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ABSTRACT

An audiovisual sensory test on 66 educational psychology students supported the contention expressed in Holmes' "Substrata Factor of Reading" that the individual differences in the sensory modes are not necessarily highly correlated. It further suggested that there exists an "intersensory facilitation," but that facilitation is probably not at the level of elementary perception but on the somewhat higher levels of cerebral association. Students were assigned to two groups alphabetically; those in group 1 were asked to distinguish between tone pairs and then between pairs of visual wave patterns. Group-2 students were tested first for visual and then for auditory discrimination. Statistically insignificant correlations were found between age and ability to discriminate both sound and visual pairs. No sex differences were found in either test. Although group 1 second higher than group 2, the auditory test was much easier for both groups than was the visual test. An analysis was made of the auditory and visual scores of the upper and lower 27 percent of students in order to determine whether greater sensitivity in one sense modality necessarily facilitates, inhibits, or is compensated for in the other mode. All the correlations were low and not statistically significant. It did not seem that extreme visual and auditory discrimination abilities measured by the tests were correlated. Tables and references are included. (BT)

Some Relationships Between Auditory and Visual Discriminations

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Martin Kling

INTRODUCTION

AUDITORY AND VISUAL sensitivity have been suggested as accounting for individual differences in efficiency of learning.

Horn (15) indicated that auditory, visual, and kinesthetic imagery contributed to increased efficiency of learning. However, he pointed out that "imagery and imagery types are among the most baffling problems in psychology (p. 1258)."

On the basis of the types of errors made in spelling Kallum (17) concluded that there were six types or classes of people, depending on how they received impressions and how these impressions were remembered:

1. Visuals – those who receive all the images through the eye.
2. Audiles – those who receive all the images through the ear.
3. Motiles – those who receive all the images through their motor senses.

4-6. Combinations of the above.

Other investigators who mention Kallum's imagery types are Humphrey (16), Nolde (20) and Tidyman (23).

Studies on mental imagery and its relation to learning have been made by Angell (1), Fernald (5), Griffitts (9), Holmes (12), and Lamy (19.)

Holmes (14) postulated in his *Substrata-Factor Theory of Reading* that "there are individuals who seem to favor or to be favored by *one of*

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the sense modes of perception (visual, auditory, kinesthetic) in all learning tasks" (Ch. XXXII, p. 2).

The purposes of this study were:

1. To construct an auditory and visual discrimination test.
2. To study some relationships between auditory and visual discrimination.

The significance of this study lies in its attempt to formulate and provide a method for comparing responses to changes in auditory and visual stimuli. A practical outcome may be a diagnostic test for determining the auditory and visual sensitivity of individuals and in groups for placement and teaching.

REVIEW OF LITERATURE

Some Relationships Between Audition and Vision

Surprisingly little experimental evidence exists on the relationship between audition and vision. Ryan (21) and Gilbert (8) have written general reviews on the interrelations of the sensory systems; Harris (10) published a short monograph on some theoretical and experimental physiological comparisons; and Stevens (22) attempted to utilize the concept of the decibel as a basis for comparing light and sound.

Ryan's (21) summary added historical perspective to the problem of sensory interrelationships, defined some of the areas of investigation, and cited experimental evidence.

Ryan (21) quoted Dashiell:

> Shades of our predecessors with their air-tight sense modalities! They did, to be sure, recognize the synethesias, colored hearing, number forms, and the like. . . . Such curiosa were, however, curiosa (p. 660).

Commenting on Dashiell's remarks, Ryan wrote:

> Dashiell is, we fear, too optimistic concerning modern research on perception. Many of our predecessors did have "air-tight sense-modalities," but so do many of our contemporaries. In assembling the material for this paper, the writer found quite as much factual material in papers written by "our predecessors" as he did in more modern papers (p. 660).

Studies relevant to intersensory facilitation have been reported by Hartmann (11) and Child and Wendt (3). Hartmann (11) found that bright illumination increased by 3 per cent scores for the Seashore records for pitch and intensity discrimination, in contrast to a "dark" condition with a dim light for recording judgments. Child and Wendt (3) studied the effect of time interval between a flash of light and a sound, determining auditory thresholds. The effect of light was greatest when it appeared from 0 to .5 to 1.0 second before the sound.

An attempt to compare directly subjective loudness and brightness utilizing a decibel scale for light and sound has been reported by Stevens (22). The observer was asked to choose a white light that appeared to be as bright as a standard stimulus. The subject usually chose a white light about 9 decibels less than the standard. If asked to choose a level of white noise that sounded half as loud as a standard noise, the individual did about equally well as for white light. For a direct comparison, pairs of luminances were subjectively matched by observers. The results indicated that, on the average, subjects "set the same decibel difference between the noises as the experimenter sets between the luminances" (22, p. 17).

Ryan's and Gilbert's reviews, Harris' hypotheses and psychological speculations, and Stevens' attempts to compare light and sound tend to support the possibilities that:

1. Audition and vision are similar in many ways with respect to their reaction to stimuli of frequency, duration and amplitude. (18)
2. Sensitivity of the individual neurones of audition and vision may be normally distributed.
3. Intersensory facilitation may exist.
4. The subjective determination of the loudness and brightness ratio tends to approach the objective ratio between the standard of white noise and white light.

CONSTRUCTION OF THE AUDITORY AND VISUAL DISCRIMINATION TESTS

Apparatus Used in Constructing the Auditory Discrimination Tests

The source of the stimuli for the pure tone auditory discrimination test was a General Radio beat-frequency oscillator, Type 713-B (7). A pure note of any desired frequency between 10 and 40,000 cycles per second may be obtained from this instrument.

Pure tone frequencies of 532, 516, 508, 505, 504, 468, 484, 495, and 496 cycles were fed directly into a Berlant Broadcast Recorder Drive Mechanism (2), BRX-D, which taped the pure tones at 7.5 inches per second.

Duration was controlled by splicing a continuous tape for one particular frequency level. Splices were 4.5 inches apart, or the equivalent of .6 second. Time intervals between the pairs of auditory stimuli were made by inserting a 4.5 inch blank strip of tape, also equivalent to .6 second. The recording interval between the pairs of stimuli was held constant at 24.0 inches, or the equivalent of 3.2 seconds. This method of taping affords the opportunity of arranging the stimuli in any prescribed order, eliminates elaborate timing devices, and reduces the possibility of overtones or other influences such as clicks.

The amplitude was held constant by observing and adjusting the input level control meter of the Berlant Broadcast Recorder. The approximate recording level was −5 db below tape saturation level.

Wave form specifications of the beat-frequency oscillator indicate that the total harmonic content at a frequency range of 250 to 2,000 cycles is less than that of 0.2 per cent, which assured rather pure tone production.

Apparatus Used in Constructing the Visual Discrimination Test

Because the technical problems encountered in constructing the Visual Discrimination Test proved to be particularly difficult, it appears that a statement regarding the developmental stages (including those that fell short of specifications) might be appropriate.

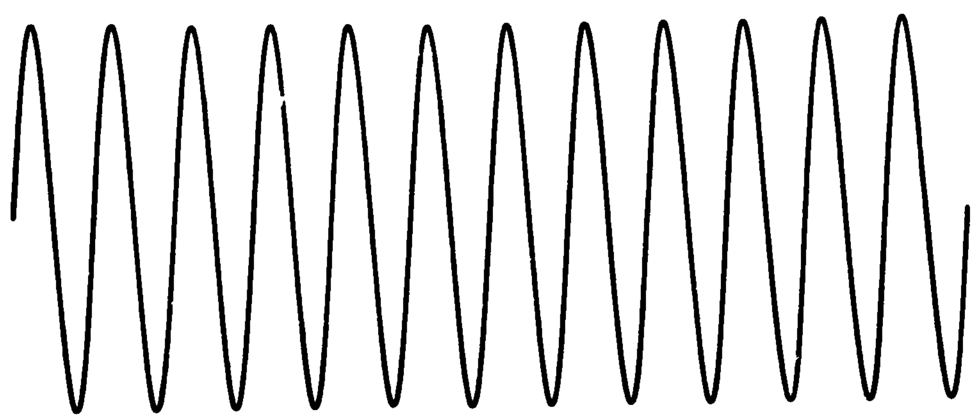
Representations of pure sine waves could not be photographed directly from an oscilloscope which used a beat-frequency oscillator as its source of alternating current. The sine waves were photographed with a Pacemaker Speed Graphic Camera set at f8, 1/25 second, using a Super Panchromatic Press Type B film with a 1/27-inch Ektar lens.

Inspection of the sine wave pattern revealed that the distances between sine wave peaks were uneven, the number of sine waves were not constant for the same frequencies, the over-all length of the sine wave patterns vary, and the thickness of the sine wave lines were not uniform. Thus, this instrument did not yield a stimulus model with the characteristics of amplitude and wave form which are as precisely controlled as is desirable.

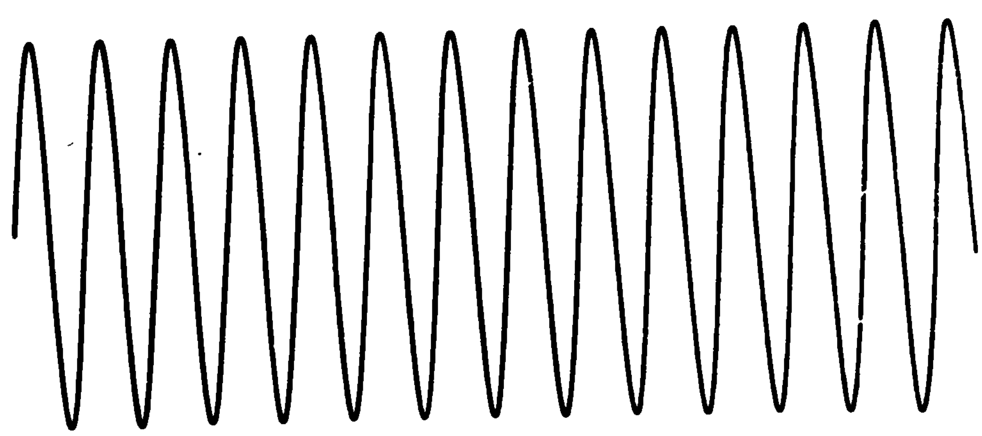
A low frequency oscillator feeding directly into an oscillographic recording system was next tried. Such instruments are known commercially as the Hewlett-Packard Frequency Oscillator, Model 202B, Serial 1624 and the Sanborn Oscillographic Recording System, Model 152-5460.

Although the oscillographic method of recording sine waves were reliable and precise it produced a sine wave pattern that was too small for purposes of this study.

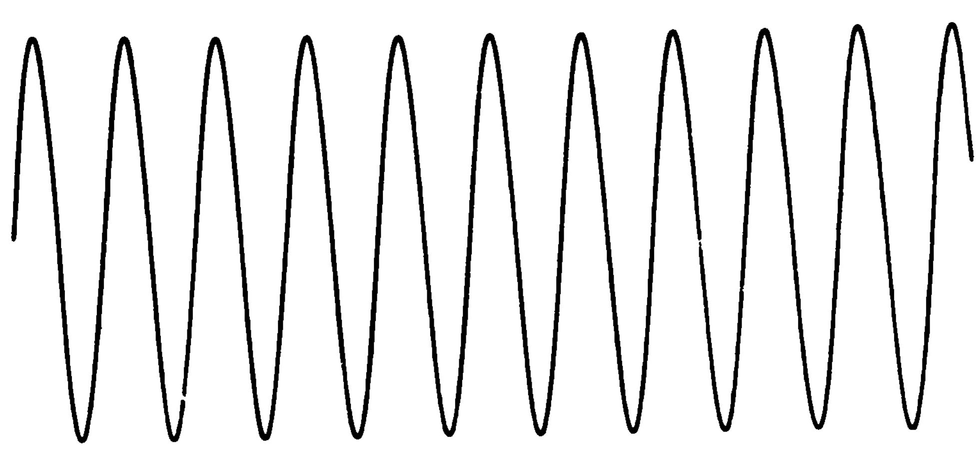
Plate I. Sine Wave Patterns — 500, 564, 436 Cycles



Standard = 500 cps



500 + 64 = 564 cps



500 - 64 = 436 cps

Finally, the mechanical differential analyzer technique, described by Crank (4), was investigated. This instrument which solves differential equations graphically appeared to meet the mathematical and visual criteria demanded in this study.

The machine equation used to present graphically the proportionate sine wave changes consisted of a second order linear differential equation (6).

The graphic solutions of the differential equations were photographed so as to eliminate the grids of the graphs. The prints were mounted by means of a dry mounting tissue process on cardboard. These prints formed the originals which were then photographed by Multichrome Laboratories of San Francisco, California. A 16 millimeter motion picture projector photographed the originals at 24 frames per second. The set-up was fixed with 45° lighting and two 500-watt bulbs.

Only one continuous film of a particular frequency was photographed at any one time. Samples of some original sine waves used are shown in Plate I.

The motion picture films were then cut, sorted and spliced to make the test. Duration was controlled by splicing sections of the film equivalent to the desired time. Seven inches of film is the same as 1 second of motion picture running time at 24 frames per second. Thus, a time exposure of .6 second would be equivalent to 4 inches of film. A recording time of 3.2 seconds is the same as 22 inches of blank light grey film.

Amplitude, length and width of all the sine waves were kept constant throughout.

Constant Stimuli Difference Method

The determination of a difference threshold by the method of constant stimuli difference requires a standard stimulus against which stimuli of varying magnitude are judged.

The method consisted of the following specific procedures:

1. Pairs of stimuli were presented in random order.
2. Each stimulus pair consisted of a standard and a comparison stimulus.
3. The standard stimulus was 500 cycles per second.
4. The per cent change for the auditory and visual was:
   Auditory: 6.4, 3.2, 1.6, 1, .8 per cent
   Visual: 12.8, 6.4, 3.2, 1.6 per cent
5. The standard stimulus was presented in counter-balanced order, that is, half of the standard stimuli were shown or heard first, and the other half last.

The advantages of the constant stimulus difference method are:

1. it makes use of all the data,
2. it avoids error of habituation which may be produced by having the subject repeat the same response several times in succession.
3. it avoids errors of expectancy; a tendency to report the expected change sooner than the stimulus appears (24), (25).

Preliminary Tryout

A preliminary tryout was made. The tests were tried out on six doctoral students in Educational Psychology. The following instructions were given for the Auditory Discrimination Test:

> In the Auditory Discrimination Test you will hear pairs of tones in rapid succession. There are 32 pairs of tones in each part and there are 5 parts. The second tone is either HIGHER, LOWER or the SAME as the first. You are to write H on your answer sheet if the second tone is HIGHER than the first, L if the second tone is LOWER, or S if the second tone is the SAME as the first. Answer every time; if you are not sure, guess. Let us do the first four pairs for practice.

Students were asked to write on the answer sheet their names, age, sex, instruments played, years of musical training and hearing difficulties. The total testing time for the Auditory Discrimination test was 25 minutes.

The directions for the Visual Discrimination Test were the following:

> In the Visual Discrimination Test you will see pairs of wave patterns in rapid succession. There are 32 pairs of wave patterns in each section, and there are four sections on your answer sheet. The distance between the peaks of the second wave pattern may either be NARROWER, EQUAL or WIDER than the distance between peaks of the first wave pattern. (Samples were given of narrower, equal or wider distances between peaks.) You are to put a check mark under the column marked either NARROWER, EQUAL, or WIDER; whichever answer appears to best describe the distance between the peaks of the second wave pattern as compared to the first wave pattern. Answer every time; if you are not sure, guess.

The height of each peak as it appeared on the screen was 6.5 inches; the length of each pattern was 16.5 inches. The illumination was 1 foot-candle. The motion picture running time was approximately 11 minutes and the total testing took 25 minutes.

In addition to identification data, students were asked to indicate whether they wore glasses, for how long and whether they had any eye difficulties.

THE STUDY

Procedure

Auditory and Visual Discrimination Tests were administered to 66 students in an introductory course in Educational Psychology. Altogether there were 42 women and 24 men. Students whose last names were in the first part of the alphabet (A-L) were placed in Group I. The rest went into Group II. Group I took the auditory test first, then the visual test. Group II followed the opposite sequence.

Table I shows that Group I was significantly better than Group II on the Auditory Test.

TABLE I

Significance of Difference Between the Means Of Auditory and Visual Discrimination Tests

	Auditory Discrimination Test			
Group	N	Mean	SD	CR
I	33	137.00	11.25	
				2.38*
II	33	130.00	12.60	

	Visual Discrimination Test			
Group	N	Mean	SD	CR
I	33	65.32	7.04	
				1.70
II	33	62.40	7.00	

* Significant at the .05 level of confidence.

Group I was also superior to Group II in visual discrimination. Group I had 12 persons and Group II had 15 who wore glasses, but Group I had worn glasses longer than Group II. However, the differences were not statistically significant. The correlation between the number of years that glasses were worn and visual discrimination was only −.07. Therefore the difference between the groups in number of years that glasses had been worn was not related to visual discrimination.

Effect of Seating Position on Visual Scores

The distance from the screen (10 to 28 feet) or extreme left—right position and the scores on the visual test were analyzed by use of the t test for differences between the means. No significant relationship was found between the extreme groups.

Reliability

Reliabilities for the sub-tests and total test scores of the Auditory and Visual Discrimination Tests were found by using the odd-even split-half technique, with correction by the Spearman-Brown formula. The reliabilities for the Auditory Discrimination Test were from .98 to .99. Reliabilities for the Visual Discrimination Test were from .97 to .99. The Auditory Discrimination Test was very easy for the sample used. This is shown by the fact that the average per cent correct for sub-tests I, II, III, IV and V was 97, 96, 86, 79, and 71, respectively.

For the sub-tests I, II, III and IV of the Visual Discrimination Test the per cent correct was 73, 52, 41, and 37 per cent, respectively.

The Auditory Test is reliable, but easy; the Visual Test is not only reliable, but shows better discriminating functions of the individual differences in this sample of students.

Validity

Auditory Discrimination Test

Correlations were computed with several tests of pitch to determine the validity of the discrimination test. The Auditory Discrimination Test correlates .64 with the Seashore, but only .16 with the Kwalwasser-Dykema-Holmes test of pitch (13).

The Seashore utilizes pure tones, while the K-D-H includes harmonic overtones as played on the piano. Both tests measure different aspects of auditory imagery – the Seashore tests purport to test the auditory imagery for simple pure tones, while the K-D-H tests purport to test this auditory imagery for harmonic patterns.

Visual Discrimination Test

No external criteria appeared to be available for testing the validity of the Visual Discrimination Test. The validity of the Visual Discrimination Test, in the absence of external criteria, rests upon the rationale of its construction and demands made upon the subjects.

Some Relationships Between the Auditory and Visual Discrimination Tests

The Pearson r between the Auditory and Visual Discrimination Test for the 66 subjects is .03. Since this correlation is negligible, it may be concluded that each test is measuring independent abilities.

Since the Seashore and the K-D-H tests require the subject to compare patterns of auditory imagery and the Visual Discrimination task involves a comparison of visual patterns of imagery; a rank order correlation was computed between the scores of 25 subjects for these two auditory tests and the Visual Discrimination Test. The rank order correlation between the Seashore pitch and the Visual Discrimination Test is .35, while that for the K-D-H is found to be .40.

An analysis of the upper and lower 27 per cent for auditory and visual scores was made in order to determine whether greater sensitivity in one sense modality necessarily facilitates, inhibits or is compensated for in the other mode. Table II indicates the rank order correlation between the auditory and visual tests for the upper and lower 27 per cent.

TABLE II

Rank Order Correlation Between Auditory and Visual Discrimination Tests for Upper and Lower 27 Per Cent

Auditory Mode	*N*	*Correlated With*	*r*
Upper 27%	17	Visual Discrimination	.17
Lower 27%	17	Visual Discrimination	—.09
Visual Mode			
Lower 27%	17	Auditory Discrimination	.19
Upper 27%	17	Auditory Discrimination	.11

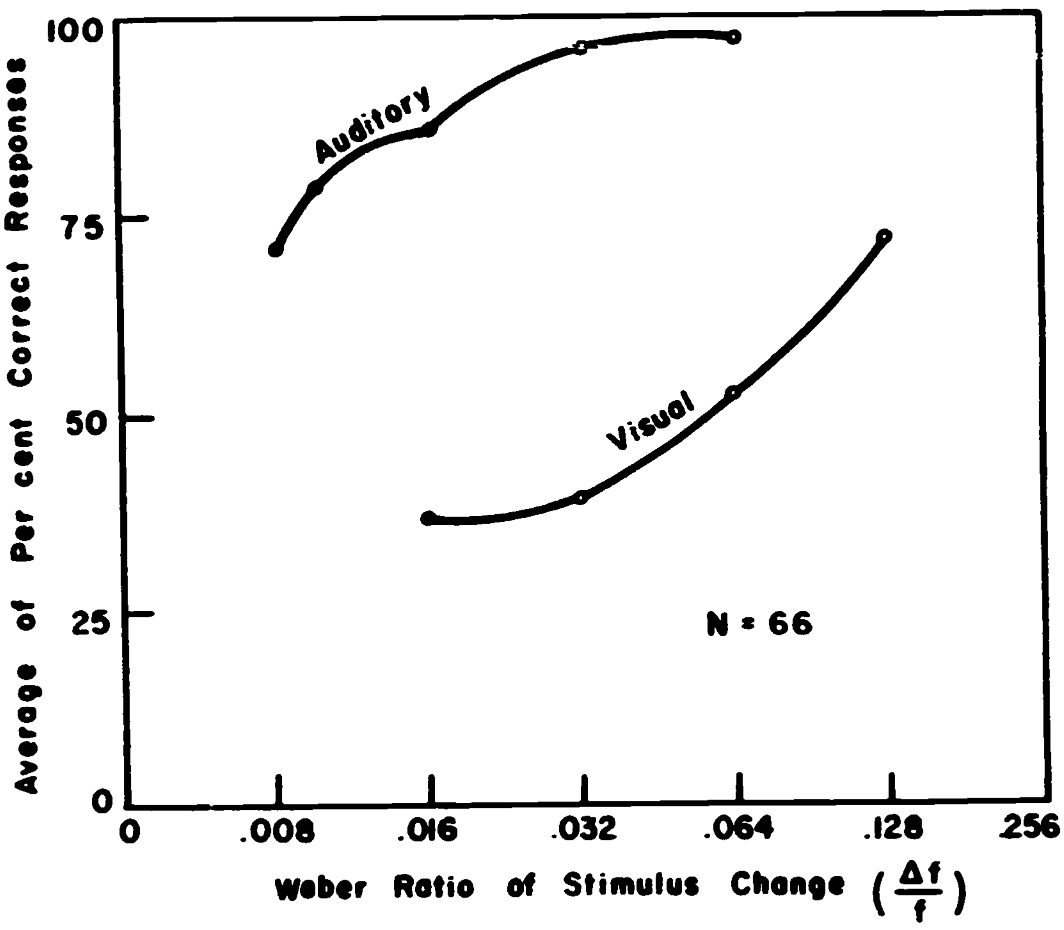
All the correlations were low and not statistically significant. Consequently, it does not seem that extreme visual and auditory discrimination abilities, as measured by the tests used in this study, are correlated.

Comparison of Auditory and Visual Curves

Figure 1 shows a comparison of the auditory and visual discrimination curves.

The auditory curve is negatively accelerated; for a Weber Ratio of .008 the correct responses averaged 71 per cent, and a Weber Ratio of .064 increased the correct responses to an average of 97 per cent. This high per cent of responses means that the test was easy and many items were not discriminating. The visual curve is positively accelerated. For a Weber Ratio of .016 the correct responses averaged 37 per cent, discrimination therefore is here only slightly better than chance; and, a Weber Ratio of .128 increases the average per cent correct responses to 73 per cent. This curve shows that the Visual Discrimination Test was very difficult at one extreme and approached an adequate level of discrimination at its other extreme.

Figure 1. Comparison of Auditory and Visual Discrimination Curves



Comparison of the curves reveals that the Auditory Discrimination Test is much easier for the subjects than the Visual Discrimination Test.

The Difference Limen (50 per cent point on the curve) for this visual test was at a Weber Ratio of .053. Because this Auditory Discrimination Test was not sufficiently difficult, its Difference Limen could not be determined; inspection of the graph, however, shows that it lies below a Weber Ratio of .008, at a level probably close to .081.

Age and Sex Differences

Correlations between chronological age (18 to 29 years) of the subjects and their auditory discrimination scores yielded an r of −.20, while a correlation between age and visual discrimination scores is .22. Both correlations are not statistically significant.

No sex differences were found on either the Auditory or Visual Discrimination Tests.

Limitations of the Study

The findings of this study are limited to type of sample, frequency range and methods used.

Theoretical Implications

The experimental results of this study lend support to the contention expressed in Holmes' (14) *Substrata Factor of Reading* that the individual differences in the sensory modes are not necessarily highly correlated. It further suggests that if, as is indicated by Ryan (21), Gilbert's (8), Harris' (10) and Stevens' (22) work, that there exists an "intersensory facilitation"; such facilitation is probably not at the level of elementary perception, but on the somewhat higher levels of cerebral association.

Implications for Further Research

The range of frequency used in the tests should be extended to include the extremes in either mode, in order to determine the Difference Limen for Auditory Discrimination and find the Weber Ratio where both curves intersect at both extremes.

Individual differences in Difference Limens should be analyzed and compared.

Additional data, such as intelligence, visual and auditory perceptual scores, and school subjects, such as reading and spelling, should be utilized for analyzing the results.

The effects of auditory and visual discrimination training should be studied.

Lastly, a longitudinal study should be conducted to determine the relationship between maturation and the interrelationships of auditory and visual discrimination.

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