STUDIES IN ÆSTHETIC PROCESSES.

THE STRUCTURE OF SIMPLE RHYTHM FORMS.

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I. PROBLEMS AND METHODS OF EXPERIMENTATION.

The investigation of the problems presented by the psychological phenomena of rhythm has of late years occupied much attention and been pushed in a variety of different directions. Some researches have been concerned with an analysis of rhythm as an immediate subjective experience, involving factors of perception, reaction, memory, feeling, and the like; others have had to do with the specific objective conditions under which this experience arises, and the effect of changes in the relations of these factors; still others have sought to coördinate the rhythm experience with more general laws of activity in the organism, as the condition of most effective action, and to affiliate its complex phenomena upon simpler laws of physiological activity and repose; while a fourth group has undertaken a description of that historical process which has resulted in the establishment of artistic rhythm-types, and has sought to formulate the laws of their construction.[1]

This differentiation has already made such progress as to constitute the general topic a field within which specialization is called for, instead of an attempt to treat the phenomenon as a whole. It is the purpose of this paper to describe a set of experiments having to do with the second of these problems, the constitution of objective rhythm

forms. In the determination of such forms it is, of course, impossible to avoid the employment of terms descriptive of the immediate experience of rhythm as a psychological process, or to overlook the constant connection which exists between the two groups of facts. The rhythm form is not objectively definable as a stable type of stimulation existing in and for itself; the discrimination of true and false relations among its elements depends on the immediate report of the consciousness in which it appears. The artistic form is such only in virtue of its arousing in the observer that peculiar quality of feeling expressed in calling the series of sensory stimuli rhythmically pleasing, or equivalent, or perfect. In no other way than as thus dependent on the appeal which their impression makes to the æsthetic consciousness can we conceive of the development and establishment of fixed forms of combination and sequence among those types of sensory stimulation which arouse in us the pleasurable experience of rhythm. The artistic rhythm form cannot be defined as constituted of periods which are 'chronometrically proportionate,' or mathematically simple. It is not such in virtue of any physical relations which may obtain among its constituents, though it may be dependent on such conditions in consequence of the subordination to physical laws of the organic activities of the human individual. The view must be subjectively objective throughout.

The need for simplicity and exactness has led to the very general employment of material as barely sensorial as could be devised for the carrying on of experiments upon rhythm. Rich tones and complex combinations of them are to be avoided, for these qualities are themselves immediate sources of pleasure, and the introduction of them into the material of experimentation inevitably confuses the analysis which the observer is called upon to make of his experience and of the sources of his pleasure in it. Still more objectionable than the presence of such complex musical tones in an investigation of rhythm is the introduction of the symbols of rational speech in concrete poetical forms. This element can be only a hindrance to the perception of pure rhythmical relations, in virtue of the immediate interest which the images called up by the verbal signs possess, and further, in view of the fact that the connections of significant thought impose upon the purely rhythmical formulation of the series of stimulations an unrelated and antagonistic principle of grouping, namely, the logical relations which the various members of the series bear to one another.

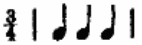
The demand for a simplification of the material which supports the rhythm experience, for the purpose of obtaining a more exact control

over the conditions of experimentation, has been met by the invention of a variety of devices whereby the sequences of music, song and poetical speech have been replaced by elementary conventional symbols as the vehicle of the rhythmical impression or expression. On the one side there has commonly been substituted for musical tones and rhythmical speech the most simple, sharply limited and controllable sounds possible, namely, those due to the action of a telephone receiver, to the vibrations of a tuning-fork placed before the aperture of a resonator, or to the strokes of metallic hammers falling on their anvils. On the other side, the form of the reproduced rhythm has been clarified by the substitution of the finger for the voice in a series of simple motor reactions beaten out on a more or less resonant medium; by the use—when the voice is employed—of conventional verbal symbols instead of the elements of significant speech; and—where actual verse has been spoken—by a treatment of the words in formal staccato scansion, or by the beating of time throughout the utterance. The last of these methods is a halting between two courses which casts doubt on the results as characteristic of either type of activity. There is no question that the rhythmic forms of recitative poetry differ vastly from those of instrumental music and chanted speech. The measures of spoken verse are elastic and full of changefulness, while those of music and the chant maintain a very decided constancy of relations. The latter present determinable types of grouping and succession, while it is questionable whether the forms of relationship in spoken verse can ever be considered apart from the emotion of the moment. In so far as the rhythmic form which these differing modes of expression embody are to be made the subject of experimental investigation their characteristic structures should be kept intact as objects of analysis in independent experiments, instead of being combined (and modified) in a single process.

The apparatus employed in the course of the present investigation consisted of four different pieces of mechanism, one affording the vehicle of expression throughout the series of reproduced rhythms, the others providing the auditory material of the various rhythms apperceived but not designedly reproduced. The first of these consisted of a shallow Marey tambour, placed horizontally upon a table with its rubber film upwards, and connected by means of rubber-tubing with a pneumographic pen in contact with the revolving drum of a kymograph. A Deprez electric marker, aligned with the pneumographic stylus, afforded a time record in quarter seconds. Upon this tambour, placed within comfortable reach of the reactor's hand, the various rhythm types were beaten out. The impact of the

finger-tip on the tense surface of the drum gave forth a faint and pleasing but at the same time clearly discernible and distinctly limited sound, which responded with audible variations of intensity to the differing stresses involved in the process of tapping, and which I have considered preferable to the short, sharp stroke of the Kraepelin mouth-key employed by Ebhardt. The rate of revolution in the drum was so adjusted to the normal range of excursion in the pneumographic pen as to give sharp definition to every change of direction in the curve, which hence allowed of exact measurements of temporal and intensive phases in the successive rhythm groups. These measurements were made to limits of 1.0 mm. in the latter direction and of 0.5 mm. in the former.[2]

The second piece of apparatus consisted of an ordinary metronome adjusted to beat at rates of 60, 90, and 120 strokes per minute. This instrument was used in a set of preliminary experiments designed to test the capacity of the various subjects for keeping time by finger reaction with a regular series of auditory stimulations.

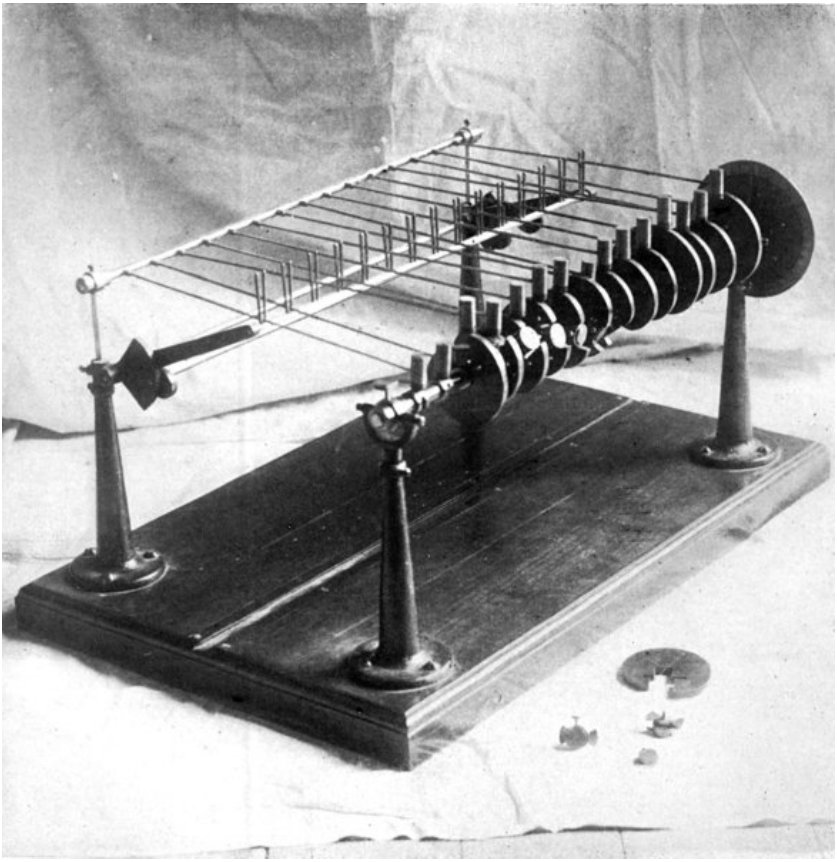
The third piece of apparatus consisted of an arrangement for producing a series of sounds and silences, variable at will in absolute rate, in duration, and, within restricted limits, in intensity, by the interruptions of an electrical current, into the circuit of which had been introduced a telephone receiver and a rheostat. Portions of the periphery of a thin metallic disc were cut away so as to leave at accurately spaced intervals, larger or smaller extents of the original boundary. This toothed wheel was then mounted on the driving-shaft of an Elbs gravity motor and set in motion. Electrical connections and interruptions were made by contact with the edge of a platinum slip placed at an inclination to the disc's tangent, and so as to bear lightly on the passing teeth or surfaces. The changes in form of a mercury globule, consequent on the adhesion of the liquid to the passing teeth, made it impossible to use the latter medium. The absolute rate of succession in the series of sounds was controlled by varying the magnitudes of the driving weights and the resistance of the governing fans of the motor. As the relation of sounds and intervals for any disc was unalterable, a number of such wheels were prepared corresponding to the various numerical groups and temporal sequences examined—one, for example, having the relations expressed in the musical symbol  ; another having that represented in the symbol  and so on. Variations in intensity were obtained by mounting a second series of contacts on the same shaft

and in alignment with those already described. The number of these secondary contacts was less than that of the primary connections, their teeth corresponding to every second or third of those. The connections made by these contacts were with a second loop, which also contained within its circuit the telephone receiver by which the sounds were produced. The rheostatic resistances introduced into this second circuit were made to depart more or less from that of the first, according as it was desired to introduce a greater or slighter periodic accent into the series. This mechanism was designed for the purpose of determining the characteristic sequences of long and short elements in the rhythm group.

The fourth piece of apparatus consisted essentially of a horizontal steel shaft having rigidly attached to it a series of metallic anvils, fifteen in number, on which, as the shaft revolved, the members of a group of steel hammers could be made to fall in succession from the same or different heights. The various parts of the mechanism and their connections may be readily understood by reference to the illustration in Plate VIII. On the right, supported upon two metal standards and resting in doubly pivoted bearings, appears the anvil-bearing shaft. On a series of shallow grooves cut into this shaft are mounted loose brass collars, two of which are visible on the hither end of the shaft. The anvils, the parts and attachments of which are shown in the smaller objects lying on the table at the base of the apparatus, consist of a cylinder of steel partly immersed in a shallow brass cup and made fast to it by means of a thumb-screw. This cup carries a threaded bolt, by which it may be attached to the main shaft at any position on its circumference by screwing through a hole drilled in the collar. The adjustment of the anvils about the shaft may be changed in a moment by the simple movement of loosening and tightening the thumb-screw constituted by the anvil and its bolt. The device by which the extent of the hammer-fall is controlled consists of cam-shaped sheets of thin wood mounted within parallel grooves on opposite sides of the loose collars and clamped to the anvils by the resistance of two wedge-shaped flanges of metal carried on the anvil bolt and acting against the sides of slots cut into the sheets of wood at opposite sides. The periphery of these sheets of wood—as exhibited by that one lying beside the loose anvils on the table—is in the form of a spiral which unfolds in every case from a point on the uniform level of the anvils, and which, by variations in the grade of ascent, rises in the course of a revolution about its center to the different altitudes required for the fall of the hammers. These heights were scaled in inches and fractions, and the series employed in these experiments was as follows: 1/8, 2/8,

3/8, 5/8, 7/8, 15/8, 24/8 inch. Upon a corresponding pair of standards, seen at the left of the illustration, is mounted a slender steel shaft bearing a series of sections of brass tubing, on which, in rigid sockets, are carried the shafts of a set of hammers corresponding in number and position to the anvils of the main axis. By means of a second shaft borne upon two connected arms and pivoted at the summit of the standards the whole group of hammers may at any moment be raised from contact with the cams of the main shaft and the series of sounds be brought to a close without interrupting the action of the motor or of the remainder of the apparatus. By this means phases of acceleration and retardation in the series, due to initial increase in velocity and its final decrease as the movement ceases, are avoided. The pairs of vertical guides which appear on this gearing-shaft and enclose the handles of the several hammers are designed to prevent injury to the insertions of the hammer shafts in their sockets in case of accidental dislocations of the heads in arranging the apparatus. This mechanism was driven by an electrical motor with an interposed reducing gear.

PSYCHOLOGICAL REVIEW. MONOGRAPH SUPPLEMENT, 17. PLATE VIII.



Opposite p. 314.

The intervals between the successive hammer-strokes are controlled in the following way: on the inner face of the group of pulleys mounted on the main shaft of the mechanism (this gang of pulleys appears at the extreme right in the illustration) is made fast a protractor scaled in half degrees. Upon the frame of the standard supporting these pulleys is rigidly screwed an index of metal which passes continuously over the face of the scale as the shaft revolves. The points of attachment (about the shaft) of the cams are determined by bringing the point of fall of each cam in succession into alignment with this fixed index, after the shaft has been turned through the desired arc of its revolution and made fast by means of the thumb-screw seen in the

illustration at the near end of the shaft. Thus, if three strokes of uniform intensity are to be given at equal intervals apart and in continuous succession, the points of fall of the hammers will be adjusted at equal angular distances from one another, for example, at 360°, 240°, and 120°; if the temporal relations desired be in the ratios 2:1:1, the arrangement will be 360°, 180°, 90°; if in the ratios 5:4:3, it will be 360°, 210°, 90°; and so on. If double this number of hammers be used in a continuous series the angular distances between the points of fall of the successive hammers will of course be one half of those given above, and if nine, twelve, or fifteen hammers be used they will be proportionately less.

An interruption of any desired relative length may be introduced between repetitions of the series by restricting the distribution of angular distances among the cams to the requisite fraction of the whole revolution. Thus, if an interruption equal to the duration included between the first and last hammer-falls of the series be desired, the indices of position in the three cases described above will become: 360°, 270°, 180°; 360°, 240°, 180°, and 360°, 260°, 180°. In the case of series in which the heights of fall of the various hammers are not uniform, a special adjustment must be superimposed upon the method of distribution just described. The fall of the hammer occupies an appreciable time, the duration of which varies with the distance through which the hammer passes. The result, therefore, of an adjustment of the cams on the basis adopted when the height of fall is uniform for all would appear in a reduction of the interval following the sound produced by a hammer falling from a greater height than the rest, and the amount of this shortening would increase with every addition to the distance through which the hammer must pass in its fall. In these experiments such lags were corrected by determining empirically the angular magnitude of the variation from its calculated position necessary, in the case of each higher member of the series of distances, to make the stroke of the hammer on its anvil simultaneous with that of the shortest fall. These fixed amounts were then added to the indices of position of the several cams in each arrangement of intervals employed in the experiments.

This apparatus answers a variety of needs in practical manipulation very satisfactorily. Changes in adjustment are easily and quickly made, in regard to intensity, interval and absolute rate. If desired, the gradation of intensities here employed may be refined to the threshold of perceptibility, or beyond it.

The possible variations of absolute rate and of relative intervals within

the series were vastly more numerous than the practical conditions of experimentation called for. In two directions the adaptability of the mechanism was found to be restricted. The durations of the sounds could not be varied as were the intervals between them, and all questions concerning the results of such changes were therefore put aside; and, secondly, the hammers and anvils, though fashioned from the same stuff and turned to identical shapes and weights, could not be made to ring qualitatively alike; and these differences, though slight, were sufficiently great to become the basis of discrimination between successive sounds and of the recognition upon their recurrence of particular hammer-strokes, thereby constituting new points of unification for the series of sounds. When the objective differences of intensity were marked, these minor qualitative variations were unregarded; but when the stresses introduced were weak, as in a series composed of 3/8-, 2/8-, 2/8-inch hammer-falls, they became sufficiently great to confuse or transform the apparent grouping of the rhythmical series; for a qualitative difference between two sounds, though imperceptible when comparison is made after a single occurrence of each, may readily become the subconscious basis for a unification of the pair into a rhythmical group when several repetitions of them take place.

In such an investigation as this the qualification of the subject-observer should be an important consideration. The susceptibility to pleasurable and painful affection by rhythmical and arrhythmical relations among successive sensory stimuli varies within wide limits from individual to individual. It is of equal importance to know how far consonance exists between the experiences of a variety of individuals. If the objective conditions of the rhythm experience differ significantly from person to person it is useless to seek for rhythm forms, or to speak of the laws of rhythmical sequence. Consensus of opinion among a variety of participators is the only foundation upon which one can base the determination of objective forms of any practical value. It is as necessary to have many subjects as to have good ones. In the investigation here reported on, work extended over the two academic years of 1898-1900. Fourteen persons in all took part, whose ages ranged from twenty-three to thirty-nine years. Of these, five were musically trained, four of whom were also possessed of good rhythmic perception; of the remaining nine, seven were good or fair subjects, two rather poor. All of these had had previous training in experimental science and nine were experienced subjects in psychological work.

II. THE ELEMENTARY CONDITIONS OF THE APPEARANCE OF THE RHYTHM IMPRESSION.

The objective conditions necessary to the arousal of an impression of rhythm are three in number: (*a*) Recurrence; (*b*) Accentuation; (*c*) Rate.

(*a*) *Recurrence*.—The element of repetition is essential; the impression of rhythm never arises from the presentation of a single rhythmical unit, however proportioned or perfect. It does appear adequately and at once with the first recurrence of that unit. If the rhythm be a complex one, involving the coördination of primary groups in larger unities, the full apprehension of its form will, of course, arise only when the largest synthetic group which it contains has been completed; but an impression of rhythm, though not of the form finally involved, will have appeared with the first repetition of the simplest rhythmical unit which enters into the composition. It is conceivable that the presentation of a single, unrepeated rhythmical unit, especially if well-defined and familiar, should originate a rhythmical impression; but in such a case the sensory material which supports the impression of rhythm is not contained in the objective series but only suggested by it. The familiar group of sounds initiates a rhythmic process which depends for its existence on the continued repetition, in the form of some subjective accentuation, of the unit originally presented.

The rhythmical form, in all such cases, is adequately and perfectly apprehended through a single expression of the sequence.[3] It lacks nothing for its completion; repetition can add no more to it, and is, indeed, in strict terms, inconceivable; for by its very recurrence it is differentiated from the initial presentation, and combines organically with the latter to produce a more highly synthetic form. And however often this process be repeated, each repetition of the original sequence will have become an element functionally unique and locally unalterable in the last and highest synthesis which the whole series presents.

Rhythmical forms are not in themselves rhythms; they must initiate the factor of movement in order that the impression of rhythm shall arise. Rhythmical forms are constantly occurring in our perceptional experience. Wherever a group of homogeneous elements, so related as to exhibit intensive subordination, is presented under certain temporal conditions, potential rhythm forms appear. It is a mere accident whether they are or are not apprehended as actual rhythm forms. If

the sequence be repeated—though but once—during the continuance of a single attention attitude, its rhythmical quality will ordinarily be perceived, the rhythmic movement will be started. If the sequence be not thus repeated, the presentation is unlikely to arouse the process and initiate the experience of rhythm, but it is quite capable of so doing. The form of the rhythm is thus wholly independent of the movement, on which the actual impression of rhythm in every case depends; and it may be presented apart from any experience of rhythm.

There is properly no repetition of identical sequences in rhythm. Practically no rhythm to which the æsthetic subject gives expression, or which he apprehends in a series of stimulations, is constituted of the unvaried repetition of a single elementary form, the measures,  for example. Variation, subordination, synthesis, are present in every rhythmical sequence. The regular succession is interrupted by variant groups; points of initiation in the form of redundant syllables, points of finality in the form of syncopated measures, are introduced periodically, making the rhythm form a complex one, the full set of relations involved being represented only by the complete succession of elements contained between any one such point of initiation and its return.

(*b*) *Accentuation.*—The second condition for the appearance of the rhythm impression is the periodic accentuation of certain elements in the series of sensory impressions or motor reactions of which that rhythm is composed. The mechanism of such accentuation is indifferent; any type of variation in the accented elements from the rest of the series which induces the characteristic process of rhythmic accentuation—by subjective emphasis, recurrent waves of attention, or what not—suffices to produce an impression of rhythm. It is commonly said that only intensive variations are necessary; but such types of differentiation are not invariably depended on for the production of the rhythmic impression. Indeed, though most frequently the basis of such effects, for sufficient reasons, this type of variation is neither more nor less constant and essential than other forms of departure from the line of indifference, which forms are ordinarily said to be variable and inessential. For the existence of rhythm depends, not on any particular type of periodical variation in the sensory series, but on the recurrent accentuation, under special temporal conditions, of periodic elements within such a series; and any recurrent change in quality—using this term to describe the total group of attributes which constitutes the sensorial character of the elements involved—which suffices to make

the element in which it occurs the recipient of such accentuation, will serve as a basis for the production of a rhythmical impression. It is the fact of periodical differentiation, not its particular direction, which is important. Further, as we know, when such types of variation are wholly absent from the series, certain elements may receive periodical accentuation in dependence on phases of the attention process itself, and a subjective but perfectly real and adequate rhythm arise.

In this sense those who interpret rhythm as fundamentally dependent on the maintenance of certain temporal relations are correct. The accentuation must be rhythmically renewed, but the sensory incentives to such renewals are absolutely indifferent, and any given one of the several varieties of change ordinarily incorporated into rhythm may be absent from the series without affecting its perfection as a rhythmical sequence. In piano playing the accentual points of a passage may be given by notes struck in the bass register while unaccented elements are supplied from the upper octaves; in orchestral compositions a like opposition of heavy to light brasses, of cello to violin, of cymbals to triangle, is employed to produce rhythmical effects, the change being one in *timbre*, combined or uncombined with pitch variations; and in all percussive instruments, such as the drum and cymbals, the rhythmic impression depends solely on intensive variations. The peculiar rhythmic function does not lie in these elements, but in a process to which any one of them indifferently may give rise. When that process is aroused, or that effect produced, the rhythmic impression has been made, no matter what the mechanism may have been.

The single objective condition, then, which is necessary to the appearance of an impression of rhythm is the maintenance of specific temporal relations among the elements of the series of sensations which supports it. It is true that the subjective experience of rhythm involves always two factors, periodicity and accentuation; the latter, however, is very readily, and under certain conditions inevitably, supplied by the apperceptive subject if the former be given, while if the temporal conditions be not fulfilled (and the subject cannot create them) no impression of rhythm is possible. The contributed accent is always a temporally rhythmical one, and if the recurrence of the elements of the objective series opposes the phases of subjective accentuation the rhythm absolutely falls to the ground. Of the two points of view, then, that is the more faithful to the facts which asserts that rhythm is dependent upon the maintenance of fixed temporal intervals. These two elements cannot be discriminated as forming the objective and subjective conditions of rhythm respectively. Both are

involved in the subjective experience and both find their realization in objective expressions, definable and measurable.

(*c*) *Rate.*—The appearance of the impression of rhythm is intimately dependent on special conditions of duration in the intervals separating the successive elements of the series. There appears in this connection a definite superior limit to the absolute rate at which the elements may succeed one another, beyond which the rapidity cannot be increased without either (*a*) destroying altogether the perception of rhythm in the series or (*b*) transforming the structure of the rhythmical sequence by the substitution of composite groups for the single elements of the original series as units of rhythmic construction; and a less clearly marked inferior limit, below which the series of stimulations fails wholly to arouse the impression of rhythm. But the limits imposed by these conditions, again, are coördinated with certain other variables. The values of the thresholds are dependent, in the first place, on the presence or absence of objective accentuation. If such accents be present in the series, the position of the limits is still a function of the intensive preponderance of the accented over the unaccented elements of the group. Further, it is related to the active or passive attitude of the æsthetic subject on whom the rhythmical impression is made, and there appear also important individual variations in the values of the limits.

When the succession falls below a certain rate no impression of rhythm arises. The successive elements appear isolated; each is apprehended as a single impression, and the perception of intensive and temporal relations is gotten by the ordinary process of discrimination involved when any past experience is compared with a present one. In the apprehension of rhythm the case is altogether different. There is no such comparison of a present with a past experience; the whole group of elements constituting the rhythmic unit is present to consciousness as a single experience; the first of its elements has never fallen out of consciousness before the final member appears, and the awareness of intensive differences and temporal segregation is as immediate a fact of sensory apprehension as is the perception of the musical qualities of the sounds themselves.

The absolute value of this lower limit varies from individual to individual. In the experience of some persons the successive members of the series may be separated by intervals as great as one and one half (possibly two) seconds, while yet the impression is distinctly one of rhythm; in that of others the rhythm dies out before half of that interval has been reached. With these subjects the apprehension at

this stage is a secondary one, the elements of the successive groups being held together by means of some conventional symbolism, as the imagery of beating bells or swinging pendulums. A certain voluminousness is indispensable to the support of such slow measures. The limit is reached sooner when the series of sounds is given by the fall of hammers on their anvils than when a resonant body like a bell is struck, or a continuous sound is produced upon a pipe or a reed.

In these cases, also, the limit is not sharply defined. The rhythmical impression gradually dies out, and the point at which it disappears may be shifted up or down the line, according as the æsthetic subject is more or less attentive, more or less in the mood to enjoy or create rhythm, more passive or more active in his attitude toward the series of stimulations which supports the rhythmical impression. The attention of the subject counts for much, and this distinction—of involuntary from voluntary rhythmization—which has been made chiefly in connection with the phenomenon of subjective rhythm, runs also through all appreciation of rhythms which depend on actual objective factors. A series of sounds given with such slowness that at one time, when passively heard, it fails to produce any impression of rhythm, may very well support the experience on another occasion, if the subject try to hold a specific rhythm form in mind and to find it in the series of sounds. In such cases attention creates the rhythm which without it would fail to appear. But we must not confuse the nature of this fact and imagine that the perception that the relations of a certain succession fulfil the the form of a rhythmical sequence has created the rhythmical impression for the apperceiving mind. It has done nothing of the kind. In the case referred to the rhythm appears because the rhythmical impression is produced, not because the fact of rhythmical form in the succession is perceived. The capacity of the will is strictly limited in this regard and the observer is as really subject to time conditions in his effortful construction as in his effortless apprehension. The rhythmically constructive attitude does not destroy the existence of limits to the rate at which the series must take place, but only displaces their positions.

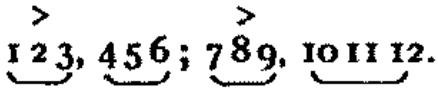
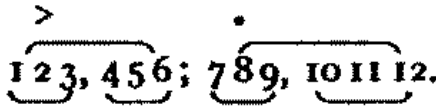
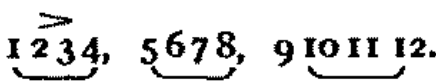
A similar displacement occurs if the periodic accentuations within the series be increased or decreased in intensity. The impression of rhythm from a strongly accented series persists longer, as retardation of its rate proceeds, than does that of a weakly accented series; the rhythm of a weakly accented series, longer than that of a uniform succession. The sensation, in the case of a greater intensive accent, is not only stronger but also more persistent than in that of a weaker, so that the members of a series of loud sounds succeeding one another at any

given rate appear to follow in more rapid succession than when the sounds are faint. But the threshold at which the intervals between successive sounds become too great to arouse any impression of rhythm does not depend solely on the absolute loudness of the sounds involved; it is a function also of the degree of accentuation which the successive measures possess. The greater the accentuation the more extended is the temporal series which will hold together as a single rhythmic group.

This relation appears also in the changes presented in beaten rhythms, the unit-groups of which undergo a progressive increase in the number of their components. The temporal values of these groups do not remain constant, but manifest a slight increase in total duration as the number of component beats is increased, though this increase is but a fraction of the proportional time-value of the added beats. Parallel with this increase in the time-value of the unit-group goes an increase in the preponderance of the accented element over the intensity of the other members of the group. Just as, therefore, in rhythms that are heard, the greatest temporal values of the simple group are mediated by accents of the highest intensity, so in expressed rhythms those groups having the greatest time-values are marked by the strongest accentuation.

Above the superior limit a rhythm impression may persist, but neither by an increase in the number of elements which the unit group contains, nor by an increase in the rate at which these units follow one another in consciousness. The nature of the unit itself is transformed, and a totally new adjustment is made to the material of apprehension. When the number of impressions exceeds eight or ten a second —subject to individual variations—the rhythmical consciousness is unable longer to follow the individual beats, a period of confusion ensues, until, as the rate continues to increase, the situation is suddenly clarified by the appearance of a new rhythm superimposed on the old, having as its elements the structural units of the preceding rhythm. The rate at which the elements of this new rhythm succeed one another, instead of being more rapid than the old, has become relatively slow, and simple groups replace the previous large and complex ones. Thus, at twelve beats per second the rhythms heard by the subjects in these experiments were of either two, three or four beats, the elements entering into each of these constituent beats being severally three and four in number, as follows:

TABLE I.

Simple Trochaic,	four	beats per second:	
Dipodic Trochaic,	"	"	
Simple Dactylic,	three	"	

The only impression of rhythm here received was of a trochaic or dactylic measure, depending upon an accent which characterized a group and not a single beat, and which recurred only twice or thrice a second. Sometimes the subjects were wholly unaware that the elements of the rhythm were not simple, a most significant fact, and frequently the number reported present was one half of the actual number given. During the continuance of such a series the rhythm form changes frequently in the apprehension of the individual subject from one to another of the types described above.

It cannot be too strongly insisted on that the perception of rhythm is an *impression*, an immediate affection of consciousness depending on a particular kind of sensory experience; it is never a construction, a reflective perception that certain relations of intensity, duration, or what not, do obtain. If the perception of rhythm in a series of impressions were dependent on intellectual analysis and discrimination, the existence of such temporal limits as are actually found would be inconceivable and absurd. So long as the perception of the uniformity or proportion of time-relations were possible, together with the discrimination of the regular recurrence in the series of points of accentuation, the perception of rhythm should persist, however great or small might be the absolute intervals which separated the successive members of the series. If it were the conception of a certain form of relation, instead of the reception of a particular impression, which was involved, we should realize a rhythm which extended over hours or days, or which was comprehended in the fraction of a second, as readily as those which actually affect us.

The rate at which the elements of a series succeed one another affects the constitution of the unit groups of which the rhythmical sequence is composed. The faster the rate, the larger is the number of impressions

which enter into each group. The first to appear in subjective rhythm, as the rate is increased from a speed too slow for any impression of rhythm to arise, are invariably groups of two beats; then come three-beat groups, or a synthesis of the two-beat groups into four, with major and minor accents; and finally six-and eight-beat groups appear. When objective accentuation is present a similar series of changes is manifested, the process here depending on a composition of the unit-groups into higher orders, and not involving the serial addition of new elements to the group.

The time relations of such smaller and larger units are dependent on the relative inertia of the mechanism involved. A definite subjective rhythm period undoubtedly appears; but its constancy is not maintained absolutely, either in the process of subjective rhythmization or in the reproduction of ideal forms. Its manifestation is subject to the special conditions imposed on it by such apprehension or expression. The failure to make this distinction is certain to confuse one's conception of the temporal rhythmic unit and its period. The variations of this period present different curves in the two cases of subjective rhythmization and motor expression of definite rhythm forms. In the former the absolute duration of the unit-group suffers progressive decrease as the rate of succession among the stimuli is accelerated; in the latter a series of extensions of its total duration takes place as the number of elements composing the unit is increased. The series of relative values for units of from two to eight constituents which the finger reactions presented in this investigation is given in the following table:

TABLE II.

No. of Elements.	**Proportional Duration.**
Two,	1.000
Three,	1.109
Four,	1.817
Five,	1.761
Six,	2.196
Seven,	2.583
Eight,	2.590

This progressive extension of the rhythm period is to be explained by the mechanical conditions imposed on the expression of rhythm by processes of muscular contraction and release. Were it possible freely to increase the rate of such successive innervations, we should expect to find a much greater constancy in the whole period occupied by the series of reactions which composes the unit. The comparatively unsatisfactory quality of these larger series, and the resolution of them into subgroups described elsewhere in this paper, are due to this inability to accommodate the series of motor reactions to the subjective rhythm period.

On the other hand, the temporal value of the unit which appears as the result of subjective rhythmization undergoes a progressive decrease in absolute magnitude as the rate of succession among the undifferentiated stimuli is accelerated. The series of values for units containing from two to eleven constituents is given in the following table:

TABLE III.

No. of Elements.	**Duration in Seconds.**
Two,	2.00
Three,	1.75
Four,	1.66
Seven,	1.75
Nine,	1.50
Eleven,	0.97

If the time-value of the simple rhythm group here depended solely on the relation of the successive stimuli to the subjective rhythm period, no progressive diminution should be presented, for in proportion as the absolute value of the separating intervals decreases the true nature of this period should be more clearly manifested. It is scarcely to be doubted that the complexity of its content is likewise a determinant of the temporal value of this period, and that to this factor is to be attributed the changes which are here presented.[4]

In subjective rhythmization the number of elements which compose

the unit is dependent solely on the relation of the subjective rhythm period to the rate of succession among such elements. In objective rhythm, as has been pointed out, a free treatment of the material is rendered impossible by the determination of specific points of increased stress, in virtue of which a new unit of change appears, namely, the whole period elapsing from any one occurrence of accentuation to its return.

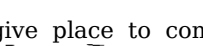
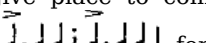
But this is not the sole determinant of the numerical limits of the simple group in such objective rhythms. The structural unit must indeed adhere to the scheme given by the period of the recurrent accentuation; but the point at which simple successions of this figure give place to complex structures (at which  is replaced by  , for example) may conceivably be hastened or retarded by other factors than that of the simple rate of succession. The degrees of segregation and accentuation which characterize the rhythmic unit are elements which may thus affect the higher synthesis. Increase in either of these directions gives greater definition to the rhythmic figure and should tend to preserve the simple group in consciousness. The latter relation was not made the subject of special investigation in this research. The former was taken up at a single point. The sounds were two in number, alternately accented and unaccented, produced by hammer-falls of 7/8 and 1/8 inch respectively. These were given at three rates of succession, and three different degrees of segregation were compared together. In the following table is given, for six subjects, the average number of elements entering into the group-form, simple or complex, under which the rhythm was apprehended:

TABLE IV.

Ratio of Beat-interval to Group-interval.	**Value in Seconds of Average Interval, 5/12**	**3/12**	**2/12**
1.000: 1.400	3.5	5.3	9.0
1.000: 1.000	4.0	5.4	9.6
1.000: 0.714	5.2	8.4	10.8

The quantitative relations presented by these figures are consistent throughout. For every rate of speed the average rhythmic group is

smallest when the interval separating the successive groups is at its maximum; it is largest when this interval is at its minimum; while in each case a median value is presented by the relation of uniformity among the intervals. In the second as well as the first of the ratios included in the foregoing table the interval which separates adjacent groups is felt to be distinctly longer than that internal to the group; in the third the relative durations of the two intervals are those which support psychological uniformity. In the latter case, in consequence of the freer passage from group to group, the continuity of the rhythmical series is more perfectly preserved than in the former, and the integration of its elements into higher syntheses more extended.

The extension of the numerical limits of the rhythm group in subjective rhythm which appear in consequence of progressive acceleration in the rate of succession is given for a series of six different values of the separating intervals in the following table, the figures of which represent the average for six observers:

TABLE V.

HIGHEST UNITS WHICH APPEAR.

Value of interval in secs.:	12/12	7/12	5/12	3/12	2/12	1/12
No. of el's in rhythm group:	2.5	3.0	4.0	7.0	9.0	11.0
Average duration of group:	2.500	1.750	1.666	1.750	1.500	0.917

SIMPLE UNITS.

No. of els. in simplest group:	2.5	2.3	2.9	3.7	4.7	5.0
Duration of simplest group:	2.50	1.34	1.21	0.92	0.78	0.41

The rate of increase here presented in the number of elements is not sufficiently rapid to counterbalance the acceleration of speed and maintain a constancy in the duration of the group. The greatest value of this period is coördinated with the slowest rate of succession, the lowest with the most rapid. As the speed increases, the duration of the rhythmic unit is shortened. Its average duration for all rates here included is 1.680 sec., or, without the first of the series (one-second intervals, at which only two of the observers received the impression of rhythm), 1.516 sec. These values are not for the simplest combinations, but for the highest synthetical unit which was immediately apprehended in the series of stimulations. This compounding becomes more pronounced as the rate of succession is accelerated, but even at intervals of 5/12 and 7/12 sec. it is the characteristic mode of apprehension.

The number of elements in the simple groups of which these higher units are composed, and their average duration, are also given in the table. These likewise show a progressive increase in number, but of a much slower rate than that manifested by the total synthesis of elements. That is to say, in subjective rhythm as well as in objectively figured series, subordinate rhythmical differences in the material sink out of consciousness less rapidly than the inclusion of fresh elements takes place; in other words, the organic complexity of the rhythmic unit increases with every acceleration in the rate of succession. The duration of these simple structural groups, as may be inferred, decreases with such acceleration, but at a much more rapid rate than is the case with the total reach of rhythmical apprehension, the value of that unit which appears in connection with the highest speed here included being less than half a second. The 'liveliness' of such rapid measures is thus a resultant of several factors. It is not a consequence solely of the more rapid rate at which the individual stimuli succeed one another, but depends also on the shortening of the periods of both these rhythmical units and on the progressive divergence of the simple from the complex group.

The influence of the rate of succession on the rhythmical unit is not confined to its segregation from adjacent groups, but affects the internal configuration of the measure as well. With every acceleration in rate the relative preponderance of the interval following the accented element (in rhythms having initial stress) increases; as the rate is retarded, smaller and smaller degrees of difference in the values of accented and unaccented intervals are discriminated. In this regard the influence of reduction in the absolute value of the separating intervals is analogous to that of increased accentuation

within the group. In fast tempos and with high degrees of emphasis the interval following the initial accent is relatively longer, that following the unaccented relatively shorter, than at slow tempos and with weak emphasis. This is but another way of expressing the fact that as the elements of the auditory series succeed one another more and more slowly the impression of rhythm fades out and that as their succession increases in rapidity the impression becomes more and more pronounced. The following table presents these relations in a quantitative form for trochaic rhythm. The figures represent the number of times the second, or group interval, was judged to be greater than, equal to, or less than the first or internal interval of the group. Three rates were compared together, having average intervals of 5/12, 3/12 and 2/12 sec. Six observers took part, but only a small number of judgments was made by each, to which fact is probably to be attributed the irregularities of form which appear in the various curves:

TABLE VI.

Ratio of 1st to 2d	**5/12**			**3/12**			**2/12**		
Interval.	**+**	**=**	**-**	**+**	**=**	**-**	**+**	**=**	**-**
1.000: 1.057	95.0	0.0	5.0	100.0	0.0	0.0	100.0	0.0	0.0
1.000: 1.000	94.7	5.3	0.0	86.0	10.5	3.5	87.5	12.5	0.0
1.000: 0.895	40.0	60.0	0.0	46.2	49.6	3.3	74.1	18.5	7.4
1.000: 0.846	41.0	50.0	9.0	39.4	54.6	6.0	40.0	52.0	8.0
1.000: 0.800	20.0	60.0	20.0	13.0	70.0	17.0	53.8	46.2	0.0
1.000: 0.756	29.4	23.5	47.1	21.8	43.4	34.8	28.0	72.0	0.0
Av. for all ratios,	53.3	33.1	13.5	51.1	38.0	10.8	63.9	33.5	2.6

Within the limits of its appearance, as the figures just presented indicate, the force, definition and persistency of the rhythmical impression do not continue uniform. At the lowest rates at which rhythm appears the integration of the successive groups is weak and their segregation indistinct. As the rate increases the definition of the rhythmic form grows more precise, group is separated from group by greater apparent intervals, and the accentuation of the groups becomes more pronounced. In subjective rhythmization of an undifferentiated series, likewise, the impression of segregation and periodic accentuation grows more forcible and dominating as the rate

increases. The sensitiveness to form and dynamic value in the successive groups also increases up to a certain point in the process of acceleration. As expressed in the capacity to discriminate departures from formal equivalence among the groups, this function reached its maximum, for those concerned in this investigation, at rates varying individually from 0.3 sec. to 0.6 sec. in the value of their intervals.

It is in virtue of its nature as an impression, as opposed to a construction, that every structural unit, and every rhythmical sequence into which it enters, possesses a distinct individual quality, by which it is immediately apprehended and discriminated from other forms, as the face of an acquaintance is remembered and identified without detailed knowledge of the character of any feature it possesses. For what persists from the reception of a rhythm impression and becomes the basis of future recognition and reproduction of it, is not the number of beats in a unit or sequence, nor the absolute or relative intensity of the components of the group; it is the quality of the groups as individuals, and the form of the sequence as a whole. The phrase and verse are as vividly conceived as the unit group; the stanza or the passage is apprehended as immediately and simply as the bar or the measure. Of the number and relation of the individual beats constituting a rhythmical sequence there is no awareness whatever on the part of the æsthetic subject. I say this without qualification. So long as the rhythmical impression endures the analytic unit is lost sight of, the synthetic unit, or group, is apprehended as a simple experience. When the rhythm function is thoroughly established, when the structural form is well integrated or familiar, it becomes well-nigh impossible to return to the analytic attitude and discern the actual temporal and intensive relations which enter into the rhythm. Even the quality of the organic units may lapse from distinct consciousness, and only a feeling of the form of the whole sequence remain. The *Gestaltsqualität* of the passage or the stanza is thus frequently appreciated and reproduced without an awareness of its sequential relations, though with the keenest sense of what is necessary to, or inconsistent with, its structure; so that the slightest deviation from its form is remarked and the whole sequence accurately reproduced.

In order to isolate and exhibit the tendency toward rhythmization in regularly repeated motor reactions, one should examine series of similar movements made at different rates both as an accompaniment to a recurrent auditory stimulus and as free expressions of the motor impulse independent of such objective control. In the former of these cases the series of stimuli should be undifferentiated in quality as well as uniform in time. The rhythm which appears in such a case will

contradict the phases of an objective series which prescribes its form, and the evidence of its existence, presented under such adverse conditions, should be indubitable.

As preliminary to their special work the members of the experimental group were tested in regard to the promptness and regularity of their reactions (by finger flexion) in accompanying a periodically recurrent stimulus given by the beating of a metronome; records were taken also of their capacity to estimate and maintain constant time relations by freely tapping at intervals of one, two and five seconds. Of the latter type of reaction the records show that a temporal grouping of the reactions is presented in every rate of tapping. This, owing to the large absolute intervals, is uniformly in groups of two, the first member of which is of shorter, the second of longer duration. There is likewise an intensive differentiation of the alternate reactions. Thus a double rhythmical treatment appears, but while with intervals of two seconds the phases of temporal and intensive rhythm coincide, at rates of one and five seconds they are opposed, that is, the accentuation falls on the initial reaction which is followed by the shorter interval. This doubtlessly marks the emergence of that tendency to initial accentuation which was subsequently found to prevail in all expression of rhythm.

The types of reaction which these records afford leave no doubt that a fuller investigation of the matter would show the constant presence, in all such forms of activity, of a rhythmical automatization of the series. The special problems which such an investigation should first resolve, relate to the dependence of the amount of rhythmical differentiation on the rate of succession among the reactions; the relation of the form of this reaction series to factors of attention and control; and the significance, in connection with the process of rhythmization, of auditory stimuli produced by and accompanying the reaction series, that is, the comparison of soundless and sounded reactions.

In the second set of experiments the reactor was directed simply to accompany the beating of a metronome by a light tapping with the forefinger on a rubber-surfaced tambour connected with a pneumographic registering pen, with which was aligned an electrical time-marker also actuated by the metronome. Three rates of tapping were adopted, 60, 90 and 120 beats per minute. No specific instructions were given as to direction or keenness of attention on the part of the reactor; the most natural and simple accompaniment was desired. Occasionally, for comparison, the reactor was directed to attend closely to each successive beat as it occurred.

Certain questions as to the applicability of the material here interpreted to the point in question, and as to its relation to the objective conditions of experimentation, must be met at the outset. The first of these is as to the actual uniformity of the metronome series. Objective determination of its temporal regularity is unnecessary (in so far as such a determination looks toward an explanation of the form of tapping by reference to inequality in the metronomic intervals). That the rhythmical phases which appear in the accompaniment are not due to inequality in the stimulation intervals, is shown by the reversal of relations between the metronome and its accompaniment which occur in the midst of a continuous series of taps. To speak roughly, a break occurs every twentieth beat. I do not refer to minor irregularities occurring within the single group but not affecting the form of the rhythmical accompaniment. The latter appeared with surprising rarity, but when found were included in the continuous calculation of averages. But in every score or so of beats a stroke out of series would be interpolated, giving the form | 1 >2 1 2 >1 |; the accompaniment being coördinated during the second portion of the whole series with opposite phases of the metronome from those with which its elements were connected in the earlier part. Moreover, the dependence of this grouping of the sounds on subjective attitudes may readily be made to appear. When attention is turned keenly on the process its phases of rhythmical differentiation decline; when the accompaniment becomes mechanical they mount in value. When the observer tries to mark the ticking as accurately as possible, not only does the index of his motor reactions become more constant, but the sounds of the instrument likewise appear more uniform. The observers report also that at one and the same time they are aware of the regularity of the metronome and the rhythmical nature of their tapping, while yet the conviction remains that the accompaniment has been in time with the beats. Furthermore, if the phases of ticking in the metronome were temporarily unlike, the motor accompaniment by a series of observers, if accurate, should reproduce the time-values of the process, and if inaccurate, should present only an increase of the mean variation, without altering the characteristic relations of the two phases. On the other hand, if the series be uniform and subjectively rhythmized by the hearer, there should be expected definite perversions of the objective relations, presenting a series of increasing departures from the original in proportion as the tendency to rhythmize varied from individual to individual.

On the other hand, a rhythm is already presented in the sounds of the metronome, occasioned by the qualitative differentiation of the

members of each pair of ticks, a variation which it was impossible to eliminate and which must be borne in mind in estimating the following results.

Five reactors took part in the experiment, the results of which are tabulated in the following pages. The figures are based on series of one hundred reactions for each subject, fifty accompaniments to each swing and return of the metronome pendulum. When taken in series of ten successive pairs of reactions, five repetitions of the series will be given as the basis of each average. The quantitative results are stated in Tables VII.-XIV., which present the proportional values of the time intervals elapsing between the successive reactions of an accompaniment to the strokes of a metronome beating at the rates of 60, 90 and 120 per minute.

TABLE VII.

I. AVERAGES ACCORDING TO REACTORS OF ALL RATES FOR BOTH PHASES.

(*a*) In Series of Ten Successive Pairs of Beats.

Subject.	***I***	***II***	***III***	***IV***	***V***	***VI***	***VII***	***VIII***	***IX***	***X***
J.	1.000	1.005	1.022	1.053	1.044	1.116	1.058	1.061	1.055	1.052
K.	1.000	1.027	1.057	1.111	1.093	1.086	1.074	1.096	1.093	1.071
N.	1.000	1.032	1.062	0.990	1.009	0.980	1.019	1.040	1.067	1.040
Aver.	1.000	1.021	1.047	1.051	1.049	1.061	1.050	1.066	1.072	1.054

TABLE VIII.

(*b*) First and Second Halves of the Preceding Combined in Series of Five.

Subject.	***I***	***II***	***III***	***IV***	***V***
J.	1.058	1.031	1.041	1.054	1.048
K.	1.043	1.050	1.076	1.102	1.082

N.	0.990	1.025	1.051	1.028	1.024
Aver.	1.030	1.035	1.056	1.061	1.051

TABLE IX.

AVERAGES OF ALL RATES AND SUBJECTS ACCORDING TO PHASES OF METRONOME.

(*a*) In Series of Ten Successive Reactions in Accompaniment of Each Phase.

Phase.	***I***	***II***	***III***	***IV***	***V***	***VI***	***VII***	***VIII***	***IX***	***X***
First,	1.000	1.055	1.102	1.097	1.082	1.066	1.053	1.123	1.120	1.074
Second,	1.000	0.988	0.992	1.007	1.016	1.055	1.015	1.009	1.024	1.001

TABLE X.

(*b*) First and Second Halves of the Preceding Combined in Series of Five.

Phase.	***I***	***II***	***III***	***IV***	***V***
First,	1.033	1.054	1.112	1.108	1.078
Second,	1.027	1.001	1.000	1.015	1.008

TABLE XI.

AVERAGES OF ALL SUBJECTS ACCORDING TO RATES AND PHASES OF METRONOME.

(*a*) First Phase, Series of Ten Successive Reactions.

Rate.	*I*	*II*	*III*	*IV*	*V*	*VI*	*VII*	*VIII*	*IX*	*X*
60	1.000	1.168	1.239	1.269	1.237	1.209	1.265	1.243	1.237	1.229
90	1.000	1.048	1.063	1.095	1.086	1.069	1.102	1.127	1.168	1.095
120	1.000	1.004	0.942	1.043	1.057	0.978	0.949	1.065	1.065	0.967

TABLE XII.

(*b*) Second Phase, Series of Ten Successive Reactions.

Rate.	*I*	*II*	*III*	*IV*	*V*	*VI*	*VII*	*VIII*	*IX*	*X*
60	1.000	0.963	0.942	0.947	1.009	0.695	0.993	0.995	1.023	0.996
90	1.000	0.893	0.987	1.018	1.036	1.005	0.995	1.000	0.977	1.000
120	1.000	1.000	0.990	1.048	1.040	1.007	0.986	1.030	1.037	0.962

TABLE XIII.

AVERAGES OF ALL SUBJECTS AND BOTH PHASES OF METRONOME ACCORDING TO RATES.

(*a*) In Series of Ten.

Rate.	*I*	*II*	*III*	*IV*	*V*	*VI*	*VII*	*VIII*	*IX*	*X*
60	1.000	1.065	1.140	1.108	1.123	0.952	1.129	1.119	1.130	1.112
90	1.000	0.970	1.025	1.056	1.061	1.037	1.048	1.063	1.072	1.047
120	1.000	1.000	0.990	1.048	1.040	1.007	0.986	1.030	1.037	0.962

TABLE XIV.

(*b*) Above Combined in Series of Five.

Rate.	*I*	*II*	*III*	*IV*	*V*
60	0.976	1.097	1.129	1.119	1.117
90	1.018	1.009	1.044	1.059	1.054
120	1.003	0.993	1.010	1.042	1.001

In the following table (XV.) is presented the average proportional duration of the intervals separating the successive reactions of these subjects to the stimulations given by the alternate swing and return of the pendulum.

TABLE XV.

Subject.	Rate: 60.	Rate: 90.	Rate: 120.
B.	0.744 : 1.000	0.870 : 1.000	0.773 : 1.000
J.	0.730 : 1.000	0.737 : 1.000	0.748 : 1.000
K.	0.696 : 1.000	0.728 : 1.000	0.737 : 1.000
N.	0.526 : 1.000	0.844 : 1.000	0.893 : 1.000

The corresponding intensive values, as measured by the excursion of the recording pen, are as follows:

TABLE XVI.

Subject.	Rate: 60.	Rate: 90.	Rate: 120.
B.	(1.066 : 1.000)	0.918 : 1.000	(1.010 : 1.000)
J.	0.938 : 1.000	0.943 : 1.000	0.946 : 1.000
K.	0.970 : 1.000	0.949 : 1.000	(1.034 : 1.000)
N.	0.883 : 1.000	0.900 : 1.000	0.950 : 1.000

These figures present a double process of rhythmic differentiation, intensively into stronger and weaker beats, and temporally into longer and shorter intervals. The accentuation of alternate elements has an objective provocative in the qualitative unlikeness of the ticks given by

the swing and return of the pendulum. This phase is, however, neither so clearly marked nor so constant as the temporal grouping of the reactions. In three cases the accent swings over to the shorter interval, which, according to the report of the subjects, formed the initial member of the group when such grouping came to subjective notice. This latter tendency appears most pronounced at the fastest rate of reaction, and perhaps indicates a tendency at rapid tempos to prefer trochaic forms of rhythm. In temporal grouping the coördination of results with the succession of rates presents an exception only in the case of one subject (XV. B, Rate 120), and the various observers form a series in which the rhythmizing tendency becomes more and more pronounced.

Combining the reactions of the various subjects, the average for all shows an accentuation of the longer interval, as follows:

TABLE XVII.

Rate.	**Temp. Diff.**	**Intens. Diff.**
60	0.674 : 1.000	0.714 : 1.000
90	0.795 : 1.000	0.927 : 1.000
120	0.788 : 1.000	0.985 : 1.000

The rhythmical differentiation of phases is greatest at the slowest tempo included in the series, namely, one beat per second, and it declines as the rate of succession increases. It is impossible from this curve to say, however, that the subjective rhythmization of uniform material becomes more pronounced in proportion as the intervals between the successive stimulations increase. Below a certain rapidity the series of sounds fails wholly to provoke the rhythmizing tendency; and it is conceivable that a change in the direction of the curve may occur at a point beyond the limits included within these data.

The introduction from time to time of a single extra tap, with the effect of transposing the relations of the motor accompaniment to the phases of the metronome, has been here interpreted as arising from a periodically recurring adjustment of the reaction process to the auditory series which it accompanies, and from which it has gradually diverged. The departure is in the form of a slow retardation, the return is a swift acceleration. The retardation does not always continue until a point is reached at which a beat is dropped from, or an extra one

introduced into, the series. In the course of a set of reactions which presents no interpolation of extra-serial beats periodic retardation and acceleration of the tapping take place. This tertiary rhythm, superimposed on the differentiation of simple phases, has, as regards the forms involved in the present experiments, a period of ten single beats or five measures.

From the fact that this rhythm recurs again and again without the introduction of an extra-serial beat it is possible to infer the relation of its alternate phases to the actual rate of the metronome. Since the most rapid succession included was two beats per second, it is hardly conceivable that the reactor lost count of the beats in the course of his tapping. If, therefore, the motor series in general parallels the auditory, the retardations below the actual metronome rate must be compensated by periods of acceleration above it. Regarded in this light it becomes questionable if what has been called the process of readjustment really represents an effort to restore an equilibrium between motor and auditory processes after an involuntary divergence. I believe the contrasting phases are fundamental, and that the changes represent a free, rhythmical accompaniment of the objective periods, which themselves involve no such recurrent differentiation.

Of the existence of higher rhythmic forms evidence will be afforded by a comparison of the total durations of the first and second five-groups included in the decimal series. Difference of some kind is of course to be looked for; equivalence between the groups would only be accidental, and inequality, apart from amount and constancy, is insignificant. In the results here presented the differentiation is, in the first place, of considerable value, the average duration of the first of these groups bearing to the second the relation of 1.000:1.028.

Secondly, this differentiation in the time-values of the respective groups is constant for all the subjects participating. The ratios in their several cases are annexed:

TABLE XVIII.

Subject.	**Ratio.**
J.	1.000 : 1.042
K.	1.000 : 1.025

N. 1.000 : 1.010

It is perhaps significant that the extent of this differentiation—and inferably the definition of rhythmical synthesis—corresponds to the reported musical aptitudes of the subjects; J. is musically trained, K. is fond of music but little trained, N. is without musical inclination.

The relations of these larger rhythmical series repeat those of their constituent groups—the first is shorter, the second longer. The two sets of ratios are brought together for comparison in the annexed table:

TABLE XIX.

Subject.	**Unit-Groups.**	**Five Groups.**
J.	1.000 : 1.354	1.000 : 1.042
K.	1.000 : 1.388	1.000 : 1.025
N.	1.000 : 1.326	1.000 : 1.010

It is to be noted here, as in the case of beating out specific rhythms, that the index of differentiation is greater in simple than in complex groups, the ratios for all subjects being, in simple groups, 1.000:1.356, and in series of five, 1.000:1.026.

There is thus present in the process of mechanically accompanying a series of regularly recurring auditory stimuli a complex rhythmization in the forms, first, of a differentiation of alternate intervals, and secondly, of a synthesis of these in larger structures, a process here traced to the third degree, but which may very well extend to the composition of still more comprehensive groups. The process of reaction is permeated through and through by rhythmical differentiation of phases, in which the feeling for unity and equivalence must hold fast through really vast periods as the long slow phases swing back and forth, upon which takes place a swift and yet swifter oscillation of rhythmical values as the unit groups become more limited, until the opposition of single elements is reached.

III. THE CHARACTERISTICS OF THE RHYTHMICAL UNIT.

A. *The Number of Elements in the Group and its Limits.*

The number of elements which the rhythmical group contains is related, in the first place, to the rate of succession among the elements of the sequence. This connection has already been discussed in so far as it bears on the forms of grouping which appear in an undifferentiated series of sounds in consequence of variations in the absolute magnitude of the intervals which separate the successive stimuli. In such a case the number of elements which enter into the unit depends solely on the rate of succession. The unit presents a continuous series of changes from the lowest to the highest number of constituents which the simple group can possibly contain, and the synthesis of elements itself changes from a succession of simple forms to structures involving complex subordination of the third and even fourth degree, without other change in the objective series than variations in tempo.

When objectively defined rhythm types are presented, or expression is given to a rhythm subjectively defined by ideal forms, these simple relations no longer hold. Acceleration or retardation of speed does not unconditionally affect the number of elements which the rhythm group contains. In the rhythmization of an undifferentiated series the recurrence of accentuation depends solely on subjective conditions, the temporal relations of which can be displaced only within the limits of single intervals; for example, if a trochaic rhythm characterizes a given tempo, the rhythm type persists under conditions of progressive acceleration only in so far as the total duration of the two intervals composing the unit approximates more closely to the subjective rhythm period than does that of three such intervals. When, in consequence of the continued reduction of the separating intervals, the latter duration presents the closer approximation, the previous rhythm form is overthrown, accentuation attaches to every third instead of to alternate elements, and a dactylic rhythm replaces the trochaic.

In objective rhythms, on the other hand, the determination of specific points of increased stress makes it impossible thus to shift the accentuation back and forth by increments of single intervals. The unit

of displacement becomes the whole period intervening between any two adjacent points of accentuation. The rhythm form in such cases is displaced, not by those of proximately greater units, but only by such as present multiples of its own simple groups. Acceleration of the speed at which a simple trochaic succession is presented results thus, first, in a more rapid trochaic tempo, until the duration of two rhythm groups approaches more nearly to the period of subjective rhythmization, when—the fundamental trochaism persisting—the previous simple succession is replaced by a dipodic structure in which the phases of major and minor accentuation correspond to the elementary opposition of accented and unaccented phases. In the same way a triplicated structure replaces the dipodic as the acceleration still continues; and likewise of the dactylic forms.

We may say, then, that the relations of rate to complexity of structure present the same fundamental phenomena in subjective rhythmization and objectively determined types, the unit of change only differing characteristically in the two cases. The wider range of subjective adjustment in the latter over the former experience is due to the increased positive incentive to a rhythmical organic accompaniment afforded by the periodic reinforcement of the objective stimulus.

An investigation of the limits of simple rhythmical groups is not concerned with the solution of the question as to the extent to which a reactor can carry the process of prolonging the series of elements integrated through subordination to a single dominant accentuation. The nature of such limits is not to be determined by the introspective results of experiments in which the observer has endeavored to hold together the largest possible number of elements in a simple group. When such an attempt is made a wholly artificial set of conditions, and presumably of mechanisms, is introduced, which makes the experiment valueless in solving the present problem. Both the direction and the form of attention are adverse to the detection of rhythmical complications under such conditions. Attention is directed away from the observation of secondary accents and toward the realization of a rhythm form having but two simple phases, the first of which is composed of a single element, while within the latter fall all the rest of the group. Such conditions are the worst possible for the determination of the limits of simple rhythm groups; for the observer is predisposed from the outset to regard the whole group of elements lying within the second phase as undifferentiated. Thus the conditions are such as to postpone the recognition of secondary accents far beyond the point at which they naturally arise.

But further, such an attempt to extend the numerical scope of simple rhythm groups also tends to transform and disguise the mechanism by which secondary stresses are produced, and thereby to create the illusion of an extended simple series which does not exist. For we have no right to assume that the process of periodic accentuation in such a series, identical in function though it be, involves always the same form of differentiation in the rhythmical material. If the primary accentuation be given through a finger reaction, the fixating of that specific form of change will predispose toward an overlooking of secondary emphases depending on minor motor reactions of a different sort. The variety of such substitutional mechanisms is very great, and includes variations in the local relations of the finger reaction, movements of the head, eyes, jaws, throat, tongue, etc., local strains produced by simultaneous innervation of flexor and extensor muscles, counting processes, visual images, and changes in ideal significance and relation of the various members of the group. Any one of these may be seized upon to mediate the synthesis of elements and thus become an unperceived secondary accentuation.

Our problem is to determine at what point formal complication of the rhythmical unit tends naturally to arise. How large may such a group become and still remain fundamentally simple, without reduplication of accentual or temporal differentiation? The determination of such limits must be made on the basis of quantitative comparison of the reactions which enter into larger and smaller rhythmical series, on the one hand, and, on the other, of the types of structure which appear in subjective rhythmization and the apprehension of objective rhythms the forms of which are antecedently unknown to the hearer. The evidence from subjective rhythms is inconclusive. The prevailing types are of two and three beats. Higher forms appear which are introspectively simple, but introspection is absolutely unable to solve the problem as to the possible composite nature of these extended series. The fact that they are confined to even numbers, the multiples of two, and to such odd-numbered series as are multiples of three, without the appearance of the higher primes, indicates the existence in all these groups of secondary accentuation, and the resolution of their forms into structures which are fundamentally complications of units of two and three elements only. The process of positive accentuation which appears in every higher rhythmical series, and underlying its secondary changes exhibits the same reduction of their elementary structure to double and triple groups, has been described elsewhere in this report. Here it is in place to point out certain indirect evidence of the same process of resolution as manifested in the treatment of

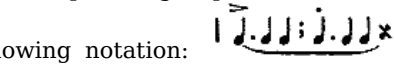
longer series of elements.

The breaking up of such series into subgroups may not be an explicitly conscious process, while yet its presence is indispensable in giving rhythmical form to the material. One indication of such undiscriminated rhythmical modification is the need of making or avoiding pauses between adjacent rhythmical groups according as the number of their constituents varies. Thus, in rhythms having units of five, seven, and nine beats such a pause was imperative to preserve the rhythmical form, and the attempt to eliminate it was followed by confusion in the series; while in the case of rhythms having units of six, eight, and ten beats such a pause was inadmissible. This is the consistent report of the subjects engaged in the present investigation; it is corroborated by the results of a quantitative comparison of the intervals presented by the various series of reactions. The values of the intervals separating adjacent groups for a series of such higher rhythms are given in Table XX. as proportions of those following the initial, accented reaction.

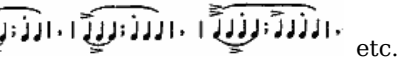
TABLE XX.

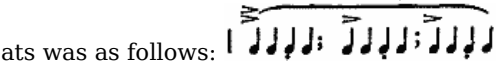
Rhythm.	**Initial Interval.**	**Final Interval.**
Five-Beat,	1.000	1.386
Six "	1.000	0.919
Seven "	1.000	1.422
Eight "	1.000	1.000
Nine "	1.000	1.732
Ten "	1.000	1.014

The alternate rhythms of this series fall into two distinct groups in virtue of the sharply contrasted values of their final intervals or group pauses. The increased length of this interval in the odd-numbered rhythms is unquestionably due to a subdivision of the so-called unit into two parts, the first of which is formally complete, while the latter is syncopated. In the case of five-beat rhythms, this subdivision is into threes, the first three of the five beats which compose the so-called unit forming the primary subgroup, while the final two beats, together with a pause functionally equivalent to an additional beat and interval, make up the second, the system being such as is expressed in the

following notation:  The pause at the close of the group is indispensable, because on its presence depends the maintenance of equivalence between the successive three-groups. On the other hand, the introduction of a similar pause at the close of a six-beat group is inadmissible, because the subdivision is into three-beat groups, each of which is complete, so that the addition of a final pause would utterly unbalance the first and second members of the composite group, which would then be represented by the following notation:  that is, a three-group would alternate with a four-group, the elements of which present the same simple time relations, and the rhythm, in consequence, would be destroyed. The same conditions require or prevent the introduction of a final pause in the case of the remaining rhythm forms.

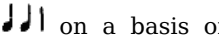
The progressive increase in the value of the final interval, which will be observed in both the odd-and even-numbered rhythms, is probably to be attributed to a gradual decline in the integration of the successive groups into a well-defined rhythmical sequence.

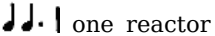
This subdivision of material into two simple phases penetrates all rhythmical structuring. The fundamental fact in the constitution of the rhythmical unit is the antithesis of two phases which we call the accented and the unaccented. In the three-beat group as in the two-beat, and in all more complex grouping, the primary analysis of material is into these two phases. The number of discriminable elements which enter each phase depends on the whole constitution of the group, for this duality of aspect is carried onward from its point of origin in the primary rhythm group throughout the most complex combination of elements, in which the accented phase may comprise an indefinitely great number of simple elements, thus:  etc. An indication of this process of differentiation into major and minor phases appears in the form of rhythm groups containing upwards of four elements. In these the tendency is, as one observer expresses it, 'to consider the first two beats as a group by themselves, with the others trailing off in a monotonous row behind.' As the series of elements thus bound up as a unit is extended, the number of beats which are crowded into the primary subgroup also increases. When the attempt was made to unite eleven or twelve reactions in a single group, the first four beats were thus taken together, with the rest trailing off as before. It is evident

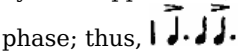
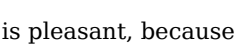
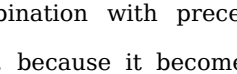
that the lowest groups with which attention concerned itself here were composed of four beats, and that the actual form of the (nominally) unitary series of eleven beats was as follows:  .

The subscripts are added in the notation given above because it is to be doubted if a strictly simple four-beat rhythm is ever met with. Of the four types producible in such rhythm forms by variation in the accentual position, three have been found, in the course of the present investigation, to present a fundamental dichotomy into units of two beats. Only one, that characterized by secondary accentuation, has no such discriminable quality of phases. Of this form two things are to be noted: first, that it is unstable and tends constantly to revert to that with initial stress, with consequent appearance of secondary accentuation; and second, that as a permanent form it presents the relations of a triple rhythm with a grace note prefixed.

The presence of this tendency to break up the four-rhythm into subgroups of two beats explains a variety of peculiarities in the records of this investigation. The four-beat rhythm with final accent is found most pleasant at the close of a rhythmical sequence. The possibility of including it in a continuous series depends on having the final interval of 'just the right length.' If one keeps in mind that a secondary initial accent characterizes this rhythm form, the value required in this final interval is explained by the resolution of the whole group into two units of three beats each, the latter of the two being syncopated. The pause is of 'just the right length' when it is functionally equal to two unaccented elements with their succeeding intervals, as follows:  .

Likewise in four-rhythms characterized by initial stress there appears a tendency to accent the final beat of the group, as well as that to accent the third. Such a series of four may therefore break up in either of two ways, into  on a basis of two-beat units, or into  on a basis of three-beat units.

The persistence of these simple equivalences appears also in the treatment of syncopated measures and of supplementary or displaced accents. Of the form  one reactor says, and his description may stand for all, "This deliberate introduction of a third accent on the last beat is almost impossible for me to keep. The single group is easy enough and rather agreeable, but in a succession of groups the

secondarily accented third beat comes against the first of the next group with a very disagreeable effect." This is the case where no pause intervenes between the groups, in which case the rhythm is destroyed by the suppression, in each alternate simple group, of the unaccented phase; thus,  alone is pleasant, because it becomes  , but in combination with preceding and succeeding groups it is disagreeable, because it becomes in reality  , etc. A long pause between the groups destroys this disagreeableness, since the lacking phase of the second subgroup is then restored and the rhythm follows its normal course.

The amphibrachic form,  , is more difficult to maintain than either the dactylic or the trochaic, and in a continuous series tends to pass over into one of these, usually the former. 'With sufficient pause,' the reactors report, 'to allow the attitude to die away,' it is easily got. The same inability to maintain this form in consciousness appears when a continuous series of clicks is given, every third of which is louder than the rest. Even when the beginning of the series is made coincident with the initial phase of the amphibrachic group the rhythmic type slips over into the dactylic, in spite of effort. In this, as in the preceding type of reaction, if the interval separating adjacent groups be lengthened, the rhythm is maintained without trouble. The 'dying away' of the attitude lies really in such an arrangement of the intervals as will formally complete a phrase made up of simple two-beat units.

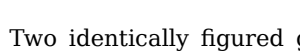
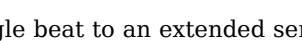
The positive evidence which this investigation affords, points to the existence of factors of composition in all rhythms of more than three beats; and a variety of peculiarities which the results present can be explained—and in my estimation explained only—on the basis of such an assumption. I conclude, therefore, that strictly stated the numerical limit of simple rhythm groups is very soon reached; that only two rhythmical units exist, of two and three beats respectively; that in all longer series a resolution into factors of one of these types takes place; and, finally, that the subordination of higher rhythmical quantities of every grade involves these simple relations, of which, as the scope of the synthesis increases, the opposition of simple alternate phases tends more and more to predominate over triplicated structures.

Variation in the number of elements which enter into the rhythmic unit does not affect the sense of equivalence between successive groups, so long as the numerical increase does not reach a point at which it

lessens the definiteness of the unit itself. For the purpose of testing this relation the reactors beat out a series of rhythm forms from 'one-beat' rhythms to those in which the group consisted of seven, eight and nine elements, and in which the units were either identical with one another or were made up of alternately larger and smaller numbers of elements. Two questions were to be answered in each case; the manner in which these various changes affected the sense of rhythmical equivalence in the alternate groups, and the variations in affective quality which these changes introduced into the experience. With the former of these problems we are here concerned. From 'one-beat' to four-beat rhythms the increase in number of constituents in no way affects the sense of rhythmical equivalence. Beyond this point there is a distinct falling off. 'The first part of the rhythm begins to fade away before the end of the second,' says one; and another: 'The series then reverts to a monotonous succession without feeling of rhythm.' This decline marks those groups composed of an odd number of elements much earlier and more strongly than those which contain an even number. The sense of equivalence has fallen off at five and practically disappears at seven beats, while groups of six and eight retain a fairly definite value as units in a rhythmical sequence. This peculiar relation must be due to the subconscious resolution of the larger symmetrical groups into smaller units of three and four constituents respectively.

Likewise the introduction of variations in the figure of the group—that is, in the number of elements which enter into the groups to be compared, the distribution of time values within them, the position of accents, rests, and the like—does not in any way affect the sense of equivalence between the unlike units. Against a group of two, three, four, or even five elements may be balanced a syncopated measure which contains but one constituent, with the sense of full rhythmical equivalence in the functional values of the two types. Indeed, in the case of five-beat rhythms the definition of values is greater when such opposition finds place than when the five-beat group is continuously repeated. This is to be explained doubtlessly by the more definite integration into a higher rhythmical unity which is afforded under the former conditions.

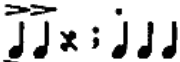
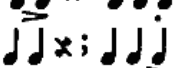
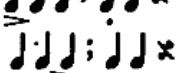
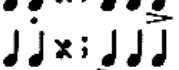
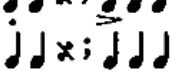
The number and the distribution of elements are factors variable at will, and are so treated in both musical and poetical expression. The condition which cannot be transgressed is the maintenance of strict temporal relations in the succession of total groups which constitute the rhythmical sequence. These relations are, indeed, not invariable for either the single interval or the duration of the whole group, but

they are fixed functions of the dynamic values of these elements and units. Two identically figured groups (*e.g.*, ), no more possess rhythmically substitutionary values than does the opposition of a single beat to an extended series (*e.g.*, ) , apart from this factor of temporal proportion. Those groups which are identical in figure must also be uniform in duration if they are to enter as substitutionary groups into a rhythmical sequence.[5] When the acatalectic type is alternately departed from and returned to in the course of the rhythmical sequence, the metrical equivalents must present total time-values which, while differing from that of the full measure in direction and degree, in dependence on the whole form of their structure, maintain similar fixed relations to the primary type. The changes which these flexible quantities undergo will here only be indicated. If the substitutionary groups be of different figures, that which comprises the larger number of elements will occupy the greater time, that which contains fewer, the less.

I do not forget the work of other observers, such as Brücke, who finds that dactyls which appear among trochees are of less duration than the latter, nor do I impugn their results. The rhythmical measure cannot be treated as an isolated unit; it must always be considered in its structural relations to the rhythmical sequence of which it forms a part. Every non-conforming measure is unquestionably affected by the prevailing type of the rhythmical sequence in which it occurs. Brücke points out the converse fact that those trochees and iambs are longest which appear in dactylic or other four-measures; but this ignores the complexity of the conditions on which the character of these intrusive types depends. The time-values of such variants are also dependent on the numerical preponderance of the typical form in the whole series. When a single divergent form appears in the sequence the dynamic relations of the two types is different from that which obtains when the numbers of the two approach equality, and the effect of the prevailing form on it is proportionally greater. Secondly, the character of such variants is dependent on the subordinate configuration of the sequence in which they appear, and on their specific functions within such minor rhythmical figures. The relative value of a single dactyl occurring in an iambic pentameter line cannot be predicated of cases in which the two forms alternate with each other throughout the verse. Not only does each type here approximate the other, but each is affected by its structural relation to the proximately higher group which the two alternating measures compose. Thirdly, the quantitative values of these varying forms is related to their logical significance in the verse and

the degree of accentuation which they receive. Importance and emphasis increase the duration of the measure; the lack of either shortens it. In this last factor, I believe, lies the explanation of the extreme brevity of dactyls appearing in three-rhythms. When a specific rhythm type is departed from, for the purpose of giving emphasis to a logically or metrically important measure, the change is characteristically in the direction of syncopation. Such forms, as has been said elsewhere, mark nodes of natural accentuation and emphasis. Hence, the dactyl introduced into an iambic or trochaic verse, which, so far as concerns mere number of elements, tends to be extended, may, in virtue of its characteristic lack of accentuation and significance, be contracted below the value of the prevailing three-rhythm. Conversely the trochee introduced into a dactylic sequence, in consequence of its natural accentuation or importance, may exceed in time-value the typical four-rhythm forms among which it appears. The detailed examination of the relation of temporal variations to numerical predominance in the series, to subordinate structural organization, and to logical accentuation, in our common rhythms, is a matter of importance for the general investigation which remains still to be carried out. In so far as the consideration of these factors entered into the experimental work of the present research, such quantitative time relations are given in the following table, the two types in all cases occurring in simple alternation:

TABLE XXI.

Rhythm.	1st Meas.	2d Meas.	Rhythm.	1st Meas.	2d Meas.
	1.000	1.091		1.000	1.140
	1.000	1.159		1.000	1.021
	1.000	1.025		1.000	1.267
	1.000	0.984		1.000	1.112
	1.000	0.766		1.000	1.119

As the disparity in numerical constitution increases, so will also the

divergence in time-value of the two groups concerned. When differentiation into major and minor phases is present, the duration of the former will be greater than that of the latter. Hence, in consequence of the combination of these two factors—*e.g.*, in a syncopated measure of unusual emphasis—the characteristic time-values may be inverted, and the briefer duration attach to that unit which comprises the greater number of elements. Intensive values cannot take the place of temporal values in rhythm; the time form is fundamental. Through all variations its equivalences must be adhered to. Stress makes rhythm only when its recurrence is at regular intervals. The number of subordinate factors which combine with the accented element to make the group is quite indifferent. But whether few or many, or whether that element on which stress falls stands alone (as it may), the total time values of the successive groups must be sensibly equivalent. When a secondary element is absent its place must be supplied by a rest of equivalent time-value. If these proper temporal conditions be not observed no device of intensive accentuation will avail to produce the impression of metrical equivalence among the successive groups.

B. *The Distribution of Elements Within the Group.*

(*a*) The Distribution of Intensities.

In the analysis of the internal constitution of the rhythmic unit, as in other parts of this work, the investigation follows two distinct lines, involving the relations of rhythm as apprehended, on the one hand, and the relations of rhythm as expressed, on the other; the results in the two cases will be presented separately. A word as to the method of presentation is necessary. The fact that in connection with each experiment a group of questions was answered gives rise to some difficulty in planning the statement of results. It is a simple matter to describe a particular set of experiments and to tell all the facts which were learned from them; but it is not logical, since one observation may have concerned the number of elements in the rhythmic unit, another their internal distribution, and a third their coalescence in a higher unity. On the other hand, the statement of each of these in its own proper connection would necessitate the repetition of some description, however meager, of the conditions of experimentation in connection with each item. For economy's sake, therefore, a compromise has been made between reporting results according to distribution of material and according to distribution of topics. The evidence of higher grouping, for example, which is afforded by

variations in duration and phases of intensity in alternate measures, will be found appended to the sections on these respective classes of material.

In all the following sections the hammer-clang apparatus formed the mechanism of experimentation in sensory rhythms, while in reactive rhythms simple finger-tapping was employed.

In comparing the variations in stress which the rhythmical material presents, the average intensities of reaction for the whole group has been computed, as well as the intensities of the single reactions which compose it. This has been done chiefly in view of the unstable intensive configuration of the group and the small amount of material on which the figures are based. The term is relative; in ascertaining the relations of intensity among the several members of the group, at least ten successive repetitions, and in a large part of the work fifty, have been averaged. This is sufficient to give a clear preponderance in the results to those characteristics which are really permanent tendencies in the rhythmical expression. This is especially true in virtue of the fact that throughout these experiments the subject underwent preliminary training until the series of reactions could be easily carried out, before any record of the process was taken. But when such material is analyzed in larger and smaller series of successive groups the number of reactions on which each average is based becomes reduced by one half, three quarters, and so on. In such a case the prevailing intensive relations are liable to be interfered with and transformed by the following factor of variation. When a wrong intensity has accidentally been given to a particular reaction there is observable a tendency to compensate the error by increasing the intensity of the following reaction or reactions. This indicates, perhaps, the presence of a sense of the intensive value of the whole group as a unity, and an attempt to maintain its proper relations unchanged, in spite of the failure to make exact coördination among the components. But such a process of compensation, the disappearance of which is to be looked for in any long series, may transpose the relative values of the accented elements in two adjacent groups when only a small number of reactions is taken into account, and make that seem to receive the major stress which should theoretically receive the minor, and which, moreover, does actually receive such a minor stress when the value of the whole group is regarded, and not solely that member which receives the formal accentuation.

The quantitative analysis of intensive relations begins with triple rhythms, since its original object was to compare the relative stresses

of the unaccented elements of the rhythmic group. These values for the three forms separately are given in Table XXII., in which the value of the accented element in each case is represented by unity.

TABLE XXII.

Rhythm.	**1st Beat.**	**2d Beat.**	**3d Beat.**
Dactylic,	1.000	0.436	0.349
Amphibrachic,	0.488	1.000	0.549
Anapæstic,	0.479	0.484	1.000

The dactylic form is characterized by a progressive decline in intensity throughout the series of elements which constitute the group. The rate of decrease, however, is not continuous. There is a marked separation into two grades of intensity, the element receiving accentual stress standing alone, those which possess no accent falling together in a single natural group, as shown in the following ratios: first interval to third, 1.000:0.349; second interval to third, 1.000:0.879. One cannot say, therefore, that in such a rhythmic form there are two quantities present, an accented element and two undifferentiated elements which are unaccented. For the average is not based on a confused series of individual records, but is consistently represented by three out of four subjects, the fourth reversing the relations of the second and third elements, but approximating more closely to equivalence than any other reactor (the proportional values for this subject are 1.000; 0.443; 0.461). Moreover, this reactor was the only musically trained subject of the group, and one in whom the capacity for adhering to the logical instructions of the experiment appears decidedly highest.

In the amphibrachic form the average again shows three degrees of intensity, three out of four subjects conforming to the same type, while the fourth reverses the relative values of the first and third intervals. The initial element is the weakest of the group, and the final of median intensity, the relation for all subjects being in the ratio, 1.000:1.124. The amphibrachic measure begins weakly and ends strongly, and thus approximates, we may say, to the iambic type.

In the anapæstic form the three degrees of intensity are still maintained, three out of four subjects giving consistent results; and the order of relative values is the simple converse of the dactylic.

There is presented in each case a single curve; the dactyl moves continuously away from an initial accent in an unbroken decrescendo, the anapæst moves continuously toward a final accent in an unbroken crescendo. But in the anapæstic form as well as in the dactylic there is a clear duality in the arrangement of elements within the group, since the two unaccented beats fall, as before, into one natural group, while the accented element is set apart by its widely differentiated magnitude. The ratios follow: first interval to second, 1.000:1.009; first interval to third, 1.000:2.084.

The values of the three elements when considered irrespective of accentual stress are as follows: First, 1.000; second, 1.001; third, 0.995. No characteristic preponderance due to primacy of position appears as in the case of relative duration. The maximum value is reached in the second element. This is due to the coöperation of two factors, namely, the proximity of the accentual stress, which in no case is separated from this median position by an unaccented element, and the relative difficulty in giving expression to amphibrachic rhythms. The absolute values of the reactions in the three forms is of significance in this connection. Their comparison is rendered possible by the fact that no change in the apparatus was made in the course of the experiments. They have the following values: Dactylic, 10.25; amphibrachic, 12.84; anapæstic, 12.45. The constant tendency, when any difficulty in coördination is met with, is to increase the force of the reactions, in the endeavor to control the formal relations of the successive beats. If such a method of discriminating types be applied to the present material, then the most easily coördinated—the most natural—form is the dactyl; the anapæst stands next; the amphibrach is the most unnatural and difficult to coördinate.

The same method of analysis was next applied to four-beat rhythms. The proportional intensive values of the successive reactions for the series of possible accentual positions are given in the following table:

TABLE XXIII.

Stress.	**1st Beat.**	**2d Beat.**	**3d Beat.**	**4th Beat.**
Initial,	1.000	0.575	0.407	0.432
Secondary,	0.530	1.000	0.546	0.439

Tertiary,	0.470	0.407	1.000	0.453
Final,	0.492	0.445	0.467	1.000

The first and fourth forms follow similar courses, each marked by initial and final stress; but while this is true throughout in the fourth form, it results in the first form from the preponderance of the final interval in a single individual's record, and therefore cannot be considered typical. The second and third forms are preserved throughout the individual averages. The second form shows a maximum from which the curve descends continuously in either direction; in the third a division of the whole group into pairs is presented, a minor initial accent occurring symmetrically with the primary accent on the third element. This division of the third form into subgroups appears also in its duration aspect. Several inferences may be drawn from this group of relations. The first and second forms only are composed of singly accented groups; in the third and fourth forms there is presented a double accent and hence a composite grouping. This indicates that the position in which the accent falls is an important element in the coördination of the rhythmical unit. When the accent is initial, or occurs early in the group, a larger number of elements can be held together in a simple rhythmic structure than can be coördinated if the accent be final or come late in the series. In this sense the initial position of the accent is the natural one. The first two of these four-beat forms are dactylic in structure, the former with a postscript note added, the latter with a grace note prefixed. In the third and fourth forms the difficulty in coördinating the unaccented initial elements has resulted in the substitution of a dipodic division for the anapæstic structure of triple rhythms with final accent.

The presence of a tendency toward initial accentuation appears when the average intensities of the four reactions are considered irrespective of accentual position. Their proportional values are as follows: First, 1.000; second, 0.999; third, 1.005; fourth, 0.981. Underlying all changes in accentuation there thus appears a resolution of the rhythmic structure into units of two beats, which are primitively trochaic in form.

The influence exerted by the accented element on adjacent members of the group is manifested in these forms more clearly than heretofore when the values of the several elements are arranged in order of their proximity to that accent and irrespective of their positions in the group. Their proportional values are as follows:

TABLE XXIV.

2d Remove.	1st Remove.	Accent.	1st Remove.	2d Remove.
0.442	0.526	1.000	0.514	0.442

This reinforcing influence is greater—according to the figures just given—in the case of the element preceding the accent than in that of the reaction which follows it. It may be, therefore, that the position of maximal stress in the preceding table is due to the close average relation in which the third position stands to the accented element. This proximity it of course shares with the second reaction of the group, but the underlying trochaic tendency depreciates the value of the second reaction while it exaggerates that of the third. This reception of the primitive accent the third element of the group indeed shares with the first, and one might on this basis alone have expected the maximal value to be reached in the initial position, were it not for the influence of the accentual stress on adjacent members of the group, which affects the value of the third reaction to an extent greater than the first, in the ratio 1.000:0.571.

The average intensity of the reactions in each of the four forms—all subjects and positions combined—is worthy of note.

TABLE XXV.

Stress.	Initial.	Secondary.	Tertiary.	Final.
Value,	1.000	1.211	1.119	1.151

The first and third forms, which involve initial accents—in the relation of the secondary as well as primary accent to the subgroups—are both of lower average value than the remaining types, in which the accents are final, a relation which indicates, on the assumption already made, a greater ease and naturalness in the former types. Further, the second form, which according to the subjective reports was found the most difficult of the group to execute—in so far as difficulty may be said to be inherent in forms of motor reaction which were all relatively easy to manipulate—is that which presents the highest intensive value of the whole series.

In the next group of experiments, the subject was required to execute a series of reactions in groups of alternating content, the first to contain two uniform beats, the second to consist of a single reaction. This second beat with the interval following it constitutes a measure which was to be made rhythmically equivalent to the two-beat group with which it alternated. The time-relations of the series were therefore left to the adjustment of the reactor. The intensive relations were separated into two groups; in the first the final reaction was to be kept uniform in strength with those of the preceding group, in the second it was to be accented.

The absolute and relative intensive values for the two forms are given in the following table:

TABLE XXVI.

Rhythm.	**1st Beat.**	**2d Beat.**	**3d Beat.**	**Value.**
Syncopated Measures	13.00	15.12	16.50	Absolute.
Unaccented,	1.000	1.175	1.269	Relative.
Syncopated Measures	10.95	11.82	16.11	Absolute.
Accented,	1.000	1.079	1.471	Relative.

These averages hold for every individual record, and therefore represent a thoroughly established type. In both forms the reaction of the syncopated measure receives the greatest stress. In the first form, while the stress is relatively less than in the second, it is at the same time absolutely greater. The whole set of values is raised (the ratio of average intensities in the two forms being 1.147:1.000), as it has already been found to be raised in other forms difficult to execute. To this cause the preponderance is undoubtedly to be attributed, as the reports of every subject describe this form as unnatural, in consequence of the restraint it imposes on an impulse to accent the final reaction, *i.e.*, the syncopated measure.

In the next set of experiments the series of reactions involved the alternation of a syncopated measure consisting of a single beat with a full measure of three beats. The same discrimination into accented and unaccented forms in the final measure was made as in the preceding

group. The series of absolute and relative values are given in the following table.

TABLE XXVII.

Rhythm.	1st Beat.	2d Beat.	3d Beat.	4th Beat.	Value.
Syncopated Measures	9.77	8.96	9.61	13.78	Absolute.
Unaccented,	1.000	0.915	0.983	1.165	Relative.
Syncopated Measures	11.57	11.07	11.5	21.50	Absolute.
Accented,	1.000	0.957	0.996	1.858	Relative.

These averages hold for every subject where the syncopated measure receives accentuation, and for two out of three reactors where it is unaccented. The latter individual variation shows a progressive increase in intensity throughout the series.

Here, as in the preceding forms, a well-established type is presented. Not only when accentuation is consciously introduced, but also when the attempt is made—and in so far as the introspection of the reactor goes, successfully made—to maintain a uniformity among the reactions of the full and syncopated measures, the emphasis on the latter is unconsciously increased. In the accented form, as before, there is a clear discrimination into two grades of intensity (ratio of first three elements to final, 1.000:1.888) while in the unaccented no such broad separation exists (ratio of first three elements to final, 1.000:1.156).

The type of succession in each of these forms of reaction is a transformed dactylic, in which group should now be included the simple four-beat rhythm with final accent, which was found to follow the same curve. The group begins with a minor stress in both of the present forms, this stress being greater in the unaccented than in the accented type. This preponderance I believe to be due to the endeavor to repress the natural accent on the syncopated measure. In both forms the intensive value of the second element is less than that of the third, while the intensity of the initial reaction is greater than that of either of these subsequent beats. This form of succession I have called a *transformed dactylic*. It adheres to the dactylic type in possessing initial accentuation; it departs from the normal dactylic succession in

inverting the values of the second and third members of the group. This inversion is not inherent in the rhythmic type. The series of three beats decreasing in intensity represents the natural dactylic; the distortion actually presented is the result of the proximity of each of these groups to a syncopated measure which follows it. This influence I believe to be reducible to more elementary terms. The syncopated measure is used to mark the close of a logical sequence, or to attract the hearer's attention to a striking thought. In both cases it is introduced at significant points in the rhythmical series and represents natural nodes of accentuation. The distortion of adjacent measures is to be attributed to the increase in this elementary factor of stress, rather than to the secondary significance of the syncopation, for apart from any such change in the rhythmical structure we have found that the reactions adjacent to that which receives accentual stress are drawn toward it and increased in relative intensity.

Further quantitative analysis of rhythmical sequences, involving a comparison of the forms of successive measures throughout the higher syntheses of verse, couplet and stanza, will, I believe, confirm this conception of the mutable character of the relations existing between the elements of the rhythmical unit, and the dependence of their quantitative values on fixed points and modes of structural change occurring within the series. An unbroken sequence of dactyls we shall expect to find composed of forms in which a progressive decrease of intensity is presented from beginning to end of the series (unless we should conceive the whole succession of elements in a verse to take shape in dependence on the point of finality toward which it is directed); and when, at any point, a syncopated measure is introduced we shall look for a distortion of this natural form, at least in the case of the immediately preceding measure, by an inversion of the relative values of the second and third elements of the group. This inversion will unquestionably be found to affect the temporal as well as the intensive relations of the unit. We should likewise expect the relations of accented and unaccented elements in the two-beat rhythms to be similarly affected by the occurrence of syncopated measures, and indeed to find that their influence penetrates every order of rhythm and extends to all degrees of synthesis.

To the quantitative analysis of the intensive relations presented by beaten rhythms must be added the evidence afforded by the apprehension of auditory types. When a series of sounds temporally and qualitatively uniform was given by making and breaking an electric circuit in connection with a telephone receiver, the members of a group of six observers without exception rhythmized the stimuli in

groups—of two, three and four elements according to rate of succession—having initial accentuation, however frequently the series was repeated. When the series of intervals was temporally differentiated so that every alternate interval, in one case, and every third in another, stood to the remaining interval or intervals in the ratio, 2:1, the members of this same group as uniformly rhythmized the material in measures having final accentuation. In triple groups the amphibrachic form (in regard to temporal relations only, as no accentuation was introduced) was never heard under natural conditions. When the beginning of the series was made to coincide with the initiation of an amphibrachic group, four of those taking part in the investigation succeeded in maintaining this form of apprehension for a time, all but one losing it in the dactylic after a few repetitions; while the remaining two members were unable to hold the amphibrachic form in consciousness at all.

(*b*) The Distribution of Durations.

The inquiry concerning this topic took the direction, first, of a series of experiments on the influence which the introduction of a louder sound into a series otherwise intensively uniform exerts on the apparent form of the series within which it occurs. Such a group of experiments forms the natural preliminary to an investigation of the relation of accentuation to the form of the rhythm group. The apparatus employed was the fourth in the series already described. The sounds which composed the series were six in number; of these, five were produced by the fall of the hammer through a distance of 2/8 inch; the sixth, louder sound, by a fall through 7/8 inch. In those cases in which the intensity of this louder sound was itself varied there was added a third height of fall of two inches. The succession of sounds was given, in different experiments, at rates of 2.5, 2.2, and 1.8 sec. for the whole series. The durations of the intervals following and (in one or two cases) preceding the louder sound were changed; all the others remained constant. A longer interval intervened between the close and beginning of the series than between pairs of successive sounds. After hearing the series the subject reported the relations which appeared to him to obtain among its successive elements. As a single hearing very commonly produced but a confused impression, due to what was reported as a condition of unpreparedness which made it impossible for the hearer to form any distinct judgment of such relations, and so defeated the object of the experiment, the method adopted was to repeat each series before asking for judgment. The first succession of sounds then formed both a signal for the appearance of the second repetition and a reinforcement of the apperception of its material.

In order to define the direction of attention on the part of the observer it was made known that the factors to be compared were the durations of the intervals adjacent to the louder sound in relation to the remaining intervals of the series, and that all other temporal and intensive values were maintained unchanged from experiment to experiment. In no instance, on the other hand, did any subject know the direction or nature of the variation in those quantities concerning which he was to give judgment. In all, five subjects shared in the investigation, C., E., F., H. and N. Of these C only had musical training. In the tables and diagrams the interval preceding the louder sound is indicated by the letter B, that following it by the letter A. Totals —judgment or errors—are indicated by the letter T, and errors by the letter E. The sign '+' indicates that the interval against which it stands is judged to be greater than the remaining intervals of the series, the sign '=' that it is judged equal, and the sign '-' that it is judged less.

The first series of changes consisted in the introduction of variations in the duration of the interval following the loud sound, in the form of successive increments. This loud sound was at the third position in the series. All intensive relations and the duration of the interval preceding the louder sound remained unchanged. The results of the experiment are presented in the following table.

TABLE XXVIII.

Ratio of A to Other Intervals.	**B**			**A**			**Errors**			**Total judgts.**	**Per cent. of errors**
	+	=	-	+	=	-	B	A	T		
1.000 : 0.625	2	2	2	4	2	0	4	2	6	12	50
1.000 : 0.666	4	2	0	1	3	2	4	5	9	12	75
1.009 : 0.714	5	3	0	2	2	4	5	6	11	16	69
1.000 : 0.770	5	4	0	1	1	7	5	8	13	18	72
1.000 : 0.833	1	5	0	0	0	6	1	6	7	12	50
Totals,	17	16	2	8	8	19	19	27	46	70	

The value of the interval following the louder sound is correctly reported eight times out of thirty; that preceding it is correctly reported sixteen times out of thirty. The influence which such a change in intensive value introduced at a single point in a series of sounds

exerts on the apparent relation of its adjacent intervals to those of the remainder of the series is not equally distributed between that which precedes and that which follows it, but affects the latter more frequently than the former in a ratio (allowing latitude for future correction) of 2:1. In the case of interval A the error is one of underestimation in twenty-seven cases; in none is it an error of overestimation. In the case of interval B the error is one of overestimation in seventeen instances, of underestimation in two. The influence of the introduction of such a louder sound, therefore, is to cause a decrease in the apparent duration of the interval which follows it, and an increase in that of the interval which precedes it. The illusion is more pronounced and invariable in the case of the interval following the louder sound than of that preceding it, the proportion of such characteristic misinterpretations to the whole number of judgments in the two cases being, for A, 77 per cent.; for B, 54 per cent. The effect on interval A is very strong. In the second group, where the ratio of this interval to the others of the series is 3:2, it is still judged to be equal to these others in 50 per cent. of the cases, and less in 35 per cent. Further, these figures do not give exhaustive expression to the whole number of errors which may be represented in the judgments recorded, since no account is taken of greater and less but only of change of sign; and an interval might be underestimated and still be reported greater than the remaining intervals of the series in a group of experiments in which the relation of the interval in question to these remaining intervals ranged from the neighborhood of equivalent values to that in which one was double the other. If in a rough way a quantitative valuation of errors be introduced by making a transference from any one sign to that adjacent to it (*e. g.*, - to =, or = to +) equal to *one*, and that from one extreme sign to the other equal to *two*, the difference in the influence exerted on the two intervals will become still more evident, since the errors will then have the total (quantitative) values of A 46, and B 19, or ratio of 1.000:0.413.

Next, the position of the louder sound in the series of six was changed, all other conditions being maintained uniform throughout the set of experiments. The series of intervals bore the following relative values: A, 0.900; B, 1.100; all other intervals, 1.000. The louder sound was produced by a fall of 0.875 inch; all others by a fall of 0.250 inch. The louder sound occurred successively in the first, second, third, fourth and fifth positions of the series. In the first of these forms it must of course be remembered that no interval B exists. The results of the experiment are shown in the following table:

TABLE XXIX.

Position in series	Apparent Values. B			A			Errors. B	A	T	% of Errors in tot. judg. B	A	Ditto quant. B	A
	+	=	-	+	=	-							
1				2	6	6	0	12	12		85.7		85.7
2	2	8	2	1	7	4	10	11	21	83.3	91.6	73.3	91.6
3	1	9	3	1	8	3	10	11	21	76.9	91.6	71.9	91.6
4	1	8	4	2	6	5	9	11	20	69.2	84.6	52.8	84.6
5	0	12	0	0	4	8	12	12	24	100.0	100.0	60.0	100.0
Totals,	4	37	9	6	31	26	41	57	98	82.3	90.7	64.5	90.7

Total judgments, 113; Errors (B = 31), A = 57.

The relatively meager results set forth in the preceding section are corroborated in the present set of experiments. That such a variation of intensity introduced into an otherwise undifferentiated auditory series, while it affects the time-values of both preceding and following intervals, has a much greater influence on the latter than on the former, is as apparent here as in the previous test. The number of errors, irrespective of extent, for the two intervals are: B, 82.3 per cent, of total judgments; A, 90.7 per cent. When the mean and extreme sign displacements are estimated on the quantitative basis given above these percentages become B, 64.5; A, 90.7, respectively—a ratio of 0.711:1.000.

The direction of error, likewise, is the same as in the preceding section. Since the actual values of the two intervals here are throughout of extreme sign—one always greater, the other always less—only errors which lie in a single direction are discriminable. Illusions lying in this direction will be clearly exhibited, since the differences of interval introduced are in every case above the threshold of discrimination when the disturbing element of variations in intensity has been removed and the series of sounds made intensively uniform. In case of a tendency to underestimate B or overestimate A, errors would not be shown. This problem, however, is not to be met here, as the results show; for there is recorded a proportion of 82.3 per cent. of errors in judgment of interval B, and of 90.7 per cent. in judgment of interval A, all the former being errors of overestimation, all of the

latter of underestimation.

The influence of position in the series on the effect exerted by such a change of intensity in a single member can be stated only tentatively. The number of experiments with the louder sound in position five was smaller than in the other cases, and the relation which there appears cannot be absolutely maintained. It may be also that the number of intervals following that concerning which judgment is to be given, and with which that interval may be compared, has an influence on the accuracy of the judgment made. If we abstract from this last set of results, the tendency which appears is toward an increase in accuracy of perception of comparative durations from the beginning to the end of the series, a tendency which appears more markedly in the relations of the interval preceding the louder sound than in those of the interval which follows it. This conclusion is based on the succession of values which the proportion of errors to total judgments presents, as in the annexed table.

TABLE XXX.

Percentage of Errors for Each Position.

Interval.	***I***	***II***	***III***	***IV***	***V***	
B.		83.3	76.9	69.2	(100)	Irrespective of
A.	85.7	91.6	91.6	84.6	(100)	extent.
B.		73.3	71.9	53.8	(60)	Estimated
A.	85.7	91.6	91.6	84.6	(100)	quantitatively.

Next, the relation of the amount of increase in intensity introduced at a single position in such a series to the amount of error thereby occasioned in the apprehension of the adjacent intervals was taken up. Two sets of experiments were carried out, in each of which five of the sounds were of equal intensity, while one, occurring in the midst of the series, was louder; but in one of the sets this louder sound was occasioned by a fall of the hammer through a distance of 0.875 inch, while in the other the distance traversed was 2.00 inches. In both cases the extent of fall in the remaining hammers was uniformly 0.25 inch. The results are given in the following table:

TABLE XXXI.

Ratio of Interval B to Interval A.	Interval B.[1]						Interval A.					
	0.875 in.			2.00 in.			0.875 in.			2.00 in.		
	+	=	-	+	=	-	+	=	-	+	=	-
1.000 : 1.000	0	6	0	0	4	2	0	5	1	0	0	6
0.909 : 1.000	2	4	0	0	4	2	0	2	4	2	2	2
0.833 : 1.000	0	6	0	0	4	2	4	0	2	1	3	2
0.770 : 1.000	0	6	0	2	2	2	2	4	0	4	0	2
0.714 : 1.000	0	6	0	1	5	0	6	0	0	2	2	2
Totals,	2	28		3	19	8	12	11	7	9	7	14
T.E., T.J.,	2		30	11		30	13		30	21		30
and per cent.,	6.6%			36.6%			60.0%			70.0%		

[1]Interval B in these experiments is of the same duration as all others but that following the louder sound; hence, judgments in the second column are correct.

Again the markedly greater influence of increased intensity on the interval following than on that preceding it appears, the percentage of errors being, for B (both intensities), 21.6 per cent.; for A, 56.6 per cent. Also, in these latter experiments the direction of error is more definite in the case of interval A than in that of interval B.

The influence of changes in intensity on the amount of error produced is striking. Two intensities only were used for comparison, but the results of subsequent work in various other aspects of the general investigation show that this correlation holds for all ranges of intensities tested, and that the amount of underestimation of the interval following a louder sound introduced into an otherwise uniform series is a function of the excess of the former over the latter. The law holds, but not with equal rigor, of the interval preceding the louder sound. So far as these records go, the influence of such an increase of intensity is more marked in the case of interval B than in that of interval A. It is to be noted, however, that the absolute percentage of errors in the case of A is several times greater than in that of B. I conclude that A is much more sensitive than B to such influences, and that there is here presented, in passing from intensity I. to intensity II., the rise of conditions under which the influence of the louder sound on B is first distinctly felt—that is, the appearance of a threshold—and that the rate of change manifested might not hold for higher intensities.

Lastly, the rate at which the sounds of the series succeeded one another was varied, in order to determine the relation which the amount of influence exerted bore to the absolute value of the intervals which it affected. Three rates were adopted, the whole series of sounds occupying respectively 2.50 secs., 2.20 secs, and 1.80 secs. The results are summed in the following table:

TABLE XXXII.

Ratio of Interval B to Interval A.	**Rate: 2.5 secs.**						**Rate: 2.2 secs.**						**Rate: 1.8 secs.**					
	B			**A**			**B**			**A**			**B**			**A**		
	+	=	-	+	=	-	+	=	-	+	=	-	+	=	-	+	=	-
1.000 : 1.000	2	8	0	0	8	2	0	8	2	0	2	8	0	4	0	0	2	2
0.917 : 1.000	0	8	2	4	6	0	3	8	0	0	8	3	2	2	0	0	2	2
0.846 : 1.000	1	9	0	5	4	1	3	8	0	3	7	1	6	5	0	1	8	2
0.786 : 1.000	1	10	0	11	0	0	6	6	0	7	3	4	6	2	2	2	6	2
0.733 : 1.000							4	2	0	4	0	2	4	6	0	8	0	2
0.687 : 1.000							5	3	1	6	1	2	2	6	0	7	0	1
Totals	4	35	2	20	18	3	21	35	3	20	21	20	20	25	2	18	18	11

These results are converted into percentages of the total number of judgments in the following table:

TABLE XXXIII.

Rate of Success.	**B**				**A**			
	+	=	-	Errors.	+	=	-	Errors.

2.5	secs	10	85	5	15		49	44	7	51		
2.2	"	36	59	5	41		33	34	33	67		
1.8	"	43	53	4	47		38	38	24	62		

In the case of interval A the direction of the curve of error changes in passing from Rate II. to Rate III. In the case of interval B the increase is continuous.

This increase in the percentage of error is, further, distinctly in the direction of an accentuation of the overestimation of the interval B, as is shown in the percentage of cases in which this interval appeared greater than the rest of the series for each of the three rates.

If the three rates be combined in the one set of results, the difference in the effects produced on the interval following the louder sound and on that which precedes it becomes again apparent. This is done in the table below.

TABLE XXXIV.

Ratio	**B**			**A**			**B**			**A**		
	+	=	-	+	=	-	T.E.	T.J.	%	T.E.	T.J.	%
I.	2	20	2	0	12	12	2	24	8.5	12	24	50.0
II.	5	18	2	4	16	5	5	25	20.0	21	25	84.4
III.	10	22	0	9	19	4	10	32	31.0	23	32	72.0
IV.	13	18	2	20	9	8	13	33	39.0	17	37	46.0
V.	8	8	0	12	0	4	8	16	50.0	4	16	25.0
VI.	7	9	1	13	1	3	7	17	41.0	4	17	24.0

The overestimation of the interval before the louder sound also tends to increase in extent with the actual increase in duration of the interval following that sound over the other intervals of the series.

Thus, the form which the sensible time-relations of such a limited series of sounds present is found to be intimately dependent on the intensive preponderance of certain elements within it, on the degree of increased stress which such elements receive, on their local position in the series, and on the rate at which the stimulations succeed one

another. The knowledge of these facts prepares us for the whole series of relations manifested in the special quantitative investigations reported in the sections which follow. In the first of these is presented the time-relations obtaining among the successive reactions of the various rhythm types discussed in the preceding division of this part, the section, namely, on the distribution of intensities.

In the first group of reactions the series was not to be consciously accented, nor to be divided into groups by the introduction of pauses. The reactor was required only to conceive it as a succession of two-beat groups continuously repeated, the way in which the groups should be defined, whether by counting or otherwise, being left to his own discretion. The experimental group was composed of five subjects.

The following table presents the quantitative results of an analysis of the material in series of ten successive pairs of reactions, upon the basis of unity as the value of the first element.

TABLE XXXV.

Quantities.	***I***	***II***	***III***	***IV***	***V***	***VI***	***VII***	***VIII***	***IX***	**X**
Whole Meas.,	1.000	0.894	1.035	0.912	1.000	0.877	1.070	0.877	1.070	0.841
First Inter.,	1.000	1.142	1.071	1.142	1.000	1.285	1.000	1.214	1.000	1.214
Second Inter.,	1.000	0.837	1.023	0.860	1.000	0.744	1.093	0.767	1.093	0.790

Within the limits of the calculation no progressive change appears, either of acceleration or of retardation, whether in general or on the part of individual reactors. In narrower ranges the inconstancy of the periods is very marked, and their variations of clearly defined rhythmical character. The duration of the total measures of two beats is throughout alternately longer and shorter, the average of their values presenting a ratio of 1.000:0.847. The order of this arrangement, namely, that the longer period precedes the shorter in the larger group, is drawn from the fact that measurements consistently began with the initial reaction of the series.

An analysis of the constituent intervals of the unit group, as shown in the second and third lines of the table, reveals the existence of a complex subordinate rhythm. The two components of the rhythmical

group do not increase and decrease concomitantly in temporal value in composing the alternate long and short measures of the fluent rhythm. The movement involves a double compensating rhythmical change, in which the two elements are simultaneously in opposite phases to each other. A measure which presents a major first interval contains always a minor second; one introduced by a minor first concludes with a major second. The ratios of these two series of periodic variations must themselves manifestly be different. Their values are, for the first interval of the measure, 1.000:1.214; and for the second interval, 1.000:0.764. The greater rhythmical differentiation marks the second of the two intervals; on the variations of this second interval, therefore, depends the appearance of that larger rhythm which characterizes the series. The ratios of these primary intervals are less consistently maintained than are those of the rhythmical measures built out of them. It will be noted that in both intervals there is a tendency for the value of the difference between those of alternate groups to increase as the tapping progresses. This change I have interpreted as indicative of a progressive definition in the process of rhythmization, depending on an increase in coördination and differentiation of the reactions as the series advances.

A simple stress on alternate elements was next introduced in the series, forming a simple trochaic measure repeated without interruption. The quantitative results follow, arranged as in the preceding experiment.

TABLE XXXVI.

Quantity.	***I***	***II***	***III***	***IV***	***V***	***VI***	***VII***	***VIII***	***IX***	**X**
Measure,	1.000	1.035	1.070	1.035	1.087	1.070	1.071	1.052	1.070	1.070
1st Int.,	1.000	1.000	1.111	1.000	1.055	1.111	1.166	1.111	1.111	1.111
2d Int.,	1.000	1.025	1.051	1.051	1.102	1.051	1.025	1.025	1.051	1.051

Here again there is no progressive acceleration or retardation. The rhythmical differentiation of alternate measures is very slight—the average ratio of the first to the second being 1.000:0.993—but is of the same type as in the preceding. The excess in the amount of this differentiation presented by the first type of reaction over the second may be due to the presence of a tendency to impart rhythmical character to such a series of reactions, which, prohibited in one

form—the intensive accent—finds expression through the substitution for this of a temporal form of differentiation.

In this trochaic rhythm the phases of variation in the constituent intervals of the measure are concomitant, and their indices of differentiation almost identical with each other. Their values are, for the first, 1.000:0.979; and for the second, 1.000:0.995. The higher index is that of the first interval, that, namely, which follows the accented beat of the measure, and indicates that the rhythmical change is due chiefly to a differentiation in the element which receives the stress.

In iambic measures similarly beaten out there is likewise no acceleration nor retardation apparent in the progress of the tapping. The temporal differentiation of alternate measures is of the same extent as in the preceding group, namely, 1.000:0.991. the proportional quantitative values of the measure and its constituent intervals, taken in series of ten successive repetitions, are as follow:

TABLE XXXVII.

Quantity.	***I***	***II***	***III***	***IV***	***V***	***VI***	***VII***	***VIII***	***IX***	**X**
Measure,	1.000	0.979	1.000	0.979	1.020	0.979	0.979	1.020	0.979	0.979
1st Int.,	1.000	0.941	0.941	1.000	1.000	0.941	8.082	0.941	0.941	0.941
2d Int.,	1.000	1.000	1.032	0.967	1.032	1.000	1.000	1.032	1.000	0.967

The alternation of greater and less duration in the rhythm groups is due to a variation in the time-value of the second interval only, the index of average change in the first member being zero. That is, the greater index of instability again attaches to that element which receives the stress. Though this holds true throughout these experiments, the amount of difference here is misleading, since on account of the smaller absolute value of the first interval the proportional amount of change within it which passes unrecorded is greater than in the case of the second interval.

In general, the larger temporal variations of the trochaic and iambic rhythm forms are too slight to be significant when taken individually. The evidence of rhythmical treatment in such a series of reactions, which is strongly marked in the unaccented form, nevertheless receives reinforcement from these inconsiderable but harmonious

results.

The proportional values of the variations in alternate measures for accented and unaccented elements are given in the following table, in which the figures for the trochaic and iambic forms are combined:

TABLE XXXVIII.

Interval.	***I***	***II***	***III***	***IV***	***V***	***VI***	***VII***	***VIII***	***IX***	**X**
Accented,	1.000	1.000	1.083	1.000	1.041	1.000	1.083	1.000	1.041	1.000
Unacc.	1.000	1.000	1.000	1.035	1.071	1.000	0.964	1.000	1.000	1.000

It is perhaps worthy of note that in this table a still higher rhythmical synthesis of regular form appears in the accented elements if the figures be taken in series of four consecutive pairs of reactions.

In the group of triple rhythms next taken up—the dactylic, the amphibrachic and the anapæstic—each type presents an increase in the duration of the unit group between the beginning and end of the series, but without any regular curve connecting these terms. Neither the average results nor those of the individual subjects show anywhere a decrease of duration in the progress of the tapping. The proportional results for each of the three rhythm forms, and their averages, are given in the following table.

TABLE XXXIX.

Rhythm.	***I***	***II***	***III***	***IV***	***V***	***VI***	***VII***	***VIII***	***IX***	**X**
Datyl.,	1.000	1.062	1.062	1.087	1.087	1.075	1.125	1.112	1.125	1.112
Amphib.,	1.000	1.000	1.000	1.069	1.085	1.046	1.046	1.046	1.046	1.035
Anapæs.,	1.000	1.012	1.023	1.012	1.037	1.037	1.023	1.059	1.023	1.084
Average,	1.000	1.024	1.036	1.060	1.060	1.060	1.072	1.072	1.072	1.084

When all types and subjects are thus combined the summation of these inconstant retardations presents sharply differentiated terms and a curve uninverted at any point.

A separate analysis of the components of the rhythmical group shows,

for the dactylic form, an important increase in duration in only one of the three intervals, namely, that following the element which receives accentual stress. The proportional values for these intervals follow.

TABLE XL.

Interval.	***I***	***II***	***III***	***IV***	***V***	***VI***	***VII***	***VIII***	***IX***	**X**
First,	1.000	1.153	1.153	1.153	1.153	1.231	1.193	1.193	1.231	1.231
Second,	1.000	0.917	0.917	1.000	0.917	0.917	0.917	0.917	0.917	0.917
Third	1.000	1.000	1.033	1.066	1.055	1.066	1.133	1.066	1.066	1.066

Since the progressive variation does not penetrate the whole measure, but affects only a single constituent having a strongly marked functional character, the process of change becomes unlike that of true retardation. In such a case, if the increase in duration be confined to a single element and parallel the changes in a simultaneous variant of a different order, we should regard them as functionally connected, and therefore interpret the successively greater periods of time occupied by the rhythmical measures as constituting no real slowing of the tempo. The measure of relative tempo in such a case consists in the ratios of the successive durations of the rhythmical units after the subtraction of that element of increase due to this extraneous source. Here, since the increase is confined to that member of the group which receives accentual stress, and since the increase of accentuation is typically accompanied by an extension of the following interval, the changes presented do fulfil the conditions of a progressively increased accentuation of the rhythm group, and to this origin I think it is undoubtedly to be attributed. It is to be noted that the final interval also undergoes a slight increase, while the median suffers a similarly slight decrease in duration as the series progresses.

In the amphibrachic form the changes manifested by the constituents of the unit group are more obscure. No progressive retardation of the accented element is apparent. In the initial and final intervals the difference in duration between the first and last members of the series is small and appears early in the process. If we assume the general application of the laws of change presented in the preceding section, there should be here two influences concerned in the determination of the relations presented, the factors, namely, of position and accent. The falling of the accentual stress on the median interval eliminates

one of the two factors of progressive reduction in that element and replaces it by a factor of increase, thereby doing away with the curve of change; while at the same time it decreases the changes which occur in the bounding intervals of the group by removing the accent from the first and by the proximate position of its own accent tending to reduce the last interval.

Under this same assumption there should be expected in the anapæstic form of rhythm an exaggeration of the progressive increase in the final interval, together with a further reduction in the duration of the initial; since from the falling of the accent on the final interval two factors of increase combine, while in the initial, which immediately follows the accented interval in the series, a positive factor of reduction appears. This is actually the type of change presented by the quantitative relations, which are given as proportional values in the following table.

TABLE XLI.

Interval	***I***	***II***	***III***	***IV***	***V***	***VI***	***VII***	***VIII***	***IX***	**X**
First,	1.000	0.950	1.000	0.950	1.000	0.950	1.000	1.000	1.000	1.050
Second,	1.000	1.100	1.000	1.050	1.100	1.000	1.000	1.050	1.100	1.000
Third,	1.000	1.073	1.073	1.024	1.024	1.122	1.098	1.098	1.098	1.146

Between its first and last terms the first interval shows a departure slightly less than that of the previous rhythm from the rate of change which characterizes the dactylic type; but if the average values of the whole series of intervals be taken in each of the three cases, the progressive reduction will be seen clearly to continue in passing from the second to the third form. The figures annexed give these averages as proportions of the first interval in the series.

TABLE XLII.

Rhythm.	**1st Interv.**	**Av. of all others.**
Dactylic,	1.000	: 1.188

Amphibrachic, 1.000 : 1.019
Anapæstic, 1.000 : 1.000

The relations of the various intervals in the three forms are put together here for comparison:

TABLE XLIII.

Rhythm.	**1st Interval.**	**2d Interval.**	**3d Interval.**
Dactylic,	1.000 : 1.231	1.000 : 1.000	1.000 : 1.066
Amphibrachic,	1.000 : 1.045	1.000 : 1.000	1.000 : 1.054
Anapæstic,	1.000 : 1.050	1.000 : 1.000	1.000 : 1.146

An analysis of the factors of accentual stress and of position in the rhythmical group in isolation from each other, confirms the assumptions already made as to their influence in defining the form of the rhythmic unit. Table XLIV. exhibits the series of temporal changes taking place in accented and unaccented intervals, respectively, for the three forms combined, and therefore independent of position in the group.

TABLE XLIV.

Interval	***I***	***II***	***III***	***IV***	***V***	***VI***	***VII***	***VIII***	***IX***	**X**
Accented.	1.000	1.064	1.064	1.064	1.064	1.094	1.094	1.064	1.094	1.129
Unaccented,	1.000	1.000	1.000	1.080	1.040	1.040	1.040	1.040	1.040	1.040

Similarly, in Table XLV. are given the proportional values of the series of intervals in order of their position in the group and independent of accentual stress:

TABLE XLV.

Interval	***I***	***II***	***III***	***IV***	***V***	***VI***	***VII***	***VIII***	***IX***	**X**
First,	1.000	1.043	1.087	1.043	1.087	1.043	1.043	1.121	1.043	1.121
Second,	1.000	1.000	1.000	1.043	1.000	0.956	1.000	0.956	1.000	0.956
Third,	1.000	1.028	1.028	1.055	1.028	1.083	1.083	1.083	1.083	1.083

The former table makes clear the predominance of the increase in the accented element over the average of all unaccented elements of the series; the latter shows the independence of increase in the initial and final, and of decrease in the median interval, of any relation to the position of the accentual stress. Both the intensive accentuation and the demarcation of successive groups thus appear to be factors of definition in the rhythmic unit. Those types which are either marked by a more forcible accent or separated by longer pauses are more distinctly apprehended and more easily held together than those in which the accent is weaker or the pause relatively less. It would follow that the general set of changes which these series of reactions present are factors of a process of definition in the rhythmical treatment of the tapping, and are not due to any progressive change in the elementary time relations of the series.

The figures for measures of four beats are incomplete. They show an increase in the average duration of the group from first to last of the series in three out of the four forms, namely, those having initial, secondary and final stress.

Of the relative amounts contributed by the several elements to the total progressive variation of the measures in the first form, the least marks those intervals which follow unaccented beats, the greatest those which follow accented beats; among the latter, that shows the greater increase which receives the primary accent, that on which falls the secondary, subconscious accent shows the less; and of the two subgroups which contain these accents that in which the major accent occurs contributes much more largely to the progressive change than does that which contains the minor.

When the phases of accented and unaccented elements are compared, irrespective of their position in the rhythmic group, the same functional differences are found to exist as in the case of triple rhythms. Their quantitative relations are given in the following table.

TABLE XLVI.

Phase.	***I***	***II***	***III***	***IV***	***V***	***VI***	***VII***	***VIII***	***IX***	**X**
Accented.	1.000	1.103	1.069	1.172	1.241	1.139	1.206	1.310	1.241	1.310
Unacc.,	1.000	1.083	1.128	1.169	1.159	1.208	1.169	1.250	1.169	1.169

The cause of the apparent retardation lies, as before, in a change occurring primarily in the accented elements of the rhythm, and this progressive differentiation, it is inferable from the results cited above, affects adjacent unaccented elements as well, the whole constituting a process more naturally interpretable as a functional accompaniment of progressive definition in the rhythmical treatment of the material than as a mark of primary temporal retardation.

The contribution of the several intervals according to position in the series and irrespective of accentual stress is given in the table following.

TABLE XLVII.

Interval	***I***	***II***	***III***	***IV***	***V***	***VI***	***VII***	***VIII***	***IX***	**X**
First,	1.000	1.136	1.136	1.182	1.227	1.227	1.227	1.273	1.318	1.318
Second,	1.000	1.042	1.042	1.125	1.166	1.042	1.042	1.083	1.083	1.166
Third,	1.000	1.150	1.250	1.250	1.250	1.250	1.400	1.400	1.450	1.450
Fourth,	1.000	1.059	1.059	1.147	1.179	1.147	1.179	1.294	1.206	1.179

A rhythmical alternation is here presented, the contributions of the first and third elements being far in advance of those of the second and fourth. The values of the minor pair are almost equal; of the major the third exceeds the first. Under the assumption already made this would indicate the existence at these points of nodes of natural accentuation, of which the second marks the maximum reached in the present series.

The determination of relative time-values for accented and unaccented intervals was next sought by indirect experimentation, in which the affective aspect of the experience was eliminated from consideration, and account was taken only of the perception of quantitative variations in the duration of the successive intervals. Proceeding from the

well-known observation that if every alternate element of a temporally uniform auditory series receive increased stress, the whole series will coalesce into successive groups of two elements in which the louder sound precedes and the weaker follows, while the interval which succeeds the unaccented sound, and which therefore separates adjacent groups, will appear of greater duration than that which follows the accented element, the investigation sought by employing the method of right and wrong cases with a series of changing time-values for the two intervals to determine the quantitative proportion of the two durations necessary to produce the impression of temporal uniformity in the series.

Two rhythm forms only were tested, the trochaic and dactylic, since without an actual prolongation of considerable value in the interval following the louder sound, at the outset, no apprehension of the series as iambic or anapæstic could be brought about. The stimuli were given by mechanism number 4, the distance of fall being 2/8 and 7/8 inch respectively for unaccented and accented sounds. The series of changes included extreme proportional values of 0.714 and 1.769 in duration of the two intervals. Six persons took part in the investigation. In the following table is given the percentage of cases in which the interval following the unaccented element was judged respectively greater than, equal to, or less than that which followed the accented element, for each of the series of ratios presented by the time-values of the intervals in trochaic rhythm.

TABLE XLIX.

Ration of Unaccented to Accented Interval.	**Unaccented Interval Judged to be**					
	+		**=**		**-**	
1.000 : 1.769	0.0	per cent.	100.0	per cent	0.0	per cent.
1.000 : 1.571	12.5	"	50.0	"	37.5	"
1.000 : 1.400	22.0	"	56.0	"	22.0	"
1.000 : 1.222	16.0	"	84.0	"		
1.000 : 1.118	26.0	"	74.0	"		
1.000 : 1.000	61.6	"	38.4	"		

1.000 : 0.895	100.0 "	
1.000 : 0.800	88.8 "	11.2 "
1.000 : 0.714	100.0 "	

The anomalous percentage which appears in the first horizontal row needs explanation. The limit of possible differentiation in the time-values of accented and unaccented intervals in a rhythmical group is characteristically manifested, not by the rise of a perception of the greater duration of the interval following the accented element, but through an inversion of the rhythmical figure, the original trochee disappearing and giving place to an iambic form of grouping, the dactyl being replaced by an anapæst. In the case in question the inversion had taken place for all subjects but one, in whom the original trochaic form, together with its typical distribution of intervals, remained unchanged even with such a great actual disparity as is here involved.

For this group of observers and for the series of intensities taken account of in the present experiment, the distribution of time-values necessary to support psychological uniformity lies near to the ratio 1.400:1.000 for accented and unaccented intervals respectively, since here the distribution of errors in judgment is arranged symmetrically about the indifference point. Overestimation of the interval following the louder sound appears by no means invariable. Under conditions of objective uniformity the judgment of equality was given in 38.4 per cent, of all cases. This cannot be baldly interpreted as a persistence of the capacity for correct estimation of the time values of the two intervals in the presence of an appreciation of the series as a rhythmical group. The rhythmic integration of the stimuli is weakest when the intervals separating them are uniform, and since the question asked of the observer was invariably as to the apparent relative duration of the two intervals, it may well be conceived that the hearers lapsed from a rhythmical apprehension of the stimuli in these cases, and regarded the successive intervals in isolation from one another. The illusions of judgment which appear in these experiences are essentially dependent on an apprehension of the series of sounds in the form of rhythmical groups. So long as that attitude obtains it is absolutely impossible to make impartial comparison of the duration of successive intervals. The group is a unit which cannot be analyzed while it continues to be apprehended as part of a rhythmical sequence. We should expect to find, were observation possible, a solution of

continuity in the rhythmical apprehension in every case in which these distortions of the normal rhythm form are forced on the attention. This solution appears tardily. If the observer be required to estimate critically the values of the successive intervals, the attention from the outset is turned away from the rhythmical grouping and directed on each interval as it appears. When this attitude prevails very small differences in duration are recognized (*e.g.*, those of 1.000:1.118, and 1.000:0.895). But when this is not the case, the changes of relative duration, if not too great for the limits of adaptation, are absorbed by the rhythmical formula and pass unobserved, while variations which overstep these limits appear in consciousness only as the emergence of a new rhythmic figure. Such inversions are not wholly restricted by the necessity of maintaining the coincidence of accentuation with objective stress. With the relatively great differences involved in the present set of experiments, the rhythmical forms which appeared ignored often the objective accentuation of single groups and of longer series. Thus, if the second interval of a dactyl were lengthened the unaccented element which preceded it received accentuation, while the actual stress on the first sound of the group passed unobserved; and in a complex series of twelve hammer-strokes the whole system of accentuation might be transposed in the hearer's consciousness by variations in the duration of certain intervals, or even by simple increase or decrease in the rate of succession.[6]

In the experiments on dactylic rhythm the changes introduced affected the initial and final intervals only, the one being diminished in proportion as the other was increased, so that the total duration of the group remained constant. The figures, arranged as in the preceding table, are given in Table L.

The percentage given in the case of the highest ratio is based on the reports of two subjects only, one of them the exceptional observer commented on in connection with two-beat rhythms; for all other participants the anapæstic form had already replaced the dactylic. The distribution of values which supports psychological uniformity in this rhythmic figure lies between the ratios 1.166, 1.000, 0.800, and 1.250, 1.000, 0.755, since in this region the proportion of errors in judgment on either side becomes inverted. The two rhythmic forms, therefore, present no important differences[7] in the relations which support psychological uniformity. A comparison in detail of the distribution of judgments in the two cases reveals a higher percentage of plus and minus, and a lower percentage of equality judgments throughout the changes of relation in the dactylic form than in the trochaic. This

appears to indicate a greater rhythmical integration in the former case than in the latter. On the one hand, the illusion of isolation from adjacent groups is greater at every point at which the intervening interval is actually reduced below the value of either of the internal intervals in the dactylic than in the trochaic rhythm; and on the other, the sensitiveness to differences in the whole series is less in the case of the trochee than in that of the dactyl, if we may take the higher percentage of cases in which no discrimination has been made in the former rhythm as a negative index of such sensibility.

TABLE L.

Ration of Unaccented to Accented Interval.	**Unaccented Interval Judged to be**					
	+		**=**		**-**	
1.000 : 2.428					100.0	per cent
1.000 : 2.000	20.0	per cent.	33.3	per cent	46.7	"
1.000 : 1.666	33.2	"	23.9	"	42.9	"
1.000 : 1.400	39.0	"	46.0	"	15.0	"
1.000 : 1.182	60.0	"	37.2	"	2.8	"
1.000 : 1.000	85.4	"	12.2	"	2.4	"
1.000 : 0.846	89.2	"	10.8	"		
1.000 : 0.714	100.0	"				
1.000 : 0.660	96.0	"	4.0	"		

The increase in the number of inverted forms which occur is coördinated percentually in the following table with the successive increments of difference between the accented and unaccented intervals of the group:

TABLE LI.

Rhythm.	**2.428**	**2.000**	**1.769**	**1.666**	**1.571**	**1.400**	**1.222**	**1.182**	**1.118**

Trochaic,			93.7		74.0	44.2	25.0	25.0
Datylic,	93.6	54.0		39.4		18.4		

These figures are corroborative of the preceding conclusions. The dactylic figure is maintained in the presence of much greater differences in the relative durations of accented and unaccented intervals than is the trochaic. In the latter, inversions not only appear earlier in the series, but become the (practically) exclusive mode of apprehension at a point where not fifty per cent, of the dactyls have suffered transformation. At a certain definite stage in the process the tendencies toward the two forms of apprehension balance each other, so that with the slightest change in direction of attention the rhythmical figure inverts and reverts to the original form indifferently. These points are defined, in the case of the two rhythms here reported on, by the following (or intermediate) ratios: Trochaic-Iambic, (1.400-1.571): 1.000; Dactylic-Anapæstic, (1.666-2.000): 1.000.

The temporal conditions of such equilibrium are a strict function of the degree of accentuation which the rhythm group presents. The location of the indifference point must, therefore be independently determined for each intensive value through which the accented element may pass. Its changes are given for five such increments in the following table, in which the values of the various intervals are represented as proportions of the absolute magnitudes which appear in the first, or undifferentiated series.

TABLE LII.

Intensive	Form.		1st Interval.	2d Interval.	3d Interval.
1/8	1/8	1/8	1.000	1.000	1.000
3/8	1/8	1/8	1.042	1.010	0.948
7/8	1/8	1/8	1.142	1.021	0.862
15/8	1/8	1/8	1.146	1.042	0.808
24/8	1/8	1/8	1.291	1.000	0.708

IV. THE COMBINATION OF RHYTHMICAL GROUPS IN

HIGHER SYNTHESES AND THEIR EQUIVALENCES.

In the elaboration of higher rhythmical forms the combination of formally identical groups is rather the rule than the exception, since in poetical structures the definition of the metrical form and the maintenance of its proper relations depend on a clear preponderance of its own particular unit-type over local variants. In the experimental investigation of composite rhythm forms the temporal relations of structures presenting such likeness in their constituent groups were first taken up. In the conduct of the research those differences of intensity which are actually expressed and apprehended in the utterance of a rhythmic sequence were uniformly employed. While there is no doubt that a succession of perfectly identical forms would, under the requisite temporal conditions, be apprehended as presenting major and minor phases of accentuation, yet in the expression of rhythmic relations the subordination of accents is consistently observed, and all our ordinary apprehension of rhythm, therefore, is supported by an objective configuration which fulfils already the form of our own subjective interpretation.

The temporal relations of these major and minor phases cannot be considered apart from the index of their respective accentuations. As the distribution of elements within the simple group fluctuates with the changes in intensive accentuation, so does the form of temporal succession in larger structures depend on the relations of intensity in their primary and secondary accentuations. The quantitative values hereafter given apply, therefore, only to those specific intensities involved in the experiment. Two types were chosen, the trochee and the dactyl. The series of sounds was given by successive hammer-falls of 7/8 and 1/8 inch for the major, and 3/8 and 1/8 inch for the minor phase. The distribution of time-values within each group was made on the basis of previous experimentation to determine those relations which support psychological uniformity. These internal relations were maintained unchanged throughout the series of ratios which the durations of the two groups presented. Four subjects took part in the experiment. The quantitative results in the composition of trochaic forms are given in the following tables (LIII., LIV.), the figures of which present, in the form of percentages of total judgments, the apprehension of sensible equality or disparity in the two groups.

In the earlier set of experiments the series of ratios diverged in both directions from unity; in the later it departed in one only, since every divergence in the opposite direction had, in the previous experiments, been remarked at once by the observer. In this second set the series of

differences is more finely graded than in the former; otherwise the two sets of figures may be considered identical. Using the equilibrium of errors as an index of sensible equality, the two trochaic groups are perceptually uniform when the temporal ratio of major and minor lies between 1.000:0.757 and 1.000:0.779.

TABLE LIII.

Ratio of Duration of 1st Group to 2d.	**2d Group Judged to be**		
	+	=	-
1.000 : 1.250	100 per cent.		
1.000 : 1.116	100 "		
1.000 : 1.057	100 "		
1.000 : 1.000	100 "		
1.000 : 0.895	68 "	22 per cent.	
1.000 : 0.800	25 "	75 "	
1.000 : 0.714			100 per cent.

Ratio of Duration of 1st Group to 2d.	**2d Group Judged to be**		
	+	**=**	**-**
1.000 : 1.000	100.0 per cent.		
1.000 : 0.973	87.5 "	12.5 per cent.	
1.000 : 0.870	66.6 "	33.3 "	
1.000 : 0.823	33.3 "	22.2 "	44.4 per cent.
1.000 : 0.777		50.0 "	50.0 "
1.000 : 0.735	33.3 "	33.3 "	33.3 "
1.000 : 0.694		33.3 "	66.6 "

In the dactylic form, as in the second trochaic series, ratios varying from unity in one direction only were employed. The results follow:

TABLE LV.

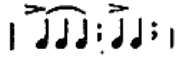
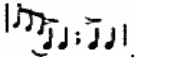
Ratio of Duration of 1st Group to 2d.	2d Group Judged to be +	=	-
1.000 : 1.000	100.0 per cent.		
1.000 : 0.946	62.5 "	37.5 per cent.	
1.000 : 0.915	33.3 "	66.6 "	
1.000 : 0.895	8.3 "	33.3 "	58.3 per cent.
1.000 : 0.800		40.0 "	60.0 "

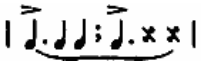
As in the preceding case, when relations of equality obtained between the two subgroups, the secondary period in every instance appeared longer than the primary. This prolongation was uniformly reported as displeasing. The distribution of values which here support psychological uniformity lies between 1.000:0.915 and 1.000:0.895, that is to say, the difference of phases is less marked than in the case of the simpler trochaic composite. This is a structural principle which penetrates all rhythmical forms. The difference in the case of both of these composites is less than in the opposition of phases within the simple group, in which for identical intensities and (practically) the same group of observers these presented the ratio 1.000:0.714. It is evident that the relative differentiation of accented and unaccented intervals due to specific variations in intensity is greater than is that of successive groups characterized by similar differences of accentual stress; and if still more extensive groups were compared it would unquestionably be found that a further approximation to equality had taken place.

In the integration of rhythmical groups this subordination of the intensive accents which characterize them is not the sole mechanism of higher synthesis with which we are presented. Another mode is the antithesis of rhythmical quantities through verse catalepsis. Such variation of the rhythmical figure can take place in two directions and in two only: by an increase in the number of constituents, giving what may be called *redundancy* to the measure, and by a decrease in their number, or *syncopation*. Each of these forms of departure from the typical figure fulfils a specific rhythmic function which determines its temporal and intensive characters, and its local position in the rhythmical sequence.

(*a*) *Redundant Measures.*—The position of such a measure is uniformly initial. On rare occasions individual observers reported an inversion of

this order in the earlier portion of the series,[8] but in no case were subjectively formulated series concluded in this way; and when the objective succession ended with the redundant measure the experience was rhythmically displeasing. In accentual stress the redundant measure is of secondary rank, the chief intensity falling upon the shorter, typical groups. Variation from the type does not, therefore, unconditionally indicate a point of accentual stress, though the two are commonly connected.

In regard to the relative duration of the redundant measure the subjective reports indicate a large variability. The dactylic form appears to be slightly longer than the trochaics among which it appears; but not infrequently it is shorter.[9] These variations are probably connected with differences in stress due to the relation which the measure bears to the accentual initiation of the whole series; for this accent apparently may fall either within the redundant measure itself or on the first element of the succeeding group, thus:  , or  .

Two rhythm forms were analyzed, the trochaic and the dactylic, the series of sounds being given by hammer-falls of 7/8 and 1/8 inch for accented and unaccented elements respectively. In each experiment full and syncopated measures alternated regularly with each other in continuous succession, giving the forms  and  .

The initiation of the series was in every case determined by chance. Six observers took part in the work with trochaic forms, five in that with dactylic. The quantitative results are given in the following tables, in each of which the relations of duration, position and stress are included.

TABLE LVI.

TROCHAIC FORM.

Ratio of 1st	**Second Group**	**Apparent**

Ratio of 1st to 2d Group.	Judged to be 2d Group			Accentuation of Second Group.			
	+	=	-	Final	+	=	-
1.000 : 1.000	55.5%	44.4%		100%	71.5%	28.5%	
1.000 : 0.946		83.3	16.6%	100	30.0	70.0	
1.000 : 0.895	66.6	11.1	22.2	100	30.0	60.0	10.0%
1.000 : 0.846	16.6	41.6	41.6	100	40.0	60.0	
1.000 : 0.800	16.6	41.6	41.6	100	40.0	60.0	
1.000 : 0.756	49.9	24.9	24.9	100	40.0	60.0	
1.000 : 0.714	16.6	41.6	41.6	100	20.0	80.0	

TABLE LVII.

DACTYLIC FORM.

Ratio of 1st to 2d Group.	Second Group Judged to be 2d Group			Apparent Accentuation of Second Group.			
	+	=	-	Final	+	=	-
1.000 : 1.000	100.0%			100%	40.0%	60.0%	
1.000 : 0.946		83.3%	16.6%	100	40.0	60.0	
1.000 : 0.895		66.6	33.3	100	20.0	80.0	
1.000 : 0.846		37.5	62.5	100	40.0	60.0	
1.000 : 0.800			100.0	100	40.0	60.0	

The syncopated measure, like the redundant, bears to the acatalectic group specific relations of duration, accentual stress, and position in the rhythmical sequence. In position it is final. This relation is independent of the factor of duration, on which the order of elements in the simple measure depends. Even the excessive shortening which occurs in the trochaic form, when the full measure has a duration

almost one and one half times as great as the syncopated, brings about no inversion of the order.

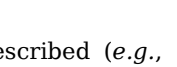
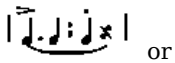
In duration the syncopated group is a shortened measure. The amount of reduction necessary to preserve rhythmical proportion with the rest of the sequence is greater in the trochaic than in the dactylic form, as in the relation of accented to unaccented elements in the simple measure it is greater than in the case of the trochaic, a principle of structure which has already been pointed out.

There is similar evidence in beaten rhythms to show that when a full measure is elided, the pause which replaces it is of less value than the duration of a syncopated measure. When trochaic rhythms were beaten out with a distinct pause after each measure, the relative values of the two intervals were 1.000:2.046. Such a pause cannot be equivalent to a suppressed beat and its interval; I regard it as functionally equal to a whole measure. If that value be allowed for the second interval which it possesses in the same rhythm type when no pause is introduced, namely, 1.000:0.920, the first two intervals will have a value—in terms of linear measurement—of 1.93 + 1.77 or 3.70. The value of the suppressed measure would therefore be 2.15, a ratio of acatalectic to elided group of 1.000:0.581.

Iambic rhythm beaten out without separating pauses presents the following ratio between first and second intervals, 1.000:1.054; on the introduction of a pause between the measures the ratio becomes 1.000:2.131. The assignment of these proportional values gives 1.68 + 1.77, or 3.45, as the duration of the first two intervals, and 1.81 for the pause, a ratio of 1.00:0.524.

In continuous dactylic tapping, the values of the successive intervals are 1.000; 0.756; 0.927; with a separating pause their relations are 1.000; 0.692; 1.346. These being analyzed as before, the elided measure will have the relative value of 0.419. This shows a decline in the proportional duration of the elision as the total value of the measure elided increases. There can be little question that this principle applies also to the value of elisions of higher rhythmic structures as well.

In intensity the syncopated measure is a point of increased accentual stress. This relation is not constantly maintained in the trochaic form, in which at one ratio the accent appears reduced;[10] in the dactylic form divergences are all in the direction of an apparent increase in accentuation. In rhythms beaten out the form of succession was always

prescribed (*e.g.*,  or  but not either at the subjects' preference), so that no material was there afforded for a determination of the primacy of particular figures; but the results must of course show any tendency which exists toward an increased accentuation of the syncopated measure. It needs but a cursory reference to the statements of these results in Pt. III., B, of this paper, to observe how constant and pronounced this tendency is.[11]

Conclusive evidence of the integration of simple rhythm forms in higher structures is presented by the process of increasing definition which every rhythmical sequence manifests between its inception and its close. This process is manifested equally in the facts of sensory apprehension and those of motor reproduction of rhythm forms. On the one hand, there is a progressive refinement in the discrimination of variations from temporal uniformity as the series of stimulations advances; and correspondingly, the sequence of motor reactions presents a clearly marked increase in coördination taking place parallel with its progress. A rhythmical form is thus given to the whole succession of simple measures which are included within the limits of the larger series, a form which is no less definite than that exhibited by the intensive and temporal relations of the rhythmical unit, and which, there can be little doubt, is even more important than the latter in determining the character of the rhythm experience as a whole.

The presentation of experimental results bearing on this point will follow the lines already laid down. Only that part of the material which is derived from the apprehension of sensory rhythm forms can be applied to the determination of this formal curve for the ordinary metrical types and their complications. The facts of progressive coördination presented by beaten rhythms are based on the repetition of simple forms only. The completion of the evidence requires a quantitative analysis of the temporal relations presented by the whole sequence of integrated measures which compose the common verse forms: dimeter, trimeter, etc. This matter was not taken up in the present investigation.

The perception of variations in the measures of an iambic pentameter line was first taken up. The series of sounds was produced by the fall of hammer, the distances traversed being, for the accented elements 0.875 inch, and for the unaccented, 0.250 inch. The series was followed by a pause equal to one and a half measures, and was repeated before judgment was made. The time occupied by the series of sounds was 2.62 seconds. The intervals between the successive

sounds were adjusted on the basis of previous experimentation concerning the most acceptable relations between the durations of accented and unaccented intervals. Their values were in the ratio 1.000:0.714 for accented and unaccented respectively. The variations were introduced in a single element, namely, the interval following the accented beat of the group, which, in this form of rhythm, is also the inter-group interval. This interval was changed by successive increments of one seventh its original value, or one twelfth the duration of the whole measure. Four such additions were made, the final value of the interval standing to its original duration in the ratio 1.000:0.636. The same series of changes in the duration of the accented interval was made successively in each measure of the pentameter series. In all these experiments the subjects were in ignorance of the character and position of the changes introduced. The results appear in the annexed table.

TABLE LVIII.

	Position in Series.				**Percentage Values.**			
Ratios.	***I***	***II***	***III***	***IV***	***I***	***II***	***III***	***IV***
1.000 : 1.000	0	0	0	0	0	0	0	0
1.000 : 0.874	4	4	4	7	40	40	40	70
1.000 : 0.777	6	6	8	10	60	60	80	100
1.000 : 0.700	6	6	10	10	60	60	100	100
1.000 : 0.636	6	6	10	10	60	60	100	100

In the five horizontal rows on the left of the table are set down the number of times, out of a total of ten judgments, the interval in question was perceived to be greater than the like interval in other groups, under the original relation of uniformity and for the four successive increments. On the right these numbers are given as percentages of the whole number of judgments. These figures show an increase of discriminative sensibility for such changes as the series advances. The percentage of correct discrimination, as it stands in the table, is the same for the first and second positions in the line, but this coincidence is to be attributed to accident, in consequence of the relatively small number of judgments on which the results are based,

rather than to a functional indifference in the two positions. I conclude that fuller experiments would show a curve of continuous increase in the number of correct judgments for the whole series of measures here included. If we number the series of ratios given above from one to five, the thresholds of perceptible change for this series of positions, expressed in terms of this numerical series, would be: I., 4.1; II., 4.1; III., 3.9; IV., 3.6.

Secondly, in a series of five trochaic measures, the intervals separating the groups—which in this case follow the unaccented beat—were successively lengthened by increments identical with those employed in the preceding set of experiments. The results are presented in the table below, arranged similarly to the previous one.

TABLE LIX.

	Position in Series.				**Percentage Values.**			
Ratios.	***I***	***II***	***III***	***IV***	***I***	***II***	***III***	***IV***
1.000 : 1.000	0	0	0	0	0.0	10.0	0.0	0.0
1.000 : 0.874	1	1	3	4	16.5	16.5	50.0	60.0
1.000 : 0.777	4	4	5	6	66.0	66.0	83.0	100.0
1.000 : 0.700	6	6	6	6	100.0	100.0	100.0	100.0
1.000 : 0.636	6	6	6	6	100.0	100.0	100.0	100.0

These results are essentially identical with those of the preceding section. The sensitiveness to small differences in duration within the rhythmical series becomes continuously greater as that series proceeds. The thresholds of perceptible change in terms of the numerical series of ratios (as in preceding paragraph) are as follows: I., 4.0; II., 4.0; III., 3.7; IV., 3.6.

Finally, the intensity of the preceding sound was increased as well as the duration of the interval separating it from the following stroke. The measure employed was the trochaic, the interval suffering change was that following the accented beat—in this case, therefore, the intra-group interval. The relations obtaining among the unchanged measures were, as to duration of accented and unaccented elements, 1.000:0.714; as to intensity, 0.875:0.250 inch. Instead of a series, as in

the preceding experiments, only one change in each direction was introduced, namely, an increase in duration of a single accented element of the series from 1.000 to 1.285, and an increase of the same element in intensity from 0.875 to 1.875 inch fall. The results are given in the annexed table:

TABLE LX.

Position in Series.	**Duration. Interval Following Louder Judged to be**						**Stress. Increased Stress.**			
	+		=		-		Times Noted.		Not Noted.	
I.	8	per cent.	92	per cent.	0	per cent.	40	per cent.	60	per cent
II.	42	"	50	"	8	"	42	"	58	"
III.	57	"	36	"	7	"	54	"	46	"
IV.	67	"	26	"	7	"	62	"	38	"
V.	30	"	40	"	40	"	60	"	40	"

The figures show that in regard to the discrimination of changes in duration occurring in intervals internal to the rhythm group, as well as in the case of intervals separating adjacent groups, there is a progressive increase in sensibility to variations as the succession of sounds advances. This increased sensitiveness is here complicated with another element, the tendency to underestimate the duration of the interval following a louder sound introduced into a series. The influence of this second factor cannot be analyzed in detail, since the amount of underestimation is not recorded unless it be sufficient to displace the sign of the interval; but if such a quantitative method be applied as has already been described, the results show a continuous decrease in the amount of underestimation of this interval from the first position to the fourth, or penultimate, which presents the following relative values: 92, 66, 50, 40. A phase of rapid increase in the amount of underestimation appears in the fifth or final position, represented on the above scale of relative values by 120. This falling off at the end of the series, which appeared also in previous experiments, can be attributed only to an interference with the functions which the several measures bear in the process of

comparison, and indicates that the accuracy of judgment is dependent on a comparison of the measure or element in question with those which follow as well as with those which precede it.

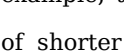
The results presented in the preceding section form the statement of but one half the evidence of higher rhythmical synthesis afforded by the material of the present investigation. We turn now to the second set of results. It deals, in general, with the quantitative relations of rhythmic forms which find expression through finger reactions. Portions of this evidence have already been presented, through motives of economy, in connection with the discussion of the phases of differentiation in intensity and duration which such beaten rhythms manifest. The burden of it, however, is contained in the results of an analysis, form by form, of the proportional mean variations which characterize these types of rhythmic expression. This method has been applied to a study (*a*) of the characters of the constituent intervals of the unit, in their relation to accentuation and position; (*b*) of the simple group which these elements compose; and (*c*) of the forms of higher synthesis manifested by the variations in successive groups. The first of these relations concerns, indeed, only the internal organization of the simple group, and has no direct bearing on the combination of such groups in higher syntheses; but, again for the sake of economy, the items are included with the rest of the material.

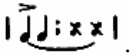
The application of such a method, as in all treatment of material by mean variations, involves much labor,[12] and on that account alone the lack of its employment to any considerable extent in previous investigations may be excused; but to this method, as it seems to me, must the final appeal be made, as an indisputable means by which all questions concerning the refined features of rhythmical organization, the definition of units and the determination of the forms in which they enter into larger rhythmic quantities, are to be settled.

Of all the possible forms of rhythmic apprehension or expression, the material for such a statistical inquiry is most readily obtainable in the form of a series of finger reactions, and to such material the application of the method in the present investigation has been restricted.

In the first experiment of this group the reactor was asked to tap out a series in which temporal, but not intensive variations were introduced; the strokes were to be of uniform strength but separated into groups of two beats. No directions as to length of pause between the successive groups were given, but the whole form of the groups was to

be kept absolutely constant. The reports of the subjects were uniformly to the effect that no accent had been introduced. At a cursory examination no intensive grouping was apparent. These records were the earliest analyzed, when only time relations were in mind, and no measurements were made of variations in strength. Only the mean variations of the intervals, therefore, will here be taken up.

A word first as to the relative value of the two intervals and its significance. The form of a rhythmical series is determined in every part by subordination to principles of strict temporal arrangement. Every suppression of elements in such a series, every rest and syncopated measure has as positive and well-defined a function as have the successive reactions and their normal intervals. If such a pause is made as we find introduced in the present case, its value must be a fixed function of the system of durations of which it forms a part, whether it replace an element in a rhythmical unit, or a subgroup in a higher rhythmical quantity. In general, the value of such a rest is less than the duration of a corresponding full measure or interval. For example, the syncopated forms  and are demonstrably of shorter average duration than the corresponding measures  and ; and the pause occurring at the close of a syncopated line—such as that in the middle of a catalectic trochaic tetrameter—should be found of less value than that of the regular foot.

In the present instance two reactions are made, a pause follows, then the reactions take place again, and so on. The intervals separating successive groups of reactions thus result from the coalescence of two periods, the interval which would regularly follow the reaction and the additional pause at its close. The value of the latter I interpret as functionally equivalent to a group of two beats and not to a single interval; that is, the rhythm beaten out is essentially quadruple, the second member of each composite group being suppressed, as follows:  .

To estimate the proper value of such a rest the average relative duration of first and second intervals was taken in a continuous series of two-beat measures, in which the first member was accented sufficiently to define the rhythmical groups. The ratio was 1.000:0.760. In the present instance the values of the simple initial interval and the composite interval which follows it are, in terms of the linear measurement, 1.55 mm. and 3.96 mm. Assuming the above ratio to

hold, the duration of a period which included the second beat-interval and a group-rest should be 1.16 + 1.55 + 1.16 = 3.87 mm. This is slightly less than the actual value of the period, whereas it should be greater. It must be remembered, however, that the disparity between the two intervals increases with initial accentuation, and in consequence the proportional amounts here added for the second interval (1.16 to 1.55) should be greater. This interval is not rhythmically 'dead' or insensitive. The index of mean variation in all reactors is greater for the first than for the second interval (or interval + pause) in the ratio 1.000:0.436, that is, the value of the latter is more clearly defined than that of the former, and the reactor doubly sensitive to variations occurring within it.

An analysis of the variations of these intervals separately in series of four groups reveals a secondary reciprocal rhythm, in which the changes in value of the mean variation at any moment are in opposite directions in the two intervals. These values in percentages of the total duration of the periods are given in the following table.

TABLE LXI.

Interval.	**1st Group.**	**2d. Group.**	**3d Group.**	**4th Group.**
First,	15.4 per cent.	26.4 per cent.	13.8 per cent.	30.3 per cent.
Second,	12.4 "	7.0 "	9.6 "	7.5 "

Without measurement of their intensive values, interpretation of these variations is speculative. They indicate that the pairs of beats are combined in higher groups of four; that the differences of mean variation in the first interval are functions of an alternating major and minor accentuation, the former occurring in the second and fourth, the latter in the first and third; and that the inversely varying values of the mean variation in the second interval are functions of the division into minor and major groups, the reduced values of the second and fourth of these intervals being characteristic of the greater sensitiveness to variations occurring in the group pause than to changes occurring within the group.

The fixity of the group is markedly greater than that of the simple interval. In the one case in which the mean variation of the group is

greater than that of the elementary period the material involved was meager (five instead of ten repetitions) and the discrepancy therefore insignificant.

The difference in the mean variation of the first and second intervals respectively rises to an individual maximum of 3.000:1.000, and averages for all subjects 2.290:1.000; the fixity, that is to say, of the inter-group interval in this form of tapping is more than twice as great as that of the intra-group interval. The fixity of the larger rhythmical quantities is greater than that of the smaller, whether the relation be between the elementary interval and the unit group, or between the synthetic unit and its higher composite. The average mean variation of the beat intervals exceeds that of the whole group in the relation of 1.953:1.000. The differentiation of larger and smaller groups is less clear. When the material is taken in groups of eight successive beats the mean variation is less in the case of every subject than when taken in fours, in the ratio 1.000:1.521. The comparative values for groups of two and four beats is reversed in two thirds of the cases, yet so that an average for all subjects gives the ratio 1.000:1.066 between groups of four and two beats. The whole series of values arranged on the basis of unity for the mean variation of the beat interval is given in Table LXII.

TABLE LXII.

Proportional.	**Single Beat.**	**2-Beat Group.**	**4-Beat Group.**	**8-Beat Group.**
M.V.	1.000	0.512	0.480	0.320

The persons taking part in the investigation were next required to make a series of reactions composed of unit groups of two beats, in each of which the first member received accentuation, a simple trochaic rhythm. In this type the relation of intra-group to inter-group interval remains unchanged. In all subjects but one the mean variation of the first interval exceeds that of the second in the average ratio 1.722:1.000. The amount of difference is less than in the preceding type of reaction. In the former there is presented not an intensively uniform series, but an irregularly rhythmical grouping of intensities, in dependence on the well-defined parallel types of temporal differentiation; in the latter such intensive differentiation is fundamental and constant in its form. Assuming the character of the second interval to remain unchanged, there is in the intensive fixity of

the initial accented element, on the one hand, and the alternate assertion of the impulse to accentuation and repression of it in the attempt to preserve uniformity, on the other, an occasion for the difference in the relation of the mean variation of this interval to that of the following in the two cases. It is to be expected that there should be less irregularity in a series of reactions each of which represents an attempt to produce a definite and constant rhythmical accent, than in a series in which such an accent is spasmodically given and repressed.

For a like reason, the difference in value between the mean variations of the elementary interval and the unit group should be less in the case of the positive rhythm form than in that of a series which combines a definite temporal segregation with an attempt to maintain intensive uniformity. The mean variation of the interval is still of greater value than that of the unit group, but stands to it in the reduced ratio 1.000:0.969.

The relations of higher groups present certain departures from the preceding type. In three cases out of five the unit has a greater fixity than its immediate compound  , with an average ratio of 0.969:1.072. The original relation, however, is reëstablished in the case of the next higher multiple, the eight-beat group, the whole series of values, arranged on the basis of unity for the simple interval, being as follows:

TABLE LXIII.

Proportional.	**Single Beat.**	**2-Beat Group.**	**4-Beat Group.**	**8-Beat Group.**
M.V.	1.000	0.969	1.072	0.859

An analysis of the material in successive pairs of two-beat groups revealed a pronounced rhythm in the values of the mean variations of the first and second members of the pair respectively, the fixity of the second group being much greater than that of the first, the mean variation having a ratio for all subjects of 0.801:1.000. The interpretation of this rhythmical variation, as in the preceding reaction series, must be speculative in the absence of quantitative measurement of intensive changes, but is still not left in doubt. The rhythmic material is combined in larger syntheses than the groups of

two beats, alternately accented and unaccented, which were avowedly in mind. This secondary grouping appears in at least a measure of four beats, into which the unit group enters as the elementary interval entered into the composition of that unit. In this larger group the initial period, or element of stress, is characterized by a greater mean variation than the unaccented period which follows it. There are present in this first interval two factors of instability: the factor of accent, that element which receives the stress, being in general characterized by a greater mean variation than the unaccented; and the factor of position, the initial member of a rhythmical group, independent of accentuation, being marked by a like excess of mean variation over those which follow it. The interpretation of the latter fact lies in the direction of a development of uniformity in the motor habit, which is partially interrupted and reëstablished with the ending and beginning of each successive group, large or small, in the series of reactions.

Further, when the material is arranged with four unit groups in each series, the same relation is found to hold between the first period composed of two unit groups and the second like period, as obtained within these pairs themselves. The mean variation of the first period of four beats is greater than that of the second in the case of all subjects but one, with an average ratio for all subjects of 1.000:0.745. The analysis was not carried further; there is, however, nothing which points to a limitation of the process of synthesis to groups of this magnitude; rather, to judge from the close approximation in definition of the two orders manifested here, there is suggested the probability that it is carried into still higher groupings.

In the next rhythmical type analyzed—the iambic form—that relation of the first to the second interval holds which was found to obtain in the preceding forms. The excess of mean variation in the former over the latter presents the ratio 1.274: 1.000. In amount it is less than in either of the previous types (2.290:1.000 and 1.722:1.000). For here, though both elements have constant relations as accented or unaccented members of the group, the factor of stress has been transferred from the initial to the final beat. Instead, therefore, of combining in a single member, the factors of inconstancy due to stress and to position are distributed between the two elements, and tend to neutralize each other. That the preponderance of irregularity is still with the initial interval leads to the inference that position is a greater factor of inconstancy than accentuation.

Also, the group presents here, as in the preceding forms, a greater

fixity than does the individual interval. This relation holds for all subjects but one, the average mean variations of the simple interval and of the unit group having the ratio 1.000:0.824.

In larger groupings irregularities in the relations of higher and lower again occur, and again the greater constancy obtains between the first and second orders of higher grouping (in which for only one subject has the lower group a greater fixity than the higher, and the averages for all subjects in the two cases are in the ratio 1.149:0.951), and the lesser constancy between the unit group and the first higher (in which two subjects manifested like relations with those just given, while three present inverted relations). The whole series of relations, on the basis of unity for the mean variation of the simple interval, is given in Table LXIV.

TABLE LXIV.

Proportional.	**Single Beat.**	**2-Beat Group.**	**4-Beat Group.**	**8-Beat Group.**
M.V.	1.000	0.824	1.149	0.951

There is also presented here, as in the preceding forms, a synthesis of the material into groups of four and eight beats, with similar differences in the fixity of the first and last periods in each. A single subject, in the case of each order of grouping, diverges from the type. The ratio of difference in the mean variations of the first and second members of the groups is, for series of four beats, 1.000:0.657, and for series of eight beats, 1.000:0.770. This indicates a diminishing definition of rhythmical quantities as the synthesis proceeds, but a diminution which follows too gradual a curve to indicate the disappearance of synthesis at the proximate step in the process.

Three-beat rhythms were next taken up and the same method of analysis carried out in connection with each of the three accentual forms, initial, median, and final stress. In these types of rhythm the intra-group intervals are more than one in number; for the purpose of comparison with the final, or inter-group interval, the average of the first and second intervals has been taken in each case.

The results agree with those of the preceding types. The mean variation of the interval separating the groups is less throughout than

that of the average group-interval. The ratios for the various rhythm types are as follows:

TABLE LXV.

Rhythm Form.	Initial Stress.	Median Stress.	Final Stress.
Ratios,	1.000 : 0.758	1.000 : 0.527	1.000 : 0.658

This relation, true of the average intra-group interval, is also true of each interval separately. Among these ratios the greatest departure from unity appears in the second form which all subjects found most difficult to reproduce, and in which the tendency to revert to the first form constantly reasserts itself. The difference in value of the mean variations is least in the first form, that with initial accent, and of intermediate magnitude in the third form when the accent is final. The contrary might be expected, since in the first form—as in the second also—the factors of stress and initial position are both represented in the average of the first two intervals, while in the third form the factor of stress affects the final interval and should, on the assumption already made concerning its significance as a disturbing element, tend to increase the mean variation of that interval, and, therefore, to reduce to its lowest degree the index of difference between the two phases. That it does so tend is evident from a comparison of the proportional mean variations of this interval in the three forms, which are in order: initial stress, 4.65 per cent.; median stress, 4.70 per cent., and final stress, 7.15 per cent. That the consequent reduction also follows is shown by the individual records, of which, out of four, three give an average value for this relation, in forms having final stress, of 1.000:0.968, the least of the group of three; while the fourth subject departs from this type in having the mean variation of the initial interval very great, while that of the final interval is reduced to zero.

If, as has been assumed, the magnitude of the average mean variation may be taken as an index of the fixity or definition of the rhythm form, the first of these three types, the ordinary dactylic is the most clearly defined; the second, or amphibrachic, stands next, and the third, the anapæstic, has least fixity; for in regard to the final interval, to the average of the first and second and also to each of these earlier

intervals separately, the amount of mean variation increases in the order of the accents as follows:

TABLE LXVI.

Interval.	Initial Stress.	Median Stress.	Final Stress.
First,	5.82 per cent.	9.95 per cent.	11.95 per cent.
Second,	6.45 "	7.87 "	9.77 "
Third,	4.65 "	4.70 "	7.15 "

In these triple rhythms, as in the two-beat forms, the simple interval is more variable than the unit group, and the lower group likewise more unstable than the higher. The series of proportional values for the three forms is given in the table annexed:

TABLE LXVII.

Rhythm Form.	Single Interval.	3-Beat Group.	6-Beat Group.
Initial Stress,	1.000	1.214	1.037
Median "	1.000	0.422	0.319
Final "	1.000	0.686	0.524

A comparison of the second and third columns of the table shows an excess of mean variation of the smaller group over that of the larger in each of the three forms. It is true also of the individual subjects except in two instances, in each of which the two indices are equal. This proportion is broken in the relation of the primary interval to the unit group in the dactylic rhythm form. A similar diversity of the individual records occurred in the two-beat rhythms.

The same indication of higher groupings appears here as in the case of previous rhythms. Rhythmical variations are presented in the amount of the mean variations for alternate groups of three beats. Chronologically in the records, as well as in dependence on theoretical

interpretation, the first member of each higher group is characterized by the greater instability. The amounts of this difference in coördination between the first and last halves in series of six beats is set down for the three rhythm forms in the following table:

TABLE LXVIII.

Stress.	First Half.	Second Half
Initial,	1.000	0.794[1]
Median,	1.000	0.668
Final,	1.000	0.770

[1]These figures are made up from the records of three out of four subjects. In the exceptional results of the fourth subject no mean variation appears in the first half and 6.3 per cent, in the second, making the average for the whole group 1.000:1.023.

There is still other evidence of higher rhythmical grouping than these oscillations in the amount of the mean variation of alternate groups. Exactness of coördination between the individual intervals of successive groups might undergo development without affecting the relative uniformity of such total groups themselves. But, throughout these results, an increase in coördination between the periods of the whole group takes place in passing from the first to the second member of a composite group. The relation here is not, however, so uniform as in the preceding case. The series of proportional values is given on page 403.

TABLE LXIX.

Stress.	First Half.	Second Half
Initial,	1.000	0.846[1]
Median,	1.000	1.064
Final,	1.000	0.742

[1] Here also the records of three subjects only are

involved, the results of the same reactor as in the preceding cases being discarded. Including this, the ratio becomes 1.000:1.016.

The index of mean variation for the individual elements of the group also shows a progressive decrease from first to last as follows:

TABLE LXX.

Stress.	Interval I.	Interval II.	Interval III.
Initial,	5.82 per cent.	6.45 per cent.	4.65 per cent.
Median,	9.95 "	7.87 "	4.70 "
Final,	11.95 "	9.77 "	7.15 "

The relation holds in all cases except that of I. to II. in the rhythm with initial stress. From this table may be gathered the predominance of primacy of position as a factor of disturbance over that of stress. Indeed, in this group of reactions the index of variation for the accented element, all forms combined, falls below that of the unaccented in the ratio 6.95 per cent.:7.91 per cent.

In rhythms of four beats, as in those of three, the estimation of values is made on the basis of an average of the mean variations for the three intra-group intervals, which is then compared with the final or inter-group interval. As in those previous forms, sensitiveness to variations in duration is greater throughout in the case of the latter than in that of the former. The proportional values of their several mean variations are given in the annexed table:

TABLE LXXI.

Interval.	Initial Stress.	Secondary Stress.	Tertiary Stress.	Final Stress.
Intra-group,	1.000	1.000	1.000	1.000

Inter-group,	0.941	0.775	0.725	0.713

This relation, true of the average of all intra-group intervals, is not, as in the preceding forms, true of each of the three constituent intervals in every case. In the second and fourth forms, those marked by secondary and final stress, it holds for each member of the group of intervals; in the first form it fails for the second and third intervals, while in the third form it fails for the last of the three.

The proportional amount of this difference in mean variation continuously increases from beginning to end of the series of rhythmical forms. This cannot be interpreted as directly indicative of a corresponding change in the definition which the four forms possess. The absolute values of the several mean variations must simultaneously be taken into account. First, then, in regard to the final pause there is presented the following series of values:

TABLE LXXII.

Stress.	**Initial.**	**Secondary.**	**Tertiary.**	**Final.**
M.V.	6.57 per cent.	9.50 per cent.	4.90 per cent.	15.70 per cent.

A very striking rhythmical alternation in the magnitude of the mean variation thus occurs according as the accents fall on the first member of the subgroups when its amount is smaller or on the second member when it is larger. Further, the cases noted above, the second and fourth forms, in which each of the intra-group intervals is severally of greater mean variation than the final pause, are just those in which the index of mean variation in the final pause itself is at a maximum.

The average mean variations of the earlier intervals thus present changes which are analogous to and synchronous with those of the final pause. Their values in proportion to the whole duration of the intervals are as follows[13]:

TABLE LXXIII.

Stress.	Initial.	Secondary.	Tertiary.	Final.
M.V.	6.98 per cent.	12.25 per cent.	6.57 per cent.	22.00 per cent.
M.V.	6.87 "	11.56 "	6.15 "	20.45 "

Those rhythmical forms having their accentual stress initial, or on the initial elements of the subgroups, are marked by a sensitiveness almost twice as great as those in which the stress is final, or on the final elements of the subgroups.

Finally, if we take the whole series of intervals severally, we shall find that this rhythmical variation holds true of each element individually as it does of their average. The whole series of values is given in the table annexed.

TABLE LXXIV.

Stress.

Interval.	Initial.	Secondary.	Tertiary.	Final.
First,	9.57 per cent.	13.23 per cent.	9.00 per cent.	11.45 per cent.
Second,	5.53 "	10.60 "	8.70 "	9.00 "
Third,	5.83 "	12.93 "	2.00 "	12.90 "
Fourth,	6.57 "	9.50 "	4.90 "	7.85 "

It is an obvious inference from these facts that the position of the accent in a rhythmical group is of very great significance in relation to the character of the rhythmical movement. The initial accent gives incomparably greater coördination and perfection to the forms of uttered (produced) rhythm than does the final. It is in this sense the natural position of the accent, because on the success and fluency of this coördination the æsthetic value of the rhythm depends.

In general, though not so unequivocally, the four-beat rhythms show a progressive increase of stability in passing from the simple interval to the group, and from the smaller group to the larger. The series of values for the four accentual positions follows.

TABLE LXXV.

Stress.	Single Interval.		4-Beat Group.		2-Beat Group.	
Initial,	7.27	per cent.	8.20	per cent.	8.17	per cent.
Secondary,	11.60	"	9.60	"	6.25	"
Tertiary,	3.20	"	3.40	"	2.25	"
Final,	10.22	"	6.30	"	6.00	"
Average,	8.07	"	6.87	"	5.67	"

Here, as in the preceding rhythmical forms, the most constant relation is that of smaller and larger groups, in which no exception occurs to the excess of mean variation in the former over the latter. The cases in which this relation is reversed are found, as before, in comparing the simple interval with the duration of the unit group; and the exceptional instances are just those, namely the first and third forms, in which the mean variation of this uncompounded interval is itself at a minimum. This means that the simple interval presents a more mobile character than that of the group; and while in general it is less stable than the latter, it is also the first to show the influence of increased coördination. Training affects more readily the single element than the composite measure, and in the most highly coördinated forms of rhythm the simple interval is itself the most perfectly integrated unit in the system of reactions.

Here, as in the preceding rhythmical forms, evidence of higher grouping appears in the alternate increase and decrease of mean variation as we pass from the first to the second subgroup when the material is arranged in series of eight beats. The proportional values of the indices are given in the following table:

TABLE LXXVI.

Subgroups	Init. Stress	Sec. Stress	Tert. Stress	Fin. Stress
1st Four,	1.000	1.000	1.000	1.000
2d Four,	0.950	0.762	0.984	0.790

The first member of the larger group, in the case of every rhythm form here in question, is less exactly coördinated than the second, the interpretation of which fact need not here be repeated. Several

additional points, however, are to be noted. The differences in stability of coördination which are encountered as one passes from the first to the last of the four rhythm forms, extends, when the reactions are analyzed in series of eight beats, to both members of the compound group, but not in equal ratios. The mean variation of the second and fourth forms is greater, both in the first and second subgroups, than that of the corresponding subgroups of the first and third forms; but this increase is greatest in the first member of the composite group. That is, as the group grows more unstable it does so mainly through an increase in variation of its initial member; or, in other words, the difference in variability of the beat intervals of the first and last subgroups reaches its maximum in those rhythmic types in which the indices of mean variation for these intervals are themselves at their maxima.

This process of coördination, with its indication of a higher rhythmical synthesis, appears also in the transformations in the value of the mean variations in duration of the total groups, when the material is treated in series of eight beats, as in table LXXVII.

TABLE LXXVII.

Subgroups.	**Init. Stress.**	**Sec. Stress.**	**Tert. Stress.**	**Final Stress.**
1st Four,	1.000	1.000	1.000	1.000
2d Four,	0.773	0.768	0.943	0.579

The total initial group, therefore, as well as each of its constituent intervals, is less stable than the second.

Within the unit group itself the values of the mean variation show here, as in the preceding forms, a progressive increase in sensitiveness to temporal variations from first to last of the component intervals. The proportional values for the four intervals in order are, 1.000, 0.786, 0.771, 0.666. The distribution of these relative values, however, is not uniform for all four rhythmical forms, but falls into two separate types in dependence on the position of the accents as initial or final, following the discrimination already made. The figures for the four forms separately are as follows:

TABLE LXXVIII.

Stress.	1st Interval.	2d Interval.	3d Interval.	4th Interval.
Initial,	9.57 per cent.	5.53 per cent.	5.83 per cent.	6.57 per cent.
Secondary,	13.23 "	10.60 "	12.93 "	9.50 "
Tertiary,	9.00 "	8.70 "	2.00 "	4.90 "
Final,	11.45 "	9.00 "	12.60 "	7.85 "

In the first type (Rhythms I. and III.) appear a descending curve followed by an ascending; in the second type (Rhythms II. and IV.) a second descending curve follows the first. The changes in the first type are not coördinated with a similar curve of variation in the intensive magnitude of the beats. It is to be noted here that the smallest mean variation presented in this whole set of results is found in that element of the first form which receives the stress, an exception to the general rule. The variations in the contrasted type have their maxima at those points on which the group initiation—primary or secondary—falls, namely, the first and third.

As in preceding rhythmical forms, while the separation of accentual stress from primacy in the series tends to increase the mean variation of that element on which this stress falls and to raise the index of mean variation for the whole group, yet the mean variation of the initial element is also raised, and to a still greater degree, reinforcing the evidence that primacy of position is a more important factor of instability than the introduction of accentual stress.

In the investigation of mean variations for units (if we may call them such) of more than four beats only a modicum of material has been worked up, since the types of relation already discovered are of too definite a character to leave any doubt as to their significance in the expression of rhythm. The results of these further experiments confirm the conclusions of the earlier experiments at every point.

These higher series were treated in two ways. In the first the reactor beat out a rhythm consisting in the simple succession of groups of reactions, each of which contained one and only one accent. These units in each case were marked by initial stress, and were composed of five, six, seven, eight and ten beats respectively. The results are given in the following table, which contains the series of mean variations in duration both for single intervals and for total groups.

TABLE LXXIX.

No. of Beats.	Acc'th Beat.	Med. Unac'th Beats.	Final Beat.	Average.	Group.
Five,	12.2 %	6.8 %	7.1 %	7.9 %	6.3 %
Six,	9.2	10.6	6.9	9.7	8.3
Seven,	7.1	5.2	7.9	5.8	3.6
Eight,	12.4	9.5	8.8	9.7	8.0
Ten,	7.5	6.6	7.3	6.8	

The averages for the combined, median, unaccented intervals are given separately from those of the final interval, for the reason that the mean variation of the latter is greater in three cases out of five than that of the former, a relation which apparently contradicts what has already been said concerning the sensitiveness to variations which marks the intervals separating rhythmical groups. The reason for this final increase in variation appears when the relative intensities of the series of reactions are considered. They are given in Table LXXX.

TABLE LXXX.

No. of Beats.	Acc. Beat.	Av. Unacc.	Final.	Pre-final.
Five,	1.000	0.543	0.518	0.500
Six,	1.000	0.623	0.608	0.592
Seven,	1.000	0.515	0.544	0.437
Eight,	1.000	0.929	0.949	0.863
Ten,	1.000	0.621	0.640	0.545

In every case the final element is marked by an increase over that which precedes it (see last two columns of table) of the average value for all rhythms of 1.000:0.900; an increase which raises it above the average value of the whole series of preceding unaccented beats in three cases out of five. To this final accentuation the increase in variation is to be attributed. Yet despite the additional element of disturbance due to this increased final stress the average value of the mean variation for this final interval is lower than that of the median

unaccented intervals in the ratio (all rhythms combined) of 0.992 : 1.000.

Turning, then, to Table LXXIX., there is presented, firstly, an excess of variation in the accented element over that of the average unaccented elements in every case but one (the six-beat rhythm in which the values are nearly identical), which for the whole series of rhythms has a value of 1.000:0.794. Secondly, in every completed case (part of the figures in the last rhythm are inadvertently lacking), the average mean variation of the single interval preponderates over that of the total group.

The second form of rhythmical tapping, in which the longer series were beaten out as pairs of equal subgroups, was added in order to determine the quantitative relations of the mean variations for alternate subgroups when such groups were purposely intended, instead of appearing in the form of unconscious modifications of the rhythmical treatment, as heretofore. At the same time the results present an additional set of figures embodying the relations here in question. They are as follows:

TABLE LXXXI.

Number of Beats.	**Intervals.**				**Groups.**			
	Acc.	**Unacc.**	**Av. 1st Half.**	**2d Half.**	**1st Half.**	**2d Half.**	**Average.**	**Total.**
Six,	27.9 %	20.9 %	23.4 %	23.0 %	14.6 %	13.3 %	13.9 %	13.8 %
Eight,	16.6	14.8	13.2	17.3	6.2	3.3	4.7	2.7
Ten,	7.9	2.6	3.4	4.0	5.9	5.2	5.5	3.1

No exception here occurs to the characteristic predominance in instability of the accented element. As regards simple intervals, the relation of first and second groups is reversed, the reason for which I do not know. It may be connected with the rapid speed at which the series of reactions was made, and its consequent raising of the threshold of perceptible variation, proportional to the value of the whole interval, to which is also due the higher absolute value of the variations which appear in both tables.

These inversions disappear when we compare the relative stability of

the first and second subgroups, in which the excess of variation in the former over the latter is not only constant but great, presenting the ratio for all three rhythms of 1.000:0.816. The characteristic relation of lower to higher rhythmical syntheses also is here preserved in regard to the two subgroups and the total which they compose.

The points here determined are but a few of the problems regarding the structure of larger rhythmical sequences which are pressing for examination. Of those proximate to the matter here under consideration, the material for an analysis of the mean variation in intensity of a series of rhythmical reactions is contained in the measurements taken in the course of the present work, and this may at a future time be presented. The temporal variations having once been established it becomes a minor point.

Such conclusions, however, are only preliminary to an investigation of the characteristic structure of the ordinary metrical forms, and to these attention should next be turned. The configuration of the common meters should be worked out both in relation to the whole formal sequence, and to the occurrence within the series of characteristic variations. There can be no question that each metrical structure, the iambic trimeter or dactylic tetrameter line, for example, composes a definite rhythmical melody within which each measure is shortened or prolonged, subdued or emphasized, according to its position and connections in the series of relations which constitute the rhythmical sequence.

These several metrical forms should be explored and the characters of each measure in the series quantitatively determined. Such an investigation would include an ascertainment of the proportional time-value of each successive measure, its average force, and its sensitiveness to variations, temporal and intensive. It should include an examination of the configuration of the single measure and the changes in distribution of accents and intervals which it undergoes as the rhythmical series advances. For the rhythm group must not be conceived as a simple unchanging form; both intensively and temporally it is moulded by its function in the whole sequence, the earlier iambic of a heroic measure being unlike the later, the dactyl which precedes a measure of finality different from that which introduces the series. Such a set of determinations will give the pure characteristic curves of our common poetical meters.

But these meters are no more simple forms than are their constituent measures. At every point their structure is subject to modification by factors which appear in the rhythmic utterance in virtue of its use as a

medium for the free expression of thought and emotion; and the manner in which the characteristic form is altered by these factors of variation must be studied. Of these variations the more important are the effects of the introduction of variants—of spondees among dactyls, of anapæsts among iambics, and the like—and the occurrence of points of origin, emphasis, interruption, and finality in special accentuations, syncopated measures, cæsural pauses and elisions. These factors influence the structure both of those measures within which they appear and of those adjacent to them. The nature and extent of this wave of disturbance and its relation to the configuration of the whole sequence call for examination.

Finally, this process of investigation should be applied to the larger structures of the couplet and stanza, that the characteristic differences in the pair or series of verses involved may be determined. These characters include the whole time occupied by each verse of the stanza, the relative values of acatalectic and catalectic verses occurring within the same stanza structure, differences in rhythmical melody between the latter forms, the variations of average intensity in the accentual elements of such lines, and a determination of the values of rests of higher and lower degrees—mid-line, verse, and couplet pauses—which appear in the various stanza forms, and their relation to other structural elements.

FOOTNOTES.

1 Description: (1) Of the psychological factors of the rhythm experience: Angell and Pierce, Ettlinger, Hauptmann, Mentz, Meumann, Stumpf, Wundt, et al. (2) Of its objective conditions and products: Binet et Courtier, Bolton, Ebhardt, Hurst and McKay, Meumann, Schumann, Sievers, et al. (3) Of its physiological accompaniments: Bolton, Brücke, Dogiel, Hausegger, Mach, Mentz, Ribot, Sherrington, Scripture, Smith, et al. (4) Of its historical evolution: Bücher, Moritz, Scherer, et al.

2 Professor Binet's doubt (*L'Année Psychologique* 1895, p. 204) that the propulsion of air from the elastic chamber and the rebound of the pen might interfere with the significance of the graphic record is more serious in connection with the application of this method to piano playing than here; since its imperfection, as that writer says, was due to the force and extreme rapidity of the reactions in the former case. The present series involved only light tapping and was carried on at a much slower average rate.

3 When the formal key-note is distinctly given, the rhythmical movement arises at once; when it is obscure, the emergence of the movement is gradual. This is a salient difference, as Bolton, Ettlinger and others have pointed out, between subjective rhythms and those objectively supported.

4 Bolton reports a similar decrease in the temporal value of the unit, and gives the following quantitative relations:

Average length of	2-group, 1.590 secs.
"	3-group, 1.380 "
"	4-group, 1.228 "
"	6-group, 1.014 "
"	8-group, 1.160 "

5 Theoretically and strictly identical; this abstracts from the coördination of such identical groups as major and minor components of a higher rhythmical synthesis, which is really never absent and in virtue of which the temporal values of the groups are also differentiated.

6 Bolton found one subject apperceiving in four-beat groups a series of sounds in which increased stress fell only on every sixth.

7 The ratios of initial to final intervals in the two cases are, for trochaic measures, 1.400:1.000, and for dactylic, 1.400 (to 1.666):1.000.

8 This was probably due to beginning the series of stimulations with the typical measure. Such beginning was always made by chance.

9 The only form taken up was the occurrence of dactylic measures in trochaic series.

10 This result is clearly irregular, and is probably due to the effect of accidental variations on a meager series of judgments. The number of these was three for each observer, making eighteen judgments in all the basis of each percentage in the table.

11 The subjective notes of the observers frequently refer to this as an explicitly conscious process, the nature of the rhythmical sequence requiring a greater stress at that point than elsewhere. Extracts are appended:

> *Trochaic Syncopation.*—"There is almost a necessity for an accent on th last beat." " ... an almost imperative tendency to emphasize the final syllable beyond the rest." "The two taps were followed by a pause and then

a tap with increased pressure." "This was not satisfactory with any adjustment of time relations so long as the stress of all three beats was the same. In attempting to make them all equal I almost involuntarily fell into the habit of emphasizing the final one."

Dactylic Syncopation.—"In this series it was easy to lay stress on the last (beat) ... this is the natural grouping; I unconsciously make such." "... of these the heavy one (accented syncopation) was much more satisfactory." "It was constantly my tendency to increase the strength of the last tap." "In this it is natural for me to make the final stroke heavy. To make the second group balance the first by equalizing the time alone is less satisfactory than by introducing elements of both time and force." "I felt that the latter part of the rhythm (unaccented syncopation) was lacking in force. Something seemed continually to be dropped at the end of each group."

The reactors frequently repeated the full measure several times before introducing the syncopated measure, which thus brought a series to its close. It will probably be found that in the actual construction of poetic measures the syncopated or partially syncopated foot is systematically introduced coincidently with points of rhythmical or logical pause.

12 In connection with this work some 48,000 individual measurements were made (for the transcription of which I am indebted to the patient assistance of my wife). Half of these were measurements of the intensity of the successive reactions; the other half, of the intervals which separated them. The former series has been employed in obtaining the averages which appear in the section on the distribution of intensities; the latter in that on the distribution of durations. The determination of mean variations was made in connection with the second series only (24,000). These quantities were combined in series of single groups, and in series of two, four, eight and ten groups, and for each of these groupings severally the mean variation of the series was computed.

13 In the second line of figures has been added the series of values of the average mean variation for all four intervals of the group.