PICTURE PERCEPTION

Organized by Claudia Carello and John Kennedy

Metric Knowledge of Three Dimensional Surface Structure

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Many theoretical analyses of 3D form perception assume that visible surfaces in the environment are perceptually represented in terms of local mappings of metric depth and/or orientation. Indeed, this approach is so taken for granted in the study of human vision that there have been few attempts to empirically demonstrate its psychological validity, and other alternative representations have seldom been considered. In an effort to shed new light on this issue, our research has been designed to investigate the accuracy with which observers can discriminate metric depth intervals or metric orientation intervals on smoothly curved surfaces.

Observers viewed computer generated images of smoothly curved surfaces defined by shading and contours. On each trial, two pairs of points designating depth intervals (Experiment 1) or orientation intervals (Experiment 2) were presented. Observers were asked to judge which of the two depicted intervals appeared larger. The results of these experiments suggest strongly that perception of metric structure from static patterns of shading and texture is surprisingly coarse grained, and that the compelling impressions of 3D form from these images is probably based on a more abstract form of visual representation. (Supported by NSF-grant BNS-8908426 and AFOSR grant 89-0016).

Tactual Perception of 3D Scenes in 2D Pictures

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One of the main problems for the blind in reading tactile pictures concerns the pick up of 3D aspects of the scene in the picture. This indicates that the double character of a visual picture (that is its being, at the same time, both a 2D surface and a 3D scene) is difficult, some say impossible, to obtain tactually. However, there are also suggestions that the blind may have a potential of perceiving at least some aspects of 3D in tactile pictures. The aim of the investigation to be described was to study the possibilities to tactually pick up a kind of stimulus variable important in visual pictures, namely texture gradients. In the first experiments the stimuli consisted of texture gradients informing about the slant of plane surfaces. Two forms of displays were used, one being patterns embossed on swell paper and read by one finger tip, the other an Optacon display (20 x 5 vibrators) fed by the subject's moving a camera over the visual pattern. In both cases there were no restrictions on the exploratory movements, but they were videotaped and could be analyzed afterwards. The result was that the magnitudes of the texture gradients were accurately judged, both in swell paper form and, somewhat less accurately, via the Optacon display. The analysis of the recordings of the exploratory finger movements suggested two different ways of exploration: Sweeping over the whole gradient and concentrating on successive exploration of its extremes. Experiments where the stimuli consisted of either the whole gradient, its central part, or its extremes gave the same degree of accuracy for the whole gradient as for the two extremes. This result indicates that a whole gradient is not necessary for judging the magnitude of a texture gradient corresponding to a planar surface at a slant. It should be noted that these experiments did not study to what extent the tactile gradients can be used for perceiving or judging slant of a surface. Experiments to study this are on their way. Other experiments concern the possibilities of tactually perceiving gradients corresponding to other kinds of 3D objects than slanted planar surfaces, especially surfaces curved in different ways. In these cases, it may not be possible to restrict the exploration to the extremes of the gradient since the whole surface has to be explored.

Anamorphs: Locating Correct or Preferred Viewpoints

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The study examined subjects' selection of viewpoint for the simplest kind of anamorphs—pictures generated from viewpoints NOT on the normal to the projection plane. Two of the pictures were of human faces, two of pairs of objects with basically cylindrical forms of cups and pots, and two of pairs of objects with essentially rectangular forms—closed boxes of different dimensions.

Seven images of each subject were created: One image on the normal to the subjects' frontal plane at a distance approximately five times as great as the mean dimensions of the subject (size) in order to obtain a noticeable degree of perspective compression across the subject from near to far; three camera angles were to the right of the zero point (at 65°, 40° and 15°) and three to the left at 115°, 140°, and 165°.

Photographs were taken with a 10.2 x 12.7 cm view camera with a flexible film plane to produce the six 'anamorphs' and one normal image. Resulting images were blown up to 40.6 x 50.8 cm posters and mounted vertically with the center of the image at camera height (nodal point of the lens). Strip markers were fixed to the floor below the posters radiating out 1.8 m from the central point at each of the seven angles noted above and at each point exactly half way between these two angles. It was assumed that no subject would choose a distance at which the contents of the poster were no longer discernible.

Subjects were asked to choose to stand at the point at which the picture 'looks best' to them. Again, pilot testing was necessary to determine the most appropriate wording for this question.

It was hypothesized that in the case of the face stimuli there is essentially no information available for correct viewpoint other than expectations about 'normal' vertical to horizontal ratios of facial proportions. At extreme angles, the face as a whole and individual features such as the nose are widened, horizontally, to such an extent that they no longer appear to be 'normal' human faces. This is not, however, information in the mathematical sense above. It is rather a set of quantitative expectations about the shapes of faces and facial features based on past experience with faces of a certain ethnic type. Faces and features too many standard deviations from the mean in any direction were judged 'abnormal' or distorted. In the case of the images of rectangular solids, there is, similarly, no information on which subjects could base a judgment of 'distorted' without the assumption of rectangularity in the first place. Given such an assumption, subjects followed Perkins' Law for additive corner angles in determining whether a particular image appeared distorted or not. For images of objects with an essentially cylindrical form, a law similar to Perkins' Law appeared to operate. In these cases, however, we extrapolated the law from the judgments instead of predicting the performance of subjects from the law.

Data were analyzed for deviations in distance and angle from the correct viewpoint, and the images analyzed as above, and, where possible, in terms of competing formulations of information available for determination of distance or angle of viewpoint.

How We Perceive Figural Incompleteness

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Pictorial representations of 'broken' or ' amputated' objects do not seem to raise any problem to visual perception theorists as long as the representation refers to patterns with a familiar shape. Some problems arise, however, when an 'amputation' is seen in an unfamiliar and irregular pattern. How can our visual system detect a condition of incompleteness in a meaningless figure? A possible line of reasoning is as follows: In structuring the visual world our visual system has to choose which parts of the visual field are figures and which parts are backgrounds. In doing so it is compelled to attribute the contours to the figures only. Consequently the backgrounds are contourless and forced to continue 'behind' the figures themselves. Amodal completion is one of the outcomes of this process. The idea suggested here is that a condition of figural incompleteness might be due to the same mechanism of contour attribution. In other words, a figure is seen as a complete pattern only if the visual system can easily ascribe the whole contour to it. When only a part of the contour is suitable to be ascribed to the figure, since other figural solutions are equally possible, it is perceived as incomplete. This is likely to happen when the pattern is indented and the indentation is bounded by two angles. In such a case, the indentation has a strong *figure-like feature* and this may turn the choice of which part of the field the contour is to be attributed rather hard for the visual system to be made. This does not mean that the contour of a figural indentation is actually to be seen as belonging to another figure or that the indentation itself tends to be seen as a real overlapping figure, but simply that there is a conflict between two opposite structuring mechanisms. The former and favored one tending to give rise to a single 'amputated' object totally contoured and the latter favoring the perception of two 'non-amputated' figures, one of which is partially occluded by the other and lacking in a part of the contour.

If this explanation is tenable one should expect an 'amputated' figure to be readier, in appropriate conditions, to release part of its contour to adjacent parts of the visual field. In other words, an 'amputated' figure should more easily yield the emergence of amodal completion and figural stratifications, such as transparency effects. In order to test this hypothesis two experiments were carried out. Two sets of figures, previously chosen as 'complete' or 'amputated' patterns by 50 subjects were used in both experiments. The first experiment was aimed at ascertaining whether amputated figures give rise to more visible amodal completion than complete figures. Thirty subjects were asked to assess the strength of figural completion by a magnitude estimation procedure. The second experiment was aimed at ascertaining whether 'amputated figures', put in a suitable figural condition, give rise to more visible effects of transparency than complete figures. Thirty subjects served as observers and the same procedure as in the first experiment was used. Results show that 'amputated' figures tend to get a better amodal completion and to induce a stronger effect of transparency than complete figures.

Dynamical Constraints on Pictorial Action Lines

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The salience of various pictorial techniques in specifying movements in pictorial representations has been investigated by many researchers (e.g., Friedman and Stevenson, 1980; Carello, Rosenblum, & Grosofsky, 1986). It has been shown that action lines—shown emanating from the back of characters—is a highly effective means to portray movement (Carello et al., 1986). Carello and her colleagues propose that action lines provide a (depicted) structural record of some transformation suggesting that such lines have a lawful basis. The current experiments address this hypothesis by testing the perceptual power of a class of action lines which are generated from real events. These lines were produced by having a darkened actor wearing point-lights (Johannson, 1975) perform a number of actions in front of an open-lens camera. The resultant photographs were shown to subjects under various conditions to determine how well they could recognize the events performed in each picture. The results suggest that although completely naive subjects were not good at recognizing the depicted events, once told of the photographic technique (or given a list of the performed events) subjects show striking proficiency. Further experiments test whether subjects are sensitive to various subtle dynamic differences in the depicted events. Results are discussed in terms of pictorial convention, dynamic specification, and formless invariants.

Pictorial Cues of Causality, Cues of Concreteness, and Subject's Interests in Causality as Favoring a Special Variety of Illusory Contours

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For some years now our study group has identified an interesting variety of 'illusory contours' which are added to the better known types due to indices of three-dimensionality (superimpositions, chiaro-scuro, etc.) or to other factors. The 'illusory contours' we have studied are determined by the pictorial representation of cause and effect relationships which involve groups of people and inanimate objects. For example, different people are represented on paper through thin closed contours, acting in a coordinated way, pushing, hitting, exploring, listing, supporting, climbing, descending, reclining, etc. In favorable conditions the objects complementary to these operations appear at a level of reality of perception at degrees of 'subjective clarity' and of other figural properties which are clearly measurable through scales of subjective experience (i.e., eleven step scales ranging from 0 to 10).

In recent developments of such studies, the relevant role of various conditions and of their interaction has been delineated through experimental procedures. a) The essential role of the pictorial cues of activity and passivity, given mainly by some specific forms and positions of the human figures which strongly stimulate attributions of causality (to act or to receive actions within the relationship with the external reality), has been verified. Otherwise these forms and positions would result as incongruous. The causal attributions seem to have the function of preventing or reducing such incongruities. b) Also the presence of figural matter cues is fundamental: In actual fact, these 'illusory contours' are strongly favored by the use of rough rather than smooth, and opaque rather than transparent surfaces. There is also an interesting interaction between meaning and contrast of brightness. c) An important role is also played by the subjects' interest in establishing cause and effect connections. Thus the phenomena we have studied are more intense in subjects who, because of their personality's structure or because temporarily subjected to stress (overloading of conflict), are intolerant of incongruities. The same phenomena are less intense in subjects who are tolerant of incongruities or who have just undergone a period of relaxation.

The results of these studies allow the delineation of the theoretical model which accounts for expectations activated by the predisposed pictorial cues, by conditions of observation, and by the observer's dispositions. Thus the model also makes it possible to predict further phenomena.