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THE EFFECTS OF CULTURE AND ENVIRONMENT ON ASSIMILATION AND CONTRAST ILLUSIONS

by

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ABSTRACT

The present study was concerned with the effects of culturally mediated experience on the perception of geometric illusions. While a variety of perceptual tasks has been employed in the cross-cultural context, the most extensive research has been conducted on visual illusions. One limitation of this research is the fact that it has been concerned primarily with two straight line configurations (the Müller-Lyer and the Horizontal-Vertical illusions) and explanatory efforts have been related directly to these types of targets. The present study attempted to broaden the extent of cross-cultural research in this area by employing two curvilinear illusions differing along the assimilation-contrast dimension. The problem was to determine the effect of culture and environment on these two types of illusions, using as subjects rural and urban Indian-Metis and white school children in Manitoba. The results showed that the Delboeuf (assimilation) illusion and the Titchener Circles (contrast) illusion produced different effects, but in neither case was culture alone the significant determinant. For the Delboeuf illusion, a significant effect of environment was found with city subjects of both racial groups showing a greater susceptibility to the illusion. On the other hand, for the Titchener Circles illusion, the interaction of race and environment was significant. That is, Indian-Metis rural and white urban groups displayed the greatest degree of distortion.

These results were discussed in terms of perceptual demands that different environments place on individuals and the consequent adaptation of these individuals to the demands.

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CHAPTER I

INTRODUCTION

Culture and Perception: A Brief Overview

The idea that experience in different cultures may influence perceptual behavior has appeared sporadically in psychological and anthropological writings for over a century. The possibility of such differences was first raised in the area of color perception when it was observed that certain modern color concepts, particularly those differentiating at the blue-green end of the spectrum, were absent in many of the ancient writings (Gladstone, 1858). Considerable controversy arose as to whether such deficiencies reflected a genuine inability to discriminate colors on the part of ancient people or mere differences in color vocabulary.

The issue is a difficult one and, by the beginning of this century, studies had appeared which supported both points of view. Rivers (1901a) carried out extensive color vision tests among the Murray Islanders of New Guinea and found considerably less sensitivity to the color blue in this group than in a comparison sample in England. However, Woodworth (1905-1906) reported the contradictory finding of no special deficiency for greens, blues and violets on a color discrimination test among Filipinos. Like the ancients, neither of these groups had a special color terminology for the blue-green dimension.

The controversy over the role of color in perception has not yet been resolved conclusively despite considerable experimental and theoretical concern (Allen, 1879; Titchener, 1916; Ray, 1952; Conklin, 1955). Nevertheless, it has served a valuable function in arousing interest in a possible relationship between culture and all aspects of perception.

A curious phenomenon which has attracted the attention of students of perception is the reported inability of primitive individuals to recognize the content of a photograph if they have never before seen a photograph. Herskovits (1959) reported an instance in which a Bush Negro African woman was unable to recognize a photograph of her son until the details of the representation were pointed out to her. This phenomenon, however, does not lend itself to unambiguous interpretation since picture recognition presupposes understanding of a number of conventions (e.g., representing colored objects as a series of greys, representing three-dimensional objects on a two-dimensional plane) which are unique to Western culture. As in the case of reputed differences in color perception it is difficult to determine if failure to recognize a photograph signifies a genuine perceptual difference or merely an artifactual one stemming from differences in cultural and linguistic conventions.

More conclusive evidence for a relationship between culture and perception may be found in the more recent efforts to elucidate the problem. Bagby (1957) reported significant differences between Mexicans and Americans on a test of perceptual dominance in which scenes of both cultures were viewed stereoscopically. He found that Americans reported seeing the American scene more frequently than did Mexicans, a finding which strongly suggests that cultural experience predisposes people to identify or perceive material whose content is most familiar to them. Hudson (1960) compared literate and illiterate groups in South Africa in the perception of depth cues such as superimposition, perspective and object size in drawings and photographs. He found that the literate sample perceived depth in these representations far more frequently than did the illiterate group who had not been exposed to pictorial material in the past. In fact, not a single illiterate saw the photograph as three-dimensional. Again, this seems to represent a clear instance where experiences, mediated by culture, produce a genuine perceptual difference. Still more recently, Berry (1966) demonstrated that Eskimos scored significantly lower on a test of closure than did either Temne from Sierra Leone or a sample of Scots. This finding was consistent with his hypothesis that Eskimos, trained as hunters in a barren land, would have a greater awareness to small detail in their environment and hence, score lower on a test of closure.

Cultural Differences in the Perception of Geometric Illusions

Experimental demonstrations. Some of the earliest perceptual tasks to be employed in cross-cultural research were the geometric illusions which had been extensively investigated by experimental psychologists beginning in the middle of the nineteenth century. Interest in this field was first aroused when Rivers (1901b; 1905) collected data on two illusions from the Murray Islanders of New Guinea, the Todas of Southern India, and a comparison group in England. Using two different kinds of apparatus for each of the two illusion figures, he demonstrated that the English subjects (*S*s) were more susceptible to the Müller-Lyer, but less susceptible to the Horizontal-Vertical illusion than either non-Western group.

(Examples of the illusions are shown in Appendix A). These results were exceedingly provocative, uncovering as they did perceptual differences in both directions between Western and non-Western samples. In explaining his results, Rivers postulated that the two illusions belonged to different classes in the sense that they tapped different functions. For the Müller-Lyer illusion, he felt that English Ss scored higher because of a cultural habit of attending to the figure as a whole. On the other hand, primitive groups tended to be more analytic in their approach and, therefore, more adept at picking out parts embedded in the total context. To explain the lesser susceptibility of the English to the Horizontal-Vertical illusion, Rivers argued that the English were more likely to employ non-sensory "tricks" in arriving at their estimates of line length, while primitives relied more upon purely sensory data.

While these explanations seem somewhat vague, Rivers' study represents the pioneering venture in the area of cross-cultural differences in perceptual distortion. Recently, his findings have been confirmed by Segall, Campbell, and Herskovits (1966) in a massive cross-cultural comparison of fourteen non-Western and three Western samples. The illusions studied were the Müller-Lyer, the Sander Parallelogram and the "L" and "T" forms of the Horizontal-Vertical illusion (see Appendix A). Their results showed that all three Western samples were significantly more susceptible to the Müller-Lyer than were the non-Westerners, and this trend was present in both adults and children. The findings were less clear-cut for the Sander Parallelogram; they seemed to indicate greater susceptibility on the part of Westerners. For the Horizontal-Vertical illusion, a different pattern of results emerged. European groups demonstrated only a moderate level of susceptibility with illusion scores sometimes higher and sometimes lower than those of non-Europeans. Once again, as in the study by Rivers, differences in susceptibility in both directions had been demonstrated.

A number of subsequent studies have replicated these findings. For example, Morgan (1959) found significantly less susceptibility to the Muller-Lyer illusion among illiterate mine laborers in Africa than among Europeans. Hautaluoma and Loomis (1972) employed the same materials that Segall <u>et al</u>. used and found lesser susceptibility to the Müller-Lyer but greater susceptibility to the Horizontal-Vertical illusion for Afghan as compared to American boys. As a by-product of a broader investigation, Jahoda (1966) found significant cross-cultural effects for both the Müller-Lyer illusion and the Horizontal-Vertical illusion. Finally, Bonte (1962) using an earlier version of the materials used by Segall <u>et al.</u>, replicated their findings among samples of Bashi and European South Africans. However, with a different apparatus, she found small insignificant differences in the wrong direction, a difficulty which was subsequently attributed to a peculiarity in the apparatus.

<u>Theoretical considerations</u>. Two major approaches have been adopted in an attempt to explain cross-cultural differences in susceptibility to geometric illusions. The first of these is the view advanced by Pollack and Silvar (1967) that physiological factors such as the deeper retinal pigmentation of non-European individuals may explain their lowered sensitivity to the Müller-Lyer illusion. They tested this prediction on two samples which

differed in retinal pigmentation and found a correlation of -.745 between illusion strength and color of pigment. However, this finding has been criticized by Bayer and Pressey (1972) on the grounds that the study confounds racial origin with pigmentation. That is, the deeply pigmented sample in the experiment was composed primarily of Negro Ss, while the light pigmented group was composed primarily of white Ss. In order to remove the confounding influence of race and culture these investigators used only white Ss of five different degrees of retinal pigmentation. In contrast to Pollack, they found no evidence of differences in susceptibility to the Müller-Lyer illusion as a function of pigmentation.

A more compelling interpretation of cross-cultural differences is the empiricist position favored by Segall et al. (1966). In their view, perceptual inference habits are learned in response to culturally mediated experience and are then misapplied in the illusion situation. Cultures differ in the kinds of perceptual habits they elicit, and these differences may be manifested in different responses to illusory targets.

Within this empiricist orientation, Segall et al. explain their findings specifically in terms of the perspective theory of illusions. This theory, originally proposed by Thiery (1895; 1896) states that illusory phenomena are caused by reading depth features into two-dimensional line drawings so that parts corresponding to distant features expand, and those corresponding to nearby features contract. For example, the Müller-Lyer figure, when viewed in a vertical position, may represent the corner of a building viewed from the inside (the obtuse-angled figure) or from the outside (the acute-angled figure). When perspective is read into the picture, the oblique vertical appears farther away and longer than it actually is, while the acute vertical appears closer, and shorter than its true length (see Appendix A). People living in Western societies will be most susceptible to this mistaken inference habit because (a) they are more accustomed to viewing "carpentered", rectangular buildings and (b) the convention of representing three-dimensional objects as two-dimensional line drawings is firmly entrenched in Western culture. Consequently, one might predict greater susceptibility to the Müller-Lyer and Sander Parallelogram illusions in Western samples.

On the other hand, for the Horizontal-Vertical illusion, it is argued that the distortion stems from the perceptual habit of interpreting a vertical line as representing a horizontal distance which extends away from the observer. This habit is misapplied in viewing the Horizontal-Vertical illusion drawing with the result that the vertical line appears longer than the horizontal line of the same length. In the view proposed by Segall et al. (1966), the tendency of interpreting the vertical as a foreshortened horizontal should be most ingrained in people accustomed to viewing open vistas and broad expanses. Thus, the illusion should be strongest for people living on the plains, least for those living in the jungle, and at an intermediate level for urban European environments. Generally, this relationship was found to hold in their data.

The theory put forward by Segall et al. stresses the importance of learning and not biological variables as the primary determinant of cultural differences in perception. As such, the theory commits them to predicting not only inter-cultural but also intra-cultural differences where sufficient variation in environment occurs within a particular group. In fact, such differences were found between rural and urban Zulus on the rotating trapezoidal window illusion (Allport & Pettigrew, 1957). The results seemed to indicate that differences in experience, and not race, were the critical factor in perceptual differences.

Considerable research has been generated in an attempt to assess the validity of the factors which Segall et al. postulate to explain cross-cultural differences in the perception of illusions. In order to remove the confounding influence of race in assessing each of these factors, a number of studies have been carried out using samples drawn from within a single culture. One such study was conducted by Jahoda (1966) using three groups of illiterate Ghanaians who differed primarily in the degree of "carpenteredness" present in their environment. Contrary to expectation, no differences in susceptibility to the Müller-Lyer were found across samples, although the Ghanaian group as a whole was significantly less susceptible than a comparable sample of British students. In this study, Jahoda eliminated the factor of three-dimensional viewing by using only illiterate Ss in Ghana (Hudson, 1960). When no significant intra-cultural differences were demonstrated across variations in rectangularity, he postulated that the two factors operate in combination in producing the relevant inference habits. In the absence of three-dimensional viewing, variations in "carpenteredness" may not be sufficient to produce detectable differences.

Berry (1968) reasoned that any failure to demonstrate intra-cultural differences in susceptibility across variations in environment may result from a confounding of the ecological and developmental factors. He notes that these two factors are known to influence illusion susceptibility in opposite directions for the Müller-Lyer, yet societies high in "carpenteredness" (predicting high susceptibility) are usually also high in level of perceptual development (predicting low susceptibility). To test this theory he used two groups of Eskimos from settlements differing in degree of "carpenteredness" but matched in terms of scores on a test of perceptual development. As predicted, after removing the confounding effect of development, significant differences in susceptibility between rural and urban Eskimos were found.

Further support for the "carpentered environment" hypothesis may be found in a study by Stewart (1972). Using seven Zambian and one American sample which differed in "carpenteredness", she found increases in susceptibility with increases in "carpenteredness" for the Müller-Lyer, the Sander Parallelogram and the Ames distorted window.

While Jahoda, Berry and Stewart attempted to isolate the factor of "carpenteredness", Davis (1970) concerned himself with the influence of the ability to interpret two-dimensional line drawings in perspective on the Müller-Lyer effect. As an index of this ability, he chose level of education which he believed correlated with literacy and, therefore, three-dimensional viewing (Hudson, 1960). Using groups of Banyankole adults of differing levels of education he found, contrary to his hypothesis, that the most educated (i.e., the most skilled at interpreting two-dimensional drawings as three-dimensional objects) were, in fact, least susceptible to the Müller-Lyer illusion. However, it is questionable that this study represents an adequate test of the role of three-dimensional viewing as education level is only a very crude index of this ability. In fact, according to a developmental viewpoint, increases in education would result in a more sophisticated and analytic use of the habit, and a corresponding decrease in illusion strength. The results seem to support this claim.

Considerably less cross-cultural research has been generated for the Horizontal-Vertical illusion than for the Müller-Lyer illusion. According to the view set forward by Segall et al. (1966) this illusion should be most pronounced for those living on the open plains who are more experienced in interpreting the vertical as a foreshortened horizontal in perspective distance. In many instances, however, the fit of the data is not very good.

A notable example of this is a study by Jahoda (1966). Using the "└─" form of the illusion among three groups in Ghana differing in openness of environment he found, contrary to the theory, that the group living in the dense forest area had the highest illusion effect, while those in more open areas had an almost zero effect. Similarly, Segall et al. reported some inconsistencies in the rank ordering of samples within their data. This was most notable in the case of the Zulus who had the lowest illusion scores of any group, and yet inhabited an environment that should have induced very high susceptibility. Similar equivocal evidence has been found by Morgan (1959) with at least one form of the illusion.

Deregowski (1967) believes that many of these inconsistencies between data and theory may be resolved by recognizing that the two forms of the illusion ("└" and "┬") belong to two different classes, with the ┬-form being confounded by a dichosection illusion unrelated to the Horizontal-Vertical. If only the results for the └ form of the figure are examined, a much better fit to the theory is attained. In Jahoda's study, only the "┬" form of the illusion was used, and therefore the results are not interpretable in terms of a perceptual inference habit.

However, Wober (1970) found no correlation between scores on a test of perceptual inference and the strength of the Horizontal-Vertical illusion. This fact calls into question the entire logic of the theory that lines on paper represent aspects of three-dimensional reality.

The Suggestion of New Directions. The scope of research in this area was broadened considerably in recent years as the result of a classic cross-cultural venture in Ghana and Scotland (Jahoda & Stacey, 1970). In addition to the usual rectilinear figures employed in previous research in this area (i.e., the Müller-Lyer illusion, the Sander Parallelogram, and the two forms of the Horizontal-Vertical illusion) these investigators tried out a number of configurations which are not so easily interpretable in terms of the viewpoint proposed by Segall *et al*. (1966). These targets included the Titchener Circles, the Boring Circles, the Poggendorff illusion, the Helmholtz Square, the Judd illusion, the Hering illusion, and the Wundt illusion. The *S*s were university students in both countries, but were divided into groups on the basis of whether they were trained or untrained in the fields of art and architecture. The primary purpose of the investigation was to determine whether cross-cultural differences would be found among subjects exposed to "lengthy formal education of a similar type" and, if so, whether such differences would persist even after specialized training that would be relevant to the making of perceptual judgments.

The results were positive in both instances. For *S*s matched in terms of general education, but lacking any specialized art training, highly significant cross-cultural differences were found on all but the Müller-Lyer and ⊤ -form of the Horizontal-Vertical illusion. With the exception of the └ -form of the Horizontal-Vertical and the Helmholtz Square, the Scots were more susceptible than the Ghanaians on every illusion. When similar comparisons were made between students with specialized training, four of these differences disappeared including those for the └ -form of the Horizontal-Vertical, the Helmholtz Square, the Poggendorff illusion and the Sander Parallelogram. Of the six remaining differences, the Scots were more susceptible in every case.

That differences were found on so diverse a collection of illusions seems to attest to the pervasiveness of the influence of culturally mediated experience on perception. It is interesting to note that this influence seems to be demonstrated most strongly for illusions that have not been considered in previous cross-cultural research. The findings strongly suggest that there are a number of new avenues to be explored before the complex relationship between culture and perception, as demonstrated through susceptibility to visual illusions, is fully understood.

Statement of the Problem

While research on cultural differences in susceptibility to visual illusions represents a valuable contribution to the psychology of human perception, it is apparent that much more work is needed before these differences are understood. In surveying the literature, the primary weakness of previous research seems to lie in the fact that it deals exclusively with a theory based upon the reputed similarity of illusion drawings to two-dimensional representations of real-life scenes. This theory, which forms the foundation for both the "carpentered environment" and "foreshortening of verticals" hypotheses, has considerable intuitive appeal for at least some illusory figures (e.g., the Müller-Lyer illusion, the Ponzo illusion). However, for a number of other figures particularly those characterized by curvilinear components, the theory is decidedly less appropriate. Moreover, the bulk of recent research in this area has shown perspective theory to be inadequate (e.g., Fisher, 1968; Pressey, Butchard, & Scrivner, 1971). In view of these difficulties it seems that a new approach to the problem is merited.

One distinction which has been made repeatedly in the theoretical analysis of illusions is the distinction between assimilation and contrast illusions. If the total configuration is conceived of as a focal stimulus which is embedded in a context of inducing stimuli, then an assimilation illusion is one in which the focal stimulus appears more like (assimilates to) the inducing stimuli. In a contrast illusion, the opposite distortion is manifested. That is, the focal stimulus becomes less like (is contrasted to) the inducing parts. Previous cross-cultural research has never explored the assimilation-contrast dimension. Therefore, the primary purpose of the present study was to determine if cross-cultural differences would be found for these two types of illusion. As examples of each type, the Delboeuf and Titchener Circles illusions were chosen (see Delboeuf and Titchener Circles illusions, Appendix A). These particular targets were selected because of their basic configural similarity which permitted an efficient testing procedure. In addition, these illusions are curvilinear and curvilinear configurations have only once before been employed in a cross-cultural context.

A second major purpose of the study was to see if perceptual differences would be exhibited by the Indian-Metis people in Manitoba. The bulk of previous research has used Africans as subjects with comparisons made in such wide-ranging settings as Ghana and Scotland. The present study sought a much more limited comparison between Indian-Metis and white school children living in Manitoba. In an attempt to separate out the complex effects of culture and environment both rural and urban samples were tested for each of these groups.

Three additional variables were considered in designing the experiment. These were size of the inducing circle, age, and sex. The major reason for including these variables was to ensure that the method which was selected was valid. For example, it is a well-known fact that a large inducing circle produces shrinkage and a small one produces expansion in the Titchener Circles illusion, but that the opposite relationship holds in the Delboeuf illusion. If these relationships were to be verified in the present study, then a high degree of confidence in the method would be justified. Similarly, on the basis of previous research one would expect the Delboeuf to decrease with age and the Titchener Circles to increase with age in all groups (Santostefano, 1963; Wohlwill, 1960; Wapner & Werner, 1951) and that girls would have higher illusion scores than boys (Pressey & Sweeney, 1970). Only if these three subsidiary variables produced orderly data would evidence for cross-cultural differences be considered reliable.

CHAPTER II

EXPERIMENTAL METHOD AND RESULTS

Method

Design

Six independent variables were employed in the experiment. The variables were: (i) race (Indian-Metis and white), (ii) environment (rural and urban), (iii) type of illusion (Delboeuf and Titchener Circles), (iv) age (6 plus 7 years and 8 plus 9 years), (v) sex (male and female), and (vi) size of the inducing circle (8, 12, 22, and 32 millimeters). Both types of illusion and size of the inducing circle were within-S variables. The remaining variables were between-S variables. A schematic representation of the design appears in Table 1.

While an attempt was made to equate for age and sex across groups, practical considerations made perfect balancing impossible. The number of each type of S that was tested is shown in Table 1. In the interests of stability of data, all Ss were retained for the analysis.

Subjects

The Ss were 76 white and 75 Indian-Metis children between the ages of 6 and 9 years. They were tested in schools in three locations in Manitoba viz., Pelican Rapids, Winnipegosis and Winnipeg.

In accordance with the design, samples were chosen which (a) differed in racial origin but were matched for environment and (b) which differed in environment but had a common racial origin. Here

TABLE 1

Schematic Representation of the Design

Between-Subject Variables				Within-Subject Variables	
				DELBOEUF	TITCHENER
				8 18 22 32	8 18 22 32
Indian-Metis (n = 75)	Rural (n = 42)	Male (n = 24)	Age 6 + 7 (n = 10		
			Age 8 + 9 (n = 14)		
		Female (n = 18)	Age 6 + 7 (n = 8)		
			Age 8 + 9 (n = 10)		
	Urban (n = 33)	Male (n = 17)	Age 6 + 7 (n = 8)		
			Age 8 + 9 (n = 9)		
		Female (n = 16)	Age 6 + 7 (n = 8)		
			Age 8 + 9 (n = 8)		
White (n = 76)	Rural (n = 40)	Male (n = 20)	Age 6 + 7 (n = 9)		
			Age 8 + 9 (n = 11)		
		Female (n = 20)	Age 6 + 7 (n = 12)		
			Age 8 + 9 (n = 8)		
	Urban (n = 36)	Male (n = 20)	Age 6 + 7 (n = 11)		
			Age 8 + 9 (n = 9)		
		Female (n = 16)	Age 6 + 7 (n = 9)		
			Age 8 + 9 (n = 7)		

environment was defined primarily in terms of visual environment including both natural and man-made phenomena. Socio-cultural characteristics such as economic status and degree of western contact were also taken into account but only in a general way. The three communities sampled in fulfilling these conditions were Pelican Rapids which provided the Indian-Metis Rural sample, Winnipegosis which provided the White Rural sample, and Winnipeg which provided the Indian-Metis Urban and the White Urban samples.

The Community of Pelican Rapids. The community of Pelican Rapids, numbering 800 Indian-Metis residents, is situated along the northern part of Lake Winnipegosis about 400 miles from the city of Winnipeg. The community itself consists of an older part spread along the banks of the Shoal River, and the town centre containing the new government housing section and the community facilities of the church, the store, and the hall. A fully modern, well-equipped school services the settlement under the authority of the provincial educational system. Ecologically, uninhabited bush country surrounds the area on all but the lake side. A twisty gravel road extends twenty miles west from the town and connects with the major highway to the north and south. Until this road was built, five years ago, the settlement was accessible only by boat. As a result, contact with the outside world has been unusually limited in the past. Today the inhabitants of the reserve are largely unemployed although some fishing and hunting are still carried out. For the most part the people rely upon welfare for their survival.

The Community of Winnipegosis. Winnipegosis, with 800 residents of primarily Ukrainian and Anglo-Saxon descent, is situated on the southern part of Lake Winnipegosis, approximately 300 miles from the city of Winnipeg. Like Pelican Rapids, the town is located west of Highway 10 in a generally wooded area along the lakeshore. Standard western-style buildings are found in both communities, although Winnipegosis has relatively more of them than does Pelican Rapids. A modern consolidated school has recently been built in the town and children are bussed in from the surrounding farming area.

While Winnipegosis bears certain ecological similarities to Pelican Rapids, on a number of other dimensions the match was far from perfect. Probably most important, the residents of Winnipegosis have never known the isolation that the residents of Pelican Rapids have. Furthermore, although the community is not a prosperous one, it is not dependent primarily upon welfare for its livelihood. While perfect balancing across all factors besides visual environment would have been ideal, no truly comparable community existed. Accordingly, Winnipegosis was chosen as the best possible alternative.

The Metropolis of Winnipeg. Winnipeg is a modern, metropolitan city of about 500,000 which is located in the south central plains of Manitoba. It is a typical urban, westernized environment with numerous concrete buildings, paved roads, and houses lined along city blocks.

The particular area of the city chosen for study was the North-

End -- an area containing a large concentration of Indian-Metis people. Living conditions in the North End are generally poor across all ethnic groups. In recent years, the area has benefitted from a number of government programmes designed to improve housing and community facilities. A number of new schools have been built, many of which contain an approximately equal number of Indian-Metis and white children. Only children who had lived in Winnipeg all their lives were considered in choosing the sample.

Apparatus

The stimulus materials were drawn with black ink on 5-x 7-inch white cards. There were four variations of the Delboeuf configuration and four variations of the Titchener Circles configuration. Specifically, for each card, a standard circle 20 mm. in diameter was paired with an inducing circle which could be either 8, 18, 22, or 32 mm. in diameter. In addition, three control cards on which only the standard circle was drawn, were included (see Delboeuf figure, control, and Titchener Circles figure, Appendix A). All cards were laminated to protect them from wear.

The apparatus consisted of three components, namely an oscilloscope, an audio generator, and a transformer. The transformer converted sine waves emanating from the audio generator into two voltages separated out of phase so that a circle was displayed on the screen of the oscilloscope. The size of the circle could be altered by varying the voltage of the audio generator. A ten-turn potentiometer was located in the transforming device, and the S could adjust the circle on the screen to any size desired by turning this device. The actual size chosen could be read off by the experimenter (E) from the ten-turn potentiometer. The apparatus was placed on a wooden stand and S sat with his chin on the holder so that the viewing distance to the screen was held constant at about 24 inches.

Procedure

The stimulus cards were randomized for each S (see randomization procedure, Appendix B) and were mounted in a slot below the screen. The S's task was to adjust the circle on the screen to appear equal to the circle which the E indicated on the stimulus card. For each card presented, S made one ascending judgment and one descending judgment. The ascending trial began with a circle of 0 mm. diameter (a dot) and the descending trial began with a circle diameter of 40 mm. The order of ascending-descending judgments was constant within-Ss and randomized across Ss. Before each testing period, the size of the circle was calibrated with a template to be certain that no changes in voltage had occurred to alter its size. If necessary, suitable adjustments were made.

Because the Ss were young children a rather lengthy standardized instruction procedure was devised to precede the experiment. The pre-test procedure was carried out in three phases.

First, with the display circle preset at the standard size of 20 mm., E demonstrated to the child how, by turning the dial in one direction he could make a larger circle on the screen, while by turning it in the other direction he could make a smaller circle.

The child was then allowed to practice turning the dial until E felt he had become sufficiently skillful at it. Younger children were generally more clumsy initially, and therefore more time was spent with them at this phase.

After completion of this first phase, a plastic template with circles of varying size drawn upon it was placed over the screen. The child then made two ascending judgments and two descending judgments so that his circles would appear to be the same size as those on the plastic disk. Specifically, he was asked to make a circle equal to the "second smallest" circle, the "largest" circle, the "smallest circle" and "a dot". After each judgment the E checked upon the child's accuracy. This phase was intended to increase the child's skill in making fine distinctions in size.

The third phase of the pre-test procedure was carried out in the same manner as the actual experiment except that only control cards were used, and feedback was given to the child after each judgment. Thus a card was placed in the slot under the screen of the oscilloscope and the child was instructed to "make the circle on the screen the same size as the circle on the card." Both ascending and descending judgments were obtained for each card, with the order dependent upon the predetermined order for the experiment. The E recorded each estimate made by S. A minimum of six practice judgments (three ascending and three descending) preceded the experiment. The criterion performance set was that three of the six judgments be within a range of .25 units above or below the standard size or within

.50 units of each other where a S consistently over- or underestimated the standard.

This was essentially a teaching phase, and E drew S's attention to inaccurate judgments by demonstrating the correct circle size and comparing it to his own incorrect judgment. The S was then required to repeat the judgment and to "fix it" as he had been shown. Accurate judgments, on the other hand were rewarded with praise. Through all of these measures it was hoped that as careful and reliable data as possible could be derived for the experiment proper.

Results

In analyzing the data, illusion scores were derived by subtracting the mean of the control scores from the average of the ascending and descending scores for each target. Positive or negative signs were then assigned to each derived score in accordance with whether or not the distortion was operating in the expected direction. A sample protocol with the appropriate transformation appears in Appendix C.

Preliminary Analyses

The three validation variables included in the experiment were subjected to a preliminary analysis. In assessing their effects, the data were collapsed over all groups.

Size of the inducing circle. (a) Delboeuf - the effect of this variable on the Delboeuf illusion is shown in Figure 1. For purposes of comparison, equivalent data from a sample of university students[1]

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[1] Unpublished study by A.W. Pressey entitled "The Titchener Circles and Delboeuf illusions as measured by the method of adjustment."

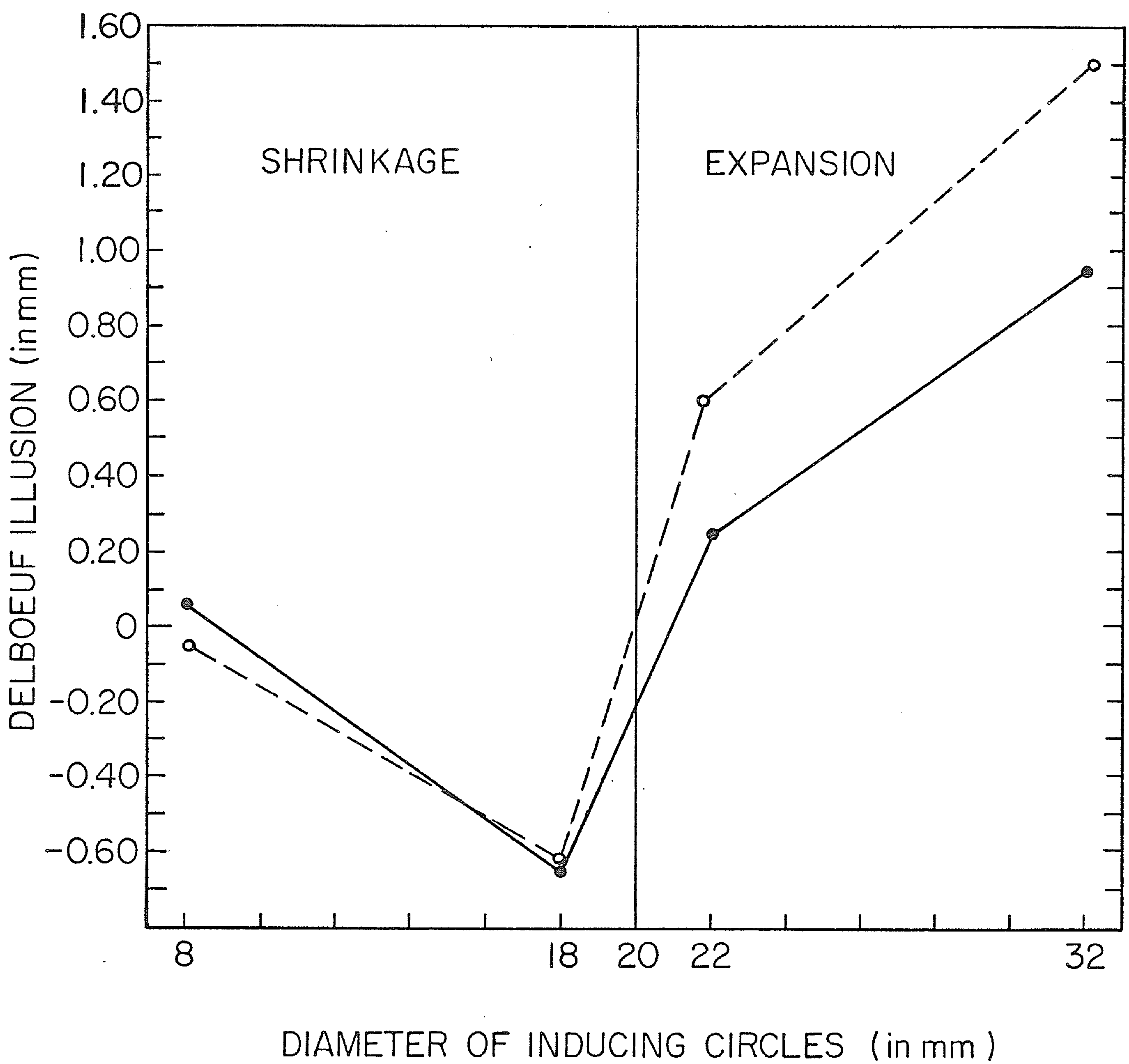

Fig. 1. Delboeuf illusion as a function of size of the inducing circle. (Dotted curve represents Pressey's data from a sample of University students.)

are plotted on the same Figure.

The figure shows that although the absolute levels of the illusion differ somewhat between children and adults, the form of the function remains the same. In both instances, a strong negative illusion occurred when the context circle was 18 mm, a finding which strongly suggests that this configuration should not be considered as a Delboeuf-assimilation illusion. All other inducing circles elicited positive Delboeuf effects, although the strength of the effect was much greater for the extreme expansion (32 mm) circle than for the extreme shrinkage (8 mm) circle.

(b) Titchener Circles - The magnitude of the Titchener Circles illusion as a function of size of the inducing circle is shown in Figure 2. Comparison data from a sample of university students[2] appears on the same Figure.

Here again, the form of the function is identical for children and adults, although the absolute levels are somewhat higher for children. In both groups, the extreme expansion (8 mm) Titchener Circles illusion elicits the strongest effects.

Thus, for both the Delboeuf and Titchener Circles illusion the present data essentially replicated previous findings. This provided the first indicator of the validity of the method.

Sex. Mean illusion scores for both boys and girls on all four variants of the Delboeuf and Titchener Circles illusion are shown in Table 2.

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[2] Unpublished study by A.W. Pressey entitled "The Titchener Circles and Delboeuf illusions as measured by the method of adjustment."

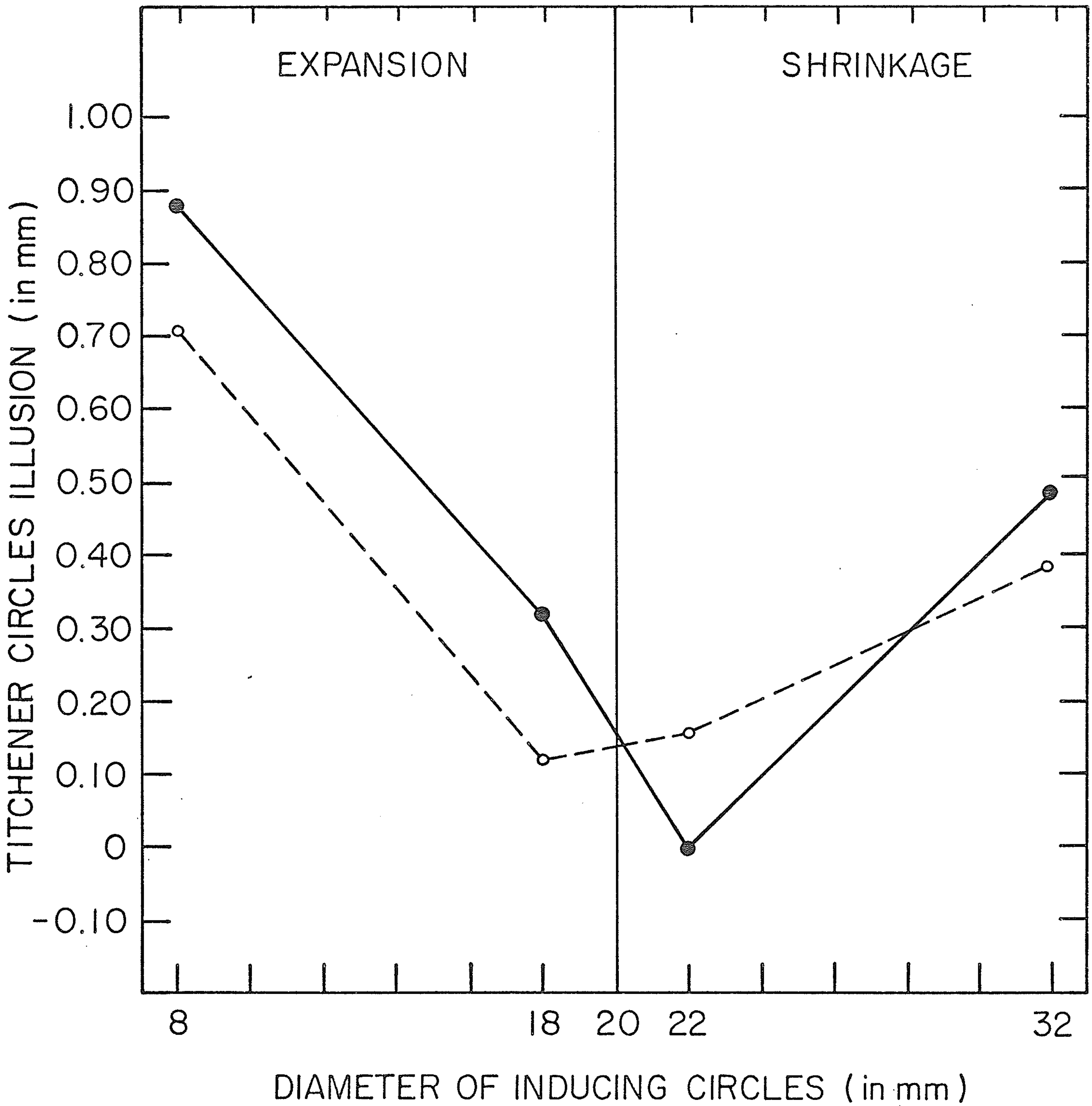

Fig. 2. Titchener Circles illusion as a function of size of the inducing circle. (Dotted curve represents Pressey's data from a sample of University students.)

TABLE 2

Mean Scores of Boys and Girls on the Delboeuf and Titchener Circles Illusions (in mm)

Sex	Delboeuf 8	Delboeuf 18	Delboeuf 22	Delboeuf 32	Titchener Circles 8	Titchener Circles 18	Titchener Circles 22	Titchener Circles 32
Girls (n - 70)	.20	-.80	.24	1.04	.88	.28	.01	.52
Boys (n = 81)	-.08	-.52	.24	.84	.84	.32	-.02	.48

The table shows that, in general, girls are more susceptible to the illusion than boys, with the differences being more marked in the case of the Delboeuf illusion. For both the Delboeuf and Titchener Circles illusions the greatest difference between boys and girls occurs with the 8 and 32 mm variants, although the largest of these differences (on the 32 mm Delboeuf) was not significant statistically ($t = 1.04$; $p < .05$). The negative Delboeuf illusion (18 mm) also elicits a marked difference between boys and girls, and this difference is in the traditional direction.

The finding of greater illusion susceptibility for girls, though not significant statistically, is consistent with earlier findings of Pressey and Sweeney (1970) for the Poggendorff illusion. This provided further reason for confidence in the method.

Age. Mean illusion scores for 6- and 7-year olds versus 8- and 9-year olds for both the Delboeuf and Titchener Circles illusions are shown in Table 3.

TABLE 3

Mean Scores of 6- and 7-year olds versus 8- and 9-year olds on the Delboeuf and Titchener Circles Illusions (in mm)

	Delboeuf				Titchener Circles			
	8	18	22	32	8	18	22	32
6 and 7 (n = 75)	.08	-.76	.40	1.12	1.08	.32	-.16	.48
8 and 9 (n = 76)	.08	-.56	.08	.76	.68	.28	.12	.52

For the Delboeuf illusions, a clear trend toward decreased susceptibility with age is evident, especially for the Delboeuf expansion illusions (22 mm and 32 mm) and for the negative Delboeuf illusion. Indeed, the difference between the illusion scores for the young and old groups at 32 mm was statistically significant ($t = 2.27$; $p<.05$). For the Titchener Circles illusion, however, the relationship is less clear. Although there is some slight indication of an increased illusion effect with age for the 32 mm figure, for the extreme Titchener expansion figure (8 mm), a substantial decline is evident. A t-test revealed that this difference was significant at the .05 level of confidence ($t = 2.56$). This, of course, is contradictory to all previous findings.

Main Analysis for Race and Environment

From the preliminary analyses it became apparent that although the expected trends were present, the 18 and 22 mm contextual figures were not discriminating clearly for the two remaining validation variables of age and sex. Furthermore, the 18 mm Delboeuf figure appeared not to be producing assimilation effects at all, since the direction of the distortion was opposite to what would have been expected. For these reasons it was decided that, for the purposes of the main analysis, maximum discrimination would be attained by using only the scores from the targets with the largest and smallest contextual magnitudes. Thus, a separate illusion score was obtained for the Delboeuf and Titchener Circles illusions by summing the scores for the 8 and 32 mm configurations. The resulting sums were submitted to two separate analyses of variance in which race and environment were the main variables.

Delboeuf Illusion. Mean Delboeuf illusion scores for each of the four samples tested appear in Table 4. The results of the

TABLE 4

Delboeuf Illusion Score* Means for Indian-Metis and White Rural and Urban Samples

	Indian-Metis	White
Rural	.74	.74
Urban	.96	1.56

*Illusion scores presented are sums of the 8 and 32 mm contextual figures.

analysis of variance are summarized in Table 5.

TABLE 5

Analysis of Variance of Delboeuf Illusion Scores for Indian-Metis and White Rural and Urban Samples

Source	df	SS	MS	F	P
Race	1	20.86	20.86	2.21	NS
Environment	1	63.94*	63.94	6.79	.01
Race & Environment	1	22.05	22.05	2.34	NS
Within	147	1385.25	9.42		
Total	150	1491.73			

**SS adjusted for unequal subclass numbers by the use of harmonic means of N.

The results showed a significant main effect for environment, with urban groups more susceptible to the illusion than rural groups. No significant effects were found for either race or the interaction of race and environment.

Titchener Circles Illusion. Mean Titchener Circles illusion scores for each of the four samples appear in Table 6. The results of the analysis of variance are summarized in Table 7.

The results showed no significant main effects for either race or environment, but that the interaction between race and environment was significant.

The overall pattern of results for both the Delboeuf and Titchener Circles illusions is summarized in Figure 3.

TABLE 6

Titchener Circles Illusion Score* Means for Indian-Metis and White Rural and Urban Samples

	Indian-Metis	White
Rural	1.60	1.08
Urban	1.20	1.56

*Illusion means presented are sums of 8 and 32 mm contextual figures.

TABLE 7

Analysis of Variance of Titchener Circles Illusion Scores for Indian-Metis and White Rural and Urban Samples

Source	df	SS	MS	F	P
Race	1	1.80*	1.80	.19	NS
Environment	1	.21	.21	.02	NS
Race and Environment	1	40.06	40.06	4.13	.05
Within	147	1426.70	9.71		
Total	150	1450.56			

*SS adjusted for unequal subclass numbers by the use of harmonic means of N.

The figure shows that for both Indian-Metis and white subjects urban groups are more susceptible to the Delboeuf illusion than are

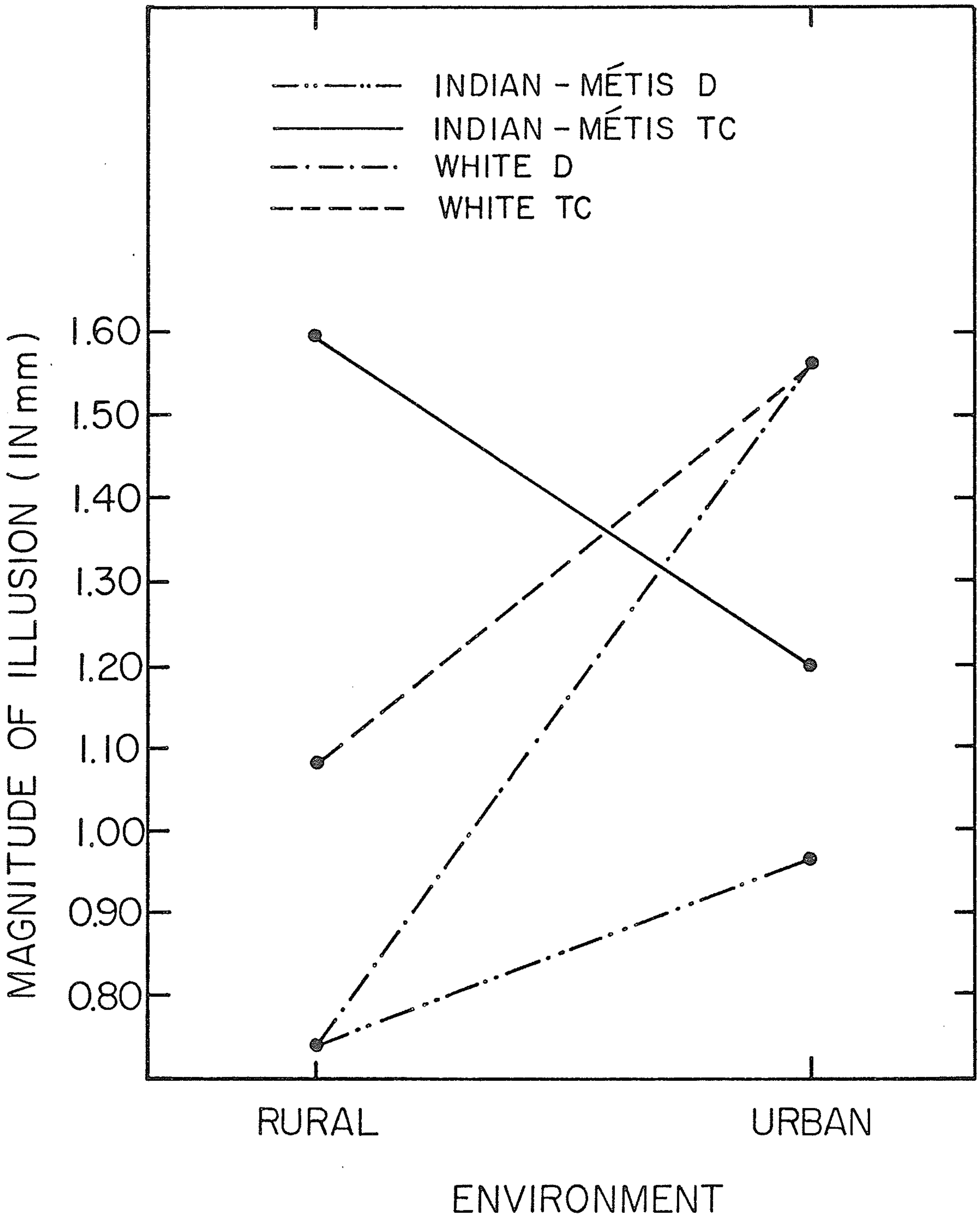

Fig. 3. Delboeuf and Titchener Circles illusion magnitude as a function of race and environment.

Rural groups. On the Titchener Circles illusion, however, white urban Ss are more susceptible, but Indian-Metis urban Ss are less susceptible than their respective Rural counterparts.

CHAPTER III

DISCUSSION

Main Effects

The significant effect of environment found for the Delboeuf illusion reaffirms the notion that cross-cultural differences are manifestations of important experiential differences which exist between cultural groups. A fundamental difference of this sort is experience in rural and urban environments. When this factor was balanced out by matching rural and urban groups in the present study, cross-cultural differences disappeared, and were replaced by intracultural differences which were dependent upon environment. Such differences have previously been found between rural and urban Eskimos on the Müller-Lyer illusion (Berry, 1969) and between rural and urban Zulus on the rotating trapezoidal illusion (Allport & Pettigrew, 1957). For these two illusions and for the Delboeuf illusion, urban life seems to be a powerful modifier of perceptual behaviour with urban groups showing greater susceptibility to distortion than rural ones. This influence is apparently not so clear for the Titchener Circles illusion because, in this case, it is the interaction of race and environment rather than environment alone which is the significant determinant.

In interpreting these findings, explanations relating to a perspective theory of illusions do not seem appropriate. As stated earlier, this theory attributes illusory distortion to the similarity between illusion figures and two-dimensional representations of real life scenes. Whatever the validity of the theory for the Müller-Lyer and Horizontal-Vertical figures, it does not appear to be adequate for the curvilinear configurations that were employed in the present study. No proponent of perspective theory has explained the Delboeuf and the Titchener Circles illusions on the basis of perspective clues, and until such an analysis is presented and assessed, it is probably not fruitful to continue to theorize in these terms.

Another approach which seems to be more promising is to examine the nature of assimilation and contrast and determine whether these concepts might provide the key to understanding the role of environment in illusions.

Piaget's analysis of perception provides one approach to the assimilation contrast dimension. According to Piaget (1969) there are two ways by which the act of perception can occur. The first of these, which he has termed "centration" is a primitive process whereby the organism receives and interprets visual input primarily at a sensory level. This is pure perceptual activity which can be accomplished in a single glance. As the course of development proceeds, however, this lower-level process gives way to a more active perceptual mode in which memory and cognitive functions come into play. At this stage, the organism is capable of successive centrations and visual comparisons between different parts of the visual field. Piaget uses the term "decentration" to refer to this higher level of perceptual activity.

The physical structure of a stimulus configuration is also important from Piaget's point of view because it governs the perceptual mode that is elicited. For example, centration would be prominent in the Delboeuf figure, because the contextual circle is concentric with the focal circle and can be processed in a single glance. Thus, an individual whose perceptual style is predominantly one of centration would exhibit a large distortion on this figure. A more decentrated, analytical mode of viewing this figure, however, would result in a decreased illusion effect.

On the other hand, in the Titchener Circles illusion the contextual circles are non-concentric and the entire configuration can not be processed easily in a single glance. Here an individual whose perceptual style is one of centration would exhibit a small distortion effect while decentration would enhance contrast effects and thus produce an increase in the size of the distortion.

Thus when Piaget's theory is extended to the concepts of assimilation and contrast it would seem that assimilation effects are associated with the process of centration, while contrast effects are associated with the process of decentration.

We may now ask how different environments may influence perception so as to effect an individual's susceptibility to geometric illusions. The simplest way is to argue that environments differ in the kinds of perceptual demands which they make upon individuals and this may influence the speed of the transition from primitive to higher level functioning, that is, from a centrative style to a decentrative style. Thus, rural environments, consisting primarily of natural phenomena may provide a more complex visual array than do urban environments, which contain a preponderance of relatively stereotyped, man-made phenomena. Children brought up in the country, then, will be relatively more practised at making finer perceptual discriminations than are city children, and may in fact precede them in the formation of more sophisticated, analytical perceptual habits. In other words, in an illusion such as the Delboeuf which involves, in Piaget's terms a large degree of centration, rural children should display a smaller distortion than urban children of the same chronological age.

The problem with this analysis is that it would predict that the Titchener Circles illusion should be larger in rural children than in urban children of the same age. However, although this trend upheld for the Indian-Metis group, it is reversed for the White children. Thus,evidence for an "environmental demand" hypothesis is ambiguous for the Titchener Circles illusion.

The interaction between race and environment in the Titchener Circles illusion is a puzzling one as it is not obvious what the Indian Rural and White Urban samples have in common that would predict their equivalent susceptibility to the illusion. In fact, these two groups probably differed more than any other two in terms of environmental and cultural factors. It would seem that the best approach to these data at the present time is to defer speculation on the causative factors until the trends found in the present study are replicated.

Additional Findings and Some Suggestions for Future Research

A close correspondence between adult and children's scores as a function of size of the inducing circle was evident for both the Delboeuf and Titchener Circles illusions. More than anything else this serves to indicate that children can produce reliable perceptual judgments, as measured by the method of adjustment. The great advantage of the apparatus which was used was its game-like appeal for children, and this no doubt contributed to the reliability of their perceptual judgments.

Another interesting finding in respect to the size of the inducing circle was the presence of a negative illusion for the 18 mm Delboeuf configuration. The assumption is usually made that the test circle will assimilate to a small circle in the same way it assimilates to a larger circle, but this assumption does not appear to be tenable. This effect undoubtedly is reliable since it replicates the negative illusion found in adults by Pressey.

The sex variable has not been systematically investigated on past research with children, although the trends which were found in the present study are in the same direction as those found by Pressey and Sweeney (1970) for the Poggendorff illusion. These findings suggest that sex differences in perception provide another area that could fruitfully be explored, particularly from a developmental standpoint.

One of the most intriguing findings in the present study was the decline in the magnitude of the Titchener Circles with age, a finding which is contradictory to all previous research (Wapner & Werner, 1957; Weintraub and Cooper, 1972). In attempting to understand this discrepancy, the major distinction between the present and previous investigations is that, in the present study, a method of adjustment was employed. While it might be argued that the age trends are unreliable because of an unreliable method, the fact that the results confirmed expectations for so many other variables provides strong evidence for its validity.

This issue is a vital one to the major developmental theories of perception (Piaget, 1969, Wapner and Werner, 1957). For example, Piaget links his notion of centration and decentration with what he calls Type I and Type II illusions. Presumably, Type I illusions are those which decline with age and Type II illusions are those which increase with age. The configurations which were said to be Type II illusions included the Ponzo, the filled-space and the Titchener Circles illusions. Recent evidence has shown, however, that the Ponzo and the filled space illusions decline with age rather than increase as was previously believed (Pressey, in press). If the present findings for the Titchener Circles illusion also turn out to be valid, this raises the rather startling possibility that there is no such thing as a Type II illusion. If this were true, some of Piaget's fundamental propositions about perception would be brought into question.

CHAPTER IV

SUMMARY AND CONCLUSIONS

The present study measured the Delboeuf and Titchener Circles illusions in four groups of school children in Manitoba. These included an Indian-Metis Rural group, an Indian-Metis Urban group, a White Rural group, and a White Urban group. A method of adjustment was employed in which an oscilloscope was used to provide a circle of variable size. There were four variations of each configuration, and ascending and descending judgments were obtained for each subject. Control conditions were also included and illusion scores were derived by subtracting the mean of the control scores for each contextual figure.

Analyses of variance were carried out separately for the two types of illusion figures. The results showed a significant main effect for environment on the Delboeuf illusion, with rural groups being less suceptible than urban groups. For the Titchener Circles illusion, however, a significant interaction of race and environment was found.

These results were discussed in relation to the perspective-theory of illusions and to Piaget's theory of perceptual development. A tentative explanation in the form of an "environmental demand" hypothesis was set forward.

An additional finding of great interest was the fact that the Titchener Circles illusion declined in magnitude with age. If valid, this finding raises the possibility that a fundamental reassessment of developmental theories of perception may be required.

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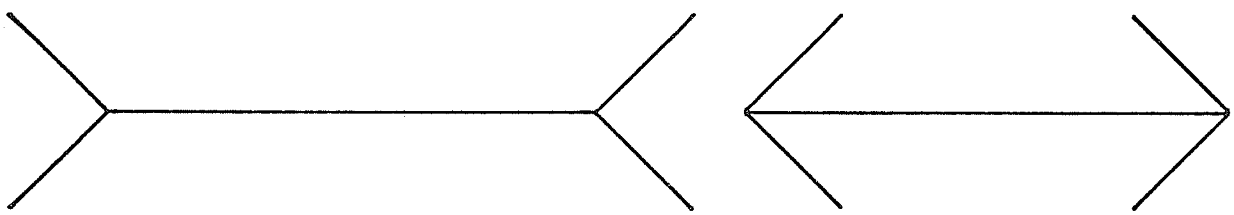
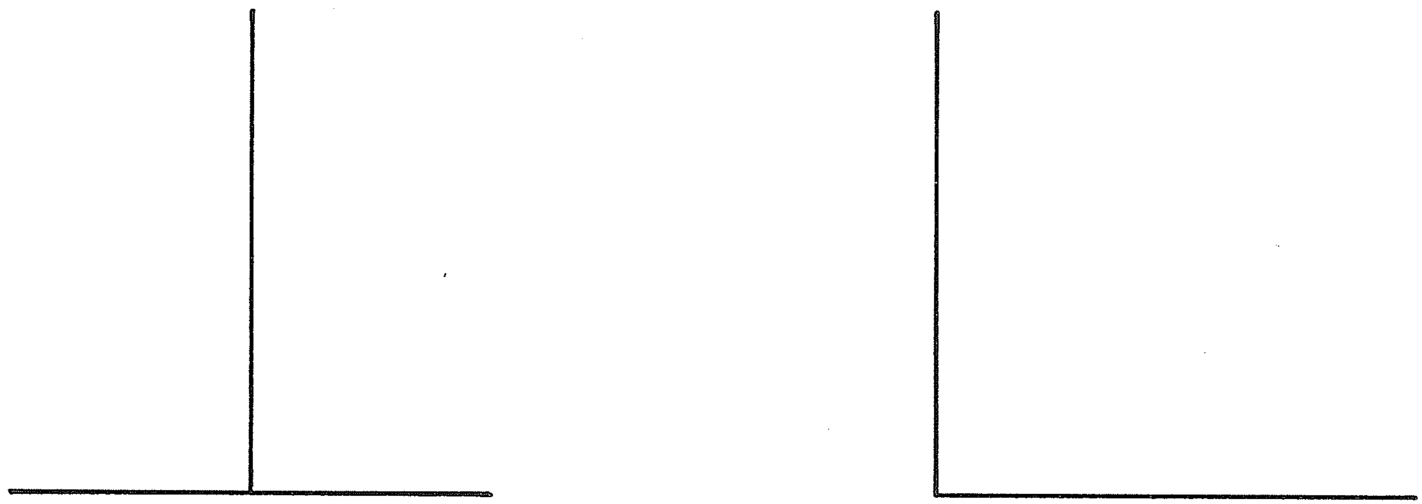
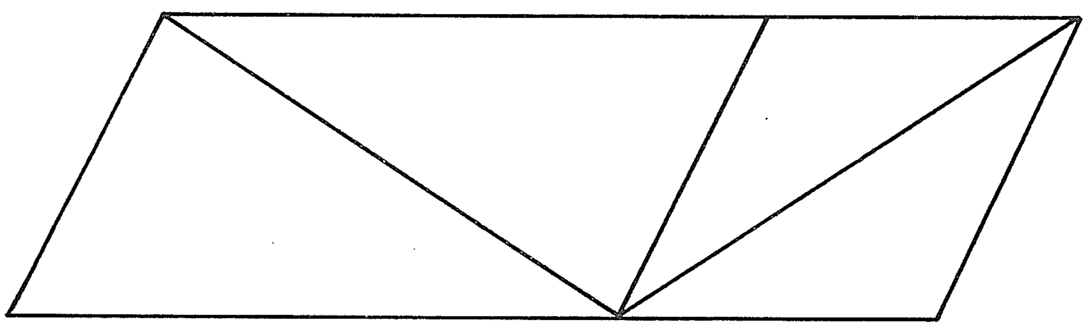
APPENDIX A



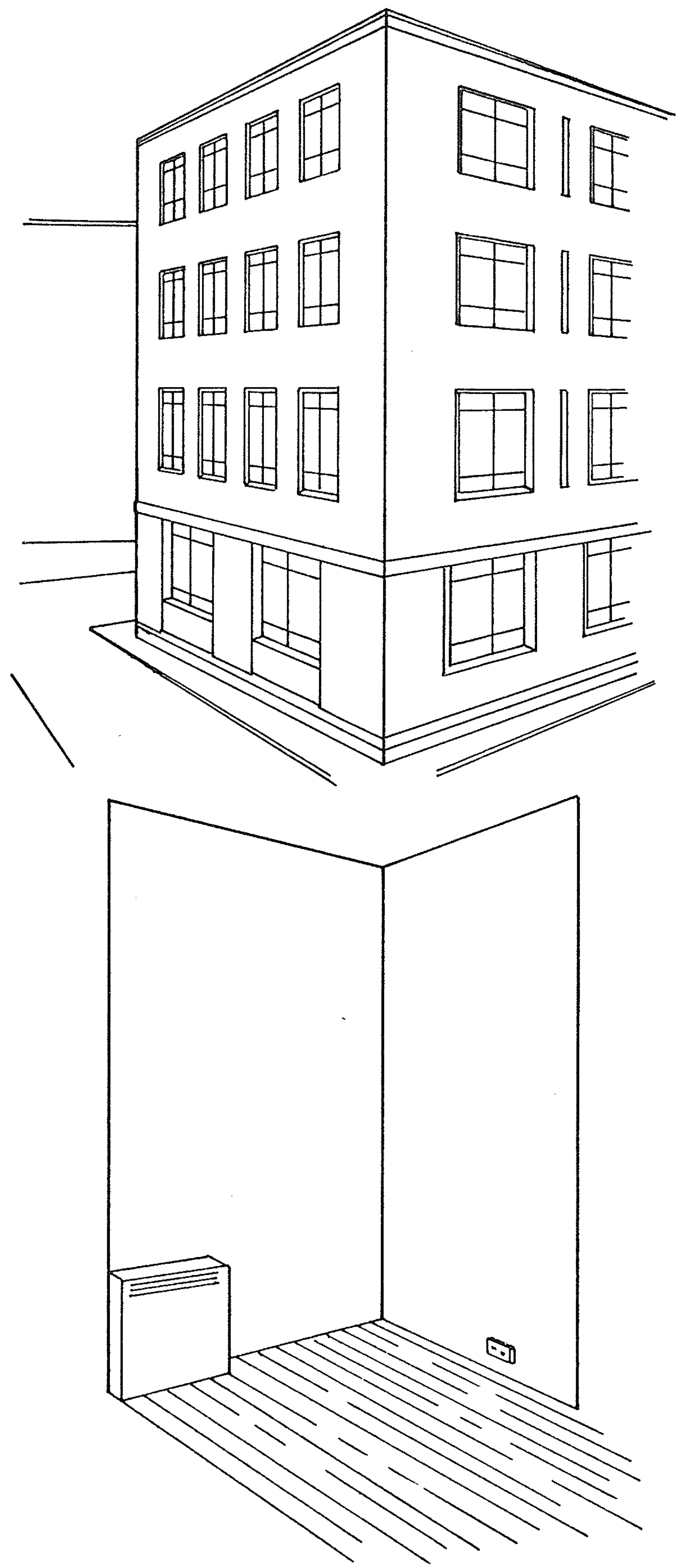
The Müller-Lyer illusion.



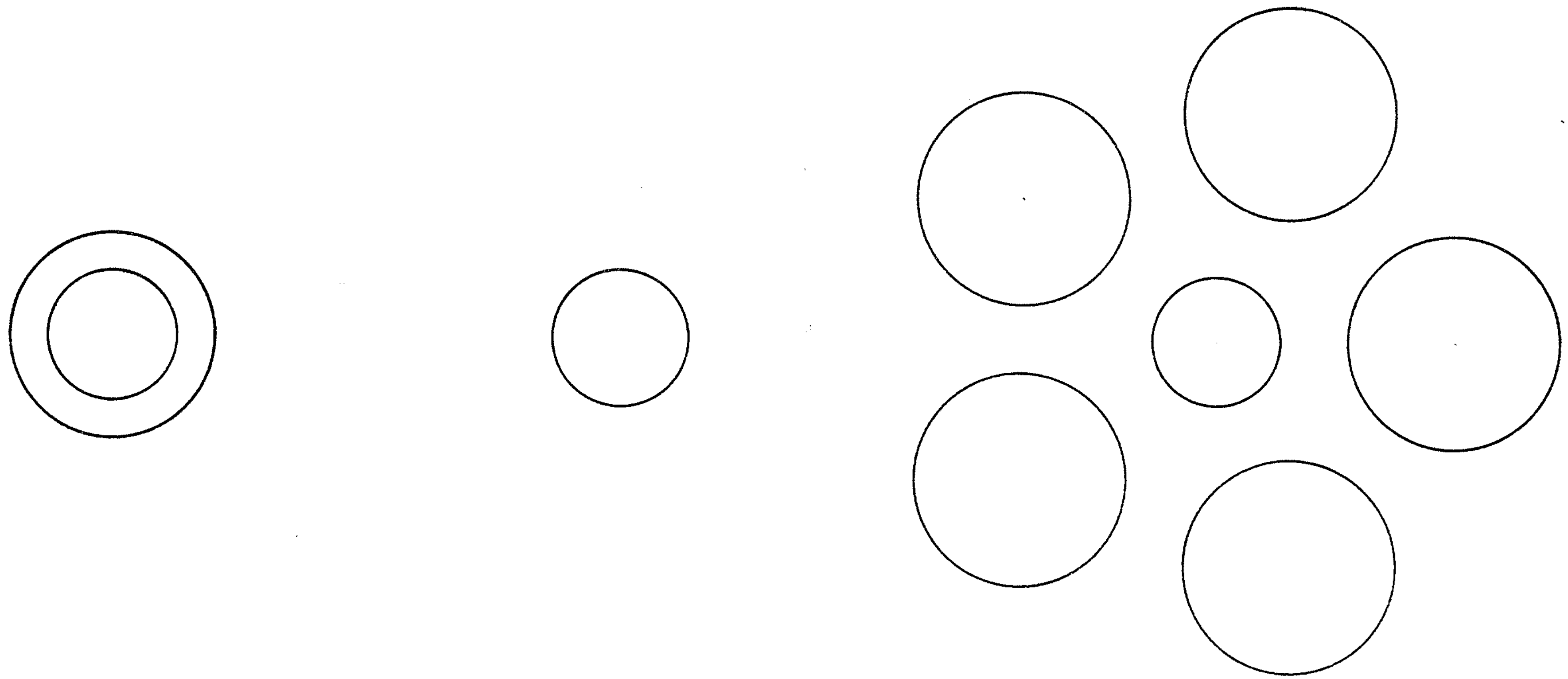
The horizontal-vertical illusion (T and L forms).



The Sander parallelogram illusion.



The Müller-Lyer as right-angles viewed in perspective.



Test materials - Delboeuf illusion, control and Titchener Circles illusion (standard circle = 20mm. in diameter; inducing circle = 32mm. in diameter).

APPENDIX B

RANDOMIZATION PROCEDURE

<u>Stimuli</u> - Delboeuf (D) = 8, 18, 22, 32 mm.

Titchener Circles (TC) = 8, 18, 22, 32 mm.

Control (C) = 20, 20, 20 mm.

Numbers were assigned to each of the stimulus cards according to the following procedure.

	D	TC	C
8	1	5	9
18	2	6	10
22	3	7	11
32	4	8	

The order of presentation of the numbered cards was randomized for all subjects prior to the testing procedure. A deck of cards with the king and queen removed was used for this purpose.

APPENDIX C

APPENDIX C

DATA SHEET

	8	18	22	32	8	18	22	32			
	1	2	3	4	5	6	7	8	9	10	11
TC	5.105	5.22	5.0	4.76							
Raw	4.96	5.055	4.855	4.89							
Score	5.04	5.14	4.93	4.83							
D					4.83	5.32	5.32	5.22			
Raw					4.75	5.0	4.865	5.035			
Score					4.79	5.16	5.10	5.13			
Control									5.06	4.81	4.96
Raw									4.98	4.74	4.675
Score											

Σ x Control = 29.23

$\bar{x}$ Control = 4.87

Illusion	Smaller 1	Smaller 2	Larger 1	Larger
TC*	+.17	+.27	-.06	+.04
D*	.08	-.29	+.23	+.26

*Multiply scores by four to get illusion effect in millimeters.