sage, or (iii) a hypersensitive protein product.

The cellular physiology of this controllable instability may be interpreted in terms of several equally plausible hypotheses (redox changes, enzyme activation, feed-back mechanisms) which are amenable to experimental tests (4).

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Cultural Differences in the Perception of Geometric Illusions

Abstract. *Data from 15 societies are presented showing substantial intersocietal differences of two types in susceptibility to geometric optical illusions. The pattern of response differences suggests the existence of different habits of perceptual inference which relate to cultural and ecological factors in the visual environment.*

Stimulus materials based upon geometric illusions were prepared in 1956 for standardized administration under varying field conditions in an effort to encourage the collection of cross-cultural data that might bear on the nativist-empiricist controversy concerning space perception (1). Over a 6-year period anthropologists and psychologists administered these tests to 14 non-European samples of children and adults, ranging in size from 46 to 344 in 12 locations in Africa and one in the Philippines, to a sample (N = 44) of South Africans of European descent in Johannesburg, to an American undergraduate sample (N = 30), and to a house-to-house sample (N = 208) in Evanston, Ill. In all, data were collected from 1878 persons. Analysis of these protocols provides evidence of substantial cross-cultural differences in response to these materials. The nature of these differences constitutes strong support for the empiricistic hypothesis that the perception of space involves, to an important extent, the acquisition of habits of perceptual inference.

The stimulus materials to be considered here consisted of 39 items, each one a variation of one of four figures constructed of straight lines, generally referred to in the psychological literature as perceptual, or geometric illusions. These were the Müller-Lyer figure (12 items), the Sander Parallelogram (seven), and two forms of the Horizontal-vertical figure (nine and eleven). For each illusion the discrepancy in length of the segments to be compared varied from item to item so as to permit the employment of a version of the psychophysical method of constant stimuli. As each stimulus was

shown to a respondent, his task was simply to indicate the longer of two linear segments. To minimize difficulties of communication, the materials were designed so that the linear segments to be compared were not connected to the other lines, and were printed in different colors. Respondents could indicate choice by selecting one of two colors (saying *red* or *black*) in response to the Horizontal-vertical items, and by indicating *right* or *left* for the other illusions. Other steps taken to enhance the validity of response protocols included the administration of a short comprehension test requiring judgments similar to, but more obvious than, those demanded by the stimulus figures. Nonetheless, since no amount of precautionary measures could insure the elimination of all sources of error (for example, communication difficulties, response sets, and so forth) which could result in artifactually produced cross-cultural differences, an internal consistency check was made and all protocols containing gross departures from orderliness were withheld from analysis. (Another analysis was performed with all 1878 cases included, and the results were substantially the same as those obtained in the analysis of consistent cases only.)

The analysis proceeded as follows: Each respondent's four protocols were first examined for evidence of internal consistency. To be considered consistent, a protocol had to contain no more than one Guttman error (2). Each consistent protocol was then assigned a score which was simply the total number of times in that stimulus set that the respondent chose the typically overestimated segment. The mean of these

scores was computed for each sample, and differences between pairs of means were evaluated by *t*-tests with significance levels modified by the Scheffé procedure (3) to compensate for the increase in error rate that accompanies nonindependent, multiple comparisons.

On both the Müller-Lyer and Sander Parallelogram illusions the three "European" samples made significantly more illusion-produced responses than did the non-European samples. (The innumerable *t* ratios resulting can only be sampled here. For example, on the Müller-Lyer illusion, comparisons of the Evanston sample with the non-European samples resulted in *t* ratios ranging from 7.96 to 15.39. A value of 3.57 is significant at the *p* = .05 level by the Scheffé test.) On the latter two illusions, the European samples had relatively low scores, with many, but not all, of the non-European samples having significantly larger mean scores. (For these illusions, the largest *t* ratios, up to 17.41, were found between pairs of non-European groups. Comparisons involving the Evanston sample and five non-European groups resulted in *t*'s ranging from 11.04 to 4.69.) When the samples were ranked according to mean number of illusion responses on each illusion, and the rank order correlations among the five illusions factor-analyzed, two orthogonal factors emerged; the Müller-Lyer and Sander Parallelogram illusions loaded highly on one, and the Horizontal-vertical illusions loaded highly on the other. Thus, the overall pattern of intersample differences indicates not only cross-cultural differences in illusion susceptibility, but in addition a systematic variation in those cross-cultural differences over two classes of illusion figures.

Both to illustrate and substantiate the findings which emerged from the analysis just described, proportions of individuals in each sample choosing the typically overestimated segment were computed for each item, separately for each illusion set. Psychophysical ogives were then constructed from these proportions and points of subjective equality (PSE) determined graphically. Table 1 contains PSE scores and mean number of illusion-responses for all samples on each of the illusions. (The scores shown in Table 1 were computed for internally consistent cases only, and, except where otherwise noted, the groups consisted of children and adults combined. In samples containing both children and adults, children typically had higher means and PSE's. Combining children and adults
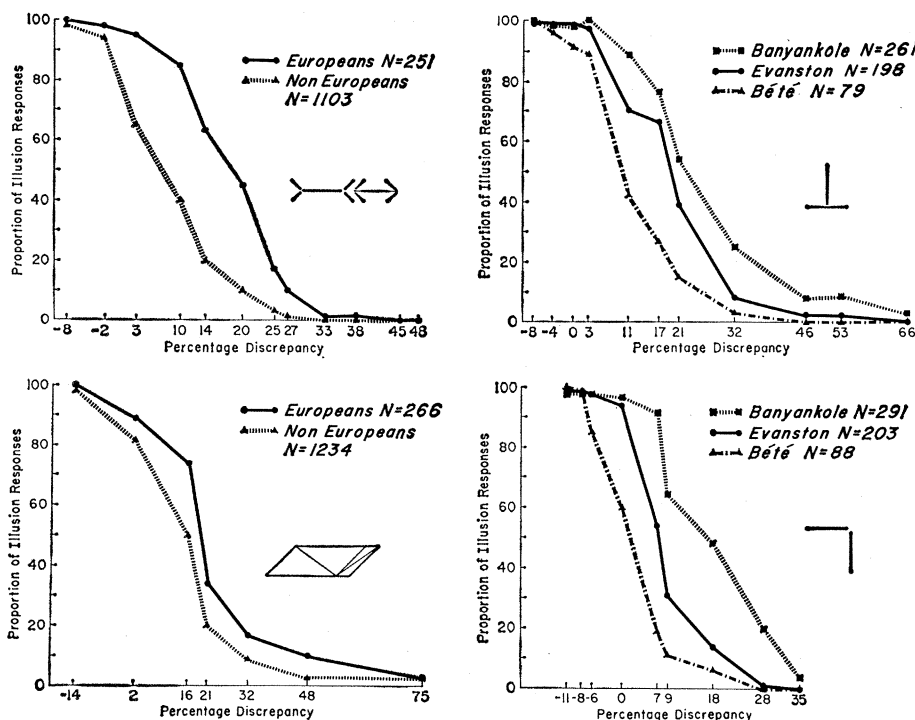
Fig. 1. Psychophysical ogives based on proportions of illusion responses to item of varying percentage discrepancy. (Upper left) Müller-Lyer illusion responses plotted for Europeans (three samples combined) and non-Europeans (all other samples combined). (Lower left) Sander Parallelogram illusion responses plotted for same two combined groups. (Upper right) Horizontal-vertical (⊥) illusion responses by one European and two non-European samples. (Lower right) Horizontal-vertical (⊓) illusion responses by same three samples. These graphs are all based on internally consistent cases only.

Table 1. Points of subjective equality and mean number of illusion responses.

Group	N	PSE (%)	Mean	Group	N	PSE (%)	Mean
Müller-Lyer illusion				*Horizontal-vertical illusion* (⊥)			
Evanstonians	188	20.3	5.36	Suku	69	21.0	6.55
N. U. students*	27	16.2	5.00	Banyankole	261	22.5	6.54
S. A. Europeans*	36	13.5	4.33	Dahomeans†	57	22.3	6.49
Dahomeans†	40	11.9	4.23	Toro	105	20.0	6.44
Senegalese	125	12.2	4.18	Ijaw School†	46	20.7	6.28
Ijaw School†	54	6.6	3.67	S. A. mineboys*	69	19.3	6.27
Zulu	35	11.2	3.66	Fang	98	19.3	6.18
Toro	86	10.3	3.56	Senegalese	130	22.7	6.11
Banyankole	224	9.3	3.45	Ijaw	86	19.5	6.06
Fang	85	6.2	3.28	Bushmen*	41	19.5	5.93
Ijaw	84	6.5	3.16	*Evanstonians*	198	18.4	5.81
Songe	89	6.2	3.07	Songe	91	18.2	5.80
Hanunoo	49	7.7	3.00	N. U. students*	29	18.7	5.72
Bete	75	3.2	2.72	Hanunoo	52	15.3	5.46
Suku	61	2.8	2.69	S. A. Europeans*	42	15.0	5.33
Bushmen*	36	1.7	2.28	Zulu	35	9.5	4.80
S. A. mineboys*	60	1.4	2.23	Bete	79	9.8	4.62
Sander-parallelogram illusion				*Horizontal-vertical illusion* (⊓)			
N. U. students*	28	19.9	3.54	Dahomeans†	63	19.2	6.52
Evanstonians	196	19.1	3.27	Toro	98	19.5	6.38
Ijaw School†	53	18.3	3.15	Banyankole	291	17.0	6.15
S. A. Europeans*	42	17.4	2.98	Ijaw School†	57	18.4	6.02
Zulu	67	18.5	2.97	Suku	69	9.0	5.74
Senegalese	198	15.7	2.90	S. A. mineboys*	69	11.5	5.71
Fang	96	17.3	2.86	Songe	95	8.9	5.60
Ijaw	98	16.9	2.74	Ijaw	97	8.9	5.55
Banyankole	262	17.3	2.69	Fang	105	9.1	5.49
Dahomeans†	58	16.0	2.55	Bushmen*	39	8.6	5.15
Hanunoo	52	13.5	2.52	Zulu	74	7.8	5.03
Toro	105	14.3	2.49	*Evanstonians*	203	7.2	4.90
Songe	97	14.7	2.41	N. U. students*	30	7.2	4.83
Bete	86	12.8	2.37	Hanunoo	53	6.3	4.70
Suku	91	9.7	2.14	S. A. Europeans*	42	5.0	4.67
S. A. mineboys*	71	8.7	2.06	Senegalese	168	6.0	4.45
(Bushmen not administered this set)				Bete	88	2.0	3.81

* Adults only.   † Children only.

as in Table 1 tends to attenuate some intersample differences.) Figure 1 contains four sets of ogives which illustrate (i) the lesser susceptibility of the combined non-European samples as compared with the combined European samples to the Müller-Lyer and Sander Parallelogram illusions, and (ii) the greater susceptibility to the two Horizontal-vertical illusions shown by one non-European sample group as compared to one European sample, and the lesser susceptibility of another non-European sample. Examples of the four illusions are also presented in Fig. 1.

Cross-cultural comparisons made over a half-century ago by Rivers (4) also indicated that two non-Western peoples were simultaneously less susceptible to the Müller-Lyer illusion and more susceptible to the Horizontal-vertical illusion than were a group of English respondents. Since the non-European samples uniformly perform better than Europeans on one type of illusion and generally worse on the others, any explanation based on presumed contrasting characteristics of "primitive" and "civilized" peoples is difficult to maintain. Rather, evidence seems to point to cross-cultural differences in visual inference systems learned in response to different ecological and cultural factors in the visual environment. In a monograph now in preparation which reports the present study in detail (5), Rivers' findings as well as our own are shown to be in accord with an empiricistic, functionalistic interpretation which relates visual response habits to cultural and ecological factors in the visual environment.

An example of a cultural factor which seems relevant is the prevalence of rectangularity in the visual environment, a factor which seems to be related to the tendency to interpret acute and obtuse angles on a two-dimensional surface as representative of rectangular objects in three-dimensional space. This inference habit is much more valid in highly carpentered, urban, European environments, and could enhance, or even produce, the Müller-Lyer and Sander Parallelogram illusions. This interpretation is consistent with traditional explanation of these illusions. Less clearly, the Horizontal-vertical illusion can perhaps be understood as the result of an inference habit of interpreting vertical lines as extensions away from one in the horizontal plane. Such an inference habit would have more validity for those living in open, flat terrain than in rain forests or

canyons. An examination of such factors, and thorough examination of alternative explanations of our findings, are contained in the forthcoming monograph. Whether or not the correct environmental features have been isolated, the cross-cultural differences in susceptibility to geometric illusions seem best understood as symptomatic of functional differences in learned visual inference habits (6).

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5. M. H. Segall, D. T. Campbell, M. J. Herskovits, "The influence of culture on perception," in preparation. This report includes an examination of age differences as well as total sample differences. Included also is a development of the theoretical arguments suggested here, presented in the context of a review of the literature bearing on the nativist-empiricist controversy, and a discussion of the significance of these data for the anthropological concept of cultural relativism.
6. Space does not permit mention of all the many individuals and organizations that contributed to this project. Major thanks are due those who assisted us in the collection of the data: D. Bender, M. Boye, R. Clignet, H. Conklin, J. Fernandez, J. Golden, I. Kopytoff, N. Leis, P. Leis, B. LeVine, A. Merriam, P. Morgan, E. Perlman, H. Reuning, and N. Scotch. Supported by funds provided by the Program of African Studies at Northwestern University and the Ford Foundation. Special thanks are due D. W. Norton for advice and assistance in data analysis.

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Abnormal Hemoglobin Studies in Taiwan Aborigines

Abstract. No abnormal hemoglobins were detected in a survey of blood samples from three of the largest aboriginal tribes of Taiwan. Samples from 655 individuals of the Ami, Paiwan, and Atayal tribes were examined by Smithies' method of vertical starch gel electrophoresis at pH 9.0. Only the A hemoglobins were found.

The fact that several abnormal hemoglobins, including types E, G, H, J, K, O, and Q, occur among Asian ethnic groups prompted us to survey Taiwan aborigines for abnormal hemoglobins. The aborigines in Taiwan are grouped by some anthropologists (1, 2) into at least eight tribes, with some subtribal divisions. The tribal classification is based on language, cultural characteristics, and past and present geographical location on the island. The total aboriginal population of Taiwan currently exceeds 150,000 persons; the individual tribes vary in population from approximately 1500 (for the Yami tribe on the small island of Lan Yu, or Orchid Island, or Botel Tobago) to more than 50,000 (for the Ami tribe on the east central coast). The Atayal tribe, with nearly 40,000 members, is the second largest, and the Paiwans, with slightly more than 30,000, are third largest. The Atayals inhabit the mountainous regions in the northern half of the island, and the Paiwans inhabit the mountainous area in the southern quarter.

No extensive research has been done by anthropologists on the possible relationships among the Taiwan aborigines and the peoples native to other parts of the Western Pacific area and Asia. The Yamis, however, have been decisively linked by language and cultural characteristics to inhabitants of the Batan Islands, the northernmost group of the Philippines (1). Nothing as definitive has been established for the other tribes.

Blood samples of children and adults of both sexes from the Ami, Paiwan, and Atayal tribes were examined. Except for pairs of husbands and wives or other pairs of individuals unrelated by birth, only one member from a family group was taken as a subject; this procedure provided a more nearly random sampling of the population. Smithies' method of vertical starch gel electrophoresis (3), with minor modifications, was combined with the pH 9.0 TRIS-EDTA-borate buffer system of Goldberg (4) for all the determinations because we consider it the most sensitive single screening procedure presently available for detecting abnormal hemoglobins.

Only the normal type A hemoglobins were found in the 655 blood samples (278 Ami, 205 Paiwan, and 172 Atayal). Our results indicate that abnormal hemoglobins occur only rarely or not at all in these three tribes. Although it seems reasonable, in view of our findings, to expect a low rate of occurrence of abnormal hemoglobin among other Taiwan aborigines, we are collecting further samples. No quantitative analyses of the relative amounts of A_1 and A_2 type hemoglobins have been made; however, visual inspection, by which any significant elevation of A_2 can be readily detected, indicated no abnormally high levels.

Additional anthropological data, both physical and biochemical, are required before possible relationships between the Taiwan aborigines and other ethnic groups can be determined. It would be of interest, for example, to obtain information concerning which of the Asian groups, including the Taiwan aborigines, may be related to the aborigines of the Western Hemisphere as a result of past migrations between the two areas. Because several workers (5) have reported a lack of abnormal hemoglobins among the aborigines of North, Central, and South America, it would appear that the Taiwan natives and other Asian groups with similar hemoglobin characteristics would be among the most likely to be investigated. It is anticipated that current haptoglobin studies will provide additional relevant information (6).

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