Illusions, Patterns and Pictures:

A Cross-Cultural Perspective

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2. Illusions

INTRODUCTION

Although there is a large number of illusory phenomena not all of these have been subject to equally intensive investigation or have been regarded as of equal interest. The following four illusions have, for theoretical reasons which we shall discuss, occupied cross-cultural researchers almost to the exclusion of all others:

(1) The Horizontal–Vertical illusion,

(2) The Muller-Lyer illusion,

(3) The Sander parallelogram,

(4) The Perspective illusion in various forms including the Ponzo illusion.

It will be recalled that both the Horizontal–Vertical and the Muller-Lyer illusions were major items in Rivers' research programme, and that he thought the effects which these figures evoke to be of different origins. This assumption of a difference between these two groups of illusions has persisted to the present day, although the hypothetical reasons for the difference have changed.

The hypotheses which have almost exclusively dominated recent cross-cultural studies of the illusions are those put forward by Segall *et al.* (1966), who have carried out the hitherto most extensive study of all the cross-cultural studies of illusions. The roots of the hypothesis can be traced to Brunswik's (1956) notion of ecological "cue validity" and the related concept that consistent encounters of certain cues direct the development of modes of perception. In consequence "The modes of operation are what they are because they are generally useful". The immediate cause which led to the investigation however is the opinion held by anthropologists (represented by Herskovits) that the basic character of human perception is affected by ecological and cultural variables and the contradictory opinion held by some psychologists that perceptual processes are essentially the same in all human beings.

These contrary views led to a "running debate" at Northwestern University. To resolve the debated issue an extensive research project was embarked upon.

Investigation of populations differing greatly in their cultures and living in different environments should enable one to clarify the issue. If no differences between such populations were observed then the claim for the impact of environment and culture would be weakened. It would not however be nullified because of the lack of control of genetic factors; a more complex and, *prima facie*, unlikely hypothesis that an egalitarian genetic mechanism redressed the imbalances introduced by the environments would still be sustainable. Lack of genetic control in such an investigation (and there are indications that susceptibility to illusions may be to some extent hereditary (Coren and Porac 1919)), restricts the interpretation of any finding of inter-group differences since these remain attributable to both genetic and environmental factors. Such restriction, although logically valid, does not in practice render the observations void. This is so because the evidence derived from a large number of environmentally disparate groups in which the genetic factors do not appear to form any definite pattern, can parsimoniously be said to support the environmental rather than the genetic interpretation of the formative influences.

If the environmental experience is such as to affect a particular type of percept, e.g. the length of a line or the size of an angle, one would expect such influence to affect all lines and angles, but with declining effect as the number of attributes which the stimuli share with the objects from which the relevant experiences were derived decreases. Hence the most efficacious manner in which one could test the effect of ecology upon perception would be to transfer people living in one ecology to another and observe their responses. A pigmy translated from the dense, closed environment of the jungle to open savannah or desert should make such errors as we would expect from a man whose experience did not provide him with opportunities of using normal distance cues. Indeed, such errors were made by Turnbull's (1961) companion, a pigmy, who on encountering cows on his first journey away from the native dense forest thought the animals to be ants; he did so although he was familiar with cows, but not with cows at a great distance.

This evidence suggests that such distance cues as there were, were not perceived correctly. The density gradients which must have stretched in front of the pigmy, the elevation in the field of view as well as other cues which might have been present did not affect his perception in the same manner as they did Turnbull's. One can try to refine this argument further and to postulate that the error was not so much due to the fault of

the basic perceptual mechanism, but to the unusual (from the pigmy's point of view) conditions in which this mechanism had to work. Such unusual conditions may call for a different weighting of various perceptual cues than that normally used by the observer. Aerial perspective, for example, is likely to be of much lesser import when objects are near to the viewer than it is when they are far away; on the other hand the significance of such density gradients as are often provided by the surfaces of the objects may with the increasing distance be lost entirely, so that the only major perceptible characteristics are those of shape and colour. Such remnants of the normal perceptual cues would thus gain greatly in importance and compounded with the cue of the aerial perspective enable an experienced observer to say: "These cows at a distance *look* as small as ants". His failure of size-constancy does not lead him astray. He discounts it and arrives at a decision by other means.

THE ECOLOGICAL EFFECT AND THE HORIZONTAL–VERTICAL ILLUSION

Although pictures and geometrical figures cannot convey all the cues presented by objects in three-dimensional space they can convey some of them, but the cues so provided are always contradicted by the cues derived from the surface on which the figures are drawn. Consider a simple vertical line on a plain piece of paper. This approximates in its retinal projection to a line which could be projected by a long straight object placed at *any* angle in the subject's median plane; it could represent a sapling, a spear inclined against a hut, or a path stretching away into the far distance in front of the observer. Obviously the first of these objects is likely to be a common experience of the inhabitants of dense forests, whilst the last is likely to be a common experience of those who inhabit open plains. A simple vertical line could therefore be used to measure the impact of the environment upon perception. The judgement of the length of such a line requires a standard against which it can be assessed; and a line orthogonal to the judged line provides such a standard, if one accepts that the ecological effect responsible for the differences of the perception of the vertical line does not affect the horizontal line equally. This being so the Horizontal-Vertical illusion figure offers a suitable measuring instrument of the ecological impact.

The essence of the measured effect lies therefore in non-isotropy of the perceptual field. In a dweller of an extremely dense, enclosing environment, where the gross of the visual stimulation is derived from vertical

planes which like stage props surround him, the panorama is essentially isotropic, i.e. it has the same properties in all directions and hence all the lines independently of their orientation are presumably subject to the same scaling effect.

The perceptual field of the dweller of open plains, on the other hand, is non-isotropic. The vertical dimensions are expanded relative to the horizontal dimensions. This is a result of extensive experience of an environment in which the notion of the "vertical" dimension is derived generally from projections of distances stretching away from the observer, whilst that of the horizontal dimension is derived from observation of features of the environment which lie in one of the observer's fronto-parallel planes. The resulting non-isotropy of the perceptual field is therefore an adaptive response of the organism to environmental press. Its effects can be detected either by transfer of an observer between environments differing in the characteristics of their pressure or by using test materials which create analogous effects.

Any material would serve the purpose and the use of illusion figures is not really necessary, although they may be thought of as being very convenient tools.

THE CARPENTERED WORLD EFFECT AND THE MULLER-LYER AND SANDER PARALLELOGRAM ILLUSIONS

The rationale for the Carpentered World effect is also derived from the consideration of individuals' experience. It rests, however, on the characteristic features of the man-made environment. It is an undisputed feature of man-made goods that they tend to display a greater regularity of form than do the natural objects encountered daily. The extent of such regularity is not, however, equal in the artefacts of all the cultures. It varies with the extent to which a particular culture imposes its own restrictions upon the vagaries of the natural phenomena; it is less in those populations whose technology is adaptive rather than transformative of the natural environment, than in those whose technology is primarily transformative rather than adaptive. A Zulu whose ploughing follows the contours of the land is, in this sense, less subject to the cultural determinants than a Chinese farmer planting rice in his rectangular paddy. The regularity of cultural artefacts increases with the sophistication of the technology and so does the number of such regular artefacts available. The reasons for this need not concern us here; what is important as far as the postulated effect is concerned is the

fact that such cultural differences exist and therefore, if perception is affected by experience, they may lead to differences in perception among various populations.

One of the more striking aspects of the regularity is the presence of right angles in the artefacts. Hence in cultures where such angles are dominant one would expect subjects to interpret other angles as right angles whenever ambiguous angles are met. In the cultures where right angles are rare one would expect no such misperceptions. One would, therefore, expect to observe differences between such cultures as that of the traditional Zulu, the inhabitants of hemi-spherical huts, engaged in contour-agriculture and having practically no rectangular artefacts, and that of the Western urban man, who lives in a block of flats furnished with rectangular furniture.

Any geometric figure containing ambiguous representations of angles could be used for investigating the postulated effect and the well known Muller-Lyer and the Sander parallelogram illusion figures can therefore be used for the purpose.

The lengths of the "shafts" of the two parts of the figure are compared in the Muller-Lyer illusion but the interest of the comparison derives not from the perceived distortion of the shafts themselves but from perception of the depicted angles involving the shafts as well as the fins of the figure. The Carpentered World hypothesis is, as we have said above, not concerned with perception of length of lines but with perception of angles. A connexion between the perception of the angles and of the lengths needs therefore to be formulated. This has been done by Gregory thus: both the elements which are contrasted in the traditional illusion (see Fig. 2.1) can be said to show a corner of, say, a building, the

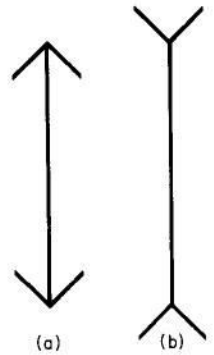

Fig. 2.1 Muller-Lyer figure. The right hand figure presents an arrangement of lines similar to that derivable from the intersections of a floor, walls and a ceiling inside a room. The left hand figure is similar to the arrangement obtainable to a viewer looking at a cuboidal building from outside.

two fins being in both cases projections of right angled joints, but whilst one of the figures represents an exterior corner of a house, the other represents an internal corner of a room. The implications of this difference are taken into account by the perceptual mechanism. The angles are perceptually interpreted as right angles and the lines connecting them appropriately "shortened" or "lengthened". Gregory (1968, 1973) argues that such typical depth cues can trigger the constancy scaling mechanism without causing perception of depth. This type of misplaced constancy scaling is called by Gregory *primary* or *depth-cue* scaling to distinguish it from secondary scaling, which involves transformation of perceptual data. Secondary scaling commonly occurs in the processing of reversible figures and can be experienced, for example, by observing the changes in the perceived size of faces of a Necker cube as it reverses. Thus whilst *primary* scaling is *upwards* from data to hypotheses, *secondary* scaling is *downwards* from hypotheses to data. The simple illusion figures, such as those discussed here, are said to evoke *primary* scaling. In the specific case of the Muller-Lyer figure the lengths of the two shafts are scaled in accordance with the depth cues which they themselves and the fins provide.

An identical argument applies to the Sander parallelogram. The illusory effect evoked by this stimulus, like that evoked by the Muller-Lyer illusion, is a distortion of perceived lengths of straight lines. As is the case with the Muller-Lyer illusion, the effect can be thought of as resulting from misperception of angles. This is apparent from Fig. 2.2, where the standard Sander parallelogram is represented as if it were

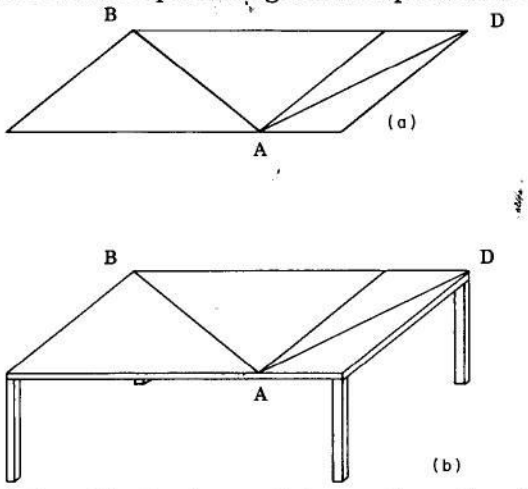

Fig. 2.2 Representation of the Sander parallelogram figure (a) on its own and (b) as if drawn on a table.

drawn on the top of a table. The drawing of the table is admittedly poor since there is no perspective convergence, but is none the less clearly recognizable. The corners are therefore perceived as right angled and line AD is perceived as being shorter than line AB.

The illusions affected by the carpenteredness are thus not dependent upon isotropy of the visual field but upon the tendency of the perceptual apparatus to treat all angles as if they were right angles.

PERSPECTIVE ILLUSIONS: THE PONZO ILLUSION

The experiential hypothesis which could be put forward to explain Perspective illusions, of which the Ponzo illusion is probably the best known example, is almost intuitively obvious. The two converging lines are thought to evoke to some extent the same percept as that evoked by a pair of parallel lines stretching away from the observer. Indeed they represent a configuration which would be obtained if such lines stretching away from an observer were projected upon a screen placed in the observer's fronto-parallel plane (provided that the focus of the projection lines were on the observer's side of the screen).

Two lines converging towards the top of a page are thus associated with the edges of a road stretching in front of the observer; two lines converging towards a side of a page with, say, top and bottom of a long wall. Under these circumstances in "real life" a stick placed at various distances along a road or along a wall would yield decreasing projections as its distance from the observer increased, and the constancy mechanism would try to compensate for this apparent shrinkage by taking account of cues indicating that the stick was at a distance, thus ensuring that the stick would be perceived as larger than it would be had the percept been based solely on its retinal projection.

The illusory effects on the figures such as that shown (Fig. 2.3) are therefore again a result of the perceptual analogy. The perceptual mechanism is tricked by the similarity of the stimuli and, notwithstanding certain contradictory cues (such as the surface of the paper) which indicate that all the elements of the figure are equidistant from the observer, indulges in constancy scaling, and the line which in the three-dimensional space would lie further away is seen as larger than the "nearer" line, in spite of being objectively equal to it.

One would expect, if the experimental factors are effective, the magnitudes of illusions evoked by the perspective figures to correlate positively with that of the Horizontal–Vertical illusion, since the postulated

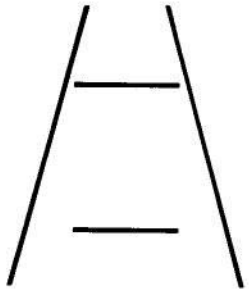

Fig. 2.3 Ponzo figure.

mechanisms responsible for both illusions embody an assumption that the effect is associated with perception of distances in the environment. One would also expect this illusion to yield results correlating positively with those of the Muller-Lyer illusion since the carpenteredness of the environment which is postulated to be responsible for the latter would ensure not only that the non-rectangular angles will be perceived as rectangular, but also that non-parallel and non-orthogonal lines will be perceived either as parallel or as orthogonal. It follows that the populations especially prone to the Perspective illusions would be those inhabiting open plains *and* living in a carpentered culture, whilst inhabitants of dense environment *and* coming from non-carpentered cultures should show relatively little proneness.

There is yet another reason why the probability of correlation between scores on these illusions would be expected. This does not involve a postulate of common determinants but rests upon the fact that a figure can be drawn which evokes an illusory effect, but is of such an appearance that it can with about equal degrees of arbitrariness be thought of as embodying elements of the Muller-Lyer figure, of the Ponzo figure, or of the Horizontal-Vertical illusion figure. Consider Figs 2.4a and 2.4b; in both of these the vertical lines are equal and are twice the length of the slanting segments. This figure evokes an illusion that the vertical on the right is longer than that on the left. This may be thought to be so because both the right and the left components consist each of a combination of two modified "Horizontal-Vertical" figures (Cormack and Cormack 1974); or it might be thought that each of the two figures is an incomplete Muller-Lyer stimulus, with a fin missing at both ends. Finally, it is possible to speculate that the fins are perceived as incomplete converging lines of the Ponzo figure.

The view that the three illusions are thus related was not shared by Segall *et al.* (1966, p. 89), who thought that the Perspective illusion reflected only that influence which affects both the Sander parallelogram and the Muller-Lyer figures but did so feebly; that it was influenced by the carpenteredness of the environment. They did not consider the possibility of the Horizontal–Vertical illusion and the Perspective illusion figures having a common determinant.

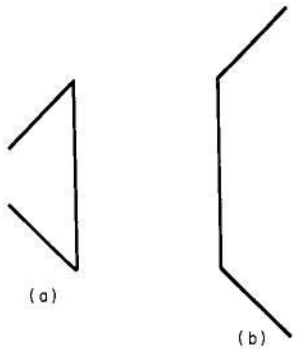

Fig. 2.4 Two figures which could be said to embody at least three of the generally recognized illusions.

The Perspective illusions have not been found to discriminate clearly between different cultural groups. Rivers in his Torres Straits studies, it will be recalled, had obtained but weak effects which he attributed to subjects' lack of interest. Segall *et al.* (1966) also obtained rather unconvincing data from their samples (see p. 36).

SOME OBJECTIONS

Before examining some of the data obtained in investigations of the Ecological hypothesis and the Carpentered World hypothesis it is necessary to examine some of the objections to these hypotheses which are so fundamental that if correct they deprive these investigations of any *raison d'être* they might possess.

First there is a very general objection which is based, one suspects, on misunderstanding of the hypotheses put forward, and which maintains that an experimental demonstration of some other influence nullifies the value of such hypotheses.

This is not so. The hypotheses do not suggest that the particular environmental effects are the sole determinants of illusions, but merely that the illusory effects are influenced by the environment. This means that other influences, both environmental and non-environmental, may be present and hence that the effect may vary even when those environmental influences which are explicitly stated in the hypotheses remain constant. Therefore demonstration of other influences such as,

say, pigmentation of the fundus oculi, does not deny the essence of the environmental hypotheses but merely shows that the extent of the effects put forward is moderated.

Other common objections are aimed not directly at the hypotheses but rather at the postulated involvement of the constancy scaling mechanisms in the phenomena. Some other mechanism could of course be postulated but it is difficult to conceive how such a mechanism could operate without affecting constancy scaling, or making the entire scheme grossly extravagant, unless the entire notion that illusion figures contain depth cues were dismissed. Suggestions of such dismissal have also been made. Several of these objections are examined in Robinson's (1972) book on illusions. We shall discuss here only those which are most pertinent to cross-cultural work.

Probably the most common of the objections uses the presence of related illusory phenomena in the "real" three-dimensional world as an argument against explanations involving notions of constancy scaling.

This argument runs as follows:

> If the illusions are a result of misapplication of the perceptual mechanism because it treats a set of lines on a plane as representing a solid, then such misapplications cannot possibly occur in the case of solids because the perceptual conflict which is present in the case of figures between the depth cues and the surface on which the figures are drawn does not arise in the "real world". Therefore illusions cannot occur in the "real world". Furthermore misapplication of the scaling mechanism in the "real world" would be grossly maladaptive.

The evidence that illusions are not confined to drawings but occur in the "real world" has been provided by several experimenters working in a single culture (e.g. by Zanflorin 1967). Such evidence is however scarcely needed for application of illusions in architecture has a long and distinguished history. Pirenne (1970) provides two fully analysed examples of such application, an arcade by Borromini in the Palazzo Spada and Michelangelo's Piazza of the Capitol. Both these architects relied on the effect of convergence of buildings upon perceived distance. They introduced convergence where none would be expected by the viewer with the effect that his perceptual mechanism is tricked to regard it as a cue for distance and hence the buildings are perceived as distorted, which is exactly what the architects desired. A humbler but much more well known version of this phenomenon occurs in the Ames room (Ittleson 1952, Gregory 1973). Brislin and Keating's (1976) intercultural study also demonstrates this effect; it seems unlikely therefore that the argument could be faulted for lack of evidence.

There is a flaw in the argument however; it lies in the assumption that when a misapplication of perceptual mechanism occurs in the "real world", it is contrary to the postulated effect of misapplied scaling.

It seems reasonable to accept that the perceptual mechanism is triggered by certain cues and that the origin of these cues is unimportant but that their relationship to other cues is. Similar configurations of cues lead to similar percepts whatever their sources, whether illusion figures or "real world" configurations.

This point is elaborated upon in the following description of the application of the ecological hypotheses to perception of the Ponzo illusion:

> All parallel edges encountered in the "real" world with the sole exception of those which are in the observer's fronto-parallel plane are projected as converging lines upon such a plane placed between the observer and the stimulus. In consequence, drawing of two converging lines evokes a scaling response appropriate in some measure to parallel lines and this leads to distortion of other elements of the figure. This distortion is the illusory effect which is measured in experimental investigation of illusion. But a retinal projection resulting from a drawing showing two converging lines is identical with retinal projections cast by two converging edges of a lamina which is placed at any inclination to the observer, with the exception of a unique position in which the inclination compensates for the convergence. Hence, if extensive experience of parallel edges leads to misperception of lines which cause projections of converging lines it is likely to do so for all such projections, whether they originate from a flat or from a three-dimensional stimulus, that is to say, illusory effects would be expected to occur in both circumstances.

Since additional visual cues, both mono and binocular, which are present in the "real world" are not found with equal intensity in stimuli used to investigate illusions, when such cues are in harmony, the illusory effect elicited by the latter is likely to be less. The inter-stimulus differences are therefore dependent on particular cues occurring and on their perceived intensity.

A reference to Fig. 2.5 will make this argument plain. In this figure density gradients are symbolically represented by circles which are of the same size when representing an invariant gradient, such as that provided by the surface of paper viewed normally, but differ in size when a variable gradient is symbolized.

All four figures show fronto-parallel projections. A shows the basic pattern and B the projection which such a pattern would yield if

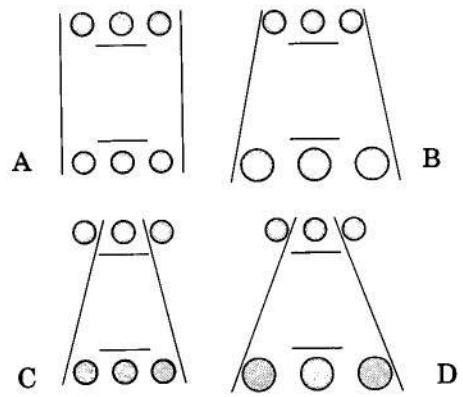

Fig. 2.5 Symbolic representation of density gradients.

presented on a plane sloping away from the observer and placed below his eye level. C shows a variant of the basic pattern in which the lines converge; it is, therefore, the common version of the Ponzo illusion, and D shows a projection of the same pattern placed on the plane receding away from the observer. Consider the organism which is concerned with determining whether the two lines are parallel. This can be done by assessing whether the information contained between the lines throughout their length remains constant as the eye moves along these lines. In our particular case this information has two components; size and number of the elements between the lines. Comparing their values at the two levels shown in each figure we obtain the following table:

Figure	*Size*	*Number*
A Drawing seen normally	same	same
B A on a receding plane	different	same
C Ponzo figure seen normally	same	different
D C on a receding plane	different	different

It is well known that figures such as B evokes perceptual transformations such that the organism tends to regard the elements as equal provided that a sufficient number of elements is exposed (see p. 187). The implication of such a transformation is an apparent decrease in the convergence of the lines forming the figure. C is of course the common Ponzo figure and D, as the above table shows, combines the effects of B and C; and the distortions which these two figures evoke would, one expects, be compounded therein. D is also a representation of a projection derived from a "real world" array having converging members. One would accordingly expect such an intensification of effect to pertain to the "real world" stimuli.

If this argument is valid, then the presence of the "real world" illusions could not be thought of as damaging to the experiential hypotheses and one would expect cross-cultural differences in perception of the traditional illusion stimuli to be parallelled by similar effects in perception of the "real world". This indeed is the case, as the studies reported below show. The above reasoning can *mutatis mutandis* be applied to the other three illusions discussed in this section: Horizontal–Vertical, Muller-Lyer and Sander parallelogram, and indeed to any illusion figure the effect of which can be claimed to be determined by an environmental influence.

Apart from the fundamental issues just discussed, the constancy scaling approach has also evoked a number of rather specific criticisms. We shall discuss two of those involving the Muller-Lyer illusion, which are of especial relevance to the notion of depiction of the third dimension.

It has been argued that the Muller-Lyer figure when presented in the linear form (Fig. 2.6) contains a self-contradictory cue. This is embodied

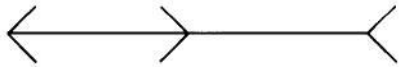

Fig. 2.6 A linear form of the Muller-Lyer illusion.

in the central arrowhead which has to be seen as portraying lines *receding* from the observer in order to frame the phenomenally nearer segment, and as inclined towards the observer in order to form the phenomenally further segment. The difficulties which interpretation of such a figure entails have been stressed by Fisher (1968). Whether these are really so fundamental is uncertain, for plane figures evoking contradictory perceptions of depth are widespread.

If they were not, then one would not be able to recognize drawings and pictures as depicting three-dimensional objects; for in all of these flatness of the surface on which the patterns appear is contradicted by the three-dimensionality of the objects which the very same patterns evoke, a point which has been made repeatedly by many (e.g. Gregory 1966, Gombrich 1962).

In the same paper Fisher put forward another objection to the theory of perceptual scaling. He showed that the figures such as 2.7a and 2.7b in which fins at both ends point in the same direction evoke illusion, albeit small, but in consistent direction; the shafts being over-

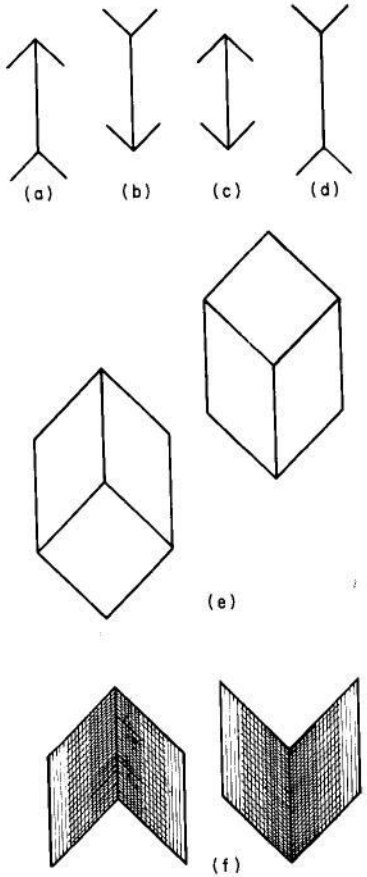

Fig. 2.7 Fisher's (1968) figures (a, b), and traditional Muller-Lyer figures (c, d). The former are reminiscent of projections of a cube (e) and Mach's book (f); and share with these figures the element of ambiguity which is common to pictorial stimuli capable of evocation of the percept of depth.

estimated. This he claims is contrary to the effect one would expect if scaling really took place, because in these figures "the perspective elements are as strongly defined" as in (c) and (d) and, furthermore, he implies that the distortions occurring should not be in the same direction. Why either of these views is held is not clear. Both (c) and (d) embody an element of convergence of the ipsilateral fins, an element which is missing in (a) and (b) whose fins, if extended, would form parallel lines. Hence it seems that the strength of perspective elements does in fact differ between the two pairs of figures. On the other hand, the difference between (a) and (b) which is alluded to

by Fisher is by no means certain as both these figures can be said to represent the nearest vertical edge of a cube, or an open book as it would appear when looked at from above or from below, with the spine of the book either close to or far away from the observer.

The recurrent problem which the above remarks illustrate is that of obtaining pure and unambiguous forms of illusion figures which would enable one to associate responses evoked with a single variable. It is doubtful whether such stimuli are at all possible and whether there are perceptual mechanisms which can be triggered by only a narrow and precisely specifiable range of stimuli, when such complex processes as pattern perception are involved.

Our brief discussion is not intended to convey in detail the critique to which the inappropriate depth scaling theories and especially Gregory's theory have been exposed. A specialist study of these issues will be found in Robinson's (1972) book. The conclusion reached therein regarding the *status quo* of both Gregory's postulates and Day's (1972) extension of Gregory's ideas is that, on the whole, Gregory's theory has a great deal of appeal largely due to its sheer neatness. It is apparent that the inappropriate scaling cannot account equally adequately for all the illusory effects, but the unifying paradigms which it offers should not be dismissed lightly.

The significance of these paradigms to development of inter-cultural studies, although often unstated, was and is considerable. With this in mind we shall now proceed to examine some of the evidence from non-Western cultures, by considering the illusions in turn.

THE HORIZONTAL – VERTICAL ILLUSION

The largest body of cross-cultural data on this illusion is that obtained by Segall *et al.* (1966) in the study to which we have already referred. This study, included a comparison of adults drawn from 15 cultures and of children drawn from 13 cultures on the two versions of the Horizontal–Vertical illusion, namely the inverted-T version and the rotated-L version. It showed that illusion was experienced in all cultures but the extent to which it was experienced varied considerably among the cultures.

The inverted-T figure yielded illusion magnitudes ranging from 8% to 24% adults and from 11% to 23% for children. The rotated-L figure yielded, as one would expect from Rivers' (p. 6) studies, a lesser effect: 2% to 19% for adults and 1% to 21% for children. The scores of the two illusions correlated significantly but not at a very high level, thus

suggesting that although the two stimuli evoke the same effect there are also other effects which are not shared. This in turn hints that the assumption that both stimuli are equally subject to ecological influence ought to be questioned. More so, because the observed age trends on the two illusion figures are not the same, higher scores being obtained for adults in seven of the 15 samples with the inverted-T figure but no such differences being observed with the rotated-L figure.

Although the results are not entirely consistent, a point which Segall *et al.* analysed thoroughly, the high illusion susceptibility of several African adult groups and the middling scores of the "Western" groups do offer support for the ecological hypothesis such that overall it emerges strengthened from the test.

It is appropriate to examine some of the observed discrepant effects in some detail. We shall begin with the disparities between responses to the two illusion figures and hence with the use of these figures as devices for measurement of the ecological influence.

The relationship between the particular aspect of the ecological press and the particular stimuli used in an experiment to evaluate the effect of such press upon perception should be relatively pure and uncontaminated by other factors. Ideally, a perfect correlation would prevail, but such ideals are not attainable and therefore one can merely hope to choose stimuli such that the obscuring effects are as unobtruding as possible. One can ask, bearing this in mind: "are the two Horizontal–Vertical stimuli used in Segall *et al.'s* study well chosen to measure the postulated effects?".

The data to hand suggest that the choice was more felicitous in the case of the L form of the illusion than in the case of the T form. There are important differences between these stimuli, the latter of which evokes illusion not simply owing to the orientation of its two component lines (as its name would erroneously suggest), but owing to at least one more factor. This was observed and investigated by Finger and Spelt (1947), who presented the two stimuli each in two orientations and noted that whilst the L-type stimulus, whether in the L or (Γ) orientation, always evoked the illusion that the vertical line was longer than it really was, rotation of the T stimulus from (⊥) to (⊢) orientation did not result in similar perception. The bisecting line of the figure continued to be seen as longer than the bisected line even though it was no longer vertical. This influence of bisection was further investigated by Kunnapas (1955). His investigation of the illusory effects by placing of the dividing line in several positions along the divided line shows that the Dichosection effect (as he called the phenomenon) remains essentially the same for all the four orientations of the figure investigated (i.e. T, inverted T

and the two T-on-its-side settings) and varies systematically with placement of the disecting line, being maximum for the central placement and least for the placements at the ends of the intersected line (i.e. for "L" configurations). In addition to this effect there is the true Horizontal–Vertical illusion by which the vertical lines tend to be overestimated.

Since the L figures are free of the Dichosection effect they must evoke a purer form of the Horizontal–Vertical illusion and have closer correspondence to the ecological effects considered by Segall *et al.* than do the T figures.

A re-examination of Segall *et al.'s* data on the assumption that only the responses to the rotated-L figure are admissible does in fact strengthen the support for the ecological hypothesis. Two of the communities, both inhabitants of open savannah (Songe and Zulu), and therefore expected to score highly on the Horizontal–Vertical illusion, do score below the median on the inverted-T version of the figure, but not on the rotated-L version. Similar difference was not, however, observed in the case of children's responses to the corresponding illusion figures. If one follows Jahoda's advice and excludes Western societies, whose literacy might affect their responses and, in addition, whose ecological experience is difficult to classify, one can classify the remaining societies by their ecological experiences as follows:

(i) *social groups living in ecologically dense compressed environment*: Fang, Bété, Ijaw, Dahomey and Hanunoo,
(ii) *savannah and desert societies*: Senegal, Ankole, Toro, Suku, Songe, Zulu and Bushman,
(iii) *unclassified groups*: mine workers in South Africa.

One would expect, if the ecological hypothesis is valid, the observers from the second group to experience stronger illusory effects than the observers in group (i); this indeed is so in the case of adults' responses to the rotated-L figure and *not* to the inverted-T figure. Children's responses are again ambiguous.

The results thus suggest that in the case of T-type figures the dichosection effect is confounded with the postulated ecological influence which is measured by the L-type figures. Since Segall *et al.'s* scores on the Muller-Lyer illusion do not correlate significantly with their scores on either version of the Horizontal–Vertical illusion for the adult samples as well as for children's responses to the inverted-T configuration whilst for the rotated-L figure the children's correlation is negative, one has to accept that the two illusions: the Muller-Lyer and the Horizontal–Vertical, do probably differ essentially. It is possible, however, that the Dichosection effect on its own correlates with the

Muller-Lyer illusion, Sander parallelogram or even the Perspective figure. To check on these possibilities Segall *et al.'s* data were analysed as follows. The group scores obtained with the rotated-L figure was subtracted from the corresponding scores obtained with the inverted-T figure. The resultant scores which were taken to indicate the Dichosection effect were then correlated with the scores on each of the three illusions just listed. In no combination of variables did the resultant correlation differ significantly from nought. Hence if the Dichosection effect is culturally influenced, this influence probably cannot be explained by either of the two hypotheses which guided Segall *et al.'s* investigations. Since the differences between the adult group means on the two figures range from a small negative difference for the Zulu (the only negative difference obtained) to a 20 times as large positive difference for the Sene, such uninvestigated and hitherto unreported and unhypothesized inter-cultural differences may well be present.

An alternative way of isolating the Dichosection effect is to present subjects with the traditional T figure but at an inclination of 45° (see Fig. 2.8). In this setting both elements of the figure have equal horizontal and vertical components and hence the illusory effect produced can only be due to Dichosection. Use of such a figure with samples drawn from Scotland and Ghana showed no significant difference in susceptibility to the Dichosection illusion between these samples (Jahoda and Stacey 1970). Thus these results do not show the expected cultural difference.

The relationship between the Dichosection scores and Muller-Lyer scores in the Scottish and Ghanaian groups is contrary to that which the re-analysis of the Segall *et al.* data would lead one to expect. In both groups the scores correlate significantly and positively. Since not only the number of data points used to calculate Scottish and Ghanaian correlations is much higher than the number used in re-analysing Segall *et al.'s* findings, but also the samples providing these data are more homogeneous than their counterparts drawn from a variety of

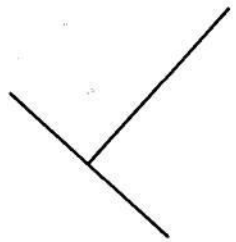

Fig. 2.8 A Horizontal–Vertical figure set at an inclination of 45°.

cultures it seems likely that Jahoda and Stacey's data offer a finer picture of the relations between various illusions. The Dichosection scores also correlate positively, but at a lower level, both with the Sander parallelogram scores (in the Ghanaian sample only) and with the Horizontal–Vertical scores (in the Scottish sample only). The implication of those correlations is unclear. The correlations with the Muller-Lyer results do not share such ambiguity and raise an important question about the relationship between the Dichosection illusion and the Muller-Lyer illusion. There appears to be no *prima facie* reason to think that the Dichosection stimulus is similar to some characteristic of the carpentered world likely to trigger the constancy mechanism. If this is so then the dichosection and the Muller-Lyer stimuli share an element which, whilst evoking illusion, cannot be explained in terms of constancy and which therefore cannot be explained in terms of the Carpentered World hypothesis either.

Several other cross-cultural studies of the Horizontal–Vertical illusion were inspired by the ecological hypothesis. Of these, that by Gregor and McPherson (1965) who used the same stimuli as Segall *et al.* is of particular interest because their samples consist of Aborigines who live in the featureless and seemingly boundless terrain of central Australia. Such populations would be expected to score very highly indeed if the ecology has the effect attributed to it. This was found to be so. In the case of both versions of the illusion figure included in the test the Aborigines obtained the highest scores yet reported on the test.

An alternative method to measurement of illusions which seems intuitively compatible with the ecological hypothesis is provided by Gregory's Pandora's Box. This instrument, described in detail on p. 128, was used by Stacey (1969). Estimates of the distance of the two ends and the bend of the L figure were obtained both when the figure was presented on its own and when it was placed on a density gradient.

These very comforting findings are not confirmed in their entirety by an experiment (Gregory 1974) using a more sophisticated version of the same apparatus and three different stimuli: (i) an inverted-T figure, (ii) an L figure and (iii) two short vertical lines displaced horizontally and vertically relative to each other.

The illusion figures were found not to evoke a consistent perception of depth: either the tops of the figures or their bottoms were seen as closer to the observer, and in the case of the figure consisting of two lines either line was on occasions seen as closer to the observer. Correlations of the differences in depth (without taking account of whether the upper or the lower parts of the figure were perceived as being nearer to the observer)

with the extent of illusion were significant both for the inverted-T figure and for the two line figure. In the former case the usual illusory effect occurred, in the latter the upper line was perceived as larger in 19 out of 20 subjects. (This effect is of particular import in the context of Jahoda's findings on reconstruction of simple pictorial arrays by young children; we shall refer to it again.) The L figure data yielded no analogous correlation. However, a comparison of the illusion scores obtained by Avery and Day (1969) by presenting an L figure in various orientations with the perceived difference in depth between two ends of a straight line presented in the same orientations yields a very high positive correlation (Gregory 1974). The conclusion put forward earlier by Stacey remains, therefore, largely unchallenged, although the perceptual mechanism appears to work in a more complex way than would appear from Stacey's observations.

It will be noted that an L figure was used in the investigations just discussed (with the exception of Avery and Day's work), whilst Segall *et al.'s* data were obtained using a rotated-L figure. In view of the complications which seem to arise whenever one attempts to investigate an apparently simple illusory effect, the implied equivalence of these two orientations of the figure ought to be questioned. The ecological hypothesis allows no prediction as to what differences in the illusory effect would be observed by comparing the responses to figures with the horizontal line at the top (such as Γ or ⊤) to those with the horizontal line at the bottom (such as L or ⌊). At one point in an attempt to clarify their hypothesis Segall *et al.* illustrate the illusion by referring to a pavement made of one yard squares. An eye looking along such a pavement would receive retinal images which would decrease with the squares' distance from the observer; but, and this is the important fact, the relative foreshortening of the sides parallel to the line of regard would be greater for the more distant squares than for the nearer squares. Further, in any particular square the foreshortening of the two edges normal to the observer's line of vision is not equal, the edge which is further away from the observer is foreshortened more drastically. A fronto-parallel projection of a square on the ground thus becomes a trapezium with the longer of its parallel sides (the base) at the bottom. A projection of a similar square drawn on a ceiling also becomes a trapezium but with its base at the top.

An explanatory illustration should not be taken to be the statement of the theory, a point which is occasionally overlooked. Segall *et al.* could, if they so wished, have chosen not a pavement, but a coffered ceiling of a cloister or some other receding horizontal surface to make their point. Furthermore, their illustration does not indicate whether when making

comparisons between sides of the squares an observer uses as a standard the further or the nearer of the edges of the square. The former would of course yield an inverted-L figure and the latter an L-figure (or the corresponding enantiomorphs). These considerations force one to question Wober's (1972) interpretation of the ecological hypothesis as suggesting that the inverted-L forms of the stimulus should lead to a lesser illusory effect than the upright forms. His short experiment in which the sequence of presentation of various forms of stimuli was apparently left uncontrolled does not yield support to his interpretation of the hypothesis and provides but unconvincing data. The effect of orientation upon perception of the Horizontal–Vertical illusion merits more detailed examination, not in least because in other lengthier studies it has led to mutually contradictory conclusions. A sample of such studies will therefore be briefly examined.

Valentine (1912) observed that the inverted-L form of the illusion yielded greater effect than the L form. Consistent results were obtained by Finger and Spelt (1947) and by Avery and Day (1969). This harmony was, however, disturbed by Shiffman and Thompson (Thompson and Shiffman 1974, Shiffman and Thompson 1975), who report just the opposite and seem to be under a mistaken impression that both Finger and Spelt's and Avery and Day's results agree with their own, that the L figure yields greater illusion than the Γ figure. The latter type of stimulus, when presented tachistoscopically, they state, led to a reversal of the usual illusion, i.e. overestimation of the relation of the horizontal line to the vertical line. This reversal is particularly puzzling since the inverted-L form, it will be recalled, was used by Segall *et al.* in their study and they do not report any of their groups as consistently yielding such responses.

Given the assumptions about scaling implicit in the ecological hypothesis the following considerations apply to all the above results. The magnitude of the illusion depends in ecological terms on:

(i) whether the observer encodes the stimulus as reposing on a plane above his usual line of sight (say, on a ceiling) or below such a line (say, on the pavement or floor),

(ii) whether he encodes the horizontal line as nearer or further from him than the free end of the *vertical* line. The two factors yield four ways in which the stimulus can be encoded and hence suggest that four different percepts may result, and affect the magnitude of the illusory effect differently.

These considerations of the suitability of stimuli for the measurement of the ecological effects extend to other figures derivative from the traditional Horizontal–Vertical stimulus. Indeed, the Horizontal–

Vertical illusion may be thought of as just a particular instance of the more general class of illusion evoked by two straight and co-planar segments. Thus when the angle between the lines of the L-type figure is varied, with one of the lines remaining horizontal, the illusory effect (which can scarcely still be referred to as the Horizontal–Vertical effect, there being no vertical) is observed to vary and a continuum of systematic changes in its strength can be traced (Morinaga *et al.* 1962). Comparison of such continua derived from analogous transformations of the three traditional types of the Horizontal–Vertical stimulus, cruciform, L-type and T-type, have been made by Cormack and Cormack (1974). Figure 2.9 summarizes in a simplified form their results. The most striking discrepancy is that between the curves obtained for the inverted T and the cruciform versions and the curve for the L version. The two former are symmetrical, the latter is not. The increase in the illusory effect which occurs when the stimulus deviates from its "tradi-

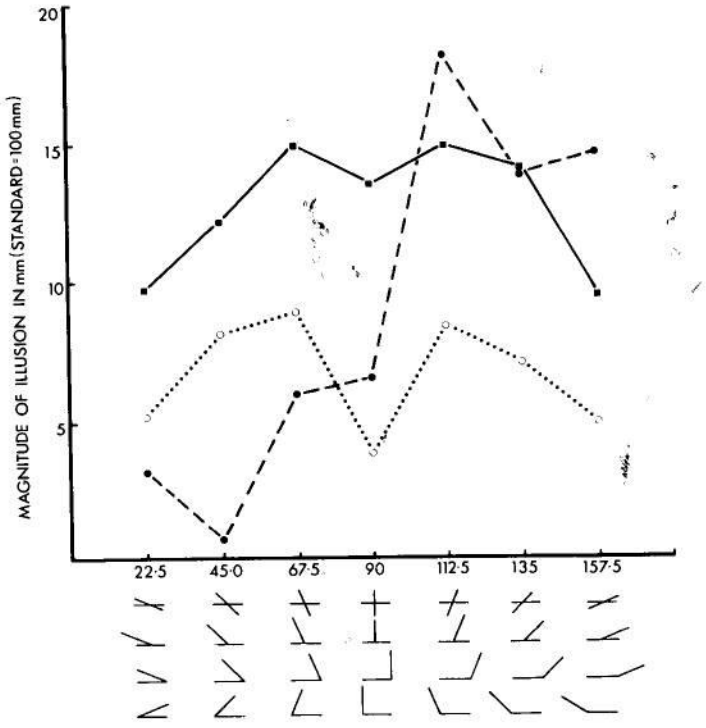

Fig. 2.9 Representation of the Cormack and Cormack (1974) results and of the stimuli used by them. Dotted line, cruciform stimuli; continuous line, inverted-T stimuli; dashed line, L stimuli.

tional" setting in the former two figures occurs whatever the sense of deviation, whereas in the case of the L figure such increase is only present when the deviation is such as to decrease the difference between the two angles formed by the arms of the figure, i.e. to open out the arms. When the arms are close together, the illusion tends to decrease, perhaps because when the free ends of the arms are near each other then the comparisons of length are very easy, as Cormack and Cormack suggest.

At the present juncture the asymmetry of the curve showing L responses is probably of less interest than the fact that all three types of stimuli yield higher illusions in one of the non-orthogonal settings of the line than in the traditional Horizontal–Vertical setting; and that in two of these settings the L curve (Fig. 2.9) shows higher illusion scores than the T curve.

Consider the influences hitherto discussed which have been said to affect the magnitude of illusion: (i) the effect of the verticality of one of the components, (ii) the section effect. Both these are at work and mutually augmentative in the inverted-T figure; only the verticality component is present in the other two figures because in the L figure intersection does not occur, and in the cruciform the two elements intersect each other and hence presumably this effect is nullified. When the vertical line is replaced by a line set at an angle, the verticality effect is *ex definitione* removed, but it is clearly replaced by some other effect since the illusion increases, or perhaps, and this appears to be more parsimonious, a strengthening takes place of the effect which was always present and which has been erroneously attributed to the verticality.

Would not more telling results have been obtained by Segall *et al.* had they used non-orthogonal stimuli?

This may well be the case. The open vistas of the hypothesis do not after all extend only directly in front of the observer, but also to the right and left of him. The orthogonal comparison is therefore unique and atypical. Yet, there may be an overriding argument for regarding Segall's *et al.'s* orthogonal stimuli as more satisfactory than the non-orthogonal figures, since the latter are likely to evoke responses correlating with responses to the Muller-Lyer stimuli to a larger extent. This may be so because the effect of the non-orthogonal stimuli may in part be due to the tendency of the perceptual mechanism to rectify the angles, the strength of such tendency being plausibly associated with the extent of exposure to the carpentered environment.

Cormack and Cormack have also studied the effect of non-orthogonality on dichosection. Comparison of their curves for L and inverted-T stimuli confirms that the dichosection effect was present when

traditional orthogonal stimuli were used. Its presence does not, however, ensure greater scores for all the inclinations of the bisecting line in the T figure. On the contrary, the increasing inclination of the "vertical" in the L figure leads to higher scores than those obtained with an equally inclined bisector of the T figure. Thus the opening up of the L figure enhances the illusion but the change of inclination of the bisector does not do so for the inverted-T figure. On the contrary, for the T figure a decrease in the illusory effect takes place at both large and small values of the angle of inclination. For the T figure presented on its side the effect of dichosection is such that it counteracts the effect of orientation and the resulting illusion is either negative or positive but relatively small.

A characteristic which may be of relevance to these findings is symmetry. Symmetry has been regarded by the *Gestalt* school as a factor contributing to figural goodness. Hochberg and Brooks (1960) have demonstrated that one of the factors which foster perception of pictorial depth is the asymmetry of patterns. Such patterns, evidence shows, tend to be seen as portraying three-dimensional objects more readily than symmetrical patterns. Asymmetrical Fig. 2.10a is, for example, more readily seen as a representation of a cube than symmetrical Fig. 2.10b.

Of the three classic "Horizontal–Vertical" figures the cruciform figure has four axes of symmetry, the T and the inverted-T versions have one axis lying in the observer's median plane and the L version one axis at 45° to the observer's median plane. One would therefore expect the perception of the third dimension and hence of illusion to increase in this order. This does not normally happen. The T figure normally evokes larger illusion than the L figure, but this, as has been pointed out above, is due to the effect of dichosection. On the other hand, given central intersection and a variable angle of inclination the illusion is larger for a certain range of angles than it is in the orthogonal setting. Such figures having a non-orthogonal bisector are, of course, asymmetrical.

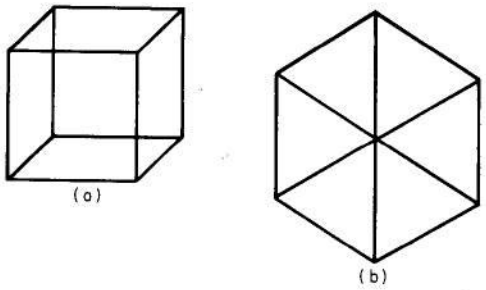

Fig. 2.10 Symmetrical and asymmetrical representations of a cube.

Similar increase in illusion evoked also occurs with the cruciform figures, in which inclination of the bisector reduced the number of the axes of symmetry from four to two.

These increases of illusion with the decrease of symmetry and hence with increased tendency to evoke perception of pictorial depth are entirely compatible both with the ecological hypothesis and with the observations of the *Gestalt* school. The absence of such increases towards the extremes of the continua of inclination which contradicts this observation does present a special problem. This irregularity can perhaps be said to be due to the increased ease of comparisons of the two lines forming the figures in question.

MULLER-LYER AND SANDER FIGURES

The data obtained by Segall *et al.* in response to the Muller-Lyer figures offer in their view "considerable support" for the Carpentered World hypothesis. Of the 15 groups of adults drawn from a variety of cultures those with the greater experience of carpentered environments were considerably more prone to the illusion than those with less experience. The Western samples were consistently at the top with percentage discrepancy scores between 13 and 19 and the other cultures' scores fell well below, down to about 1% for the Bushmen and the mineworkers.

Similar description applies to children's scores, which, whilst positively correlated with adult scores, were generally *higher* than the adult scores from the same cultural group. This finding is surprising since if the illusion susceptibility is in some measures a result of cultural exposure one would expect adults to be more susceptible than children, not vice versa. To account for this result Segall *et al.* propose an additional hypothesis that maturation brings about a more analytic approach to perception and thus modulates the effect of earlier learning. Older children, it is suggested, are better able to attend to the stimulus *per se* and to control their inferential processes. Thus the concept attention is, in some measure, restored to the explanatory role which it held in Rivers' theories.

Another aspect of the data which calls for elucidation is the detailed ranking of the societies tested on their susceptibility to illusion. This, Segall *et al.* acknowledge, cannot be explained entirely in terms of their hypothesis. However, such precise fit of data to the theory would only be possible if the carpenteredness were the only determinant of susceptibility to the illusion, but since, as the comparison between the adults' and the children's responses shows, it is not so, and since there may also

be further influences, the lack of perfect concordance cannot be said to damage the hypothesis irreparably.

The Muller-Lyer results, for both adults and children, are reported to correlate positively with the Sander parallelogram results, which form essentially the same pattern, the only notable discrepancy being the absence of a pronounced difference between the responses of adults and children. These results, too, can therefore be said to support the Carpentered World hypothesis.

Replications and extensions of studies using these two stimuli are more frequent than those of the Horizontal-Vertical studies. Some of these experiments will be examined in some detail. Bonte's (1962) studies of the Muller-Lyer illusion were inspired by Segall's findings and question these findings most vehemently. The three cultural groups tested appear not to differ in susceptibility to the illusion, although drawn from cultures which differ greatly in their carpenteredness: European, Bashi and Ba-Mbuti. Both the Bashi and the Ba-Mbuti live in the Congo. The former are agricultural people settled on a lakeshore, the latter are hunters and gatherers. Of the two groups Ba-Mbuti are certainly less exposed to a carpentered environment. The apparatus which was used to obtain susceptibility to the illusion was similar to Rivers' original apparatus.

The method of measurement was therefore entirely different from that used by Segall *et al.* Such differences in apparatus ought not, however, in themselves destroy the relative differences between the three groups on a perceptual predisposition as well ingrained as the experience of the carpentered world is said to be. Only if the stimuli presented by the two types of apparatus differed radically would one expect such a difference between responses. Segall *et al.* who have examined photographs of the apparatus reproduced in Bonte's (1960) thesis, on which the published paper is based, maintain that the stimuli used in the two studies do indeed differ in several important ways.

The most serious query about Bonte's procedure is, however, probably that pertaining to instructions. Segall *et al.'s* procedure allows for a check on whether the instructions have been understood. There is no such check possible with Bonte's slide apparatus.

While it is impossible to attach definite weight to any of the points listed, their total effect is such as to endorse Segall *et al.'s* conclusion that Bonte's finding of *no* difference between the three samples ought perhaps to be set aside until confirmatory replications have been carried out.

Berry's (1968) study comparing the Temne and the Eskimo is important because it links the concept of susceptibility to illusions with the Witkinian concept of field-dependence, which has influenced most of

cross-cultural work in recent years. A close examination of field-dependence lies beyond our scope and we merely refer an interested reader to those sources which have examined its significance for cross-cultural work (Witkin and Berry 1975) and confine ourselves to a very brief sketch of its relevance to the studies concerned with operation of perceptual mechanisms.

The essence of the concept lies in the differential ability of observers to disembed a stimulus figure from the surrounding field. This can be measured in several ways. The most apparently direct measure is that involving search for a figure concealed within a matrix of lines. A set of such stimuli differing in complexity and hence in difficulty forms the widely used Embedded Figures Test (EFT). Another measure is that involving construction of simple patterns using coloured wooden blocks. A series of such tasks forms the Kohs' Blocks test. Two further measures involve perception of verticality. In the Rod and Frame test the subjects, seated in a darkened room, adjust a luminous rod set within a luminous, square and tilted frame to the vertical. In the Body Adjustment test, subjects seated in a special chair within a tilted room similarly adjust the angle of their own bodies.

Berry (1968) postulated that the impact of a carpentered environment upon perception, which Segall *et al.* and others inspired by them (e.g. Heuse 1957, Morgan 1959, Bonte 1962, Mundy-Castle and Nelson 1962, Gregor and McPherson 1965, Jahoda 1966, Berry 1966, Deręgowski 1967, Jahoda and Stacey 1970, Richardson *et al.* 1971) sought to investigate, may be moderated by field dependence namely that increasing field-dependence will be associated with the decrease of the illusory effects. Now, since generally "African" subjects are more field-dependent and also belong to a less carpentered culture than their "European" counterparts the two opposing factors likely to influence the illusory effect are likely to affect the responses in both populations. It follows that failures to observe the expected differences between cultures may on occasion arise from the obscuring effects of field dependence. To check upon this, samples of Eskimos coming from highly carpentered and moderately carpentered environments were equated on their Kohs' Blocks scores as a measure of field dependence, and their susceptibility to the Muller-Lyer illusion compared. A significant difference in the predicted direction was observed, which was not detected when comparing unmatched Eskimo samples. Further, when the samples of the Temne drawn from similar, moderately carpentered environments were compared both the Kohs' Blocks scores and the Muller-Lyer scores were found to differ significantly, the higher illusion scores occurring in the group which was more field dependent. It is regrettable that these comparisons are intra-cultural, the Eskimos being compared

with Eskimos and the Temne with the Temne. Such comparisons do, as Berry points out, complicate the picture and the reported data themselves and make it seem doubtful whether inter-cultural matching on Kohs' scores would have been equally convincing. This is so because the relationship between the illusion and the Kohs' scores may well be more complex than it would *prima facie* seem, as comparison of both Temne groups and one Eskimo group, all of which come from a moderately carpentered environment, shows. The Muller-Lyer illusion scores and Kohs' scores are as given in the brackets in this order:

(i) Rural/Traditional Eskimos (3·8; 89·8),
(ii) Urban/Transitional Temne (3·1; 15·6),
(iii) Rural/Traditional Temne (4·0; 6·6).

It is readily apparent that although the Eskimos' illusion scores lie between those of the two Temne samples their field independence is considerably greater than that of either of the two Temne samples. Matching of samples on only one of the variables clearly calls for additional care in interpretation of the results. Nonetheless the findings are interesting and deserve more attention than they have hitherto attracted.

PERSPECTIVE ILLUSIONS

The perspective illusion drawing used by Segall *et al.* yielded an effect which the workers themselves describe as weak; and this very small illusory effect has probably led to very few significant inter-sample differences.

In addition, the results obtained do not correlate with either of those obtained with the Horizontal–Vertical stimuli, the Sander Parallelogram and the Muller-Lyer figures.

It is probably safe to assume, especially in view of other evidence which we shall presently consider, that these results are due to the particular version of the stimulus which was used.

A set of stimuli which has been repeatedly used in a series of studies of the Ponzo effect was introduced by Leibowitz *et al.* (1969). It consists of four figures. The first figure is a traditional Ponzo figure in which two lines converge towards the top of the card and two short horizontal bars lie symmetrically on the imaginary bisector of the angle formed by the longer lines. The lower of the bars is entirely contained between the lines, but the ends of the upper bar overlap them slightly. This figure will be referred to as the *geometric* figure. The second figure, which will be called the *rail-track*, portrays a grassy rail track in such a manner that the rails form a pattern of two converging lines similar to that

presented in the *geometric* figure. Two dark lines similar to the bars of the *geometric* figure and similarly placed are superimposed upon the photograph. The third figure is a photograph of a *sward* with two black bars superimposed thereon. The depth cue which this figure provides therefore embodies primarily a density gradient although it also shows some overgrown furrows which make a set of faint converging lines. Finally a *control* figure consisting simply of two parallel black bars on a plain background and looking rather like a fat equality sign. Leibowitz *et al.* (1969 and Brislin (1974)) used these stimuli to investigate the effects of culture upon perception. Their subjects came from Guam, a small island in the Pacific Ocean where such convergence cues as are associated with the Ponzo illusion are relatively seldom encountered because the terrain is hilly and overgrown and there are neither railways nor great lengths of straight road; and from Pennsylvania where such cues are plentiful and where indeed these photographs were taken. The results obtained (Fig. 2.11) show that although the illusion is perceived by the subjects from Guam, its magnitude is low and remains at about the same level for all three types of stimulus used, whereas the Pennsylvanian sample shows a steady increase in magnitude as the

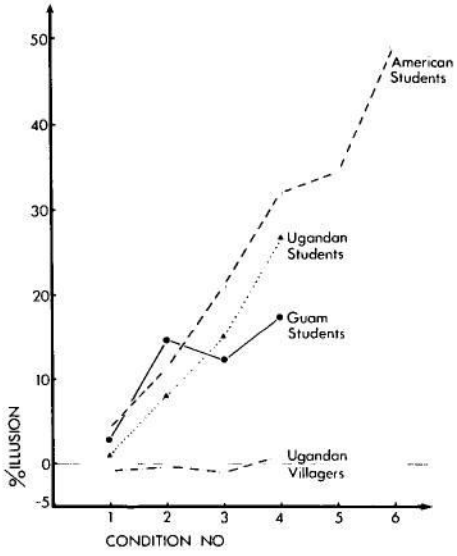

Fig. 2.11 Responses of American, Ugandan and Guam subjects to the Ponzo illusion configurations made under various conditions. The experimental conditions were: (1) control, two parallel lines above each other, (2) geometric figures, (3) photograph showing textured background, (4) photograph showing perspective convergence, (5) a monocular view of the scene, (6) a binocular view of the scene.

depth cues are increased step by step from the standard geometric figure through a photograph of the sward, a photograph of the rail-track, a view of a rail-line which was photographed seen monocularly, to a binocular view of the same rail-line.

This apparent arrest of the illusory effect in the Guam sample in spite of the increase of the depth cues may be interpreted in various ways. It could be said that this population's size constancy is relatively low in "real-world" settings and hence the plateau reached shows that they have attained the ceiling level of their performance so that any further enrichment of depth cues does not affect them greatly. This would imply that in the "real world" the constancy mechanism of the Guam observers operates at an entirely different level than that of the Pennsylvanian observers. It could also be put forward that such additional cues as are provided by the photographic stimuli are simply too weak to trigger the constancy scaling mechanism in the population not used to such cues. This postulate accords with the environmental hypothesis, but the difference between the responses of the Guam and the mainland samples to the photograph of the sward suggests that one should treat it with caution. This is so because although open spaces and views of roads and railways going into the far distance may be rare in Guam, density gradients must be commonplace.

An extension of Leibowitz's studies using the four stimuli which we have just described and in addition four other variants of the Ponzo figure was carried out by Brislin (1974). The subjects were again drawn from Guam and from Pennsylvania. An age range from 3 to 22 years was explored with a large number of subjects. The results summarized briefly were: the illusory effect increased with addition of realistic pictorial depth cues, both the *sward* and the *railway line* photographs leading to greater illusory effect than the central figure, as did the abstract perspective cue. This was true of both cultural groups. There were, however, differences between these two groups, the Guam subjects showing significantly less proneness to illusion on three of the figures; the two pictorial stimuli (the sward and the rail-lines) and the control figure consisting of two equal bars. Surprisingly there was no significant cultural difference between the responses to the geometric figure. This figure too was the sole exception to the general finding that the illusory effect increases with age in the Pennsylvanian sample. No such distinct age trend was present in the Guam sample. Further presentation of the stimuli to the Pennsylvanian sample in two orientations, with the apices of the figures either upwards or to the left, led to a significant and pronounced difference in responses in all figures used, with the sole exception of the two-bar control figure. In discussing these results Brislin states that they are supportive of the ecological hypothesis.

Another study using the Leibowitz stimuli is that of Wagner (1977). His subjects were boys and youths from Morocco and came from both urban and rural environments, each environment providing both schooled and unschooled subjects. Several unexpected results were obtained. The rail-track figure which incorporates the elements of the abstract figure yields lower scores than the abstract figure for three out of four age groups in two of the populations and in the third population it does so for all four age groups. The implication therefore appears to be that enrichment of the figure leads to a *decline* of illusory effect. Such results have not been previously reported and although conceptually conceivable, for it could be that the presence of the density gradient makes the detection of perspective more difficult, they are difficult to interpret. This difficulty is augmented by the comparison of the responses to the figures showing railway track on a density gradient with those to the figure incorporating only the density gradient. The scores of most sub-groups are about equal whichever stimulus is used. The argument which could be advanced in view of these findings is that those results are probably determined solely by the density gradients and that therefore the converging track does not affect the magnitude of the illusion. Comparison of these results with those obtained from Guam college students and Ugandan villagers (Leibowitz *et al.* 1969) is instructive. In these samples there appears to be no difference in susceptibility to illusion between the geometric figure, texture photograph and perspective photograph and there seem to be no indications of greater susceptibility to geometric figures.

There are also other surprising aspects of the findings from Morocco. The susceptibility to illusion as embodied in the geometric figure appears to decrease with age between about 7 and 19 years whilst susceptibility to illusion as embodied in the track figure appears to increase. Wagner stresses the difference between responses to the two types of stimuli and points out that Brislin (1974) considered his own data, which were similar, to be supportive of the notion that susceptibility to illusion increases with age and ignored the significant age related decrease obtained with the help of the geometric figure. This criticism seems to be misplaced. There are in the case of the geometric figure significant differences between the various age groups tested by Brislin and these are reported by him; these do not, however, constitute the consistent significant decline which Wagner finds. For example, in the case of Brislin's Pennsylvanians the youngest and the oldest groups provide scores which fall below those of intermediate groups. Perhaps

the wisest if somewhat defeatist attitude which one can adopt is that these two studies do not give us a definitive indication as to the nature of age changes, although in view of the greater number of different age groups used by Brislin (six) his data are probably more informative than those of Wagner based on four different age groups.

A comparison of Brislin's results obtained with the geometric stimulus with those of Leibowitz and Judisch (1967) shows a striking similarity of the development curve and hence supports his findings.

The extensive studies of the Leibowitz school are not the only studies in which the effect of variation of the strength of the pictorial depth cues has been observed. Suppose the Ponzo figure were presented in three ways, (i) in its usual form, (ii) forming a part of portrayal of an object known to be vertical, such as the side of a gymnastic jumping box and (iii) forming a part of portrayal of a road; could it yield such results as to affect the constancy scaling hypothesis? Newman and Newman (1974) believe that this could be so and that the results which they obtained using these very stimuli argue against such a scaling process. Their results showed that the effect of the standard, abstract version of the figure did not differ from the "gymnasium" version, but both these led to a weaker illusion than the road figure. Hence they argue that if the enhancement of the depth effect can be expected to increase the illusion one should also expect a decrease to follow from its degradation. Therefore the gymnasium figure should yield a weaker illusion than the standard figure. This does not happen. It follows, they argue, that the scaling mechanism is probably not involved in the process. The weakness of this argument lies, however, in an assumption that the three figures form a sequence on the scale of pictorial depth in which the gaps between the two meaningful figures and the abstract figure are both sufficiently large to cause difference in responses. This may not be so. The relative strengths of various cues, as the Leibowitz school has shown on several occasions, are not so easily assessed. It is possible that the gymnasium figure does not provide significantly poorer depth cues than the abstract figure and that the results obtained are perfectly reconcilable with the notion of constancy scaling, especially so since a gradation of depth cues in the Pennsylvanian sample (Leibowitz *et al.* 1969) does in fact evoke a gradation of the effect similar to that which was obtained by Newman and Newman.

Another problem which use of such stimuli as used by Newman and Newman presents is that of deciding to what extent recognition of a depicted object in which the illusion figure is incorporated can be taken as evidence that the entire picture embodies depth cues additional to those provided by the illusion figure. That is to say that such cues as

have been provided by the portrayal are eidolic, not merely epitomic (p. 106).

In contrast with the above findings Smith (1973) found the perspective (Ponzo) effect to be fairly definite. In his study three groups of Xhosa differing in the extent of Westernization were tested on an adjustable slide version of the Ponzo figure and their susceptibility to the illusion was found to increase with acculturation. Furthermore, when these subjects were subsequently presented with a figure showing very strong perspective cues, which it was hoped would introduce a "perspective set", and re-tested the scores of both the most acculturated and the moderately acculturated groups were observed to increase significantly. This flexibility of the perceptual mechanism in the more sophisticated observers strengthens the plausibility of our explanation (p. 48) of Davies's observations on the effect of education upon perception of the Muller-Lyer illusion by the Banyakole. The resistance to such inducement of perspective by the least acculturated rural group may, as Smith suggests, show a relative stability of the perceptual mechanism and a resistance on its part to process pictorial patterns as if they had some cues to the third dimension. Yet it might be noted that even this group is prone to illusion and therefore to some smaller extent apt to engage in such processing.

THE POGGENDORFF ILLUSION

This figure is notable in the cross-cultural studies for its failure to evoke consistent results. It was included by Segall *et al.* in their test booklet but the procedural difficulties encountered by the testers yielded questionable data. The illusion is not, therefore, extensively discussed in the final report on this study.

One could reasonably postulate that this illusion will be affected by both "ecological" and "carpentered" factors. These suggestions are derived from the shape of the figure (Fig. 2.12), which could be said to

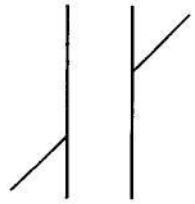

Fig. 2.12 Poggendorff figure.

consist of two Horizontal–Vertical illusion figures which ensure ecological involvement whilst acute angles made by the oblique lines suggest that carpenteredness may also affect the illusion. The ecological influence is, however, questionable because the two Horizontal–Vertical figures which are embedded in the Poggendorff figure are of a distorted T-type and they are presented on their sides, and this type of figure in this particular orientation is not appropriate for testing of the ecological effects. Therefore in terms of the two hypotheses concerned the Poggendorff illusion is probably mostly attributable to the rectification of the angles associated with the Carpentered World hypothesis. This postulate has the support of Robinson (1972) who thinks that such rectification may indeed be the cause of the Poggendorff illusion as well as of the Zöllner illusion and agrees with Parker's (1974) observation of the role of lateral inhibition in the visual system. Inhibition, according to Parker, makes it unnecessary to postulate the constancy mechanism in explanation of these illusions. If this is so, then, accepting the likely assumption that the extent of inhibition is not affected by experience, one is forced to conclude that the illusions in question are solely affected by the innate characteristics of the perceptual mechanism.

CLASSIFICATION OF ILLUSIONS

The very disparities and contradictions obtained in the inter-cultural studies of the most commonly investigated illusions reported above provide a warning against attempts to derive a taxonomy of these phenomena from a single set of stimuli used with a culturally homogeneous sample of subjects. Unfortunately many of the published studies of classification of illusions do so.

Classification of illusion figures presents the same difficulties as classification of any other phenomena which involve more than one variable. Such stimuli cannot be classified merely by the magnitude of the effects which they evoke without considering causes which are inherent in them. The dangers of such simplistic approach are apparent from the fact that adoption of such an approach would make us classify the Horizontal–Vertical illusion together with the Muller-Lyer illusion since in both of these the illusory effect takes the form of overestimation of the length of a line. Yet classification by using geometric features is equally unsatisfactory since, e.g. the fins of a Muller-Lyer figure can be gradually opened out until they are normal to the shaft and the figure arrived at is therefore an I-shaped arrangement of two Horizontal–Vertical figures. Similarly the shape of the fins can be varied leading to figures which are clearly different in appearance.

All these figures evoke illusions and their classification would be of little import were it not for the fact that different theoretical explanations advanced do not fit all the figures equally well. The Carpentered World hypothesis, for example, seems a plausible explanation for the illusory effect of the Muller-Lyer figure, but not for an arrangement of circles.

Application of factor analysis, a certain sign of conceptual despair, cannot resolve the issues because the factors which emerge are not the same in all cultures. This is clearly shown by Jahoda and Stacey's (1970) correlation matrix between illusion scores obtained from Scottish and Ghanaian subjects. According to this Scottish responses to the Horizontal–Vertical illusions correlate with their responses to Helmholtz's square and Sander parallelogram; but Ghanaian responses to the same stimulus correlate with those to Helmholtz's square, Sander parallelogram, Muller-Lyer and Dichosection. Similarly the correlation with the Muller-Lyer responses in the Scottish sample are: with Dichosection responses, with Titchener circles and with Sander parallelogram, while the Ghanaian sample responses to Muller-Lyer also correlate with Sander parallelogram scores, and with Dichosection scores, but not with the scores on Titchener circles; on the other hand, they correlate with both the Horizontal–Vertical and Helmholtz's square. This sample of correlations clearly shows considerable disparities between the two cultural groups. One cannot obviously classify illusion figures as if they were mere physical entities since the effects associated with them are psychological. Therefore clusters which the responses to such figures form in different cultures are entirely different and do not correspond to the *a priori* notions derived from them about the features of such figures. That is to say, the explanation of such clusters lies not in the nature of the figures but in the nature of the perceptual processes triggered by these figures. In so far as these processes are influenced by culture this implies that a parallel analysis of the relevant features of culture is really needed to arrive at a fully satisfactory taxonomy.

The intra-cultural attempts at determining the relationship between illusory effects evoked by various stimuli, most notably such as those of Taylor (1974, 1976) are really attempts at deriving a more convincing taxonomy of illusions than that which can be intuited from unsystematic observations. The complex relationships which emerge from such studies are however to an cross-cultural psychologist suggestive rather than convincing. This is so for two reasons. One of these particularly close to the heart of the students of cultural differences is that the

populations which were used in those factorial studies were culturally homogeneous and are unlikely therefore to present a universally valid taxonomy. Indeed the very data which we have reviewed in this chapter and which show considerable inter-cultural differences question any assumption of universality.

The second reason which can be advanced against too hasty an acceptance of such taxonomies as definitive is the fact that the intuitive element has not been entirely eliminated by the use of such techniques. This is so because each of the illusions used is represented by a limited number of figures which the experimenter chooses, presumably because he judges them to be typical of a particular illusion. By doing this he imposes an *a priori* categorization upon a phenomena which could be thought to form a continuum. (The Muller-Lyer illusion and the Horizontal-Vertical illusion do, for example, as Gregory has pointed out form a continuum, for by gradually modifying the angle of the fins of the Muller-Lyer stimulus from outward to inward pointing one passes through a point at which the fins are normal to the shaft. In this position the figure could be thought of as consisting of two Horizontal-Vertical illusions.) The taxonomy derived may therefore be tainted with arbitrariness to an unacceptable degree.

These caveats are not intended to suggest that such intra-cultural studies as hitherto have been carried out are devoid of interest to cross-cultural psychologists. They provide a rich source of hypotheses by imposing a degree of organization upon otherwise untidy data. For example, Taylor's data suggest that the perceptual mechanism responsible for the Ponzo figure, in its traditional orientation with lines converging towards the top of the figure, may be entirely different from the mechanism responsible for the illusion evoked when the figure is turned through a right angle.

The observations also on occasion support cross-cultural findings. Thus Taylor's observations also suggests unambiguously that the Poggendorff illusion seems to be an embodiment of a factor which is not shared by the other illusions commonly used in cross-cultural work. It is therefore pertinent to recall that Poggendorff was the blackest of the sheep in the Segall *et al.* flock and gave results which were found difficult to interpret.

It seems possible that such factorial studies are probably more helpful when they yield negative than when they yield positive results. As shown above, the fact that scores on two illusions share a factor does not imply that they are a result of operations of the same perceptual mechanism, although there is a modicum of probability that it is so. When, however, no common factor is shared by illusions, that is their

effects are essentially different, there seems to be no reason for postulating a common mechanism; a point which has to be considered when evaluating data obtained on what are thought to be variants of the same illusion.

The difficulties of taxonomy of illusions, which, as we have seen, are considerable, were swept aside in a comparison of performance on two figures assumed by Ahluwalia (1978) to embody the same perceptual cues. The figures were: a conventional form of the Muller-Lyer illusion consisting of two figures, one with inward and one with outward pointing arrows and Delboeuf's illusion consisting of two pairs of equal circles and straight lines so arranged that in one figure the line connects the two circles and in the other it intersects them and forms their diameters.

The subjects were drawn from two environments in Zambia; urban and rural. The urban subjects came from a carpentered environment, the rural ones were assumed to be from a largely uncarpentered environment. Its uncarpenteredness is not, however, extreme; certainly not as severe as that of some of the environments described by Segall *et al.* Notably, Zambian rural school buildings are rectangular as are some other official buildings. Some tools and vehicles used in the area also embody strong carpentered features. Notwithstanding this contamination the two groups were found to differ greatly in their illusion scores, the rural populations being, as expected, less prone to the illusion.

If the two figures used do really embody the same perceptual cues, then the results can be interpreted as demonstrating the effect of the differential carpenteredness upon perception of figures which do not contain "angular" perspective cues. Therefore either the illusory effect is misnamed and does not really depend on perceptual perspective cues or it is due to some other more general factor of which angularity is but one manifestation. The exact nature of this effect is, however, difficult to assess because the environmental factors interact singly or conjointly with other factors (the age of the observers, the type of stimulus, the sex of the observer and the colour of the stimuli) and the analysis by Ahluwalia does not concern itself with these complications.

That such complexities arise is shown by Gregor and McPherson's (1965) comparison of two groups of Aborigines, one of which has settled and for two generations lived in the carpentered environment of a mission station and the other has lived in a reserve traditionally inhabiting circular windbreaks. Segall *et al.'s* stimuli were used. The results showed no difference between the samples on the Muller-Lyer illusion and the expected effect on women only in the case of the Sander parallelogram. This is a much more confused result than that described above, especially so since the descriptions of the groups suggest that the

differences between them in terms of carpenteredness were more radical than between the Zambian samples.

Since Segall *et al's* data showed, and the Zambian data confirm, a distinct decline of illusion susceptibility with age, one could argue that the weakness of the Australian data obtained from adults could have been effected by such a decline and the same explanation could be offered for absence of a significant difference between Ghanaian and Scottish students tested by Jahoda (1970) and between different groups drawn from Ghana (Jahoda 1966). Such a simple explanation suggested by Ahluwalia is, however, suspect because the effect of ageing upon susceptibility is not simple. Both Walters (1942) and Wapner and Werner (1957) report complex development trends. The susceptibility to Muller-Lyer illusion decreases from the age of 6 years to the early teens and then increases from 15 years to 19 years. One can but agree with Wohlwill (1960) who stresses the importance of investigating the entire age ranges.

The changes of illusion susceptibility with age are central to the Piagetian theory of illusions, which, it has been suggested, might be helpful in understanding cross-cultural differences in susceptibility.

Piaget (1969) divides illusions into primary and secondary. The primary illusions are said to be those which show the following developmental characteristics. Their qualitative attributes (the location of the positive and negative spatial maxima and of the median zero illusion in relation to the proportions of the figure) do not alter with age of observers whilst the illusory effects generally decline, sometimes remain constant, but never increase with increasing age. These illusions are thought of as "simple field effects" resulting from an interaction of elements appearing well-nigh simultaneously in a single "field of concentration"; they can in consequence be evoked by tachistoscopically presented stimuli.

In contrast, secondary illusions result from stimuli which require subjects to relate centrations in space or time. Since the activities leading to the establishment of such relations change with maturation so do the resulting illusions. The magnitude of such illusions typically increases up to a certain age.

The essential difference, therefore, between the types of stimuli evoking the two types of illusion is their complexity. If the stimulus is sufficiently complex to call for active structuring, then the illusion is of Type 2, otherwise it is of Type 1.

These notions were invoked by Wagner (1977), who replicated in Morocco some of the work done by Leibowitz and his associates and described above. Wagner's findings presented a surprising effect: the Ponzo illusion evoked by simple geometric stimuli was observed to

decrease with the age of the observer whilst the illusion evoked by the two photographic stimuli showed no such effect. This led to a postulate of an important new effect which Brislin (1974) is said to have misinterpreted, and an invocation of the Piagetian taxonomy as an explanatory concept. Unfortunately, such conclusion seems to be premature for there is a number of earlier studies showing clear *increase* of this illusion with age, when presented in a simple geometrical form; although this increase in the magnitude of the illusion between the ages of 4·5 years by Wagner *et al.* Farquhar and Leibowitz (1971) data show a very rapid increase in the magnitude of the illusion between the ages of 4·5 years (the youngest group tested) and about 8 years of age, the illusion increasing from about 2·5% to about 14·6%.

Extension of the Ponzo studies to other populations reveals further complexity of the associated effects. Ugandan subjects inhabiting the same environment but differing greatly in educational attainment also differ greatly in their susceptibility to illusions evoked by Leibowitz's stimuli (Leibowitz and Pick 1972). The results, which are plotted in Fig. 2.11, clearly show a consistent failure to respond to the illusion by Ugandan villagers and a susceptibility in Ugandan students similar to that of the Guam and Pennsylvanian students. Since both Ugandan groups live in the same environment the difference between them must be attributable to some other factor.

The possibility that pictorial sophistication might be responsible for the difference was suggested earlier when considering cultural differences in susceptibility to the Muller-Lyer illusion.

The essential element of such sophistication is the ability to perceive pictorial depth. Failure to do so implies that such cues as density gradient or perspective convergence are unlikely to be correctly interpreted and, if the illusion depends on perception of pictorial depth, the illusion is unlikely to occur.

THE EFFECT OF EDUCATION

One of the cultural variables which is intimately connected with pictorial sophistication and which might affect perception of illusions is the extent of formal education. This influence is difficult to control in Western samples since general compulsory education makes large and controllable variations in this attribute unlikely and confines them to those sub-divisions of population already differing considerably on account of other variables such as health or genetic endowment. Intra-cultural comparisons do on the other hand offer opportunities for such investigations.

The possibility that education may affect perception of illusion figures was implicit in Jahoda's (1966) comment that pictorial perception may be influenced by it. The impact of education has subsequently been investigated by Davies (1970). Segall *et al.'s* Muller-Lyer figures as well as a set of specially made Muller-Lyer figures were used by Davis with adult Banyakole subjects from Uganda. The subjects were divided into three groups according to their educational attainment, it being implicitly assumed that the process of education was not selective and therefore that the subjects within the groups were equally well endowed genetically. The results were mildly supportive of the notion that the illusory effect depends on education and implied that, contrary to Jahoda's suggestion, education tends to reduce the effect. Some uncertainty about the finding lies in the lack of consistency in the subjects' responses to the stimuli. It appears that the first set of stimuli presented evoked no definite educational trend nor did the second presentation in the case of one of the two samples tested. It was only the second and the third trials in one of the samples which showed the reported decline with education. The reason for this could therefore be that groups differing in education differ also in the way in which they react to exposure to new stimuli and perhaps to the very task of being tested. The more educated subjects adapt to such a situation with greater ease and therefore the decline of the illusory effect which is associated with repeated presentation of the stimulus begins, in their case, relatively early. The less educated do not adapt as easily and the decline, if any, is therefore retarded. This creates the difference between these groups on later trials. If this is so then the experiment could be interpreted as measuring both the effect of education on the magnitude of illusion and on experimental adaptation. Such interpretation makes a definite conclusion about the influence of education impossible.

Nor do Jahoda and Stacey's (1976) observations clarify the issue. They compared Scottish and Ghanaian subjects lacking in systematic training in drawing and allied skills and found them to differ in their responses to L-type figures of the Horizontal–Vertical illusion. The Ghanaian students were more susceptible than the Scottish, a result which accorded with the Ecological hypothesis. Counterparts of these subjects who had had the appropriate training did not, however, differ. The results thus suggest that the cultural differences in susceptibility to the illusion may perhaps be overcome by training and that they may be consequences of learning; and therefore that the environment hypothesis is plausible.

But this suggestion is also weakish for we do not know to what extent subjects' perceptual skills affected their choice of training; whether, for example, only those pupils who had outstanding spatial abilities chose to undergo training in subjects using such skills and, if so, whether this tendency was equally strong in both cultures.

OTHER HYPOTHESES TESTED INTERCULTURALLY

The main two hypotheses discussed related to the effects of the ecological exposure (the Ecological hypothesis) and of experience with rectangular objects (the Carpentered World hypothesis).

Other hypotheses have also been put forward to explain cross-cultural differences in susceptibility to illusions. Rivers' early notions have already been discussed. His suggestion that attention may be an important factor has been reviewed by Doob (1966), who thought that the more analytic attitude the non-Western populations have may be responsible for their lesser susceptibility to illusions. Segall *et al.* (1966, p. 184) made little of this suggestion since for them it lacked the support of a plausible ecological condition which would provide a functional hypothesis.

Davis and Carlson (1970), on the other hand, subjected the idea of the dominant role of attentional factors in cross-cultural differences in perception of the Muller-Lyer illusion to an empirical investigation. The procedure used by them involved two variants of instructions which differed in the extent to which they drew the subject's attention to the lines which had to be compared. The results obtained were inconclusive. The strongest and in a way most surprising effect is the significantly lower susceptibility to illusions observed in the Ugandan students than in both Western groups *and* in a sample of rural Banyakole adults. Another noteworthy finding is that the magnitude of the effect varies with types of stimuli used, an observation already reported by Bonte. Davis *et al.* regard the difference between their two African samples as being confirmatory of Davis's (1970) earlier report that more sophisticated subjects make more discriminating judgements and hence are less prone to the illusion. Granted that this is so the reported finding is in agreement with Segall *et al.'s* hypothesis, provided one can justify the lesser potency of such sophistication in the West and thus explain the yawning gap between the results obtained with Ugandan and American university samples.

Another and entirely different kind of hypothesis explored in cross-cultural studies of illusions is that based on pigmentation of the eye. This is said to affect perception of patterns and hence of illusions. Since the illusions are central, as Julesz's (1971) work has shown, such an eff-

ect cannot explain them completely but it may account for cross-cultural differences in this respect. It has too a certain attraction in that it suggests that such cultural differences as have been observed are essentially peripheral; that "we are all the same below the fundus oculi" if not beneath the skin. This factor has probably contributed considerably to the popularity of the idea. The experimental investigation has not, however, obtained unambiguously supportive evidence. Since the hypothesis involves pigmentation it is physiological rather than cultural and as such will not be discussed further here. A discussion of relevant recent findings can be found in Deręgowski (1980).

There is only one reasonably firm conclusion which the data proffer; there are cross-cultural differences in proneness to illusions and hence in the manner in which the perceptual mechanisms operate, among cultures.

One cannot proceed beyond this important but rather general statement with much certainty. The nature of the factors which are responsible for the difference remains obscure. Although the evidence inclines towards the ecological and environmental influences it does not do so with much vigour and the possibility of genetic influences remains practically unexplored. Many of the studies are mutually contradictory.

The reasons for such a confusing pattern of results lie in the nature of the stimuli and the nature of the postulated influences, and the relationship between them.

There appears to be no psychologically pure version of an illusion stimulus (with the sole possible exception of the Poggendorff illusion). Various illusion figures are correlated. Nor do there appear to be cultures which are identical but for one crucial attribute which is of especial interest to a student of illusions. Thus there is fuzziness both in the definition of the experimental populations and of the experimental measures. A great degree of ambiguity resulting from the interaction of the two need not therefore offer surprise.

The importance of the general conclusion is two-fold, it confirms that the limits within which human perceptual apparatus operates are broader than those which could be determined by intra-cultural experimentation, and it suggests that there may be other stimuli than illusion figures which are perceived differently in different cultures.

Such differences would certainly be expected to arise in the case of pictures which often incorporate illusory elements to evoke perspective, but the differences may also occur with simple patterns having neither illusory properties nor the power to represent other objects.

We shall now examine cross-cultural data pertinent to perception of such patterns.

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