EXPERIMENTAL STUDIES OF RHYTHM AND TIME

BY J. E. WALLACE WALLIN, PH.D.
The New Jersey State Village for Epileptics at Skillman

II. THE PREFERRED LENGTH OF INTERVAL (TEMPO)[1]

A. THE PREFERRED TEMPO AS DETERMINED BY THE METHOD OF PAIRED COMPARISON OF METRONOME CLICKS

The question as to what particular tempo, or length of interval between auditory impressions, is felt to be the most pleasing, or the most favorable for rhythmizing sounds, has been investigated by various methods, and conclusions have been reached which have not always been in complete accord. It seemed to the writer that the problem ought to be investigated afresh by means of different methods.

In the first investigation recorded here a method of paired comparison of the beats of a metronome (Verdin's make) was employed. The notches on the pendulum of the instrument were so arranged that the following speeds could be obtained by properly sliding the pendulum weight: 40, 48, 56, 63, 72, 80, 88, 92, 96, 100, 104, 108, 112, 116, 120, 124, 128, 132, 136, 140, 144, 148, 152, 156, 160, 168, 176, 184, 192, 200 and 208. A few times, as the rates of the clicks became nearly equal, the weight was moved half way between the notches, so as to halve the difference between the two rates. The half-way point was not determined precisely, but the resulting errors are probably negligible.

[1] An earlier article in this series on 'Qualitative Limens or Grades of Rhythm, and the Difference Limens in the Perception of Time,' appeared in the PSYCHOLOGICAL REVIEW for March, 1911. The remaining articles will detail the results of experiments on the estimation of the mid-points between pairs of different tempos by two methods, and the grouping of metronome clicks into the maximum number of speed categories Some of the topics discussed here will come up again in these later articles. The metronome experiments described in this article were made in 1905; the observations of the rhythmical responses in the theaters were made from time to time during 1905 and 1906.

The accuracy of the metronome was determined by means of the Hipp chronoscope and a 100-DV fork, particularly by means of the latter. A Deprez marker, electrically connected with the metronome, recorded the contacts made by the swings of the pendulum on the smoked drum of a kymograph along the time line. The metronome was allowed to click off about a dozen beats before the measurements were recorded. It was found that all the rates measured which were faster than 60 per minute were slightly too slow and that the required correction differed somewhat for different tempos. The 1.50 sec. interval (40 beats per minute) was too *fast* by .13 sec., and the 1 sec. interval by .008 sec. The following intervals were too *slow* by the amount indicated: .909 sec. (66 per minute), by .003 sec.; .833 sec. (72 per minute), by .016 sec.; .682 sec. (88 per minute), by .023 sec.; .625 sec., by .013 sec.; .50 sec., by .032 sec.: .416 sec., by .012 sec.; .375 sec., by .011 sec.; .340 sec., by .16 sec.; .320 sec., by .015 sec.; and .288 sec., by .017 sec. (These are all fork measurements, except for .416 and .625.) No measurements were made for some of the speeds selected as the most favorable; in such cases the correction found empirically for the nearest rate was used.[1]

The 'make' and the 'break' checks showed considerable regularity when each was considered separately, but the make checks were closer together than the break, except in two cases, where they were .12 sec. and .024 sec. slower (for the 1.37 and .912 speeds). The differences were as follows: .007 sec. (rate, 60 per minute), .007 (72 per minute), .012 (88 per minute), .004 (120 per minute), .027 (160 per minute), .042 (184 per minute), and .033 sec.[2] (208 per minute). The swings of the pendulum in the two directions were not therefore precisely equal; but the irregularity apparently had little

[1] In 1906 measurements were made by the fork of the rates 80, 96, 104, 112, 124, 126 and 144 (beats per minute). Each interval was found to be too slow by the amount indicated in parenthesis: .75 sec. (by .025 sec.); .625 (.021); .577 (.032); .535 (.026); .484 (.023); .476 (.033); and .416 (.25). By consulting the table it will be noticed that the correction used for .577 was .009 sec. smaller than the empirical result, and .013 too small for .416 sec. These errors are immaterial for the purpose in hand.

[2] In the 1906 measurements the 'break' records were likewise shorter by about the same amounts, except for the speeds (corrected readings) .507 and .775 sec.

influence on the subjects' judgments, for, according to the introspections, the beats were heard as regular, except for Ho for the faster speeds, by H once in the middle of a series, by I once with a slow speed, by K once or twice, and by Wa, J, E, Ea and Z, who at times heard the first few beats as irregular.

Twenty subjects served in the investigation, which was carried out at Princeton, 18 being second-year students in experimental psychology (seniors), one a graduate student in psychology and one a professor of psychology (Professor Warren).

The procedure was as follows: With their backs toward the instrument the subjects listened to pairs of different speeds of clicks, about a dozen clicks for each speed. The initial pair compared always consisted of the extreme rates, 208 and 40. To one half the 208 rate was presented first; to the other half, the reverse. The order was changed during the successive comparisons, so that during half the time the first series consisted of the faster rate and the second series of the slower rate. After having listened to the initial pair, the subjects were asked to state which tempo was preferred, or which was felt to be the more agreeable.

The next step was to compare the selected or preferred tempo with the speed adjacent to the non-preferred tempo. To illustrate: suppose that 208 was preferred to 40; 208 was then compared with 48, then, if still preferred, with 56, and so on until some slower rate was selected. The slower rate was then, in turn, compared with 200; then if preferred, with 192, etc. Each preferred rate was repeated until preference was expressed for the other member of the pair. In this way the speeds, by a series of successive approachments, grew more and more alike until finally the rates were objectively equal.

Here it is of interest to state that the point of equality was sometimes anticipated. Speeds which were objectively different were pronounced equal 16 times by 12 subjects. In half of these mistaken judgments the speeds differed by two beats per minute (the slowest pair confused being 63 and

65 and the fastest 198 and 200); in seven, by 4 beats (the extreme rates confused being 96 and 100 and 204 and 208); and in one case by 12 beats.[1] It will be observed that in all of these instances the differences in the time between the rates are decidedly above the limits of the ability to discriminate different durations of sounds, which according to Helmholtz is 1/132 and according to Exner 1/500 sec.; and that they are also larger than the threshold of difference for empty intervals. Hall and Jastrow found that a variation of 1/60 of empty intervals between clicks 4.27 sec. apart was always correctly noticed, while one of 1/120 was nearly always noticed. Our differences were from 1/30 to 1/5 sec. In the case of these confused judgments there could, in theory if not in practice, be no choice between the rates (except possibly in three cases in which the mistakes were rectified). In all cases, however, the steps were continued until the speeds became objectively equal.

After the speeds had become objectively equal, the subjects listened to about five pairs of the same speeds (without being told that they were equal), and reported their observations respecting the rates and the preference. The introspections showed that the rates were judged equal 37 times, unequal 21 times and doubtful 5 times. The rates were judged to be faster in the first series 8 times as against 14 times in the second series, indicating that the last or most frequent of series of equal sounds appear to be faster. The last series was preferred 16 times, the first 33 times, and no-preference judgments were made 28 times. It is therefore apparent that when the rates of clicks are objectively equal, the tendency is about twice as strong to prefer the first series as the second. That is, the rate which is subjectively slower is more agreeable. There were some subjects, however, who always preferred the last series, some always the first, and some changed their preferences.

These preferences while the rates were objectively equal may be compared with the relative number of preferences

[1]Twice a rate which was two beats slower than the other was called faster, and once when the difference was 8 per minute. The faster rate was judged slower five times, with the rates differing by 2, 4, 12 and 16 per minute (the latter three for I.)

for the two series before the rates became equal. The first was preferred in the gross 309 times, and the second 318. Here the tendency is in the opposite direction, but the difference is so small as to be practically negligible, as was to be expected from the fact that the time order was alternately changed. There were six subjects, however, in which the order of sequence had a considerable influence on the results. Three preferred the first series of beats about twice as frequently as the second (Ho, McD, Wa), and three just the reverse (K, J, E). With nine the number of times the first was preferred more frequently than the second, or vice versa, did not exceed three times each (C, T, L, W, H, Co, Ea, Z, Wy). While it thus appears that the constant time errors can be ruled out for the majority by alternating the series, for a considerable number this appears not to be the case.

After having listened to the same speeds, as just described, the subjects were, finally, asked to give close attention while two longer series of the same speeds were clicked off, and then to state whether they were entirely satisfied with the preferred interval they had selected. The results given in the tables (Tables I. and II.) represent these final preferences. It was found that the great majority (sixteen) were satisfied with the selections they had made, and that only four changed their preferences: three to a slightly slower speed and one to a faster one. This seems to show that the preferences were quite decided. Four stated that it was easy to arrive at a decision, two that it was usually easy, and two that it was sometimes difficult. That there were difficulties involved in making the comparisons, of which the subjects may not always have been clearly conscious, will be seen presently.

To arrive at the final choice, it was found that the subjects were obliged to change their preference on an average of 8.5 times. But the individual differences in this respect were quite considerable. Five changed less than four times (Mo, T, L, E and Z), while seven changed more than ten times (M, C, B, H, Wa, J, E).

At what point in listening to the second series of clicks was the preference made? According to the introspections,

the decision is most frequently reached in the early part of the second series. Nine so reported (one did so usually, and another did so except when the rates were close together), while three made the choice in the middle of the series and five toward the close or after the close of the series. The promptness in deciding on the preferences would seem to indicate that the judgments were largely of the *immediate type*. The subjects were asked whether their judgments were immediate; that is, based directly upon the sensory impressions, or whether they were of the reflective type. Seventeen considered that they were based directly upon the sensations, or upon the immediate effects of the excitations; and five stated that they had to reflect more or less to arrive at a choice (one between the series concerning the first series, and two when the rates approached equality).

If we conclude that the comparison judgments and choices were of the immediate type, are we then justified in inferring that the first series of sounds remained in the mind during the second or part of the second series, as after sensations or primary memories? On this point ten reported that they could easily carry or retain the first speed, two could do so fairly well, and two found it possible to ideate or image the earlier tempos. But a considerable majority—even those who said they retained the first series well—resorted to various expedients by means of which to retain or reinvisage the first tempo. Ten tapped (the first series) with the fingers, some quite frequently, some only when the rates were nearly equal, and nearly all did so with the express purpose of keeping the first series in mind (M, B, J, C, Ea, Z, Ko, Wy, I and T). Movements of the foot (by W, C and Ko) and of the head (by Mo; W, who felt his head swaying, and L, who moved unconsciously) were reported less often, three times each. One used certain muscular strains or tensions for the purpose of retaining the first rate (Wa), and one visualized a line in space for the same purpose (E). While four, on enquiry, stated that they did not vocalize the beats (W, I, H and Wa), three did (L, as 'drum, drum,' and Ko and Wy, as 'tick-tack'), and one believed that he did. This vocalization may

have been merely a tendency toward rhythmical expression, rather than an effort to reinvisage the earlier tempo. Apparently these facts warrant the conclusion that the first tempo was usually not directly (or unaided) compared with the second. The primary memories of the first series were often so vague that some means had to be invoked to revive the sensations. These means were nearly always *motor* in character. The movements or strains used served as substitutes for the first series. Vocalization would have aroused sensations of the same modality as the sensations compared, and would therefore, presumably, have proved a hindrance rather than an aid. The comparisons were then, at times, simultaneous rather than successive. The second tone series was compared with a substitute series of sensations (motor) going on at the same time.

The further consideration of the results may conveniently be made in connection with the following numbered conclusions:

1. We find a very general tendency to subjectively rhythmize periodic auditory impressions of the same intensity, provided the rates are not too slow or too fast. Only two of our subjects failed to rhythmize the beats (McD and H). Two got no rhythm at the beginning of the series (J, T); one got none when he tried to base his judgments on 'pure sensation'; two got none when the rates were very slow or very fast (L, Co); another when they were very slow (T); and one did not get any rhythm for 'some speeds.' One experienced rhythm a few times only, with the slow beats. Three got rhythms with the slow beats more readily than with the fast (Mo, M, Co), and two the reverse (Ho, Z). One asserted that he apprehended all rates as rhythmical. Within the limits of 208 and 40 sounds per minute there is thus no uniform or very clearly marked tendency. Five reported that they perceived rhythms although the beats were apprehended as equally loud, or without accent (Ko, R, Ea, Wa; Co, sometimes; Wa visualized the measures in the form of two long strokes, ——).

The dominant pattern was the trochee (— ⏑). This was

obtained by nine subjects (Ho, K, Co, Mo, T, L, J, Z and Wy). The iambic was reported by five (M; Ho, sometimes with the faster rates; B, with all rates; Co, and I. I, however, was not certain). C obtained ⏑ ⏑ — with very slow rates.

In order to ascertain the basis of the subjective rhythms, some of the observers were asked whether they noticed any qualitative difference in the tones from the two swings of the metronome pendulum for any given rate. Three felt that there was a slight difference, without being able to designate what it was (B, H and L); one perceived a difference in loudness (M); one in resonance (Wa); one heard one beat as more muffled (W); four remarked a pitch difference (I; J; H, especially with the slow rates; Co heard the second series with slow rates in a higher pitch, and the first series with fast rates); one "thought of the click on the left side as suspended and on the right side as finished"; and two did not perceive any difference. These qualitative differences were undoubtedly at the basis, at least in part, of the felt subjective rhythm. The pitch element of emphasis, surprisingly, plays the dominant rôle. It has been shown elsewhere that pitch may substitute for the elements of loudness or duration in speech centroids.[1] The metronome used is not now available, and I cannot say whether there was any objective pitch difference in the two clicks. Such differences, if they existed, were probably very small, since many subjects made no mention of them.

The main results will be found in accord with Bolton's findings; he found the same general tendency toward subjective rhythmization and preponderance of the trochee pattern.

2. It is the exception rather than the rule that different interval lengths between objectively equal sounds are felt as indifferent or neutral. One of two contrasted rates or tempos is usually preferred to the other. There were only 17 instances by ten subjects in 700 or more comparisons in which no preference was expressed. This is no doubt

[1] Wallin, 'Researches on the Rhythm of Speech,' Studies from the Yale Psychological Laboratory, 1901, IX., pp. 9–23.

partly due to the fact that the task confronting the subjects was the expression of a choice, although the subjects were not told that no-preference judgments were barred. Granting the force of this criticism, the conclusion will probably hold, that different rates of auditory impressions tend to arouse favorable or unfavorable attitudes in the listener. An analysis of the records enables us to formulate the following rule regarding neutral and doubtful judgments: intervals tend to arouse an indifferent judgment either when they are barely different or when they are very noticeably different; but, while most of the *neutral* reactions are obtained when the rates are nearly alike, most of the *doubtful* judgments are rendered when the rates are very different. Thus there were ten no-preference judgments rendered when the difference between the compared rates was 8 clicks per minute or less (half of these were four) and only 6 when it was greater (namely, 28, 48, 52, 55, 73 and 88 per minute); but there were only two doubtful judgments when the difference was 8 or less as against 16 when it was greater [namely, 16 (by four), 20 (by three), 28, 29, 32, 56, 60 (by two), 61, 64, 72, 77, 80, 81 (by two), 84, 96, 100, 108, 116 (by two), 120, 136 and 168 per minute]. One subject was responsible for nine of the doubtful judgments (Wa), two for six each (Co, E) and two for four each (Ko, Wy). This shows that only a few subjects felt uncertain about a preference, and reinforces the conclusion reached.

3. With objectively similar metronome clicks the preferred tempo for all subjects averaged .519 sec. (see Table I.). or approximately one half second (the median, .579 sec., is higher than the average).

There are, however, considerable individual differences in the preferences. The preferred rates ranged from 1.370 to .305 sec., which makes a difference of 1.065 sec. These are the extreme rates afforded by the instrument, so that it is possible that still slower or faster rates might have been selected. Neither of the extremes seems to possess any advantage. During the initial comparison between the extremes, 40 was preferred 11 times to 208 nine times. But

it is only rarely that either is finally selected; it happened only with 15 per cent. of these subjects. There were only two rates that were preferred twice each, namely .630 sec. (by E and McD) and .305 sec. (by Mo and T).

It is, therefore, difficult to trace any definite *central* tendency in respect to tempo preferences of very wide applicability—because of the varying factors that determine the choice, as we shall see—but we can recognize *types* of subjects. The results can be arranged readily into four groups, according as the preferred tempos exceed 1 sec., fall between 1/2 and 3/4 sec., and fall somewhat short of 1/2 sec. and of 1/3 sec. These four groups may be referred to as *slow*, *medium*, *fast* and *rapid*. The average speed for the slow is 1.169 sec; for the medium, .618 sec.; for the fast, .435 sec.; and for the rapid, .319 sec. Of these values, the medium interval length, which is approximately .60 sec., is evidently the most representative. It is obvious that the faster rates are preferred to the slower, since all but four selected a faster rate than .70 sec., and all except eight a faster rate than .61 sec. To what extent the arrangement of the steps on the metronome pendulum is responsible for these preferences was not determined. The metronome gave 24 speeds faster than .70 sec. (88 per minute) and only 6 slower. But when the records are analyzed it is found that the slower of the pairs of rates was selected in the aggregate by the twenty subjects 351 times, while the faster were selected only 280 times. Thus the 'weighting' of the fast end of the pendulum was overcome, very largely if not entirely, by the more abundant selections of the slower tempos.

If we accept a rate of from .50 to .60 sec. as the most probable value, or the value which will most frequently be obtained, for the preferred tempo, our result will harmonize with a number of earlier findings. Vierordt found a 'neutral' or 'adequate' interval which averaged .62 sec. Wundt's 'indifference' interval averaged .60 sec.; Stevens' interval which could be reproduced the most accurately ranged from .53 sec. to .87 sec. (Johnson, however, experimenting with practice and fatigue, found no indifference point from which

variations did not occur.) In speech it has been found that the average length of the 'complex centroid intervals'[1] is .58 sec.; and that speech series which consist of 'three-syllable sound centroid intervals,'[2] and which average .65 sec., are the most regular or periodic. Speech intervals, because speech is one of our constant psychomotor activities, ought to exercise an important influence upon the selection of the preferred rate. Reference may also be made to measurements of the most favorable period for subjective rhythmization which, according to Martius' result, is 0.50 sec. This coincides with our general average, while Meumann's favorable period for subjective rhythm is somewhat less, .40 sec., and Bolton's considerably more, 1 sec. This wide difference in the findings is probably dependent upon the varying nature of the factors which influence subjective rhythm (see points 4 and 5). Bolton found that subjective rhythmization did not occur when the interval was longer than 1.59 sec. If we assume that an interval will probably not be preferred if it is longer than the limit of subjective rhythmization, it will be noticed that the extreme rate employed in our metronome experiment falls about one fifth second short of the 1.59 sec. limit.

4. The factors which influence the preference for a given rate are numerous and vary more or less with the individual and with the circumstances of the occasion, which accounts for the wide difference found among various individuals. The introspections indicated that one or more of the following factors were operative with one or another observer: physiological irritation or pain, mental disquietude, annoyance, irritation, impatience, or repose; the strain of suspense or expectation, the effort of attention to follow, stimulation to movement, breathing, rhythmical tendency, harmoniousness or discord (tendency to harmonize with ideal beats, tunes, keeping time, preconceived rhythms, suggestions), temperament and associations and suggestions.

[1] The interval from one accented syllable to another, including pauses: cf. Wallin, 'Researches on the Rhythm of Speech,' Studies from the Yale Psychological Laboratory, 1902, IX., 118.

[2] Wallin, as cited, 104 and 110.

The most frequent objection against the slow, or very slow, rates were that they dragged and thus produced a feeling of suspense and a tendency to hurry (B, Mo, C, L, H, W, Wy and I). Three found that they irritated them or made them feel uneasy (K, Mo and Ea), one that they caused a pain in the ear (Mo), and one that they interfered with the breathing (Wa). It is noticeable that only one of these selected a rate faster than .705 sec. While three reported that the slow beats were smoother or firmer (M, J, Ko), and three that they gave a better sense of rhythm (M, Mo, Co), none of these selected a rate slower than .673 sec., while three selected 'fast' and 'rapid' rates.

The most frequent objections to the rapid, or very rapid, rates were that they were irritating or annoying (B, I, M, W), that they were too hurried (J, K, Wy), and that they required too much effort to follow (B, H, L). One found that they produced a headache (W), one that they 'hurt the head' (I), and one that they made the ear throb (Z). Two found them unrhythmical (J, C). They were jerky (Ko), discordant (C), or aroused unpleasant associations (Z, who says he is temperamentally slow), or it was difficult to carry a tune with them (Co). It is noticeable that three of these subjects, notwithstanding the objections, selected relatively fast rates. One found them livelier and more harmonious, and, consistently with these judgments, selected the most rapid tempo (Mo).

The subjects were asked whether they noticed any difference between the faster and the slower series. Three said that the faster seemed louder (K, McD, B), four the opposite (M, Mo, T, J), two that the faster were more distinct (B, Z), three that they were higher in pitch (T, E, Z), one that they made a different noise (I), and three that there was no difference (L, Wy, Ea). None of these factors seems to have exercised any influence upon the selection of the preferred interval.

Aside from the above factors which militated against the selection of rapid or slow rates, the following were the reasons given for selecting the particular rate that was chosen: it

caused the least disturbance or irritation (Wy, Ho), it was the easiest to follow (B, L), it seemed like the average time in music (McD), it gave the most pleasing rhythmical impression (L, who sought a rate that would 'fall into a chord'), it enabled the subject to carry two or three tunes (Co), it was more natural and enabled the subject to keep time to it better (I), it coincided with an 'ideal beat in the head' (Ho), and it fell in with the subject's temperamental disposition (Z).

Listening to the clicks frequently aroused suggestions, associations and images of various kinds which, no doubt, subtly influenced the preference. The faster rates suggested annoying machinery, pile drivers and steam engines, to Z and the slower a swinging pendulum, which was probably more pleasing, as he selected a slow rate. K also imaged a swinging pendulum, but he felt that it was too slow and selected a faster rate. Most frequently imaged was a clock, or the tick-tack of a clock. Of the five who did so (Wa did so only 'indirectly'), all chose slow speeds except one (Z, Ea, Wy, B, K). One imaged telegraph clicks and machinery, (Mo), and another the tick of a clock, which appealed to him, but also the clatter of horses in a race, which appealed more to him (Ko), and both chose rapid rates. One imaged through the test the stone cutters' hammers, chisels and clicks which he had observed before he had entered the laboratory; but for this he felt that he would have chosen a slower rate. He came into the laboratory with a certain set or attitude induced by the experience of the moment, and this determined his choice. One associated his preference with keeping time, singing, the movements of the hands of cheer-leaders and the heart beat, and accordingly chose a fast rate (I). One imaged a man pounding an anvil (Ea), one the ringing of a bell (Co) and one a machine (McD); what influence these suggestions had cannot be said, as the rates of operation for these objects may differ considerably. Sometimes the imagery will change. Thus E first visualized a figure eight motion for the slow ones; then (usually) the motions of a hammer, which sometimes struck higher, and once toward the close a curved hill, with the hammer moving from one part of the

hill to another. W once had an image of a man hammering on an anvil. When the beats were too slow or too fast they were not in unison. He also imaged a hammock; at the beginning he preferred long and slow swings (the records show that he selected the 40 rate three times) and a soothing rate; at the end the hammock was tossed so that it struck at both top and bottom, which made him feel seasick. It was then evidently moving faster; the rate which he selected was .687 sec. These instances indicate that form of imagery and the associations of the moment sometimes exercise a dominant influence upon the preference of tempos. Since the preferred rate depends upon so many and varied factors it seems doubtful whether we shall be able to lay down any *norm* for series of objectively similar sounds, except within wide limits.

5. Apparently there is no definable relation between any particular tempo preference and *musical capacity*, or the ability or inability to sing or play; but the preference seems to depend on the relative predominance of the melodic or harmonic elements or the rhythmic element in one's musical appreciation. Of the subjects who were interrogated, five said that they did not sing, and of these, three are in the medium group (W, E, McD), one in the fast (I), and one in the rapid (Mo). Five sang, two of these being in the medium group (J, M), one in the fast (Ko), and one in the rapid (T). Five sang a little, two being in the slow group (Ea, Wy), two in the medium (E, McD), and one in the fast (Mo). Of those asked, nine said they could carry a tune, three being in the slow group (Z could whistle a tune), two in the medium (J, E) and four in the fast (I, if a crowd was singing). One could not carry a tune (Mo, rapid tempo). Six played an instrument (usually the piano), two being in the slow group (Q, Wy), one in the medium (W), two in the fast (K; C, violin), and one in the rapid (Ho). Five played a little, three being in the medium group (B, Wa, L), one in the fast (Co), and one in the rapid (T). Of the seven who did not play, one was in the slow group (Ea), four in the medium (E, McD, M, K), one in the fast (I), and one in the rapid (Mo). There does not exist, therefore, any clear evidence of correlation between

the favored rate and the ability or inability to carry a tune, to sing, or to play.

A few of the subjects were asked to state which element they enjoyed most in music, the melody, harmony or rhythm. Three preferred the air or melody (Z in piano music), two of these selecting slow rates (Z, Ea), and one a medium rate (J). Two preferred the harmony (Z in orchestra music), both being in the slow group (Z, Wy). One, in the medium group, preferred these two elements to the rhythm (Wa). Three preferred the rhythm to either of the other two elements, and all of these selected fast rates (Co, I, Ko). We may therefore conclude that those persons who chiefly enjoy the melody and harmony in music will favor medium or slow tempos, and those who prefer the rhythm will select fast tempos.

B. The Preferred Tempo as Determined by a Method of Expression (Timing the Spontaneous Responses to Music in Theaters)

In order to study the tempo preferences under the best conditions, we must have recourse to musical rhythms. Certain musical rhythms spontaneously evoke motor tendencies, such as swaying of the body, moving the hands or fingers, chewing (gum), and especially stamping the feet in time with the music. What rates of rhythm or musical tempos tend to produce the most hearty or vigorous motor expressions, the loudest or most diffuse stamping in an audience of unsophisticated people? It may be assumed that the more vigorous the motor responses for a given rhythmical rate, the stronger is the preference for that particular rate.

In order to study the problem by this method to the best advantage, frequent visits were made to the galleries of theaters. The galleries are usually peopled by men and boys who, unaffected by the conventional restraints of the cultured theater patron, allow their feelings to find vent in spontaneous expressions. Accordingly the responses (stamps of the foot) made to different vocal and instrumental selections and stage dances were timed by means of a stop watch, or, in some cases,

an ordinary watch. The timing continued as long as the responses continued at the same intensity for a given selection. The total number of seconds elapsed was divided by the total number of stamps counted, in order to obtain the average interval length between the stamps, *i. e.*, the average tempo. It is possible that in some cases there was more than one response to a measure, so that the rate of the stamps may not always coincide with the duration of the measure, but the records were not made carefully enough to make it possible to work out the distinction with accuracy. The writer also regrets that, having only a slight expert knowledge of musical technique, he is unable to detail the results for the different kinds of musical measures or the different varieties of movements. Nothing has been attempted in this direction beyond grouping separately some of the 2/4 and 3/4 times (Table IV.). It is possible that there may be some inaccuracies in this grouping, as the writer was not always able to recognize the patterns with complete certainty. The problem invites further attention from a psychologist with a technical musical training. There remains to consider the relation of different tempo preferences to different kinds of vocal and instrumental music, to different kinds of dances, to different kinds of measures, and to different kinds of movements of the same measures. In this study the responses were timed during vaudeville, burlesque, minstrel, light opera and glee club performances.

Results.—1. It was possible to grade the responses into four classes, according to the loudness of the stamps or the pervasiveness of the tendency (*i. e.*, the number of persons who fell to beating time). Sometimes the tendency was pervasive although the stamps were not especially loud. These grades are referred to in Table III., as very good (I., a vigorous or pervasive tendency to stamp), good (II.), fair (III). and poor (IV., a feeble tendency to beat time). The average speeds of the responses for these grades are, respectively, .51, .56, .59 and .66 sec., and the general average .58 sec. This gives a difference between the successive groups of .05, .03 and .05 sec., or a difference of .15 sec.

between the best and poorest responses. The differences, in all cases small, are approximately constant from group to group.

2. It is noteworthy that the average for the most vigorous responses evoked by music corresponds precisely with the average for the preferred tempo with metronome clicks (.51 sec., cf. p. 210). It also appears that the averages for the four grades of response to the musical rhythms (from .51 to .66 sec.) correspond quite closely with the most probable value found above for the preferred tempos with metronome clicks, viz., from .50 to .60 sec. (p. 211).

3. Owing to the fact that the large and the small counts may not precisely neutralize one another in the general average, the relative distribution of the averages in ten seconds groups may furnish better indices of the preferred rates than general averages. A comparison of columns (1) to (10) in Table III. shows that the highest number of averages in any of the ten seconds groups is forty; viz., for the rates lying within .41 and .50 sec. This is followed by 32, for the .51 to .60 sec. group, and 26, for the .71 to .80 sec. group. Only ten averages come between .30 and .40 sec.; only twelve between .81 and .90 sec.; and only four between .91 and 1.00 sec. More averages (viz., 50) lie below .50 sec. than above .70 sec. (viz., 42), while the largest number comes between .51 and .70 sec. (viz., 55). It will be noticed that, although there is a large number of averages coming within our most probable value for metronome clicks (.51 to .60 sec.), the greatest number comes within the limits of .41 and .50 sec. This applies particularly to the best grade of responses, grade I., where fifteen averages come within these limits, as against nine between .51 and .60 sec., and none whatever above .80 sec., and where the majority of the averages lie between .41 and .60 sec. (viz., 24, as against a total of 18 for all the other groups). For both the second and third grade of responses, the majority of the averages are contained in the three groups extending from .41 to .70 sec. For grade II. 24 averages come within these limits, as against 18 elsewhere; and for grade III. the proportion is 22 to 8.

These facts, therefore, would seem to warrant the conclusion that the most probable limits within which the preferred tempo will come are .41 to .70 sec. This is larger by about ten seconds on either side than the most probable limits found for the metronome clicks (p. 211). All the above facts, when considered in the light of the additional experimental data cited on page 211, indicate that for most persons under oridnary conditions *auditory rates or musical tempos varying in speed from .40 to .70 sec. will be preferred*, with a pronounced tendency to choose rates toward the faster end of these limits. That the faster rates call out the strongest responses, or preferences, is indicated particularly by the distribution of the averages in the best grade of responses, grade I. We have already pointed out that the tendency with metronome beats is likewise to prefer the faster rates (p. 211).

4. As with metronome clicks, there is a considerable range between the extreme rates which evoked responses. The fastest responses measured averaged .27 sec. (grade III.), and the slowest 1.00 (grades II. and III.). Here the range, however, is smaller than the range for the clicks (from .305 to 1.37 sec.). The fact that fast and slow rates are found in all grades indicates that the preference, or the vigor of the response, is not dependent entirely upon the tempo. The catchiness and familiarity of the music, the distinctness or incisiveness of the accent and the character of the measure, are also important factors. Musical airs which are not catchy will incite to less response than catchy selections, although the tempo is the same. Tempos with barely perceptible accentuation will produce feebler motor reactions than rhythms with a decided accent. Likewise the swing required in waltz music demands a tempo which would be forbidding with other musical patterns. The responses for 3/4 time are uniformly slower than for 2/4 time (Table IV.), the differences for the corresponding grades amounting to .14, .11 and .14 sec. The slowest recorded average for the 2/4 time, .53 sec. for grade III., is faster than the fastest average for the 3/4 time, .62 sec. for grade I. The best rate for 3/4 time, according to these results, is .62 sec.; and for

the 2/4 time, .48 sec. Most of the former patterns were probably waltz times, and most of the latter two-steps.

There are also other factors which account for the distribution of the same tempos in the different grades of response. Sometimes the measurements were made under unfavorable conditions; rainy nights at times made the audience small and unresponsive; and sometimes there were few children present. Tempos which were rated as low on these nights would probably have received a higher rating if the conditions had been propitious.

TABLE I

PREFERRED TEMPOS WITH METRONOME RATES (FINAL SELECTION)

Subject	Beats per Minute	Corrected Length of Intervals in Seconds
Ho	179	.348
K	110	.566
M	108	.577
McD	98	.630
C	156	.395
Mo	208	.305
B	88	.705
T	208	.305
L	116	.536
W	90	.687
H	107	.582
Wa	104	.60
J	92	.673
Co	128	.484
E	98	.630
Ea	48	1.18
Z	40	1.37
Ko	144	.428
Wy	63	.958
I	142	.434
Ave		.519

TABLE II

PREFERRED TEMPOS ARRANGED INTO FOUR GROUPS

I. *Slow*

Subject	Corrected Interval Length Seconds
Z	1.370
Ea	1.18
Wy	.958
Ave	1.169

II. *Medium*

B	.705
W	.687
J	.673
E	.630
McD	.630
Wa	.600
H	.582
M	.577
K	.566
L	.536
Ave	.618

III. *Fast*

Co	.484
I	.434
K	.428
C	.395
Ave	.435

IV. *Rapid*

H	.348
Mo	.305
T	.305
Ave	.319

TABLE III

RHYTHMICAL RESPONSES (STAMPS) TO MUSIC IN THEATERS

Grade.	No.	Ave. Sec.	S	L	R	Distribution of Averages.									
						(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
I., V.G.	42	.51	.34	.76	.42	7	15	9	5	6	0	0	22	6	14
II., G.	49	.56	.40	1.00	.60	1	12	11	10	7	5	2	13	14	21
III., F.	32	.59	.27	1.00	.73	1	7	9	6	4	1	2	8	7	15
IV., P.	27	.66	.40	.90	.50	1	6	3	2	9	6	0	7	15	5
Ave.		.58													
Total						10	40	32	23	26	12	4	50	42	55

Grade, grade of response: I., very good (loud stamps); II., good; III., fair; IV., poor (weak stamps). No., number of series measured. The shortest series contained seven stamps; the longest 108; the majority, from 30 to 50 stamps. Ave., average time of interval between the responses, in seconds.

S, shortest average for any series. L, longest average. R, range between the longest and shortest averages.

(1) Number of averages falling between .30 and .40 sec. (2) Ditto, between .41 and .50 sec. (3) Do., between .51 and .60 sec. (4) Do., between .61 and .70 sec. (5) Do., between .71 and .80 sec. (6) Do., between .81 and .90 sec. (7) Do., between .91 and 1.00 sec. (8) Do., below .50 sec. (9) Do., above .70 sec. (10) Do., between .51 and .70 sec.

TABLE IV

Grade.	Time of Responses in ♩ Time.		Time of Responses in ♪ Time.		
	No.	Ave. Sec.	No.	Ave. Sec.	D
I., V.G.....	13	.62	15	.48	.14
II., G.	20	.64	9	.53	.11
III., F.	12	.67	4	.53	.14
IV., P.	13	.73	0		

Explanation of signs: see Table III. D, difference (amount by which ♪ is shorter than ♩ in the corresponding grade).