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The legibility of upper and lower case letters on overhead projection transparencies with Grade VIII students under classroom conditions.

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THE LEGIBILITY OF UPPER AND LOWER CASE LETTERS ON OVERHEAD PROJECTION TRANSPARENCIES WITH GRADE VIII STUDENTS UNDER CLASSROOM CONDITIONS

By

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INTRODUCTION

Statement of Problem

The study was designed to investigate the legibility of upper and lower case letters on transparencies for the overhead projector with Grade VIII students, under normal classroom conditions.

The study included an analysis of the legibility of the four categories of lower case letters: ascenders, descenders, vowels, and the remaining letters with no extenders.

The investigation also included an analysis of the legibility of upper and lower case letters by sex, by age, and by distance from the screen.

Justification for the Study

The overhead projector has several advantages that no other single projector possesses. The instrument may be used in a lighted classroom, the operator faces his students, the instructor may make his own materials, the instructor (or student) may write or draw on acetate sheets and simultaneously project the images, the presentation may be paced to the students' capabilities, and step-by-step development

is possible by a masking technique known as progressive revelation. These advantages are fully developed by Brown, Lewis and Harcleroad.[1]

Research with the overhead projector has shown significant contributions in certain subject areas. One study was conducted in the New York City schools in 1966. It was designed to compare the effectiveness of the overhead projector with the traditional use of the chalkboard. The subject was first-year bookkeeping.

> Results showed that the experimental students progressed through the year's study at a faster pace than control students, and that there was no obvious loss in quality of enthusiasm with the experimental subjects. In fact, they exceeded the achievement of their control counterparts on a few unit tests and on the comprehensive end-of-term examination.[2]

Another study was done at the University of Texas in the field of engineering drawing. "Findings were statistically the same, especially in terms of instructional time saved, increased student interest in the course, and the enthusiasm of teachers for the overhead projector method."[3]

Still another investigation was conducted in the Technical High School in Rochester, New York.

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[1] James W. Brown, Richard B. Lewis, and Fred F. Harcleroad, AV Instruction Media and Methods (3rd ed.; New York: McGraw Hill Book Company, 1969), pp. 239-241.

[2] Ibid., p. 256.

[3] Ibid., pp. 256-257.

> The results were that (for tenth, eleventh and twelfth grade technical students) there is no room for doubt that the visualizing power of the overhead projector increases the depth of learning and considerably decreases the time required to cover a given area of subject matter.[4]

These, and other investigations, have established the effectiveness of the projector, as such. However, research on the materials used with this projector has been minimal.

The materials (transparencies) for the overhead projector are easily made and relatively inexpensive. Permanent transparencies may be prepared on clear acetate with special pens. Copy machines may be used to reproduce any teacher-made originals, to copy the printed page, or to duplicate commercially prepared printed originals. Finished projectuals are also available from commercial firms at nominal cost.

Materials used with other media have been subject to considerable investigations by educational researchers and by research teams of commercial producers. The AV Communication Review is a publication for professionals in the audio-visual field. It describes the current, educational research on equipment, materials, and methods. Although replete with research abstracts on the other media, there are very few

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[4]William Robinson Crosby, "The Feasibility of Adopting the Overhead Projector in Technical Education in the Rochester Technical High School," AV Communication Review, XIV, No. 2 (Summer, 1966), 273-274.

investigations concerned with transparencies for the overhead projector.

One of the leading commercial producers of instructional materials is Encyclopaedia Britannica Educational Corporation. The president of this firm noted, "We have cooperated in research studies of recognized national significance."[5] Many of these studies are well-known, such as: Project Discovery in Shaker Heights, Ohio, and Project Springboard in the State of Oregon. The materials used in these projects were basically films, filmstrips, and tapes.

Regardless of their affiliation, investigators have conducted very little research on transparencies for the overhead projector.

This study was designed to contribute to the effective selection, construction, and use of projectuals for the overhead projector.

The remainder of this study consists of four chapters. Chapter II presents a survey of the literature in areas where the type of lettering might be critical. The sources consulted included the following: (1) authorities in reading instruction, (2) the research conducted for commercially printed news media and advertising firms, (3) service organizations concerned with publicly displayed signs,

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[5]Warren Everote, Educational Film Catalog (Chicago, Illinois: Encyclopaedia Britannica Educational Corporation, 1968), inside front cover.

(4) experts in the audiovisual field.

The third chapter describes the procedure, methods and materials used to execute the experiment in the classroom.

Section four of this study presents the statistical analyses computed from the results of the test instruments, and the last section discusses these results and their implications.

A glossary of terms used in this study may be found in Appendix A.

C H A P T E R II

RELATED READING

This section of the study examined the literature pertinent to the use of upper and lower case letters in various areas. Research on reading by educational, commercial, and public service organizations provided substantial direction in designing the remainder of the study. The educational researchers consulted included the leading specialists in reading instruction. The commercial investigators were represented by advertising firms and news media. The public service organizations included such agencies as the Bureau of Public Roads of the U.S. Department of Commerce, and the Division of Fisheries and Game, where lettering on signs might be considered critical. Finally, the literature written by leaders in the audiovisual field was consulted to establish research patterns in this area.

Research on Reading

Educators interested in the development of reading skills have made pertinent studies on the use of upper and lower case letters. The area of reading readiness has received considerable attention. Most studies have shown that pre-school experiences with written symbols determine

the child's success in beginning reading. Gates has observed, "It is obvious that success in reading depends in no small measure on the equipment and attitudes of a child at the time of beginning to read."[1]

In the home during pre-school years, either the parents or other members of the family attempt to teach the younger children to recognize the letters of the alphabet. McKee and Harrison mentioned that, "Parents usually use all capitals in teaching him to print because they have found that capitals are more easily recognized and also more easily made than small letters."[2] The family's influence is substantiated by Durrel and Murphy, who stated that, "Some children can name all capital letters and many lower case letters when they enter school. The average child knows the names of twelve capital letters and nine lower case letters."[3] This is verification of earlier research by Gates, who said of the child entering school, "The lower case or small letters are

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[1]Arthur I. Gates, The Improvement of Reading (3rd ed.; New York: The Macmillan Company, 1947), p. 26.

[2]Paul McKee and M. Lucile Harrison, Getting Ready to Read: A Pre-Reading Program (Boston: Houghton Mifflin Co., 1966), p. 3.

[3]Donald D. Durrell and Helen A. Murphy, Speech-to-Print Phonics: A Phonics Foundation for Reading (New York: Harcourt, Brace and World, Inc., 1964), p. 143.

least well-known."[4] The same researcher made an additional observation on reading readiness: "The child whose curiosity leads him to examine letters and numbers on doors, on boxes in the kitchen and stores, on street signs, and in words wherever seen is one whose analytical abilities will serve him well in reading."[5] This investigator suggests that the child to whom Gates refers, had been exposed, mainly, to capital letters -- those found more effective in advertising and attention value.

The concept of reading readiness has changed several times since reading instruction began in the United States. The traditional acceptance of a certain chronological age has long passed. Today, it is recognized that some basic abilities are pre-requisite to actual reading instruction, and, that they may be learned prior to formal schooling. Of these abilities, visual discrimination is foremost. In describing such discernment, Betts wrote, "The ability to be a good observer of the likenesses and differences among word forms appears to be an important factor in reading and spelling situations."[6]

After the child learns to discriminate between real

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[4]Arthur I. Gates, Manual of Directions for Gates Reading Readiness Tests (Rev. ed.; New York: Teachers College, Columbia University, 1942), p. 5.

[5]Ibid.

[6]Emmet Albert Betts, Foundations of Reading Instruction; With Emphasis on Differentiated Guidance (New York: American Book Company, 1954), p. 132.

objects, his next step is to distinguish between pictures of those objects. Subsequently, he must differentiate between letter or word symbols representing real objects. Thus, the sequence develops from the real object to the less real picture of the object, to the abstract symbol of the object. This is a very complex process, but vital to reading readiness. Bond and Wagner noted, "The child engages in no other activity that requires as high a degree of visual discrimination as does reading."[7]

With the introduction of formal reading instruction, any deficiencies in reading readiness become acute. If the child was denied a favorable home environment, such that readiness activities could not be encouraged, he is at a definite disadvantage. According to Durrell, "Lack of reading readiness is mainly the lack of two things: a knowledge of letter names and forms, and the ability to notice separate sounds in spoken words. . . ."[8] Most authorities agree that a knowledge of letter forms, and their spoken sounds, are essential for beginning reading. However, there is a diversity of opinion concerning the emphasis to be placed upon capital and small letters in formal reading instruction.

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[7]Guy L. Bond and Eva Bond Wagner, Teaching the Child to Read (New York: The Macmillan Company, 1966), p. 27.

[8]Donald D. Durrell, "Vocabulary Control - More or Less," The Reading Teacher, VIII, No. 1 (October, 1954), pp. 25-29.

Some authorities suggest using only upper case letters for beginning reading. Others condemn this practice and urge that both types of letters be presented at the same time.

Fries, who represents the linguistic approach to reading, wrote as follows:

> Children have learned and can learn to read using each of the various sets of letter shapes, but, because simple-line capitals have given rise to significantly fewer confusions at the beginning, we have postponed the use of 'lower case' letters and of 'cursive' letters until the 'process of reading' is well under way.[9]

The previous author further admonished, "For the first stage, and until after the principle of our alphabetic writing has been fully grasped, the letter shapes should be strictly limited to those of unadorned capital letters. . . ."[10] As corroborating evidence, Fries commented: "Telegrams for delivery have for years been typed in such capital letters only."[11] (Perhaps it was unfortunate that this researcher referred to telegrams. The reader is referred to one respondent, "The Western Union Telegraph Company," in Appendix B.)

Durrell wrote of letter styles, but was not as decisive in his comments: "It has not been established whether it is

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[9]Charles C. Fries, Linguistics and Reading (New York: Holt, Rinehart and Winston, 1963), p. 191.

[10]Ibid.

[11]Ibid.

better to teach both capital and lower-case forms of each letter at the same time, although many teachers prefer this method."[12] Regarding the last clause of this quotation, the present investigator would offer the following for the reader's consideration: "When teachers do not have scientific justification for their teaching methods, they often have a precedent of successful practice to which they can point."[13]

John R. Malone, representing "The Foundation for a Compatible and Consistent Alphabet," wrote as follows:

> Thus it would appear that initial teaching letter modes should be capitals, rather than lower case. If a synthetic intermediate alphabet (Pitman or UNIFON) is used for children, it should be one which is a surrogate of the CAPITAL characters they are apt to see and use outside of their classroom or learning experience, so that a measure of reinforcement can take place immediately, in the world around them.[14]

A more obdurate conviction was penned by Mary Aline Cox, as she advised parents in reading pedagogy, "Write the alphabet down the page in three columns. (Not capital letters! Avoid them as you would the plague!)"[15] A later

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[12]Donald D. Durrell, Improving Reading Instruction (New York: Harcourt, Brace and World, Inc., 1956), p. 73.

[13]David H. Russell and Henry R. Fea, "Research on Teaching Reading," Handbook of Research on Teaching, American Educational Research Association of the NEA (Chicago: Rand McNally and Company, 1963), p. 866.

[14]Refer to respondent, "Western Publishing Educational Services," in Appendix C, p. 2.

[15]Mary Aline Cox, Teach Your Child to Read: A Book for Parents (2nd ed.; New York: Exposition Press, 1955), p. 18.

passage from the same author lamented, "Young Bobbie had learned the capital letters in kindergarten, which is unfortunately a school custom, and had to relearn the alphabet in small letters before his confusion was overcome."[16]

In the area of programmed reading, the trend favors concomitant introduction of upper and lower case letters. Research on programmed readers versus basal readers has not been conclusive. One study was conducted in Westfield, Massachusetts with retarded readers. The results were as follows:

> In view of the fact that there were no significant differences among the criterion measures it was concluded that there were no significant differences in the effectiveness of two reading methods employed, programmed instruction and a developmental program, in promoting reading ability among retarded readers in the primary grades.[17]

The fact that there were no significant differences in the two methods of teaching reading is significant in itself. The results showed that programmed reading is equally as effective as the traditional method. In addition, the released time afforded the teacher permits her to attend more pressing problems in the classroom.

Programmed reading books are produced for all levels of a developmental reading program. Most alphabet books and

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[16] Ibid., p. 37.

[17] Ann P. Burkott and Ambrose A. Clegg, Jr., "Programmed vs. Basal Readers in Remedial Reading," The Reading Teacher, XXI, No. 8 (May, 1968), pp. 745-748.

pre-primers, directed toward the nursery school population, introduce upper and lower case letters at the same time. This is also true of primer readers prepared for the primary grades. Although the programmed readers have been published by commercial firms, they reflect the methodology of reading experts who were paid consultants. Bond and Wagner rated these products highly: "These commercially prepared materials are the work of experts in the teaching of reading: they have been carefully graded in difficulty, and have been critically formulated to give varied experience in visual discrimination."[18]

It became apparent that there were conflicting opinions between the specialists in reading instruction. This was not attributable to a scarcity of research, as is shown by this statement: "Research on reading instruction comprises more material than does research in any other part of the curriculum."[19] The following is enlightening:

> The most tantalizing and stimulating characteristic of reading research findings is their inconclusiveness. Of the various weaknesses of reading research, these three seem most important. Inadequate controls, poor control groups, and weak criteria of success. . . .[20]

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[18]Bond and Wagner, Teaching the Child to Read, p. 27.

[19]Russell and Rea, "Research on Teaching Reading," Handbook of Research on Teaching, p. 866.

[20]C. Winfield Scott, A 'Forest View of Present Research in Reading, quoted in Charles C. Fries, Linguistics and Reading, p. 4.

In summary, despite the differences among educators, the trend appears to favor Betts' philosophy, summarized below:

> Both capital and small letters should be used to approximate the appearance of type in a book. Only the first word in each sentence should be capitalized; otherwise, the pupil may be confused with later 'book' reading.[21]

Commercial and Service Organizations

An investigation into the research of commercial companies and public service organizations was fruitful. One of the largest advertising agencies in the East reported:

> Capital letters have the greatest individual recognition value, but tend to be read individually. . . . Lower case letters tend to be read as complete words or phrases, for which the eye has become conditioned through normal reading.[22]

These results were borne out by the Eastman Kodak Company. As a result of their research with projected materials, they suggested, "For titles, short statements and labels it is advisable to stick to upper case alone."[23]

The concensus of most authorities, in all fields, has indicated that upper case letters exhibit inherent characteristics which render them unique.

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[21]Betts, Foundations of Reading Instruction, pp. 413-414.

[22]"Type Lettering Color for Outdoor Advertising," Institute of Outdoor Advertising (September, 1966), p. 1.

[23]No. S-4: "Legibility Standards for Projected Material" (Rochester: Eastman Kodak Company, 1965), p. 4.

One respondent, the Massachusetts Division of Fisheries and Game, was concerned with developing conspicuous signs. This source answered: "In short, upper case may be used on occasion to attract attention, but lower case will be used in the rest of the poster."[24]

Another respondent, the U.S. Department of Commerce, submitted a bibliography of research on highway signs. Among the researchers was David Hodge, who was quoted as follows: "Hodge . . . found that upper case letters were recognized at a greater distance than lower case letters. . . . A second experiment showed that this could not be attributed to the difference in the height of the letters."[25] The present investigator interprets this as evidence of a uniqueness of capital letters. Some illumination was presented by the linguist, Fries:

> Simple capital letters have only two basic formats: circles and strokes. The letters are made up of patterns of strokes, patterns of circles, or patterns of parts of circles combined with strokes.[26]

By contrast, the lower case letters do not present the simplicity of form. These symbols introduce the ascender

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[24]Letter from Bryant R. Chaplin, The Commonwealth of Massachusetts, Division of Fisheries and Game, April 17, 1967. See Appendix D.

[25]David Hodge, "Legibility of a Uniform-Strokewidth Alphabet: Relative Legibility of Upper and Lower Case Letters," Journal of Engineering Psychology, I, No. 1 (January, 1962), 45.

[26]Fries, Linguistics and Reading, p. 125.

and descender, along with the more detailed configurations of the vowels and letters with no extenders.

J. H. Prince reported some interesting results on an experiment at Ohio State University:

> The visibility of most lower case letters varies according to their position in a word. Some of them are far more legible at the beginning of a word than at the end of it. Most are less legible in the middle of it than they are at either end.[27]

Although further research is needed to explain these findings, the present investigator suspects that the position of ascenders and descenders in a word will be a determinant of legibility.

A study by David Hodge was cited above, in which distance became a factor in the legibility of lower case letters. Warren carried out an experiment with newspaper headlines which was reported by Tinker and Paterson. The following is a summary of that research:

1. At 6 to 8 feet, the legibility of the lower case banner headlines is 5.3 percent greater than the legibility of headlines set in all capitals.

2. At 10 to 14 feet, both kinds of headlines are about equally legible.

3. At about 17 feet, the upper case headlines are 19.8 percent more legible than the lower case headlines.[28]

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[27]J. H. Prince, "Criteria for Word Formation for Maximum Legibility," Signs of the Times (January, 1958), pp. 42-44.

[28]Alice Warren, "Readability of Newspaper Headlines Printed in Capitals and in Lower Case," Journal of Applied Psychology, XXX (April, 1946), 166.

Breland and Breland reported another study of newspaper headlines: "Under the conditions of the study, headlines printed in lower case were considerably more legible than those printed in all capitals."[29]

Tinker was also active in research on the legibility of newspaper print. He noted a possible explanation for the superior legibility of lower case letters:

> Lower-case printing is much more legible than all capital printing. Lower-case letters have more 'character' in terms of variation in shape and the contrasting of ascenders and descenders with short letters.[30]

Tinker also noted that, "Individual capital letters are more legible than lower-case letters in terms of visibility or perceptibility at a distance."[31]

From the foregoing research, this investigator formed the following conclusions: (1) upper case letters are more legible as distance becomes a factor, (2) upper case letters are more legible for short bits of information, (3) as the number of words approaches sentence form, the traditional combination of upper and lower case is indicated.

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[29]Keller Breland and Marion Breland, "Legibility of Newspaper Headlines Printed in Capitals and Lower Case," Journal of Applied Psychology, XXVIII (April, 1944), 118.

[30]Miles A. Tinker, Legibility of Print (Iowa: Iowa State University Press, 1963), pp. 34-35.

[31]Ibid., p. 42.

Audiovisual Personnel

Reference to writers in the audiovisual field was informative, but, with a few exceptions, not comprehensive. Many suggestions for lettering-style were evident in the area of graphics -- graphs, charts, posters, diagrams and cartoons. Thomas and Swartout admonished:

> People who are learning to make posters or charts often believe that fancy letters with curlicues or tall-thin letters or short-fat ones will improve their design. But they usually succeed in doing just the opposite. They make the poster difficult to read and unattractive.[32]

Wittich and Schuller also cautioned against ornamental lettering: "Use bold but simple letters, for fancy lettering is seldom effective."[33]

Similar advice was given by Brown, Lewis, and Harcleroad: "In lettering, as in the use of color, the standard rule to remember is to keep it simple. 'Fanciness' is not the goal you normally seek, but rather appropriateness and legibility."[34]

The arrangement of an effective bulletin board requires as much attention to lettering as does any other visual

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[32]R. Murray Thomas and Sherwin G. Swartout, Integrated Teaching Materials (New York: Longmans, Green and Company, Inc., 1960), p. 282.

[33]Walter Arno Wittich and Charles Francis Schuller, Audiovisual Materials: Their Nature and Use (New York: Harper and Row, Publisher, 1967), p. 165.

[34]Brown, Lewis, and Harcleroad, AV Instruction Media and Methods, p. 414.

presentation. Kinder presented a precise description:

> Step 5 PLAN THE LETTERING. Lettering ties the bulletin board together. Spacing, style, color, materials, and similar items must be attended to. Labels should be crisp, clear, accurate. Simplicity is usually better than fancy style in lettering.[35]

Perhaps the most extensively utilized visual aid, of the traditional media, is the chalkboard. Hopefully, the chalkboard will be increasingly replaced by an "electronic" substitute:

> The chalkboard has at last a competitor. The overhead projector and its tilted or angled screen show strong tendencies toward becoming standard classroom equipment for use at any moment by any student or teacher with a visual message to communicate to the group.[36]

Nonetheless, the chalkboard is a reality and serves its function. Lettering techniques, for this medium, have received considerable attention by many authors. Suggestions for legibility standards accentuated the superiority of printing versus script-writing, letter-spacing, and height of letters. Sands wrote:

> Printing is gradually displacing script for blackboard use; its effect is nearer

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[35]Thomas A. Koskey, Baited Bulletin Boards, quoted in James S. Kinder, Audio-visual Materials and Techniques (2nd ed.; New York: American Book Company, 1959), p. 347.

[36]Ronald Fredrickson and Raymond Wyman, "The Overhead Revolution," Educational Screen and Audio-Visual Guide, XLIV (November, 1965), pp. 24-25.

> to that of the reading matter that we are used to in books, newspapers, and typed letters, and it is thought to have superior legibility.[37]

This observation was also stressed by Wittich and Schuller: "Printing is usually more legible than cursive writing."[38]

Kinder added: "Lettering, writing or drawing, to be legible and neat, should employ evenly spaced letters and straight lines."[39]

A more complete summary was presented by Brown, Lewis and Harcleroad:

> Many potentially fine chalkboard presentations are spoiled because the lettering is inadequate. The most frequent error in such cases is to make letters too small and too weak to be seen from the back of the room. . . . With a viewing distance from the chalkboard of 32 feet, lettering should be at least 2 1/2 inches high. Lettering should be as simple as possible, such as bold Gothic style. . . . Letters should be "optically" spaced.[40]

The chalkboard, its techniques and devices have received extensive treatment by many authors. As a visual tool, it has survived nearly a century and a half: "The last major audiovisual revolution occurred in the 1820's when the chalkboard was recognized as part of the standard equipment

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[37]Lester B. Sands, Audio-Visual Procedures in Teaching (New York: The Ronald Press Company, 1956), p. 156.

[38]Wittich and Schuller, Audiovisual Materials: Their Nature and Use, p. 55.

[39]Kinder, Audio-visual Materials and Techniques, p. 347.

[40]Brown, Lewis, and Harcleroad, AV Instruction Media and Methods, p. 426.

required in every teaching program."[41] However, as the blackboard gradually replaced the "slate" of the eighteenth century, a more versatile tool has increasingly deposed the chalkboard. Such is the overhead projector. Wyman and Fredrickson described its preeminence as "The Overhead Revolution."[42]

A survey of works by writers in the audiovisual field, since 1960, has indicated increased attention to the overhead projector. Schultz described a presentation in English grammar:

> Remember the principle of simplicity. It might be best to show the diagramming of only one sentence on a transparency, using different colored pencils to outline individual grammatical forms.[43]

The caution against "cluttering" a transparency with too much information is well-advised. All too often, the content of a projectual sacrifices brevity and simplicity for profuseness, with its attendent diminution of clarity. The maximum amount of information which could be effectively presented on a transparency has not been defined. No doubt,

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[41]Richard W. Flint, "Using the Overhead Projector: An Overview," Know Your World, Teacher's Ed., I, No. 13 (January, 1968), p. 1.

[42]Wyman and Fredrickson, "The Overhead Revolution," Educational Screen and Audio-visual Guide, XLIV (November, 1965), pp. 24-25.

[43]Morton J. Schultz, The Teacher and the Overhead Projector: A Treasury of Ideas, Uses and Techniques (Englewood Cliffs, New Jersey: Prentice-Hall, Inc., 1965), p. 105.

it would vary with grade level and subject area. This must be relegated to future research. Nonetheless, as statistical investigations continue, they must focus on the content of the projectual. The content is the message. (McLuhan, notwithstanding.) The message should be designed and structured to convey a modicum of information in a precise manner.

Wyman emphasized the importance of conciseness: "Only the pertinent information which is best visualized should be on the screen."[44] He also mentioned a guide to avoid complexity, in a related area: "An old television rule for printed material limits the message to six lines."[45] This did not imply that it should be an inflexible law, as applied to transparencies, but that it might serve as an adjunct to simplicity.

The style of lettering, particularly, has received careful examination by leaders in the field. Wittich and Schuller wrote:

> It should be noted here that the size of the lettering used on transparencies is important if they are to be read easily. Typical book or newsprint type is too small for use with a class. Recommended for typed lettering is the 6/32 inch, primer size typewriter found in many schools.[46]

Brown, Lewis and Harcleroad were in full accord, and

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[44]Ray Wyman, "Creating Readable Transparencies," The Instructor (May, 1967), p. 104.

[45]Ibid.

[46]Wittich and Schuller, Audiovisual Materials: Their Nature and Use, p. 247.

added: "Experience has shown that for good reading, lettering on the transparency itself should be at least 1/4 inch high."[47]

A study by Adams reported the superiority of the primer typewriter over elite or pica type-face:

> The results of this investigation would indicate that the smaller-size letters (elite and pica) should be avoided in the preparation of projectuals -- certainly for viewing distances beyond twenty feet.[48]

The present investigator makes a minor suggestion relating to the use of the primer typewriter. The condition of the ribbon is critical for neat, consistent symbols. For some reason, perhaps the type-size, ribbons fatigue rapidly on these machines.

A general rule for letter-size, whether typewritten or prepared by other techniques, was described by Wyman: "The most common and accepted guideline is that letters should be one inch high for each twenty-five feet of viewing distance (1/2" at 12', 2" at 50', etc.)."[49]

As estimated by the sources cited above, appropriate letter-size is a prerequisite for effective teaching with transparencies. When lettering becomes inadequate, it not only reduces the impact of the message but may well diminish

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[47]Brown, Lewis and Harcleroad, AV Instruction Media and Methods, p. 247.

[48]Sarah Adams, Robert Rosemier, and Phillip Sleeman, "Readable Letter Size and Visibility for Overhead Projection," AV Communication Review, XIII (Winter, 1965), 412-417.

[49]Wyman, "Creating Readable Transparencies," The Instructor, p. 104.

interest and attention.

In addition to size, other aspects of lettering must be considered. The weight of the type-face, the width of lines, and letter-spacing may determine the extent of legibility. Concerning the weight of type-face, Eastman Kodak suggested: "A sans-serif medium weight face of normal proportions is always a safe bet."[50]

Wyman presented a formula for determining line-width: "For maximum legibility, the width of the lines used to make letters should be about 15 percent of the letter height."[51]

Researchers concerned with the legibility of newsprint, and Eastman Kodak Company which has been concerned with the legibility of projected materials, have conducted experiments on the spacing of letters and on line-spacing. Although the studies were not concerned with transparencies for the overhead projector, the results may well apply to this area. In fact, future research may establish common requisites in legibility standards for most projected material.

The following chapters describe the mechanics of this study, a statistical analysis of the results, and a discussion of those results.

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[50]No. S-4: "Legibility Standards for Projected Material" (Rochester: Eastman Kodak Company, 1965), p. 4.

[51]Wyman, "Creating Readable Transparencies," The Instructor, p. 104.

C H A P T E R III

PROCEDURE - METHODS - MATERIALS

Purpose of Study

The study was constructed to compare the legibility of upper and lower case letters, on transparencies for the overhead projector, with eighth-grade pupils.

The study included an analysis of the legibility of upper and lower case letters by age, by distance from the screen and by sex.

Particular emphasis was placed on a comparison of four categories of lower case letters: (1) ascenders, (2) descenders, (3) vowels, (4) no extenders.

Analysis of the results based on visual acuity was not considered defensible. Vision tests had been administered to the subjects a year earlier. The reliability of this data was questionable, particularly in view of the fact that this age-group generally experiences considerable variation in vision.

In addition, the subjects were positioned according to the usual seating plan (which was not devised by reference to visual capacity) in an effort to maintain normal classroom conditions. Consequently, the factor of vision could not be controlled.

Neither was it considered necessary to analyze the results according to intelligence quotient. Inasmuch as the school administration subscribed to homogeneous grouping, the results of the individual groups provided sufficient evidence.

Operational Mechanics

An adverse viewing situation was deliberately devised to serve a discriminant function. In the vehicle, a Tecnifax Visucom overhead projector, a 200 watt lamp was substituted for the standard 750 watt light unit.

A tachistoscopic device was attached to the projector to permit rapid projection of nonsense words.[1] On the day before the experiment, the device was used with a trial group of eighth-grade pupils. The timing was adjusted to a speed where the trial group experienced a copy error of approximately fifty percent in lower case letters. This setting was used for all subjects during the execution of the study. The tachistoscopic projection time was 7/100 second. (The rationale for time sequences appears in Appendix F.)

The projector was placed exactly six feet from the screen. The wheels were removed from the projection stand to insure stability. (As explained below, it was necessary to project the words upon the screen with near pin-point accuracy.)

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[1] A description of the device may be found in Appendix E.

Registration pins were fixed to the upper part of the stage of the projector. By this means, each word on successive transparencies was projected to a pre-determined point on the screen.

The electrical energy entering the vehicle was controlled by a constant voltage regulator. (A description may be found in Appendix G.)

The projection screen was a 70 x 70 inch matte surface, mounted in an anti-keystone position. Twenty triangular "pointers" were adherred to the screen, positioned at the center of each word projected. (Dimensions of the "pointers" appear in Appendix H.) This investigator reasoned that it would be most difficult for the subjects to anticipate the location of a single word projected upon a large, blank surface.

The room lighting was limited to artificial lights in an attempt to maintain identical conditions.

Each desk, permitting two subjects, was placed at a measured position to facilitate later analysis of results. (Distance measurements from the screen appear in Appendix I.)

Preparation of Projectuals

All transparencies were prepared in black and white. The actual production of the projectuals was done by Tecnifax Corporation. The type size was 24 point with medium weight face, sans serif. (A description of type size and letter measurements may be found in Appendix J.)

Five transparencies were constructed plus one practice instrument. (See plates I through VI.) The five transparencies contained twenty nonsense words of five letters. The practice instrument consisted of eight nonsense words of five letters. The nonsense words were those which Taylor[2] found to have a low associative value.

Each five-letter nonsense word was composed of a consonant, a vowel, a consonant, a vowel, and a consonant.

Each nonsense word consisted of all upper case, or all lower case letters. There was no intermixing of small and capital letters in the same word. An equal number (20) of upper and lower case nonsense words appeared on each projectual.

The horizontal placement of the nonsense words on each transparency, and the order of upper and lower case, was directed by random choice using the tables of random numbers by Fisher and Yates.[3]

The letter "q", and its upper case symbol, were not included in John D. Taylor's list of words and paralogs. Consequently, these symbols were omitted in this study. The frequency of each letter may be found in Appendix K.

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[2]John D. Taylor, "The Meaningfulness of Three Hundred and Twenty Words and Paralogs," (unpublished Ph.D. dissertation, Duke University, 1959), pp. 43-50.

[3]Ronald A. Fisher and Frank Yates, Statistical Tables for Biological, Agricultural and Medical Research (4th ed.; New York: Hafner Publishing Company, Inc., 1953), p. 118.

Plate I

SURAL	hyrax	karon	duroc	WILER
ZUMAP	monad	felid	nabob	PEWIT
zuber	zarac	KEVEL	JEHAD	GYRUS
DAMAN	xylan	KALAB	zoron	YUROR

Plate 11

taluk heres nisus PIPIT genet

jihad CABAL POLEF JABOT BOLUS

kabob WIKOV metis furan ZESAM

TILUS hyson gadid GORAL GOLEM

Plate III

parol	FETOR	JUPON	wyden	sopor
hakim	yolif	TAROP	pavis	lipid
nader	LATUK	NEXUS	GAMIN	NIDUS
menad	BALAS	CELOM	LORIS	calix

Plate IV

batik lapin MOHUR kapox DERAY

CUMIN velat NUMEN BUBAL zebec

YUVAL HELOT LUCES picul zobel

KALAK VUTAW bezel vinim witan

Plate V

JALEP	situs	CYCAD	TOLAN	yamen
zirol	cylix	zuren	GERAH	gojey
rowel	hexyl	GEMOT	NEROL	XYLAR
litas	REBUS	HERID	lagan	TABOR

Plate VI

DIJON xilos xuber HEXAD kupob

mujik SIGIL salol

Practice Form

The position of the nonsense words on each projectual required precision. The placement of the "pointers" on the screen, if they were to be effective, demanded a reciprocal accuracy in the transparencies. The words on each projectual were positioned so that the central letter was exposed at a pre-determined point -- directly above the "pointer."

Three types of masking techniques were used in the presentation. The first was a "static" mask with rectangular openings slightly larger than the words to be projected. It was pin-registered on the stage and remained in position throughout. (See Plate VII.)

The second masking device consisted of four flaps, constructed of cardstock, which concealed the four lines of nonsense words on each transparency. They were adherred to the projectuals and spaced so that the masking bar (described next) could slide between them. (See Figure 1.) Each flap was raised to permit sequential projection.

The third mask was a movable masking bar, constructed of cardstock, one and one half inches wide by twenty inches long. It had a rectangular opening slightly larger than the words on the projectuals. By moving this bar across a line of exposed nonsense words (one flap raised), it was possible to project one word while concealing the others. (See Figure 2.)

The size of the projected symbols was calculated

Plate VII

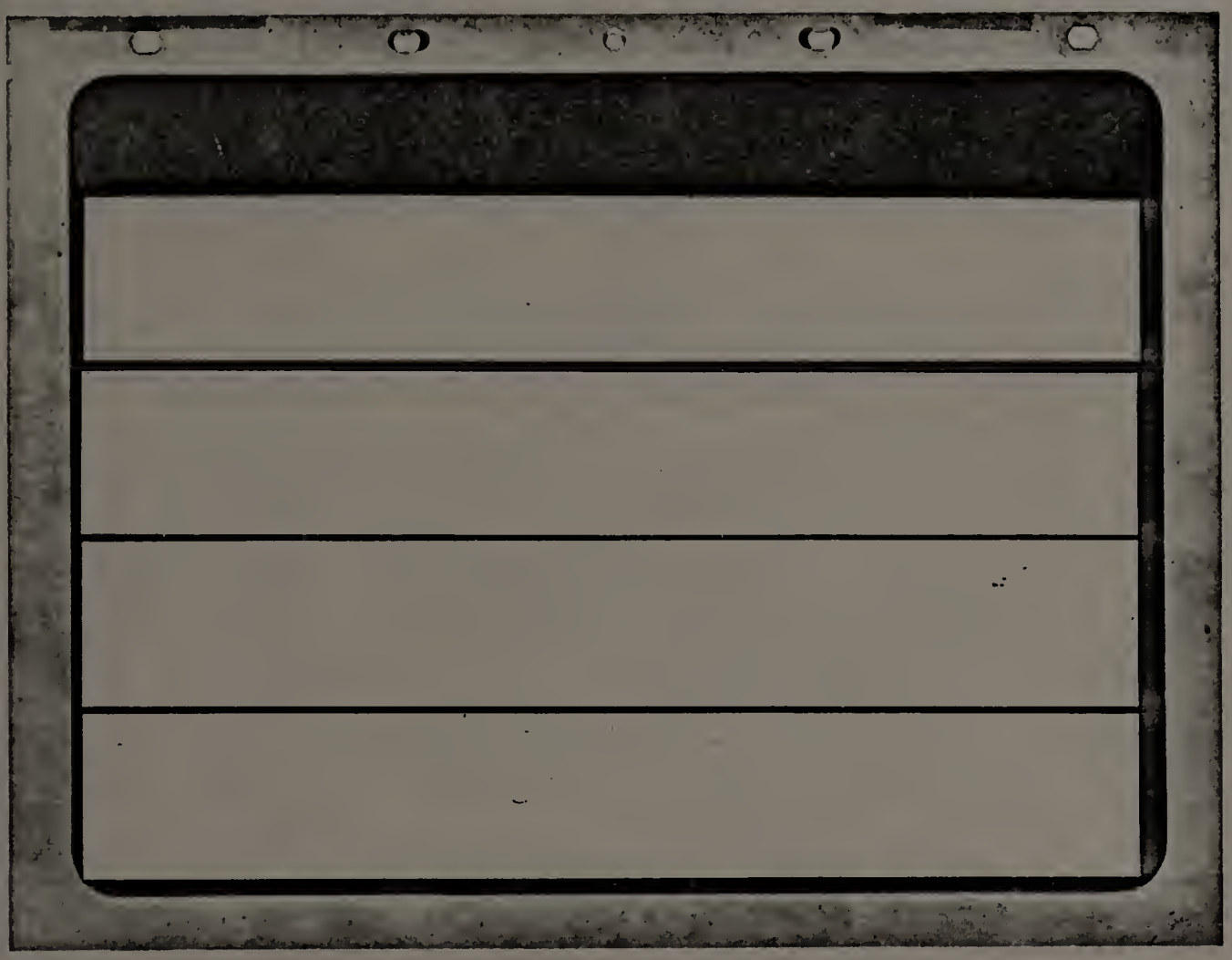

Fig. 1.--Flaps on Projectual

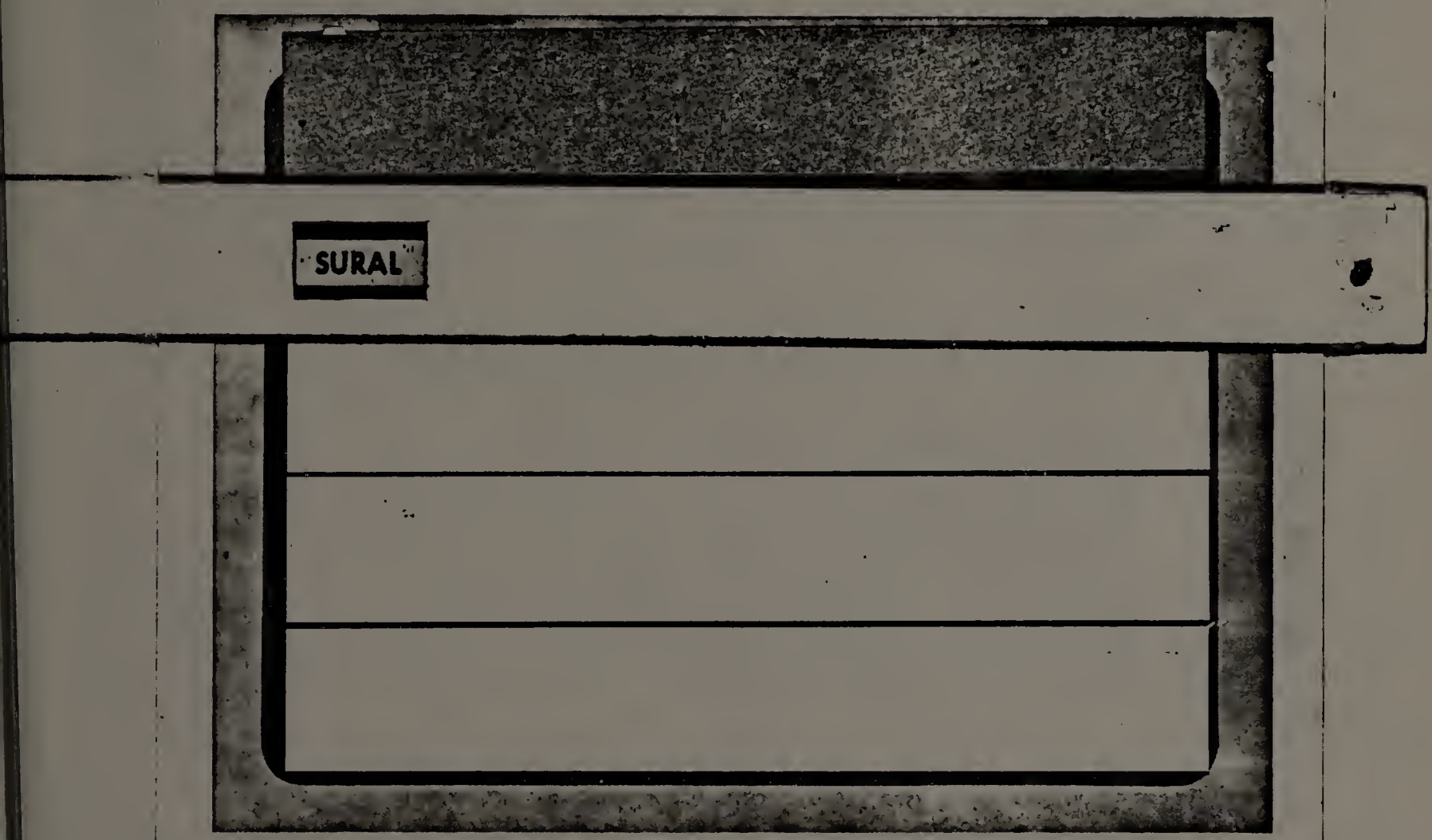

Fig. 2.--Masking Bar Positioned for Projection

according to the following formula:[4]

$$\frac{\text{size of slide image}}{\text{size of screen image}} = \frac{\text{focal length}}{\text{screen distance}}$$

These measurements may be found in Appendix J.

Classroom Procedure

Each group of subjects was exposed to the presentation at their regularly scheduled meeting in Room 103.

Sharpened pencils were provided at every table.

To standardize the procedure, when the subjects were seated, all instructions were given by pre-recorded tape. An Audiotronics, Model 300T, tape recorder was used. (A printed copy of the pre-recorded tape may be found in Appendix L.) In order to prepare the subjects for each tachistoscopic projection, it was necessary to include a tone on the pre-recorded tape which served as a "ready" signal. (A description of the tone used as a "ready" signal appears in Appendix M.)

The forms upon which the subjects copied the projected information contained separate blanks for each letter of all nonsense words. There were four rows of horizontal sets of blanks on each form. (Samples appear in Appendix N.)

Five answer forms were stapled together and placed on the tables before the subjects entered. The practice forms were separate sheets which were placed inside the tables

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[4]Raymond Wyman, "Audiovisual Devices and Techniques," Rev. ed. (unpublished manual, University of Massachusetts, 1962), p. 33.

during the test. All forms were designated by seat number (circle in the upper right) prior to the presentation.

The pre-recorded tape directed subsequent procedure.

C H A P T E R IV

RESULTS OF STATISTICAL ANALYSIS

The scores for the statistical analysis were derived from the number of errors committed by each subject.

To assess the difference in legibility between upper and lower case letters, the t test was used, according to the following formula:

$$t = \frac{\Sigma D}{\sqrt{\frac{N\Sigma D^2 - (\Sigma D)^2}{N - 1}}} \qquad \text{formula 1}$$

where D is the difference between upper and lower case letters for each subject, and ΣD is the algebraic sum of the differences. The sum of the differences was then divided by the standard error of differences which was calculated in the following manner: (1) the differences were squared, summed, and multiplied by the number of scores, (2) from this result, the square of the sum of differences was subtracted, (3) this quantity was then divided by one less than the number of scores, and (4) the square root of this number gave the standard error of differences.

This form of the t test was used because it assumes

a correlation between the groups being tested. The same formula was used to assess the difference in legibility between: (1) ascenders and descenders, (2) vowels and letters with no extenders, (3) the combined ascenders and descenders, and, the combined vowels and letters with no extenders. This formula is further discussed by Charles A. Ferguson.[1]

The results of these tests are shown in Table 1.

TABLE 1

LEGIBILITY OF UPPER AND LOWER CASE LETTERS

Group	Letter Type	Number Letters	t score
SS-1 30 Subjects	Upper Lower	250 250	10.70
SS-2 26 Subjects	Upper Lower	250 250	14.63
SS-3 31 Subjects	Upper Lower	250 250	11.23
SS-4 20 Subjects	Upper Lower	250 250	11.22
SS-5 14 Subjects	Upper Lower	250 250	2.28
Sum 121 Subjects	Upper Lower	250 250	18.89

[1]Charles A. Ferguson, Statistical Analysis in Psychology and Education (2nd ed.; New York: McGraw-Hill Book Company, 1966), p. 170.

All of the tests for groups SS-1 through SS-4 were significant at the .001 level, and the test for group SS-5 was significant at the .05 level. The results of the test for the combined five groups was significant at the .001 level. These tests clearly indicate that upper case letters are more easily read when projected tachistoscopically in groups of five letters.

A second set of tests was administered to determine the reliability of the subjects' responses to upper and lower case letters. The correlation coefficient used for this purpose was the Pearson r,[2] according to the following formula:

$$r = \frac{N\Sigma XY - (\Sigma X)\ (\Sigma Y)}{\sqrt{(N\Sigma X^2 - [\Sigma X]^2)\ (N\Sigma Y^2 - [\Sigma Y]^2)}} \quad \text{formula 2}$$

where X represented the lower case scores and Y represented the upper case scores. The sum of the product of these two scores was multiplied by the number of pairs of scores. From this quantity was subtracted the product of the sum of X and Y scores. The sum of squares of each of the lower case scores was multiplied by the number of subjects. The square of the sum of lower case scores was subtracted from that result. Likewise, the sum of the squares of each of the upper case scores was multiplied by the number of subjects, and the square of the sum of upper case scores subtracted from

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[2]Ibid., p. 111.

that result. The square root of the product of these two results, when divided into the numerator, gave the Pearson r correlation coefficient.

The results of these tests may be found in Table 2.

TABLE 2

CORRELATION COEFFICIENT OF UPPER AND LOWER CASE LETTERS

Group	Letter Type	Number Letters	Correlation Coefficient
SS-1 30 Subjects	Upper Lower	250 250	.92
SS-2 26 Subjects	Upper Lower	250 250	.93
SS-3 31 Subjects	Upper Lower	250 250	.94
SS-4 20 Subjects	Upper Lower	250 250	.94
SS-5 14 Subjects	Upper Lower	250 250	.94
Sum 121 Subjects	Upper Lower	250 250	.91

The correlations for groups SS-1 through SS-5, and the correlation for the five groups combined, were all significant beyond the .001 level. A correlation coefficient of +.90 indicated a high degree of reliability in the subjects' responses to upper and lower case letters. These tests

showed that a subject who had a large number of errors in the upper case letters also tended to make a large number of errors in the lower case letters. Conversely, those subjects who had a low number of errors in upper case letters tended to make a low number of errors in lower case.

Table 3 was constructed in order to determine the direction of further statistical tests. This table shows the percentage of error for various categories of lower case letters: (1) ascenders, (2) descenders, (3) vowels, and (4) letters with no extenders. The percentages were calculated according to the following formula:

$$\text{percentage} = \frac{(\text{total number of errors})\ (100)}{(\text{number of subjects})\ (\text{frequency of letters})}$$

The percentage of error in letters with ascenders varied from 33.33% (group SS-2; letter "f") to 88.39% (group SS-5; letter "t"). This was a considerably wide range. The percentage of error in letters with descenders also exhibited a wide range. It extended from a low of 46.15% (group SS-2; letter "g") to a high of 96.43% (group SS-5; letter "j"). The total percentage of error in these two categories was very close, with the ascenders (65.75%) slightly higher than the descenders (64.66%).

The percentage of error in reading vowels ranged from a low of 47.60% (group SS-2; letter "u") to a high of 84.26% (group SS-4; letter "a"). The error percentage for letters with no extenders ranged from 53.46% (group SS-2; letter "s") to 88.33% (group SS-4; letter "x").

TABLE 3

PERCENTAGE OF ERROR IN THE FOUR CATEGORIES OF LOWER CASE LETTERS

Type	Ltr.	No.	SS-1 (30)	SS-2 (26)	SS-3 (31)	SS-4 (20)	SS-5 (14)	Sum (121)
Asc.	b	9	56.67	55.98	70.25	57.78	65.08	61.16
	d	10	64.66	50.38	60.64	75.00	71.43	63.05
	f	3	62.22	33.33	47.31	56.67	69.05	52.07
	h	6	80.55	48.72	55.38	84.17	55.95	65.02
	k	6	45.55	51.92	66.13	65.00	67.86	57.98
	l	18	71.48	65.17	64.52	67.78	74.60	68.09
	t	8	70.00	83.17	82.26	84.37	88.39	80.47
	All	60	65.80	59.17	65.48	70.50	71.67	65.75
Desc.	g	4	70.83	46.15	66.93	76.25	80.36	66.53
	j	2	93.33	55.77	50.00	95.00	96.43	74.79
	p	7	67.14	60.99	69.58	67.86	48.98	64.46
	y	9	68.52	58.97	50.54	61.11	65.87	60.33
	All	22	70.80	56.99	61.73	69.09	65.91	64.66
Vow.	a	27	78.02	76.21	76.70	84.26	80.16	78.57
	e	21	74.76	55.86	75.73	76.19	80.27	71.82
	i	21	66.98	61.35	68.66	73.81	74.15	68.16
	o	17	69.61	68.10	72.30	74.41	77.73	71.71
	u	8	67.50	47.60	64.52	74.37	70.54	63.95
	All	94	72.41	64.44	72.85	77.50	70.54	71.44
Otrs.	c	6	85.00	76.28	78.49	73.33	86.90	79.75
	m	6	67.78	62.18	70.43	83.33	73.81	70.52
	n	18	74.63	55.55	63.98	76.94	76.19	68.36
	r	14	76.90	65.66	82.72	83.21	82.65	77.69
	s	10	74.67	53.46	79.03	80.00	75.00	72.15
	v	3	71.11	64.10	72.04	70.00	66.67	69.14
	w	3	60.00	53.85	53.76	56.67	66.67	57.30
	x	6	77.77	82.05	72.58	88.33	83.33	79.75
	z	8	72.50	78.85	81.45	74.37	72.32	76.45
	All	74	74.64	64.34	72.88	78.31	77.32	72.89

The total percentage of error in these two categories was also very close. The error in reading letters with no extenders (72.89%) was slightly higher than the performance with vowels (71.44%).

It was obvious that there were wide differences in the legibility of the four categories of lower case letters. A statistical analysis was done between the five groups to determine if the differences were significant. These tests were all calculated according to formula one.

The first set of tests was done between the ascenders and descenders. In the formula, ΣD represented the algebraic sum of the differences between ascenders and descenders, and $N\Sigma D^2$ represented the sum of the squared differences between ascenders and descenders multiplied by the number of scores. The results of these tests may be found in Table 4.

Two of the tests were significant at the .05 level. The test for group SS-1 showed significantly more errors in the descenders than in the ascenders. The test for group SS-3 showed significantly less errors in the descenders than in the ascenders. These two opposite, significant results are considered to be random effects or due to differences within groups SS-1 and SS-3. This explanation for the contradiction is further substantiated by the fact that the test for the combined groups proved no significant difference.

TABLE 4

LEGIBILITY COMPARISON BETWEEN ASCENDERS AND DESCENDERS

Group	Letter Type	Number Letters	t score
SS-1 30 Subjects	Asc. Desc.	60 22	-2.58
SS-2 26 Subjects	Asc. Desc.	60 22	.93
SS-3 31 Subjects	Asc. Desc.	60 22	2.46
SS-4 20 Subjects	Asc. Desc.	60 22	.43
SS-5 14 Subjects	Asc. Desc.	60 22	1.97
Sum 121 Subjects	Asc. Desc.	60 22	.56

The second set of tests was done between the vowels and the letters with no extenders. Following formula one, ΣD represented the algebraic sum of the differences between the vowels and the letters with no extenders, and $N\Sigma D^2$ represented the algebraic sum of the squared differences between the vowels and letters with no extenders multiplied by the number of scores. These results may be found in Table 5.

None of these tests were significant, indicating that there were no significant differences in the legibility of

vowels and letters with no extenders.

TABLE 5

LEGIBILITY COMPARISON BETWEEN VOWELS AND NO EXTENDERS

Group	Letter Type	Number Letters	t score
SS-1 30 Subjects	Vowels No Ext.	94 74	- .68
SS-2 26 Subjects	Vowels No Ext.	94 74	.10
SS-3 31 Subjects	Vowels No Ext.	94 74	- .03
SS-4 20 Subjects	Vowels No Ext.	94 74	- .55
SS-5 14 Subjects	Vowels No Ext.	94 74	.35
Sum 121 Subjects	Vowels No Ext.	94	-1.17

A third set of tests was done between the combined ascenders and descenders, and the combined vowels and letters with no extenders. Using formula one, ΣD represented the algebraic sum of the differences between the combined ascenders and descenders, and the combined vowels and letters with no extenders. $N \Sigma D^2$ represented the sum of the squared differences multiplied by the number of scores. The results of these tests may be found in Table 6.

TABLE 6

LEGIBILITY COMPARISON BETWEEN ASCENDERS AND DESCENDERS AND VOWELS AND NO EXTENDERS

Group	Letter Type	Number Letters	t score
SS-1 30 Subjects	Asc. & Desc. Vow. and No Ext.	82 168	5.96
SS-2 26 Subjects	Asc. & Desc. Vow. & No Ext.	82 168	4.95
SS-3 31 Subjects	Asc. & Desc. Vow. & No Ext.	82 168	6.62
SS-4 20 Subjects	Asc. & Desc. Vow. & No Ext.	82 168	6.46
SS-5 14 Subjects	Asc. & Desc. Vow. & No Ext.	82 168	5.94
Sum 121 Subjects	Asc. & Desc. Vow. & No Ext.	82 168	13.02

All of the tests were significant at the .001 level. The vowels and letters with no extenders showed significantly more errors than the combination of the other two -- the ascenders and descenders.

Three other analyses were suggested by the data: the legibility of upper and lower case letters (1) by sex,

(2) by age, and (3) by distance from the screen. The formula used was as follows:

$$t = \frac{\bar{X}_1 - \bar{X}_2}{\sqrt{\left(\frac{\Sigma X_1^2 - \frac{(\Sigma X_1)^2}{N_1} + \Sigma X_2^2 - \frac{(\Sigma X_2)^2}{N_2}}{N_1 + N_2 - 2}\right)\left(\frac{1}{N} - \frac{1}{N}\right)}}$$

Formula 3

This formula for the t test is explained by Chase.[3] The formula was chosen because the responses came from different subjects where there was no reason to expect a correlation between their responses.

The first set of tests was done to determine the legibility of upper and lower case letters by sex. The algebraic sum of all scores of the females was ΣX_1, and the algebraic sum of all scores of the males was ΣX_2.

The algebraic sum of the females' scores was squared and divided by the number of scores. This quotient was subtracted from the sum of the squares of the females' scores. Similarly, the algebraic sum of the males' scores was squared and divided by the number of scores. The quotient was subtracted from the sum of the squares of the male scores. The sum of both values was divided by two less than the total

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[3]Clinton I. Chase, Elementary Statistical Procedures (New York: McGraw Hill Book Company, 1967), pp. 146-149.

number of male and female scores. This result was multiplied by the reciprocal of the number of females plus the reciprocal of the number of males. The square root of this product was divided into the value of the mean of the females' scores minus the mean of the males' scores. The results of these tests may be found in Table 7.

TABLE 7

LEGIBILITY OF UPPER AND LOWER CASE LETTERS BY SEX

Group	No. Males	No. Females	Score
SS-1	10	20	.58
SS-2	10	16	- .30
SS-3	15	16	-1.79
SS-4	11	9	.82
SS-5	7	7	.48
Sum	53	68	- .72

None of these tests were significant. This would indicate that there was no difference between boys and girls in the legibility of upper and lower case letters.

The test for legibility by distance from the screen required a division of the subjects into two groups. The seating arrangement was divided approximately in half. (Figure 3 shows this division.) This partition formed two blocks of subjects -- one block nearer the screen and the other more distant. Group SS-5 was not included in this test

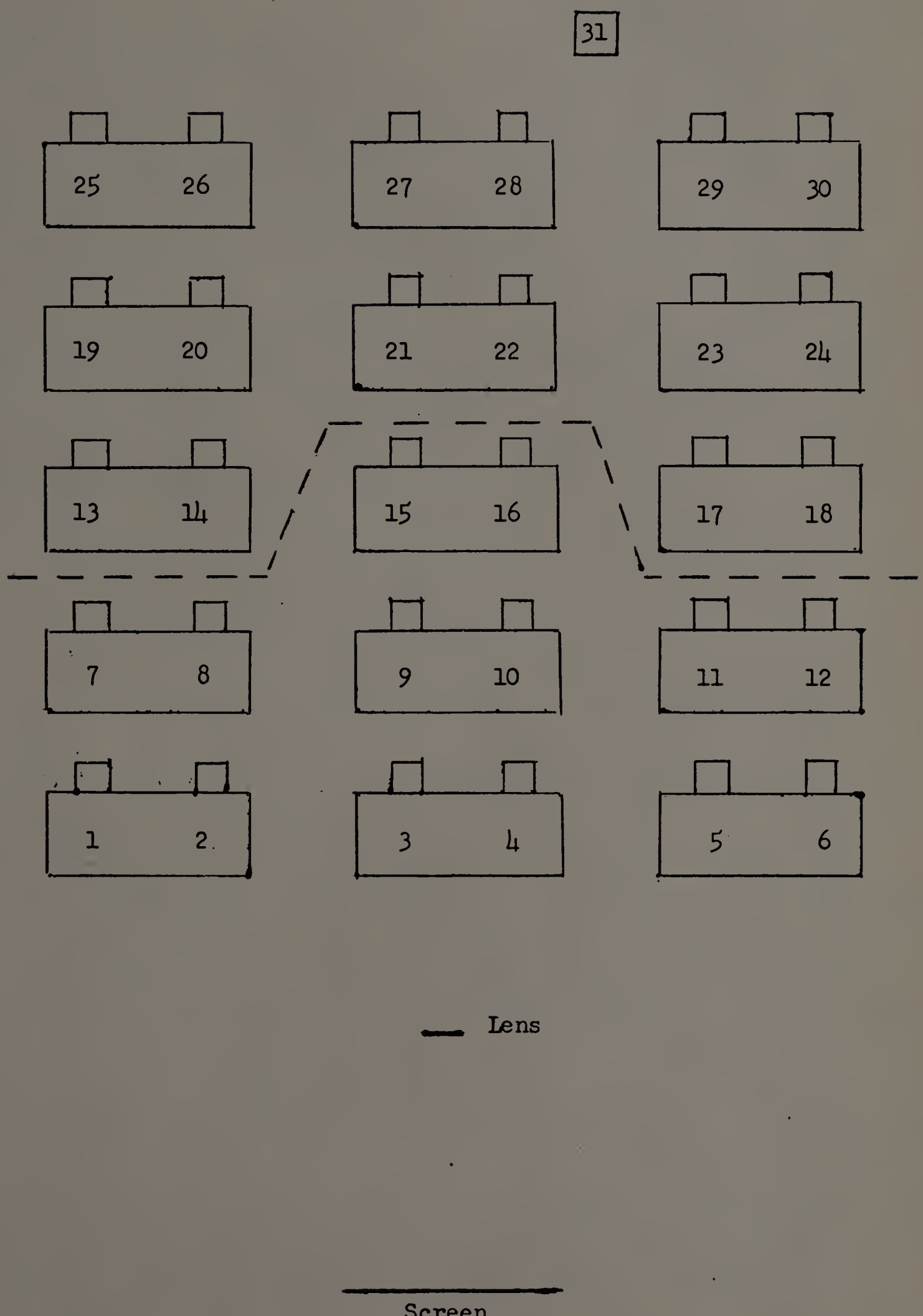

Fig. 3.--Division of Subjects for Distance Analysis

because, normally, all subjects were seated in the block nearer the screen.

The second set of tests, using formula three, was done to determine the legibility of upper and lower case letters by distance from the screen. The sum of all scores of the block nearer the screen was ΣX_1, and the sum of all scores of the block farther from the screen was ΣX_2.

In the numerator, the mean of the males' scores was subtracted from the mean of the females' scores.

The denominator of the formula was calculated in a similar manner as that for the legibility test by sex; where N_1 represented the number of scores in the block nearer the screen and N_2 represented the number of scores in the block farther from the screen. The results of these tests may be found in Table 8.

TABLE 8

LEGIBILITY OF UPPER AND LOWER CASE LETTERS BY DISTANCE

Group	No. Closer	No. Farther	Score
SS-1	14	16	-1.90
SS-2	13	13	-4.39
SS-3	14	17	-1.90
SS-4	13	7	- .46
Sum	54	53	-3.36

The test for group SS-2 was significant at the .001 level and showed that those farther from the screen made fewer errors than those nearer the screen. The results from groups SS-1, SS-3, and SS-4 showed no significant difference. However, the test for the four groups combined was significant at the .01 level.

The final analysis was done according to the age of the subjects. The ages of the subjects ranged from thirteen years and two months to fifteen years and ten months. A division was made into two nearly equal age brackets. The younger bracket ranged from thirteen years and two months to, and including, thirteen years and eleven months. The older bracket ranged from fourteen years to fifteen years and ten months.

The third set of tests, using formula three, was done to determine the legibility of upper and lower case letters by age of the subjects. The sum of all scores of the younger bracket was ΣX_1 and the sum of all scores of the older bracket was ΣX_2.

In the numerator, the mean of the scores of the older bracket was subtracted from the mean of the scores of the younger bracket.

The denominator of the formula was calculated in the same manner as that for the legibility test by sex; where N_1 represented the number of scores in the younger bracket and N_2 represented the number of scores in the older bracket.

The results of these tests may be found in Table 9.

TABLE 9

LEGIBILITY OF UPPER AND LOWER CASE LETTERS BY AGE

Group	Younger Age Block	No. Subjects	Older Age Block	No. Subjects	Score
SS-1	13-5 13-10	16	14-0 14-6	14	- .02
SS-2	13-5 13-11	15	14-0 14-8	11	.72
SS-3	13-4 13-11	20	14-0 15-2	11	-2.74
SS-4	13-2 13-11	8	14-0 15-3	12	.09
SS-5	13-6 13-9	2	14-1 15-10	12	.59
Sum	13-2 13-11	61	14-0 15-10	60	-1.54

Only one test, for group SS-3, proved significant at the .05 level. This test indicated that the older subjects made fewer errors than the younger subjects. The value of this significant difference is diminished by the fact that it was isolated, and inconsistent with the results of the tests on the other groups.

C H A P T E R V

DISCUSSION OF RESULTS

The Problem

This study was designed to compare the legibility of upper and lower case letters on transparencies. The subjects were Grade VIII students in the public schools of Northampton, Massachusetts.

The problem included an analysis of the legibility of upper and lower case letters by sex, by age, and by distance from the screen.

The investigation also included an analysis of the legibility of the four types of lower case letters. This involved the letters with ascenders, the letters with descenders, the vowels, and the remaining letters with no extenders.

The Method

One hundred nonsense words were projected tachistoscopically to 121 subjects via an overhead projector. A 200 watt lamp was substituted for the standard 750 watt unit in the projector. This reduced the brightness of the projected words to nearly one-fourth of the normal luminosity. This created a condition in which legibility differences

became more readily apparent.

The nonsense words contained five letters each, and were placed on five separate projectuals. Each projectual contained twenty nonsense words. The words were projected at a pre-determined speed of 7/100 of a second.

Upper vs. Lower Case Letters

The statistical analysis of the legibility of upper and lower case letters (Table 1) produced results which definitely established the ascendancy of upper case letters, under the conditions of this study. Of the 250 upper case letters and a similar number of lower case letters, all subjects were able to read the former with significantly less error-rate. Groups SS-1 through SS-4 derived t test scores of over ten, when a score of two is considered significant. All of the tests for these groups were significant at the level of .001. This means that t test scores so large would occur less than once in a thousand, by chance. The test for group SS-5 was significant at the .05 level, indicating a chance occurrence of less than five in a hundred. The test for the combined five groups was significant at the .001 level.

This researcher concludes that upper case letters on transparencies are easier to read when the presentation consists of short, concise information. One possible explanation for the superior legibility of upper case letters might involve their size. In any particular type face, all of the individual capital letters occupy more area on the

printed page than their small counterparts. Thus, the larger images are more readily perceived. This is true up to a certain point. As the printed material approaches sentence form, the use of upper case letters becomes self-limiting precisely because of their size. At some point, as the number of words increases, the normal eye-fixations cannot perceive the material as easily, nor as quickly, as if it were printed in lower case letters. Possibly future research might be undertaken to define the point where the normal eye-fixations become a deterent to the perception of upper case letters.

Another possible explanation of the superior legibility of upper case letters (for short, concise information) might be their simplicity of form -- as contrasted with the lower case letters. The small letters present a variety of configurations to the reader's eyes, whereas, as Fries points out, "Simple capital letters have only two basic formants: circles and strokes."[1] Perhaps their relative simplicity plus their larger size, both contribute to the ease of reading capital letters, when the information is limited.

Correlation Coefficient of Upper and Lower Case Letters

The correlation coefficient between upper and lower case letters was very high (Table 2). Groups SS-1 and SS-2 showed results of +.92 and +.93 respectively, while the remaining groups attained a high of +.94. The test for the combined

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[1]Fries, Linguistics and Reading, p. 125.

groups gave a result of +.91. These results showed that a high error-rate in upper case letters was accompanied by a high error-rate in lower case letters and, that a low error-rate was common to both. This does not imply an equal error-rate, but a proportional one.

The high correlation coefficient cannot be attributed to differences in intelligence because the subjects were grouped homogeneously. Group SS-5 represented the lowest ability level with a correlation coefficient of +.94, while group SS-1 contained the ablest subjects and showed a correlation coefficient of +.92.

An explanation for these results may lie in the plan of the study. The design directed a tachistoscopic projection speed where the error-rate was at least fifty percent in the lower case letters. This proved to be decisive and established the superior legibility of upper case letters. Consequently, the subjects who experienced a high error-rate in upper case letters also had a high error-rate in the small letters. Similarly, those with a low error-rate in the lower case letters had a low rate in capital letters.

Percentage of Error in Lower Case Letters

In this study, the percentage of error in the four categories of lower case letters prescribed the course of further analyses.

The mathematical results (Table 3) showed a wide range in the legibility of ascenders, descenders, vowels, and the remaining letters with no extenders.

Seven letters comprised the ascenders. Most errors were made with the letter "t", with one exception. (Group SS-1 had the most difficulty with the ascender "h".) Groups SS-2 through SS-5 made an error-percentage between 82 and 88. The combined groups experienced an error of 80 percent. The second most difficult ascender was the letter "l". Group SS-1 realized a percentage error of 71, group SS-2 an error of 65 percent, and group SS-5 an error of 74 percent. The combined error-percentage was 68. The letters "h", "d", "b", and "k" were read by the combined groups in that ascending order, with an error-percentage of 65, 63, 61, and 58, respectively. The individual groups showed little consistency in reading these four letters, with one possible exception. The letter "b" was read with next to the least errors by three groups. Groups SS-1, SS-4, and SS-5 showed an error of 57, 58, and 65 percent. However, the combined error showed "k" to be the second most easily read. The least percentage of error was encountered with the letter "f". Groups SS-2, SS-3 and SS-4 showed an error of 33, 47, and 57 percent, respectively. The combined error was 52 percent.

In summary, the letter "t" caused more errors in the subjects' responses. The letter "l" was the second most difficult to read, and the letter "f" the least difficult to read.

The letters with descenders numbered only four. The letter "j" caused the most difficulty. Group SS-1 showed an

error-percentage of 93, group SS-4 an error of 95 percent, and SS-5 an error of 96 percent. The combined groups experienced 75 percent error. (Groups SS-2 and SS-3 found the letter "p" most difficult with a percentage-error of 61 and 70. The descender "g" was the second most difficult to read with a combined error of 67 percent. Group SS-1 showed an error of 71 percent, SS-2 an error of 67 percent, SS-3 an error of 76 percent, and SS-5 a high of 80 percent. The letter "y" was read by three groups with next to the least difficulty. Group SS-1 showed an error-percentage of 69, SS-3 an error of 51 percent and SS-5 an error of 66 percent. However, the percentage of error for all groups combined indicated the letter "p" as next to least in legibility, with a score of 64 percent. The letter "y" gave least difficulty for the combined groups, although the individual groups varied considerably. Groups SS-1 and SS-5 experienced fewest errors with the letter "p", with scores of 67 percent and 49 percent, respectively. Group SS-2 succeeded best with the descender "g", with a percent of error of 46. Group SS-3 found the letter "j" easiest to read with an error of 50 percent.

Concisely, this segment of the study showed that two descenders were the least legible: "j" and "g", the latter having been read with less difficulty. The remaining descenders, "y" and "p", were read more easily, although the order of legibility was not defined.

A comparison of the error-percentage between the

ascenders and descenders indicated two similarities. First, there was a wide range of error in both categories. The ascenders showed a low of 33 percent and a high of 88 percent. The descenders showed a range of 46 to 96 percent. Second, the total percentage of error between the combined groups was very close. The ascenders were copied with slightly under 66 percent while the descenders were subject to a little less than 65 percent error.

The percentage of error with the five vowels showed the greatest consistency between the groups of subjects. The letter "a" was the most difficult to read, for all but group SS-5. Groups SS-1, SS-2, SS-3 and SS-4 experienced a percentage error, respectively, of 78, 76, 77 and 84. The combined error was 79 percent. (Group SS-5 found the letter "e" the most difficult with an error slightly in excess of 80 percent.) Three groups of subjects made the second highest error-rate with the letter "e". Group SS-1 showed an error of 75 percent, SS-3 an error of 76 percent, and SS-4 an error of 76 percent. The combined error was 71.82 percent. (The decimal is used here for subsequent reference.) The vowels "e" and "o" were very close in error-rate, although the latter showed slightly less with the combined groups. With the exception of group SS-2, the remaining groups, in order, showed an error of 70, 72, 74, and 78 percent. The total error for the combined groups was 71.71 percent, for the letter "o".

The letters "i" and "u" caused the least difficulty

in the subjects' responses. The vowel "i" was read by the combined groups with an error of 68 percent. The vowel "u" with an error of nearly 64 percent. The individual groups showed least uniformity in response to the letter "i". Only groups SS-3 and SS-5 found this letter next to least in reading difficulty, with errors of 69 and 74 percent. Groups SS-1 and SS-4 experienced next to least errors with the letter "u". Their error-rate was 67 and 74 percent. Although the legibility of the letter "i" was not well-defined among the individual groups, the vowel "u" proved most legible for three groups. SS-2, SS-3, and SS-5 had less percentage of error with scores of 48, 65, and 71 percent. Groups SS-1 and SS-3 succeeded best with the letter "i".

It became apparent that the letter "a" was the least legible vowel, that the letters "e" and "o" were very close in the ascending order of legibility, and that the letters "i" and "u" were the most legible.

The percentage of error in the nine letters with no extenders showed some uniformity between groups. It was obvious that the letters "c" and "x" caused most of the errors. Groups SS-1 and SS-5 found the letter "c" the most difficult, with an error-percentage of 85 and 87, respectively. Groups SS-2 and SS-4 made most errors with the letter "x", with an error-percentage of 82 and 88. The combined error, for both the letter "c" and "x" was 79.75 percent. (Group SS-3 had most difficulty in copying the letter "r", with an error rate of 73 percent.) Three groups

found the letter "r" to be third in order of difficulty. Groups SS-1, SS-4 and SS-5 rated 77, 83, and 83 percent, respectively. However, the combined groups had most difficulty with the letter "z". Two classes of subjects found the letter "s" to be fourth in order of difficulty. Group SS-1 rated 75 percent, and SS-4 rated 80 percent, while the combined groups rated 72 percent error with the letter "s". The letters "n", "z", "v", and "m" were read with varying difficulty by the individual groups. The order of legibility was not clear. The letter "w" was definitely the most legible. Groups SS-1, SS-3, SS-4 and SS-5 rated percentages of 60, 54, 57, and 66.67 respectively. (SS-5 also found the letter "v" most legible with an identical error of 66.67 percent.) The combined groups had most success with the letter "w", with an error percentage of 57.

The ascending order of legibility in letters with no extenders showed that "c" and "x" were the least legible, that "r" and "s" were next in order, and that the letter "w" was the most legible.

A comparison of the error-percentage between the vowels and the letters with no extenders indicated the same two similarities found between the ascenders and descenders. First, there was a wide range of error in both categories. The vowels showed a low of 48 percent and a high of 84 percent. The letters with no extenders showed a range of 53 to 88 percent. Second, the total percentage of error between the combined groups was very close. The vowels were copied

with an error over 71 percent, while the letters with no extenders were subject to nearly 73 percent error. These findings suggested that a statistical analysis of the four categories of lower case letters might be significant in some combination of these letters.

Ascenders vs. Descenders

Table 4 shows the results of the tests between ascenders and descenders. Groups SS-1 and SS-3 showed t scores of -2.58 and 2.46, respectively. These scores were significant at the .05 level. Group SS-1 experienced considerably more errors in the descenders. Group SS-3 experienced considerably more errors in the ascenders. These contrasting results are considered to be random effects, or produced by differences within the groups of subjects. Groups SS-2, SS-4, and SS-5 showed scores of .93, .43, and 1.97, respectively. These results were not significant. The score for the combined groups was not significant at .56. The conclusion was reached that there is no significant difference in the legibility of letters with ascenders and those with descenders.

Vowels vs. Letters with No Extenders

The results of the tests between the vowels and the letters with no extenders are shown in Table 5. The five groups of subjects, in order, received scores of -.68, .10, -.03, -.55, and .35. (The minus sign indicates slightly more errors in the letters with no extenders.) The results were

not significant. The test for the combined groups showed a score of -1.17, which was not significant. These results appeared definitive. There is no significant difference in legibility between lower case vowels and those with no extenders.

Ascenders and Descenders vs. Vowels and Others

Finally, a series of tests were done to examine a combination of the categories of lower case letters. The ascenders and descenders, together, were compared to the vowels and the letters with no extenders (Table 6). All of the tests were significant at the .001 level. All groups of subjects experienced more errors with the vowels and letters with no extenders. The results for groups SS-1 (5.96) and SS-5 (5.94) were very close. These two groups represent the extremes in ability level. Consequently, this factor was negated as a possible explanation. Group SS-2 showed a score of 4.95, while the results with groups SS-3 and SS-4 were 6.62 and 6.46, respectively. The test for the combined groups showed a score of 13.02. These decisive results indicated the superior legibility of ascenders and descenders. This investigator believes that the explanation lies in the nature of the letters. Ascenders and descenders, by virtue of their extenders, are distinctive when compared to the other lower case letters. The vertical height of the vowels (with the exception of "i") and the letters with no extenders is precisely the same. The letters with extenders, whether up

or down, occupy a larger vertical space and exhibit a discrete character. This individuality renders them more legible.

Comparison of Upper and Lower Case Letters by Sex

A series of tests were done to determine any difference in legibility between upper and lower case letters by the sex of the subjects (Table 7). Groups SS-1, SS-4, and SS-5 received scores of .58, .82, and .48. These results indicated that the males had a slight superiority in reading upper and lower case letters, although the scores were not significant. The results of the tests with groups SS-2 (-.30), and SS-3 (-1.79), showed that the females had a slight superiority in reading upper and lower case letters. These results were not significant. The combined score of -.72 implied that the females experienced slightly less difficulty in reading upper and lower case letters, but was not significant. All tests showed that there was no significant difference in the legibility of upper and lower case letters because of sex.

Effect of Distance on Legibility of Letters

Table 8 shows the results of the tests done to compare the legibility of upper and lower case letters by distance from the screen. In this part of the study, the subjects were divided into two groups (Fig. 2). Group SS-5 was not included in these tests because all subjects were normally seated in the area nearer the screen. The results were not

expected. Groups SS-1 and SS-3 each received a score of -1.90. Although not significant, this indicated that the subjects farther from the screen read the letters as well as those closer to the screen. Group SS-4 received a score of -.46, which was well below the level of significance. Group SS-2 received a score of -4.39 which was significant at the .001 level. This implied that the subjects farther from the screen read upper and lower case letters with considerably more success than those nearer the screen. The results of the combined groups showed a score of -3.36, which was significant at the .01 level. This, too, indicated the superior legibility of the letters with those farther from the screen.

This investigator viewed these results with reservations. An interpretation of the results should consider the relatively high score of group SS-2 (-4.39). This may have been a random effect within the group, and as such, dominated the results of the combined groups. Furthermore, neither of the other groups showed a significant score.

However, a factor which should be considered is the size of the projected symbols. As shown in Appendix J, the height of each upper case letter was slightly over one inch, and the length of the upper case nonsense words varied from slightly over three inches to more than five inches. The height of the lower case letters varied from a little over one half inch to slightly over one inch, while the length of the lower case nonsense words varied from nearly two and three quarter inches

to nearly five inches. It is conceivable that too large letters slow down reading when the subjects are at close range. This might be an area for future research with transparencies for the overhead projector.

Effect of Age on Legibility of Letters

A series of tests were done to determine any difference in legibility of upper and lower case letters attributable to the age of the subjects. Table 9 shows these results, along with the division of subjects, into two age brackets. The results from group SS-3 showed a score of --2.74, which was significant at the .05 level. This meant that the older subjects made fewer errors than the younger subjects. However, these results were isolated, and the significance minimized, by the scores of the remaining groups. Group SS-1 received a score of -.02, and groups SS-2, SS-4, and SS-5 showed scores of .72, .09, and .59, respectively. None of these scores was significant. The combined groups showed test results of -1.54, which was not significant. It became obvious that age was not a significant factor in the legibility of upper and lower case letters.

Conclusion

Under the conditions of this study, it was found that upper case letters were more legible than lower case letters on transparencies for the overhead projector. It is suggested that only upper case letters be used on transparencies when the presentation consists of short, concise

information. It is also recommended that if lower case letters are used on transparencies, consideration be given to their inequality and reflected in longer exposure time.

Recommended Research

This study should be replicated in other grade levels to establish the prevalence of the results. There is also a need to investigate the maximum amount of information that may be conveyed using upper case letters only. A legibility study could be made to determine the effect of letter size with near and far groups of subjects. Other investigators might examine the efficacy of color in legibility studies.

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A P P E N D I X A

GLOSSARY OF TERMS

ascender:	a stem extending upward from the body of certain lower case letters.
boldface:	characters, in print, with conspicuous or heavy lines.
descender:	a stem extending downward from the body of certain lower case letters.
extender:	a stem extending upward or downward from certain lower case letters.
legibility:	capable of being read or deciphered; distinct to the eye.
lower case:	designating the small letters of the alphabet.
mask:	an opaque material used to effect partial exposure of a transparency.
original:	the master design from which transparencies may be copied.
point:	the designation of a type body nearly equal to 1/72 inch.
progressive revelation:	a method of increasing the projected information from a transparency by the use of opaque materials.
projectual:	a large (7-1/2" x 9-1/2" or 8-1/2" x 11") transparent sheet containing information to be projected by the overhead projector.
readability:	legible; as, readable handwriting.
registration pins:	precision-made pins (by Tecnifax) used to align transparent materials.
sans serif:	lettering without the fine cross strokes.
stage:	the part of an overhead projector upon which materials may be placed for projection.

static mask: in this study, an opaqued transparency with clear rectangular areas for the exposure of words.

tachistoscopic projection: exposure of an image for 1/5 second, or less.

transparency: used, interchangeably, with projectual.

upper case: designating the capital letters of the alphabet.

vowels: the five letters of the alphabet: a, e, i, o, u.

A P P E N D I X B

LETTER FROM

WESTERN UNION TELEGRAPH COMPANY

THE WESTERN UNION TELEGRAPH COMPANY

60 HUDSON STREET

NEW YORK 13, N.Y.

April 25, 1967

Mr. Chester E. Pierce
AV Director
D. A. Sullivan School
Northampton, Mass.

Dear Mr. Pierce:

In answer to your inquiry why telegrams are printed in upper case, I am afraid the answer has little to do with the legibility factor, and was established years ago. Eliminating the upper and lower cases on teleprinters, electric typewriter-like machines used to transmit telegram information, saves considerable wear on the teleprinter itself as well as its operator. As you know most typewriters either must lift their carriages or lower their keys to strike a capital and some punctuation marks.

Similarly, teleprinters would have to operate the same way on both the send and receiving ends, and electric signals would have to be transmitted to cause the striking of capitals and some punctuation.

Newer teleprinters do have upper case characters, but not for capital letters. They are to strike numerals and the less frequently used punctuation marks, such as ampersands, asteriks, and percentages.

I hope the above will be helpful to your study.

Yours truly,

R. V. Spelleri
Publicity Manager

R V Spelleri

A P P E N D I X C

COMMUNICATION FROM

WESTERN PUBLISHING EDUCATIONAL SERVICES

THE UNIFON ALPHABET FOUNDATION
(The Foundation for a Compatible & Consistent Alphabet)
5464 South Shore Drive, Chicago, Illinois 60615 Tel. 684-2439

RECONSIDERATION OF THE MATTER OF CAPITALS VERSUS LOWER CASE AS AN INITIAL READING EXPOSURE MEDIUM

by John R. Malone, Executive Director
Foundation for a Compatible and Consistent Alphabet

Today, in the field of education, there seems to be abroad the idea that the child's first set of letters ought to be lower case letters rather than traditional Roman capitals.

This is apparently based on two assumptions:

(a) The world of print is largely lower case or capitals and the lower case, and therefore the child should become habituated to this mode of spelling and printing as early as possible to reduce confusion later.

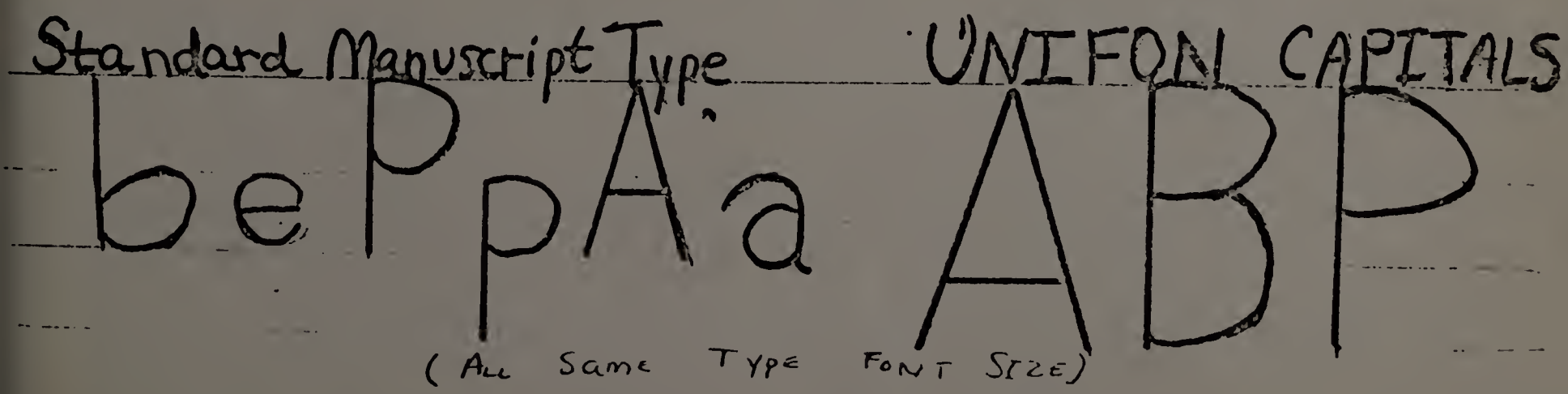
(b) The only means of reading-teaching which can be really effective for high speed reading is pattern or gestalt reading in which the child recognizes word configurations with the ascenders, descenders and other significant pattern elements, therefore learning lower case patterns from the earliest exposure onward and reducing the element of confusion in the reading process.

The two modes of setting text in type have some observable characteristics which need to be pointed out here before going on:

a	b	c	d	e	f	g	h	i	j	k	l	m	n	o	p	q	r	s	t	u	v	w	x	y	z
A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z

same physical characteristics

Letters of the same type size as above have differing legibilities. Capital letters, because of the simpler and bolder strokes can be seen at a greater distance, or seen by a lower degree of optical discrimination (index of refraction) than can lower case of the same (font) size. The sketch below of capitals and lower case of the same font size indicates why this is true.



Because of this fact, display letters on signs, boxes, cartoons, TV Commercials, name plates and titles are frequently lettered or printed in Roman capitals. As a consequence, the greatest share of all literate evidences swimming into a young child's visual awareness at home or abroad are in such capital letters. For instance, below is one child's total set of literate symbols seen as she rides from home to a commuter station with her mother to pick up her commuting father:

STOP	NEW YORK CENTRAL	ONE-DAY SERVICE
YIELD	SYSTEM	LUNCHENONETTE
SCHOOL SPEED LIMIT	REES AUTO ELECTRIC	STOP
20 MPH ON DAYS WHEN	BUILDING MATERIALS	PARKING 25¢ ALL DAY
CHILDREN ARE PRESENT	MATTESON LUMBER	NO U-TURN
SCHOOL SPEED SLOW AHEAD	GOLD BOND	CENTER PIER
YIELD RIGHT OF WAY	PAINTS	MOTOR TUNE UP DINO
SPEED ELECTRICALLY TIMED	SALES SERVICE	GARAGE
SEE TOP REALTY	NO THRU WAY	CHRIS AUTO CLINIC
FOR SALE ROSE	TAVERN	SINCLAIR
SPEED LIMIT 20 MPH	PACKAGE LIQUORS	MATTESON LIBRARY
READY	CHILDREN'S SERVICE	PICKUP AND DELIVERY
MIX CONCRETE LASTS A	STOP	CLEANERS
LIFETIME	USED CARS	STOP AHEAD
TEST DON'T GUESS	ONE-HOUR PARKING	PIZZA

The same is true of the "balloons" in comics, most food containers, trade names and TV commercials.

A second consideration for a young child is that the Roman capitals are easier to hand-letter or produce, requiring a lower degree of dexterity and visual discrimination, in order to produce legible letters in the Roman capital mode.

The world of lower case letters (newspapers, magazines, books) pertains to type of 10-point size and below, and the visibility of most of this material is below the visual discrimination capability of children until they are about seven. This is acknowledged by the fact that young children's books are printed in 12, 14, and 18-point type.

Thus it would appear that initial teaching letter modes should be capitals, rather than lower case. If a synthetic intermediate alphabet (UNIFON or Pitman ita) is used for children, it should be to see and use outside of their classroom or learning experience, so that a measure of immediate external reinforcement can take place, in the world around them.

In general, let us re-consider whether we should not go back to first things, and give the children capitals first (synthetic by way of UNIFON) and standard traditional capitals, then move on

to the lower case when some visual-oral reflexes have been established and some intimacy of contact with print has been established, then as the child's eye improves in refractive power at seven or eight years of age, move along to capitals and lower case.

A P P E N D I X D

LETTER FROM

BRYANT R. CHAPLIN

DIVISION OF FISHERIES AND GAME

The Commonwealth of Massachusetts

Division of Fisheries and Game

FIELD HEADQUARTERS, WESTBORO 01581

April 17, 1967

Chester E. Pierce
AV Director
D. A. Sullivan School
Northampton, Massachusetts

Dear Mr. Pierce:

As an editor of nearly 25 years, and in charge of this agency's printing for about 18 years, I'll attempt to answer your letter of March 22 re use of upper and/or lower case letters.

There are plenty of books on the subject of choosing type faces, too many to list here. When dealing with a printer, you always wind up using his style book - which shows the types he has in stock. Preparing material for projection, either by overhead projectors or by slides, involves additional considerations, largely of legibility. This means plain, clear type faces, usually sans serif, with the original prepared in a large enough size so that projections will be easily read by the audience. Letters selected should be heavy enough so that Eberhardt effect does not result, producing the same result as if it were out of focus.

I know of no material which specifically recommends or requires the use of upper over lower case. This decision usually a local one, made on the basis of available space and desire to have the material attract attention at a distance. 48 point caps will always look bigger than 48 point lower case. However, in runs of type approaching sentence length they will not be as easily read.

On short, upper case may be used on occasion to attract attention, but lower case will be used in the rest of the poster. You may note this is usual on posters we design.

Sincerely,

Bryant R. Chaplin, Chief
Information & Education

BRC:mp

A P P E N D I X E

DESCRIPTION OF TACHISTOSCOPIC DEVICE

The tachistoscopic device for the Tecnifax overhead projector comprised three elements: (1) a timer, (2) the tachistoscope, (3) a telegraph key to activate the tachistoscope.

The components were assembled by the School of Psychology at the University of Massachusetts, and loaned for this study.

1. The timer was a product of the Hunter Manufacturing Company, Inc., Iowa City, Iowa. Model 111-C.

2. The tachistoscope was attached to the lens barrel of the projector. It was necessary to devise dampening mechanisms to avoid undesirable vibrations when the shutter was activated. Masking tape (with a width of three quarters of an inch) was wound around the lens barrel to a thickness of approximately one quarter of an inch. A split wooden ring, of appropriate diameter, was placed over the masking tape. The wooden ring was three quarters of an inch wide, and one half of an inch thick around its circumference.
The circular ring of the tachistoscope was placed over the split wooden ring. A tightening-screw on the tachistoscope secured all mechanisms to the lens barrel.

3. The telegraph key was wired to the timer and the tachistoscope. When the key was depressed, the shutter responded to the split-second exposure of the timer.

A P P E N D I X F

RATIONALE FOR TIME SEQUENCES

While the study was being organized, this investigator experimented with time sequences in an effort to establish a point of departure for the classroom presentation. It was determined that a ten-second pause between tachistoscopic exposures would permit sufficient time for the subjects to respond, and to redirect their attention to the screen. It was also decided that a tachistoscopic projection speed of one tenth of a second would be near the critical point; that is, the speed where approximately fifty percent of the copy error would be in lower case letters.

On the day preceding the experiment, preliminary testing was done with a trial group of eighth grade students. It was necessary to enlist the services of an aide at this time. Mr. Richard Carnes, a classroom teacher, assisted with the mechanics of the experiment.

The procedure with the trial group followed, as closely as possible, the routine for the actual experiment. However, the appropriate instructions were given verbally rather than by pre-recorded tape. (The directions were read from a printed copy. The same was to become the "Instructions for Legibility Test" [Appendix K] when the time sequences were finalized.)

After the nonsense words on the practice instrument had been exposed (in the pre-determined time sequences), the

flaps on the projectual were raised so that all nonsense words were visible. The subjects were instructed to place an "x" above all the letters that were mis-copied. This investigator, and aide, made a visual examination of the subjects' responses. It was found that a faster projection speed was needed to produce a copy error of fifty percent in the lower case letters.

The exposure time was increased to 8/100 of a second for the nonsense words on the first projectual. Thereafter, the flaps on the projectual were raised so that all nonsense words were visible. The subjects were instructed to place an "x" above all errors in copy. A visual examination by this investigator, and aide, suggested a faster speed.

The nonsense words on the second projectual were exposed for 6/100 of a second. (At this speed, it soon became evident that the subjects were frustrated.) The same procedure for assessing the subjects' responses was followed as for the previous projectuals. It was obvious that the exposure time was too fast.

The nonsense words on the third projectual were exposed for 7/100 of a second. The same procedure for assessing the results was used. At this speed, the copy error was between fifty and sixty percent -- in the lower case letters. It was decided to use the same exposure time for the next projectual.

The nonsense words on the fourth projectual were exposed for 7/100 of a second. The results, again, showed

a copy error, in the lower case letters, of between fifty and sixty percent.

Time did not permit the presentation of the fifth projectual. The class period had ended.

During this trial run, it was found that the pause between tachistoscopic exposures should be ten seconds.

Subsequent analysis of the test instruments indicated that a tachistoscopic projection speed of 7/100 of a second suited the requirements of the study. An exposure time of 8/100 of a second had produced a copy error of about forty-five percent -- on the average. It was decided that the former speed would best serve a discriminant function.

As a result of the preliminary testing, the time sequences used in the experiment were these:

(1) a tachistoscopic exposure of 7/100 of a second,

(2) a pause of ten seconds between exposures.

A P P E N D I X G

DESCRIPTION OF CONSTANT-VOLTAGE REGULATOR

The constant-voltage regulator was a product of the Sola Electric Company, a division of Sola Basic Industries, Elk Grove Village, Illinois.

The regulator, type CVS, accepts input voltages of 95 to 130 volts and maintains a steady output voltage of 118 volts.

The regulator was introduced between the wall receptacle and the projector.

A P P E N D I X H

DIMENSIONS OF POINTERS

The "pointers" adherred to the screen were cut from a plastic 'electrician's' tape. Each "pointer" formed an equilateral triangle, with a base of one-half inch.

This preparation was completed the evening before the presentation to the trial group. After this presentation, the screen was recoiled and remained so until the morning when the subjects entered the classroom.

A P P E N D I X I

DISTANCE MEASUREMENTS FROM SCREEN

1. Room dimensions: 35' x 25' x 8-1/2'.

2. Screen was centered at the front of the room.

3. Top of screen: 8 feet.

4. Three rows of tables were placed at measured distances from the screen. An equilateral triangle was formed with the apex at the center of the screen and the base running along the far side of the rear tables. The altitude of the triangle was 28 feet.

5. Table tops measured 5' x 2'.

6. Horizontal distance between tables was 30 inches.

7. Vertical distance (front to rear) between tables was 30 inches.

8. Distances from center of screen to the center, and far sides, of the middle rows of tables were as follows:

1st row	12 feet
2nd row	16 feet
3rd row	20 feet
4th row	24 feet
5th row	28 feet

9. A single tablet-arm chair was placed in the rear, right (looking from front to rear) of the room. It was positioned so that any subject seated here would be 31 feet from the center of the screen.

10. The distance from the screen to the nearest subject was about 12 feet.

11. The distance from the screen to the farthest subject was about 31 feet.

A P P E N D I X J

TYPE SIZE AND LETTER MEASUREMENTS

Type size is measured by a unit called the point. A point is one-seventy-second of an inch. Seventy-two points equal one inch.

The type size used in this study was twenty-four point. Twenty-four points (24/72) equal one third of an inch. This means that the distance from the highest ascender or capital letter to the bottom of the lowest descender was one third of an inch.

The height of all upper case letters was the same. The height of all ascenders was constant, and the height of all descenders was similar. The body of the lower case letters (that is, the height of the symbols without ascenders or descenders, or without the dot over the "i") was the same.

The size of the letters and nonsense words on the projectuals were as follows:

1.	Height of upper case letters	7/32"
2.	Height of the body of lower case letters	4/32"
3.	Height of lower case letters with ascenders	7/32"
4.	Height of lower case letters with descenders	6/32"
5.	Length of longest nonsense word in upper case ("DAMAN" on Plate I)	1-3/32"
6.	Length of shortest nonsense word in upper case ("PIPIT" on Plate II)	19/32"

7.	Length of longest nonsense word in lower case ("wyden" on Plate III)	30/32"
8.	Length of shortest nonsense word in lower case ("litas" on Plate V)	17/32"

The measurements of the projected images on the screen were as follows:

1.	Height of upper case letters	1.12"
2.	Height of the body of lower case letters	.64"
3.	Height of lower case letters with ascenders	1.12"
4.	Height of lower case letters with descenders	.96"
5.	Length of longest nonsense word in upper case ("DAMAN" on Plate I)	5.62"
6.	Length of shortest nonsense word in upper case ("PIPIT" on Plate II)	3.05"
7.	Length of longest nonsense word in lower case ("wyden" on Plate III)	4.82"
8.	Length of shortest nonsense word in lower case ("litas" on Plate V)	2.73"

A P P E N D I X K

FREQUENCY OF LETTERS ON TRANSPARENCIES

Upper Case		Lower Case		Upper Case		Lower Case	
A	29	a	27	R	17	r	14
B	9	b	9	S	11	s	10
C	6	c	6	T	12	t	8
D	6	d	10	U	18	u	8
E	21	e	21	V	4	v	3
F	2	f	3	W	4	w	3
G	6	g	4	X	2	x	6
H	5	h	6	Y	6	y	9
I	11	i	21	Z	2	z	8
J	4	j	2		250		250
K	6	k	6				
L	23	l	18				
M	10	m	7				
N	10	n	17				
O	18	o	17				
P	8	p	7				

L.C. Letters with Ascenders		Corresponding U.C. Letters	
b	9	B	10
d	10	D	6
f	3	F	2
h	6	H	5
k	6	K	6
l	18	L	23
t	8	T	12
	60		64

L.C. Letters with Descenders		Corresponding U.C. Letters	
g	4	G	6
j	2	J	4
p	7	P	8
y	9	Y	6
	22		24

L.C. Letters with no Extenders		Corresponding U.C. Letters	
c	6	C	6
m	6	M	10
n	18	N	10
r	14	R	17
s	10	S	10
v	3	V	4
w	3	W	4
x	6	X	2
z	8	Z	2
	74		65

L.C. Vowels		U.C. Vowels	
a	27	A	24
e	21	E	21
i	21	I	11
o	17	O	18
u	8	U	18
	94		97

A P P E N D I X L

PRE-RECORDED TAPE:

INSTRUCTIONS FOR LEGIBILITY TEST

Hello, boys and girls. We are going to use the overhead projector to see how well you can read words when they are projected rapidly.

You notice on your desks a pencil, one practice sheet and five forms stapled together. Would you please take the pencil and the practice sheet, and write your name on the line.

You see that there are many blanks on the form, and that they are separated into fives.

You will be shown many five-letter words, one at a time. They are not real words because the letters are all jumbled up. Some are printed in capitals. Others are all small letters. The words will appear on the screen for a very short time, so look carefully. None will be repeated.

When you see the first word, write each letter in the small blanks. Then, do the same for the next word, and so on. You may write with small letters or capitals. Use those which are easier for you. We will move from left to right, just as you do in reading.

The black dots on the screen will show you the approximate center of each word.

Any questions? (Stop tape.)

(Start tape.) Be sure that you have the practice sheet to write on. Each time you hear a tone, a word will

be projected on the screen.

Ready?

(Tone, followed by 7/100 second projection. Pause for ten seconds. Repeat for eight words on practice sheet.)

Here are the words as you should have copied them. (Remove mask.) Don't bother to mark your words right or wrong. Any questions? (Stop tape.)

(Start tape.) Please put this practice sheet inside your desk. We will now begin the experiment.

Take the forms which are stapled together and write your last name, only, on the lines -- on all five sheets. (Stop tape.)

(Start tape.) Notice that the pages are numbered. Be sure to begin on page one, and change sheets when we switch to a different transparency.

We will fill the complete form this time.

We all have page one before us, and pencils ready?

(Tone, followed by 7/100 second projection. Pause for ten seconds. Repeat for twenty words on the first transparency.)

Now, fold the first page back so that the second page faces you, and lay the papers on your desk. The procedure will be the same as before. Pencils ready for the second transparency?

(Tone, followed by 7/100 second projection. Pause for ten seconds. Repeat for twenty words on the second transparency.)

Now, fold the second page back so that the third page faces you, and lay the papers on your desk. The procedure

will be the same as before. Pencils ready for the third transparency?

(Tone, followed by 7/100 second projection. Pause for ten seconds. Repeat for twenty words on the third transparency.)

Fold the third page back so that the fourth page faces you and lay the papers on your desk. Pencils ready for the fourth transparency?

(Tone, followed by 7/100 second projection. Pause for ten seconds. Repeat for twenty words on the fourth transparency.)

Fold the fourth page back so that the fifth page faces you. Pencils ready for the fifth transparency?

(Tone, followed by 7/100 second projection. Pause for ten seconds. Repeat for twenty words on the fifth transparency.)

Now, boys and girls, lay the pencil on the desk. Fold page five back so that the first page faces upward.

Remove the practice sheet from inside your desks and place it on top of the stapled forms.

A P P E N D I X M

DESCRIPTION OF TONE USED AS "READY" SIGNAL

A toy xylophone was used to produce the tone for the "ready" signal on the pre-recorded tape. The instrument was manufactured by the Tudor Metal Products Corporation, Brooklyn, New York. It was designated as Model 140.

The tone was produced by striking the metal bar "E" with a small plastic hammer. The pitch of the tone was roughly equivalent to "F" above middle "C".

A P P E N D I X N

COPY INSTRUMENTS

NAME

NAME_____

NAME_____

NAME _____

Page 4

NAME_____

PRACTICE SHEET

NAME

Approved by Raymond Ahyman
Major Advisor

Date April 24, 1969