questioned. Therefore, it is here suggested that the Bunsen-Roscoe Law, which holds within the limits of 50 to 200 msec., is one dealing with energetic summation within only one quantum structural aggregate. This would mean that the Law refers to a central and not a peripheral process. Thus, as long as the duration is kept below the time it takes to form one quantum structural aggregate, the simple product of intensity and duration determines the effectiveness of the stimulus. But when the duration is longer than the time it takes to form one aggregate—as in the case of dynamic contour perception—the increased duration does two things. It increases the subsequent speed of structuring and raises the asymmetry level in each subsequent structural aggregate. The increased duration simply increases the degree of normalizing distortion. (An increased intensity, a larger stimulus, or any factor that would increase the total quantity of energy involved in the process of stimulation would do the same thing.) Therefore, the normalizing process, in restoring the asymmetry level, swings back at a higher level and faster vibratory rate, thereby completing the structural aggregates at a faster rate and inducting a higher energy level in the subsequent structural aggregates than would be the case if the increased duration were not present in the initial stimulation.

We should be careful to note that the structuring process is not an "integrating" process. That is, the individual structural aggregates are not simply placed side by side but a structural relationship is established which leads to interactive field effects and which appears in psychological experiences. Many psychological phenomena would not appear if the process were simply an integration of discrete units; the structural relationships are what count. Moreover, the formation of the individual structural aggregate is not a summative process but a creative one. The aggregate is different and less than the sum of its parts. This view, of course, also opposes the view of the configurationalist who maintained that form was primary and prior in perception. A structuring process is primary and prior in perception and it is the structuring process that is contour- and form-producing. This view also opposes that of the classical brain-field theorists who, in explaining visual phenomena, place the "brain field" in the visual cortex. In 1940, K. U. Smith performed an experiment with a decorticate animal and reached the conclusion that at least some visual phenomena take place below the cortical level (76). In recent years the experimental work of Lashley, Chow, and Semmes has led to serious criticism of the brain field theory (47). Moreover, theorists such as Osgood point out that to ignore the historical nature (the differentiation of various parts) of the cortex is a serious omission in the brain field theory viewpoint. But more serious difficulties for the brain field theory are the recent advances in both neuro-physiology and field physics. In the recent symposium by the Macy Foundation, <u>Brain Mechanics and Consciousness</u>, there is strong indication that psychological processes take place subcortically in the reticular formations and in limited neural spaces rather than in neural nets in the cortex or involving widespread areas of the cortex as has been believed previously (1). Moreover, the concept of the electrical field upon which Köhler based his brain field theory is now regarded as a classical concept.

All fields are now believed to be quantum fields.

Statistical view. Marshall and Talbot, basing their conclusions entirely upon experimental results and physiological observations, suggest a statistical theory of sensory acuity (49). They make use of temporal modulation and discontinuities and reciprocal overlap in constructing a theory of discriminative functions in terms of populations of neural elements and propagation of composite statistical excitation. Experimental evidence contrary to the Marshall and Talbot viewpoint was found by Ratliff (1952) when he found that poorer acuity was associated with larger drifts of ocular tremor. Thus, he found that eye movements did not improve acuity as the scanning theory would predict (76).

This worker feels that to conceive of the nervous system as a statistical mechanism casts this highly differentiated organization into the role of a machine, whereas billions of years of evolution separate it from the type of machine that modern cybernetics envision (9). To contrive mathematically such obviously historical factors as the constancies within the framework of this model, as for example does F. George (34), is to reify the Marshall and Talbot model. Properties and characteristics are ascribed to the model that are not empirically present in the nervous system and gradually the reified model becomes more important than the empirical referent itself.

Smith and Gulick follow in the footsteps of Osgood and Heyer and Day (who utilize Marshall and Talbot's work to explain figural aftereffects, form perception, and static contour) in applying statistical concepts to interpret the phenomena of dynamic contour formation (57, 58, 67). Before we briefly review the interpretative scheme Smith and Gulick have outlined, let us summarize their experimental findings. (a) The sharp contours of a stimulus in motion can not be observed when its velocity exceeds a value of about 10 to 15 degrees per second. (b) By exposing a stimulus in a fixed position before and after movement contour can be maintained during movement at least up to velocities of 25 to 30 degrees per second. (c) For the production of contour during movement the relationship between the duration of exposure of the stimulus in fixed positions before and after movement (t_1 and t_2) and the velocity (V) of the stimulus is linear, within the limits studied. (d) Contour is maintained most effectively under the conditions studied when t_1 equals t_2. When t_1 does not equal t_2, t_1 is more important than t_2 in the production of contour. Thus, the introduction of the stationary phases to the presentation of the moving stimulus facilitates the perception of contour of the moving stimulus.

Utilizing Osgood's treatment of apparent movement (57) wherein two separate distributions of excitation in the cortex(which correspond to the spatially separated stimuli) are postulated to summate algebraically into one distribution whose single peak is displaced in cortical space, Smith and Gulick offer the following explanation of their data on dynamic contour formation. They postulate that both the excitation of movement and t_1 produce a specific growth and decay function in cortical space. Thus, as velocity of movement is increased and the level of excitation gradient in the cortex is decreased, increasing values of t_1 can still maintain the peaked distribution above the minimum level necessary for the perception of sharp contours. The product of the summation of the two excitations thus results in a single peaked distribution (above the minimum level for contour recognition) which is continuously displaced in cortical space. Smith and Gulick then proceed to an elaboration of the model. Since the mathematical treatment is still in the developmental stage it will not be presented here but some of the qualitative features of the Smith-Gulick model will be briefly presented.

When a stationary stimulus is presented to the eye, the level of excitation in the cortex grows in a negatively accelerated manner. The hypothethical function, Smith and Gulick postulate, reaches the minimum level of excitation required for contour resolution in about 50 milliseconds and reaches its peak in about 100 milliseconds. The delay in reaching the peak level, according to Smith and Gulick, "is due presumably to the temporarily dispersing factors of the physiological mechanisms underlying this function, such as synaptic delay, reverberation, and horizontal spread as the neural activity proceeds from the receptors to the visual cortex." There seems to be some confusion here. Perceptual development time starts from the instant the contour starts to appear in the cortex and ends when the contour has been completed. The entire course of contour development presumably runs in the cortex, thus making sub-cortical explanations superfluous. But this still leaves us with the question of perceptual development time which must be explained in terms of cortical mechanisms.

Just as excitation grows upon the presentation of a stationary stimulus, Smith and Gulick state, so does it grow when a moving stimulus is presented. The slope of the growth function for a stimulus in motion depends upon the velocity of the stimulus. At slow velocities observers could perceive contour of the moving stimulus without the summative activity from the decaying process due to t_2, whereas at the higher velocities contour was not perceived unless some contribution from the decaying process was added to the excitation resulting from the moving stimulus. Apparently, according to Smith and Gulick, for every increase of one degree per second in velocity beyond a critical level near 10 degrees per second, contour can be maintained if t_2 is increased by about 25 milliseconds.

Quantum field view. Under constant stimulus conditions (assuming eye-movements prevent adaptation), structural aggregates are formed at a constant rate which gives us the continuity and stability of our perceived world. Fig. 11 presents in a schematic fashion the three levels of experience for several visual situations.

It takes from 30 to 150 milliseconds (or the upper limit can go as high as 400 milliseconds)to form complete contours of a stationary object depending upon the shape of the stimulus and its total intensity. A more symmetrical stimulus forms contours more rapidly because the structuring process is one in which asymmetry disappears and more symmetrical structural aggregates are formed; an initially more symmetrical figure facilitates the structuring process.(20) Similarly, a stimulus at low intensity may require 90 msec. for contour formation while the same stimulus at high intensity may require only 40 msec. (Fig. 12)

The time constant of from 30 to 150 msec. reappears again and again in studies of visual phenomena. It has been hypothesized above that movement occurs over a series of structural aggregates that are inter-related with one another and which are continually displaced from reticular space every 30 to 150 msec. Our stable-stationary world is given by structural interrelationships between structural aggregates formed in the reticular centers. Ansbacher, in offering a hypothesis of visual pulsations as physiological intervals to break the continuity,

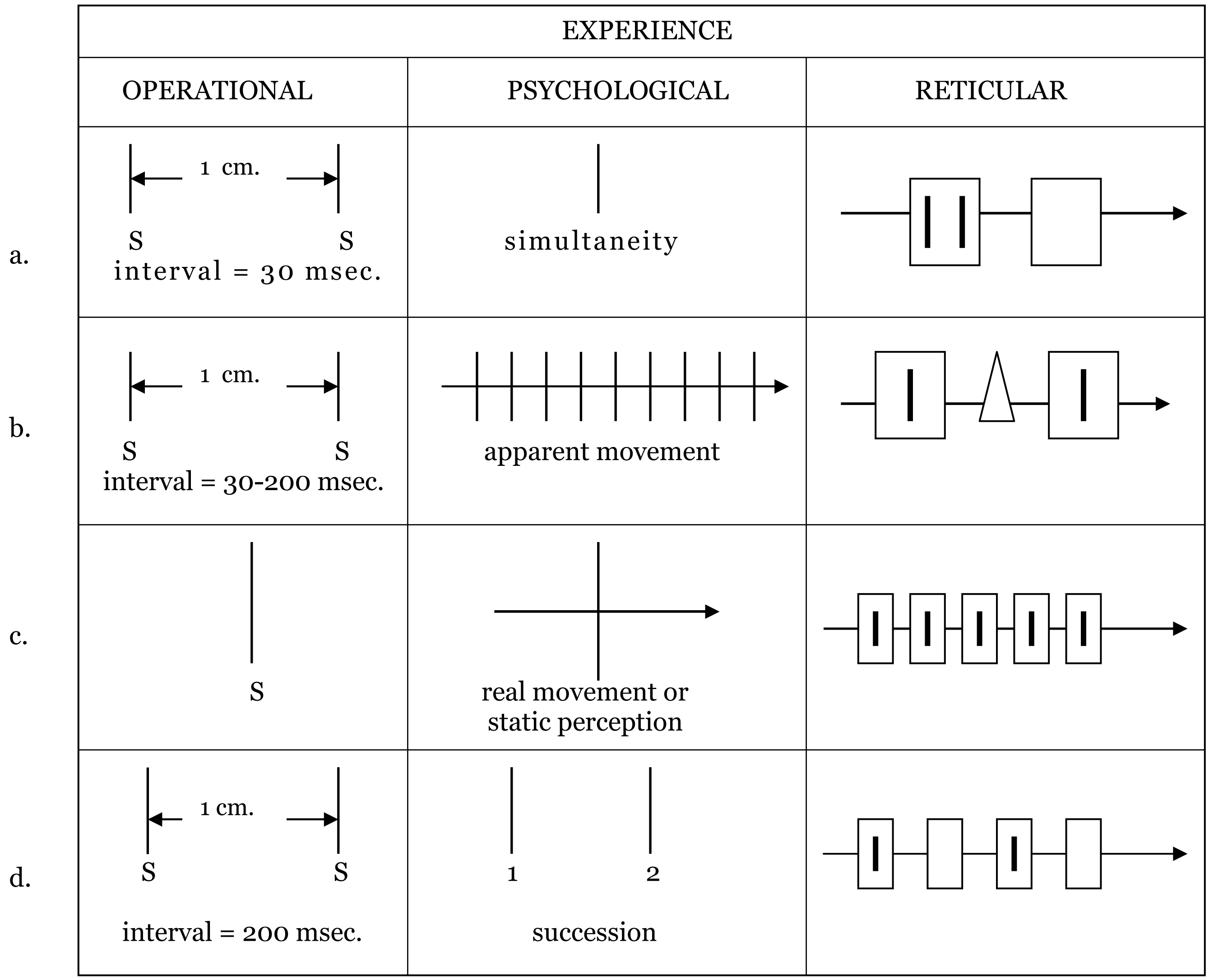


Fig. 11. Schematic illustration of three levels of experience conceived from quantum field point of view. In a, b, and d, the operational duration of line stimuli (S) is 30 – 200 msec.,while in c the duration is 1 sec. On the reticular level,the blocks represent completed individual quantum structural aggregates, the triangle, an incomplete structural aggregate. Whether or not the stimulus is represented in a particular structural aggregate is indicated by the presence or absence of the line image in that aggregate.

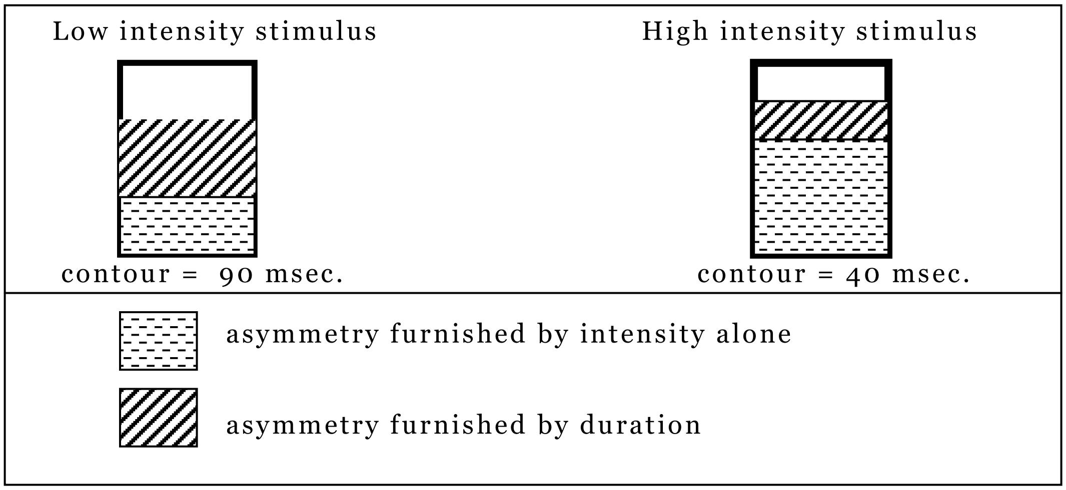


Fig. 12 Schematic representation of contribution of intensity and duration to contour formation according to quantum-field point of view.

calculates a time constant which would correspond to the duration of one pulsation. The figure he arrives at is 55 msec. He then reviews other instances in which a constant of like magnitude was found. Since this constant agrees well with what is here felt to be the structuring time of one aggregate, his summary will be repeated here.

"Where could a constant of 55 ms. fit in existing knowledge? We have found six instances where a similar value was derived: (1) Frölich found a visual sensation time of 40-150 ms., depending on the light intensity used. (a) Vierdort thought that perception was composed of single impressions which had an average duration of 41 ms. (3) Modern moving pictures are shown at the rate of 20 frames per second, which is [10?] ms.per frame including the pause. (4) For the phi phenomenon the best appearance of movement occurs at an interval of about 60 ms. [?]. In recurrent vision, the initial short dark interval lasts on the average about 40 ms. and is followed by the first positive after image, or Fering's image, which lasts about 50 ms. (Bartley) (6) Regarding flicker frequency, Bartley found that with increasing illumination the rate of last seen or marginal flicker remains constant at a frequency of about 20 per second, while objective frequency increases from below 20 to nearly 60 per second. Here again a period of approximately 55 ms. is involved." (3)

Ansbacher, in addition to summarizing much that has gone before, makes the important point that when only one pulsation (quantum structural aggregate, in terms used here) is involved, such as in contour development time, no movement is perceived although the aggregate itself is moving in space. The 55 ms. Ansbacher refers to is the 30 to 150 msec. referred to here as the unit structuring time.

Several of the many instances in the literature involving phenomena with similar temporal limits will be mentioned. Exner, using two spatially separated, successive electric sparks, found that if the time interval between them is not less than 45 milliseconds, the time-order of the sparks can be correctly perceived (14). Putting the sparks closer together in time resulted in apparent movement. G. A. Fry showed that a second flash of light may depress a first flash up to a time interval of 150 milliseconds, beyond which an illusion of movement was obtained (5). Wundt gave the mean value of 43 milliseconds as the time interval above which two stimuli are perceived as separate in time and below which they fuse into one (68). Michotte, in his study of causal processes, found that a pause of 100 milliseconds or less could be tolerated and still result in a cause-effect impression when A moves up to a stationary object 3 and seems to give it a push. Pauses of more than 100 milliseconds result in the impression of two separate events instead of a single causal process (76). It is felt that the recurrence of a time constant of the order of magnitude 30 to 150 milliseconds might well mean that the basic parameter of all sensory processes, here taken to be quantum field processes, operates in units of that magnitude.

Dynamic contour perception has been defined as the formation and maintenance of sharp edges during the actual movement of a stimulus. At very slow velocities (five degrees per second), the stimulus is perceived as sharply contoured during the entire extent of movement with only a short duration of a brief stationary phase shown initially. At these slow speeds, the moving stimulus is sharply contoured during most of the movement—i.e., all except the very beginning—even without a stationary phase. With an increase of the velocity of the stimulus to 10 or 15 degrees per second, the sharpness of the contour disappears and the edges become blurred. But if the brief stationary intervals are increased (up to a range of 1000 msec.), sharp contours can be seen up to a limiting velocity of around 30 degrees per second. Thus, dynamic contour perception is influenced to an important degree by the events preceding the stimulus movement. The following is the writer's interpretation of the phenomenon.

At a stimulus velocity below 10 to 15 degrees per second, sharp contours are more easily seen because the asymmetry (energy) level is sufficiently high in each structural aggregate that is formed. There must be a minimal level of asymmetry induction into the structural aggregate in order that sharp contours may be perceived. At low velocities, the normalizing distortion produced by the stimulus is great enough so that on the repolarizing upswing, the asymmetry inducted is high enough to produce contour. At higher velocities, the structuring rate is slower and, as a consequence, the asymmetry level inducted into each structural aggregate is less. Consequently, at the threshold there is insufficient asymmetry inducted into the structural aggregate, the sharpness of the contour disappears, and the stimulus becomes blurred. An increase in the duration of the stationary phase of the stimulus before the onset of movement produces an additional priming effect within the normalizing-respiratory process which raises both the structuring rate and the asymmetry level inducted in the subsequent structural aggregates. Or, T increases the frequency and energy level of the asymmetrical quantum structures that are inducted into subsequent structural aggregates. The increase in frequency and energy level produced by T then summates with that produced by the movement. The result of this summation of normalizing distortion is a high level of asymmetry—above the minimal level for contour perception. Thus, as velocity of movement is increased and the level of asymmetry in each structural aggregate is decreased, increasing values of T can still maintain the asymmetry level in each structural aggregate above the minimal level until a limiting point is reached.

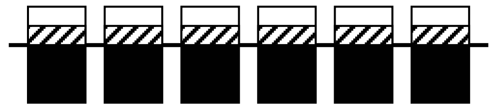
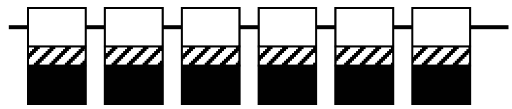
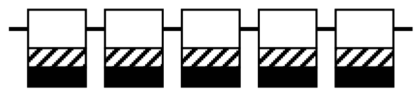
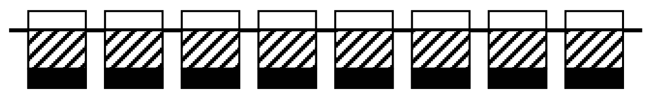
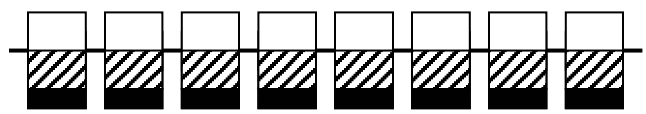
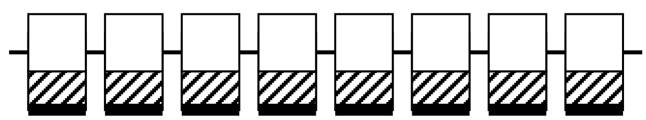
According to the results of the Smith-Gulick experiments, and those reported in Part I, contour will not be seen beyond some critical velocity regardless of the duration of T. The external velocity under the particular conditions of stimulation is approximately 30 degrees per second, but what is the internal limiting factor? This worker postulates that the "internal limiting factor" is the maximum rate at which the reticular center can form the aggregate under the particular conditions. Thus, the higher velocities of external movement (30 degrees per second) are approaching the fastest rate at which the reticular formation can form structural aggregates, no matter how long the duration of the stimulus. Since it takes approximately 150 msec. to form one structural aggregate under average conditions, the upper limit would be about six to eight structural aggregates per second under these conditions. At any velocity beyond this upper limit, the asymmetry level for each structural aggregate drops below the minimal level just as in the threshold case with insufficient stationary phase of stimulus. Thus, the speed or degree of withdrawal of structural asymmetry from a particular aggregate varies as some function of stimulus velocity.

This worker suspects that the upper limit includes that of apparent movement. Smith and Gulick, using both an initial and final stationary mass, felt that at velocities slightly more than 30 degrees per second, the excitation gradient was composed largely of that for apparent movement (66). At a velocity of 30 degrees per second, the temporal duration between the two stationary stimuli was 167 milliseconds. On the basis of other experimental evidence, it appears that contour development time -under the particular experimental conditions—is about 150 milliseconds. Thus, it appears that there is a smooth transition from real movement to apparent movement, and that the temporal duration of the latter is the upper limit of dynamic contour perception.

Fig. 13 indicates in a pictorial fashion the interpretation of dynamic contour formation which is being presented here. We shall indicate the threshold asymmetry level with a line half way up on the symbolic representation of the structural aggregates. When the stimulus reaches a velocity such that the asymmetry level in the structural aggregates drops below the threshold asymmetry level, the contour is lost. Fig. 13 illustrates what is conceived to take place at the structural aggregate level at the various speeds with various durations of the stationary phase.

Statement of Position

Liebowitz (48) speaks of a general type function which seems to run through the various discriminatory performances of visual perception. As the intensity or luminance increases, discriminatory performance increases—rapidly at first and then more slowly and finally a limiting value is approached. Leibowitz suggests that this general type function

EXPERIENCE			
OPERATIONAL		PSYCHOLOGICAL	RETICULAR
T (msec.)	V		
100	very slow	sharply contoured	 5 – 6 aggregates/sec.
	10 °/sec	sharply contoured	 5 – 6 aggregates/sec.
	15 °/sec.	blurred contours	 4 – 5 aggregates/sec.
	20 °/sec.	sharply contoured	 8 aggregates/sec.
1000	30 °/sec.	sharply contoured	 8 aggregates/sec.
1900	40 °/sec.	blurred contours	 8 aggregates/sec.

 asymmetry furnished by moving stimulus alone

 asymmetry furnished by appearance of T

Fig. 15 Illustration of effects of stimulus velocity and duration of T upon contour formation from the quantum-field point of view.

may be due to a similarity of mechanism, probably photochemical, in intensity discrimination, flicker, grating acuity, and vernier acuity. But, photochemical explanations of visual performance have been rejected by informed opinion in the physiological fields. This worker therefore postulates that this general type function is due to a central process rather than a peripheral mechanism, and that this central process is the reticular structuring process. In other words, the function is postulated to be due to the structuring rate nature of the reticular formative process. At the very onset of the stimulation, the change of the structuring rate is most rapid, then each structural aggregate is formed more slowly until the limiting structuring rate is reached. It has been postulated above that duration may be substituted for intensity in dynamic contour perception up to values of 1000 msec. If this is so, and if the central structuring process is quantal, the features of the general type function mentioned by Leibowitz should appear in the results of the experiment reported in Part I. That is, the formation of each structural aggregate, after the initial one, would take longer and longer. (Fig. 14) (It is interesting to note that this variation of structuring rate with duration is identical to the general type function that is obtained in homogeneous reactions as a function of duration in physical chemistry (62; pp.609) .)

This discussion implies that a relationship $I \times T = K$ should be obtained which would involve durations up to 1000 msec. This relationship should not be identified with the Bunsen-Roscoe Law which, in the opinion of this worker, holds for only one quantum structural aggregate. This relationship pertains to the formation of discrete quantum structural aggregates at varying rates and the limiting temporal duration refers to

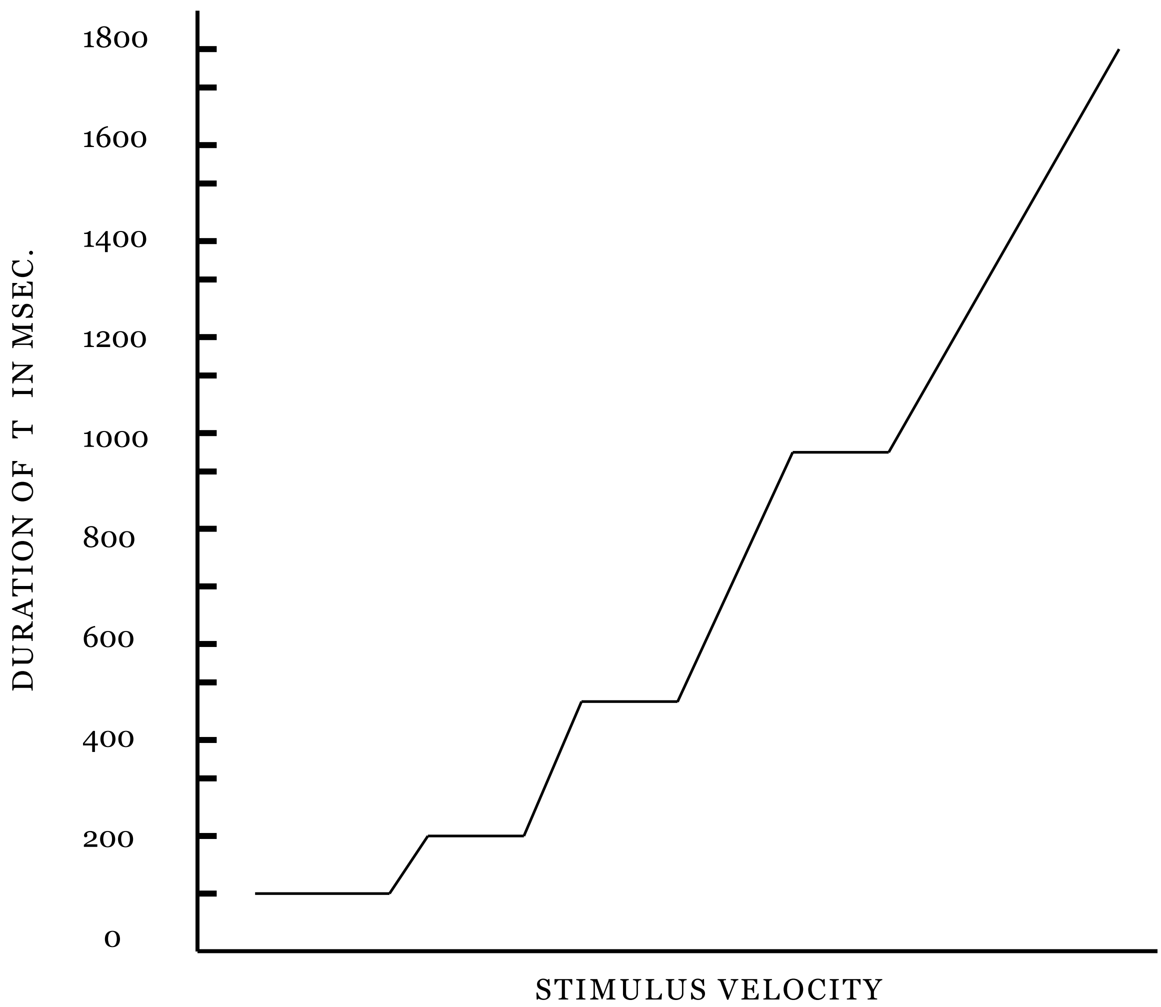


Fig. 14. Postulated general type of function for points at which contour is maintained for a moving stimulus using an initial stationary phase

the maximum structuring rate of the reticular structuring process. If such a relationship is established, this worker suggests it be called the Smith-Gulick Law after the investigators whose research led to the discovery of the phenomenon which in turn led to the relationship.

The view which is offered here rejects the parallelistic assumption (upon which both Köhler's field theory and the nerve impulse theory are based) as being an implicit dualism and that it does not account for the increase of entropy in psychological processes. In reference to the latter point, the nineteenth century view of "body-mind" processes assumed that the "body", as the cause of process, inducted more energy into "mind" which was the effect of the process. The second law of thermodynamics brought this view to a halt for it held that there must be less and not more energy in the effect than in the cause due to the increase of entropy in all real processes. The theorists of the nineteenth century could not conceive how a loss of energy or an increase of entropy could be basically involved as an effect in psychological processes. They therefore accepted the psycho-physical parallelistic assumption which implies that psychological processes are not real processes and thus served to elude this entropy requirement of the second law. Thus, the psycho-physical parallelistic assumption maintained the primitive concept of a distinction between "mind" and "body" and did not resolve the problem brought about by the requirements of the second law.

It has been stated above that the psychological processes include, rather than elude, the energetic laws and that psychological processes are unique only in the sense of being the differentiated product of 4.5 billion years of evolutionary development.[14] This worker has postulated that the "free energy" is quantum structural field asymmetry and that when free energy decreases in spontaneous processes, structural field symmetry is formed, the latter being the empirical referent for entropy. It has also been postulated that a general type process exists in the universe which has two aspects—a decrease of asymmetry in isolable processes with a formation of a quantum structural aggregate and the restoration of the asymmetry level of the structural aggregate to the asymmetry norm of the field as a whole. This process is an evolutionary process and was the process involved in the aboriginal beginnings of life upon this planet, which led to the evolution of the plant and animal kingdoms, and which now appears on its highest and next to highest levels as our cognitive and perceptual processes in the reticular formations.

Thus, once the eye changes photons of light into quantum field structures and the ear changes alterations of pressure into quantum field structures, the eye and ear are transformed into a common denominator. The neuro-physiological processes from the receptor to the cortex serve to disperse temporally and spatially the incoming stimuli to insure their maximum transaction with configurationally similar quantum field structures already present in the cortical areas as memories. The reticular projection system then converges the complexed quantum field structures. The individual quantum field structures are brought together in space

[14]The steady-state concept of von Bertalanffy,adopted by Köhler, does not get around the basic fallacy that lies at the core of both Gestalt and nerve impulse theory. The living organism surely does not tend toward a minimum of entropy production but that minimum of entropy which is involved in all real processes must still be accounted for by basic psychological theory.

and structured through time into a more symmetrical structural aggregate which is immediately followed by the normalizing-respiratory process restoring the asymmetry level in the particular aggregate. At the moments of the structuring of the aggregate we experience our psychological experiences. Thus, the psychological ultimates are quantum structuring aggregates. This worker proposes that the term "quantum-psychological" be used instead of the term "psychophysical". The former implies that we experience our psychological experiences at the moment of the formation of quantum structural aggregates and does not involve a parallelistic assumption. The structural aggregates wherein the psychological processes occur are the causal agents which initiate patterns of muscular contraction which we call behavior. A schematic summary of the nervous system is presented in Fig. 15.

The hypothesis has been offered that it takes from 30 to 150 or 200 msec. to form a complete quantum structural aggregate that this accounts for contour development time. The exact temporal magnitudes involved depend upon the shape of the stimulus, upon its spatial features, upon its brightness and on organismic variables such as attention, attitude, and meaning. Contour is part of the reticular structuring process; the parts of the contour are structured at random and when the contour is formed, figural and color qualities appear in perception. Contour per se is seen as due to the intensity differentials of quantum field structures themselves that are interrelated within a quantum structural aggregate which is usually part of a moving chain of interrelated structural aggregates. (By "intensity differentials" is meant that each quantum field structure in the aggregate had inducted into it varying degrees of structural asymmetry by

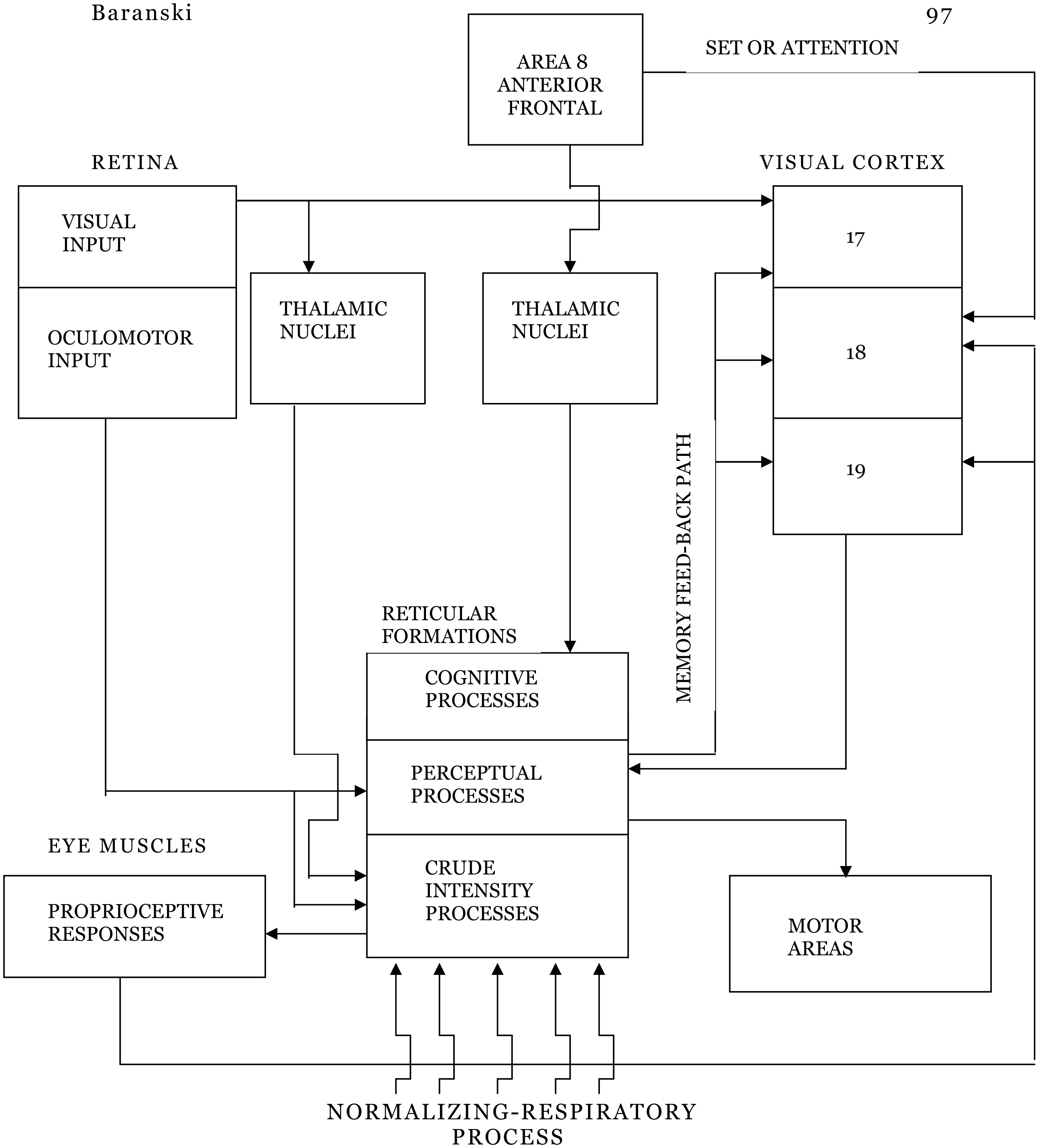


Fig. 15. Schematic summary of what is conceived to take place in nervous system during visual stimulation. The three levels of the reticular formations, the cognitive, perceptual, and crude intensity processes, are synchronized and paced by respiratory processes.

the normalizing process. The varying degrees of asymmetry induction underlie our experiences of intensity attributes.) The sharpening process thus involves the whole system: the receptor; the projection processes; the memories complexed with, and carried to the reticular system by, the stimulus; and the entire reticular structuring system.

There are also two well-established properties of contours: contours exert their forming influence inward rather than outward and contours at right angles to one another and within a range of 4.5° of visual angle interfere with each other's formations and brightness values. The first phenomenon is explained by the empirical nature of the structuring process. It involves the disappearance of more numerous asymmetrical quantum field structures and the formation of more symmetrical quantum structural aggregates. Moreover the inner formative energies of the quantum field structures must be tremendously high for the aggregate that is formed must resist the dispersing tendencies of the normalizing process. The reason for the right angle border effect on contours and the lack of these interference effects when contours are placed in parallel(33) is due to the interacting field effects which repel when at right angles to one another and which have no effect when they parallel each other.

How do increasing durations of T sharpen contours of the moving phase of the stimulus? At the threshold of dynamic contour perception each quantum structural aggregate is receiving a supra-minimal, or at least a threshold, level of asymmetry induction. At velocities above threshold, the asymmetry level in each aggregate drops below the minimal level causing the blurring of contours. A sufficiently intense or prolonged stimulus before movement produces normalizing distortion in the normalizing-respiratory process. The normalizing process, in restoring its asymmetry level, over-shoots its mark causing a brief period of super-normality (or higher asymmetry level) in the subsequent structural aggregate which raises the asymmetry level in the aggregate above that required for sharp contours. Thus T raises both the rate of structuring and level of asymmetry being restored in each structural aggregate. The level of energy restored compensates for the decrease in level caused by the increased rate of structuring and, thus, sharp contours may be seen up to a velocity of 30 degrees per second with temporal durations of 1000 msec.

From the foregoing view, it would be expected that the experiment reported in Part I would result in a step-like function rather than a smooth curve when the speed at which contour is just lost is plotted against the duration of T needed to regain contour. This would be expected only on the individual plots, since averaging of data tends to “smooth out” the curves. The individual graphs of this experiment are presented in Fig. 16 through 18, with Fig. 16 consisting of four pages. Each plot of Fig. 16 contains the data of one subject at the three contrast ratios used.

From these graphs, it can be seen that some subjects show more of a “step-like” function than others. Subjects shown in Fig. 16 a, b, g, k, l, and n show the step-like function, with a few of these approaching the shape of the hypothetical curve in Fig. 14. Even some of the subjects who do not display this characteristic, do exhibit one or more plateaus in the plot of their data. Thus a given duration of a stationary phase usually serves to retain contour for several increases of stimulus speed

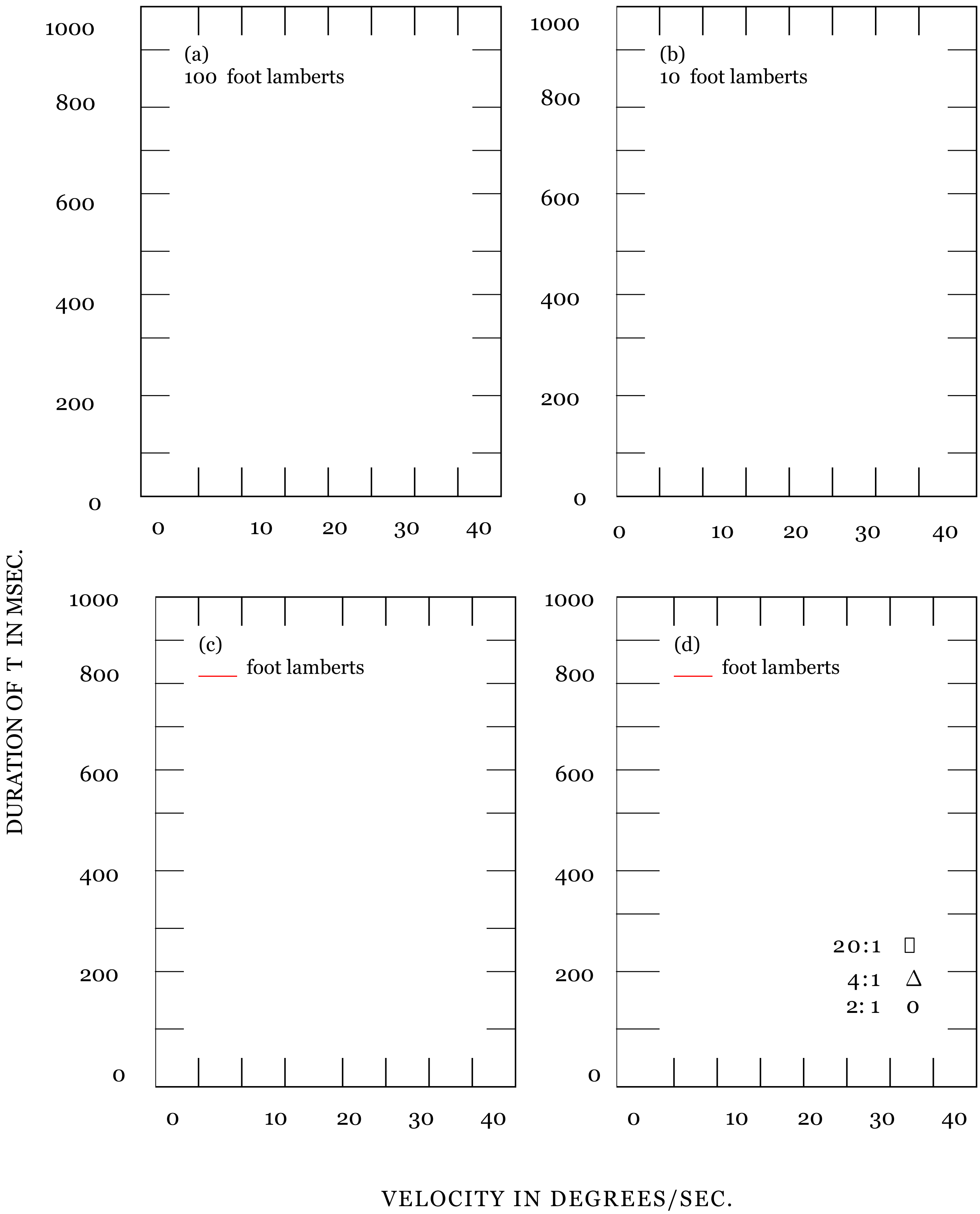


Fig. 16. Plots of individual data using the 3° stimulus

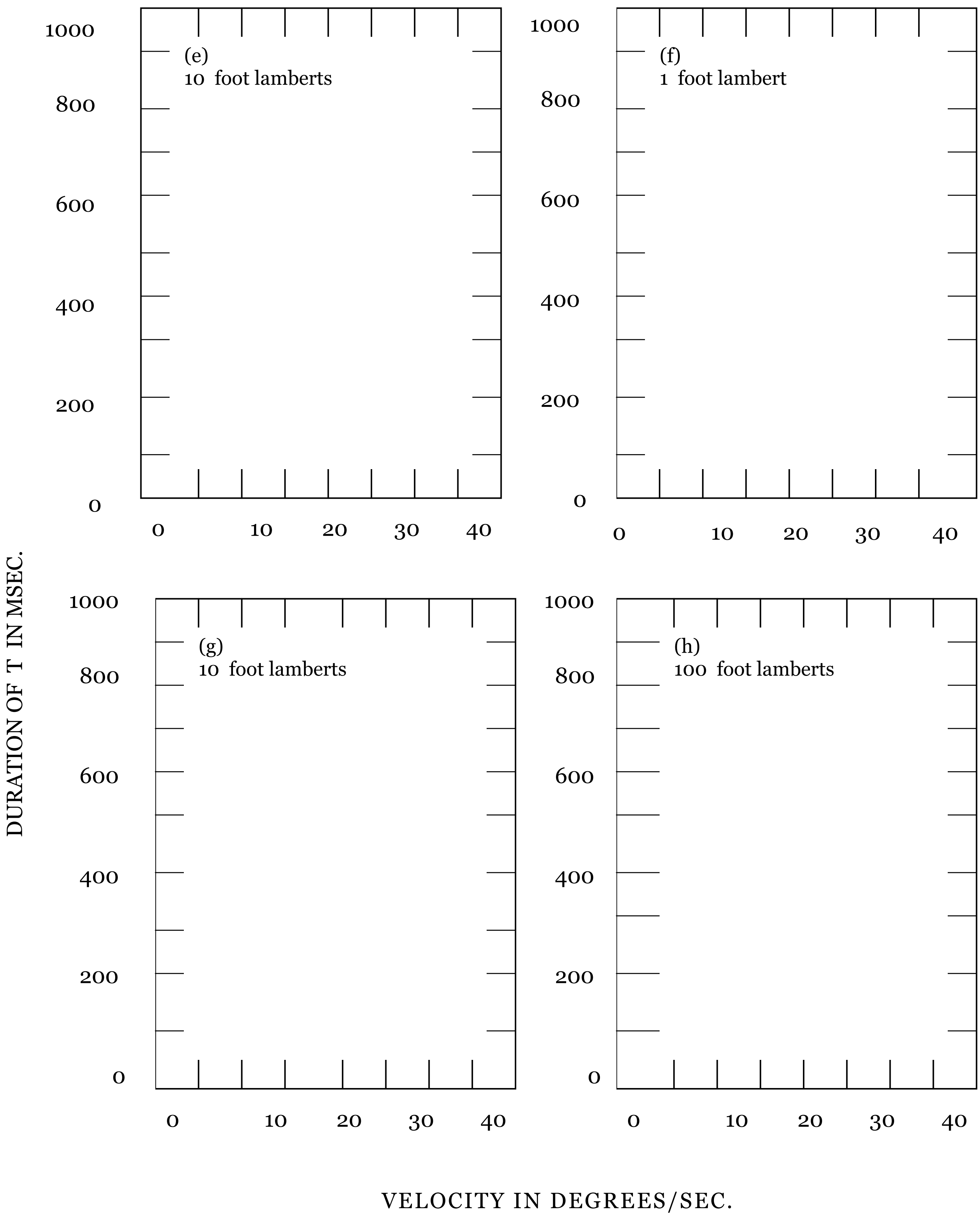


Fig. 16 (cont.) Plots of individual data using the 3° stimulus

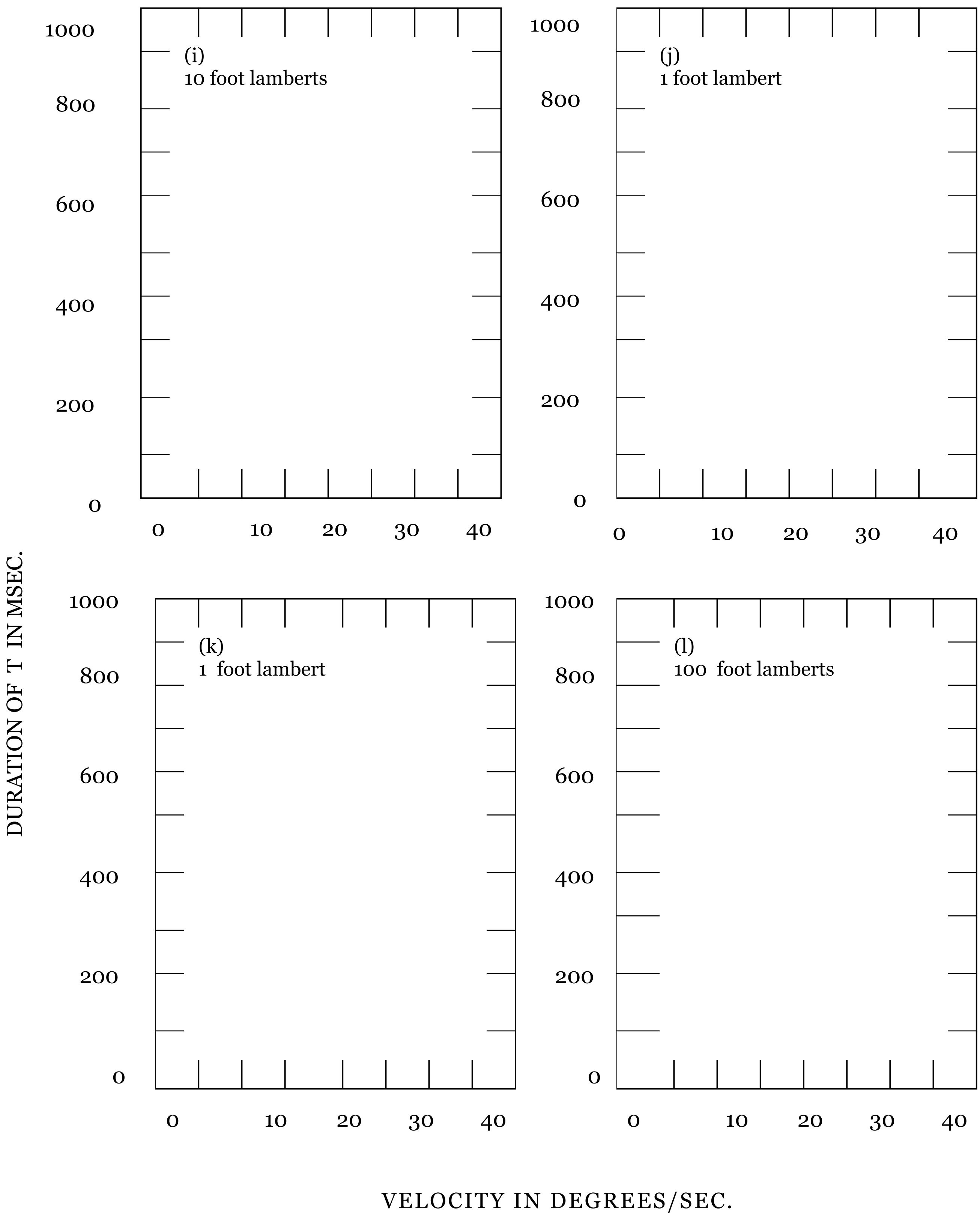


Fig. 16 (cont.) Plots of individual data using the 3° stimulus

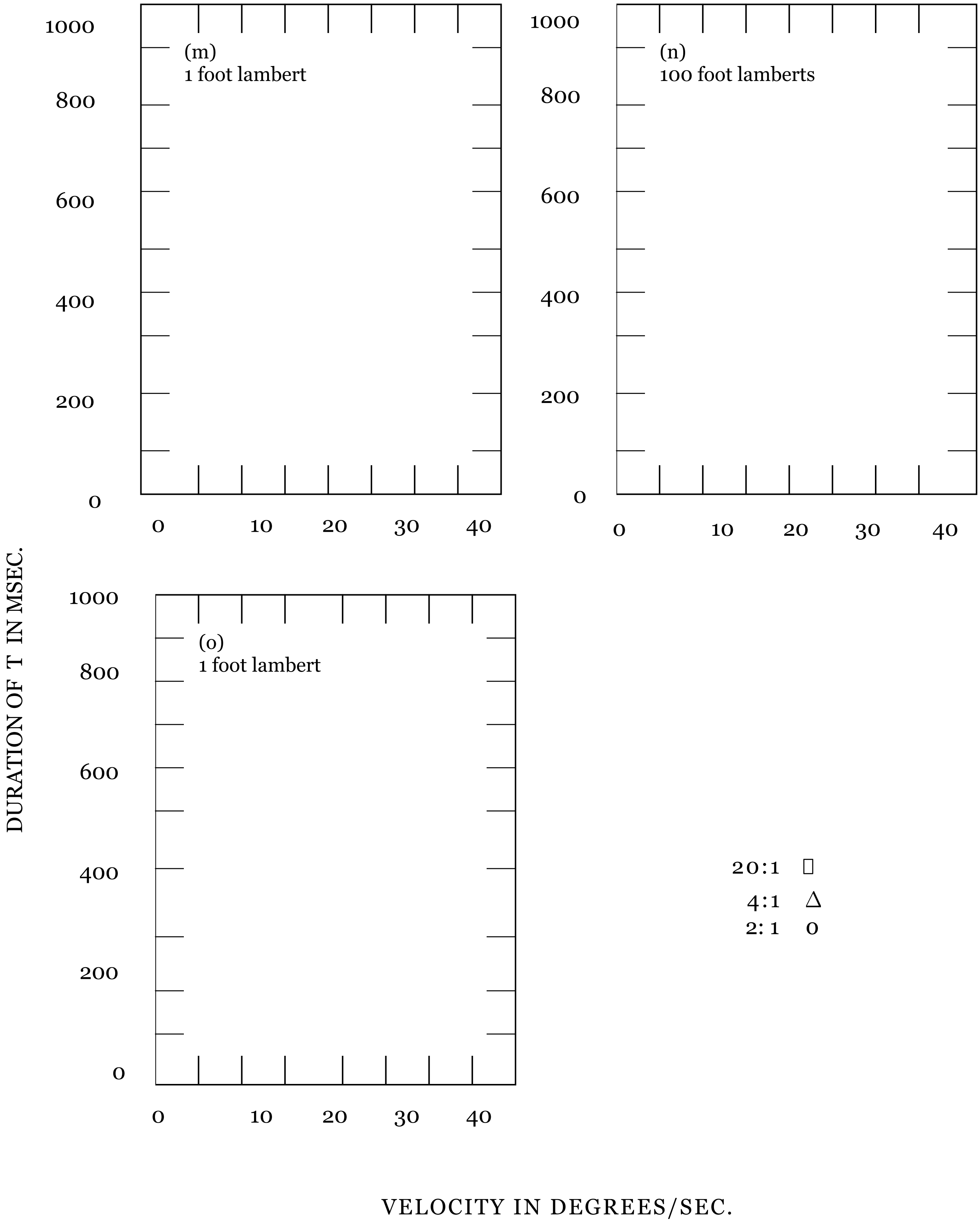


Fig. 16 (cont.) Plots of individual data using the 3° stimulus

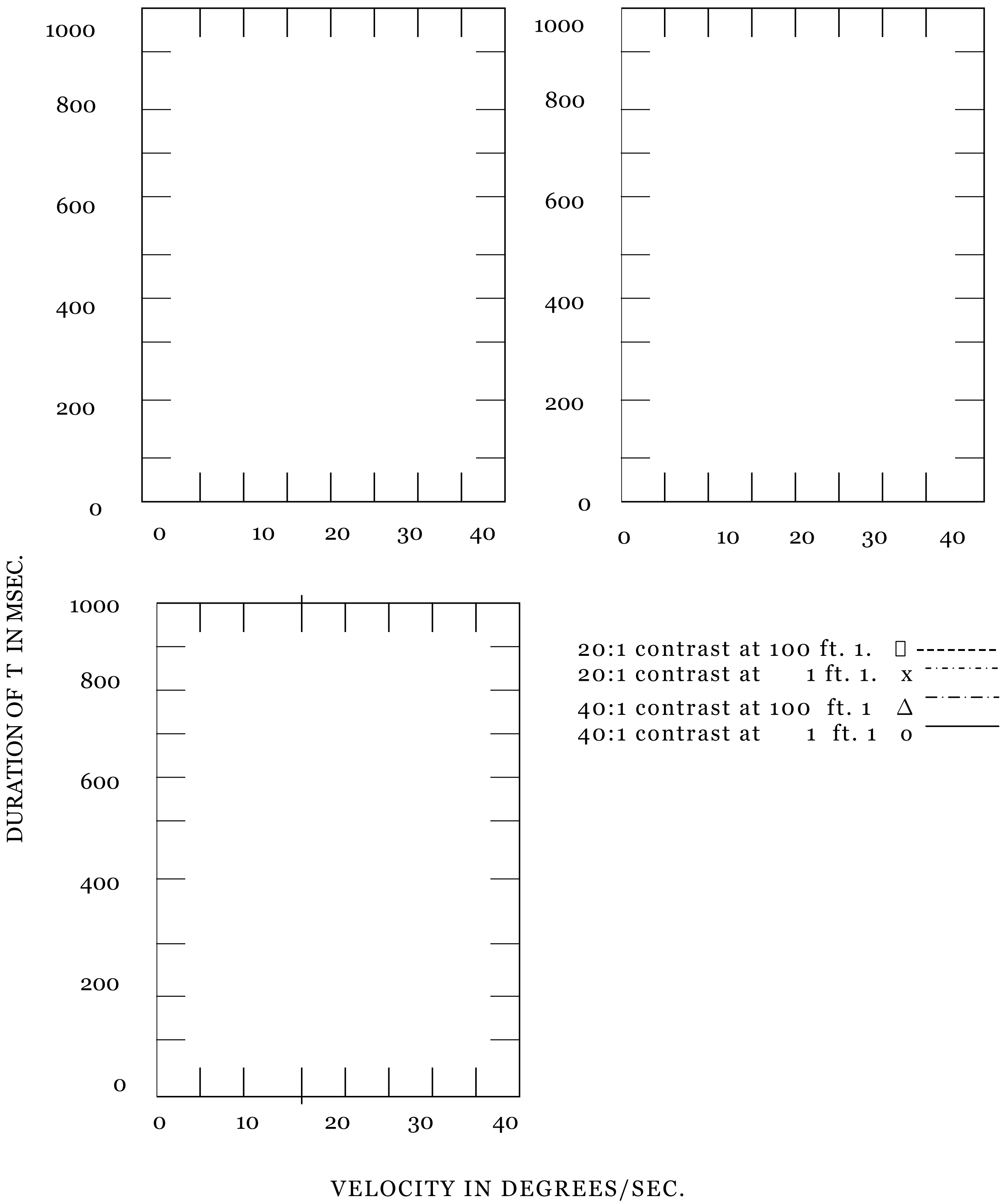


Fig. 17. Plots of individual data using the 6° stimulus

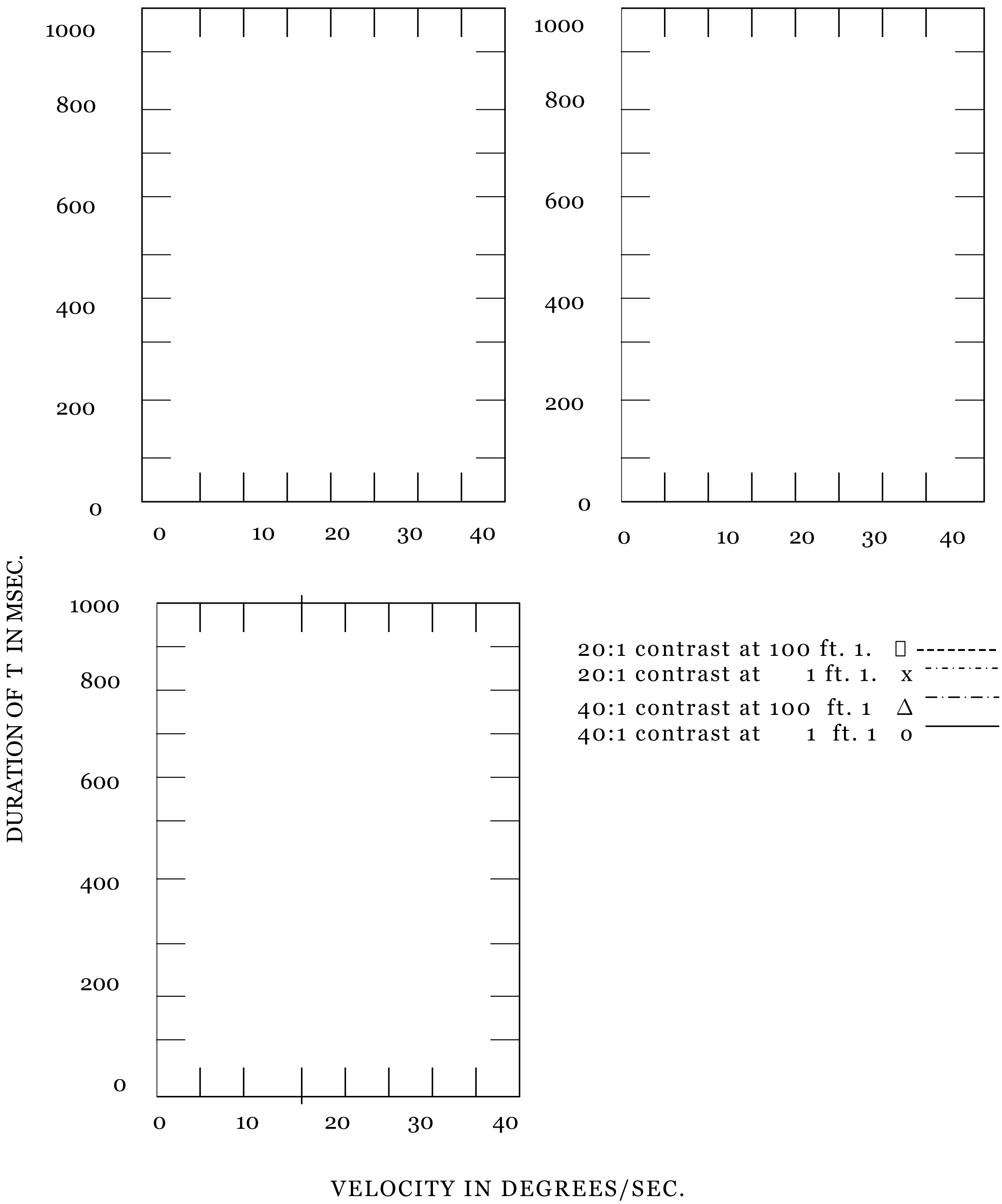


Fig. 18. Plots of individual data using the ½° stimulus

(According to the view which would predict a smooth continuous type of function, a subject at the dynamic contour threshold of a given V and T would need a continuously increasing T to retain contour for an increasing V. There would be no plateaus such as are found in this study.) When the speed becomes great enough that contour is lost, a further increase of T may again serve to regain contour. This is generally true only at speeds below 25 to 30 degrees per second, since at these speeds most subjects have difficulty seeing contour no matter the conditions.

Each subject whose data display the step-like characteristic does so more at one of the conditions than the others on which he was run. According to the quantal theorists, one of the prerequisites for finding the quantal phenomenon is that the subject's task be a relatively easy one. It would then seem that the curve which shows the most step-like behavior for each subject ought to represent the condition under which that subject most easily perceived dynamic contour. However, this is not the case. In very few cases is the curve which is most step-like in character the lowest curve, or that which represents the most easily seen contours. In this study, then, the step-like nature of dynamic contour perception does not necessarily show up to better advantage under the most facilitating condition.

The present data, however, is not definitive enough to offer conclusive evidence of a quantum-type phenomenon. But many of the functions are so step-like in character that it is difficult to see how this could be reconciled with a hypothesis of continuous discrimination.

Other Evidence For and Against the View Presented Here.

This worker has accorded dynamic contour perception special theoretical significance; he has also proposed that this psychological process displays the ultimate discontinuous (quantum) nature of the field events which underlie all our psychological processes. Is there any support for this central-quantum theory point of view in the literature?

It has long been thought by some that the neural mechanism must function in a step-wise or quantal manner, although the physiological basis of the quantization was not clear. Stevens, Morgan, and Volkmann attribute it to a central process (68). Woodworth and Schlosberg also note that, so long as the nerve impulse was thought to work like an ordinary current in a circuit, it was assumed that discrimination was continuous. But with the awareness of the "all-or-none" functioning of the nerve impulses came the expectation that sensations also must function in a step-wise manner. While von Békésy, and others, have demonstrated these steps in studies of auditory thresholds and other audition studies, there has been no adequate test of the theory in other sense fields.

Regarding the particular item of interest in this study, that of movement, Boring has made the point that it is almost independent of the properties of the sense organ and almost completely dependent upon the action of the central nervous system. (14) In their comments on the place of movement in the study of perception, a number of investigators make essentially these points: (a) that movement and temporal experiences depend upon properties of the central nervous system; (b) that movement is a unique process and a more fundamental perception than is the perception of our stable-stationary world; (c) that movement depends upon the "integration of discrete patterns" in the central nervous system; (d) that these discrete patterns shift in space and time. (3, 42, 43, 71).

Some studies seem to imply that the structuring time in other modalities is more rapid than that in the visual modality (68). However, these temporal values are not accompanied by a statement of the conditions of stimulation. They are, therefore, quite valueless as comparative indications as to the average speed of structural aggregate formation in the various modalities.

A number of studies were previously mentioned in which the temporal interval of 30 to 150 msec. occurred over and over again in visual processes, often accompanied by a postulate of discreteness and some sort of central mechanism. Those studies, as well as the several mentioned in this section, can be taken as an indication of support for a central quantum theory view of the nervous system which clearly exists quite independently of contributions from this investigator. Neisser (55) is one of the most recent to explore this question with the intention of determining which approach—the quantal or continuous—can best explain the data. His interesting work, in which he used the quantal method and then added (randomly and without the knowledge of the subject) ostch trials and two new variables, led him to conclude that the data are predominantly favorable to the quantal hypothesis.

On the other hand, Blackwell (12, 13) in a study with a similar purpose comes to the conclusion that much evidence for the quantal hypothesis may be due to the distortion of threshold data. Such distortion, he asserts, takes place most readily under the particular psychophysical conditions recommended by quantal theorists.

This worker feels that there is too much evidence supporting a quantum-type theory to be lightly dismissed in favor of one supporting continuous discrimination. However, the current quantal hypothesis is inadequate, it is felt, to explain more than just isolated cases. A new theory of sensory processes must be grounded upon basic physical phenomena, and thus will also expand eventually to explain all psychological processes. It is felt that there probably is available enough experimental evidence already for the formulation of such a hypothesis, which this worker feels will be based upon a quantum field.

Summary

An outline of the major points and a very brief background of a proposed theory of sensory processes based upon the quantum field theory of physics is presented. Of necessity, many facets and ramifications were omitted, with the emphasis being put upon visual perception since that was the area being investigated in this experimental study. Reasons are given for the belief that a comprehensive and adequate explanation of sensory processes must be based upon a central nervous process and that the underlying parameter must be one which runs throughout natural phenomena in whatever field. Individual plots of the data gathered in this experiment are used as an indication that such discrimination is far from being continuous.

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