, which remained at the top. He felt the educational increase also seemed to suppress a tendency to state choices, except for blue.

In dealing with color preferences of children, Norman and Scott (1952) questioned the degree or depth of preferences in children by reporting:

> ...with four out of 10 children Khozak 21 reversed the positions of most and least preferred colors by presenting the latter before showing kaleidoscopic pictures and not reinforcing the former...and with 15 children he changed the most preferred for 10 of the subjects (p. 193).

Eysenck (1941) maintained that blue was definitely first choice among 433 psychotic patients, but Lukins (1941) found that preferences were as varied as the personalities of the patients, and, in large measure, seemed due to associations rather than to the color itself.

Guilford (1940), in testing his hypothesis that there is a system in color preference, used two inch squares of color against a grey background. He stressed that when conducting a study, it was necessary to control the three physiological dimensions of color: hue chroma, and tint. According to Norman and Scott (1952), one of the most important results of Guilford's experiment was to suggest good reasons for previous inconsistencies. Guilford also suggested that for practical usefulness of a test result, the use of a practical situation would be best, rather than results inferred from two inch squares of color.

Goldstein (1942) agreed with Guilford that color preference was affected by biological factors. He presumed that color affected the total behavior of the organism, refuting the cultural influences and association relationships of color preference theories.

Birren (1950) feels those who are normally adjusted are outwardly integrated and like all colors, warm particularly. The inwardly integrated may favor cool, but may be unenthusiastic about color in general.

Effect of Color on Mental and Motor Skills

Goldstein (1942) found, in working with mental patients, a differential effect from red and green exposures, and to a lesser extent, with blue and yellow. In everyday life the patients found red to be upsetting,

disagreeable, exciting, while green was considered agreeable and quieting. He developed a theory that the total body has a generalized sensitivity to various light rays, with the eye as a special receptor.

He theorized that life is a condition alternating between excitation, destruction and unbalance on one extreme, with reorganization, equilibrium and rest at the opposite end. This equilibrium is most disturbed by red and yellow, least by blue and green.

Red and yellow, Goldstein writes, have an expansive effect on the organism--an awareness of the external world, while green and blue have the reverse effect, helping with concentration and contraction. Working with a small number of subjects, he found the arm movements differed under the red and green lights, even though the intention of the subject remained the same. Goldstein expressed the opinion that red incites activity, and is favorable for emotionally determined events or tasks, whereas green provides the atmosphere for carrying the task to completion.

In 1964 Nakshian hypothesized that hand tremor would be greater under red than under green lights, and that tweezer dexterity would be greater under green than under red lights. Third, he believed that subjects would be slower in tracing an arc under green light than under red. He used 48 subjects from 18-30 years of age, with good color vision. He assigned eight tasks to be performed under three conditions of red, grey, and green lights. The three conditions

appeared in six orders, resulting in a task sequence of 48 different combinations.

The main apparatus for Nakshian's tasks was a three sided wooden frame 36 inches high, 49 inches long in the center portion, with two sides, each 21 1/2 inches wide. Red, grey, and green panels fit into the frame. The floor of the frame was also color changeable. The ceiling was milky-white vinyl, with illumination from concealed lights. Recording devices were out of sight behind the walls.

While seated, the subjects were faced with colored surfaces in all directions, and were given five minuted tasks to perform. A resting time was given between each task. Different tasks were administered under three different color concentrations.

Differences in color and task sequences were insignificant. Nakshian felt the significant score differences in hand tremor and motor inhibition were inadequate support for Goldstein's theory applied to normal subjects.

Pressey (1921), in discussing the influence of color on mental and motor efficiency, stated that he found no differential effect from red, green, and blue lighting upon any of the activities tested. Pierce and Weinland, reported by Norman and Scott (1952) found that the measure of output in a factory was more satisfactory with the use of white light. Their conclusion was that the color associations of the workers created responses to the different lights, rather than the color itself being effective.

In 1959 J. A. Easterbrook wrote on "The effect of emotion on cue utilization and the organization of behavior." He summarized by writing:

> The range of cue utilization can be regarded as an index of cerebral competence, and the generalization then asserts that cerebral competence is reduced in emotion (p. 201).

Color and Mood

Two important aspects of color and mood, or emotional pattern, according to Norman and Scott (1952), are the effects of color on emotion, and the effects of emotion on color perception. None of the studies has succeeded in isolating "mood" or emotion from other mental processes. Color and mood word associations in the experiments of Odbert (1942) and Wexner (1954) have confirmed that subjects relate verbal stereotypes, rather than true effects, when responding to color. Norman and Scott report that:

> In order to measure the effect of color on the human organism, 'color' must be regarded as something in the external world, as well as in psychological experience. Similarly, the response of the organism must be defined in terms of behavior, rather than by inference words referring to assumed psychological experience (p. 219).

Prescott (1942) reports that a South American experimenter, Gorriti, worked with color and institutionalized subjects. Gorriti claimed successful use of blue glass in wards in calming the excited, and the use of red glass with persons in despondent moods, with a

resulting slight lift in the despondency. He even carried the idea into the adjoining gardens, planting blue and violet flowers in one garden, red and pink in another.

In 1938 Lewinski reported on his study of pleasantness-unpleasantness areas of response to illuminated colors. His study of 25 men and 25 women students at the University of Iowa attempted to determine the relationship between chromatic illumination and previously reported specific psychological effects of surface colors.

Two floodlights were evenly reflected on a flat white surface with the subjects nine feet away. Each subject's vision was stimulated by a mass of color: red, purple, yellow, orange, blue, green, used one at a time. The subjects were to indicate reaction to each of the successive illuminations as to degree of pleasant-unpleasant, stimulating-depressing, cold-hot. The scale went from very pleasant at one end through moderate and neutral, again through moderate to very unpleasant at the other end. Blue and green rated highest on the pleasant scale, with yellow as unpleasant to 64% of the scorers and orange unpleasant to 74%. Orange and red illuminations were most stimulating, with the placing of orange first in the warm category and red as first in the hot category. Purple was rated as most depressing by 54% of the subjects.

With the exception of the stimulating or depressing category, where 32% of the green votes were neutral, one of the most noteworthy

findings of this study was the small number of neutral responses.

A more recent illumination study by Gerard (1958) supported Goldstein's (1942) theory and the popular assumption that red is stimulating and blue is quieting. This was one of the first attempts to relate electro-cortical activation to a prolonged (10 minutes), non-flickering light giving colored radiation. The study was carried on under carefully controlled conditions. With apparatus used to record E. E. G., blood pressure, respiration, palmar conductivity, pulse, he exposed the subjects to 10 minutes of blue light, 10 minutes of white light, then 10 minutes of red light. The mean percentage changes were considered significant in the E.E.G. measurements, with respiration showing the greatest change. Questionnaires and interviews with the 24 college males were included. Subjects reported feelings of peace and well being, with pleasant thoughts during the blue periods, but had belligerent thoughts, experienced feelings of antagonism and pressure under the red light.

In tests administered by Murray and Deabler (1957) to 25 Louisiana State University male students, 69 male nursing students, and to 108 neuro-psychiatric males, the subjects were exposed to a matching game of color names and emotional mood names. Agreeing with findings by Wexner (1954), green and blue were rated most often as calm and peaceful colors by all the students in both experiments. Red was listed as the most exciting by all the subjects. Red was also

listed as powerful and defiant, while green and blue shared top place in the tender and secure categories.

In relation to mood-tones, Teichner (1968) postulated that the brain has tuning centers that result from both genetic and learned sources, as well as from the immediate physical and symbolic stimuli. His attempt to determine the degree of color and mood-tone relationship led to the findings that certain combinations appeared more often than others. He presented the possibility that cultural, biological and learned factors are all part of the mood-tone concept.

Teichner (1968), in studying the interaction of behavioral and physiological stresses, concluded that the human organism is a complex self-regulating system, responding to both physical and symbolic aspects of its environment.

Use of Color in Occupational Therapy

The value of color use in occupational therapy has been examined by Emery (1929), Lukins and Sherman (1941), and Birren (1950). They agree that color is an effective tool of the therapist, but the former associations of the patients are influential in the variety of color responses.

Lukins and Sherman (1941) reported on the Worcester State Hospital experiment in the area of colored light filters. Magenta and green had quieting effects on disturbed patients, while blue had

a striking and prolonged quieting effect. Yellow was stimulating to the depressed, and red was even more so. Lack of a quantitative measure for changes in mood responses leads such studies, even under controlled conditions, to be speculative, with written descriptions as the basis for generalizations. However,

> When a patient performs a simple, measurable task under controlled conditions, it is possible to obtain a quantitative estimate of a specific stimulus upon the activity which is measured (p. 122).

With white, red, and black yarns available for a 15 minute period, the patient was observed at loom activity. The use of the yarn was measured in number of warp yarns that were woven over and under in that 15 minute time limit. The usage of the three yarns was almost identical, with no one color being used significantly more than the others.

Contrary to this report, Emery (1929) noted that when psychiatric patients had inadvertently received some red and green yarns for weaving, the response was immediate and commanded notice. With the use of color in the yarn, previously disinterested patients wove colorful bags that seemed to have symbolic relationships with their past experiences. Marguerite Emery supported the idea that color preference is an indication of proficiency. Those patients who had regressed to the most infantile level selected yellow yarn from the basket, while four out of five of the manic-depressive group chose

red. All of the emotionally immature psycho-sexual infantilism group chose green.

The pleasure of the basket makers was obviously enhanced, according to Emery (1929), if the reed was dyed before it was used. "More animation is displayed in the labor and more pride in the finished product." (p. 432) She stated further:

> Universally acknowledged as it is to have an appeal to the emotions, color would seem to be valuable in occupational therapy where emotional disorders and depressions incident to physical illness or psychological regressions are dealt with. Indeed, it would be difficult to conceive of occupational therapy without color, for while beauty of form is rarely grasped by the untrained mind, color has an appeal to which people who live in darkness and poverty seem particularly susceptible (p. 423).

Summary

Studies concerning the effects and affects of color have been divers, being approached over an extensive period of time from interdisciplinary angles. Findings of research studies have been contradictory. A quotation from Prescott, written in 1942, might still serve as a summary of today's studies on the subject of color and its inter- and intra-human relationships:

> Some investigations present favorable results, others inconclusive, or unfavorable. In any event, only a beginning has been made in understanding the true role of light and color in everyday thinking and acting, but with further and constant research, greater progress lies ahead. In the meantime, it is clearly recognized

that man, in spite of any insufficiency of scientific data, is going to live quite happily in the presence of light and color, for where there is light, there is life, and where there is color there is beauty (p. 146).

PROCEDURE

Design of the Experiment

Selection of Subjects and Site

On the basis of longitudinal studies by Gesell (1946), eight year old boys and girls are interested in the world around them and are adaptable to new situations. The third grader has become accustomed to school routine, and is usually a self-sufficient person. Norman and Scott (1952) reported on the ease with which the color preferences of children were changed, so it could be assumed that color associations of a third grade student are not permanently set and highly influential in his responses.

An acquaintance, who is a third grade teacher in an elementary school near Portland, indicated an interest in the experiment. It was subsequently arranged to conduct the study in that school, with the active participation of three of the four third grade rooms. The fourth room would remain unchanged, serving as a control unit in the area of weather, school activities and other outside stimuli.

The four classrooms were similar in size and shape. In each room, approximately 90% of one wall was composed of windows. The students' desks faced away from the windows toward a chalk board.

The entire population of third graders, 83 students, and the four teachers were involved. Students in this school are drawn from average, middle-class American homes. (Appendices B and C)

An effort was made to select a four week period that was free of holidays, as well as a time when weather changes were expected to be minimal. Freedom from planned school events was also an important criterion for selection of the time of the experiment.

Testing Materials

Color selection was on a warm-cool-neutral basis, with identification being made from the Munsell Color Chart (1946). The 5 red, 5 green, and grey all had a value identification of 7.5. Intensities were those of the color chart, with the grey being identifiable by value alone. (Appendix F)

Performance of the students was measured through a series of academic tests. The testing consisted of spelling words and arithmetic problems of simple addition and subtraction. Subject matter was selected from that which the teachers agreed had been incorporated in the second grade study program; thus, it was assumed the material was familiar to the students. No attempt was made to measure the learning involved. An effort was made by the teachers to avoid including any of the test items in the weekly studies. Each test was administered on Monday, the first day of exposure, with the

same tests being given on Friday, the fifth day of exposure.

An octave band noise analyzer was used for noise level comparisons.

Presentation of Color

Since the clothing of the teacher was considered an important variable of the study, color was introduced through short sleeved smocks of dress length. The teachers agreed to wear the smock corresponding to her room color assignment for all in-classroom time during the week. These smocks were designed and constructed by the investigator, having enough ease to allow for a comfortable fit on all three teachers. The skirt length was changed weekly to be suitable for each instructor. The smocks rotated from room to room. They were laundered weekly, being returned to the classroom on Monday morning before the arrival of the students. (Appendix G)

Ten yards of each color was purchased, the fabric being a polyester-cotton blend in a poplin construction. Six wooden frames, five feet by three feet were built and covered with some of the same yardage. The frames were hinged in pairs, making three folding screens. The remainder of the 10 yards was used as bulletin board background, covering for students' side of teacher's desk, and as a swatch fastened to the wall beneath the chalk board.

All colored items were rotated between the three participating rooms on a weekly basis until each room had exhibited one color for one week.

Presentation of Tests

Pretests were given on the Monday and Friday of the week preceeding the introduction of color to indicate the normal performance of the students.

Color was introduced into the rooms in an A, B, C order, with D serving as the control.

The 15 spelling words were delivered to the students by a taped spelling list, preceeded by a few words of instruction. Each room had a tape recorder bearing the same message, recorded simultaneously by the same voice. Care was exercised in similarity of volume control. The recorders were rotated weekly, and the students were told they were testing tape recorders. Commercial spelling tablets were furnished, with no. 2 pencils freshly sharpened for each testing session. (Appendix E)

Arithmetic tests were duplicated. There were 16 problems of addition and subtraction. Students were limited to eight minutes for completing the test. (Appendix D)

The teachers agreed on 11:00 A. M. for presenting the spelling test, and 12:30 P. M. for the arithmetic tests. The same tests were

administered at the same time, on the same days, in the control room.

Testing Performance

Measurements of student performance made through the spelling test were: number of words completed, number of words correct, and the amount of pencil pressure in writing the words. The number of pages on which the pressure marks were discernible was the score for pencil pressure.

Two measurements were derived from the arithmetic tests: number of problems completed, and the number of correct answers.

Noise level comparisons were made through the decible readings on the Octave Band Noise Analyzer.

Summary

The study of student performance covered a four week period of time, and used the entire population of the third grade teachers and pupils in one school near Portland, Oregon. All four rooms were without added color for the first week of Monday and Friday testing. Red, green, and grey were then rotated individually among the three participating classrooms. Each color remained in each room for a period of one week. The testing, done at a specified time on Mondays and Fridays, provided the numerical data for the analysis of the effect of color on student performance.

FINDINGS AND CONCLUSIONS

Student scores for the five areas of measurement were arranged by room mean on a weekly basis, and on a color exposure basis in Tables 1 through 10.

Measurement of noise level was abandoned at the end of the third week. A short in the instrument contributed to the inadequacies of the results. The instrument registered the loudest noise, which, unfortunately, too often was the teacher's voice.

A randomized block design was used for the analysis of variance. Blocking reduces the experimental error through a reduction in the source of variation. The analysis of variance partitions the total sum of squares of deviations into portions associated with the independent variables, including error. (Tables 11a through 11 e)

No significant difference in weekly scores in room D was found through a comparison of means and these data were not included in the randomized block design. Additional student and teacher variables were thus eliminated. Differences in the block (or room) sums were to be expected. The hypotheses were based on expected differences in the treatment sums.

Four null hypotheses were posed. Each was tested with five measures of student performance.

Table 1. Pencil Pressure Score Mean - By Room and Week

Week		Day	Room Scores									
			Room A		Room B		Room C	ABC Mean		Room D	D Mean
I	*	M	2.333	*	2.525	*	2.194	2.372	*	2.650	2.662
		F	2.378		2.500		2.306			2.675	
II	R	M	2.618	N	2.881	G	2.475	2.821	*	2.750	3.125
		F	3.059		2.929		2.969			3.500	
III	G	M	3.194	R	3.176	N	2.528	3.052	*	3.133	3.266
		F	2.833		3.735		2.750			3.400	
IV	N	M	3.176	G	3.342	R	3.125	3.190	*	3.133	3.099
		F	2.912		3.263		3.325				

* = no color added
R = red added
G = green added
N = grey added

lowest no. of pages - 1
highest no. of pages - 6

See Appendix H

Table 2. Pencil Pressure Score Mean - by Room and Color

Color		Day	Room Scores						Mean
			Room A		Room B		Room C		
N.C.	1	M	2.333	1	2.525	1	2.194		2.373
		F	2.378		2.500		2.306		
Red	2	M	2.618	3	3.176	4	3.125		3.173
		F	3.058		3.735		3.325		
Green	3	M	3.194	4	3.342	2	2.438		3.007
		F	2.833		3.263		2.969		
Grey	4	M	3.176	2	2.881	3	2.528		2.862
		F	2.912		2.929		2.750		

1 - 1st week
2 - 2nd week
3 - 3rd week
4 - 4th week

highest number of pages - 6.
lowest number of pages - 1

See Appendix H

Table 3. Arithmetic Accuracy Score Mean - by Room and Week

Week		Day	Room Scores									
			Room A		Room B		Room C	ABC Mean		Room D	D Mean
I		M	12.053		11.474		13.368			10.500	
	*	F	11.842	*	10.947	*	12.632	12.052	*	11.400	10.950
II		M	11.750		9.350		10.667			11.067	
	R	F	11.250	N	9.500	G	11.111	10.604	*	10.067	10.567
III		M	10.110		9.059		12.000			10.882	
	G	F	11.278	R	9.882	N	11.059	10.564	*	11.647	11.264
IV		M	9.647		10.000		11.737			10.786	
	N	F	11.294	G	9.944	R	12.053	10.779	*	11.071	10.928

* No color added
R Red added
G Green added
N Grey added

highest score 16
lowest score 1

See Appendix H

Table 4. Arithmetic Accuracy Score Mean - by Room and Color

Color		Day	Room Scores						
			Room A		Room B		Room C		Mean
N.C.	1	M	12.053	1	11.474	1	13.368		12.052
		F	11.842		10.947		12.632		
Red	2	M	11.750	3	9.059	4	11.737		10.955
		F	11.250		9.882		12.053		
Green	3	M	10.110	4	10.000	2	10.667		10.518
		F	11.278		9.944		11.111		
Grey	4	M	9.647	2	9.350	3	12.000		10.475
		F	11.294		9.500		11.059		

1 - 1st week
2 - 2nd week
3 - 3rd week
4 - 4th week

highest score - 16
lowest score - 1

See Appendix H

Table 5. Arithmetic Completion Socre Mean - by Room and Week

Week		Day	Room Scores									
			Room A		Room B		Room C	ABC Mean		Room D	D Mean
I	*	M	16.000	*	15.632	*	15.895	15.491	*	14.150	14.975
		F	15.895		15.053		15.474			15.800	
II	R	M	15.188	N	15.050	G	15.278	15.087	*	14.400	13.867
		F	15.313		14.250		15.444			13.333	
III	G	M	14.167	R	13.706	N	15.059	14.715	*	14.353	14.735
		F	14.889		14.941		15.529			15.118	
IV	N	M	13.589	G	15.611	R	15.632	15.295	*	14.643	14.643
		F	15.589		15.611		15.737			14.643	

* no color added
R Red added
G Green added
N Grey added

See Appendix H

Out of 16 arithmetic problems lowest number completed - 0, highest number completed - 16

Table 6. Arithmetic Completion Score Mean - by Room and Color

Color		Day	Room Scores						
			Room A		Room B		Room C		Mean
N.C.	1	M	16.000	1	15.632	1	15.895		
		F	15.894		15.053		15.474		15.491
Red	2	M	15.188	3	13.706	4	15.632		
		F	15.313		14.941		15.737		15.086
Green	3	M	14.167	4	15.611	2	15.278		
		F	14.889		15.611		15.444		15.078
Grey	4	M	13.589	2	15.050	3	15.059		
		F	15.589		14.250		15.529		14.829

1 - 1st week
2 - 2nd week
3 - 3rd week
4 - 4th week

highest number completed - 16
lowest number completed - 0

See Appendix H

Table 7. Spelling Accuracy Score Mean - by Room and Week

Week	Day	Room Scores						
		Room A	Room B	Room C	ABC Mean	Room D	D Mean	Differences
I	M	7.056	8.263	7.833		8.300		
*	F	7.333	* 8.579	* 8.667	7.955 *	9.300	8.800	.845
II	M	7.588	7.905	8.625		9.143		
R	F	7.882	N 8.857	G 8.938	8.299 *	10.357	9.750	1.451
III	M	8.611	9.589	8.000		10.067		
G	F	8.722	R 9.941	N 8.667	8.925 *	10.733	10.400	1.475
IV	M	7.353	7.737	8.500		9.533		
N	F	6.941	G 8.632	R 8.950	8.019 *	9.667	9.600	1.581

* No color added
R Red added
G Green added
N Grey added

See Appendix H

Out of 15 spelling words lowest accuracy score - 1, highest accuracy score - 15

Table 8. Spelling Accuracy Score Mean - by Room and Color

Color		Day	Room Scores						Mean
			Room A		Room B		Room C		
N. C.	1	M	7.056	1	8.263	1	7.833		7.955
		F	7.333		8.579		8.250		
Red	2	M	7.588	3	9.588	4	8.500		8.742
		F	7.822		9.942		8.950		
Green	3	M	8.611	4	7.737	2	8.625		8.545
		F	8.722		8.184		8.938		
Grey	4	M	7.353	2	7.905	3	8.000		7.953
		F	6.941		8.857		8.667		

1 - 1st week
2 - 2nd week
3 - 3rd week
4 - 4th week

highest accuracy score - 15
lowest accuracy score - 1

See Appendix H

Table 9. Spelling Completion Score Mean - by Room and Color

Week		Day	Room Scores									
			Room A		Room B		Room C	ABC Mean		Room D	D Mean
I	*	M	13.944	*	14.789	*	14.722	14.532	*	13.450	13.750
		F	14.833		14.684		14.222			14.050	
II	R	M	14.647	N	14.714	G	13.875	14.599	*	13.642	13.964
		F	14.647		14.762		14.000			14.286	
III	G	M	14.833	R	14.882	N	14.111	14.403	*	13.600	14.100
		F	14.667		14.882		14.333			14.600	
IV	N	M	14.520	G	14.947	R	14.150	14.563	*	13.933	14.067
		F	14.412		15.000		14.350			14.100	

* No color added
R Red added
G Green added
N Neutral added

Out of 15 words lowest score - 6, highest score - 15

See Appendix H

Table 10. Spelling Completion Score Mean - by Room and Week

Color		Day	Room Scores						
			Room A		Room B		Room C		Mean
N. C.	1	M	13.944	1	14.789	1	14.722		
		F	14.833		14.684		14.222		14.532
Red	2	M	14.647	3	14.882	4	14.150		
		F	14.647		14.882		14.350		14.593
Green	3	M	14.833	4	14.947	2	13.875		
		F	14.667		15.000		14.500		14.387
Grey	4	M	14.520	2	14.714	3	14.111		
		F	14.412		14.762		14.333		14.475

1 - 1st week
2 - 2nd week
3 - 3rd week
4 - 4th week

highest score - 15
lowest score - 6

See Appendix H

Table 11. Analysis of Variance Tables (Appendix I)

a - Pencil Pressure

	d.f.	s.s.	m.s.	f.
Rooms	2	.2412	.1206	3.023
Treatments	3	1.0837	.3612	9.053 **
Error	6	.2393	.0399	
	11	1.5632		

b - Arithmetic Accuracy

	d.f.	s.s.	m.s.	f.
Rooms	2	6.6834	3.3417	20.0703 *
Treatments	3	4.849	1.616	9.7057 **
Error	6	.9993	.1665	
	11	12.5317		

c - Arithmetic Completion

	d.f.	s.s.	m.s.	f.
Rooms	2	.9842	.4921	2.0685
Treatments	3	1.1075	.3691	1.5514
Error	6	1.4276	.2379	
	11	3.5193		

d - Spelling Accuracy

	d.f.	s.s.	m.s.	f.
Rooms	2	2.3025	1.1512	4.99
Treatments	3	1.4831	.4943	1.6314
Error	6	1.8182	.303	
	11	5.6038		

e - Spelling Completion

	d.f.	s.s.	m.s.	f.
Rooms	2	.618	.309	4.544
Treatments	3	.011	.0037	.0025
Error	6	.409	.068	
	11	1.038		

* Sig value on f scale for 2/6 degrees of freedom at .01 level
** Sig value on f scale for 3/6 degrees of freedom at .05 level

H_{o1}: There will be no difference in student performance with the introduction of color concentration into the classroom, as opposed to student performance with no added color.

Pencil Pressure. Significant differences in score means occurred between no added color and added color. ($p < .05$) The mean score was lower with no added color than with additional color.

Arithmetic Accuracy. Significant differences in score means occurred between no added color and added color. ($p < .05$) The mean score with no added color was higher than the mean score with added color.

Arithmetic Completion. There were no significant differences in the score means. However the no added color score means ranked higher, with the color scores all lower.

Spelling Accuracy. There were no significant differences in score means.

Spelling Completion. There were no significant differences in score means.

On the basis of arithmetic accuracy and pencil pressure scores, H_{o1} must be rejected, and the working hypothesis partially confirmed. There was a difference in student performance with the introduction of color concentration into the classroom, as opposed to student performance with no added color.

H_{o2}: There will be no difference in student performance in the room with the cool color concentration and the room with the warm color concentration.

Pencil Pressure. There were no significant differences in score means between the red and green rooms. However, the red score mean was higher.

Arithmetic Accuracy. There were no significant differences in score means between the red and green rooms. However, the red score mean was higher.

Arithmetic Completion. There were no significant differences in the score means between the red and green rooms. However, the red score mean was higher.

Spelling Accuracy. There were no significant differences in the score means between the red and green rooms. However, the red score mean was higher.

Spelling Completion. There were no significant differences in the score means between red and green rooms. However, the red s core mean was higher.

On the basis of all the measurements, H_{o2} must not be rejected. There was no significant difference between the scores of the red and green rooms. However, in all five areas the red score mean was higher than the green score mean.

H_{03}: There will be no difference in student performance in the classroom with introduced neutral color concentration and performance in the classroom with warm and cool color concentrations.

Pencil Pressure. There were no significant difference between the score means of the red and green rooms and the mean score of the grey room. However, red and green score means were both higher than the grey mean.

Arithmetic Accuracy. There were no significant differences in score means between the red and green rooms and the score mean of the grey room. However, the red and green room score means were both higher than the grey mean score.

Arithmetic Completion. There were no significant differences in score means between the red and green rooms and the score mean of the grey room. However, the red and green score means were both higher than the grey room mean.

Spelling Accuracy. There were no significant differences in score means between the red and green rooms and the score mean of the grey room. However, the red and green score means were both higher than the grey mean.

Spelling Completion. There were no significant differences in score means between the red and green rooms and the score mean of the grey room.

On the basis of all the measurements, H_{o3} must not be rejected. There was no significant difference in student performance in the room with the cool color concentration and the room with the warm color concentration.

H_{o4}: There will be no difference in student performance on the first day of exposure to introduced color concentration and student performance on the fifth day of exposure to the same color.

Pencil Pressure. There was no significant difference in score means between first and fifth day of exposure to the same color.

Arithmetic Accuracy. There was no significant difference in score means between first and fifth day of exposure to the same color.

Arithmetic Completion. There was no significant difference in score means between first and fifth day of exposure to the same color.

Spelling Accuracy. There was no significant difference in score means between first and fifth day of exposure to the same color.

Spelling Completion. There was no significant difference in score means between first and fifth day of exposure to the same color.

On the basis of these measurements, H_{o4} should not be rejected. There was no significant difference in student performance on the first day of exposure to introduced color concentration and the fifth day of exposure to the same color.

DISCUSSION

Since the late nineteenth century many studies have been undertaken on the interactions of man and color in his environment. A commonly accepted assumption is that a relationship does exist between color and human behavior.

Two measurements of this study indicating significant differences in the mean scores between no added color and added color concentration were in arithmetic accuracy and pencil pressure. The mean scores were higher in arithmetic accuracy and lower in pencil pressure with no added color. Goldstein (1942) suggested that a balance of color provided the most satisfactory environment for human stability. The significantly higher arithmetic scores would support this theory, as well as the significantly lower scores in pencil pressure that occurred in the rooms with no additional color. With a total of 16 arithmetic problems, the control room scores varied only as much as four tenths of a problem from the original first week score. The three rooms with added color each varied more than two problems, the mean of the three items being 2.42 problems less than the first week's no added color scores.

Contradictory to Gerard's (1958) findings in support of Goldstein's (1942) theory that warm colors elicit different responses than cool colors, there was little difference in four of the five measurements

between the mean score of the red rooms and the mean score of the green rooms. In two of the three rooms, the green exposure followed the red exposure of the previous week. Perhaps, the weekend break was not sufficient time to overcome the effects of the red. The Monday pencil pressure mean scores for these two rooms were both higher than the mean score in the room with green following no added color. Red color concentration appeared to increase the tensions of the students, with the higher score mean in pencil pressure occurring in the red environment. Lewinsky (1938) and Goldstein (1942) both stated that red is generally an exciting color. The pencil pressure score means are supportive of this theory. In all five measurements red was higher, but the difference was not significant at the five percent probability level.

Pressey (1921) had found that, when dealing with normal subjects, the differences in performance between red and green environments were insignificant.

The findings in performance of normal students offer evidence contradictory to Goldstein's theory that green is more conducive to task completion than a red environment.

When scores from red and green rooms were compared with those of the grey room, evidence was found to support Nakshian's (1964) statement that differences in subject performance were small under red, grey, and green lights. The mean scores were lower in

grey than both red and green in every measurement except one, but the score differences were not significant.

Mean scores from the first day of exposure were not significantly different from the mean scores of the fifth day of exposure to the same color.

In the five measurements with a total of twenty Monday mean scores, and twenty Friday mean scores, all but two of the Friday means were slightly higher than the Monday scores. This increase could be attributed to the students' ability to score higher on the same material with a second exposure.

Arithmetic accuracy and arithmetic completion score means were both lower on Friday in the rooms with no added color. If this demonstrates the normal pattern of Friday fatigue, then more importance may be attributed to the increase in Friday mean scores in all other areas. Including the control room scores, for five of the seven Monday and Friday arithmetic completion tests given in rooms with no added color, the mean scores were lower on Friday. In arithmetic accuracy, four of the seven rooms with no color added had lower score means on Friday than on Monday.

Although teacher responses were not part of the study, they may not be ignored. Some of the student responses could have been in response to the teachers' attitudes.

The first teacher to use green commented she really felt happier and liked the feeling of space and solidity. During the other weeks she had the same amount of other colors, but did not mention this attitude again.

The first teacher to wear the red smock commented on the warmth of the garment. That same teacher's voice rose to carry down the hall five times in the last 45 minutes of school on Friday. Teacher B felt her students were really high on the first and third day of exposure to red, but had levelled off by Friday. Teacher A said the same at a different time. Perhaps they had discussed this. At the end of the week with red, B teacher remarked twice about how tired she felt, and that retirement was surely inviting, even though it was some years ahead.

All three teachers were noticeable and notably glum and withdrawn on the first day of living with grey. Some adjusting had taken place by Friday, but the somberness continued through the grey exposure. Reportedly, the children made few comments about the presence of the color, but there were several negative comments about grey.

Summary

The measurements with statistically significant score differences were in arithmetic accuracy and pencil pressure. The differences

were between the score means with no added color and the score means with added color. Arithmetic accuracy was highest with no added color, while pencil pressure was lowest with no added color. There were no significant score differences between red and green, but both were higher than grey in four of the five measurements, with the mean scores with red being the highest of the color treatment scores in all five areas. Teacher attitudes and possible carry over effects of previous color exposure are variables that were not examined in this study.

RECOMMENDATIONS

Design of the experiment: A longer time lapse between treatments is suggested. The week-end breaks may not have been long enough to remove the effect, if any, of the previous week's color exposure. A regular interspersing of no added color treatments among the color treatments would increase the reliability of the data collected.

Testing materials: A shorter time for completion of problems, more problems, or a combination of both might reduce the number of students completing the tests, producing a wider range of scores. The object of the study was not the effects of time pressure, but speeding up the spelling tests a bit might also reduce the number of words completed, widening the range of scores.

It is regretful that the noise level measurements were not satisfactory. There was some support on the part of the teachers for the hypothesis that noise level would be greater with the red color concentration. However, it could be that the teacher tolerance was lowered during the red exposure. There appears to have been very little study completed on noise level in relation to environmental color.

Subsequent Observations: A follow up study using Haiku poetry (Appendix A) in an attempt to determine the degree, if any, of hold-over effects of the color concentration could have been improved by having the students receive unbiased instructions from the tape

recorder, instead of from each individual teacher.

Following the four week study small spaces were created by placing the screens near corners (Appendix A). These were enjoyed by the students. There was an indication that students scoring low on the initial tests sought the corners more often than those scoring high. An inverse relationship appeared to exist between concentrated color environment and the high and low achievers. Further exploration in this area is recommended.

With all the color in our environment today, it seems important that further study be made of human performance in relation to extended color exposure. Some specific areas of future investigation might include differences in responses to color associated with: age, sex, maturity, education, economic status, color blindness, length and amount of exposure, weather, and clothing worn by students.

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Equipment

Octave Band, Noise Analyzer
General Radio Co., Model 1558-AP.

APPENDICES

APPENDIX A

Subsequent Observations

On the Monday following the removal of all additional color, all the students were asked to write a piece of Haiku poetry. The selection was to be written about a color, an attempt to determine any holdover effect from the previous weeks. The color subjects and the number of times mentioned were:

blue	13	white	5
green	10	purple	5
black	7	orange	3
yellow	7	brown	2
red	6		

In the descriptive part seven references were made to "hot" (red, orange, yellow) and six references were made to "cold" colors (blue, violet, green). Green and yellow were called "happy" on three occasions, and black was referred to as "sad". There was no apparent relationship in colors chosen and the students' recent exposures.

The folding screens were left in one room for a period of two weeks following the color study. The students used a sign-up sheet to indicate color preference in corner choice. With only two students using a corner, and only three corners, the freedom or inclination to sign for a space was quite limited.

All but four of the children signed for the use of the color corners during classroom reading time. Those not signing had scores well above the class mean in both spelling and arithmetic accuracy. Those signing once or twice were also in the above average category.

Counting both first and second choices, the total number of selections for the green corner was 47, for the red corner 44, and for the grey corner 41.

Visual inspection of data indicated a possible difference in relationship between scholastic performance of students receiving below average scores and students receiving above average scores in the no color week.

APPENDIX B

Information Prepared for Parents of Involved Students

It is planned that during the last two weeks in February and the first two weeks in March the third grade classrooms would be used as part of a study relating to color in the environment.

The regular daily schedule of teachers and students would not be significantly altered.

a small notebook would be provided for any notes or comments the teacher might wish to make during the time of the study.

APPENDIX C

Information Distributed to Teachers Involved in the Study

Study innovator's expectations for self:

Provision and care of smocks for teachers

Provision of background materials for bulletin, and installation of same.

Provision and grading of materials pertinent to third grade subject matter.

Provision of cloth-covered movable folding screens.

Provision of recording equipment.

Study innovator's expectations for teachers:

Wearing of the smock from start of school day to end of school day; each color being worn for 5 consecutive days. Total--3 colors.

Use of the academic materials supplied by innovator.

Use of Recording equipment as per a previous agreement.

Use of the folding screens as per a previous agreement.

It would be necessary for the teachers to meet with the study innovator to discuss the study. No future conferences would be necessary, but a small notebook would be provided for any notes or comments the teacher might wish to make during the time of the study.

APPENDIX D

Sample Arithmetic Test

NAME

ADDITION

(1) 6251	(2) 8888	(3) 876	(4) 5454
+ 890	+ 1537	+ 678	+ 6565
(5) 4425	(6) 976	(7) 2965	(8) 9786
+ 5626	+ 532	+ 999	+ 6265

SUBTRACTION

(1) 1111	(2) 9752	(3) 548	(4) 6543
- 222	- 363	- 62	- 2315
(5) 895	(6) 6251	(7) 765	(8) 9632
- 533	- 890	- 426	- 2639

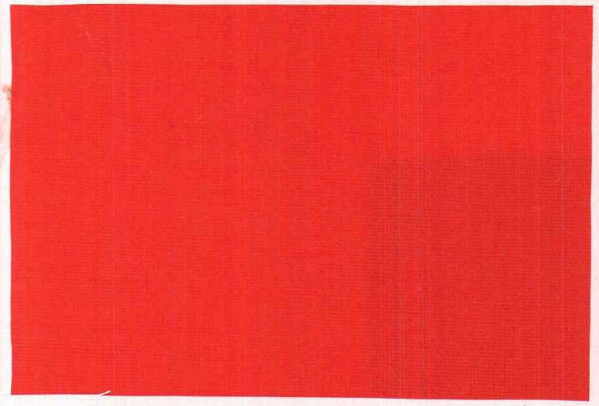
APPENDIX E

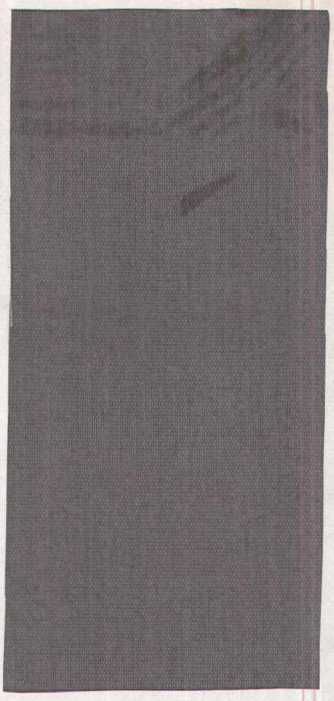
Spelling Words

1st week	2nd week	3rd week	4th week
last	into	did	hunt
took	girl	small	winter
trip	subject	farm	Saturday
weeks	smile	unit	funny
friend	father	talking	will
where	which	close	radio
month	grew	elephant	everyone
person	school	name	kitten
laugh	period	envelope	make
hammer	something	Monday	house
horse	walk	boat	circus
letter	sister	about	street
placing	when	thank	orange
learned	friends	white	apples
like	went	picture	book

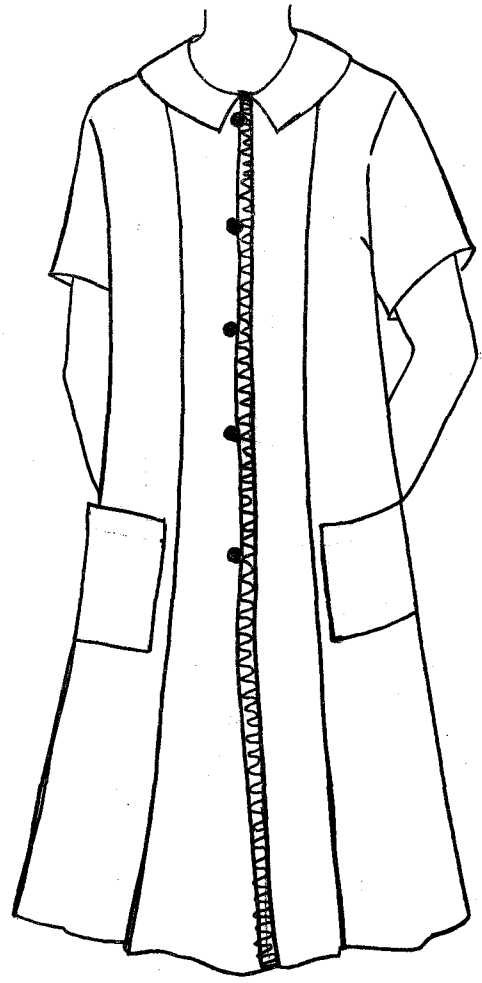
APPENDIX F

Color Samples





APPENDIX G



Adjustable features

Convertible Neckline

Dropped Shoulders

Dart-pleat

Optional Belt

Teacher Smocks

Appendix H

Table 12. Number of Students Present on Monday and Friday.

Spelling Completion and Accuracy - Pencil Pressure

Week	Room A			Room B			Room C			Room D		
	Boys	Girls	Total	Boys	Girls	Total	Boys	Girls	Total	Boys	Girls	Total
1	*9	9	19	*9	11	20	*8	10	18	*9	11	20
2	R9	8	17	N9	12	21	G9	7	16	*7	8	15
3	G9	9	18	R7	10	17	N8	9	17	*9	7	16
4	N9	8	17	G9	11	20	R9	10	19	*6	9	15

Arithmetic Completion and Accuracy

Week	Room A			Room B			Room C			Room D		
	Boys	Girls	Total	Boys	Girls	Total	Boys	Girls	Total	Boys	Girls	Total
1	*10	9	19	*9	10	19	*10	10	20	*9	11	20
2	R 8	8	16	N9	12	21	G10	8	18	8	8	16
3	G 9	9	18	R8	9	17	N 9	7	16	9	8	17
4	N 9	8	17	G8	11	19	R 9	9	18	6	9	15

* - no added color
R - Red added
G - Green added
N - Grey added

APPENDIX I

Additional Analysis of Variance

Because the score differences were not significant in Arithmetic Completion, Spelling Completion, and Spelling Accuracy, further analysis was not necessary. However, the SST scores for Pencil Pressure and Arithmetic Accuracy were separated into components to allow for the three comparisons in the hull hypotheses.

$$\text{Ho1:} \quad 3U1 = U2 + U3 + U4$$

$$\text{Ho2:} \quad U2 = U3$$

$$\text{Ho3:} \quad 2U4 = U2 + U3$$

Using the formula

$$q^2 = \frac{(\Sigma m_i T_i)^2}{n\Sigma m_i^2}$$

the total sum of squares for treatments in Arithmetic Accuracy fell into the following divisions: Ho1 = 4.458, Ho2 = .269, and Ho3 = .112.

For Pencil Pressure, the division was as follows: Ho1 = .934, Ho2 = .0435, and Ho3 = .1057.