

cuttings from the base of seedling plants root readily (1). Clonal multiplication is usually done by budding, but the effect of stock on scion yield is still unsettled (2). A new method for the propagation of cuttings from seedlings is described here in the hope that such material may be useful in the study of stock-scion relationships.

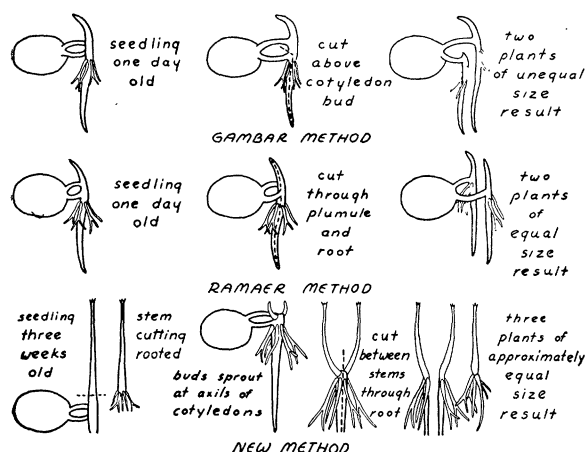


FIG. 1.

Coster (3) reports the use of twin seedlings in Java for stock-scion experiments. Methods of splitting the seedlings of *H. brasiliensis* have been described by Loomis (4) and Dykman (2). The two best-known methods are the Ramaer, in which germinated seedlings about 3 days old are split into two equal parts by a vertical cut passing through the plumule and taproot between the cotyledon petioles; and the Gambar, in which the vertical cut does not completely divide the main stem but begins at a point slightly above the axil formed by one of the cotyledon petioles with the main stem and passes obliquely inward to the center of the main stem and downward between the cotyledon petioles, dividing the taproot into two equal parts. Both these methods produce "twin" plants (Fig. 1).

In studies of regeneration in *H. brasiliensis* a new method of splitting Hevea seedlings to obtain three or more plants was developed.¹ The young stem is cut off at 6 weeks of age and planted as a cutting. As previously shown (1), this is the age at which the seedling separates from the seed and rooting potential is highest. Removal of the stem stimulates the growth of buds at the base, in the axils of the cotyledons. Generally one sprouts in each axil. When these have reached a height of about 6 in., the taproot can be split, and thus three plants are obtained (Fig. 1). The shoots from the axils of the cotyledons can also be rooted, although they take about 6 days longer than the primary stems. Removal of these shoots induces new buds to grow, and these may be removed and planted, thus offering a potentially unlimited source of material,

¹ From a dissertation submitted, as a partial requirement for the Ph.D. degree, to the Graduate School, University of Michigan, Ann Arbor.

although the sprouts tend to get smaller each time a cutting is taken. Under greenhouse conditions, as many as 7 plants have been obtained from one seed by maintaining the cuttings in a damp chamber. It seems possible that this division could go on almost indefinitely under optimum conditions.

The new method is advantageous because more than two plants are obtained from each seed and less mortality occurs among the split plants, since a better balance of root and leaf is maintained.

References

1. MUZIK, T. J. *Am. J. Botany*, **34**, 587 (1947).
2. DYKMAN, M. J. *Hevea, Thirty Years of Research in the Far East*. Waltham, Mass.: Chronica Botanica (1951).
3. COSTER, C. H. In P. Honig and F. Verdoorn (Eds.), *Science and Scientists in the Netherlands Indies*. Waltham, Mass.: Chronica Botanica (1945).
4. LOOMIS, H. F., *J. Agr. Research*, **65**, 97 (1942).

Manuscript received September 17, 1952.

The Nature of Perceptual Processes

Rayford T. Saucer

Department of Psychology,
Georgia Institute of Technology, Atlanta

In 1912 Wertheimer used the phenomenon of apparent motion to provide a point of entry into a new phase of psychological theory. Though other phenomena could have been used as a basis for the same theories, apparent motion is one of the most striking examples of the fact that the organism can and often does respond in relation to a perceptual process which displays attributes having no counterpart in the external stimulus complex. This process is produced by organizational forces within the nervous system of the organism.

A frequent objection to Gestalt theory is that there have been few efforts to relate the field forces postulated as an explanation of phenomena to the actual physiological mechanisms. While the concept of psychoneural isomorphism can hardly be denied a place in the theoretical structures of psychology, it is too often merely a convenience rather than an explanation. Other workers, not always professed followers of the Gestalt school, have chosen a path which may prove fruitful. The work of Lashley and Hebb in the field of neurophysiological theory is important to a synthesis of psychology in which phenomenology and psychobiology become parts of a rational science, a science which relies upon neither blind atomism nor metaphysical explanation. In spite of some objections, however, it is felt that field theory can be related to physiological mechanisms by recourse to study of the phenomena that provided the initial impetus to the move away from mechanical linkage of the stimulus to the perception or to the response by circumventing the organism.

By applying electronic control to the switching of light sources, investigations into the problem of ap-

parent motion have been facilitated at the Psychological Laboratories of the University of Florida. The problem has been divided into four areas; (1) parameters, (2) the relationship between real and apparent motion, (3) the relation between motion and other organized processes, and (4) the existence of some features of the organization which cannot be related to the direct sensory input. It will be noted that none of these can be said to represent any radical departure from the essential nature of the problem as outlined by Wertheimer (1), Neff (2), and Graham (3).

A report on some phases of the first question has been prepared (4). Electronic switching techniques similar to those used by Tanner (5) have been used to control the firing of crater lamps (Sylvania R1130). By use of suitable optical techniques the light output was focused into a spot subtending 1° visual angle at a distance of 0.5 m from the subject. The stimulus complex consists of two such lights, 5 cm center to center, fired 180° out of phase and presented on a ground glass screen. The time interval p was eliminated. (Actual delay between presentation of lights approaches 5μ sec.) Flash rates of 4 cps/light were sufficient to give a perception of Beta movement just slightly less than 100% of the time over a 5-min recording period without previous dark adaptation. Subjects who had been prepared with a period of 5 min or more of dark adaptation reported a periodic fluctuation of perception of Beta movement. This fluctuation has been related to the dark adaptation time. Analysis of variance supports this conclusion at better than the 1% level of confidence.

It is concluded that, although the parameters subsumed under Korte's laws are adequate in view of prior experimentation, they are not complete and should be revised. Since there is a high degree of apparent motion in the absence of any pause time p , it is concluded that in the relationship between the degree of motion and the stimulus complex some purpose might be served by substituting rate for pause time. The formalized statement is then freed from the restriction imposed by a vanishingly small value of p . In addition, some expression of the physiological state of the organism may be in order, since it has been shown that dark adaptation can be a determiner of the degree of apparent motion. It is also concluded that any statement of optimal motion must include its duration in time. The other attributes of apparent motion are such that they can be included in the expression M_t , where this expression includes apparent motion through some time interval. Except for motion, the qualities of the moving stimulus or Beta object do not differ from the qualities of the primary stimulus except under special conditions to be considered later.

Examination of the stimulus object, including both its temporal and its spatial ordering, shows that alternate areas of the screen are illuminated at a rate of 4 flashes/sec/area. The illuminated areas provide retinal stimulation which eventually results in neural proc-

esses in the occipital cortex, where they are projected on a psychospatially isomorphic projection plane. This system is to be considered isomorphic in terms of spatial attributes rather than in terms of neurospatial or neurological architecture. Thus between any two points x and y in the distant spatial organization there is an area xy . Any configuration present in xy will be so perceived, although the neurological processes responsible for the perception of the configuration need not be so located in the neurological architecture of the occipital cortex.

The isomorphic areas x' and y' will be considered primary areas, or areas in which stimulation is a direct result of the routing of the nerve impulse from the receptor. They will occupy an area which is then psychologically isomorphic to real or physical space in terms of perceived relationships between x and y . The area upon which x' and y' are projected is then viewed as a field composed of cell assemblies or matrices and other areas which are statistically uniform unless they are incorporated into other matrices by existing native or linked networks. Non-linked but prebiased cell groups which are brought to a point near conduction by summative processes may also be considered matrices. Since the term "cell assembly" refers in general to closed circuits, matrix will be used to designate both such assemblies and nonlinked groups possessing similar levels of stimulation or activity. In view of the nature of these matrices with regard to incomplete isolation of the individual cell, it is felt that any excitation will not only be confined to its proper matrix but will also excite adjacent cells in proportion to their degree of prior excitation by both prior stimuli and "noise" or statistical excitation.

That color matrices are a permanent part of the field is indicated by the following experiment. If a stable spot of colored light is exposed between the two stimulus lights, the resulting phenomenon is one of apparent motion in which the moving white spot passes through the colored spot with no change in quality or planar depth. If the stationary spot is brighter, a displacement of the moving spot results, so that the moving spot appears to go behind the stationary spot. If, however, the two lights are of equal brightness and of different hue, they may excite coexistent color matrices in the same plane.

The resulting phenomenon is then one of two color films in the same plane. Observers report that the two color films occupy the same space and are in the same plane. If the intervening spot is of such a nature that it inhibits the formation of the coexistent matrix, the process is altered, the moving spot going either behind the stationary spot or clearly in front of it. It is concluded that in such cases the process which occurs as a result of the stationary spot blocks out the intervening area so thoroughly that the motion must re-route itself in another plane.

If the two lights used to produce Beta motion are viewed through monocular filters of different hue, color mixing takes place. This is believed to indicate that,

whereas color perception is a function of both the discrete retinal cell excited and its cortical ending, color mixing need not take place in the cortex. That this statement implies a much wider range of color receptors than is postulated by the Young-Helmholtz theory is not denied.

The cortical projection plane is viewed as a construct which has some psychological validity. It is isomorphic to real space and is a field composed of cell assemblies and matrices in varying degrees of excitation, but it is not a uniform field, since there is some evidence for the existence of two organized processes which are both actually isomorphic to some distant area xy . Stimulation of areas x' and y' results in an outward spreading of excitation by virtue of the mechanisms postulated earlier. In the case of apparent motion, this spreading outward may, if continued, result in the excitation of areas which are psychospatially isomorphic to the distant area xy . Under proper repetitive conditions matrices similar to those activated by the distant stimulus may participate in an organization which will be the psychological reproduction of the distant stimulus. If the distant stimuli are congruent in all qualities, the end process is one of apparent motion, since there is now an excitation for the area isomorphic to distant area xy . Hence there is a sensory-sensory transfer of an entire organized process. This statement is supported by the fact that, if the distant stimuli are covered by congruent 1-mm grids, the entire grid pattern is transferred as an integral part of the Beta motion. The Beta object differs somewhat in the degree of resolution, indicating either some nonlinearity in the transmission network or difficulty in experimental procedure.

There is apparently a correlation between the decay time of a matrix so activated and the rate of stimulation necessary to produce optimal motion. All existing calculations, including those given by Wertheimer (1), approximate the normal alpha rhythm. (It has been observed that optimal motion is better if the distance and size as well as the intensity of the stimulus are optimized with regard to a repetition rate of 4-12 serial flashes/sec.) Time constants involved also agree closely with those determined for Gamma motion.

The entire process bears a close resemblance to the problem of measurement in general, there being considerable evidence for the operation of an uncertainty principle. If the speed of the apparent motion is reduced, the complex breaks down into extreme detail (alternation) without motion. Under these conditions the distant stimulus can be described in minute detail. In the range of repetition wherein optimal motion is found, some motion as well as some detail can be measured. If the speed of motion is increased sufficiently, a new phenomenon is found to appear. This motion has been called Omega movement. It is similar to Phi, except that in general "etwas" is present. Observers report well-organized movement of "something" which is best described as a moving shadow, without detail but possessing withal considerable thing quality. It

is then operationally something in motion, not just pure motion without something moving, but with a lack of detail.

In conclusion it may be stated that the examination of the processes of apparent motion has revealed evidence for the lateral transfer of complete sensory organizations, as well as some experimental evidence for the existence of processes which have been called co-existent. If it is possible to transfer an organization which is dependent upon direct sensory input, there is little reason to doubt the existence of the simultaneous transfer of other processes both sensory-sensory and sensory-association. If a concept can exist as an encoded matrix and can be so transferred, we can lay the foundation for a psychological theory of relationships and discrimination based on a vector-sum theory of the comparison of two perceptual organizations by the fusion resulting from the encoding of two such organizations in co-existent matrices where the previous organization of the physiological system is of such a nature that neither matrix will be favored. It is believed that this theory may have implications with regard to both conditioning and learning theory as well as perceptual organization.

References

1. WERTHEIMER, M. Z. *Psychol.*, **61**, 161 (1912).
2. NEFF, W. S. *Am. J. Psychol.*, **48**, 1 (1936).
3. GRAHAM, C. H. In S. S. Stevens, Ed., *Handbook of Experimental Psychology*. New York: Wiley (1951).
4. SAUCER, R. T. Unpublished Master's Thesis, Univ. of Florida (1950).
5. TANNER, W. P., JR. *Science*, **112**, 201 (1950).

Manuscript received October 10, 1952.

Inhibition of Tobacco Mosaic Virus Biosynthesis by 2-Thiopyrimidines¹

Frank L. Mercer, Taylor E. Lindhorst, and Barry Commoner²

St. Louis College of Pharmacy and Allied Sciences,
St. Louis, Missouri

We have previously reported that thiouracil, an analog of uracil, inhibits tobacco mosaic virus (TMV) formation in tobacco leaf tissue (1). These studies have been extended to a series of purine and pyrimidine derivatives.

Experimental material consisted of tobacco leaf discs inoculated with purified TMV and cultured in nutrient according to a method previously described (1). The TMV content of the discs at various times after inoculation was determined by the method of Commoner *et al.* (2). Results are reported as percentage of inhibition at the time at which untreated inoculated tissue contains a maximal amount of TMV (260 hr after inoculation).

¹ This work was supported by a research grant (E-250) from the National Institutes of Health, U. S. Public Health Service.

² Henry Shaw School of Botany, Washington University, St. Louis, Missouri.