B. — Communications — Individual papers:

A DYNAMIC THEORY OF BINOCULAR SPACE PERCEPTION

BY

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The left-eye-, and the right-eye-image of a binocularly perceived three-dimensional object can be described as twodimensional figures, i.e. continua of image points, in a "binocular field". This field may be considered as a force field, in which the image points of the two images attract each other. We presume that this attraction results in a displacement towards each other of disparate points, which constitutes the correlate of binocular depth. When the displacement is homonymous, i.e. when a point belonging to the left-eye-image is displaced to the left, and a point belonging to the right-eye-image is displaced to the right, there will be localization in front of the plane of fixation (Kernebene); when the displacement is heteronymous there will be localization behind this plane. The degree of depth is determined by the degree of displacement. We further presume that the attractive force increases with decreasing distance between disparate points, and that a restrictive force comes into operation when a disparate point is displaced under the influence of attraction.

By means of this theory, the following facts can be explained:

1. The phenomena of single and double vision with so-called identical points.
2. The phenomena of single and double vision with so-called disparate points.
3. Depth localization of disparate images as to its degree and its direction.
4. Depth localization of double images.
5. The thresholds of depth perception.
6. The Panum phenomenon.
7. The reversal of the Panum phenomenon in the case of increasing distance between the centers of overlapping circles.
8. The perception of depth with active change of the degree of convergence, and the fact that in fixed fixation depth perception tends to diminish.

This theory is fully independent of any neurological hypotheses although it does agree very well with recent developments in this field.

CONTRIBUTIONS EXPÉRIMENTALES À L'INTERPRÉTATION DE QUELQUES-UNES DES DÉMONSTRATIONS DE AMES DANS LA PERCEPTION

PAR

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Les AA. exposent quelques expériences effectuées pour analyser les deux phénomènes déjà observés par Ames: la fenêtre trapézoïdale et la chambre déformée. Les résultats auxquels les AA. sont parvenus ne permettent pas d'accepter sans réserve l'interprétation empiriste de Ames.

A propos de la fenêtre trapézoïdale, on obtient le même rendement perceptif (régularisation formelle et oscillation apparente) par des éléments tournants qui n'ont pas de signification, tels que par exemple deux bâtonnets ou deux disques de grandeur différente. Le problème que soulèvent de tels phénomènes perceptifs doit être posé différemment et rapporté à l'étude, déjà faite en son temps par Metzger, des lois qui règlent les organisations cinétiques visuelles, produites par des ensembles dont les projections rétiniennes se déplacent réciproquement avec un mouvement harmonique.

Lorsque — comme dans l'expérience de Metzger et dans celle que les AA. ont exécutée avec une technique un peu différente — les ensembles stimulants sont composés par des éléments de forme et de dimensions égales, le mouvement oscillatoire apparent est une des organisations perceptives cinétiques qui se réalisent spontanément. Mais tandis que, dans ces conditions, d'autres types de mouvements (par exemple, la rotation complète) s'imposent avec plus de fréquence, ce mouvement oscillatoire devient la structure cinétique prévalente lorsque les éléments de l'ensemble sont de grandeur différente. Toutefois l'asymétrie des dimensions ne semble pas être la principale cause déterminant la prédominance du mouvement oscillatoire: il faut encore qu'elle ait lieu entre des éléments de forme similaire.

Sur la base de ces résultats expérimentaux, les AA. croient pouvoir conclure que le mouvement oscillatoire est une conséquence de la tendance spontanée à l'homogénéité maximale (Musatti) dont l'action se manifeste entre les éléments partiels d'une structure unitaire. Sa fonction serait précisément de permettre à une telle structure de maintenir, une fois qu'elle est constituée, son intégration et l'homogénéité maximale qui a été atteinte.

Quant à la «distorted room», les AA. soulignent le fait que la chambre a été construite de manière que l'image rétinienne qui en résulte ne corresponde pas seulement à celle d'une infinité de chambres de forme irrégulière, mais

bien aussi à celle d'une chambre effectivement cubique. Ils pensent pourtant que le phénomène appelé «redressement perceptif» n'est pas un problème propre au dispositif de Ames, mais un problème plus général, concernant la perception de toutes formes cubiques, que le sujet «sent» comme cubiques, bien que leur image puisse correspondre à une infinité de formes irrégulières.

A propos de la rupture de la constance perceptive des objets ou des personnes situés à l'intérieur de la chambre, les AA. sont d'avis que ce phénomène dépend du fait que la chambre même assume la fonction de système de référence principal du champ visuel dans les conditions données. Ce fait détermine la localisation en profondeur des objets et des personnes qui sont dans la chambre. En conséquence, puisque le rapport entre la grandeur apparente et la distance apparente est une constante, la grandeur phénoménale des visages doit correspondre à la grandeur des images rétiniennes relatives.

Les expériences effectuées par les A. semblent démontrer le bien-fondé de cette interprétation: la partie du champ qui est vue comme système de référence impose aux autres leur localisation dans l'espace et par conséquent aussi leur grandeur.

Quant aux caractères de forme qui déterminent la partie du champ qui devient système de référence, les AA. ont pu seulement mettre en évidence le rapport d'inclusion spatiale.

GEOMETRICAL ILLUSIONS AS A PROOF OF THE INTERDEPENDENCE OF SPACE, TIME AND MOVEMENT

BY

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In my paper "Geometrisch-optische Täuschungen als dynamischer Vorgang" (Contributi del Laboratorio di psicologia, Milano 1952) I showed by numerous examples that the basis for these illusions is to be sought in optical movements. Every geometrical line has a more or less dominant direction for our eyes. Whether our eyes, following this direction, shorter or lenthten this line, depends on the dominant direction of the line. I further discovered that the geometrical illusions more or less disappear if we look at them only as parts of concrete three dimensional bodies.

These researches were confirmed by further experiments where not only

space was taken into consideration but also time and movement. Geometrical figures, as for example that of Muller–Lyer, were not shown to the subject simultaneously in a statical state but dynamically in successive movement. In this manner the figure in front of the subject actually grows, i.e. starts from one point which gradually gets longer and longer until the whole figure is completed. The best results are obtained by a film projection of these figures. These experiments led to interesting results. If the figure developed before our eyes in the same direction in which we are used to look at it, the optical illusion is still more evident than when watched only in a statical state. But if the figure is shown in successive movement in the opposite direction, contrary to our usual looking, the optical illusion disappears. The dynamically successive factor, i.e. the motorial dynamical factor is the one that in one case increased the figure, and in the other decreased it, and vice versa. The interdependence between space and time is here made evident by means of optical movement. It is interesting that this effect begins to vanish immediately if we keep on looking at the fully projected picture, which had been projected gradually. This is a new proof for the „primacy of the perception of movement over separate spacial or temporal judgment", proved by John Cohen in the well known kappa effect.

ÜBER DIE RAUMWAHRNEHMUNG IN HINSICHT AUF DIE OPTISCHEN TÄUSCHUNGEN

VON

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Über die räumlichen Verlagerungen oder Distorsionen in den optischen Täuschungen werden die folgenden zwei Sachen erwähnt:

1. die Bedeutung der Verlagerungen oder Distorsionen in der Raumwahrnehmung;
2. die Einheit der Wirkenden, um jene zu veranlassen.

1) Die anschaulichen Verlagerungen in den optischen Täuschungen werden nur in bestimmten Dimensionen den objektiven Verlagerungen gleichgestellt, aber nicht in anderen. Einige Beispiele: die anschaulichen Veränderungen der Länge oder Abstände in der Müller-Lyerschen Figur sind zwar anschaulich gleich den entsprechenden objektiven Aenderungen durch die objektiven Verschiebungen der Endpunkte der Linien, aber sie

bringen gleichzeitig nicht die anschaulichen Richtungsveränderungen mit sich, welche bei den objektiven Punktverschiebungen beobachtet werden. Umgekehrt, die anschaulichen Veränderungen der Richtungen der parallelen Linien in der Zöllnerschen Figur bringen nicht dieselben Abstandsveränderungen, die bei den objektiven Richtungsänderungen erschienen. Die anschaulichen Verlagerungen in den optischen Täuschungen unterscheiden sich von den objektiven Verlagerungen dadurch, dass bei jenen die Veränderungen nur in bestimmten Dimensionen geschehen, aber nicht immer in sonstigen Dimensionen, wie es bei diesen der Fall ist.

2) Was wirkt in den optischen Täuschungen? Beispiele: bei der Heringschen Figur buchten die parallelen Linien, die in den Strahlenlinien liegen, sich in der mittleren Gegend aus, als ob die Punkte der beiden parallelen Linien in der mittleren Gegend gegenseitig weiter zurückträten, als bei der Endgegend der Parallelen. Wenn man nun zwei Punkte, die einander in der mittleren Gegend der Parallele gegenüberstehen, herausnimmt, so erscheint der Abstand dieser zwei Punkte deutlich kleiner als der Abstand zwischen den Punkten, die ebenso von der Parallele in der Endgegend herausgenommen werden. Das soll heissen, was bei der Heringschen Figur gegenseitig wirkt, sind die Strahlen-Linien und die parallelen Linien, nicht die Strahlen-Linien und die Punkte, die von den Parallelen herausgeschnitten werden. Bei der Kontrasttäuschungsfigur der Kreise wird jeder der äusseren grösseren Kreise in zwei geteilt, nämlich in einen dem inneren kleineren Kreis näher stehenden und in einen weiter stehenden Teil. Legt man nun nur die nahe stehenden Teile, dann erscheint der innere Kreis deutlich grösser, aber wenn man die weiter stehenden Teile legt, dann erscheint der innere Kreis kleiner und der Grad der Verkleinerung ist fast derselbe wie wenn die äusseren vollen Kreise gegeben sind. Das heisst, bei dieser Kontrasttäuschung üben die näherstehenden Teile der äusseren Kreise als solche fast keinen Effekt aus. Was bei dieser Kontrasttäuschungen wirkt, sind also die ganzen Kreise, nicht die Teile davon. Es muss immer berücksichtigt werden, was bei gegebenem Fall die gegenseitig wirkende Einheit ist.

Solche Ueberlegungen scheinen mir wichtig zu sein, besonders wenn man über die Feldtheorie für die Raumwahrnehmung spricht.

PROCESSUS PERCEPTIFS VISUELS

PAR

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L'A. a examiné en détail la théorie transactionnelle dans deux publications, dont le titre était respectivement «Phénoménologie de la perception tridimensionnelle monoculaire et ses interprétations» (*Rivista di Psicologia Sociale*, 1956, *III*, 1, Torino) et: «Phénoménologie de la perception visuelle en profondeur en rapport avec la Transactional Theory", (*Archivio di psicologia, neurologia e psichiatria*, 1956, *XVII*, *VI*, Milano). Elle n'adhère pas entièrement à cette théorie, mais elle en accepte la tentative d'intégration de la théorie de la forme dans une perspective presque dialectique, qui pose son accent sur l'action, dans laquelle on assiste à l'organisation quasi expérimentale de l'objet perceptif. Le but de l'action c'est de connaître la réalité et de l'assujétir à des besoins sans cesse croissants de la personne humaine, qui est toujours sous le domaine d'une certaine culture, et qui utilise des paradigmes d'interprétation transmis où acquis dans sa propre expérience. Les lois de structuration perceptive sont créées en même temps qu'on les provoque dans la rencontre avec l'objet réel. La perception n'est pas totalement créatrice, elle est construite sur des probabilités et avec l'intervention de processus inconscients aussi bien qu'avec des calculs conscients.

Cette théorie utilise des démonstrations célèbres, dont les plus connues sont celles de A. Ames (junior), en particulier une illusion obtenue avec la rotation d'un trapézoide qui peut être interpretée de différentes façons; et une illusion de redressement d'une chambre irrégulière lorsqu'on l'observe monoculairement.

Nous avons fait d'autres expériences avec des solides en rotation, en obtenant le renversement de la perspective en même temps que le renversement de la rotation, phénomène qui est facilité si on dessine les surfaces du solide en rotation. Nous avons observé cette sorte d'équivalence interprétative pré-opérationelle dans tous les objets solides, réguliers et irréguliers, à l'exception des objets très connus par l'expérience personnelle, en particulier par le corps humain, bien qu'il possède une symétrie bilaterale qui dans beaucoup d'autres cas favorise l'inversion perspective.

Une telle résistance nous semble liée à la valeur vécue donnée au corps humain, qui nous est trop familier pour en permettre une déformation innaturelle.

Nous avons obtenu aussi des phénomènes très frappants de sélection

subjective des oscillations perceptives que l'on attribue à l'objet dont on cherche à identifier la construction réelle, lorsque nous avons doublé le trapézoide en unissant deux trapézoides égaux par le côté plus bas ou le côté plus haut. La suggestion de la perspective linéaire, bien connue, provoque dans tous les sujets la perception du battement d'ailes d'un papillon, tantôt en avant, tantôt en arrière, en rapport avec la direction suggérée par les côtés obliques des trapézoides. D'autres variations aussi, nous ont permis de conclure que, dans des conditions où les signaux externes ne sont pas très surs, le sujet interprète sur des données continuellement intégrées par des connaissances empiriques. Il n'y a pas une perception uniquement régie par des lois gestaltiques.

LES DIFFÉRENCES SENSORIELLES ET MOTRICES ENTRE LA GAUCHE ET LA DROITE

PAR

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Les recherches, exécutées par mon assistante Mlle. H. C. van der Meer, montrent une asymétrie vécue de la dimension transversale de l'espace. Cette asymétrie est la même pour les droitiers et les gauchers, et elle semble plutôt dépendre de la signification différente de la droite et de la gauche dans notre monde tel qu'il s'est constitué dans notre culture, que de l'organisation corporelle de l'homme.

1. La vitesse apparente d'un point lumineux projeté sur un écran est de $\pm$ 11 % plus rapide si on le fait mouvoir vers la gauche que dans le sens inverse. Cette différence disparaît complètement, lorsque le sujet ne suit pas du regard le mouvement, mais fixe le centre de l'écran.

2. Si l'on donne aux sujets l'instruction de déplacer le regard tranquillement et facilement plusieurs fois d'un point à fixer situé à droite, vers un point à gauche, les mouvements tournants de la tête sont exécutés inconsciemment à une vitesse $\pm$ 17 % plus grande pour les mouvements de gauche à droite que pour ceux en sens inverse.

3. On sait que la réaction opto-cinétique consiste entre autres en un mouvement circulaire subjectif, senti corporellement et accompagné du repos phénoménal du décor tournant autour du sujet. Nous avons constaté

que les sujets signalent cette sensation d'un mouvement propre plus tôt quand elle se produit vers la droite que vers la gauche.

4. Lorsqu'on regarde dans l'obscurité un point lumineux (situé dans le plan médian exactement en face du sujet) qu'on fait disparaître soudainement, puis réapparaître après un court délai, en priant le sujet de constater si la deuxième lumière se trouve à gauche ou à droite de la première, on constate que les observateurs ont une tendance inconsciente à tourner la tête plutôt vers la droite.

5. Nous avons demandé à 59 sujets, regardant dans une chambre noire un point lumineux, d'indiquer le commencement du mouvement autocinétique et de se rendre compte pendant 5 secondes du trajet que le point parcourt. On répète l'expérience plusieurs fois avec chaque sujet. Les sujets ont observé le mouvement initial 160 fois vers la droite et 106 fois vers la gauche.

6. Une ligne droite inclinée à 45° et montant de gauche à droite est désignée par des sujets adultes dans 75 % des cas comme montant, tandis qu'une ligne montant vers la gauche est conçue dans 75 % des cas comme descendante. Cette différence est, ainsi que celles observées dans les autres expériences, la même chez les droitiers et les gauchers. On serait enclin à expliquer ce résultat par l'habitude de lire de gauche à droite, mais la différence trouvée chez les adultes est absente chez les enfants jusqu'à l'âge de 15 à 16 ans.

L'hypothèse que les différences sensorielles et motrices entre la gauche et la droite se sont formées en rapport avec une polarisation spatiale d'origine culturelle, est renforcée par un grand nombre d'observations dans le domaine de la peinture, de l'ethnologie et de la linguistique.

INFLUENCE DE LA SIGNIFICATION SUR L'ILLUSION DE POGGENDORF

PAR

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L'expérience acquise peut être considérée comme une adaptation de l'homme à la réalité en général ou à une situation en particulier. Il est compréhensible que les illusions optico-géométriques n'évoluent que faiblement en fonction de l'expérience car elles ne jouent pratiquement aucun rôle dans la vie courante.

Ces illusions naissent de certaines relations entre les éléments d'une figure géométrique. Si nous établissons ces mêmes relations entre des objets concrets et que l'ensemble constitue une situation significative, l'illusion se produira-t-elle? Par exemple, une oblique coupant deux parallèles donne lieu à l'illusion de Poggendorf. Que se passera t-il si nous remplaçons l'oblique par une corde tirée par un homme, et les parallèles par une colonne?

Nous pouvons faire les hypothèses suivantes;

1. dans la situation significative, l'expérience acquise jouera un grand rôle et, tout au moins chez l'adulte, l'illusion sera fortement diminuée.
2. l'adaptation à la réalité se faisant progressivement au cours de l'enfance, on peut s'attendre à voir le rôle de la signification augmenter avec l'âge.

Une étude expérimentale fut entreprise pour éprouver ces deux hypothèses.

110 enfants de 5 à 13 ans et 54 adultes ont passé une épreuve consistant à faire 10 ajustements dans une situation significative (sur une maquette, un personnage tire une corde oblique partiellement cachée par une colonne), puis dix ajustements dans une situation non significative (le personnage est supprimé, la corde remplacée par des tiges de métal). Le degré moyen d'illusion est comparé dans les deux situations.

Il ressort de l'expérience que, pour les enfants de 5 à 7 ans, la signification n'a pas d'influence sur le degré d'illusion. Au contraire, à partir de 9 ans, la signification entraîne une diminution systématique de l'illusion, sans toutefois la supprimer entièrement, ce qui vérifie notre première hypothèse.

Cependant il apparaît que la signification agit sur l'effet de champ en établissant de nouvelles relations entre les éléments de la figure (obliques et parallèles). Cette restructuration de la figure ne devient possible qu'à partir du moment où l'espace représentatif de l'enfant est constitué (9 ans). Le rôle de la signification paraît donc lié ici à un certain niveau de développement mental.

SPATIAL LOCALIZATION OF AFTER-IMAGES

BY

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The author's investigations were carried out with the purpose of establishing facts concerning localization in the third dimension of after-images.

The first conclusion from these experiments is, that the fixation part of after-images is seen at the distance of an introduced new fixation point

and the size of after-images grows with the distance of this new fixation point from the observer. When we move the fixation point the after-images move with it.

These findings are in contradiction with Hering's contention that when he introduced a fixation point and behind it moved a sheet of cardboard serving as a background for after-images, then the size of the image varied with changing distance of this sheet of cardboard and independently of the distance of the fixation point. These experiments also established that Emmerts law must be interpreted in such a way, that the sizes of the after-images are determined not by the distance of the background on which they are seen, but by the distance of the fixation point from the observer.

Several cases were investigated using as primary objects real objects in form of coloured rods, double images and stereoscopic images produced by natural (free) stereoscopy.

When for example primary objects consisted of a binocular vertical rod serving as fixation object, and double images of another coloured rod, the after-images were seen at the distance of a new fixation point generally without any difference in distance between the after-image of the fixation rod and after-images of double images.

It is different, when for producing after-images we use stereoscopic images in the form of "walls", or slanting surfaces in natural setting and the fixation rod (in the primary image) is placed in front and then behind the "walls". Then we perceive difference in distance between the after-image of the fixation object and the after-images of the "walls" and also a relief in the "walls", i.e. inclination of the "walls" to the median plane.

When in prolonged fixation on the primary stereoscopic images we see changes in shape (relief) of the images and changes in distances (so called inversions for example), we can also observe similar changes in after-images.

On several occasions when coloured objects were used, one observed reverse reliefs in after-images to those of the primary images.

These and many other observations made in these investigations have many implications concerning general theory of depth perception, as well as the role of convergence, accomodation, visual angle and other factors; these implications are discussed by the author.

In the course of these investigations some observations on movements of after-images (and of the eyes) were made, when their position in space was not fixed by a steady fixation.

When after producing after-images we stabilize their position by fixating point on a wall for example, and then transfer our regard to the space

between the wall and the eyes, we can then observe some characteristic movements of after-images different for different kinds of them and so discover various automatic or semiautomatic movements of the eyes.

The direction of these movements is generally perpendicular to the extension of primary objects.

When for example vertical rods were used one observed several times with several subjects pendulum movement of after-images (to the right and left); the amplitude was about 10–15 Degr., and the period about 1.5 seconds. When horizontal rods were used, then pendulum movement up and down was mostly accompanied by a saccadic movement up.

These phenomena indicate, that the automatic or semiautomatic movements of the eyes are sometimes determined by the shape of primary object.

RECHERCHES SUR LES VALENCES DES DIRECTIONS SPATIALES EN FONCTION DE L'ÂGE, DU SEXE ET DU CARACTÈRE

PAR

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Plusieurs techniques de recherches ont été employées:

1. Estimation dans l'obscurité de la distance de stimuli lumineux de couleur et de position variable. Le rapport D/G des choix faits à droite et à gauche varie, dans les deux sexes, aux quatre niveaux étudiés: 7 ans (masculin: 0,68; féminin: 0,56), 10–11 ans (M: 1,22; F: 1,17), 12–13 ans (M: 1,27; F: 0,52; différence significative à P .05) et adultes cultivés (M: 0,38 ; F: 1,89; à P .001).

2. Des labyrinthes crayon-papier permettant des choix droite-gauche ou haut-bas, ont été passés par des populations des deux sexes à tous les niveaux entre 7 ans et l'âge adulte (N: 1071 sujets). Deux résultats importants: 1) l'augmentation brutale, et dans les deux sexes, des choix faits en bas, de 5–6 ans à 9–10 ans; 2) une nette différence entre les sexes au niveau de la préadolescence (à P. 001).

3. Une batterie de 32 dessins a été passée par des populations des deux sexes, à divers niveaux entre 7 ans et l'âge adulte. On a pu 1) classer les dessins selon 5 facteurs d'orientation spatiale (graphique, pragmatique, consigne, etc), dont deux facteurs bipolaires, 2) étudier l'influence de la

manipulation d'un objet sur le dessin de cet objet, en fonction de l'âge et du sexe, 3) étudier les variations de l'influence de la consigne en fonction de l'âge et du sexe, 4) étudier l'influence de la gaucherie sur chacun des cinq facteurs isolées, 5) étudier la cohérence de l'orientation des dessins dans chaque groupe et comparer en fonction de l'âge et du sexe les coefficients de cohérence (ou de rigidité mentale) obtenus.

4. Des épreuves caractérielles ont permis de chercher, dans chaque situation les liaisons possibles entre traits caractériels et orientation spatiale: celles-ci se sont avérées généralement assez faibles. La signification des orientations spatiales dépend moins de traits caractériels que de l'âge du sexe et de la situation envisagée.

DEMONSTRATION OF 3 EXPERIMENTS

BY

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Localisation, movement and after-images of movement concerned Gestalten and not points of retina.

1) The apparatus looks like a watch: 12 adjacent "squares" number 1–12 around the center. Darkness, fixation of the red center-cross, flashes in the squares of 0.05 sec.
   a) If the squares 1, 3, 5, 7, 9, 11 (group I) are flashing simultaneously with red light and are followed 0.05 sec later by the squares 2, 4, 6, 8, 10, 12 (group II) flashing white, it is not possible to perceive exact where has flashed the first red group, on the same place as the second group or on the intervalls between the squares of the second group. If the observer comes to the opinion, that the red flashes as well as the white flashes derive out of the same squares (group II) he therefore sees it also (localisation needs about 0.1 sec).
   b) Stroboscopic presentation A: apparent movement of three squares is seen, changing their colour continuously.
   Stroboscopic presentation B: ambivalent; three squares are seen to rotate in one of two equipotential directions.
   But if ambivalent presentation B is shown immediately after presentation A, there is seen a distinct movement in the opposite direction than in A. If Gestalten in B are different from Gestalten

in A, the effect is not so easy to be seen (tendency to an afterimit of movement).

2) Stripes of shadow are moving on a part of a large background with fine lines. When they stop, there is seen only an apparent movement of the stripes of shadow, but not of the similarly lines of the background, seen with the same place of the retina. If a subject comes to the opinion, that the fine lines belong to the background, in the afterimit of movement the fine lines do not move. If the same subject comes to the opinion, that these fine lines belong to the stripes of shadow, the lines move.

THE PERCEPTUAL PROCESS: SOME CONSIDERATIONS

BY

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Most psychologists would certainly agree that perception, like other aspects of behavior, should be considered an event over time. This paper is intended as an attempt to reconsider the genetic approach to problems of visual perception. Our basic consideration thus implies that we look upon perception as a process of organization, emphasizing that it needs time to be prepared, evolved and established.

Percepts are the products of late phases in this process of organization, the preparatory phases of which are therefore a valid object of study. Since preparatory phases do not generally produce percepts we do not have to conceptualize them in terms of finished products, e.g., as weak copies of established percepts or of stimulus patterns or as reflections of physiological processes hypothesized on the basis of end-product behavior.

One important characteristic of preparatory stages, as shown by tachistoscopic experiments, seems to be that they embrace numerous "possibilities" for further development. As the ideal perceptual process continues, however, more and more of these possibilities become stripped off in favor of the one possibility coinciding with stimulus.

Although we think of preliminary phases as enveloping contradictory possibilities "side by side" we should not think of them as a number of superimposed percepts, however. It would probably be more rewarding to try to relate preparatory phases to final ones in the same formal way as primary processes are related to secondary ones in psychoanalysis.

However, the ordinary experimental sources are still insufficient to account for the perceptual process. If our main postulates are correct we can learn much about it, especially its early phases, by studying such products as dreams, images, etc., i.e., products that cannot be accepted as outside reality here and now. In this way we bring the study of perception into the broader field of personality.

The perceptual process is expected to show characteristics typical of the individual, so-called consistencies or structures. Many structures refer to the longitudinal aspects of the process, the way in which certain end-stages are reached and others warded off, to all those aspects of control of the process of organization which are termed cognitive attitudes or system-principles.

The problem of perception beyond awareness must be considered crucial for the approach outlined here. A new technique for studying early, pre-conscious aspects of perception together with a number of recent results will be reported.

PERCEPTION AND PREDICTION

BY

CLAUDE A. CLAREMONT

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This paper introduces a novel concept of perception as a process forming part of the life-cycle, the function of which process is fundamentally predictive. If memory takes part in perception it is so that prediction shall benefit therefrom, and perception would have no biological value if it did not enable the animal possessed of movement to foretell in some degree the immediate, or (in higher types) distant consequences of a proposed action. This projection of the consequence acts on consciousness like a new stimulus in the sensorium.

Any prediction of consequences involves some kind of awareness of the relations called causal, but these are of an immense variety of kind and complexity, and no animal (including man) can be equally aware of all of them, though every animal shows by its behaviour an immediate awareness of some of them, and others can be learned by experience. But even experiences oft repeated will teach nothing to some animals, though they will to others. The theory is therefore advanced that the key to these differences lies not (as thought by Kant) solely in the kinds of causation but also in the kinds of mind, and the truth is that more and more kinds of causal

relationship become cognisable as we go up the scale of what is usually called intelligence.

It follows that successful perception itself will depend partly on intelligence (becoming more complete at the higher levels), since, when the mind is learning to interpret its sensorial data, the power to appreciate implications (which are relations of necessary or causal type), plays an obvious part. Fantasy, too, is needed—the power to re-combine images—for the process of "filling out" sensorial data with material furnished from the storehouse of memory. It would seem, therefore, that far from perception initiating, or preceding, other kinds of mental activity, it is itself dependent on the combined use of many mental functions impelled to co-operate by the need for action in directions laid down by the life-cycle.

Light is thrown by this thesis on the biological function of consciousness as a device permitting the fusion of memories. These could not be combined in their recorded or materialised form, any more than sound-tracks to a *film* can be combined without going on the air together and being re-recorded. But memories plus experiences, by becoming conscious together, form a new memory-trace, and this must be the physiological basis of creative imagination.

THE STABILIZATION OF PERCEPTION DURING VOLUNTARY ACTIVITY

BY

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1. Changes in the retinal image which accompany voluntary activity are usually considered to present a problem for perceptual theory, since they give rise to no sensation of world-movement such as accompanies a forced rotation of the eye-ball. Classically, some process of "compensation" has been supposed to cancel the effects of voluntary movement. More recently Johannsen (this volume) has suggested an abstractive process which could eliminate stimuli due to displacement of the image.

2. The problem alters its character if we adopt an information-flow model (1) in which *stability* of perception is the norm and we ask under what conditions perception of *change* can occur.

On this model the organism's world of activity is internally represented by the state of a hierarchic "organising system", whose statistical structure

reflects the regularities in demands made on the adaptive response-system by the world. Perceptive activity, on this model, is the "keeping up to date" of the internal state of organisation for adaptive activity (internal and external).

3. It is postulated that changes in perceptive activity occur only when sufficient information (in the technical sense) is provided by receptor-samples to justify it. As long as activity based on the current state of organization fails to lead to a significant "mismatch", the perceived world remains stable. Perception is thus likened to the framing of a null-hypothesis.

4. In voluntary movement with a stable environment it is thus suggested that retinal changes should not be considered as a *consequence* to be compensated, but as part of the *goal* to be achieved. The signals generated are informationally redundant (inadequate to justify change) as long as the world matches the present state of organization which controls voluntary movement. If retinal change were *prevented* from occurring, this would generate mismatch and give an impression of world-movement.

5. The extraction of statistically significant filtrates directly from recepta, which is sometimes suggested as a model of perception itself, is here considered as a means of statistically biassing the organizing activity towards successful adaptation. Perception, however, is not associated in the present model with the activity of the filter, but with the adaptive response which it evokes or guides in the organizing system.

REFERENCE

1. MacKay, D. M., Towards an Information-Flow Model of Human Behaviour. *Brit. J. Psychol.* 47, 30–43, 1956.

FORM RECOGNITION AND DETAIL RESOLUTION

BY

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A series of studies was initiated to investigate the effects of various quantifiable amounts of deresolution upon the ability of subjects to designate particular forms which are surrounded by a group of other forms. The stimulus materials used in the studies were generated from a 10.000 cell square matrix in which certain cells were selected to be "figure" cells by various random and contingent probability determinations. The resulting

matrix consisted of a group of forms in which each form consisted of various arrangements and numbers of square figure cells. For any given set of random and contingent probability values used to determine these figure cells, a sample of forms were generated. These forms, thus, were drawn from a statistically specifiable population of forms. The complex matrix displays were then deresolved by various amounts. In the experimental procedure, the subjects were shown a "standard" form complex and were instructed to designate as quickly as possible where a specified form in the complex was located among a group of alternate form complexes. Four amounts of deresolution were used. Each "standard" form for each condition of resolution was used in combination with each "alternate" form for each condition of resolution. This resulted in sixteen resolution combinations.

The results indicate that as the degree of resolution difference between the standard and alternate forms increases, there is a marked increase in the time required by the subjects to perform the task. When the standard forms and the alternate forms are of the same resolution, the subjects perform better as the amount of deresolution of these forms increases, even though there is a loss in the detail of the forms. It is hypothesized that the high resolution contains more detail than need be used by the subjects. This excess of detail may cause the subjects to perseverate on the minor details of these forms whereas when the detail is lost through deresolution the subjects respond to the gross aspects of the form and can do so more efficiently.

EMMERT'S LAW AND SIZE CONSTANCY

BY

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In 1940, Boring derived Emmert's Law mathematically from the "law" of size constancy and showed that they were different aspects of the same law. This depended on the assumption that Emmert's Law referred to the "apparent" size of after-images. In fact, as intended by Emmert, the law applies to the "real" size of after-images, that is, their size as measured on the surface onto which they are projected. So the law is related, not to the "law" of size constancy, but to the Euclidean law of the diminution of the retinal image with increasing distance. An object of constant size produces a decreasing retinal image with increasing distance; so when the

retinal image is constant (as in the after-image), with increasing distance the "object" becomes larger.

This was pointed out by Young in 1950. After correspondence, Boring agreed that the law as worked out by Emmert applied to "real" sizes, but said that there must be another "Emmert's law", referring to "apparent" sizes, because it could be deduced from the "law" of size constancy.

Now, this assumes something which is not self-evident, and has a bearing on theories of apparent size. Boring assumes that what applies to the apparent size of objects must apply to that of after-images; it is equivalent to saying that they will show the same constancy; but it seems possible that the fact which distinguishes the two situations, that is, the knowledge in one case that what one is seeing in an actual object, might contribute to the size constancy.

An experiment was set up to compare the constancy of after-images and objects under exactly similar conditions. After verifying Emmert's original law, the apparent sizes of the projected (circular) after-images were estimated by comparing them with sets of standard circles at half the distance. The objects were circles of the same size and colour as the projected after-images. They were placed at the same distance as the after-images and compared in the same way with standard circles.

Most subjects showed some constancy for the images, but there was much greater constancy for the objects. It was concluded that no law about the apparent size of after-images can be derived from the "law" of the apparent size of objects, or vice-versa; and that the recognition that what is seen is a real object contributes to the constancy.

THE SIMILARITY PARADOX — CERTAIN FIGURE-GROUND AND INTERSENSORY EFFECTS

BY

ALASTAIR JAMES WEIR

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In all the experiments to be described, E projects a series of ten abstract line figures tachistoscopically; S is then required to draw them from memory. Two types of series are used, one a control comprising ten heterogeneous figures, the other containing both heterogeneous figures and ones similar to each other.

EXPERIMENT I

Here four series are used, one heterogeneous and three comprising seven similar and three heterogeneous figures each. In the latter three series, the degree of similarity is varied from series to series. One series contains slightly, one moderately and one highly similar figures.

(1) The slightly similar figures are accurately reproduced more frequently than the figures in the same serial positions in the heterogeneous series. The moderately similar figures are reproduced more frequently still, but the highly similar figures are not reproduced significantly differently from those in the heteregeneous series.

(2) The heterogeneous figures in the slightly similar series are accurately reproduced less frequently than the corresponding figures in the heterogeneous series. From this point, further increases in the similarity of the similar figures increase the frequency of reproduction of the heterogeneous figures in the same set.

(3) The above effects take place in spite of the fact that the similarity of the slightly similar figures is hardly ever perceived by S.

EXPERIMENT II

Here one heterogeneous series and three containing both slightly (i.e. subliminally) similar and heterogeneous figures are used. One series contains three, one five and one seven similar figures.

(1) All series containing subliminally similar figures are accurately reproduced more frequently than the heterogeneous series.

(2) The mean frequency of accurate reproduction of the similar figures in the series containing five is greater than that in the series containing three.

EXPERIMENT III

Here the four series as for Experiment I are presented on homogeneous, heterogeneous or similar coloured backgrounds and accompanied by similar or heterogeneous auditory patterns.

(1) The homogeneous backgrounds increase the frequency of reproduction in all series containing similar figures.

(2) The similarity of the auditory signals is found to be subliminal, and they markedly reduce the frequency of reproduction of the series containing subliminally similar figures.

GENERAL CONCLUSIONS

1. The frequency of reproduction of figures will vary directly with their similarity when the similarity is slight, inversely when it is great.
2. Background homogeneity or lack of structure facilitates the reproduction of all series involving figural similarity.
3. Subliminal auditory similarity inhibits the effect of the subliminal similarity of visual figures on reproduction.

ANALYSIS OF THE MECHANISMS UNDERLYING PERCEPTUAL CONSTANCY

BY

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Perceptual "constancy" refers to the observation that the perceived shape, size, and brightness, as well as other characteristics of objects, tend to remain constant despite changes in the physical characteristics of the corresponding retinal image. The inability to predict the perceived properties of objects from specification of their retinal image correlates poses the question of the mechanisms subserving this biologically important phenomenon. Analysises of the mechanism has been initiated by determination of the influence of the same independent variables on the perception of shape, size, and, in some cases, brightness. If exposure duration is reduced, a different effect on the magnitude of the constancy phenomenon is obtained depending upon whether shape, size, or brightness perception is being investigated. Reduction of exposure duration reduces the tendency toward shape constancy, has little effect on size constancy, and improves brightness constancy. A second independent variable was concerned with the preservation of the constancy effect in photographs of test-objects compared with viewing the test-objects themselves. For shape, constancy is reduced about 50 % in the photographs, but for size, the photographs preserve almost none of the constancy effect obtained while viewing the test-object. Variation of intelligence level also produces different effects on shape and size constancy In the perception of shape, feebleminded subjects exhibit a rather high tendency toward constancy. As groups of progressively lower intelligence level are tested, less and less tendency toward constancy is exhibited. University

undergraduates who have been awarded scholarships produce matches which approach a prediction based on retinal image theory. For the perception of size, feebleminded subjects again exhibit high constancy but university students demonstrated an even greater effect.

Perceptual constancy has historically been considered to manifest itself when the stimulus situation is complex, i.e., when there are stimuli in the visual field in addition to the discriminative stimulus. The present results suggest that the nature of these stimuli and/or their mode of interaction with the discriminative stimulus is different for the perception of shape, size, and brightness. The problem of the mechanisms underlying perceptual constancy is seen to consist of specification of the cues and the mode of operation of these cues in relation to the various perceptual characteristics, and the investigation of the process by which they serve to produce the common result of perceptual stability.

L'ORIENTATION RELATIVE DES MOUVEMENTS DANS LA PERCEPTION DE LA CAUSALITÉ

PAR

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L'interprétation, donnée par le Prof. Michotte, du phénomène du lancement et des autres formes de causalité perceptive découvertes et analysées par lui-même, se fonde essentiellement sur la notion d'ampliation du mouvement. L'ampliation du mouvement dépend à son tour de la présence d'un certain nombre de facteurs, qui assurent, à la fois, la ségrégation des deux objets, leur intégration spatio-temporelle, et leur hiérarchisation.

L'analyse expérimentale de M. Michotte, et les recherches particulières de M. Yela ont montré que certains facteurs qui pouvaient apparaître comme des conditions sine qua non de l'ampliation et, en conséquence, de l'effet causal (priorité temporelle du mouvement de l'objet moteur, contiguïté temporelle entre les deux mouvements, contiguïté spatiale entre les deux objets) sont en réalité seulement des conditions favorables, dont l'absence peut être compensée par le concours d'autres conditions.

Ainsi par exemple la contiguïté spatiale, le «choc» entre l'agent et le patient, est certainement une condition très favorable à l'effet lancement, mais elle n'est absolument pas nécessaire, puisqu'on peut réaliser aussi le

lancement à distance. Et aussi avec le choc à distance on peut obtenir un effet causal très marqué en accentuant la hiérarchie des vitesses.

Nos expériences montrent que l'orientation des deux mouvements, de l'agent et du patient, dans la même direction ou dans des directions peu divergentes est également une condition très favorable, mais pas absolument nécessaire, car en compensant l'absence de cette condition on peut aussi obtenir une impression causale lorsque le mouvement du patient se développe dans une direction diamétralement opposée à celle du mouvement de l'agent.

De cette façon on a pu produire des effets paradoxaux de lancement inversé à distance; tandis que d'autres situations, au lieu d'être vécues comme formes de lancement, réalisent sur le plan phénoménal des impressions d'attraction active. On a obtenu aussi ce même phénomène d'attraction dans des situations qui ne sont pas assimilables au lancement mais semblent présenter une affinité avec l'effet entraînement.

Du point de vue théorique ces phénomènes semblent rentrer, sans effort, dans le cadre du schéma interprétatif du Pr. Michotte, fondé sur l'ampliation du mouvement.

A STUDY OF STABILITY OF DISCRIMINATION IN A VISUAL MATCHING TEST

BY

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Since color matching is based upon discrimination of differences, the scatter of a succession of repeated matches will reflect the normal distribution of discrimination judgments. To evaluate this relationship, each one of a group of six subjects repeated a test of 40 matches ten times. The matching colors consisted of ten saturation steps in each one of the principal hues, red, yellow, green, and blue. Differences between adjacent steps in the series were of a size that precluded correct matching of all 40 samples by any subject except in very rare cases.

It was found that (a) the group was relatively homogeneous with mean scores ranging from 61–70, (b) the standard deviations were small, ranging from $\pm$ 4 to $\pm$ 8, (c) the data indicated that more precise measures may

be obtained by several successive tests of any given subject, and (d) the judgments were normally distributed.

The distributions of errors for each of the four hues were essentially the same. The standard deviation of each distribution was computed. These were arbitrary units differing in the case of each hue. The standard deviations of the red and the yellow hues were compared with the just-noticeable-differences of saturation for comparable colors from a previous study. It is interesting that these two just-noticeable-differences had almost identical ratios to the standard deviations of the present analysis.

Observation of techniques used in matching and reports from subjects indicated that a "match" was never a simple and direct judgment of equality. It was instead an inference from, or an evaluation of, a number of discriminations or judgments of difference. For most observers, the possibilities of match were quickly reduced to two or three chips that were not readily discriminated as different. The final choice tended to reflect the number of times each pair of chips was discriminated. Single matches, obviously, were not fixed. This accounts for the greater stability of scores with repeated testing.

SOME CONTRIBUTIONS TO THE STUDY OF COMPLEX PERCEPTIONS

BY

ENZO SPALTRO

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Perceptive structures are often influenced by non-perceptive structures. However the researches about the subjective scales of evaluation seem to find that these non-perceptive structures can be employed for a "measurement" of the perceptive structures.

Otherwise the uncertain income is very important in the forming of perceptive structures: this uncertain income is the "aspettativa" that a perceptive event may happen; the researches about the subjective probability seem to have proved all this.

In this research the author has been searching a rational point of view in the study of the problem of the importance that some evaluative structures have in the forming of a "complex perception".

That, which was studied, of a linear mathematical function is the founda-

tion of the ratios of the studied variables. These are loudness acoustical time, visual time, numerosity, duration, movement, acceleration and trajectory. Since these variables were increased by means of a linear mathematical law (or a function), the author thought that perhaps the "aspettativa" toward the ulterior developments of the studied variable might be dependent from the "complex perception" of the ratios of the variable that the subject evaluates.

Of course the author, looking for a validation of such an hypothesis, pointed out a method composed by a magnetic recorder and a photographic film, which gave him the possibility of putting some question to the subjects about their "prevision" toward the future ratios of the variable they saw and listened to increase for a certain time.

Above all an analysis of the "aspettativa" proved that the subject perceives in an ipervalutative manner after a short time (2"), and in an ipovalutative manner after a longer time (5").

The results of such experiments give us the possibility of doing several remarks in this field of psychology at the bounderies between perception and evaluation.

A SIMPLE ANOMALOSCOPE FOR MEASURING VARIATIONS OF COLOUR VISION AND COLOUR BLINDNESS

BY

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It is clear that tests of colour blindness using coloured wools or beads, lantern tests and pseudo-isochromatic tests do not discriminate efficiently between degrees and kinds of defect. They may be used as "dichotomous" tests to divide the "normal" from the "colour blind", but, for many purposes in industry and in occupations involving response to colour signals, it is very important to make more subtle and detailed subdivisions. For research on colour vision and colour blindness the dichotomous tests are of little value.

In order to meet these difficulties it is desirable to use an anomaloscope by means of which given individuals being tested may be compared with norms for the whole population, or given populations may be compared with each other to detect racial differences.

A simple anomaloscope has been devised, in which either monochromatic gelatine filters can be used, or monochromatic "interference" filters transmitting very narrow spectral bands. The filters can be changed to give several different tests. Of these the most important are the Rayleigh Equation (red + green = yellow), the yellow-blue equation (yellow + blue = neutral) and the bluegreen-violet equation (bluegreen + violet = blue). Such tests can be used to detect and measure all important forms of colour vision variation and defect, and can be carried out quickly and efficiently.

The test apparatus is light and portable, can be used with 12-volt accumulators if necessary, and the tests can be carried out in diffused daylight. A simple form of the psycho-physical method of limits is applied, and, as the apparatus and technique are standardised, the results of one group of tests can be compared directly with those of other groups.

The forms of variation and defect to be detected and measured by these tests which are most important are as follows:

1) small deviations of mid-matching point and/or increases of matching range among all or any of the colour pairs tested, and darkening of the violet;
2) extreme deviations of mid-matching point and/or increases of matching range in the colour anomalous, with or without darkened red;
3) red-green dichromacy, with or without darkening of the red;
4) total colour blindness;
5) colour vision defects resulting from illness, accidents or the use of drugs.

DIE HAND ALS FAKTOR DER WAHRNEHMUNG DER RAUMRICHTUNGEN

VON

R. NATADZE

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1. Als Hauptfaktor der Wahrnehmung der rechts-links-Richtung wird in der traditionellen Psychologie die „imaginäre Mediane" betrachtet, die unseren Körper senkrecht in zwei symmetrische Teile teilt.

2. Eine derartige Lösung der Frage ruft folgende Zweifel hervor:
   a) Diese Lösung der Frage betrifft nur die bewusste Wahrnehmung von rechts und links. Doch orientieren wir uns im Alltagsleben

grösstenteils in diesen Richtungen, ohne uns dabei bewusst zu werden, ob es sich um rechts oder links handelt.

b) Um die Rolle des zweiten Faktors, d.h. des Hand-Faktors festzustellen, ist es notwendig, ihn dem „Mediane-Faktor" (d.h. dem Faktor der Körperseite) gegenüberzustellen.

Der Zweck der vorliegenden Untersuchung ist die Rolle jeder der zwei Faktoren — des „Mediane-Faktors" und des Hand-Faktors — im Prozess der unmittelbaren unbewussten Orientierung in der rechts-links-Richtung festzustellen.

3. Die Untersuchung wurde an Hand einer originellen Variante der experimentellen Methode der „fixierten Einstellung" durchgeführt, die bereits seit dreissig Jahren von der Schule der georgischen Psychologen (Usnadze u.a.) angewandt wird.

Hauptergebnisse:

a) Bei der Erzeugung einer durch fixierte Einstellung bedingten Täuschung der haptischen Wahrnehmung der Grösse zweier Kugeln steht die Kontrasttäuschung stets (100 %) in Übereinstimmung mit der Hand und nicht mit der Körperseite: werden die Objekte mit *gekreuzten* Armen wahrgenommen, so entspricht die Kontrasttäuschung nicht der Körperseite, sondern der Hand.

b) Nach der Fixation der Einstellung durch die *optische* Wahrnehmung des grossen und des kleinen Objekts, die sich rechts und links befinden, entspricht bei der nachfolgenden *haptischen* Wahrnehmung der „kritischen" (gleichen) Objekte mit *gekreuzten* Armen (d.h. wenn die Hände den Körperseiten gegenübergesetzt sind) die Wahrnehmungtäuschung stets (100 %) der Hand und nicht der Körperseite.

c) Wenn die fixierte Einstellung ohne Wahrnehmung, bloss auf Grund einer optischen Vorstellung von zwei Objekten verschiedener Grösse entstanden ist, dann ergibt meistens die nachfolgende haptische Wahrnehmung der kritischen (gleichen) Objekte mit gekreuzten Armen eine, nicht der Körperseite, sondern der Hand entsprechende Kontrasttäuschung.

4. Auf Grund der dargelegten Feststellungen halten wir das Vorherrschen des Hand-Faktors gegenüber dem „Mediane-Faktor" bei der unmittelbaren Orientierung in der rechts-links-Raumrichtung für bewiesen.

5. Die bedeutende Rolle des Hand-Faktors auch bei der bewussten Wahrnehmung der rechts-links-Richtung hat sich auch in der grossen Hemmung und Desorientierung in der rechts-links-Raumrichtung ge-

äussert, die bei vielen V.P.-en während der Wahrnehmung von Objekten mit gekreuzten Armen eintrat.

6. Der „Hand-Faktor" spielt eine führende Rolle unter den subjektiven Wahrnehmungsfaktoren der rechts-links-Richtung. Doch was die objektive Situation betrifft, so hat sich folgendes erwiesen: je differenzierter die objektive Situation ist, eine um so grössere Rolle spielt sie in der unmittelbaren Raumorientierung. Und umgekehrt: je homogener die objektive Situation ist, eine desto grössere Rolle spielen bei der Raumorientierung die subjektiven Faktoren: die Hand und die Seite des eigenen Körpers.

A PROBABILISTIC MODEL FOR VISUAL PERCEPTION

BY

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This paper represents a preliminary disclosure of a theory of cognitive organization which has been developed at Cornell University during the last five years, and for which a working electronic model is now being planned at the Cornell Aeronautical Laboratory. The mathematical theory upon which the model is based will be referred to as the *theory of statistical separability*. The model is in the same tradition as the theories of Hebb and Hayek: i.e., it represents an essentially empiricist approach to perception, building up generalizations and classifying stimuli in such a way as to reflect the structure and regularities of its experience. The electronic model of the system will have an optical input, and a printer or set of signal lights as an output. It is predicted that after a period of training, the system will exhibit capabilities for discrimination, association, and stimulus generalization.

An essential feature of the system is that it is fundamentally probabilistic, rather than deterministic, in its operation. It makes use of statistical parameters of impulse distributions to discriminate different stimuli, and consequently there is always a probability of error attached to its performance. The theory of statistical separability enables us to predict this probability as a function of the organization of the nerve net, and as a function of the experiential history of the system. Preliminary results of a computational program indicate that a network consisting of only a few thousand active elements should be able to memorize millions of complex optical patterns,

and associate them to suitable outputs, with a high probability that any particular discrimination will be correct.

The theory of statistical separability represents an important advance in the theory of cognitive systems on at least three counts:

(1) If the planned experiment proves successful, this is the first time that a set of theoretical principles will have been clearly proven to generate a perceptual capability, in a system of completely known structure.

(2) The model should enable us to compare the perceptual capability resulting from an empiricist hypothesis with the known characteristics of perception in a biological organism. While the Cornell model will not attempt to simulate all of the essential aspects of human visual perception, it should at least demonstrate that there is no fundamental fallacy in logic in the empiricist contention that perceptual organization may be acquired through experience.

(3) The theory of statistical separability makes no assumptions which are either quantitatively, anatomically, or physiologically incompatible with our knowledge of a biological nervous system. The number of functional units with which the system will operate successfully is surprisingly small, by biological standards, and the particular connections between units can be entirely random in their microscopic detail, so long as the statistical distributions of connections have the required characteristics.