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Adelphi International Conference on Illusory Contours: A report on the Conference

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and

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On November 24-26, 1985, Adelphi University in Garden City, New York, hosted the International Conference on Illusory Contours. The conference was organized by Glenn E. Meyer of Lewis and Clark College in Portland, Oregon, and Susan Petry of Adelphi University. It was partially funded by the United States Air Force Office of Scientific Research (No. 86-0028) and Adelphi University.

This was the first conference to be held devoted exclusively to the topic of illusory contours, and discussion was indeed lively. The keynote speaker was R. H. Day of Monash University. R. L. Gregory of University of Bristol and Stanley Coren of University of British Columbia were the featured speakers. Twenty-eight additional papers were presented, representing work from a large segment of the major researchers in the field. Speakers came from as far away as Australia, Italy, England, and Scotland, and papers and additional material from England, Scotland, the Netherlands, and Germany were presented in absentia (our "illusory conferees," a term coined by William Dember). Although Gaetano Kanizsa was not able to be present, he sent greetings through Walter Gerbino of the University of Trieste, who also presented a paper which he coauthored with Kanizsa.

Among the topics covered were: neurological data and theoretical models of illusory contours; psychophysical investigations of brightness, hue, configuration, threshold, and temporal factors; phantoms and motions; transparency and texture segregation; cognitive and higher order perceptual contributions; and illusory contours and art. While theoretical positions were hotly debated and defended, ways of going beyond a narrow theoretical framework were frequently suggested and encouraged. In particular, a suggestion to use the term "illusory surfaces" in place of the numerous other terms currently in use was received with great interest and support. Finally, there were several ideas for collaborative work between various researchers in the field.

We are most grateful to the U.S. Air Force Office of Scientific Research, the hard-working students and staff at Adelphi, and especially the Conference participants for their ideas, cooperation, spirit, and enthusiasm.

In the following pages are the abstracts of the papers presented at the conference. They are grouped by session in the order of presentation.

Reprints of this complete section may be obtained from Susan Petry at the Department of Psychology, Adelphi University, Garden City, NY 11530.

Keynote presentation
Some data, some problems, some speculations

R. H. DAY
Monash University, Clayton, Victoria, Australia

This paper is in three parts. The first is a review of our work on the role of induced contrast and apparent depth in the formation of illusory contours. The second is concerned with a simple, but probably critical, demonstration of the occurrence of illusory contours in the absence of induced contrast. The third and longest part of the paper is more speculative, and contains two proposals—that illusory contours derive from the occurrence in a pattern of some of the stimulus correlates, or "cues," that are normally associated with edges, and that in this sense they fall into a broader class of perceptual phenomena deriving from artificial or contrived cues. Some cues for "edgeness," including stepfunction gradients of luminance and texture, overlay of one pattern by another, corners due to perspective, parallactic movement of objects at different depths, and terminations of lines and stripes, are suggested. When one or more of these are contrived, an impression of "edgeness" occurs. The more cues, the stronger the appearance of contour. Since different cues probably activate different processes, it is considered inappropriate to attempt to tie illusory contours to a single process. Simulated depth from contrived depth cues, simulated forms from moving elements (Johansson), simulated transparency from overlapping regions of different luminance (Metelli), and apparent (phi) movement are regarded as further instances of this class of perceptual simulations.

SESSION I
COGNITIVE PROCESSES

GLENN E. MEYER, *Moderator*

Set and subjective contour

STANLEY COREN, Featured Speaker
University of British Columbia
Vancouver, British Columbia, Canada

CLARE PORAC
University of Victoria, Victoria, British Columbia, Canada

and

LEONARD H. THEODOR
York University, Toronto, Quebec, Canada

In two separate experimental paradigms, perceptual set is shown to affect certain aspects of the appearance of subjective contours. In the first, direct set induction is shown to affect the apparent shape of subjectively contoured figures. In the second, implicit set is provided by context and measured via induction of changes in the apparent depth of the subjectively contoured figures.

Configuration and brightness as causal factors in subjective contours: Two direct tests

PHILLIP J. KELLMAN and MARTHA LOUKIDES
Swarthmore College, Swarthmore, Pennsylvania

The causal status of configural and brightness factors in subjective contours is noted as a central and persisting issue. Two lines of research are presented in which these factors are subjected to more direct test than in previous research. Configural effects were tested by refining earlier efforts (e.g., Kellman & Cohen, 1982; Prazdny, 1983) to create subjective figures in physically and perceptually homogeneous space. Computer-generated subjective contour displays were used in which black and white solid and striped inducing elements contrasted with a medium gray background. Subjects were instructed to adjust the brightness of the inducing elements to eliminate subjective contours and to eliminate center-surround brightness differences. All subjects were able to eliminate brightness differences between the center and surround, but strong subjective contours and figures persisted throughout.

Brightness was tested as a causal factor using displays that do not ordinarily give a subjective figure but have the same sections of "real" contour bounding a central area as in some effective displays. By "seeding" the central area with individually undetectable pixels of greater intensity, pools of brightness were created that might be assimilated into subjective contours and figures. Seeding was guided by a model of the lateral inhibitory effects that would occur with certain effective subjective contour-inducing elements. The subjective contours and figures that would be expected if brightness can be an initiating factor were not seen by any subject.

The results suggest that configurational variables, but not processes of brightness or lightness perception, are causal in the standard type of subjective contour display. Moreover, the results provide clear support for human edge perception in the absence of any surface quality differences, that is, in both physically and perceptually homogeneous space.

An information processing analysis of illusory figures

NICOLA BRUNO
Cornell University, New York, New York

and

WALTER GERBINO
University of Trieste, Trieste, Italy

Four experiments concerning amodal completion behind an occluding illusory figure are presented. Phenomenological analysis suggests that completion of elements inducing illusory figures differs from mental integration, and involves functional effects comparable to those observed when completion occurs behind a real figure. Our research had two aims: (1) testing whether completion behind an illusory figure facilitates recognition, and (2) clarifying the genesis of illusory figures. "Same/different" response times were registered in either sequential (Experiments 1-3) or simultaneous (Experiment 4) matching tasks. Experiment 1 demonstrated that matching a complete target, such as a diamond, with a physically truncated form is facilitated when the latter looks completed behind an illusory figure, with respect to a control condition in which it looks truncated. Experiments 2 and 3, in which both complete and truncated targets were used, allowed us to reject two simple models of the completion process, based on either spontaneous organization or problem solving. The comparison of Experiments 3 and 4 indicated that amodal completion can inhibit matching on the basis of topographical identity alone, when the corresponding mosaic solution is not preactivated.

Cognitive contours and perceptual organization

DRAKE BRADLEY
Bates College, Lewiston, Maine

Two categories of subjective contours, ambiguous and animated, are demonstrated and discussed. In ambiguous configurations, subjective contours are perceived in a variety of different arrangements. The "objects" delineated by these contours can vary in shape, depth, orientation, brightness, and surface color. Animated films of subjective contours show that they undergo substantial deformation in shape during rotation and distortion of the inducing elements, and during rotation of the subjective object itself. In some animated sequences, subjective contours are seen by naive observers only after the subjective objects are rotated, thereby providing kinetic information about relative depth. The organizational effects associated with ambiguous and animated subjective contours reveal the need to more fully integrate sensory and cognitive theories of subjective contours.

Cognitive intervention in perceptual processing

IRVIN ROCK
Rutgers University, New Brunswick, New Jersey

It is argued that a purely bottom-up, contrast theory of illusory contour is inadequate because naive observers may not perceive the effect, because some patterns that should elicit it do not, and because figure-ground reversal is a necessary prerequisite of it, an aspect of which is a perceptual completion of the pattern fragments. It is therefore argued that the achievement of the effect requires cognitive intervention in perceptual processing. Following the initial perception of the fragments, a hypothesis of the presence of the figure in what had been the ground region is first cued by detected incompletion or alignment. The hypothesis is sustained and preferred if and only if it exactly accounts for and is consistently supported by the stimulus. The enhanced lightness of the illusory figure may then be more in the nature of a perceptual rationalization than a primary cause, although a type of contrast based on the perceived belongingness of the figure percept to the fragment regions may contribute to or determine the sign of the contrast.

SESSION II
MECHANISMS AND THEORY

BARBARA GILLAM, *Moderator*

Reductionism versus holism: Levels of explanation and the subjective contour illusion

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Galveston, Texas

Attempts to explain the perception of subjective contours can generally be classified as being largely either reductionistic or holistic in nature. Reductionistic explanations are usually couched in physiological terms, and appeal to data-driven ("bottom-up") types of processes occurring at the more peripheral levels of the nervous system. In contrast, holistic explanations are typically couched in psychological terms, and appeal to conceptually driven ("top-down") processes. Although most holistic theorists probably view subjective contour perception as being the result of events transpiring in the nervous system, they hold that these events are occurring at more central levels of the nervous system and are agnostic with regard to the exact nature of the molecular neural events underlying the illusion, preferring to view the system on a molar level instead.

Although reductionistic explanations have contributed to our understanding of subjective contours, certain aspects of their perception, such as attentional effects (Pritchard & Warm, 1983), are difficult to subsume under a completely reductionistic account, given our currently rather poor state of knowledge concerning the molecular nature of neural events subserving complex processes such as attention. The resolution of the reductionism/holism question may indeed, as Hofstadter has proposed in his "Ant Fugue" essay, lie in the Zen word "mu," which unasks the question by recognizing the falseness of the dichotomy between the two. A fully satisfactory account of the illusion will probably appeal to explanations on both levels.

Epistemology of subjective contours

JOHN M. KENNEDY
University of Toronto, Toronto, Ontario, Canada

Perceptual evidence that subjective contours do not exist does not make the contours vanish. Therefore, they are not cognitive contours, that is, hypotheses to explain perceptual evidence. It is proposed that subjective contours, in most of the standard displays, are perceptually nonexistent. Supporting studies find that subjects can pick out the unreal dividing line from among a set of real lines. Both sharp and fuzzy subjective contours are judged to be unreal. Bright and dark subjective figures are judged unreal. Contours that join elbows of chevrons are judged unreal. Assimilation is judged unreal. Bright, clear, and misty surfaces in Kanizsa triangles are judged unreal. Solid objects are judged, by adults and by children, to have unreal subjective figures. When lines are dense, the contrasting subjective figure is judged real.

Illusory figures and pictorial objects

THEODORE PARKS
University of California, Davis, California

Illusory figures give the impression that the artist has physically altered parts of the display when, in fact, he has not. On neither logical nor phenomenological grounds can it be said that such patterns are "pictures" or the results "pictorial." This is so despite a good deal of recent evidence that they, too, are the result of creative processes within the visual system.

Neural mechanisms of subjective contours

ROBERT SHAPLEY
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and

JAMES GORDON
Hunter College of CUNY, New York, New York
and Rockefeller University, New York, New York

The neural mechanisms that contribute to the perception of subjective contours were studied in psychophysical experiments by varying contrast magnitude and sign, color, spatial separation, and temporal modulation frequency, and by using monoptic and dichoptic presentation of the patterns that induce subjective contours. Two kinds of patterns were used. One was the standard set of Pacman-like figures at the corners of Kanizsa-like squares. The other was a pattern we invented—a circle of constant luminance or chrominance on a gradient of luminance or chrominance. The experimental results imply that the mechanisms responsible for subjective contours have the following properties: (1) They are excited by both positive and negative contrast; (2) they integrate the absolute

value of contrast over a length of 0.75° of visual angle; (3) their contrast threshold is close to the detection threshold for the inducing patterns; (4) they cannot follow temporal modulation of more than 6 Hz; (5) they receive binocular input; (6) they receive input from chromatic neural channels and can integrate signals elicited by stimuli with opposite color contrast. The neural mechanisms involved in the perception of subjective contours are probably involved in form perception generally. Properties 1-6 listed above help explain other aspects of form perception, namely the appearance of herringbone patterns, shape invariance with variation in contrast, and "binocular luster."

Our work was supported by grants from the National Eye Institute (EY-1472) and the Air Force Office of Scientific Research (84-0278).

Neural dynamics of boundary completion and textural grouping: Emergent segmentations and contour visibility

STEPHEN GROSSBERG and ENNIO MINGOLLA
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(Presented by Ennio Mingolla)

A real-time visual processing theory is used to analyze and explain a wide variety of perceptual grouping and segmentation phenomena, including the grouping of textured images, randomly defined images, and images built up from periodic scenic elements. The theory explains how "local" feature processing and "emergent" features work together to segment a scene, how segmentations may arise across image regions that do not contain any luminance differences, how segmentations may override local image properties in favor of global statistical factors, and why segmentations that powerfully influence object recognition may be barely visible or totally invisible. The theory provides a unified explanation of several ostensibly different Gestalt rules. The theory also provides a consistent framework of design principles and mechanistic implementations for both "real" and "subjective" contour perception.

The relationship between spatial filtering and subjective contours

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The Kanizsa triangle represents a class of illusions which provide contours that are perceived but are not physically present in the original object. The question arises as to what visual processes, for example, physical or cognitive, govern the visibility of subjective contours. Spatial filtering based on visual physiology has been shown to create physical intensity distributions from the Kanizsa triangle that generally correspond to the shape of the subjective contour, which suggests that the basis for subjective contours may be physical rather than cognitive.

To further determine the degree to which spatial filtering based on biological data could be contributing to the visibility of subjective contours, a number of experiments using digital image-processing techniques were conducted. Solid and outline Kanizsa triangles and two versions of an Ehrenstein illusion were filtered into 1, 1.5, and 2-octave bandwidth channel-filtered images whose center frequencies ranged from 0.5 to 128 cycles per picture width in 1-octave steps. These filtered images were also added linearly and examined after each addition. The channel-filtered images provide smoother subjective contours relative to the earlier ideal filtered images. Examination of the filtered images reveals the physical existence of subjective contours in the low- to mid-bandpass spatial frequency regions. However, linear addition does not produce a filtered image that contains a subjective contour that fully agrees with the perception of the original figure. These findings suggest that other mechanisms and/or nonlinearities in channel image summation are needed to fully explain the appearance of subjective contours.

In sum, these data provide further evidence that fundamental visual filtering mechanisms are a prime candidate for why we see subjective contours. However, further research is needed to fully understand how these filtering mechanisms combine to create the images that we see.

SESSION III
MOVEMENT, KINETIC, AND FLICKER EFFECTS

JAMES GORDON, *Moderator*

What does the brain do with illusory contours?

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What does the brain do with illusory contours? In a world that is so rich in *real* contours, it is hard to see what evolutionary advantages would accrue from the ability to construct illusory edges. But consider one of our arboreal ancestors trying to avoid a leopard seen against a screen of foliage. To this creature, illusory contours may play a vital role as an *anticamouflage* device. Many animals in nature have developed splotches in order to break their outlines, and the ability to see illusory contours may have evolved specifically to foil this strategy (Ramachandran, 1985). Collinear edges induce illusory contours because, through millions of years of trial and error, the visual system has "learned" that such edges are *usually* produced by occlusion.

Other countercamouflage strategies include the ability to segment the scene using stereo disparity and motion parallax. Evidence will now be presented showing that the processing of stereopsis and motion is strongly influenced by the presence of illusory contours.

We began with a square matrix of four circular 1°-wide black disks from which we removed right angle sectors. This created the impression of a white "subjective" square with its four corners occluding the disks ("illusory contours"). The display in the other eye was identical except for a horizontal disparity introduced between the edges of the cut sectors so that an illusory white square floated out in front of the paper. We superimposed a "template" of this stereogram on a vertical square-wave grating (6 cycles/degree) and found that the illusory square pulled the corresponding lines of grating forward even though the grating was at *zero* disparity—an illusion that we call "stereoscopic capture" (Ramachandran & Cavanagh, 1985). Capture was not observed if the template was superimposed on horizontal gratings; the grating then remained flush with the background. Also, the effect was enhanced considerably if the disparity between cut sectors was an exact multiple of the grating periodicity. When a deliberate phase shift was introduced, one usually saw transparency instead of capture.

Analogous effects were observed in apparent motion ("motion capture"). By removing sectors from disks in an appropriately timed sequence, we could generate apparent motion of an illusory square. When a template of this display was superimposed on a grating, the lines appeared to move vividly with the square even though they were physically stationary (Ramachandran, 1985). We conclude that segmentation of the visual scene into surfaces and objects can profoundly influence the early visual processing of stereopsis and apparent motion. However, there are interesting differences between stereocapture and motion capture, which probably reflect differences in natural constraints. The implications of these findings for computational models of vision will be discussed.

Approaching the edge: An object perception view of static and kinetic subjective contours

PHILLIP J. KELLMAN and MARTHA LOUKIDES
Swarthmore College, Swarthmore, Pennsylvania

A new theory of static and kinetic subjective contours is proposed, linking them closely to perception of partly occluded objects in ordinary environments. We assert that perceiving the unity of spatially separate visible areas in subjective contours and in ordinary perception of partly occluded objects depends on the same perceptual process; whether the resulting unitary object is perceived modally (subjective figures) or amodally (partly occulded objects) depends on an additional and independent step determining the ordering in depth of the object and the adjacent surface.

Two observations motivating this view are the often unnoticed bistability of ordinary static subjective contours, and the existence of other perceptual phenomena in which modal and amodal completion of a given object alternate over time. In addition, this view offers a unified explanation of both static and kinetic subjective contours.

A sketch of a computational model is presented in several steps. (1) In the static case, mathematical discontinuities in a real contour that result in concave object boundaries are suggested as initiating factors. (2) Single discontinuities are not sufficient for perception of an overlying (or protruding) object. It is also necessary that a discontinuity be connectable to other discontinuities along continuous (straight or smoothly curving) paths, that these connections be unspecified by surface qualities (i.e., the middle area is occluded or homogeneous), and that these continuously connectable discontinuities jointly yield a closed figure. If these conditions are fulfilled, a unitary object is detected. (3) A final step determines from available depth information whether the body of this unitary object, whose contour inflection points are visible, is perceived as lying behind an occluding object or in front of a homogeneous surface. With insufficient depth information, the position of the unitary object is bistable.

Kinetic subjective figures (Kellman & Cohen, 1984) are treated in the same way, except that the initial discontinuity information can be given solely by kinetic optical occlusion. Two new kinetic subjective contour phenomena are presented as illustrative. In one, the inducing elements are specified outside of the luminance domain, by accretion and deletion of texture at the edges of rotating square areas in a field of random dots. Interruptions in such inducing elements are sufficient for perception of a complete subjective figure. A second display separates the inducing events (interruptions) in time, giving kinetic subjective figures with kinetically specified inducers.

The fit of these new demonstrations, as well as many better known phenomena, with an object-perception view of subjective contours is noted, especially with regard to the irrelevance of the luminance domain and the parallels between figural specification across gaps in space and in time. Aspects of the theory requiring further refinement are discussed.

Phantom contours and brightness induction effects with flickering gratings

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Phantom contours are illusory contours seen when a square or sine-wave grating is moved or flickered behind a relatively dark occluding surface. A faint continuation of a vertical grating will be seen on the surface of the occluding strip when the grating is visible above and below the occluder. Brightness induction is a brightness contrast phenomenon seen with similar displays in which regions under dark bars of the grating appear lighter than the regions under the light bars, on the occluder surface. I have recently looked at the effect of flicker frequency of gratings and reflectance of occlusive strip on the probability of the two incompatible illusions. The role of these two variables in the relative dominance of brightness contrast and brightness assimilation processes will be discussed.

The effects of temporal manipulations on subjective contour strength

SUSAN PETRY, ROBERT GANNON, and MATTHEW DAILEY
Adelphi University, Garden City, New York

Although considerable research has been conducted on subjective contours, there has been little work concerning the effects of temporal manipulations. We investigated some of the temporal parameters of subjective contours in a series of three experiments. In the first, brightness and sharpness estimates of several subjective contours and control figures were made as a function of stimulus duration. Although the control figures typically showed the classic brightness enhancement function, this effect was less evident in the subjective contours where it always occurred at longer stimulus durations. In the second experiment, stimuli were presented for varying durations which were interrupted for brief light periods (on-off-on). The results, though complex, indicated that this interruption has a greater effect on real than on subjective contours, particularly at short durations. In the third experiment, subjective contour-inducing elements were flickered for 4 sec at several flicker rates and spatial locations. Subjective contours were greatly enhanced by flicker despite the lower total effective stimulus energy, but were even more enhanced by a rotating flicker, which produced apparent motion in the inducing elements only. These results indicate that subjective contours are both quantitatively and qualitatively different from real contours with respect to sensitivity to temporal manipulations and may be best characterized as being mediated not merely by a transient system, but by a motion-detecting system.

Phantom figures affect orientation discrimination performance

JAMES BROWN
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Moving visual phantoms involve a figure/ground distinction accompanied by the perception of contours and surfaces where none physically exist. Orientation discrimination performance was superior for targets presented in perceived phantom (figure) versus perceived nonphantom (ground) regions of a physically homogeneous space. These findings are interpreted as support for the idea of different mechanisms or channels in the visual system specialized for the processing of figure and ground.

Structure and motion: Illusory projective transformations

VICTOR KLYMENKO and NAOMI WEISSTEIN
State University of New York, Buffalo, New York

The efficacy of several image transformations in producing a motion-induced contour was tested. The null transformation, a stationary image, served as the baseline condition. The transformations associated with rotation in depth, polar rotation in depth, and zooming rotation in depth are superior to the null transformation; however, the looming, zooming, and zoom-looming transformations are not significantly better than the null transformation. There is a parallel between the results reported here on contour perceptibility and previous findings on the perception of three-dimensional structure in motion.

SESSION IV
MEASUREMENT

THEODORE PARKS, *Moderator*

Increment thresholds in illusory contour line patterns

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Two experiments are reported in which increment thresholds were measured in line patterns displaying brightness enhancement and illusory contours.

In line patterns, it has been argued (Day & Jory, 1978) that strong brightness enhancement occurs as a result of dissimilation of brightness at line ends and assimilation of brightness between line edges. It is to be expected that if lateral inhibitory processes mediate line-end dissimilation, this local contrast effect will be reflected in a shift in the increment threshold. In the first experiment, increment thresholds were measured in a grating pattern broken across the center to form an illusory contour. On the basis of previous experiments (Day & Jory, 1978), which showed line-end acuity to be enhanced relative to line-edge acuity, it was expected that the increment threshold at line ends would be lower relative to the region offset from line ends. Using a random double-staircase procedure, subjects reported the presence or absence of a target located between line ends or offset from line ends. The results supported the expectation. The increment threshold was significantly lower in the region of enhanced brightness at line ends than in the region offset from line ends.

In the second experiment, increment thresholds were determined at a number of locations across the Ehrenstein figure. It was expected that the thresholds between the radiating lines would be higher relative to the threshold in the central region of brightness enhancement. Increment thresholds were determined using the same procedure as for the first experiment. The results showed a marked drop in increment threshold in the region of brightness enhancement relative to the thresholds between the radiating lines.

These results show that brightness changes in line patterns correspond to shifts in visual sensitivity between line edges and ends. In short, assimilation and dissimilation of brightness are important determinants of illusory brightness.

Illusory contour phenomena from inducing elements defined solely by spatiotemporal correlation

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Vivid and perceptually salient subjective contour phenomena occur readily when moving inducing objects (which change form so as to "stimulate" the presence of an occluding shape) are defined solely by (the differences in) temporal correlation in random dot cinematograms. These effects indicate that subjective contours are a result of processing at higher cortical regions not directly coupled to a single source of sensory information (e.g., brightness domain edge detection).

Subjective figures: The measurement of inhomogeneity induced by lines

MARCO SAMBIN
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A model of explanation, based on the hypothetical construct "induced inhomogeneity," can be used to describe the formation of subjective figures induced by lines. The criterion used is judgments in the apparent strength shown by subjective figure-inducing patterns.

In a first experiment, 18 psychology students judged the apparent strength of sets of subjective figures in which the following parameters were varied in turn: length, thickness, number of inducing lines, and circumference of the circle which the lines were implying. It was found that the four parameters are connected with apparent strength (linear regression; lowest $r^2 = .83$, $\alpha = .005$).

A second experiment was carried out twice, first by 16 psychology students at the University of Krakow (Poland) and then by 16 psychology students at the University of Padua (Italy). Both student samples had to judge 108 subjective figures in which the four parameters were varied together. The 1620×2 judgments were analyzed by a multiple stepwise regression. Each of the four parameters can explain a significant portion of the variance, and the regression equation enables us to rank the parameters as follows: thickness, circumference, length, and number. On the basis of the equation coefficient values, and with the aid of some mathematical transformations, the following points have been demonstrated: (1) numerically expressed links between length and apparent strength conditions, (2) transformation of length variations in surface variations, (3) links between extension of the induced inhomogeneity and length-thickness variations, (4) a measure of the increase in apparent strength due to a given line, (5) a transformation of the apparent strength units into metrical units, and (6) the absolute measurement of an induced inhomogeneity.

In a third experiment, the findings were applied to subjective figures induced by lines made of dots or strokes. The inducing power of differently dotted and stroked lines was calculated.

The main conclusion that can be drawn is that it has been possible to measure in metrical terms an illusory phenomenon in which the main feature is not directly present in the stimulation but only induced by secondary parts of the array.

Effects of luminance and inducing area on the apparent strength of subjective contours

JOEL S. WARM, WILLIAM N. DEMBER, ROBERT A. PADICH, JOHN BECKNER, and SCOTT JONES
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Category ratings of perceived sharpness/clarity were obtained for real and subjective contours with solid and striped inducing areas as a function of target luminance. A reduction in luminance of 10 log units was accompanied by a linear decline in the visibility of real contours. The visibility of subjective contours also declined over this range, but was more resistant to luminance changes than was that of real contours. The results are inconsistent with Dumais and Bradley's (1976) report that the strength of subjective contours is enhanced by dim light. They are also inconsistent with brightness contrast and feature detector accounts of subjective contours, which would predict that the strength of such contours would be more susceptible to the degrading effects of luminance reductions than would that of real contours.

SESSION V
HIGHER ORDER PROCESSING

SUSAN PETRY, *Moderator*

Illusory surfaces as perceptual postulates

RICHARD GREGORY, FEATURED SPEAKER
University of Bristol, Bristol, England

Perhaps we should think of illusory surfaces rather than contours, if we think of them as masking or eclipsing objects. This notion is that the visual system postulates objects to account for surprising gaps. This explanation is in terms of procedures rather than basic physiology. Some evidence will be presented.

We have recorded from area 17 in the cat and find no response to illusory contours—so cognitive contours can't con cat cortex.

The aggregation of collinear lines

BARBARA GILLAM
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Subjective contours are often considered to be organizations of overlying forms. This usually involves the coherence of the collinear components of fairly complex figures. It is not often recognized that a strong coherence also exists for overlaid forms when it would be ecologically inappropriate for a subjective contour to complete the form. The parameters underlying coherence of collinear lines may be the same in the two cases, even though the phenomenological outcome is different, depending on the context. Some of these parameters are described.

Contour sharpness and perceptual transparency

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In conditions in which figural aspects of the stimulus are favorable for inducing brightness differences between the subjective contour area and the background due to assimilation and contrast, these induced brightness effects are not sufficient to lead to subjective contour formation. In the particular type of stimuli to be dealt with in this paper, transparency rules must be obeyed for sharp contours to arise.

The functional equivalence of illusory and objective brightness enhancement

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and

BILLIE SALZMAN and
CHRISTOPHER YOUNGWORTH
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The hypothesis that the illusory brightness associated with subjective contour displays is functionally equivalent to objective brightness enhancement was tested with a series of related tasks. Subjects adjusted the illuminance of the inducing areas of a subjective contour configuration until the figure it bounded appeared just noticeably brighter (jnb) than its physically isoluminant background and then produced a physical match to the brightness of the figure and its background. An increase in flux was needed to match the figure, and a decrease in flux was needed to match the background, indicating both a perceptual brightening of the figure and a darkening of its background. Subjects also adjusted the inducing area illuminance of a small subjective square situated on a large subjective square until the small square appeared jnb than its large square background. Results support the hypothesis that the illusory brightness of the large subjective square functioned like objective changes in brightness, in that it altered the brightness characteristics of a figure centered upon it. Additional tasks were performed, which, in general, provided support for the hypothesis that illusory brightness can function in a manner similar to objective variations in flux.

Can we see constructs? Thirty years of illusory figures

WALTER GERBINO and GAETANO KANIZSA
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The theoretical significance of illusory figures is evaluated, with reference to the energetic versus informational dichotomy. We emphasize the modal character of the phenomenon, and discuss empirical evidence supporting an energetic model.

The elasticity of their shape, the direction of color modifications, and the conditions of their very existence suggest that illusory figures are constrained by natural laws. Admittedly, in some instances, they can be conceived of as logically plausible results of a reasoning-like activity. Finally, we stress the general difference between ratiomorphic and naturalistic explanations of visual perception.

A skills analysis of the perception of illusory contours

ANGUS R. H. GELLATLY
and MELANIE J. BISHOP
University of Keele, Keele, England

Subjects examined two stimulus figures that do not usually yield perception of illusory contours. When the figures were viewed in rapid alternation, the subjects reported perceiving a central illusory rectangle in apparent motion. Once achieved, perception of the rectangle persisted even when one of the stimulus figures was then viewed alone. It is suggested that perception of illusory shapes is better described in terms of more or less automatic procedures of interpretation than as due to either physiological or cognitive mechanisms. Perceiving illusory contours is a matter of perceptual skill.

Amodal figures and the tendency toward continuation

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In many displays in which an anomalous figure is present, the inducing figures are not complete but continue for a short distance under the anomalous surface. An analysis of some additional, new displays suggested that the "tendency toward continuation," rather than physical brightness contrast, be considered as the principal causal factor of amodal figure perception. Continuation tendency is a frequently occurring perceptual phenomenon that takes different forms, from amodal completion under physically present figures to phenomenal permanence that continues beyond a physical termination.

Textural segregation and subjective contours

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An attempt was made to produce a configural superiority effect using contexts composed of illusory contours. In Experiments 1 and 2, it was found that detection of a line segment was not better with illusory contour contexts that mimicked the standard configural superiority contexts. In fact, the illusory contours seemed to interfere with line detection. Experiment 3 tested whether a target could be better detected if the target itself contributed to the formation of an illusory contour.

It was suggested that the time it takes to process an illusory contour precludes its aiding in line detection. A second more powerful effect appeared to be that the inducing elements of the subjective contour seem to mask the configural information responsible for the usual superiority effects. This conjecture was tested using a textural segregation task in Experiments 4 and 5. It was found that the groupings that might mediate the configural superiority effect are masked by the contour-inducing elements as they reduce preattentive segregation. The data suggest that distinctiveness of elements and attention are important to both contextual superiority effects and textural segregation.

Allusory contours

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Allusory contours refer to figures in which a geometrical design carries with it minimal information that can be organized into a coherent image. Such organization can be dependent upon relatively low-level processes, such as brightness averaging, but when it is complete, subjective contours defining the boundaries of the image are seen. Examples of such allusory contours will be shown.