# THE DYNAMICS OF SPIRAL MOVEMENT IN MAN

by

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# THE DYNAMICS OF SPIRAL MOVEMENT IN MAN.

## Introduction

The science of Psychology aims to predict and control human behavior. In order to achieve these purposes, psychologists have approached the study of behavior in devious ways. Some have considered human activity the functioning of a machine, and attempted to understand it by investigating its isolated parts. Others have attempted to identify faculties which appeared to control behavior. Still others have regarded behavior as a series of reflex acts and as the unfolding of inherited patterns of response. These diverse approaches to the study of "human nature" have yielded such concepts as association, mental chemistry, attention, the act, the self, the conditioned reflex and many others. In spite of these numerous attempts, the goal of prediction has not been achieved. Some maintain that we must refine our techniques. Others are bold enough to assert that our presuppositions are incorrect and that our methods, as a result, are sterile.

To the latter group a new and apparently more fruitful methodology has been opened up by modern discoveries in the field of relativistic dynamics (11). Just as the conception of the universe as an organic system simplifies many of the problems of the astronomer and physicist, so to the psychologist, the conception of behavior as the dynamic resultant of field forces offers a new and fruitful method of approximating the aims of prediction and control of that behavior. (30,31,17) The assumptions of this approach are: (1) natural phenomena are systems, organized in space and time, an assumption conceded by relativistic physics (21, 20). (2) Organization implies that the system is integrated toward some future or 'goal'. (14, 39, 31) (3) The presence of future ends within the system demands that there will be activity, which will occur in the shortest (or longest) possible route toward that end, as the system attempts to gain equilibrium. (4) All activity within the system will be controlled by the system as a whole, so that if the forces within the system are considered as vectors, the resulting activity will be a resultant of those forces (17, 30). (5) Since the whole is organized it must have uniform, complementary laws. Thus the laws which apply to the activity of one part, will apply to the activity of any part. These are laws of dynamics given an organismic interpretation. (30)

Applying these implications to the study of behavior it becomes obvious that insofar as we are able to measure the forces (vectorial) determining behavior, we will achieve our goal of prediction, and insofar as we can control those forces, we will be able to control behavior. Herein lies the purpose of the present study. The principles which are discovered under the present conditions will be transposable, theoretically, to behavior in general, or to any particular example of behavior in which we are interested.

## Purpose of the Experiment.

The aim of the experiments herein reported is further insight into the dynamics of gross human behavior, obtained from a functional analysis of walking.

Walking was selected as the means of achieving this purpose because:

1. It is one activity in which the entire organism is obviously involved. According to our assumptions, the entire organism is involved in every act, since the activity of any part of a system affects the entire system (1).

2. The conditions of walking can be easily controlled.

3. The form of the activity (the subject's course) can be objectively observed and studied. According to our assumptions all behavior is patterned in accordance with dynamic principles. (Law of least action, closure, symmetry, etc.) In this experiment we are standing outside of the responding organism and are observing the pattern of its behavior under different conditions of field structure.

## History

A history of the problem falls naturally into two divisions; studies of walking and studies in dynamics.

All of the studies on walking have a common conclusion. If people walk, deprived of the ordinary means of orientation, they follow a spiral path. It is a common knowledge that a man lost in the woods, or in the dark or fog will walk in circles until he regains his orientation. Similar behavior has been observed in protozoa (23), birds, mice (8), rabbits, kangaroos (23) and in numerous intermediary forms. One of the earliest studies of this phenomenon was made by F. O. Guldberg (10) in Germany in 1897. He made his subjects walk through the woods, swim, and steer a boat in the dark. Under all of these conditions circular paths were followed. He believed that the circularity resulted from structural asymmetry in the subjects, plus an instinct for circular movement. He concluded that circular movement was the basic movement of animal life.

In 1901, H. S. Jennings (13) remarked that in spite of the numerous reports of spiral movement in organisms, no adequate theory had been advanced to explain the phenomenon. The theory which he advanced attributes the spiral path of organisms to structural asymmetries plus an attempt to compensate for them. For example, a paramecium is not bilaterally symmetrical. If it simply swam forward, these asymmetries would cause it to move in constant circles. To go beyond this restricted movement, the paramecium revolves on its long axis as it swims, with the result that its range of movement is greatly increased since the circling on the body axis compensates for its structural irregularities. The principle is the same as that followed by a rifle bullet. Jennings believes that the relationship between the length of the organism and the frequency of its spiral bears out this hypothesis.

The most complete and systematic investigation of spiral movement in organisms was contributed by A. A. Schaeffer (23, 24, 25, 26) who studied the phenomenon for over six years in numerous animal forms from the ameba to man. His conclusion was that "no forward moving organism has yet been found that does not move in some form of spiral path when there are no orienting senses to guide it." In his experiments on man, Schaeffer studied the paths of subjects who walked straightaway blindfolded, drove an automobile blindfolded, walked around imagined circles, swam straightaway blindfolded, and walked around figure eights and squares. He also made comparative studies on mental defectives and normal subjects under the influence of a drug. Spiral paths resulted under all of these conditions. He next attempted to determine the mechanism which caused spiraling. Schaeffer rejected the theories based on physical asymmetries because such asymmetries are permanent while the size of the spiral and its direction vary in the same individual. Moreover, asymmetry would not account for the spiral course in which a blindfolded subject drives a car. Another important consideration is that subjects who walked alternately backward and forward traced a spiral which was similar to those traced when they walked continually forward.

Schaeffer also rejects an explanation of spiraling on the basis of any localized structure such as the semicircular canals, because the spiraling is present in organisms in which no such structure exists. "There is already enough evidence on hand to make it highly probable that the same mechanism is at work in man that operates in the ameba. And those anatomical structures of brain and muscle and sense organ which are peculiar to mammals or vertebrates cannot offhand be assumed to control a mechanism which functions perfectly in animals lacking these structures." Schaeffer's conclusion is that "the path of man is the projection of a helical spiral on a plane surface." And, "the fundamental path followed by moving organisms is therefore a spiral, and it is only through the agency of orienting senses that organisms are able to change their direction of movement. The great diversity of form observed in organisms that move in spiral paths indicates that the automatic mechanism regulating the direction of the path is not dependent upon or connected with morphological structures, but is much more fundamental in its nature affecting the protoplasm directly."

The conclusion which we will draw from these studies is that spiral movement is a universal basic form of animal movement, which can not be considered caused by any local structure or form. We believe that Schaeffer's experiments justify this conclusion since spiral courses were followed by animal forms in which organs of equilibrium were lacking. Moreover spiral movement can not be attributed to bodily asymmetry since it appeared in those cases in which blindfolded subjects instructed a driver where to steer an automobile.

Up to the present time, however, no satisfactory hypothesis that might account for this universal phenomenon has been proposed. Since spiral movement is so universal it would seem that it must also be a fundamental mode of activity, an understanding of which should add greatly to our mastery of psychological problems in general, especially all of those where <u>motility</u> is involved. Indeed, the thesis is here suggested, that, as a general problem in methodology, it would be fruitful to assume all motility to be modifications of some basic form of response. This basic form would seem to be spiral movement.

Our second historical approach is concerned with the dynamics of movement, and the determination of form. The latter problem was considered by Theodore A. Cook in his book entitled The Curves of Life. His thesis was, that form is a diagram of the forces which have worked to produce an organism. He was particularly interested in organisms whose growth took the form of a logarithmic spiral. He studied spiraling plants, protozoa, metazoa, snails and other shell bearing animals, and the horns of vertebrates. Then he proceeded to examples of spirals in architecture and art. Regarding the mathematics of the spiral he says (page 6), "Is the logarithmic spiral the manifestation of the law which is at work in the increase of organic bodies? If so, it may be significant that Newton showed in his Principia, that if attraction had generally varied as the inverse cube instead of as the inverse square of the distance, the heavenly bodies would not have revolved in ellipses but would have rushed off into space in logarithmic spirals. Professor Goodsir therefore asked, if the law of the square is the law of attraction, is the law of the cube (that is, of the cell) the law of production?"

Three years after the appearance of Cook's book, another, dealing with the same subject was written by D'Arcy Thompson (27). This latter book, while also interested in the examples of spiral form, treated in greater detail the geodesics, mechanics and mathematics of form. Thompson proves that the form of organisms is necessarily what it is. In other words, form is not arbitrarily, but dynamically determined. The direction of growth of a plant, the formation of honeycomb cells, cell division and partitioning, the formation of muscles and bones and even the length of stride in walking, are all phenomena occurring in accordance with the principles of dynamics and geodesics.

The immediate historical approach to this study lies in recent developments in Gestalt psychology. Since the publication of Köhler's "Physischen Gestalten" in 1920 and Koffka's "Grundlagen der Psychischen Entwicklung" in 1925 it has become increasingly apparent that the laws of behavior are the laws of dynamics, given a Gestalt or organismic interpretation. Wheeler, in "The Laws of Human Nature" proposes eight transposable principles, defined as laws of dynamics, and in "The Principles of Mental Development", Wheeler and Perkins make use of fifteen dynamic laws. Recently Lewin and Brown (4, 16, 17) have attempted definite applications of similar laws in more precise form, to problems in emotional and social behavior. This study may be considered a direct test and outgrowth of suggestions from these latter works.

## Methods

A functional analysis of walking was made by varying all conditions, both objective and subjective, which were considered significant in determining the subject's path of motion.

The variations which were studied were:

1. Subject's degree of general orientation.

The majority of the subjects were allowed to walk to the field where the experiment was conducted. To study the effect of general orientation, five subjects were blindfolded and driven to the field in a car by such a devious route that none of them knew where he was at any time during the experimental period.

2. General environmental conditions.

The experiment was conducted both with and without the presence of persons in the environment, other than the subject and experimenter; both with and without wind or sun; with sounds excluded as far as possible and with sounds present.

3. Body position.

At various times the subjects were instructed to walk in a normal position, tipped to the side, leaning forward or leaning backward.

4. Position of hands.

The influence of the position of the hands was studied under four conditions: (a) used as in normal walking, (b) on hips, (c) hung limp at sides, and (d) in pockets.

5. Ears.

The influence of audition was checked by testing subjects without dampening methods; other subjects who were prevented from hearing and still others who wore a watch over one ear. The watch was worn to control the subject's rate of walking.

6. Conditions of walking.

a. Constant, normal walking.

b. Step and rest type of movement.

c. Walking under tension or under relaxation.

d. Walking at different rates of speed. The three speeds employed were:

1 step every 2 seconds ( 8 ticks of watch)

1 step every 1 second ( 4 ticks of watch)

1 step every ½ second ( 2 ticks of watch)

7. Definiteness of goal.

a. Subject told to walk in a straight line. (Blindfolded)

b. Subject allowed to locate some object and then, blindfolded, told to walk to the object.

c. Subject attempts to walk in a straight line toward a constant sound.

d. Subject hears a single sound and then attempts to walk to the spot from which the sound came.

e. Subject told to walk to a point which he 'sees' only in visual imagery.

f. Subject walks, blindfolded, along a straight line after seeing the line.

g. Subject told to walk, in the easiest way, entirely passive to direction. In order to insure this disregard for direction, some subjects were told to count their steps, others were told to concentrate on their rate of walking, others to think only of maintaining tension or relaxation, and still others were asked to day-dream.

The actual experimentation can be divided into five parts. <u>In the first part</u>, twelve subjects walked under all of these conditions. From their results those factors were determined which made observable differences in the paths traced.

<u>In the second part</u>, thirty-nine subjects were tested under those conditions which Part I had shown to be important. The form of the subjects' paths under the different conditions was given particular note in this experiment.

A sample experiment included walking

1. For 10 minutes relaxed, indifferent to direction, at the rate of 1 step every 8 ticks of the watch (2 seconds);
2. For 5 minutes, under tension, indifferent to direction at the same rate. (To produce tension, the subject was

asked to make a speech or else to simply concentrate on tensing his muscles and stiffening his body.)

3. For 5 minutes relaxed, passive to direction, at the rate of 1 step every 4 ticks of the watch (1 second).
4. For 5 minutes, passive to direction, tense, at the same rate (1 step per second).
5. For 5 minutes, passive to direction, relaxed, at the rate of 1 step every 2 ticks ($\frac{1}{2}$ second).
6. For 5 minutes, passive to direction, tense, at the rate of 1 step every 2 ticks.
7. Three widths of the field (50 yards each) trying to walk in a straight line.
8. To a constant whistle. (This was done twice).
9. Along a chalk line. (either seen or imaged.)
10. To a point either seen previous to the attempt, or imaged.

This required slightly over an hour. Periods of time are only approximate. An exact record was not obtained.

A further word is necessary regarding the experimental technique in Part II. The subject and experimenter walked to the field on which the experiment was conducted, a football stadium, marked off in the standard manner. In the center of the field, (Middle of 50 yard line) the subject was blindfolded and a device, which served the double purpose of supporting a watch and deadening environmental noises, was attached to his ears. He was then given instructions and proceeded to carry them out. The experimenter followed him, a few feet in the rear, and charted the course on a sheet of paper ruled in the same manner in which the stadium was lined. If the subject came to the edge of the field, he was redirected and permitted to continue on his way.

<u>In the third part</u> of the experiment, three subjects were studied under the same conditions as those used in Part II, but an improved and more complete technique was employed which yielded additional data. In the first place, a larger field was used. This eliminated the necessity of restarting and redirecting the subjects every few minutes. Records were taken of walking during longer periods of time. A large cardboard box was converted into a hood, which excluded all cues from light and heat from the sun's rays, and reduced other cues such as sound and breeze. The box covered as much of the subject's body as was possible without interfering with his locomotion. A watch was attached to the inside-center-front of the box, at the level of the subject's forehead.

The length of time during which the subject walked was recorded by a stop-watch. The subject's path was staked every 10 steps with a long nail to which a numbered mailing tag was attached. At the completion of the experiment, the distance between these tags was measured. A record was taken of the subject's route of walking, the distance traversed in each ten steps, the total distance and the total time involved.

The fourth and fifth parts of the experiment were attempts to clarify and expand certain results of the preceding experiments.

Experiment four was an attempt to answer the question, "What activity may be expected from a subject to whom no positive instructions have been given?" Five naïve subjects were taken one at a time, blindfolded and instructed not to remove the blindfold. No other instructions were given. For a period of five minutes, their behavior was observed, and at the end of that time they were asked to write an introspection over their thoughts and behavior during that time.

Experiment five was undertaken in order to discover why a blindfolded subject, under instructions to walk in a straight line, to a constant sound, traced a sigmoid spiral course whose waves decreased in size as the sound was approached. The goal selected was a bell which sounded continually. The blindfolded subject started from a point 50 feet away and attempted to walk in a straight line toward the source of the sound.

A further study of this phenomenon was conducted by marking off, in six foot lengths, a straight 50 foot line, at one end of which was the bell. At each six foot mark, the blindfolded subject attempted to point a yard stick, mounted on a surveyor's transit, in the place usually occupied by a telescope, toward the source of the sound. His angular error was recorded in degrees.

## Results

The results of Part I and Part II will be treated together since they were obtained by the same experimental technique.

The subject's general orientation made no observable difference in the path which he traced. Subjects who were blindfolded and taken to the field in a car exhibited similar behavior when at a later date they were tested after walking normally to the field. Apparently the loss of vision and hearing disorients a normal subject to a very great extent. It was also noted that in most cases, subjects who had walked to the field were unable to point to the north correctly, after a few minutes of blindfold walking. Absolute direction and absolute orientation do not exist under the experimental conditions.

General environmental conditions affect different subjects to different extents, and have different effects on the same subject when he is walking under different instructions. When the instructions were "walk in a straight line", the sun and wind gave considerable assistance to some of the subjects. When the instructions were "make yourself indifferent to direction, just walk in the easiest way" the sun seemed to have no effect. In fact subject W. R., who frequently introspected as he walked, several times made remarks such as "Here comes that darned sun around again" which indicated that the warmth of the sun gave him some orientation. His course, however, was almost identical on cloudy days and sunny days. The effect of the sun may be summarized as giving some orientation and therefore helping a subject to walk in a straight line, if that is his purpose. On the other hand, if he is passive regarding his direction, the influence of the sun is very slight in determining his path. No subject was able to walk in a straight line, by means of the orientation he gained from the sun's rays.

The wind is somewhat more important than the sun in determining a subject's direction. A strong wind makes a subject walk in a path which resembles a row of e's written in longhand. The longer axis of movement in such cases is in the direction in which the wind blows. A mild breeze has less effect, and assists orientation but little. A naïve subject is apt to report that the breeze is shifting in its direction, rather than to realize that he is walking in spirals. (See Appendix for introspections.) A subject who is walking under tension and indifferent to direction is frequently upset emotionally by the wind. It throws him off his course and makes it difficult for him to maintain his balance. He is more apt to resist the force of the wind than the individual who is walking relaxed.

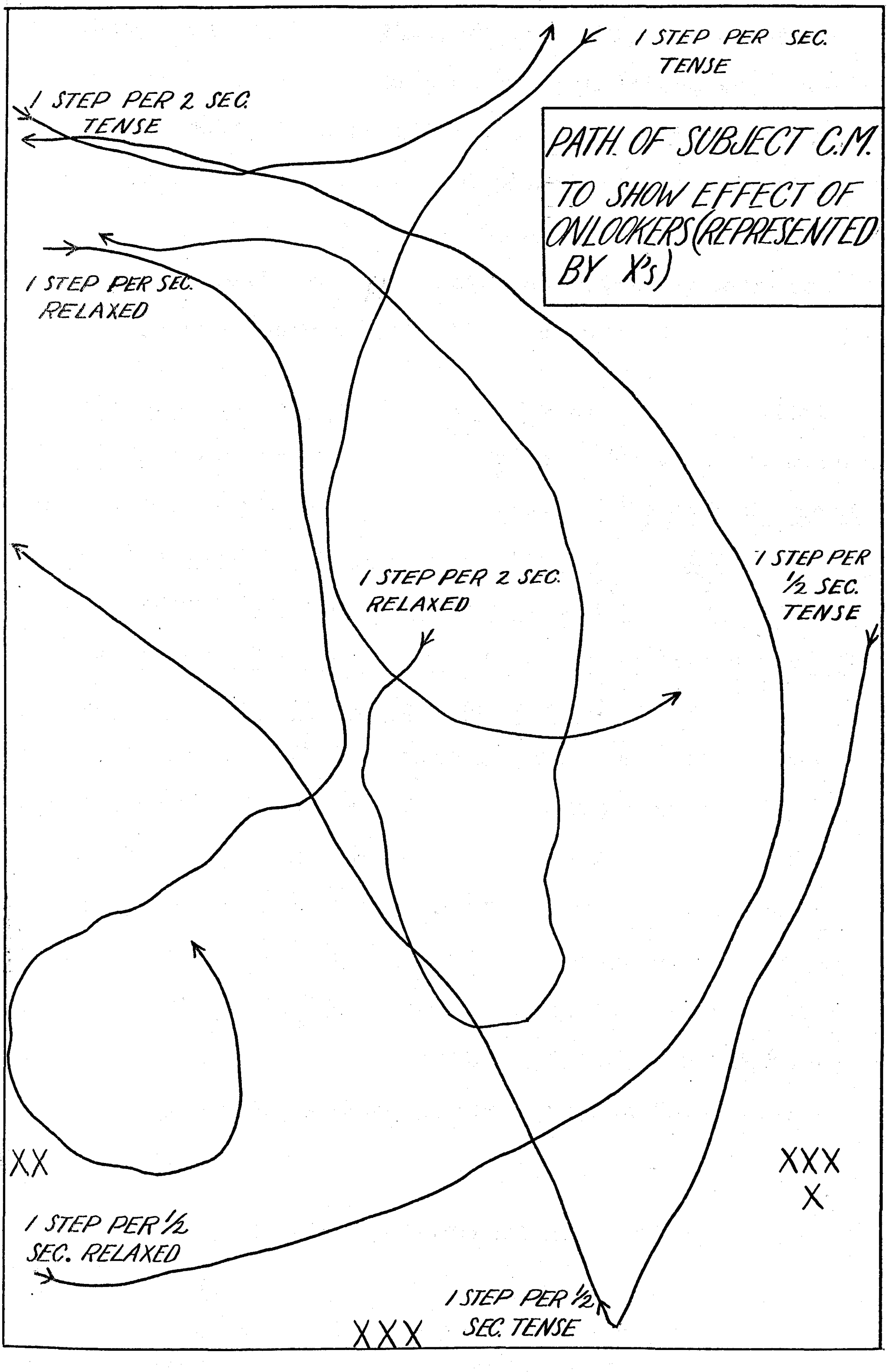
Two young women acted as subjects in the presence of a number of men who were "working out" for track. While the men were at one end of the field, the women were highly aware of them. Even when the subjects were passive to direction and walking "in the easiest way" their paths deviated away from the position of the men. (See Plate I, C M.) These were the only instances in which the presence of persons in the field produced a noticeable change in the form of the path.

The effect of the subject's body position will be treated fully in Part III and therefore will not be discussed here. It was discovered that the body position did affect the form of the path traced by the subject.

The position of the hands, whether hanging at the sides limply, used as in normal walking, placed on the hips or in the pockets, made no observable difference in the subjects' paths.

Our results on the effect of sound are at variance with Schaeffer's, but this is explainable on the basis of the conditions under which the experiment was performed. The study, from which he concluded that spiralling was unaffected by the subject's ability or inability to hear, was conducted in an isolated region where extraneous sounds were unimportant as orienting factors. The present study was conducted on the campus where the subjects were familiar with the sounds and knew their location. For example, a street car could be heard for a long distance as it ascended the hill, and, three times, subjects were observed to change

PLATE I


1 STEP PER SEC.
TENSE
PATH OF SUBJECT C.M.
TO SHOW EFFECT OF
ONLOOKERS (REPRESENTED
BY X's)
1 STEP PER 2 SEC.
TENSE
1 STEP PER SEC.
RELAXED
1 STEP PER 2 SEC.
RELAXED
1 STEP PER
½ SEC.
TENSE
XX
XXX
X
1 STEP PER ½
SEC. RELAXED
1 STEP PER ½
SEC. TENSE
XXX

their direction as they walked, so that they continued to face the moving car. On being questioned later, the subjects denied doing this consciously. In general, sounds were difficult to locate and probably played only a small part in determining the routes. No difference could be noted in a subject's path depending on which ear wore the watch. This was systematically tested in twelve subjects.

<u>All subjects walked in spiral paths.</u> It is obvious that <u>all</u> such factors as the sun, wind, environmental sounds, slant of ground, <u>et cetera</u>, functioned <u>not as cues by means of which the subjects guided themselves in a spiral path but were disturbances that had the effect of modifying or of producing irregularities in the path. The basic form of the path, under homogeneous field conditions is a helical spiral.</u> The size of the spiral varied in the same subject at different times and frequently under the same conditions. The diameter of the smallest spirals was 18 feet. (WR, walking at the rate of 1 step every 2 seconds, relaxed and indifferent to direction.) The diameter of the largest spiral was 600 feet. (MR, attempting to walk in a straight line.) The average diameter of the spirals, for all subjects and under all conditions, when passive to direction was 228 feet.

When walking, passive to direction, and relaxed, as speed increased,

a. the size of the spiral increased in 84.5% of the cases

b. the size of the spiral decreased in 10.5% of the cases

c. there was no correlation between size and speed in 5.2% of the cases. Thus, <u>size of the spiral is generally proportional to the speed of walking</u>. (See Plates I - VIII)

When walking, passive to direction, under tension, as the speed increased,

a. the size of the spiral increased in 73.4% of the cases

b. the size of the spiral remained constant in 6.5% of the cases.

c. the size of the spiral decreased in 13.3% of the cases

d. there was no relation between speed and size of the spiral in 6.5% of the cases. (See Table I)

Tension increased the size of the spiral over the size under relaxation in 55.5% of the subjects; caused a decrease in 33.3%, and brought about no recordable difference in 11.2% of the subjects. (See Table III)

When the subjects were relaxed, the size of the spirals increased in over 84% of the cases as their rate of walking increased. When walking under tension, only 55.5% of the subjects increased the size of their spirals proportional with their speed of walking. The difference may be explained in terms of the type of tension involved. Some subjects had what may be called a 'closed' reaction, in which the tension inhibited movements.

The subjects appeared to be carrying a heavy load which required slow deliberate movement. Other subjects showed an 'open' reaction, in which the tension was expended through movement. In these cases the size of the spirals increased proportional to the acceleration of velocity.

In the results, taken as a whole, there was no marked tendency for the subjects to spiral to the right, rather than to the left, or vice versa.

26.3% of the subjects alternated right and left turns.
31.6% showed marked preference for right turns.
11.0% showed marked preference for left turns.
31.1% spiraled to the right and left without any observable system. (See Table III)

The course of 82.5% of the subjects became smoother (i. e., less minor fluctuations) under tension than under relaxation. The reverse was true of 12% of the cases. (See Table III)

Constant movement decreased the size of the arcs over the 'step and rest' type of movement.

Fluctuations in direction were more frequent and erratic in children than in adults. (See Plates VI - VII)

Table I

Relative Spiral Circumference Averages

produced by subjects walking Relaxed.

| Subject | One step per 2 sec I | One step per sec. II | One step per ½ sec. III | Ratio of II/I in per cent. | Ratio of III/I in per cent. |
|---|---|---|---|---|---|
| WA. | 205 ft. | 141 ft. | 244 ft. | 68.8 | 118.95 |
| LA. | 283 ft. | 460 ft. | 501 ft. | 162.6 | 177.15 |
| BS. | 490 ft. | 238 ft. | 819 ft. | 48.6 | 167.1 |
| BR. | 190 ft. | 240 ft. | 339 ft. | 126.5 | 178.5 |
| BJ. | 117 ft. | 120 ft. | 610 ft. | 102.5 | 521.8 |
| CM. | 205 ft. | 284 ft. | 484 ft. | 138.4 | 236. |
| HD. | 157 ft. | 440 ft. | 659 ft. | 280. | 419.6 |
| HK. | 99 ft. | 188 ft. | 407 ft. | 190. | 411.7 |
| HB. | 377 ft. | 275 ft. | 462 ft. | 72.9 | 122.4 |
| LR. | 283 ft. | 521 ft. | 260 ft. | 184.3 | 91.9 |
| MR. | 189 ft. | 249 ft. | 302 ft. | 131.8 | 159.7 |
| MM. | 80 ft. | 352 ft. | 602 ft. | 440. | 752. |
| OW. | 396 ft. | 397 ft. | 460 ft. | 100.2 | 116.1 |
| PT. | 119 ft. | 109 ft. | 89 ft. | 91.6 | 74.75 |
| RN. | 278 ft. | 364 ft. | 702 ft. | 130.9 | 252.2 |
| TC. | 121 ft. | 290 ft. | 520 ft. | 238.9 | 429.4 |
| WR. | 43 ft. | 83 ft. | 160 ft. | 193.1 | 371.9 |
| SB. | 183 ft. | 140 ft. | 255 ft. | 76.5 | 139.4 |
| SJ. | 142 ft. | 380 ft. | 457 ft. | 267.5 | 321.3 |
| PC. | 240 ft. | 374 ft. | 662 ft. | 155.9 | 275.8 |
| KE. | 96 ft. | 213 ft. | 620 ft. | 222. | 646. |
| Averages: | 204.6 ft. | 279 ft. | 496 ft. | 136.16 | 242. |

Table II

<u>Relative</u> <u>Spiral</u> <u>Circumference</u> <u>Averages</u> produced by subjects

walking under <u>Tension</u>

| Subject | One step per 2 sec<br>I | One step per sec.<br>II | One step per $\frac{1}{2}$ sec.<br>III | Ratio of II/I in % | Ratio of III/I in per cent |
|---|---|---|---|---|---|
| WA. | 565 ft. | 388 ft. | 377 ft. | 68.75 | 66.7 |
| LA. | 426 | 482 | 484 | 112.9 | 113.6 |
| BS. | 380 | 388 | 428 | 102.2 | 112.6 |
| BR. | 294 | 290 | 282 | 98.6 | 95.9 |
| BJ. | 90 | 282 | 523 | 313.4 | 584. |
| CM. | 282 | 258 | 659 | 91.5 | 231.9 |
| HD. | 492 | 568 | 733 | 115.5 | 149.1 |
| HK. | 176 | 206 | 314 | 117.6 | 178.4 |
| HB. | 379 | 490 | 943 | 129.3 | 248.7 |
| LR. | 188 | 204 | 566 | 108.4 | 300.9 |
| MR. | 458 | 378 | 258 | 82.5 | 55.1 |
| MM. | 121 | 347 | 513 | 286.3 | 424. |
| OW. | 167 | 206 | 565 | 123.3 | 338. |
| PT. | 156 | 240 | 684 | 154. | 427.8 |
| RN. | 807 | 119 | 770 | 14.77 | 95.5 |
| TC. | 123 | 131 | 163 | 106.3 | 132.6 |
| WR. | 79 | 2402 | 148 | 3410. | 187.2 |
| SB | 191 | 220 | 253 | 115.1 | 132.5 |
| Averages: | 299 ft. | 422 ft. | 482 ft. | 141.2% | 161. % |

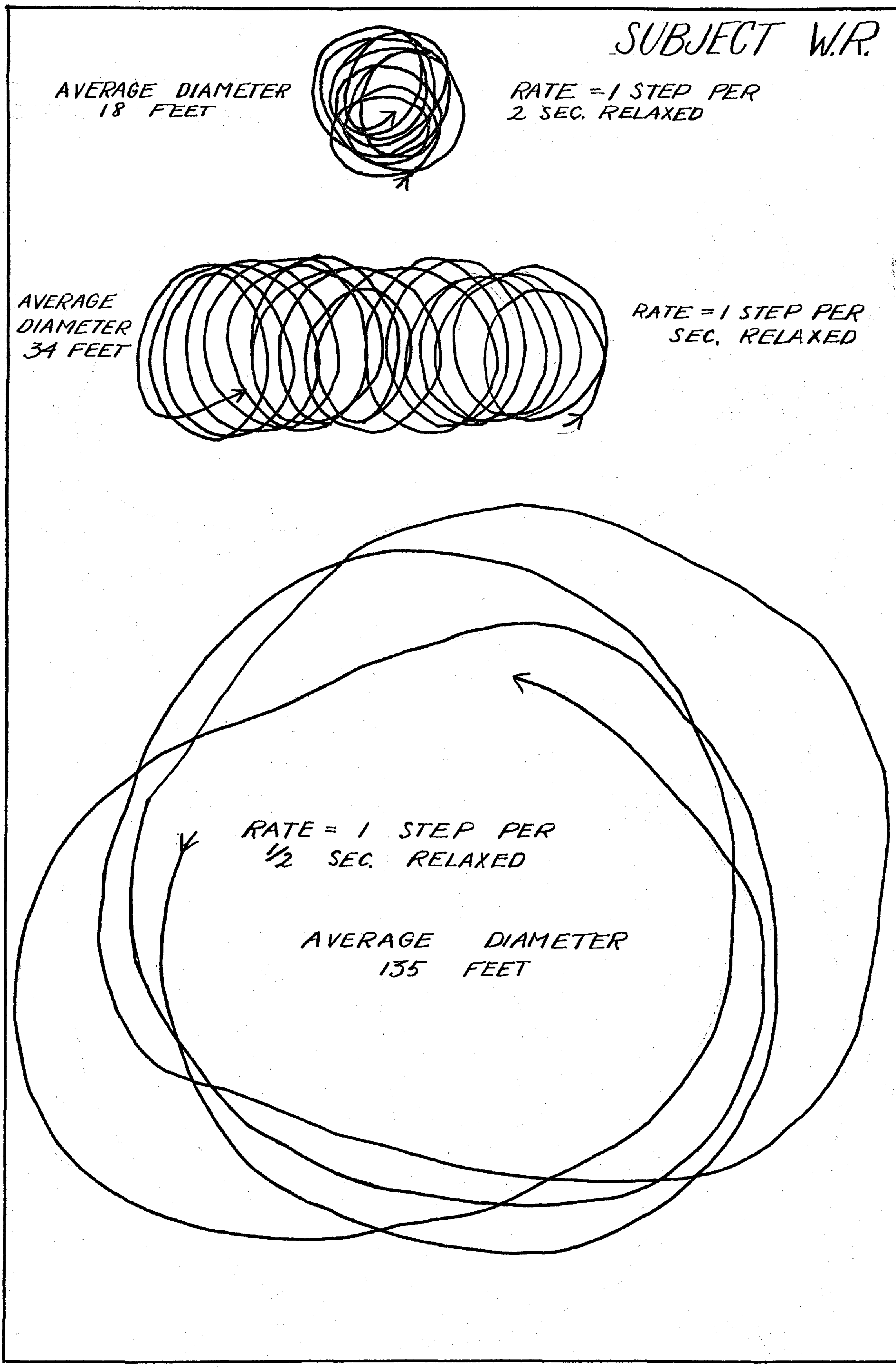
General Data Concerning Spiraling under Tension and Relaxation.

| Subject | Relation of size of spiral to speed of walking | Does tension increase or decrease spiral size | Does subject tend to turn right, left, or alternate | Is course more regular under tension or relaxation. | Does increase of speed make the spiral smoother |
|---|---|---|---|---|---|
| WA. | + | increase | varies | relaxation | yes |
| LA. | + | same | alternates | tension | yes |
| BS. | + | decrease | alternates | T | yes |
| BR. | - | increase | alternates | T | yes |
| BJ. | + | decrease | right | T | yes |
| CM. | + | increase | varies | T | yes |
| HD. | + | increase | alternates | T | yes |
| HK. | + | same | alternates | T | yes |
| HB. | + | increase | right | T | yes |
| LR. | varies | decrease | alternates | T | yes |
| MR. | + | increase | alternates | T | yes |
| MM. | + | same | right | T | yes |
| OW. | + | decrease | left | T | yes |
| PT. | - | increase | right | same | yes |
| RN. | + | increase | varies | T | yes |
| TC. | + | decrease | varies | T | yes |
| WR. | + | increase | left | T | yes |
| SB. | + | increase | right | T | yes |
| EK. | + | increase | right | T | yes |
| BM. | + | decrease | right | T | yes |
| WL. | + | decrease | right | relaxation | yes |

The frequency of changes in direction, from right to left and _vice versa_, was greater under relaxation than under tension in 95.8% of the cases. As speed increased, both under tension and relaxation, the frequency of changes in direction decreased per unit of space.

_The more definite the goal, other things being equal, the more direct the course to it._ Under instructions to "walk in a straight line", all of the subjects made straighter paths than those made under instructions to walk in the easiest way. The average diameter of the spirals under instructions to walk in the simplest way was 228 feet. Under instructions to "walk in a straight line" the average diameter was 326 feet, an increase of 23%. Thus, the more definite the goal, the straighter the course to it. When a subject is told to walk in the easiest way, passive to direction, the instructions set up no definite point to which he is to go. He is given a method of walking, not an end toward which he is to walk. If, on the other hand, he is told to walk to a certain spot or told to walk in a straight line, his conscious field becomes more highly structured. He has a definite act to perform. A great difference could be noted in the subjects' behavior. When told to walk in a straight line, or to walk toward an object, they became more active, more interested, and gave indications of being under greater tension. (See Plate IX for diagrams of paths made under instructions which varied the definiteness of the goal. See appendix for relevant introspections.)

PLATE II



SUBJECT W.R.
AVERAGE DIAMETER
18 FEET
RATE = 1 STEP PER
2 SEC. RELAXED
AVERAGE
DIAMETER
34 FEET
RATE = 1 STEP PER
SEC. RELAXED
RATE = 1 STEP PER
1/2 SEC. RELAXED
AVERAGE DIAMETER
135 FEET

PLATE III

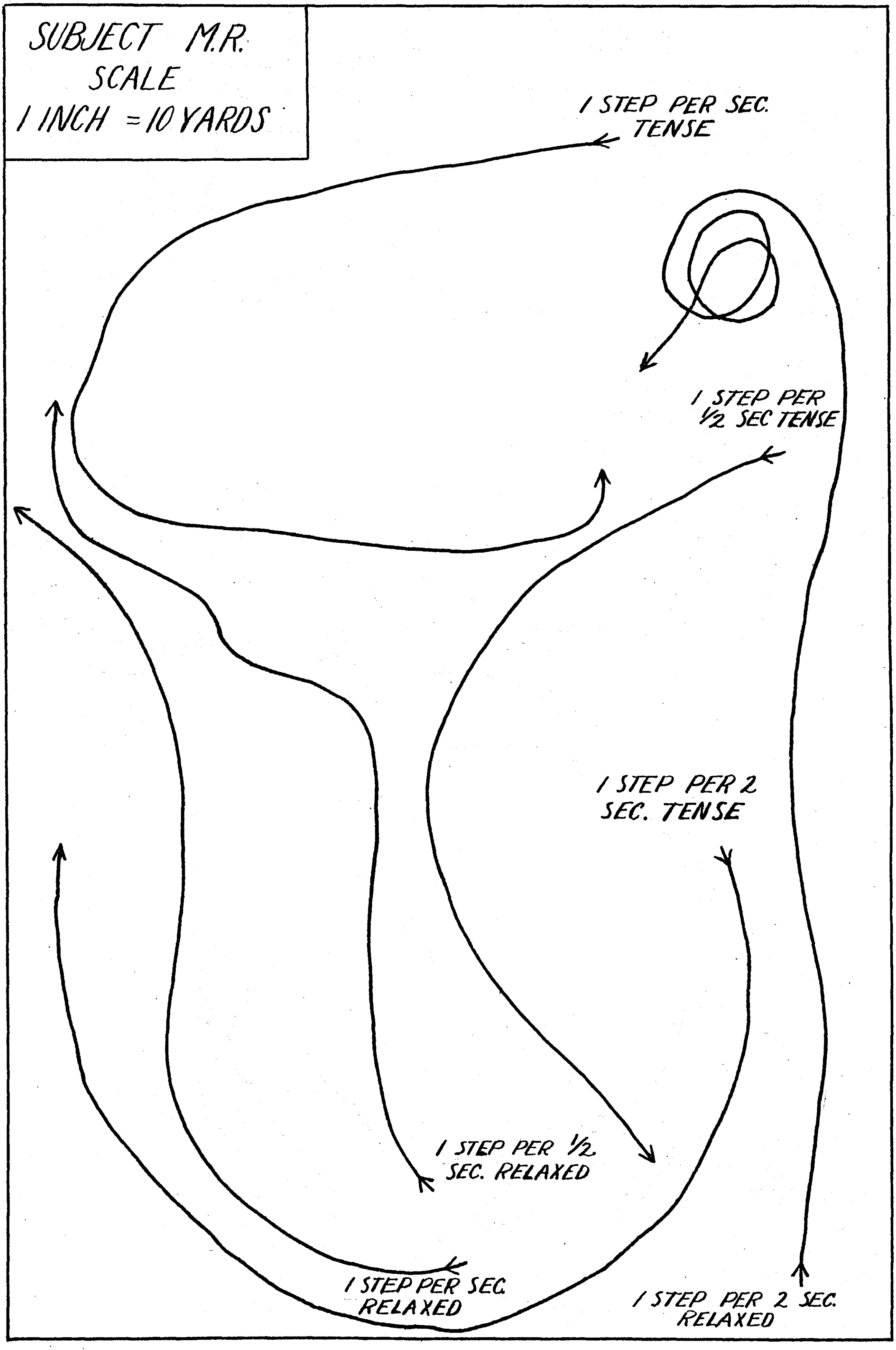

SUBJECT M.R.
SCALE
1 INCH = 10 YARDS
1 STEP PER SEC.
TENSE
1 STEP PER
½ SEC TENSE
1 STEP PER 2
SEC. TENSE
1 STEP PER ½
SEC. RELAXED
1 STEP PER SEC.
RELAXED
1 STEP PER 2 SEC.
RELAXED

PLATE IV

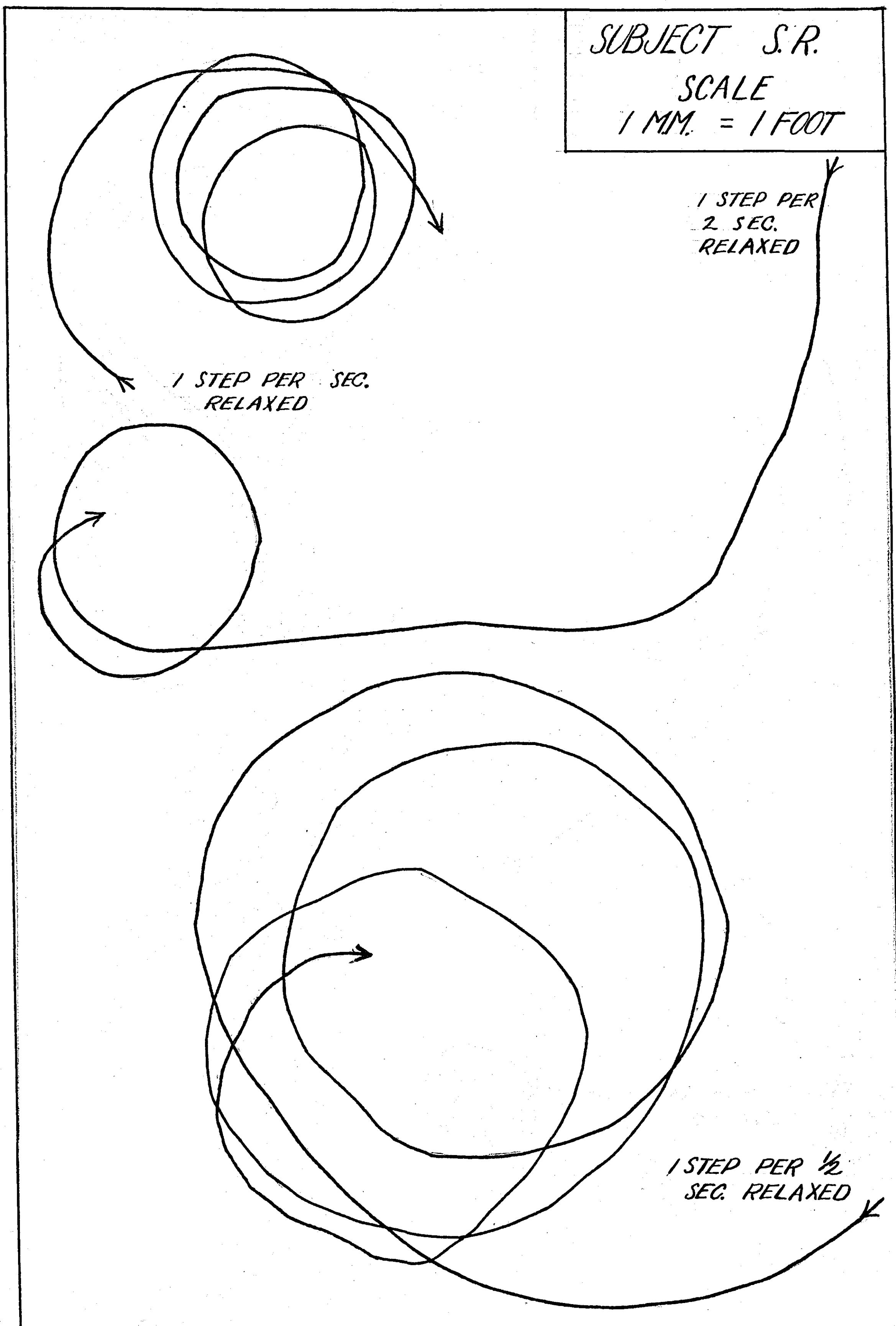
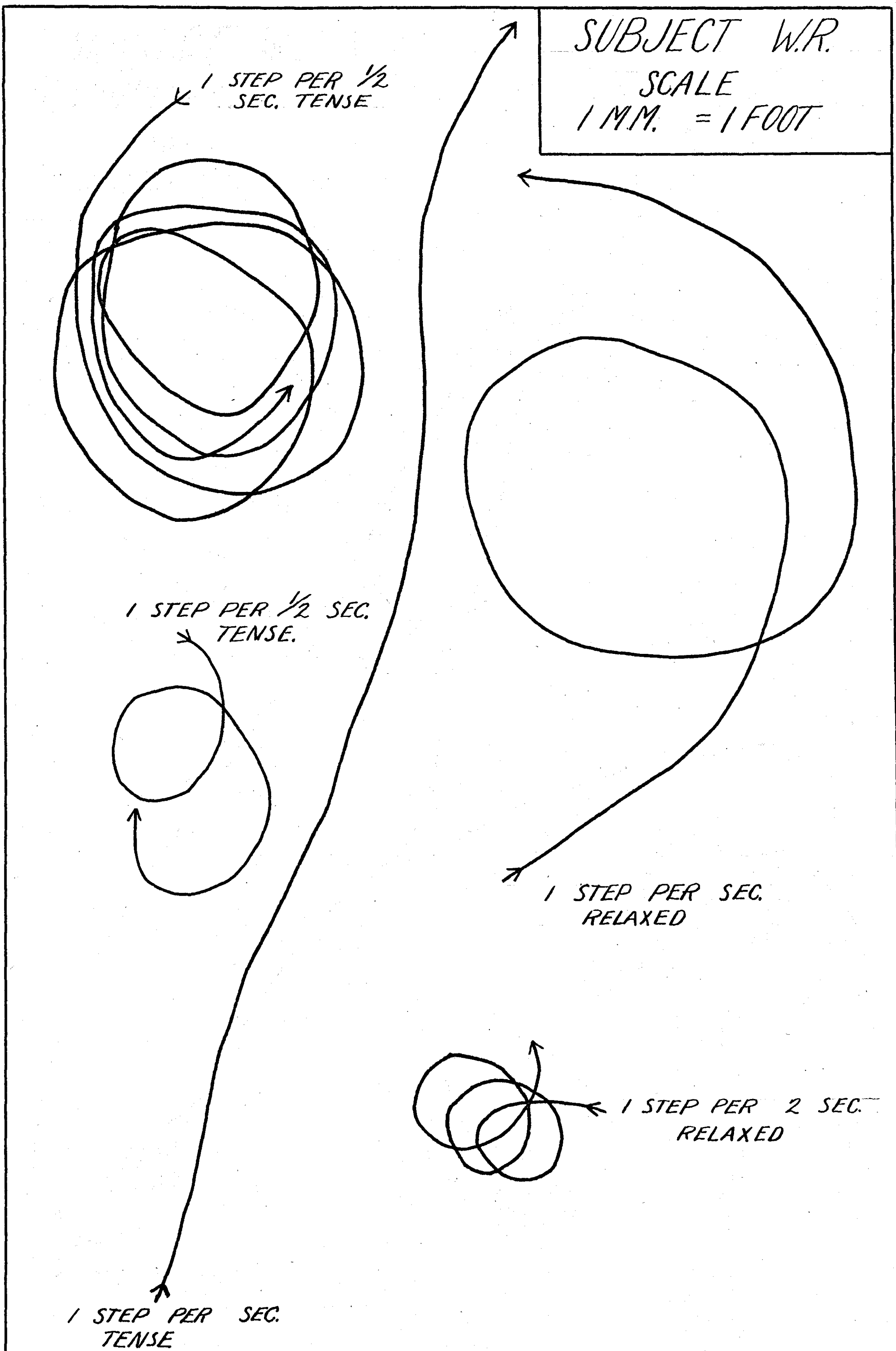
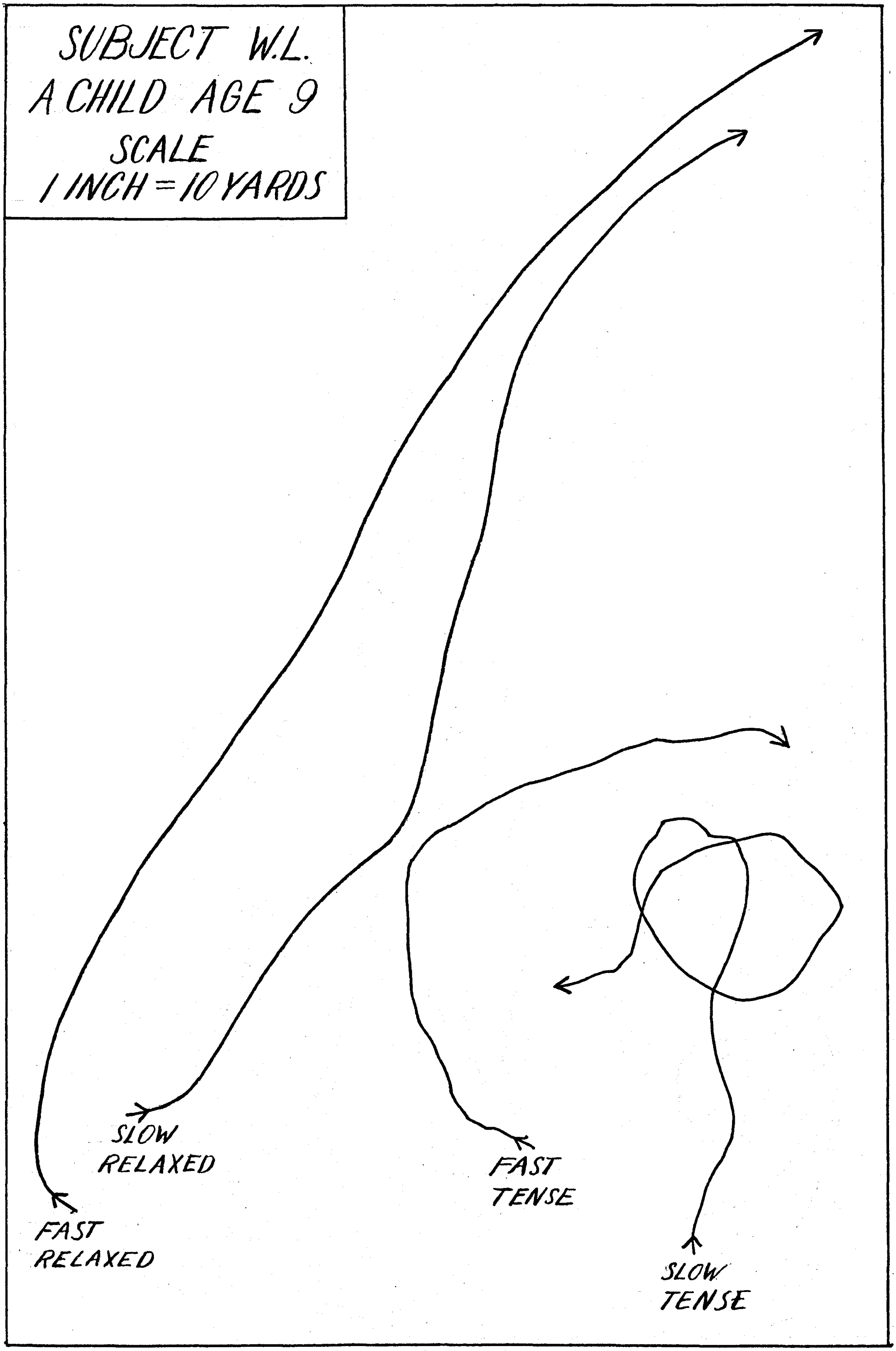

SUBJECT S.R.
SCALE
1 MM. = 1 FOOT
1 STEP PER
2 SEC.
RELAXED
1 STEP PER SEC.
RELAXED
1 STEP PER ½
SEC. RELAXED

PLATE V


SUBJECT W.R.
SCALE
1 MM. = 1 FOOT
1 STEP PER ½
SEC. TENSE
1 STEP PER ½ SEC.
TENSE.
1 STEP PER SEC.
RELAXED
1 STEP PER 2 SEC.
RELAXED
1 STEP PER SEC.
TENSE

# PLATE VI


SUBJECT W.L.
A CHILD AGE 9
SCALE
1 INCH = 10 YARDS
SLOW
RELAXED
FAST
RELAXED
FAST
TENSE
SLOW
TENSE

# PLATE VII

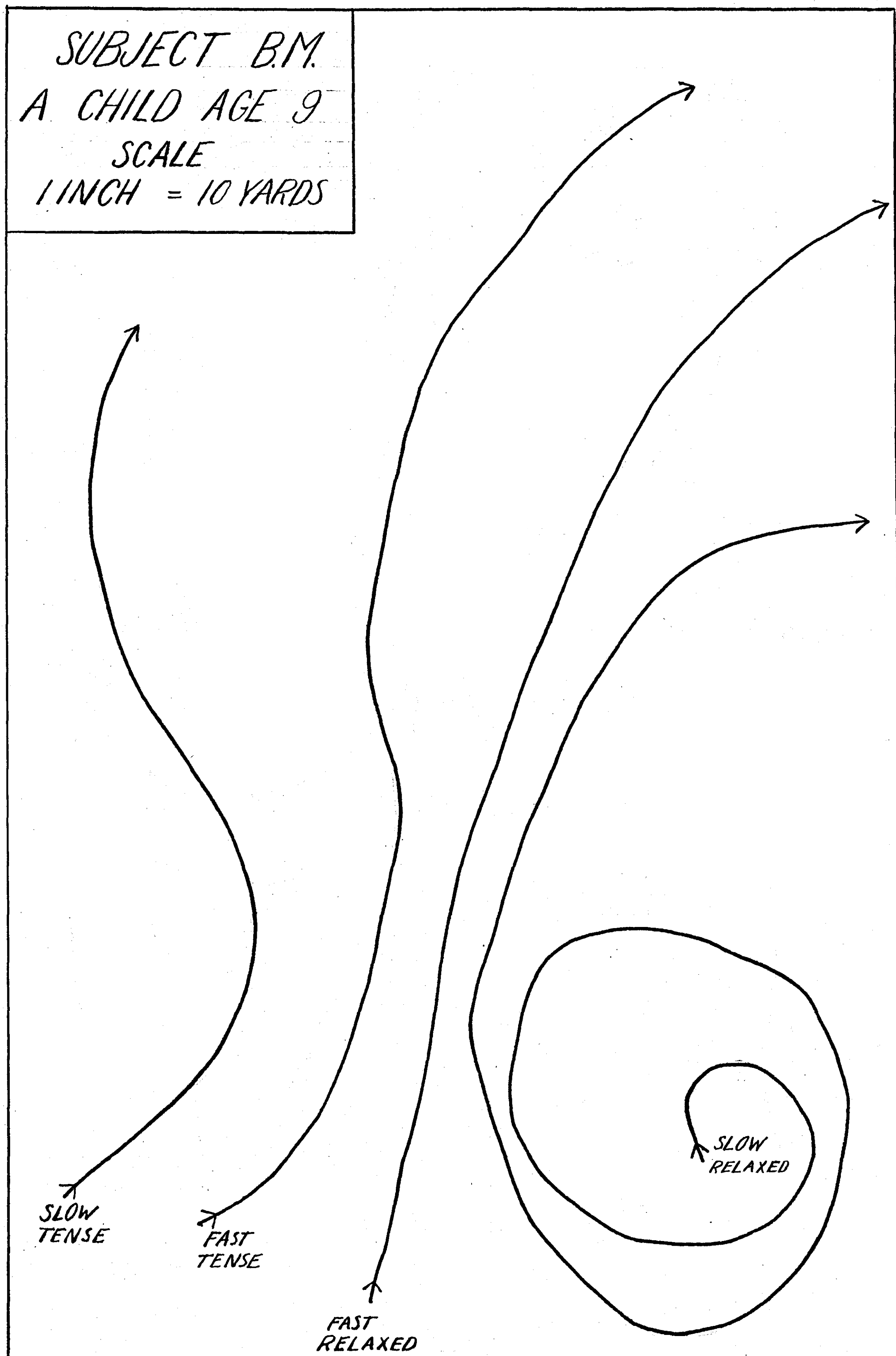
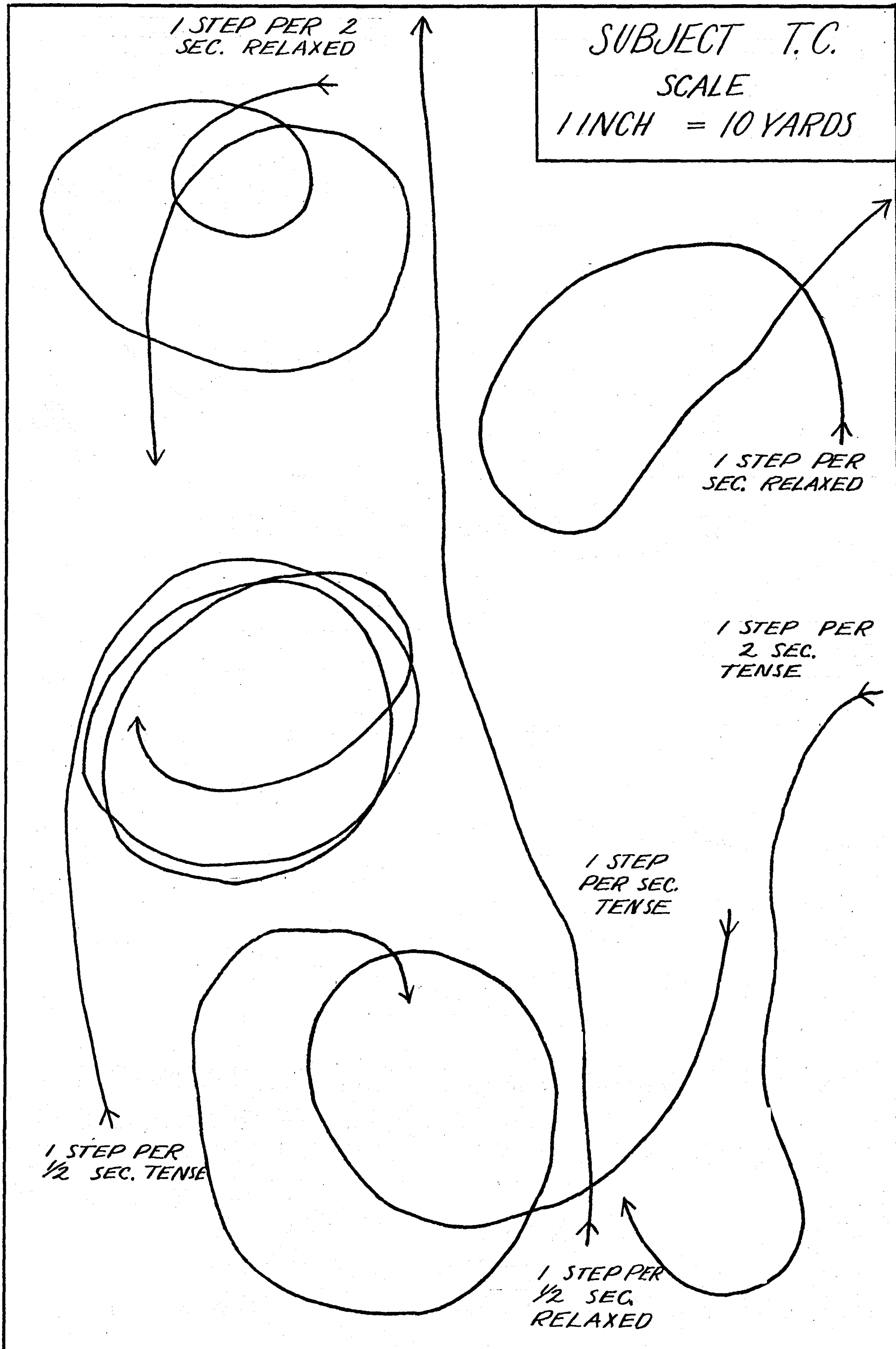
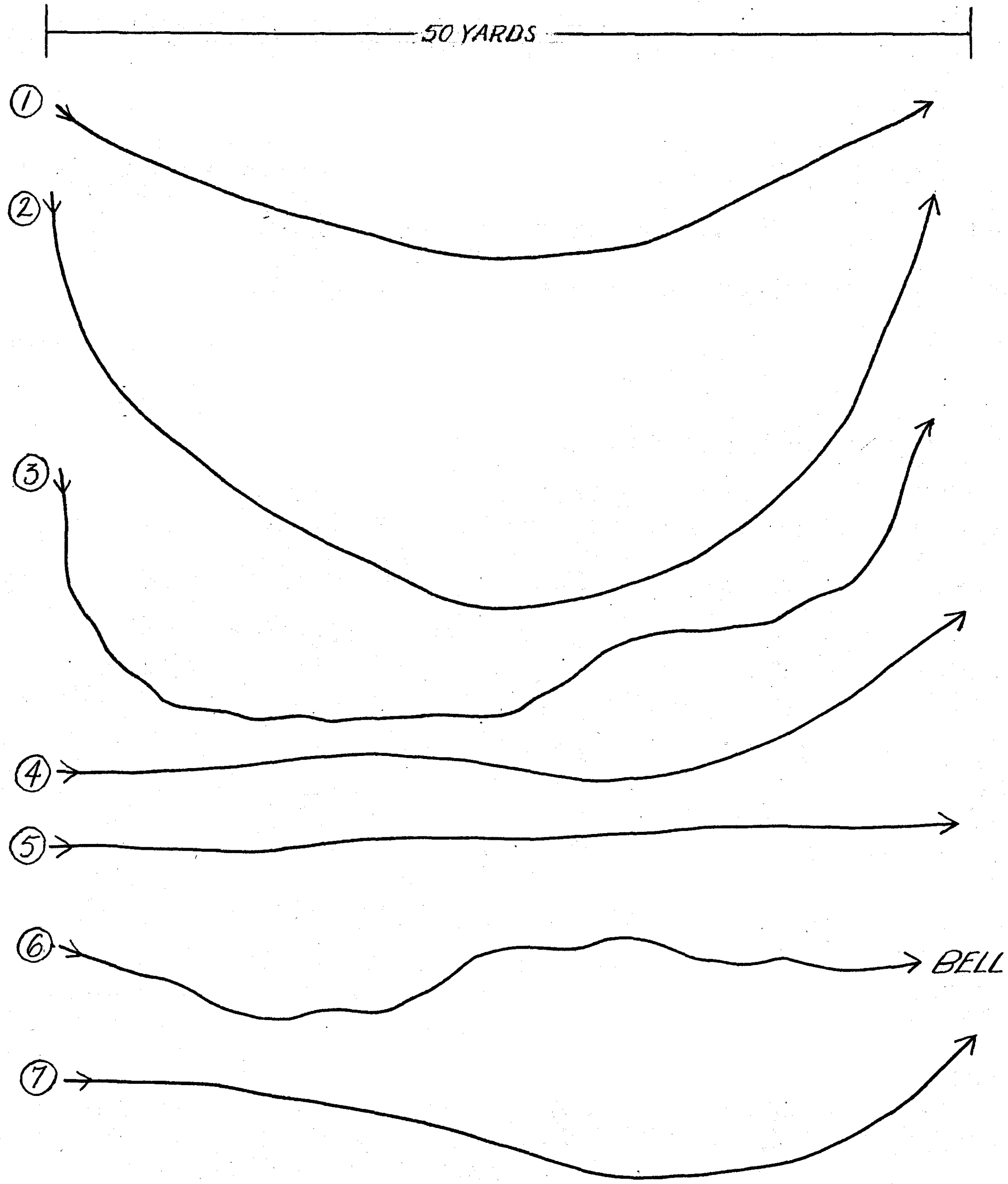

SUBJECT B.M.
A CHILD AGE 9
SCALE
1 INCH = 10 YARDS
SLOW TENSE
FAST TENSE
FAST RELAXED
SLOW RELAXED

PLATE VIII



SUBJECT T.C.
SCALE
1 INCH = 10 YARDS
1 STEP PER 2 SEC. RELAXED
1 STEP PER SEC. RELAXED
1 STEP PER 2 SEC. TENSE
1 STEP PER SEC. TENSE
1 STEP PER ½ SEC. TENSE
1 STEP PER ½ SEC. RELAXED

PLATE IX




1- W.R.-WALKING IN A 'STRAIGHT LINE'-TO PREVIOUSLY SEEN PT.
2- W.R.-WALKING IN A 'STRAIGHT LINE'
3-W.R.-USING ALL POSSIBLE CUES TO WALK IN A 'STR. LINE'
4- S.R.-WALKING IN A 'STRAIGHT LINE'
5- S.R.-WALKING IN A 'STRAIGHT LINE' TO A POINT IMAGED
6- S.R.-WALKING IN A 'STRAIGHT LINE' TO SOUND OF BELL
7- H.K.-FOLLOWING A PREVIOUSLY SEEN STRAIGHT LINE

## Results of Experiment III.

The data obtained in this experiment augmented the preceding data since it represented a different and more detailed attack on the problem of movement. In addition to the previous results, data on time and length of stride were obtained.

A summary of the results for Subject SR follows:

| Speed and Tension<br>One step per | Av. length of stride in inches | Actual time per step in seconds. | Rate of walking in seconds per foot. | Av. circumference of spirals |
|---|---|---|---|---|
| 2" relaxed | 15.4 | 2.16 | 1.77 | 193.9 |
| 1" relaxed | 18.27 | .95 | .62 | 130.5 |
| ½" relaxed | 21.53 | .6 | .33 | 256.2 |
| 2" tensed | 16.87 | 1.88 | 1.33 | 191.6 |
| 1" tensed | 17.86 | .89 | .59 | 220.2 |
| ½" tensed | 18.51 | .65 | .42 | 253.5 |

Summary of results for Subject WR.

| | | | | |
|---|---|---|---|---|
| 2" relaxed | 12.15 | 2.5 | 2.22 | 54. |
| 1" relaxed | 24.9 | .735 | .354 | 272. |
| ½" relaxed | 23.18 | .5 | .26 | 284. |
| 2" tensed | 13.6 | 3.2 | 3.6 | 79.6 |
| 1" tensed | 32. | .384 | .312 | 2402. * |
| ½" tensed | 22.5 | .476 | .253 | 147.8 |

* Subject changed posture from 'closed' to 'open' type, releasing energy through movement rather than through holding body rigid.

Summary of results for Subject PT

| Speed and Tension<br>One step per | Av. length of stride in inches | Actual time per step in seconds. | Rate of walking in seconds per foot. | Av. circumference of spirals |
|---|---|---|---|---|
| 2" relaxed | 27.4 | .845 | .37 | 325 ft. |
| 1" relaxed | 23.15 | .93 | .483 | 467 |
| ½" relaxed | 25.7 | .508 | .237 | 757 |
| 2" tensed | 25.05 | .729 | .348 | 156.4 |
| 1" tensed | 23.6 | .634 | .322 | 240. |
| ½" tensed | 25.6 | .468 | .22 | 684. |

These results of walking at the rates of one step every two seconds, one step every second and one step every one-half second under tension and relaxation indicate the following facts:

1. Length of stride increases with the speed of walking, under conditions of both tension and relaxation.
2. The size of spirals increases as the speed of walking increases.
3. A subject's estimatation of time is affected by his speed of walking and bodily tension.

See Appendix for complete introspections describing walking under the above conditions.

The following tables present the results obtained when the subjects walked with their bodies bent, at the rate of one step per 2 seconds

Subject SR.

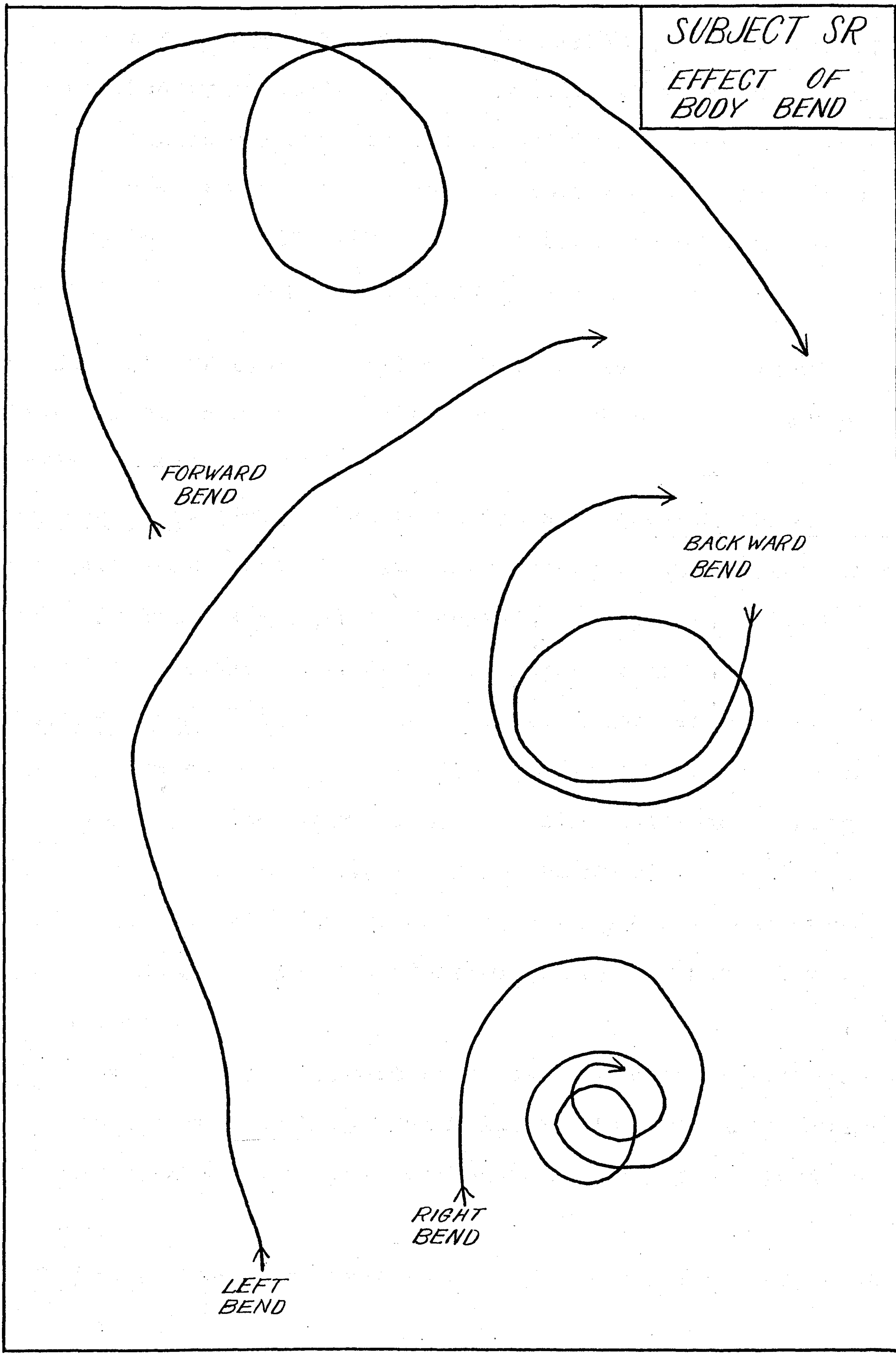
| Direction of body bend | Av. length of stride in inches | Actual time per step in seconds | Rate of walking in seconds per foot | Av. circumference of spirals |
|---|---|---|---|---|
| Forward | 21.12 | 1.45 | .82 | 211.4 |
| Backward | 16.8 | 1.8 | 1.29 | 132.2 |
| Right | 14.36 | 1.61 | 1.34 | 68.9 |
| Left | 15.96 | 2.01 | 1.52 | 798. |

Subject PT.

| Direction of body bend | Av. length of stride in inches | Actual time per step in seconds | Rate of walking in seconds per foot | Av. circumference of spirals |
|---|---|---|---|---|
| Forward | 26.7 | .666 | .3 | 200 |
| Backward | 24.8 | .484 | .234 | 256 |
| Right | 26. | .654 | .302 | 193 |
| Left | 24.7 | .618 | .3 | 333 |

Subject SR. spiraled consistently to the right when walking under instructions to "go in the easiest way, and be passive to direction." When he walked with his body bent forward, he used a long stride and walked in rather large spirals. When he leaned backwards, his stride and spiral size were reduced approximately 20% and 38% respectively. A right body lean reduced the length of stride and size of spiral to a greater extent than the other variations studied. The most interesting results were obtained when the subject walked with his body bent to the left. His path (See Plate X) fluctuated to the right and left in a very unstable manner, making, as a whole, a long arc to the right. The path gives a pictorial representation of the subject's behavior.

PLATE X


SUBJECT SR
EFFECT OF BODY BEND
FORWARD BEND
BACKWARD BEND
LEFT BEND
RIGHT BEND

He seemed very much disturbed while walking, and apparently had difficulty maintaining his balance. He said that this part of the experiment was the most difficult for him, though he didn't know why. These results indicate that body lean affects the subject's stride, his estimation of time, and the size of the spirals which he traces.

Subject PT. showed similar behavior, though there was less variation under the different conditions. His introspections follow:

Forward bend. "Found that there was much greater tendency to oscilate back and forth than under upright condition. Right and left balance seemed to generally upset, but not in any specific direction, i. e., to the right or left."

Backward bend. "Was under considerable muscular strain. Much more than bending forward. Orientation was more upset than under previous condition. Had difficulty in walking at all, and seemed to be tipping from one side to the other. Could not determine beforehand which step would balance me. Had to take several extra steps to get my balance. Field was all deranged."

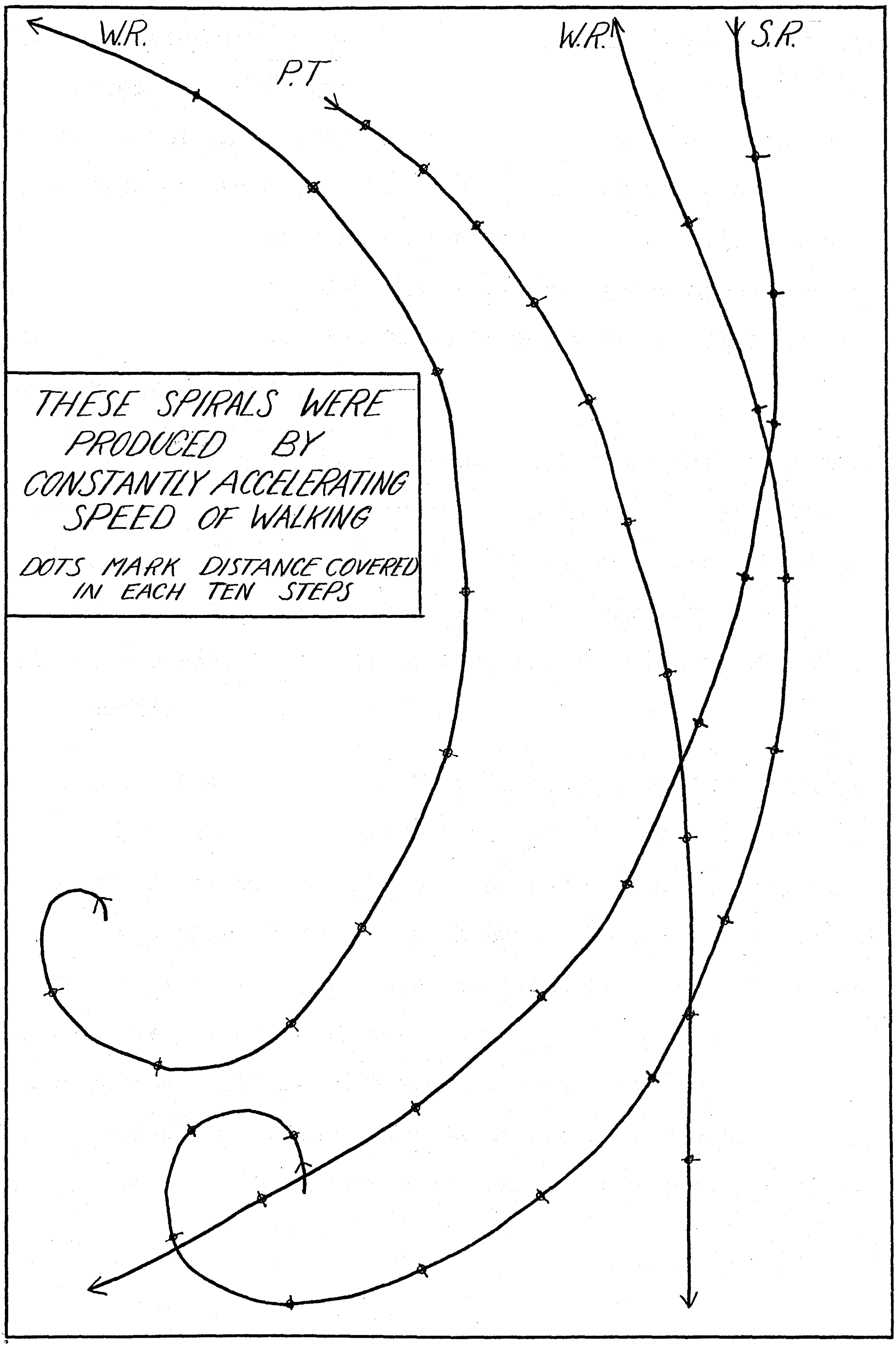
Right bend. "Very difficult to walk. There was a tendency to walk to the left to keep from falling. Was primarily aware of body strain and disorientation with respect to right and left."

Left bend. "Much the same as right band, with the opposite compensation."

The effect of acceleration on the form of the subject's path was studied. As might be expected, the more rapidly he walked, the longer his stride and the smaller the angle of curvature, i. e., the larger the spiral. The subject began at the rate of 1 step every three seconds and gradually increased his speed to the maximum. The resulting curve closely approximates a logarithmic spiral," the curve of growth" (Thompson). (See Plate XI)

The curve obtained from a subject who attempts to walk at a constant rate for five minutes or more has three characteristic phases, all of which are stages in a single process. (1) The first few steps, usually between 30 and 100, trace a very wide arc. (2) this arc leads into a circular or spiral form of smaller dimensions. (3) There is no sharp dividing line between the third phase and the second. The third phase is characterized by smaller and smaller spirals. The total path resembles a reverse logarithmic spiral...the curve of degeneration.

These observed changes have their subjective counterpart. Subject SR. introspects, "When I start to walk, I try for awhile to walk at the speed you told me to, and when I get that down, I let my mind wander or day dream and just keep walking 'till you tell me to stop."
Subject BR. states, "I always feel pretty well oriented when I start to walk. The feeling probably arises from the fact


W.R.
P.T.
W.R.
S.R.
THESE SPIRALS WERE PRODUCED BY CONSTANTLY ACCELERATING SPEED OF WALKING
DOTS MARK DISTANCE COVERED IN EACH TEN STEPS

that my environment is most stable when I am standing still. This makes me feel stable and oriented. When I walk I ignore direction and think only of my rate of walking and either relaxation or tension as demanded by the experimenter. After I've walked an hundred feet or so, it usually feels as though I am rather detached from the environment, and just drifting along. Sometimes it seems as though I am circling, but I try to ignore it."

There are exceptions to this typical series of changes. Subject WR., for example, in one experiment consistently increased the size of the spirals which he traced. He accounted for this by volunteering the information that he felt very sleepy in the beginning, but that the walk had awakened him.

The effects of wind and field slope were investigated. It was found that both wind and the sloping ground produced the same effect on the subjects' course. Whereas normally the spirals closely overlap each other they form a series of small script "e's" which move downhill, or down wind if those factors are present. As the intensity of the wind, or the slope of the field is increased, the distance between the "e's" increases. When either force was sufficiently strong, the course became a wide arc approximating a straight line.

Results of Experiment IV.

In this experiment, five subjects were instructed to refrain from removing their blindfolds. No other instructions were given. Their behavior was observed for five minutes, and at the end of that time they were asked to write an introspection describing their thoughts and feelings during the period.

Subject SR.

Remained motionless for one minute, then said, "Whenever you are about ready, tell me." Two minutes, fifteen seconds: shifted weight to other foot. No other observable changes during the five minute period.

His introspection: "After the box was placed over my head, I was turned around. I heard the footsteps of the experimenter and then there was silence. First I thought that he had forgotten something and had gone after it. I remembered that we had checked everything thoroughly. Next, I thought that he was compiling data about our location, etc. I became a little uneasy and said, 'Whenever you are about ready, tell me.' I received no answer. I became more uneasy and shifted my weight to my right foot. I was constantly alert for returning footsteps. Since I had no instructions and my instructor had placed me, I didn't change my position."

Subject WH.

Fifty-five seconds after starting asked, "Is this a silence test?" One minute, forty-five seconds: he shifted weight without moving feet off the ground.

His introspections: "No instructions were given to me in this experiment, therefore I had no idea what was expected of me. The experimenter merely put the goggles on me and then walked away. I thought I might have to write something because I could hear the pencil moving behind me. When the experimenter failed to instruct me further I remained as passive as possible. I wanted to shift my position a few times but didn't. My reason for not moving more is hazy, but probably was due to the fact that I thought I might be expected to remain immovable. I wanted to say something, but was afraid I would spoil the experiment so remained silent. My last movement was the result of weariness in my legs."

Subject OW.

Was in almost constant motion during the five minute period. At first he paced slowly back and forth, then began to walk in circles, later reversed direction of circles. At the end of first minute he asked, "How long does this go on?" Thirty seconds later, "If you want to know how my directions are, they are gone."

His introspection: "At first I moved because I find that I can keep my balance better that way. Then, after I realized that I was to receive no instructions, I assumed that Mr. Brigden was interested in my movements, so I consciously moved about the room, because I thought that he wanted me to. After I had located the walls and various large objects in the room, I attempted to walk in as large a circle as possible. Since Mr. Brigden did not answer my questions, I assumed that he did not wish to reveal his location. I wondered how long the experiment would last, and if I was doing satisfactorily.

Subject VW.

Neither moved nor spoke during the five minute period.

His introspection: "For the moment I had no idea as to the exact purpose of the experiment though I thought it was connected with work on circular movement. Then as I stood waiting for instructions, I noted a slight swaying of the body and thought of the neurological test for the Romberg sign. After that I tried to stand as still as possible. I quite definitely had the intention of standing as motionless as possible."

Subject TC.

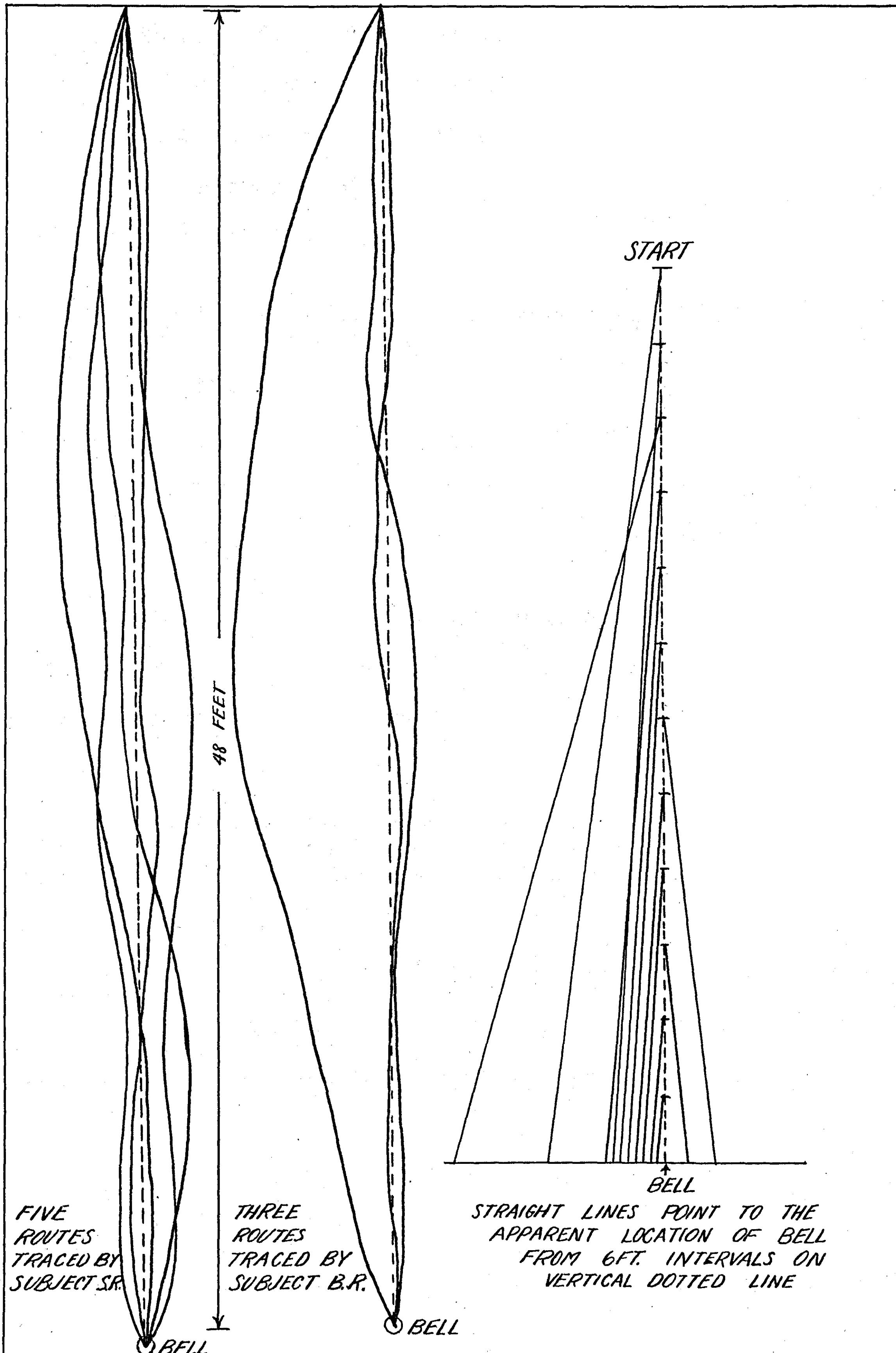
Whistled during the first minute, then asked, "What am I supposed to do, if any?" Three minutes and twenty seconds later he asked, "Am I allowed to walk around?" On receiving no answer, after a few seconds pause, he took one step forward.

His introspection: "When the blindfold was put on, I waited calmly for a signal, seconds passed and I became impatient. I was ready to go, but no signal. I finally asked what I was supposed to do. No answer. I swayed back and forth and finally took a step. I began to settly myself then to calmness. I was resigned to immovability and then the experimenter called time. I still had a sense of incompleteness; of needing action."

Results of Experiment V.

The purpose of this experiment was to study goal localization as it affected the course of a subject who attempted to walk toward the goal in a straight line. The goal selected was a bell which sounded continually. The blindfolded subject started from a point 50 feet away and attempted to walk in a straight line toward the source of the sound. Plate XII shows eight routes followed by two subjects. All subjects traced a wavy course which gradually narrowed in its fluctuations as it approached the bell. Why, we may ask, when the goal is a point with a definite location, does the subject not walk to it in a straight line? The subject himself (SR) answers the question. "When I started to walk, the bell sounded as though it were a generalized sound coming from an area about two feet high and about fifteen feet long. I tried to walk toward the spot in the middle of this area which seemed loudest. The sound soon seemed to be coming from the left, so I moved more in that direction. It seemed as though I couldn't pull myself far enough over, and then an instant later the sound seemed to be farther to the right. The area of sound narrowed down as I approached and when I was told to stop (three feet from the bell) I felt as though the bell had contracted to a round area of sound about eight inches in diameter. It became constantly clearer and more definite during all the time I walked toward it." Similar experiences were reported by all the subjects.

# PLATE XII



48 FEET
BELL
FIVE ROUTES TRACED BY SUBJECT S.R.
THREE ROUTES TRACED BY SUBJECT B.R.
BELL
START
BELL
STRAIGHT LINES POINT TO THE APPARENT LOCATION OF BELL FROM 6FT. INTERVALS ON VERTICAL DOTTED LINE

In the second part of Experiment V, four subjects attempted to aim a yardstick at the source of the sound (the bell), at six foot intervals along a straight line. Their errors were recorded in degrees. The following table indicates the results.

| Subject | Av. error for all distances | P. E. av. |
|---|---|---|
| SR. | 3.4 | .523 |
| BR. | 4.4 | .875 |
| WH. | 3.14 | .750 |
| OW. | 3.7 | .595 |

The low P. E. indicates how constant the errors were. As a matter of fact, there was a slight increase in the angle of error of localization as the subject became farther removed from the sound. If we assume that the angular error of localization remains constant, it follows that the projection of the angle would mark off a greater and greater distance on a horizontal line running through the bell, as the subject moved away from the bell.

These results are taken to mean that the 'goal' of the subject, from a dynamic, field standpoint is an area having the diameter of the error of localization.

## Discussion

In order to understand the significance and implications of our results, let us make an analysis of movement. We shall begin by asking the question, Why does a person walk at all? In order to answer this question let us clarify what we mean by person. Biologically, a person is a complex organism, all of whose parts bear certain functional relationships to each other. A knowledge of this fact does not guarantee an understanding of the organism's behavior. This is true, because in the first place the organism never acts independently of its environment. Thus a knowledge of the environment is imperative. Moreover, an understanding of a person's behavior demands that the forces within and without the individual be reduced to common terms. It would be futile to attempt to predict an organism's behavior in a given environment, if we considered the organism in terms of structure, and the environment in terms of function.

Since both the person and his environment exhibit the properties of dynamic fields, a fruitful set of terms and concepts to use in our study will be those of dynamics. Thus we can speak of the person as a part of a field. His properties and activities will be 'field determined'. His behavior will have the properties of a vector. It is in these terms then, that we will define our person.

Now to return to the original question: Why does a person walk at all? The dynamic answer must be that the field is unbalanced, i. e., there is a difference in potential in the field. The subject's walking is the method by which the field, including the subject, is to return to equilibrium. Some readers may wish to ask how the subject knew that the field was disequilibrated, how he knew that walking would re-establish equilibrium, and why he was interested in re-balancing the field. These questions will arise only in the minds of those people who forget that the subject is a dynamic part of the field. While he is a unit in himself, he is at the same time an integral part of a larger field. Moreover, the terms equilibrium and disequilibrium refer to field dynamics rather than the subject's impression of the field. Phenomenologically, the disequilibration occurs when the subject is given the instructions to walk, and accepts them, or agrees to walk. The subject does not say, "Those instructions disequilibrate my distribution of energy, and, by following them, equilibrium will be established." He agrees to help in the experiment; the experimenter tells him what to do, so he does it.

The results of Experiment IV demonstrate that as soon as the observers agreed to be subjects in the experiment certain changes took place. Tensions were established, and in the absence of instructions regarding their release, the subjects proceeded to set up goals toward which they might strive. TC. was the only subject to specifically mention a "sense of incompleteness" in his introspection. However, four of the observers verbally expressed the same feeling at the termination of the experiment. The results rather definitely demonstrate that no activity takes place in the absence of a goal, toward which it may be directed. Expressed dynamically, when tensions were aroused in the subject by his acceptance of the role of observer; and since the field had not been structured by the experimenters instructions, the subject proceeded to effect a structurization which represented his notion of the field arrangement desired by the experimenter. This leads us to the next question concerning movement.

Where does a subject walk? Let us consider this problem in terms of dynamics. All writers on this subject agree that there is only one possible answer. All disequilibrated fields return to equilibrium by the most direct route possible under the existing conditions. Since the field we are considering is a dynamic field, our subject must resolve his tensions by the shortest possible route. When we speak of longer and shorter routes, we refer to the length of the path in relation to the field in which the course is traced. But we have already stated that movement has the properties of a vector: direction and force. Thus, in those cases in which there were no other complicating vectors in the field, the course would be a simple one since it would be determined by a single vector. In those cases in which the field is heterogeneous, including numerous factors which effect the moving subject, the path will be more complex, i. e., its direction will show greater fluctuations. This does not mean however that in a complex heterogeneous field, the subject follows a path which is other than the simplest possible route under the existing conditions of field structure. Whenever we speak of <u>least action</u> or <u>shortest route</u> we imply the added phrase: <u>under the existing field structure</u>. Otherwise least action and shortest route are meaningless. Comparatives and superlatives are always relative to a field. We are now faced with two mutually exclusive alternatives. Either all behavior does not follow the shortest possible path, or else there is only one possible path which movement could follow. Consistency demands that we espouse the latter alternative. Instead of speaking of longer or shorter routes, we can speak of THE route of a subject in a field.

The statement "movement has the properties of a vector" demands some expansion. We examine a vector diagram in a physics book and see a 4 cm. line pointed north, a 3 cm. line pointed northeast and a 2 cm. line pointed west. The problem is to discover the resultant. It will be a line having a certain length and direction. Unfortunately this line does not represent the path which a subject would follow, whose stimulation might be symbolized by the component vectors. The resultant vector merely gives the force and its direction at a point. It is important to mention this fact for two reasons. In the first place, no subject's course was straight. Thus if motion followed the direction of the vectorial resultant, we would be faced with a dilemma. Either all subjects' courses would be straight lines or else their course would not have the properties of vectors. In the second place, a subject can be stopped at any time. This would not be true if he had to walk to the end of the line symbolizing the resultant vector. If we realize that the resultant vector is merely a force at a point and that at another point the alignment of stresses will be different, we shall have no difficulty with the concept of vectors.

In answering the question "Where does a subject walk?" we must consider one more characteristic of movement within a field. A subject will continue to walk until he reaches his goal. This has been shown to be true also in the case of rats (2, 3). Although the position of the goal was changed and the spatial relationships between start and goal were altered, the rats continued to search through the maze until the goal was reached. The search would be terminated at any time if the experimenter placed some food before the rat. Similarly the walking movements of a subject can be terminated at any time by the word "Stop". To the subject this signifies the achievement of the end. In terms of dynamics, equilibrium has been achieved.

Both the objective results and the introspections of the subjects reveal that the goal is not a static point in space, but that it is in itself, with reference to the subject, a variable. A subject (MR.) who had just walked for 10 minutes at the rate of 1 step every 2 seconds, indifferent to direction, when asked to define what his goal had been, stated "Well, I tried to do what you asked me to, to take one step every 8 ticks of the watch and just walk in the easiest way indifferent to where I went. I was very relaxed, and when a gust of wind hit me, it almost knocked me over." Compare this with the same subject's introspection following an attempt to walk in a straight line. "I have a feeling that I didn't go exactly straight, but I don't know which way I did go. I tried to think what it felt like to walk straight, with my eyes open, and then tried to get the same 'feel'. Whenever I felt as though I was beginning to turn to one side I would try to compensate for it by increasing my tension on that side and slightly twisting my body in the direction I thought was correct. I was very tense all the time I walked. I couldn't seem to help it. If I tried to relax, it felt as though I was not going straight." Nothing is said in either of these introspections about the goal being a point in space. But suppose that the subject is told to try to walk to a definite spot in space. What will be the nature of the goal location under those conditions?

This problem was studied in Experiment V. The results obtained when a subject attempted to walk toward a constant sound in a straight line, indicated that <u>while the goal physically occupied a single point in space, it was phenom-</u>

enologically an area whose size varies with the subject's distance away. On the basis of the results of the second part of Experiment V in which the subject attempted, at various distances, to point a meter stick toward the source of the sound, we can formulate a more exact statement of the relationship between the 'goal area' and the subject's distance from it. The goal is an area whose size varies in direct proportion to the subject's distance away from it. Under these conditions, the geographic definiteness of the goal varies inversely with its size.

Another principle of motion is deducible from our data. The straightness of the route leading to the goal is proportional to the energy expended in that direction. The following data are presented in defense of this principle.

Instructions demanding the expenditure of increased energy produce a straighter path. In all cases in which a subject was told to walk faster, his path more nearly approximated a straight line. More energy is required to increase one's speed of walking. Both the subject's introspection and records of increase in pulse rate are indicative of this conclusion.

Instructions to increase tension while walking produced straighter paths in 55.5% of the cases studies, more curved paths in 33.3% and produced no recordable difference in 11.2%. On the basis of these statistics one might be inclined to doubt the soundness of the principle under consideration.

However, our qualitative data come to our aid. Those subjects who made straighter courses under tension expressed their tension goalward in the form of longer steps and <u>more frequent steps</u>! In spite of the fact that they were instructed to walk at a certain rate, under tension they increased their speed of walking beyond that rate. Those subjects whose course became more curved under tension apparently turned their tension inward so that it had an inhibitory effect. Their stride became shorter and their estimation of time was affected in such a way that they stepped less frequently then the instructions demanded. Since the statement of our law refers to energy expended in the direction of the goal, any change which retards a subject in his movement toward the goal can not be assumed to fall under the law.

The longer a subject walks under a given set of instructions, the more curved his course becomes. As he walks he becomes fatigued, he has less energy to direct toward the goal, thus his course increases in curvature, to a pattern which requires less energy to maintain.

Let us attempt to trace the relationship between the two facts: (1) that the path becomes increasingly straight with increased energy expenditure in the direction of the goal, and (2) that a route becomes straighter as the goal is approached. As the goal is approached, it becomes more definite, thus <u>the more definite the goal the straighter the path to it</u>. When a subject is 50 feet away from a bell, his movement is only in the general direction of the sound since his localization of it is inaccurate. As he approaches the sound, it becomes more definitely localized and he is able to direct a greater proportion of his energy goalward toward a fixed point, with the result that his path becomes straighter. In other words, the straighter the path, the more energy is expended per unit of distance forward toward the goal. This is also true of the first problem where acceleration means greater expenditure of energy per unit of distance forward in a linear dimension. It thus appears that the second fact mentioned above (the more definite the goal, the straighter the path to it) is an example of the more general proposition, that the straightness of the route leading to the goal is proportional to the energy expended in that direction.

If our reasoning is correct, more energy should be expended by a subject when attempting to walk in a straight line than when he walks in the easiest way. A simple experiment proves that this is true. Five subjects attempted to walk in a straight line and their pulse rate was measured. The average for the group was 77.8 beats per minute. The same group next walked at the same rate, but indifferent to direction. The average rate was 64.8 beats per minute, a difference of 20%. The subjects agreed that it required much more effort and alertness to 'walk in a straight line' than to walk in the easiest way, which was a spiral. It is interesting to note that with a 20% increase in energy expenditure, the curvature of the paths traced decreased

20%. Insufficient data have been obtained to demonstrate conclusively the existence of a constant relationship between the curvature of the path and energy expenditure.

## Theoretical

The theory which will be proposed is based on the assumption of a dynamic unified field. We have defined a <u>unified field</u> as an organized system of energy in which every part is capable of affecting every other part, and in which every part derives its properties and activities from its position in the system as a whole. The field is given. It is not built up from its parts by any synthetic or additive process. In fact, to assume the opposite would lead into a hopeless dilemma. If we were to suppose that any whole is composed of discrete, separate, unorganized parts, our first problem would be to put these parts together because in nature as we see it and study it there is activity between the parts. There are only two alternative methods of doing this. Either there is something within the parts which will join them together, or else some agent outside the parts must join them. If the first possibility were true, our original assumption would be false because the parts would not be separate and distinct. They would always be in certain relationships with each other, and thus parts of a larger a priori system. If the second alternative were true, we would be violating the law of parsimony and adding something, not given in the beginning. Our problem could never be solved in this way, because it would lead to an illogical infinite regress of causation. All nature, as we know it, is organized and patterned. We simply start by assuming this organization.

Our conception of organization must be broad enough to include all forms, inorganic, organic, man. As long as any unit affects or is affected in any way by a whole, it is a part of that whole. Thus a human subject is just as much a part of a physical environment, just as much a part of the field structure as a stone on the ground, or the air that he breathes. If either were lacking, he would not be there, and if he were lacking, there would be a different field; a field without man, rather than a field including man. We must assume that our subject is a dynamic part of the structure of the field. It is just as impossible to add structure to a field, as it is to make a whole out of parts, for both represent the same thing.

Having stated our assumption: the primacy of the organized field, we turn to the phenomenon in which we are particularly interested, movement within the field. We have already experimentally demonstrated that movement in man takes place only when there is a goal (phenomenological) or differential of potential (dynamical). Given a disequilibrated system, movement will take place in such a way that balance and equilibrium will be reestablished. As Leibniz (1646-1716) stated it, "Chaque chose finit toujours par s'accomoder a son milieu." (19).

Maupertuis (1698-1759) studied the paths of moving bodies from a dynamic point of view. In 1740 he presented to the Paris Academy his famous principle of least action. Maupertuis observed that as we pass from any given initial configuration of a system, to any given final configuration, the work done when the final configuration is reached is a maximum or a minimum. Mach evaluates Maupertuis' contribution in the following terms. "Maupertuis gave a new impulse to the theologising bent of physics by enunciation of his principle of least action. In the treatise which formulated this obscure principle, and which betrayed in Maupertuis a woeful lack of mathematical accuracy, the author declared his principle to be the one which best accorded with the wisdom of the Creator. Maupertuis's principle would in all probability soon have been forgotten, had Euler (1707-1783) not taken up the suggestion. Euler magnanimously left the principle its name, Maupertuis the glory of the invention, and converted it into something new and really serviceable. What Maupertuis meant to convey is very difficult to ascertain. What Euler meant may be easily shown by simple examples. If a body is constrained to move on a rigid surface, for instance, on the surface of the earth, it will describe when an impulse is imparted to it, the shortest path between its initial and terminal positions. Any other path that might be prescribed to it, would be longer or would require a greater time." (20)

Hamilton, in 1834, extended the principle of least action to apply to both conservatice and non-conservative systems. His statement was as follows (#): "The time mean of the difference of kinetic and potential energies is a minimum

(#) As stated by A. G. Webster, The Dynamics of Particles, Leipzig, Teubner, 1904. 98-99. cf. Wheeler, The Science of Psychology, Crowell, N. Y. 1929, p. 81.

for the actual path between given configurations as compared with infinitely near paths which might be described in the same time between the same configurations...Nature tends to equalize the mean potential and kinetic energies during a motion."

In 1927 Reiser stated the principle as follows: "In passing from an earlier to a later stage the sequence through which the system passes is such that the mean or average value of the difference between the potential and kinetic energies during the interval of time will be a minimum." (22)

These various statements of the principle of least action confirm our assumption that the world is an organized energy system. It would be a startling and unintelligible discovery if some one found that a given act took place over the shortest route in time, when the world was an aggregate of parts. In fact <u>shortest route</u> would be meaningless. It is because energy systems are organized units that least action, shortest route, and potential have meaning. Potential refers to a differential of energy as a field-determined factor. No force is inherent in an object. Its energy is derived from the field. As Max Planck points out, it is "not the local force, as in Newtonian mechanics, but the integral force, that is to say, the potential, which enters the fundamental equations." It is meaningless to talk about the state of a single particle except as that state stands in a certain relationship with the whole system of particles. It was Ostwald who showed that two chemicals reacted together because each had a different potential. Thus a change took place in which heat was given off and equilibrium achieved. Similarly if an electric circuit is closed, establishing an electrical field, the current will flow until the potentials are equalized. If the current is made to light a bulb or ring a bell, we see the effect of the electromotive force in one point in space and might erroneously say that the change is located at that point. However, each part of the system is equally essential, functionally, and the system as a whole works because it represents an energy differential.

As Wheeler says, "There are exceptions to this statement (least action), notably in the field of optics, which need not concern us here, where movement is over the longest route in time. In either event complete organization in a given system of energy is implied, whether we are deding with <u>maxima</u> or <u>minima</u>. Our interest in the law rests in this assumption of complete organization, without which least and greatest have no significance." (29)

We now proceed to a theory of spiral movement. It is interesting to note that the results of the experiment and the assumptions with which we started put certain demands or restrictions on our formulation of a theory. Our theory must consider the field as an organized unit in which the subject and field structure are parts. To start with any other assumption would preclude the possibility of treating the subject and the field together in the same terms.

Our theory must not consider spiraling determined within, or solely by the walker. The experiment has demonstrated that wind, slope of the ground, and the experimenter's instructions, none of which can be considered as properties of the subject, all produce their effect on the subject's path. Moreover, our theory must not be based on the assumption that spiraling is produced by physical asymmetries in the subject. Schaeffer showed that a blindfolded subject would drive a car in spirals. Physical asymmetries would have been inoperative under those conditions. Moreover, subjects who walked alternately backward and forward spiraled in the same way as when they walked constantly forward. Physical asymmetries would have altered the form of the spiral under the two conditions had they been the cause of spiraling. Another limitation which we must observe in formulating the theory is that spiraling can not be explained in terms of specialized organs such as the semicircular canals, because organisms lacking these structures (ameba, etc.) exhibit spiral movement. Not only is it impossible to explain spiraling in terms of the organism alone, but it is also impossible to account for the phenomenon entirely in terms of the environment. Our results show that the same subject will inscribe spirals of different size under the same conditions of field structure, a fact which we have attributed to fatigue or other changes within the subject. Spiral movement must be considered as a changing spatio-temporal relationship, characteristic of an interaction between an organized field and an internally organized part of that field. The condition which beings about this changed relationship is a potential difference within the field, with the moving part one of the terms and the external field structure the other term.

In formulating our theory therefore, we must consider movement as the result of potentials rather than as the result of local discrete forces. Discrete forces imply discrete parts, whose presence in the field we have shown to be an impossibility. Potentials represent an organized field, which we began by assuming and then attempted to demonstrate experimentally.

A final fact which our theory must embrace is that motion must occur in the line of least action. Every curve will represent the shortest route by which the field potentials could be balanced under the existing field structure.

<u>Movement occurs in the shortest possible route under the existing conditions of field structure.</u> In a homogeneous field, of low potential relative to the moving part, spiral movement will always occur. When the differential between the moving part and the field is less (or small) the diameter of the spiral will be less (or small) and the velocity of the movement will be slow. When the differential is larger the

diameter of the spiral and the velocity of the moving object will be greater. We may postulate that the diameter of the spiral will be proportional to the velocity of the moving part. This is because time, space and motion are one configuration, under the field-structure theory, and one factor cannot be varied without correspondent variations in the others.

Since the key-word of the theory is field-structure, we will define it before proceeding. Field-structure is the totality of organized potentials or gradients in a dynamic system. The potentials are organized of necessity, since in the absence of organization a dynamic system would not exist. By gradient we mean an extended continuum of ascending or descending potential. For example, movement takes place because one part of a field has a lower potential than another part. A gradient of energy thus exists between these two points, and movement will occur in the direction of the point of lowest potential, from any higher point on the gradient.

Examples of field structure which were effective in the experiment on walking are the goal gradient which was the most important single factor, wind, sun, ground slope, sounds and objects.

We will now consider our theory in two ways. We will show first that it is deducible from our original assumption, and second, that it applies to our experimental results.

To demonstrate that the explanation of spiral movement which we have offered is derivable from our assumption of the organized field we will attempt to prove the impossibility of movements over any but the shortest route in such a field. Movement is the resultant of <u>all the forces</u> in the field. Its extent and direction will be rigidly determined by <u>all</u> of those forces, so that given a certain set of forces, <u>only one movement is possible</u>. This movement would of necessity be the most direct movement possible in that field at that time, for, if it were not, we are led directly to a self-contradiction. Let us assume the actual path is infinitesimally longer than the shortest possible route. Then, either the increment of movement occurred without a cause, or else it is possible for a field to contain forces which are not a part of it. Since causation without a cause, and relationship between definitionally unrelated things are impossible, we are forced to reject the possibility of a moving body following a path which is longer than the shortest route under the given conditions.

The question may be raised, "What determines whether a helical spiral, a sigmoid spiral or a straight line will be the shortest course between two points.". The answer to this question may be derived logically and demonstrated experimentally. In each case we must consider the relation of the goal, or position of low potential, to the field as a whole. If the experimental instructions fail to establish a definite point toward which the movement is to be directed, <u>and merely gives a method of walking, the goal becomes generalized</u>, and might be described as "away from here". <u>This type of goal extends 360 degrees around the subject.</u> Every point in the field has a lower potential than the subject's present location. The farther from the present location, the lower the potential, in all directions. Since the field is thus homogeneous and, up to now, we have presupposed an infinite number of possibilities of direction, how is it that the subject moves only in <u>one</u> direction, namely, that of a helicoid spiral? It would be sheer mysticism to assume that the organism takes the helicoid path in virtue of his own independent "fiat." We have assumed a dynamic relation <u>between</u> the organism and its environment. The two constitute a unit. What, in the nature of the whole, in this case, explains the spiral path? We must assume the explanation in an assumed fundamental characteristic of space-time-energy configurations. According to Eddington, "There are certain curves which can be defined on a curved surface without reference to any frame or system of partitions, viz., the geodesics or shortest routes from one point to another. The geodesics of our curves space-time supply the natural tracts which particles pursue if they are undisturbed. We observe a planet wandering around the sun in an elliptic orbit. A little consideration will show that if we add a fourth dimension (time), a continual moving on in the time dimension draws out the ellipse into a helix. Why does the planet take this spiral track instead of going straight? It is because it is following the shortest track: and in the distorted geometry of the curved region around the sun, the spiral track is shorter than any other between the same point." (9, p. 124-5)

Thus, in the absence of a specific goal, and because space-time itself is curved -- structured under laws of dynamics (least action) --a path, other things being equal, will, under the simplest condition, be a spiral. Any other route produces "friction." In the case of human beings, any other route requires more effort.

Our next problem is to explain the sigmoid spiral. A sigmoid spiral path indicates a more specifically located goal; one toward which a subject can at least point and say, "there it is." In all probability, he will be incorrent in his goal localization if his course to the goal is a sigmoid spiral, for this pattern of movement appears when the goal is an area with respect to the subject. It has been experimentally demonstrated that the size of the area is a function of the subject's distance from the goal. Moreover, the size of the waves, which a subject traces, increases with his distance from the goal. Thus, the extent of the fluctuations in a sigmoid spiral course is proportional to the apparent size of the goal. Dynamically we may assume that, with indefiniteness of the goal, the subject will take a curved path in the general direction of the goal-area, but, finding shortly, that he is heading away, he curves back. So long as the curve does not take him beyond his error of localization he is satisfied that he is approaching it, thus he continues on his curved path which takes him, eventually to a point where, although poorly localized, the position of the goal, relative to his direction, informs him that he is again headed away from it again. He curves back. In this way, the error of localization, that is, the area of the goal, conditions the amplitude of the sigmoid spiral.

A straight path is traced only when the field is highly structured with respect to the subject and the goal is a point. This situation can obtain only when the field is sharply structured <u>gradient-wise</u>, and the goal is at one end of the gradient. A blindfolded subject is unable to walk in a straight line because neither of these requisites is satisfied. In fact under normal conditions a straight course is a rarity. As one walks about a building and on the street his course is usually a sigmoid spiral, unless he attempts consciously to walk in a straight line.

A further question may be raised concerning these facts. How is it that a spiral movement is shorter than a straight line under any conditions? The answer can be given only in terms of field structure. The form of the path is dependent on the amount of energy involved and its direction. In a homogeneously structured field, it requires less energy to walk, drive a car or swim in spirals than to attempt to approximate a straight line. The objective goal is an area, not a point under these conditions. Expenditure of energy would be required to reduce this area in size. But in a homogeneous, unobstructed field, the moving body takes the shortest route in time. Therefore, it does not expend unnecessary energy in reducing the area of the goal to a single point. Further, when circumstances raise the potential of the moving object relative to the homogeneous field, the object will circumscribe a larger spiral. For if the energy is available, it will be expended in the most direct fashion. A helpful analogy may be found in the example of a person swinging a weight, in horizontal circles, on the end of a string. Thus if very little energy is used, the diameter of the circular path will be relatively small; if more energy is used, the size of the arc increases. Similarly, as a subject walks faster, the size of the arcs which he inscribes increases.

David Burns gives us another example of spiral movement in his book "Introduction to Biophysics" (5). "A thin test tube very often cracks in a spiral way. The more homogeneous and isotropic be the glass, the more even and regular will be the spiral. That is, the crack tends to follow the shortest course on the surface of the tube between the point of origin of the crack and the point diametrically opposite..a ring formation. Generally, however, the ring winds into a helicoid form and is continued."

Burns' statement that, "The more homogeneous and isotropic be the glass, the more even and regular will be the spiral" is in perfect harmony with our results on walking, in which it was apparent that the more homogeneous the field, the more regular the subject's spiral. Our experimental results bear out our general theory. On the basis of this theory we would predict that minor fluctuations in field conditions would cause the path of the subject to waver or become slightly modified, but they would not obliterate the general form of the path. This turned out to be the case. If a subject feels the sun's rays, or is buffetted by a gusty wind, or is aware of disturbing influences, his path will lose its regularity but not its major characteristic of form. If the subject maintains considerable tension as he walks, the complexity of field structure is relatively diminished. A greater differential of potential is required to disturb his course when he walks under tension. Thus instructions to maintain tension while walking produced smoother paths in 82.5% of the cases. Step-and-rest walking increased the size of the spirals over constant walking. Introspections indicate that the former type of movement permitted a more stable field structure than the latter. (WR.): "When I pause between steps, my environment seems to be more static, but more definitely visualized. When I make continuous movement, I can visualize the field less well. There is less structurization of the field." Fluctuations in direction were more frequent and erratic in children than in adults. The field was very unstably structured for the children. Wide fluctuations took place without any apparent objective cause. A wide arc would be interrupted by a sudden sharp turn. All of these facts indicate that under the simplest field structure, a subject will follow a regular course and that as the field structure becomes more complex or more unstable, the subject's course will lose its regularity.

One important conclusion of the experiment is that <u>the more definite the goal, other things being equal, the more direct the course to it.</u> This might be stated as a corollary of the theory as well as a conclusion of the experiment, because not only was this statement demonstrated in 100% of the results but it offers a verification and enlargement of the theory under consideration. It states that the shortest possible route which a moving body can follow is a function of the expanse of the goal toward which the motion is directed. The reason for this is that the more definite the goal, the more direct the resolution of differential between it and the field, or to express the same thing in another way, the sharper the goal gradient. Thus we can express the straightness of the path in terms of energy involved. <u>The straightness of the route leading to the goal, is proportional to the energy expended in that direction.</u> This is borne out in two ways. The arcs circumscribed by rapidly moving objects in a homogeneous field are of a more gradual curvature, that is, "straighter" than those circumscribed by slowly moving objects. Also, objects moving in a straight line toward a goal are expending all of their energy at high potential toward their remote end. Thus the two cases, circular movement and straight-line movement, are brought under the same general principle.

Our theory therefore predicts that, if a moving object accelerates in a homogeneous field, its path will be a spiral of decreasing curvature. Since we have postulated that the curvature will be proportional to the velocity, we can predict that the spiral will be logarithmic. This actually turns out to be the case. Subjects instructed to accelerate their speed, starting at the rate of one step in two seconds, until they were running at top speed (under blindfolded condition) traced logarithmic spirals of astonishing regularity. (See Plate V.)

If the goal is an area, energy will not be directed toward any single part of it, but toward maintaining a constant relationship with the total area. If the goal is a point, all of the energy will 'flow' toward it in a straight line. A physical parallel helps to understand the point. Suppose that a one-billion-gallon-a-day river is one mile wide at a certain point. The water will be very shallow and will probably flow slowly. Let us suppose that at another point the river is fifty feet wide. There the water will be deep and will flow rapidly. Furthermore, at the mile-wide-point the river will, other things being equal, follow a winding course, while at the narrower point the concentrated force of the water would soon make a straight channel.

A similar situation, dynamically, can be duplicated in human behavior. Let the goal of the subject be a bell ringing at a distance of 50 feet, so that its localization is undifferentiated. This means that the goal is an extent corresponding to the error of localization. When the subject walks toward this bell, his path resembles the winding of the river at its wide point. As he approaches the bell, the sound becomes more intense and more definitely localized. He is able to direct a greater proportion of his energy in its exact direction and his path as a result more nearly approximates a straight line. (See Plate XII)

## Conclusions

The first and most general conclusion of this study is that a dynamic, organismic approach to the study of human behavior is justified and valuable.

We believe that this is true because all nature appears to exhibit the characteristics of dynamic systems. Modern research in Chemistry, Biology, Physics, Astronomy and Psychology offer new evidence daily indicating that nature is a single, organized system of energy. Any phase of nature should be studied, therefore, in terms of this organization. It would be absurd to study some problem in terms of units which did not apply, such as measuring volts in terms of square feet or water pressure in terms of hours. It is equally useless to attempt to understand and interpret nature in terms of units and concepts which are inapplicable. The present study has attempted to deal with one aspect of nature in terms which have been demonstrated to be applicable and therefore useful in many phases of science. The results of the study indicate that this approach is applicable to the phase of nature under investigation.

The dynamic organismic approach has enabled us to make predictions regarding movement. The majority of the results of the experiment were predicted before the results were obtained. In those instances in which inaccurate predictions were made, the error was discovered later to be due to some factor that had been overlooked or had not been seen in its proper relationship to the whole problem.

Insofar as we are able to predict the nature of movements, we should be able, theoretically, to prédict all behavior, since all behavior is movement. Actually, this goal of prediction is in most cases of behavior as yet impossible, because in any particular case, our knowledge of field conditions is limited and also because at present our knowledge is relatively general and undifferentiated with respect to relativistic dynamics. However, the fact that in a simple case we are able to predict with some accuracy may both encourage us and strengthen our confidence in the methods employed.

The dynamic organismic approach has enabled us to control behavior. Insofar as we are able to prédict, we can control behavior in proportion to the extent of our ability to control field conditions. For example, we can predict that a subject will walk in a straighter path 100% of the time, if the only factor which is varied is the instruction to walk faster. By instructing him to walk faster we can control the form of his behavior.

More specifically, if we place a human being in a homogeneous field we can predict that, other things being equal, he will move in a spiral whose diameter varies directly with his velocity. We can predict that when he moves in a field, structured gradient-wise, that is, with a point as a goal, he will approximate a straight line movement toward the goal. We can predict that, if the goal is an extent, smaller than the field, his path will approximate a pendular wave-like course whose total amplitude corresponds to the error of localizing the goal. We can predict that, when the movement accelerates, the path will approximate a logarithmic spiral. We can predict that if the field is not stably structured, as in the case of children, direction of the path will be more variable. Furthermore, in terms of our theory we can understand how all of this should occur.

We believe that the dynamic approach to the study of behavior is justified since it reduces all behavior to common terms. Walking movement, bodily tension, goals, Will, etc., all become factors in a single field. Thus we are justified in using them and considering them together. To extend the same principle one step further, by considering behavior dynamically we are justified in reducing it to the same terms as our dynamic environment, and treating human activity in the same manner as physical activity. We know that the physical world does affect people, thus there must be some commonbasis on which both function.

For all of these reasons we believe that a dynamic, organismic approach to the study of human behavior is justified.

The results of the experiments herein reported indicate the following conclusions:

1. Movement takes place only when there are potentials in a field. Movement is the means by which these potentials are balanced.

2. Movement occurs in the shortest possible route under the existing conditions of field structure.

   a. The more definite the goal, other things being equal, the more direct the course to it.

   b. The straightness of the route leading to the goal is proportional to the energy expended in that direction.

3. The goal is an area whose size varies in direct proportion to the subject's distance away from it.

   a. Under these conditions, the geographic definiteness of the goal varies inversely with its size.

4. All of our 51 blindfolded human subjects walk in spiral paths. The spiral may have any of the modes of a helical spiral: circle, helix, or sigmoid spiral. The size of the spiral varies in different individuals and in the same individual at different times and under different conditions.

   a. The longer the subject walks under instructions to move at a constant rate, the smaller the spiral tends to become.

   b. The smallest spirals were obtained when subjects walked slowly, relaxed and indifferent to the direction of their movements in a homogeneous field.

   c. The largest spirals were obtained when subjects attempted to walk in a straight line, rapidly and under tension.

5. The size of the spiral is generally proportional to the speed of walking.

6. Constant acceleration produces a curve which closely approximates a logarithmic spiral.

7. It is possible to reason logically from one form of spiral movement to another assuming certain changes in field conditions. In a homogeneous field, with no definitely structured goal, the path is a helical spiral. As the goal becomes structured in the field, the helicoid shifts to a sigmoid which straightens out as the goal is approached. This field is independently structured gradient-wise, the gradient terminating as the goal area. When this goal area reduces toward a point the field structure becomes more sharply formed gradient-wise and the path approximates a straight line.

8. The paths traced by subjects under tension were smoother, i. e., more regular than those traced by the same subjects under relaxation, in 82.5% of the cases.

9. The verticle angle of the subject's body influences the length of his path per unit of time, and the curvature of the path.

10. There was no marked tendency for the subject to spiral to the right rather than to the left, or <u>vice versa</u>.

11. Length of stride increases with the speed of walking, under conditions of both tension and relaxation.

## Appendix

The following introspections are offered with the belief that they are just as valuable, importat and relevant as any other type of data. The evaluation of introspections has gone from one extreme to the other in the history of psychology. We disagree with both those who believe that introspection is the best way of gaining an understanding of the mind, and with those who evaluate introspection as superfluous and unscientific. The middle course seems pree ferable. Inso far as introspection represents a subject's reaction to his environment and is treated as his description of his experience it has a definite scientific merit. Instead of attempting to answer criticisms we will demonstrate that the use of introspection is justified in a dynamic study of human behavior.

A dynamic theory implies a monism. No materialistic-idealistic or mind-body distinction is believed to exist. For purely descriptive purposes we sometimes speak of "mind" and "body", the former to mean that activity whose resultant alone we can see, and the latter to mean the extended individual form. However, if "mind" can affect "body" or <u>vice versa</u> they both must be parts of a single configuration. If this is true, the same laws and potentials act on each. Each is a part of an energy system. As long as we accept data from one part of a system, we must accept it from another. Thus as long as we accept the measurement of a ruler, or the deflection of a voltmeter, we must accept introspective material. Introspection is field determined just as much as the voltmeter reading and it is as valid as the ruler reading for the purpose specified. Different experimenters may obtain diverse answers from the ruler, and different subjects may give different introspections following the same experience. Insofar as the experimenters and subjects accurately describe their experiences, their results are valid. Each tells what he experiences <u>under the existing conditions</u>.

<u>Effect of wind.</u>

DP. "I think I must have gone in circles because the wind came from different directions."

BB. "Seems as though the wind has been blowing from different directions and noises come from all around."

WR. "I have absolutely no sensation of change of direction or curving. It is the funniest thing to see that sun and feel the wind go around and around. I feel no inclination toward a circle at all."

<u>Effect of tension and walking rapidly.</u>

BR. "When I'm tense I try to fight everything. It is very difficult not to try to go straight."

BR. "When I walk faster, I notice a much greater tendency to tense up." (Instructions were to walk rapidly, but relaxed)

WR. "I know that I'm going in circles but I'm going in the way that takes the least effort."

BB. "I couldn't relax when I did that." (Instructions were to walk rapidly, but relaxed)

RH. "Tensing the body tends to make you go in a straight line since it structures the field."

The following introspection was written in answer to the question, "What is the difference between walking tense and walking relaxed at the rate of one step every eight ticks of the watch?"

SB. "When I was relaxed I had a hard time to keep my balance. I had no particular goal, and had instructions to walk as relaxed as possible. I merely let myself go and worried only about the watch that regulated my cadence. The only thing that made walking difficult was the wind.

When I walked as rigidly as possible I never thought about keeping my balance. My muscles hurt some after I had walked a while. Several times I caught myself forgetting to count the ticks of the watch that regulated my cadence. I was relieved when I was instructed to stop."

The following introspections describe relaxed and tense walking at different speeds.

<u>One step per 2 seconds, relaxed.</u>

WR. "Was conscious of turning to the left, otherwise field was homogeneous." (Subject traced 3 spirals with 54 feet -

average diameter)

PT. "I found that there was more sidewise deviation than with the faster speeds. There was a definite awareness of the external stimulus field, the steps each being determined by the easiest path. I found that there was a change in the structure of the figure. One time the ticks of the watch would predominate for a few seconds, then the walking sounds of the experimenter would predominate, then the sound of a car would appear, then I would think about some outside unrelated incident for a few seconds. Occasionally I would become aware of a particularly difficult choice of where to put my foot down. This would occur if I tried to go opposite to the easiest place. There seemed to be more right and left deviations than under faster speeds." (Subject traced 2 circles whose average circumference was 324 feet)

<u>One step per two seconds, tense.</u>

WR. "I tensed my arms, shoulders, hands, and back I crept forward as if springing at some object. The field was more structured. Had a tendency to visualize surroundings, even in color. Noises would intensify the structurization, but made no difference in orientation. At the end, I felt the whole pattern ready to 'break over' into shift to the right." (Subject traced 1 1/3 circles whose average circumference was 272 feet)

PT. "Much as the other tense conditions, but found it a little different than others in that stimulus field would figure occasionally; not as much as in a relaxed condition. Felt that there was more right and left deviation than under conditions of one step every second or half second, yet not as much as under relaxed. (Subject traced 1 1/3 spirals with 467 feet the average circumference)

<u>One step per second, relaxed.</u>

PT. "I noticed that under the relaxed condition there was a much greater awareness of turning. I was aware in each case of just letting my foot down where it was the easiest; this oftentimes I knew was out of line with my previous path, either to the right or left. I had no awareness of the general path, except for these deviations. I did not think at any time of compass direction; was completely disoriented throughout all of the experiment as to directional orientation. Did I have right and left orientation." (Subject circle of 757 feet circumference)

<u>One step per second, tense.</u>

WR. "I threw all of my energy into hurling myself forward. The field was more stable; structured goal ahead. Posture bent backward, head thrown back as though looking upward; long steps. Everything seemed pointed ahead. Did not know I was going straight ahead." (Path was actually a very wide arc.) (Subject traced spiral of 76.9 feet circumference)

PT. "When I tensed, I clenched my fists, raised my shoulders and made my legs stiff. I also breathed deeply. I tried to imagine that I was intensely angry. I was not aware for the most part of any deviation in my path, from right to left or <u>vice versa</u>. I thought that I was walking in a much straighter path than under relaxation. There was no awareness of orientation. (Subject made 3.3 spirals of 156.4 feet average circumference.)

<u>One step per ½ second, relaxed.</u>

WR. "The field was structured homogeneously for the most part. There was no directional orientation. At brief intervals I felt as though I swerved to the left. Had a feeling of being drawn to the left. But most of the time I seemed to be going straight ahead. Once a gust of wind affected me for about 10 seconds, and I felt myself automatically turning into the wind, to the right, It was not voluntary." (Subject made a large circle with a circumference of 2402 feet.)

PT. "I was again aware of sidewise deviations; the field seemed blocked in certain directions, e. g., to the left, and as a consequence I would take the next step to the right. If I tried to step to the left under this condition, I found a large amount of muscular pulling in the other direction, so that if I stepped to the left I was off balance. It was much easier to step to the right. It was as if someone was pushing me from the left side. I had no direction (compass) orientation." (Subject made 2 1/3 spirals whose average circumference was 240 feet.)

One step per ½ second, tense.

WR. "Felt hemmed in. My whole postural set patterned as if carrying a heavy load. Walked with arms, shoulders, back and legs tense, on tiptoe, like a horse pulling a heavy load up hill. Took short steps." (Subject made 8 spirals of 147.8 feet average circumference.)

PT. "There seemed to be less right and left deviation than when I walked relaxed. I seemed to be going in a straight line, but did not particulerly think about orientation or path. Seemed to be consumed by condition of tenseness. External field was totally ground, body tone and tenseness was the figure in experience." (Subject traced one large spiral whose circumference was 684 feet)

Accelerated walking.

WR. "As I accelerated I could feel compulsion to straighten out. The field tended to structure, and I tried to visualize the goal ahead. At times felt inhibited by fear of crashing into the wire."

PT. "At slow speed felt awareness of stimulus field and right and left deviations. As I speeded up, seemed to have a goal before me, directly in front. Felt that latter half of path was very straight, but there was no effort to make it so. Concentrated on speed. In the last half, speed occupied the figure."

Several subjects had the experience of suddenly feeling that they were lost. PC. had been walking in a large arc. Suddenly he made a change of direction and then a very small circle. As he made his change of direction, he gave a helpless gesture and said, "I'm lost!" SH. had a similar experience and said, "I've lost my 'set'!"

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