

An Experimental Study of Emotional Adaptation
to an Exciting Stimulus,

by

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An Experimental Study Of Emotional Adaptation
To An Exciting Stimulus.

This is an investigation in the field of emotion. The study is an attempt to measure the degree of adaptation of a group of subjects, to an exciting stimulus.

In describing the nature of an emotion David Wechsler¹ says,

"The phenomena which have usually been distinguished as constituting an emotion are: first, the perception of some unusual or threatening fact; second, some bodily changes; and third, a subjective state, or affect."

In this study, we have provided the threatening or unusual fact--the exciting situation, and have measured some of the bodily changes. The subjective state, however, we have not investigated in this experiment.

It has been found that two of the readily measurable indicators of emotions are the changes in the cardiac and respiratory responses, the most obvious of these changes being changes in rates of heart beat and respiration. We have, therefore, in this experiment made measurements of changes in heart and respiration

¹Wechsler, David. Psychol. Rev., 1925, 32, p 235

rates, with our particular interest centering on the individual differences in adaptation to the emotional stimulus, as indicated by changes in these rates.

Before going into the details of this study, it would be well to consider some of the experimental work done in the field of emotions.

Conklin and Dimmick¹ say of the recording of emotional responses, that their experiments have demonstrated, first that emotions may be set up under laboratory conditions, and be subjected to psychological description. Also that it is possible to work out the gross structure of the emotive pattern in the case of fear. This pattern is akin to the pattern of perception, core and context. It is related to the pattern of the action consciousness. The core of an emotion consists, as in the case of perception, of those sensory elements that are referred to the stimulus. In addition there is a context which consists of images or sensations or both. In most subjects, the response is mainly organic, but its presence does not make an emotion, nor its absence preclude emotion. Various classifications of emotions are not based on the mental components or the patterns of the emotions, but rather upon the action-meanings which the particular patterns of the particular mental elements carry, for the experiencing individual. They are, therefore, not psychological

¹Conklin and Dimmick, Am. J. Psych. 1925, 36, 96-102

but logical, and are determined by the classifier's tendencies to explicate or to generalize, and by their evaluation of the responses.

This exposition gives some indication of the conclusions of Conklin and Dimmick upon the general nature of emotion, and shows the great complexity of the emotional response, of which we shall consider only a small portion.

Carney Landis⁴ and Ruth Gullette, worked on the systolic blood pressure and inspiration-expiration ratio during emotional excitement. Their purpose was to present:

- "(1) a comparison of normal, or "passive" blood pressure records, and then blood pressure records during emotional excitement;
- (2) and an analysis of systolic blood pressure reactions during emotional disturbance;
- (3) an examination of sex differences in blood pressure reactions;
- (4) the relations existing between introspected feeling and vascular reactions; and
- (5) an analysis of some incomplete data on inspiration-expiration ratio."

This last part of the experiment was incomplete because of great apparatus difficulties. An attempt was made to discover any general rhythms or waves of blood-pressure disturbance which might extend through the experiment. They found that apparently no general trend or pattern exists, or if it does, it is not readily identified. That is, a series of emotional situations failed to produce any uniform change in blood pressure in more than 4 out of 21 subjects studied.

⁴Landis, Carney, and Gullette, Ruth, . J. Comp. Psych., 1925
5, 221-253

Cumulative emotional disturbance, which was evident in the behavior of all subjects, had no constant correlate in systolic blood pressure.

In another experiment Landis⁴ worked on the basal metabolic rate during emotional excitement. In this article he reviews the work done along these lines to the date of his writing, which sums up as follows:

- "(1) Metabolic rate is not diagnostic or symptomatic of any particular psychosis or of the emotional content of that psychosis.
- (2) The phase of manic-depressive insanity, with its supposedly altered emotional content may or may not affect the metabolic rate.
- (3) Unpleasant emotional disturbance following suggestion is usually attended by a rise in metabolic rate.
- (4) Extreme emotional disturbance or traumatic shock in animals is attended by a decreased metabolic rate.
- (5) The suggested causes for metabolic increase during emotional disturbance are:
 - (a) increase of super adrenal or thyroid(?) activity;
 - (b) greater metabolism of the central nervous system; and
 - (c) increased muscular tonus or incomplete relaxation."

He then states that his study takes as its purpose:

"an attempt to answer, or shed light upon the following questions; Will slight emotional stimulation, such as is afforded by music, affect metabolism? What is the effect of pronounced emotional upset upon metabolism? Is metabolism a measure of the degree of emotional upset? What is the relationship between metabolic changes during emotional excite-

⁴Landis, Carney. Am. J. Physiol. 1925, 74, 188-203

ment and other physiological reactions occurring at the same time?"

In his experiment, he found that a 46 hour fast, coupled with 34 hours insomnia, failed to affect the metabolic rate. He also found that anticipation of strong electrical stimulation raised the metabolic rate, but the emotional disturbance caused by the electrical stimulation slowed down the metabolic rate. He says that anger is sometimes accompanied by an increase in metabolic rate, and sometimes by a decrease. In conclusion he says,

"Emotional disturbance, per se, does not lead to changes in the metabolic rate which are always in the same direction or of the same magnitude. Conversely changes in metabolic rate cannot be considered as direct measures of emotional disturbance or cumulative emotional upset."

In a third experiment, Landis¹ worked on reactions during severe emotional upset. He summarizes the experiment as follows:

"This experiment had as its goal the induction of a pronounced emotional upset. This was brought about by a forty six hour fast, together with a period of thirty six hours of insomnia, followed by strong electrical stimulation. Records were taken of blood pressure, respiration, metabolic rate, gastric and rectal contractions, general behavior, together with a subsequent verbal report of the subject's experience. The following points have been brought out by this study:

1. Electrical stimulation, under the conditions of this experiment gave an initial effect of a very rapid rise of blood pressure, the disappearance of the respiration or prim-

¹Landis, Carney. J. Comp. Psych. 1926, 6, 221-242

ary waves in the blood pressure curve, together with a marked cardiac irregularity. This was followed by a gradual resumption of regular cardiac function and a gradual fall of pulse pressure as the stimulation continued. After the stimulation ceased, the level of systolic blood pressure generally fell, while the pulse pressure rose to normal, the record quickly resuming a normal appearance.

2. The electrical stimulation caused an augmented respiratory rate; a deep gasping, thoracic respiration followed by an increasing tendency toward rapid, shallow breathing.
3. The stimulation gave rise to gastric contraction in one subject and caused a temporary stoppage of contraction in the case of the second subject. The stimulation caused a stoppage of rectal contraction.
4. The elements of fatigue, nausea and increased irritability play major roles in pronounced emotional upset.
5. The evidence of this experiment shows that arrhythmicity of physiological function is a mark of the onset or shock period of emotional disturbance but is not a part of the pronounced upset.
6. Behavior during the experiment was marked by incoordination, increased irritability, and loss of drive.
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8. The problem of severe emotional upset is in all probability either the same as, or closely akin to, that of surgical shock. The experiment demonstrated factors which do not constitute the basis of emotional upset, little however can be said as to just what really does constitute the physiology of an emotional upset."

These studies by Landis emphasize the complexity of the physiological factors involved in emotions, and give many of the measurements of phases of the emotional reaction into which we will not venture in this study.

Another technique that has been developed in working on emotions is the measurement of the Psychogalvanic phenomenon. R. J. Bartlett,⁴ working on the psychogalvanic phenomenon, tried to produce, under experimental conditions, mental states in which 'feeling' should dominate any accompanying cognitional or conational awareness, and secured tachogram records of the accompanying changes in resistance of the subject's hand.

In the conclusion he states:

"The psychogalvanic phenomenon follows a variety of complex changing mental states many of which would ordinarily be described as 'emotional' and yet may yield to introspective enquiry, cognition and / (or) conation only. It seems best in the present state of our knowledge to describe these complex states as 'orectic processes' in which 'feeling' and 'striving' mingled; but in view of the fact that when cognized, the initial phase of markedly conative experience, accompanied by the deflection on the galvanometer, is reported to be dominantly subjective in character, and that large deflections are obtained when the dominant awareness is one of being impressed by the cognized stimulus, it seems probable that the mental cause of the physiological change that brings about the deflection is of the nature of passive endurance or enjoyment, rather than of active striving or willing."

The tendency of the purely passive state to pass into and be lost in an active one makes the search for crucial tests under experimental conditions a difficult one, but our work seems to indicate that the shape of the

⁴Bartlett, R. J. Brit. J. Psych. 1927-28, 18, 30-50

tachogram curve varies with the nature of the differing mental states that immediately precede the 'reflex'.

The experiment shows that there is a common feeling element, but that in itself is possibly insufficient explanation of the physiological change recorded by the galvanometer. We need on the conative side, the equivalent of the purely subjective pathic state that we have argued is the common factor in all feeling. Possibly that equivalent can best be described as a change in attentional attitude. Possibly the ultimate mental basis of the phenomenon is a change from non-voluntary awareness of, to voluntary attention to a pathic state of the self, coupled, by speedy 'external reference' with a becoming aware of a possibly 'significant' change in, or differentiation of the presentational 'continuum'.

A study has been made by W. E. Blatz⁴ at the University of Chicago, on the Cardiac, respiratory and electrical phenomena involved in the emotion of fear.

The emotion was aroused by precipitating the subject backwards unexpectedly while he was seated in a chair. All of the subjects were given three 'normal' sittings, that is, records of the physiological functions were made without the emotional stimulus, to approximate the normal physiological rates. Then all of the subjects were given two sittings in which the falls were given. Then the group was

⁴Blatz, W. E. J. Exp. Psych. 1926, 8, 109-132

divided, one group being given two more 'normal' readings, and then another 'fall', while the other group were given eight falls in two sittings, then another normal and then another fall.

Blatz summarizes his results as follows:

- "1. The only adaptive process that was manifested during the three normal sittings was a reduction in the heart rate in 12 of the 18 subjects. This change was not observed in relation to the cardiac rhythm nor in the electrical conditions. In 4 of the 7 subjects there were only slight indications of adaptation as far as respiratory changes were concerned.
2. The sudden arousal of fear, by falling, involves the following changes:
 - (1) Cardiac....
 - (a) An immediate initial acceleration followed by a decided retardation, then a less marked but more prolonged acceleration phase, and finally a subsequent gradual retardation,
 - (b) An initial augmentation of the force of the heart beat which persists with but slight decrement for longer than 6 minutes,
 - (c) A marked irregularity of the cardiac rhythm. These changes were observed in all of the subjects. The degree of the change differed with individuals as did the duration of the effect.
 - (2) Respiratory....
 - (a) An immediately retarded rate in 9 out of 11 records.
 - (b) An increase in the value of the respiratory index above unity in 9 out of 11 records.
 - (c) Inspiratory stimulus during falling in all cases.
 - (3) Electrical.... Striking changes in the electrical condition of the body in the nature of an increased development of the electromotive force, this effect had a latent period of 0.5 sec. to 3.0 sec.,

- and was prolonged over a period of 1 to 6 minutes. There were no exceptions to the appearance of this phenomenon after falling.
3. There are two essential components of a response to a stimulus in order that the subject label the experience 'fear':
 - (1) An organic response of a complex nature
 - (2) A gross muscular adaptive response.
 4. Information regarding the stimulus reduces the organic effect which it produces.
 5. Repetition of the falling, with knowledge of the subject, decreases all of the effects in degree and duration with the exception of the respiratory index which reaches a high level after the second fall in 6 out of 7 cases. The duration of the effects were reduced in all subjects.
 6. Repeated presentation of the stimulus, with knowledge of the subject exaggerates the adaptive effect.
 7. Anticipation of the stimulus, after having once experienced it, causes an increase in the heart rate in 15 out of 18 subjects.
 8. Assumption of a normal condition, after a period of stimulation, is always accompanied by a decrease in the heart rate.
 9. An unexpected presentation of the same stimulus within a relatively short time will overcome the adaptive effect and produce effects which resemble those of the initial fall."

This experiment represents the nearest approach to similarity with our experiment.

A. Rendle Stone⁴ investigated as a research problem, the reaction of memory to affective states. He discusses a study made by Wohlgemuth, wherein Wohlgemuth found a slightly greater tendency for the forgetting of pleasant experiences than for the forgetting of unpleasant one's, but he says,

⁴Stone, A. Rendle, Am. J. Psych. 1925, 36, 112-124

"There is no difference whatever in the effect of each feeling, as the variation is so slight as to be accounted for by individual difference."

Stone says that emotion in memory is indicated by change of blood pressure, either increase or decrease, and that this emotion affects the memory. The likelihood being that the blood pressure will increase and the memory become better. He also says that the emotion of horror reacts on the memory in inverse ratio to the direction, and direct ratio to the intensity of the concomitant change in blood pressure. (This is offered as a possible explanation of the absentmindedness, forgetfulness, and stuttering of lovers.) The emotion of grief has a decided influence on memory. This influence may be either positive or negative. The concomitant change in blood pressure may either be a rise or a fall.

Landis and Gullette,¹ in an article in the Journal of Comparative Psychology, quote from Sheppard,

"All moderate nervous activity tends to constrict the peripheral vessels and to increase the volume and size of the pulse in the brain. All moderate bodily activity likewise increases heart activity. Strange stimuli cause both an exciting and an inhibiting effect, which is seen in the heart rate. They also cause a double reaction in the brain. The most marked effects are at changing periods, particularly with the incoming stimulus. Lastly the activity of any part, or the prominence of sensations from any part, tend to counteract constriction in that part."

¹Landis and Gullette, J. Comp. Psych. 1925, 5, 221-224

Landis says,

"It will be seen from this that the vascular reaction depends upon the strength of stimulus, while the resulting reaction does not of itself constitute either pleasantness or unpleasantness."

Experimental Data:

Purpose: The purpose of this experiment is to determine some of the individual differences in emotional adaptation, as indicated by the cardiac and respiratory changes occurring after the administration of an emotional stimulus. In this experiment the fear response was used, taking as the principal element of the stimulating situation, a loud noise, which is considered by many psychologists to be one of the unconditioned stimuli for fear. This stimulus was used in conjunction with other forms of stimulating apparatus, which will be more fully described under 'apparatus'. The changes in rate of heart beat, and in breathing rates were recorded, and an attempt made to determine the number of applications of the stimulus required for each subject to become adapted to the stimulus, when the applications were made successively at one sitting. Our chief interest was in the individual differences in time and number of stimulations necessary for the

subject to become adapted to the stimulus. We considered that the subject was adapted to the stimulus when there was no increase of heart rate and breathing rate above the normal rate for that subject, upon presentation of the situation.

Apparatus: The apparatus used in this experiment included: A "guillotine" which was four feet high, one foot wide, with an eight inch "knife". The guillotine was made of wood, including the knife, and painted black, with a silvered edge on the knife. The subject's arm is to be placed directly under the knife, and there is an arm rest constructed, with a slit which represents the slot through which the knife should cut the arm. There is a copper brass coil directly beyond the arm rest which the subject is to grasp while the experiment is being performed. This copper coil is so constructed that hot and cold water could be passed through it, giving an added stimulus of temperature contrast. To the bottom of the table on which the guillotine stands is attached an automobile horn, which is connected to the guillotine and to a battery so that the falling of the knife makes a connection as it starts down, and breaks the connection again

as the stops strike the wires at the bottom of the descent. The administration of the stimulus was recorded on a kymograph record by the pressing of a telegraph key connected to an electric marker. This telegraph key was pressed by the experimenter at the same time as the release cord for the knife was pulled.

The time line was recorded on the kymograph by a pendulum timer connected through dry cell batteries to an electric marker. The time was recorded in intervals of one second.

The heart rate was recorded by a sphygmograph attached to the wrist pulse of the subject and connected to a tambour. The respiratory rate was recorded by means of a Sumner pneumograph likewise attached to a tambour, so that there were four lines recorded simultaneously on the kymograph record, namely; time, stimulus, heart rate, and breathing rate. Each drum was used twice, with four lines around the lower half of the record, and four similar lines around the top portion of the record.

The guillotine was set up on one table in the laboratory, with the recording apparatus on another table, and a screen erected between the subject and the recording apparatus, so that the

subject could not see the record as it was being made.

On the following page is a sketch of the guillotine used in this experiment, the letters on which indicate:

A.....the first connection for the horn, which is made by the falling of the knife.

B.....the second connection, which is broken as the knife comes to rest immediately above the arm.

C.....the copper coil used to hold on to, which can also be used for temperature contrast.

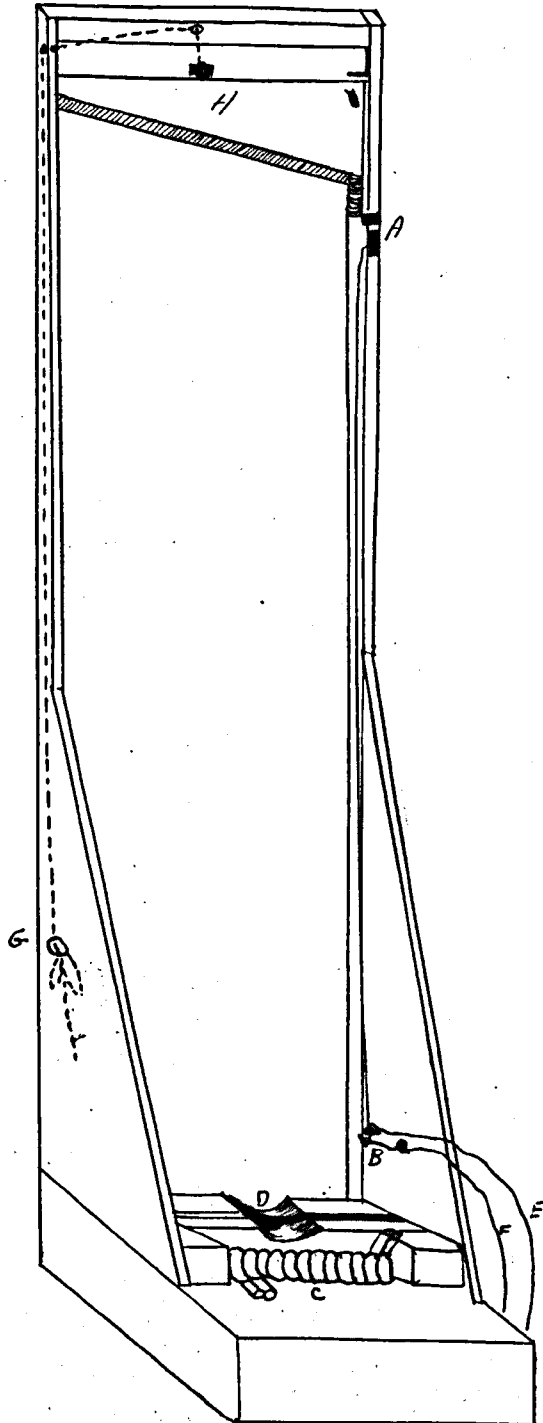
D.....the arm rest, directly below the sharpened edge of the knife.

E.....the wire to the horn.

F.....the wire to the battery.

G.....the release string for the knife.

H.....the knife.



Procedure:

Forty two subjects were used in this experiment. Twenty one for the preliminary records which were taken to secure an average reaction to one stimulation, and twenty one for the series of stimulations to determine the number of stimulations necessary for them to become adapted to the stimulus. In the preliminary records, two records were made for each subject, one taking the normal heart and breathing rates, the other the rates following the stimulation.

In the adaptation series the number of records taken for each subject depended upon the length of time it took each individual to become adapted to the stimulus, so that for this series 158 records were made. With the forty two records that were made in the preliminary series, this makes a total of 200 records.

The subjects were taken from a group of the experimenter's friends, and a class in General Psychology at the University of Arizona.

As the subjects were brought into the laboratory for the experiment, they were kept in the laboratory and the experimenter

conversed with them for a short while after the apparatus was connected, to get them accustomed to the unfamiliar situation of the laboratory and the apparatus, so that the heart and breathing rates would not be affected by the novel situation. This did not present a very great difficulty, because of the fact that all of the subjects were known to the experimenter personally, and the experiment had been described to them in a way that made it seem an interesting experience.

After the subject had become accustomed to the apparatus, the normal record was taken, then the stimulus was given, immediately after the normal record had been made, so that if anything had been affecting the normal rate, it was still in effect when the stimulus was given, and the rate was normal as taken for that period.

For the adaptation series, the same procedure was carried out, with the exception that the process was repeated until the records showed that adaptation had occurred.

The normal records were counted in thirty second intervals, and the records after stimulations counted in ten second intervals.

Results:

Table number one shows a normal rate of breathing and heart beat for a period of 30 seconds for twenty one subjects, and records for rates for three ten second periods after one stimulation. From this table it can be seen that there are nine subjects who show an increase in the rate after the stimulation, seven show a decrease in rate, and four show no perceptible change. The average for the twenty one subjects, however, shows a decided increase. Alone this table would not be indicative of anything in particular. It does show, however, that there is a wide range in individual responses to the stimulus. There is no evidence here to show that a group of individuals respond similarly to the same stimulus, but on the other hand, there is evidence from the heterogeneity of the responses that there is no definite trend in the nature of the response, except in so far as it does deviate from the normal rate. In the case of the inspiration rate, (which is what has been counted in this case) there is little change indicated by the count. There was however, an almost universal tendency to take one sharp inspiration as the stimulus occurred, and to

hold the breath for a second or more. Immediately following this gasp, the breathing tended to become a little more rapid, so that the interval for which the breath was held did not affect the rate by making it slower, and on account of the period of holding, the period of more rapid inspiration did not tend to make the rate more rapid.

Table number two shows heart rate and inspiration rate for another twenty one subjects, for a period of thirty seconds taken when the subject was in a normal condition and these are followed by rates taken for three ten second intervals after each stimulation for enough stimulations to show that the subject has become adapted. The graphs following the tables show much more readily than the tables, the fluctuations in the nature of the responses of the individual subjects. Six subjects show an increase of heart rate, with a gradual return to the normal rate, while seven show a decrease and then return to the normal. Nine of them, however, show fluctuations, decreasing, then increasing, or vice versa, with a return to the normal rate as the subject becomes adapted. Here again, the important thing for our consideration is the

difference in the individual responses. We find no uniformity in the nature of the response, the only generalization that can be made is that there is a change in the rate until the subject becomes adapted to the stimulus.

The inspiration rate in these subjects corresponds very closely to that of the group to which only one stimulation was given. For the first few stimulations there was a sharp intake of breath which was held for a short interval, and then released, following which the rate was increased until the number of inspirations corresponded very closely with the normal number for the ten second intervals. As the subject became adapted there was no sharp intake nor any holding of the breath, so that the rate was not only the same as the normal rate, but as regular. The group average in both the heart rate and the inspiration rate was computed, and the average for the heart rate shows a slight but constant decrease and a return to normal, while the breathing rate does not show that the stimulus made any effect upon the inspiration rate.

Our major interest in this investigation

centered around the individual differences in number of stimulations necessary for adaptation. From the figures in the table the average number of stimulations necessary for adaptation to occur is 3.38. It can be seen from the table that two subjects became adapted after one stimulation, three after two stimulations, eight after three stimulations, two after four stimulations, and five after five stimulations, with only one of the twenty one subjects requiring six stimulations for adaptation to occur.

In general, those subjects who took the greatest number of stimulations to become adapted, were those who showed the most marked deviation from the normal rate after the first or second stimulations. On the other hand, those two who became adapted after the first stimulation did not show any very great disturbance of heart rate, nor very great irregularity of respiration on the first stimulation; in fact, from the small amount of deviation from the normal rate, it is probable that there really was no excitement aroused in those subjects by this stimulus.

Let us next consider the responses of the individual subjects as shown by the graphs:

Subject A

This subject shows a slight increase of the rate of heart beat at the first stimulation, and still greater increase in the second stimulation, with a drop in the third interval, another rise in the fourth interval, followed by a return to normal. There was a small but steady fluctuation after this last time that the normal rate was reached, as is shown on the graph in deviations from the line of the average rate of heart beat. It must be remembered however, that this line is an average, and that were it the regular number of beats for each ten second interval that it too would show these fluctuations probably. This return to the normal rate did not occur until after the fifth stimulation, so that we may say that the subject did not become adapted to the stimulus until it had been administered five times.

The breathing rate does not show any particular variation, except that it was noted on the records that the breathing

was very irregular. There was a gasp as the stimulus was given, followed by holding of the breath, with an increased rate immediately following, so that the rate in intervals of ten seconds does not show much fluctuation.

Subject B

Subject B shows a decrease in heart rate, with a gradual return to normal. Here again the normal rate would most likely contain a fluctuation if counted in ten second intervals, but the curve made by this subject's rate in adapting to the stimulus shows a fluctuation first above and then below the normal rate, which is more extensive than it is reasonable to suppose that the normal amount of fluctuation would include. After the third stimulus, this curve shows no greater amount of variation than can be expected for a normal rate, so that we may say that the subject became adapted to the exciting stimulus after three applications.

Here too, the breathing was slightly irregular on the first stimulus, but after that the breathing rate was not only regular as to rate, but quite regular in the timing

of the inspirations and their depth.

Subject C

This subject shows a decreased heart rate until after the third stimulation. The fact that the number of beats as counted in intervals of ten seconds never goes above the normal rate, indicates a genuine decrease in rate. It is probable that the successive stimulations tended to lower the heart rate so that it remained constant at a slightly lower rate than normal for quite a period of time. The limitations of the available apparatus prevented a measurement of the continuous heart rate for a long enough period to determine exactly the length of time it would take the rate to return to the true normal. However, the fact that the rate remained constant after the application of the stimulus for three successive intervals indicates that the subject has become adapted.

The breathing rate for this subject was increased slightly for the first few stimulations, due to the rapidity of breathing after the gasp at the application of the stimulus. After the third stimulation

however, the gasp was not present, nor the increase of rate.

Subject D

Subject D shows a very slight increase in heart rate, with a return to a constant record that coincides exactly with the average normal rate. This increase is not apparent after the third application of the stimulus, so that subject D became adapted to the exciting stimulus after three successive applications.

The breathing in the case of this subject was retarded for the first stimulation because of a long period of holding of the breath after the sharp intake immediately following the stimulus.

Subject E

This subject showed the most perfect and the most rapid adaptation of the entire group. There is a slight increase in rate for the first stimulation, but even this increase is very slight. The stimulus was administered to this subject eight times, and after the first stimulation the heart rate remained constant at the same level

as the average normal rate. This gives a complete and rapid adaptation to the exciting stimulus.

There was no particularly sharp intake of the breath, even for the first stimulus for this subject, and the only irregularity was a slight increase in the interval following the first stimulus.

Subject F.

The stimulus was administered eight times to this subject, and after the third stimulus there was a constant fluctuation below the average normal rate. From the slight amount of fluctuation after the first three applications of the stimulus, it is doubtful if the stimulus served to arouse excitement in this subject. However, the fact that the fluctuations remained constant after the third stimulation, if the stimulus did excite the subject, would indicate that adaptation had occurred after three stimulations.

The breathing showed one sharp intake after the first stimulation, with no more sharp irregularities following the stimulus after that. This one sharp intake, however,

would indicate that possibly there was some excitement indicated by the fluctuations of the heart rate for the first three stimulations.

Subject G

This subject showed marked fluctuations of the heart rate for the first three stimulations, with a return to the constant level of the average normal rate. First the rate increased, then decreased, then increased again and then another decrease, followed by one more increase before the rate became constant. This subject is interesting because of the way the heart rate changes, first showing increase, then decrease, with continuous fluctuations above and below the normal rate until the rate becomes constant.

The usual sharp intake of the breath was shown in the first three stimulations for this subject, though there is not any change in the inspiration rate because the period of holding of the breath after the sharp intake was equalized by a little more rapid breathing during the ten second

interval immediately following the stimulus.

Subject H

There is a sharp decrease in the heart rate in the case of this subject, immediately following the first stimulation. Before the rate becomes constant at the normal rate, there are two other fluctuations of a decreasing nature. The rate becomes constant at the average normal level after the third stimulation, indicating that complete adaptation has occurred at that time.

The breathing in this subject showed no marked irregularities after the first stimulation. With the occurrence of the first stimulus there was a very sharp intake of the breath, followed by quite rapid breathing which overbalanced the effect of the short holding after the intake, so that the rate is slightly more rapid than normal.

Subject I

This subject shows one sharp increase immediately after the first stimulation,

with only one more fluctuation of the heart rate before the rate becomes constant, at a slightly slower rate than that of the average normal rate. It is possible that this one fluctuation is not caused by the stimulus, but the fact that after that one fluctuation there were no more for a period including seven stimulations, might indicate as in the case of subject C, that the stimulus caused a decrease of the rate which lasted, even though the subject had become adapted to the stimulus.

The breathing for this subject shows sharp intakes, with very short holding periods, followed by increased rate, for the first two stimulations.

Subject J

Subject J shows a decided decrease after the first stimulation, with two fluctuations of a decreasing nature following this first more marked decrease. The first stimulation shows the decided drop in heart rate, with an increase in the second stimulation period, and another

decrease in the third, but the fourth and fifth stimulation periods show the heart rate remaining constant at the level of the average normal rate, showing that the subject was adapted after the third stimulation.

There were no marked changes in the breathing rate for this subject, the rate was very little different than the normal rate in every stimulation period, not showing enough fluctuation to bring it above what might be expected as variation in the normal rate. There were no sharp gasps in the case of this subject, immediately after the stimulation. The only evidence on the breathing record to indicate the effect of the stimulus was a little deeper breath after the stimulus.

Subject K

This subject shows the most marked fluctuations of the entire group. There is a decided increase for the first three stimulation periods, followed by a marked decrease for the next two periods, after which the rate becomes constant a little

below the average normal rate. These fluctuations are interesting in that they show that the response to the stimulus is not uniform, that the rate may decrease and then increase, in the same subject, and in response to the same stimulus. The rate becomes constant after the fifth stimulation, showing that it takes that many applications of the stimulus for that subject to become adapted.

The breathing here was very irregular in regard to depth of inspiration following the first three stimulations, and the rate is a little slower than normal throughout, but the breathing was not so sharp just after the stimulus as was the case in most of the subjects who became adapted more readily.

Subject L

Subject L shows a decided decrease in heart rate following the first stimulation, with two other fluctuations of a decreasing character before the rate resumes the level of the average normal

rate. The normal rate is reached after the third stimulation, and remains constant at that level, indicating that adaptation was complete after three stimulations.

There is one extremely sharp intake of breath shown for this subject immediately after the first stimulus, with gasps of lesser degree after the second and third stimuli, with no noticeable irregularities after that.

Subject M

This subject shows a marked increase in heart rate for the first two stimulations with the rate becoming constant a little above the average normal rate after the second stimulation, showing that the subject has become adapted with two applications of the stimulus. An interesting factor brought out in this subject's record, in contrast to some of the others is that this case showed an increase of heart rate as a response to the stimulus, and the rate became constant a little above the average normal rate, whereas in many

of the subjects who showed decrease in rate as a response to the stimulus, the rate became constant after adaptation at a little lower level than the average normal rate.

Breathing for this subject was very regular throughout, showing no particularly sharp gasps, holding, or any other peculiarity, except a little slower rate in the first ten second interval after the first stimulation.

Subject N

This subject shows a very decided decrease in the heart rate, with a very gradual return to the normal rate, the rate becoming constant at the average normal rate after the sixth stimulation. This shows that the subject did not become adapted to the stimulus until after it had been given six times.

The sharp gasp at the presentation of the stimulus was present in this case, until the third stimulation period, after which the breathing was regular and quite even.

Subject O

Subject O shows an increase of heart rate for the first stimulation, with a gradual return to the normal rate, the rate becoming constant at the normal level after three stimulations. This subject showed very clearly the nature of the adaptation because of the one sharp increase, and the gradual return to the normal level, where it stayed.

The breathing record for this subject was regular and at the normal rate after the first stimulation period, wherein there was the usual sharp inspiration followed by a short period of holding, which was made up for by a little more rapid breathing immediately following the holding.

Subject P

This subject shows a very great decrease in rate for the stimulation periods before adaptation occurs. The rate decreases gradually so that the end of the second stimulation period it has reached its minimum, this being

followed by a gradual return to the normal rate, at which it becomes constant after the fourth stimulation. For this subject then, four stimulations were required for adaptation.

The breathing showed a light increase in rate for the first stimulation period, followed by a decrease for the second period, with sharp gasps present for the first three stimulation periods.

Subject Q

This subject shows one sharp decrease for the first stimulation, after which the rate returns to the average normal rate and becomes constant. This shows that adaptation occurred after one stimulation.

The breathing record showed one sharp gasp following the first stimulation, returning immediately to the normal rate.

Subject R

This subject shows a very marked decrease in heart rate following the first stimulation, with an increase following the second stimulation which brings the

rate nearer to the normal rate, this being followed by another decrease, and then a return to the normal rate. The rate becomes constant after the fifth stimulation, at a little faster rate than the average normal rate, showing that adaptation occurs after five applications of the stimulus, for this subject.

The breathing for this subject likewise shows a decrease, the initial gasp and holding being of sufficient length to decrease the rate.

Subject S

This subject shows a steady but rather slight fluctuation above and below the average normal rate, mostly of an increasing nature, until after the fifth stimulation.

The period of holding after the initial gasp, for this subject was sufficiently long to decrease the breathing rate for the first three stimulation periods.

Subject T

For this subject the records of the

heart rate show a decrease, followed by an increase, then another decrease, with a gradual reduction of the extent of the fluctuations until after the fourth stimulation the fluctuations remained the same so that the average rate from these fluctuations would coincide with the average normal rate. The constancy of the fluctuations after the fourth stimulation period indicates that adaptation had set in by that time.

The breathing rate showed an increase for the first three stimulation periods, with no marked sharp intake of breath, but rather a period of rapid breathing.

Subject U

This subject shows fluctuations, chiefly of an increasing nature, around the average normal heart rate, for the first five stimulations. These fluctuations are not enough to be, in themselves, very indicative of excitement, but the fact that the rate becomes constant at a very little less than the

normal rate after the fifth stimulation period, indicates that these fluctuations were in the nature of a response to the exciting stimulus.

The breathing records for this subject show a decrease for the first four stimulation periods, caused by the long period of holding the breath after the initial gasp.

Group Average

The group average shows a slight decrease, until the fourth stimulation period. Beginning with the fifth period, enough subjects had become adapted, and had been dropped from further recording in the tables, that the few subjects who comprise the remainder of the group average graph cause a marked deviation from the normal average rate. The one subject who was carried through the table for eight stimulation periods causes the greatest irregularity in this graph. The normal rate for that one subject was, however as high as the last record for the stimulation periods, so that in the last

period of the graph of the group average, only one subject's records on the adaptation series are being compared with the average normal rate for the group.

Summary of results:

Number of stimulations necessary for adaptation:

1 stimulation-----	2 subjects
2 stimulations-----	3 subjects
3 stimulations-----	8 subjects
4 stimulations-----	2 subjects
5 stimulations-----	5 subjects
6 stimulations-----	1 subject

The average number of stimulations necessary for adaptation is 3.38, the range of number of stimulations necessary being from one to six stimulations.

Nature of the changes in heart rate as response to the stimulus.

Increase in rate shown by six subjects.

Decrease in rate shown by seven subjects.

Fluctuations around the normal rate shown by nine subjects.

Conclusions: This experiment shows that there is an adaptive effect in emotional situations, when the stimuli are given successively. If a period of time had elapsed, and the process been repeated, the results would show more definitely the nature of the adaptation, together with some indication of its permanency.

The important thing brought out by this investigation is the extent of the individual difference in adaptation to the emotionally exciting stimulus. We found that some subjects showed slight disturbance of cardiac and respiratory function and became adapted with great promptness, while others showed more radical changes and took a much greater period of time to become adapted. We found that the range of number of stimulations necessary for adaptation was from one to six stimulations, these figures being based on the study of twenty one subjects.

The study shows that there is no uniform trend in the nature of the response to the stimulus, nor in the time of adaptation.

Some comparisons may well be made between the results of this study, and some of the studies reviewed in the introduction. The study by Blatz, reviewed on pages eight to ten, is the one which most nearly corresponds to the study we have made. The stimulus used by Blatz was, however, a more severe stimulus, requiring a gross muscular response, so that it is doubtful if complete adaptation could ever be obtained in that case. He does find, however, that the rates of heart beat and respiration were reduced, and he says that it is the only indication of the adaptive effect.

Blatz found that the heart rate was accelerated immediately after the stimulus, then retarded, then another acceleration phase, and another gradual retardation to the normal rate. We found here, that this is not universal, some of the subjects showing no retardation, and some showing no acceleration. This incongruity can perhaps be explained by the fact that the nature of the stimulus used by Blatz caused a more severe upset and a more extensive response than the one which we used.

In Landis' experiment on severe emotional upset, reviewed on pages five and six, he says that the electrical stimulation caused an augmented respiratory rate and a deep, gasping, thoracic respiration followed by an increasing tendency toward rapid, shallow breathing. This is very similar to what we found to be true of the breathing records. A deep gasp followed by increasing tendency to rapid, shallow breathing.

Landis also found that the application of the stimulus brought a marked cardiac irregularity, which was followed by a gradual resumption of regular cardiac function and a gradual fall of pulse pressure as the stimulus continued. This is possibly an adaptive effect to continuous stimulation, whereas in our experiment we secured an adaptive effect to successive stimuli.

Our experiment shows similarities to these other experiments, but the other experiments reviewed in the introduction, though they served as an orientation in the field of emotional investigation, offer no

direct comparisons with the present study.

We may summarize our conclusions then,
as follows:

- (1). In this experiment, relatively great individual differences were found in the rate of adaptation to an emotionally exciting stimulus. Measuring the rate of adaptation in terms of the number of repetitions of the stimulus before adaptation occurred, it was found that the individuals required from one to six presentations of the exciting stimulus.
- (2). There is no uniform trend in the nature of the cardiac response to the emotional stimulus, except that it does deviate from the normal function.
- (3). Adaptation occurred in all of the twenty one subjects, with from one to six successive applications of the stimulus, so that we may say that an individual can become adapted to an emotional stimulus

.the length of time required
for adaptation varying with
the individual.

Implications for further investigation:

Some of the interesting questions which were raised during this investigation, which could be the basis for further investigation, are:

- (1). Do those subjects who become adapted to this stimulation become adapted to generally exciting stimuli in every-day life, in the same proportion of time?
- (2). What individual differences may be found in the length of time the effects of adaptation persist?
- (3). If the adaptive effect is overcome by the passing of time, will adaptation to a second series of successive stimuli be any more prompt than the first process of adaptation?
- (4). What would be the cumulative effect of frequent adaptations?

TABLE I

TABLE SHOWING AVERAGE REACTION TO SINGLE STIMULUS

Sub.	normal rate		rate after stimulation					
	30 sec.		1st 10 sec.		2nd 10 sec.		3rd 10 sec.	
	H	R	H	R	H	R	H	R
A	29	4	14	4	12	3	10	3
B	38	7	13	5	12	4	13	3
C	27	8	9	3	8	2	8	2
D	37	9	13	5	12	3	12	3
E	34	10	10	4	11	3	11	4
F	34	10	13	4	12	3	11	4
G	38	11	13	4	12	3	11	4
H	48	10	15	5	13	3	14	4
I	36	11	13	4	12	3	12	3
J	44	5	19	2	16	2	18	3
K	40	12	14	4	11	3	12	3
L	45	9	14	4	13	2	14	3
M	32	8	12	2	11	3	11	2
N	39	6	11	2	11	2	11	2
O	46	6	15	3	15	2	15	2
P	40	7	16	3	15	3	17	3
Q	33	10	13	3	11	3	12	4
R	40	9	14	2	13	3	12	3
S	40	9	14	4	14	4	13	3
T	41	9	15	3	14	2	15	2
U	39	8	13	4	12	5	12	4
Ave.	38.095	8.47	13.47	3.52	13.81	2.91	14.54	3.04

H = Heart rate

R = Respiration rate

Subject A

Number of heart beats

15

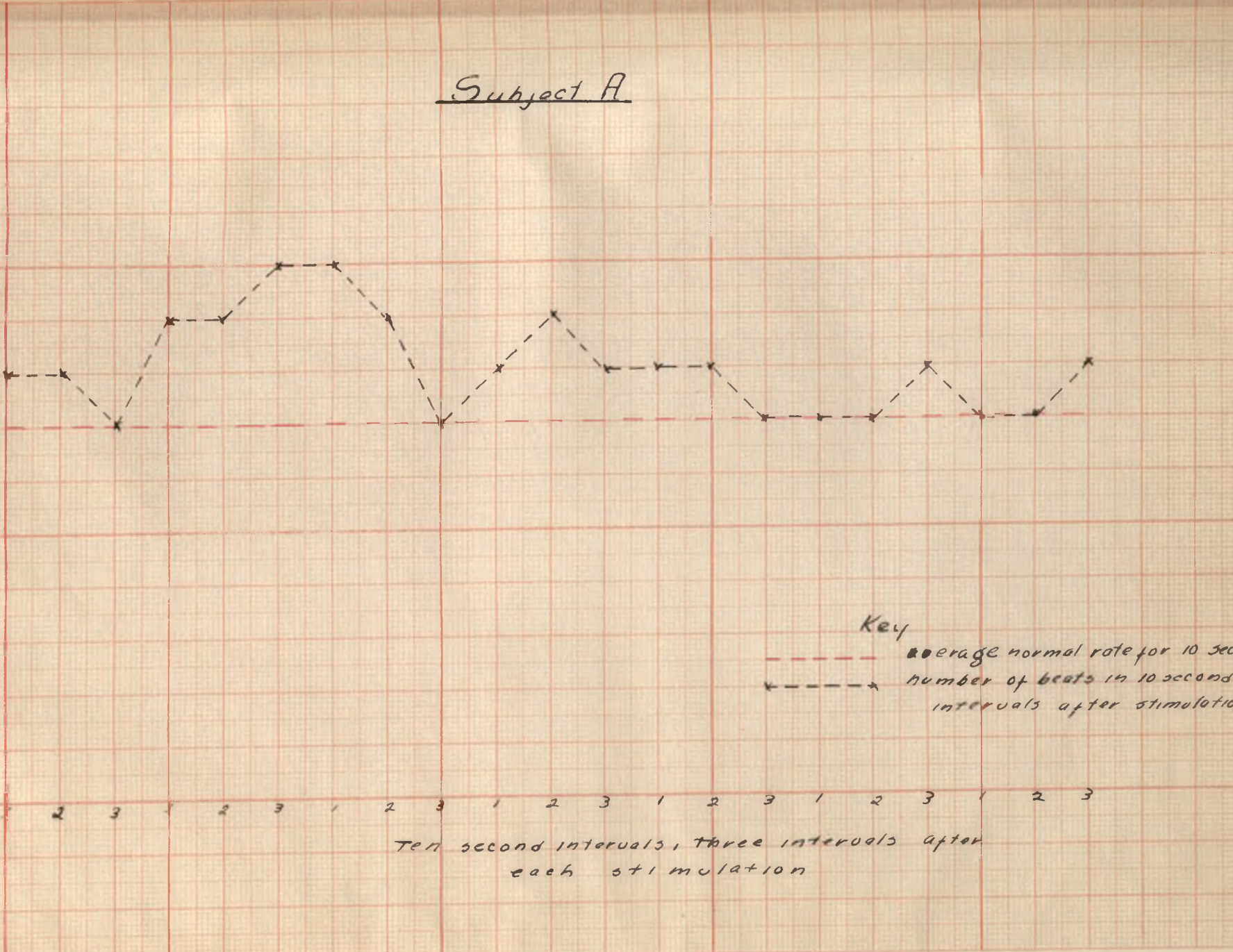
10

5

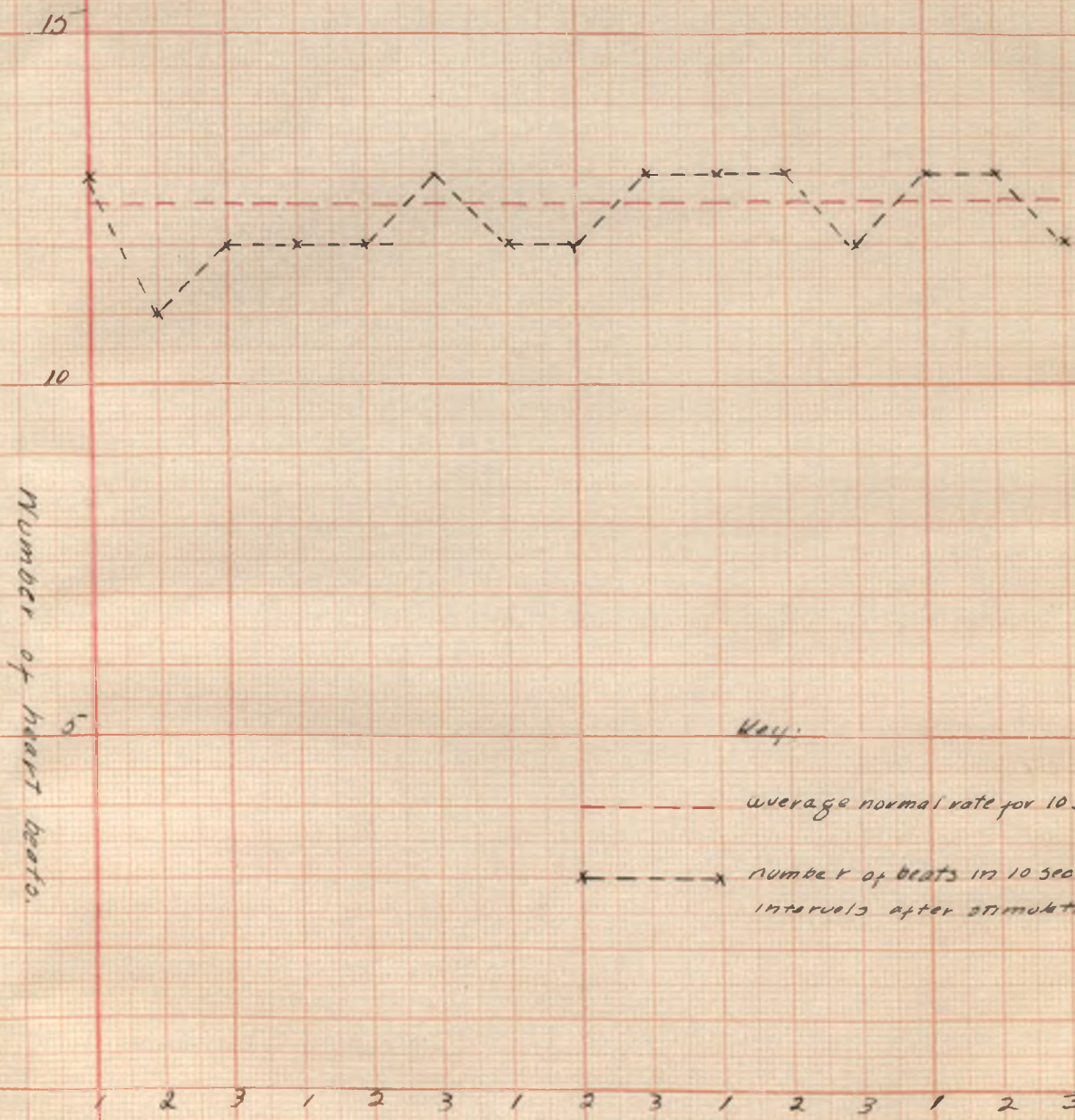
1 2 3 1 2 3 1 2 3 1 2 3 1 2 3 1 2 3 1 2 3

Ten second intervals, three intervals after each stimulation

Key
- - - average normal rate for 10 seconds
- - - x number of beats in 10 second intervals after stimulation

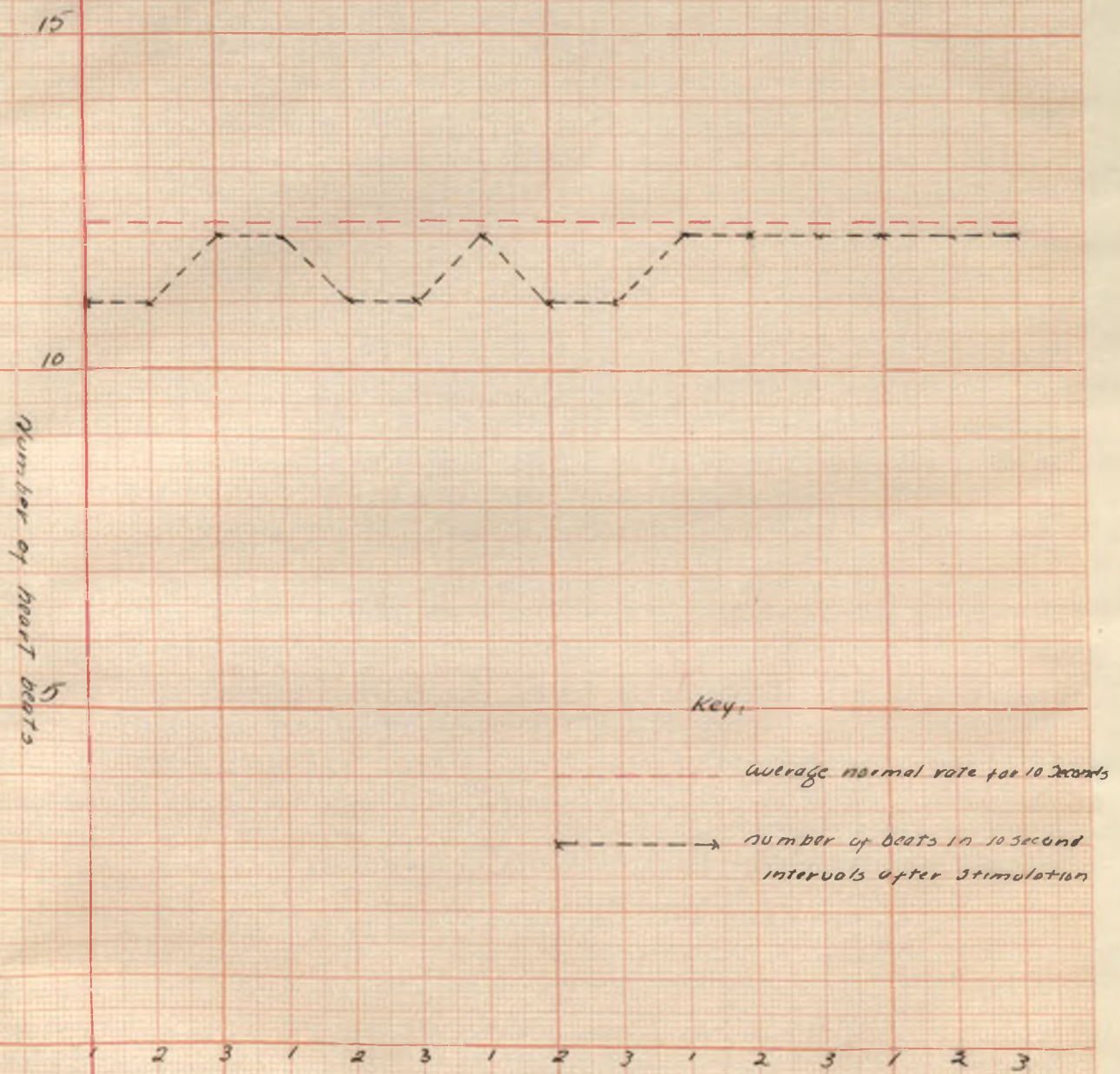


Subject B



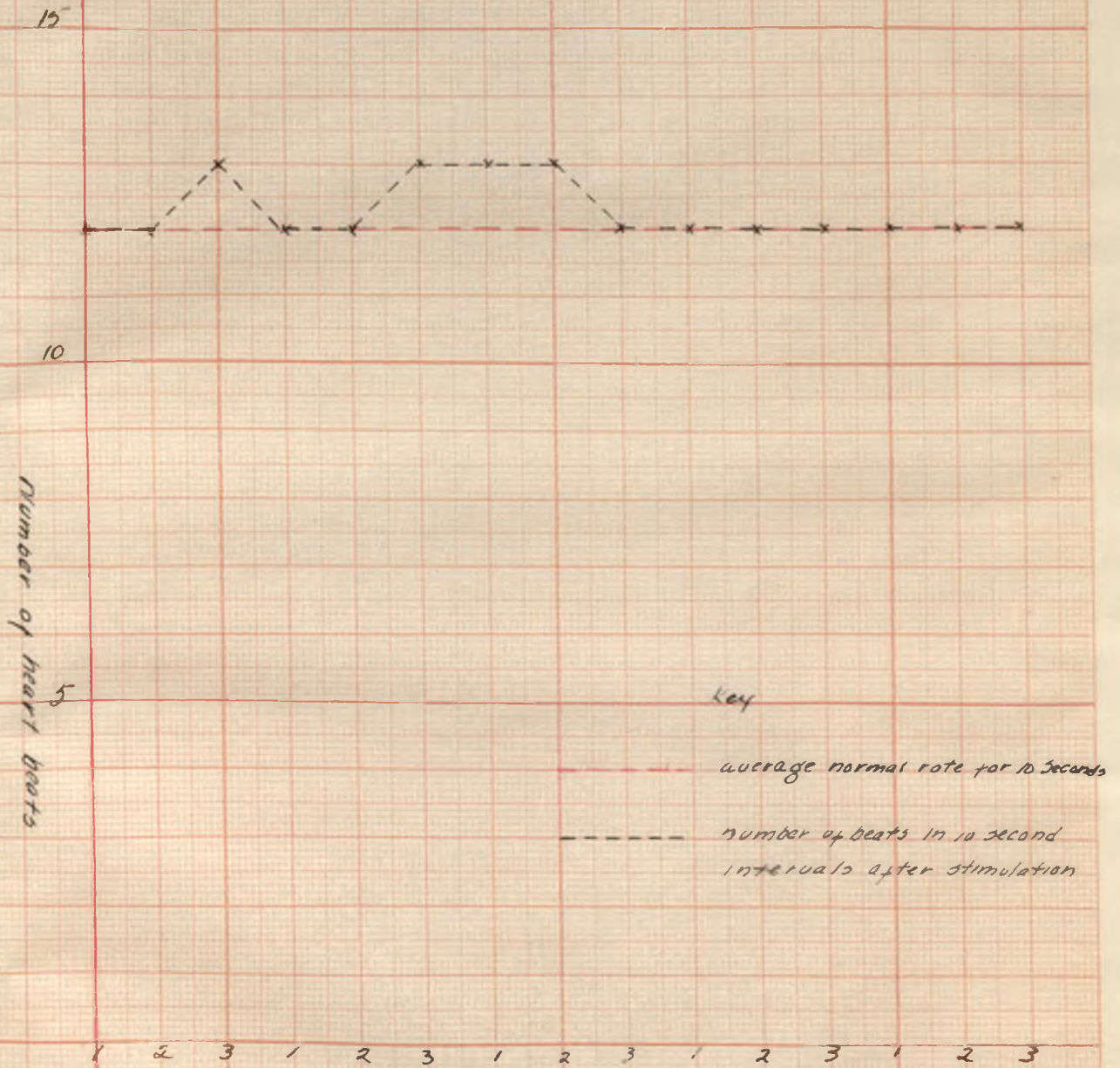
Ten second intervals, three intervals after each stimulation

Subject C.



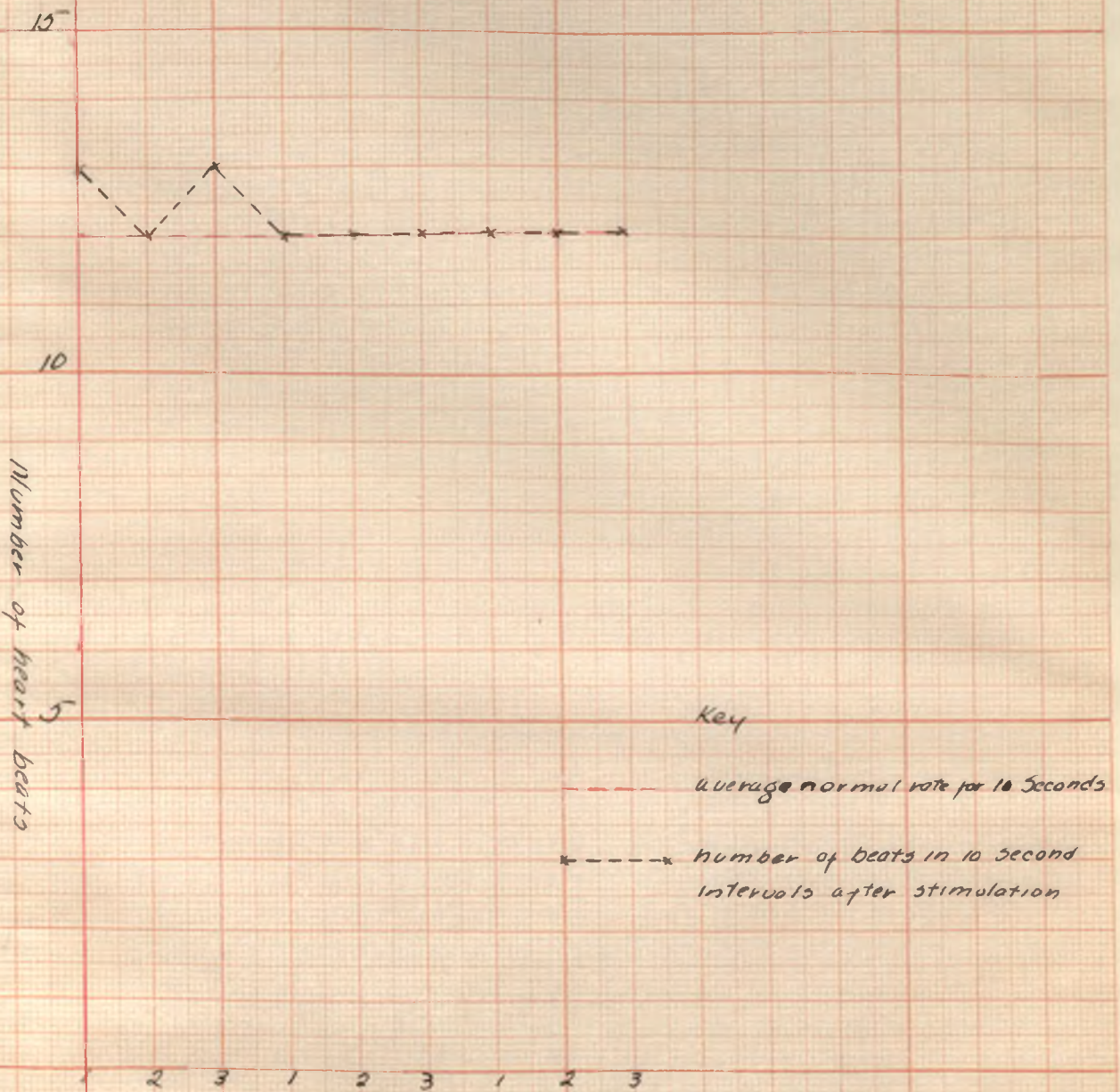
Ten second intervals, three intervals after each stimulation.

Subject D



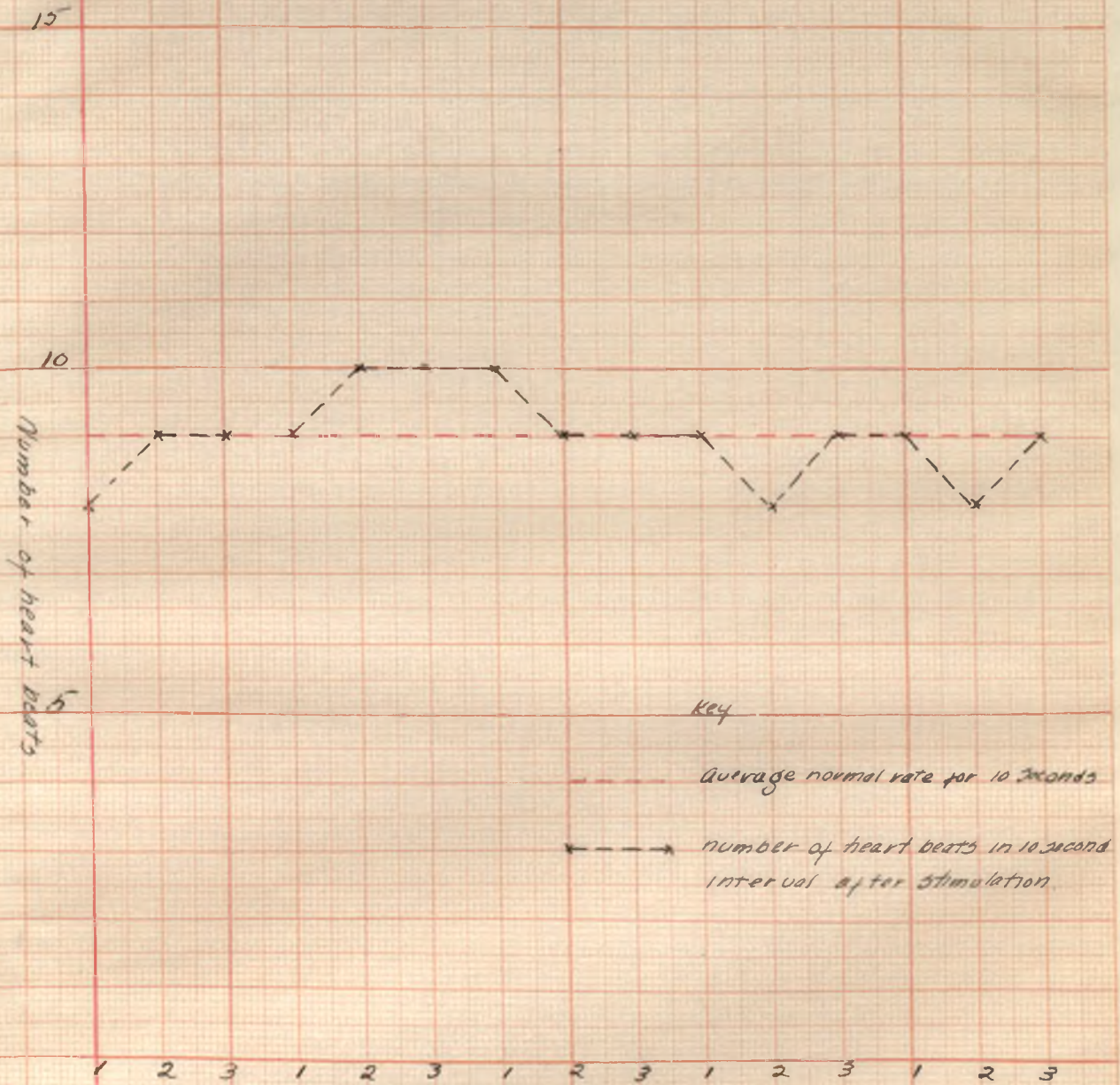
Ten second intervals, three intervals after each stimulation.

Subject E



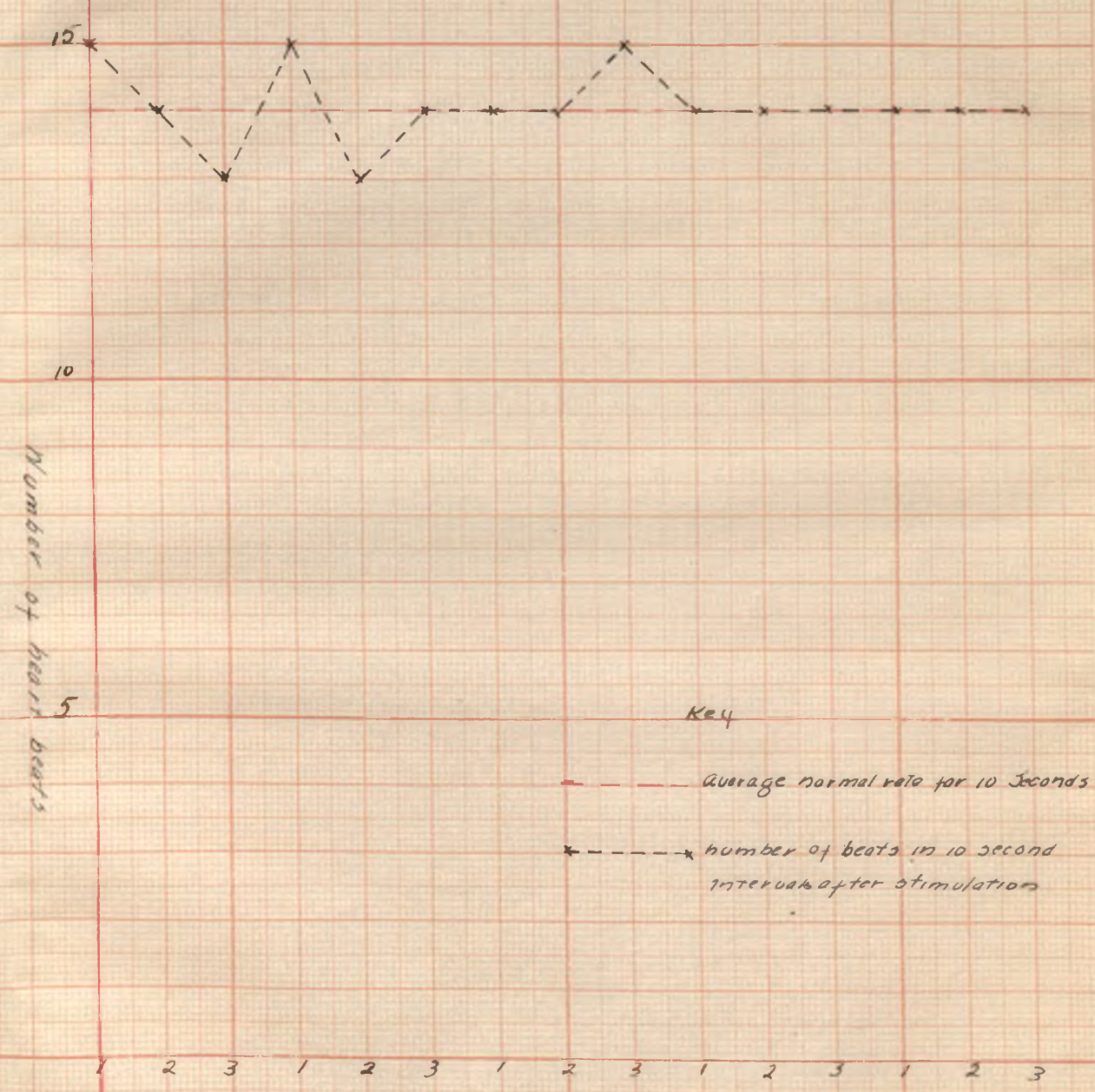
Ten second intervals, three intervals after each stimulation

Subject F



Ten second intervals, three intervals after each stimulation

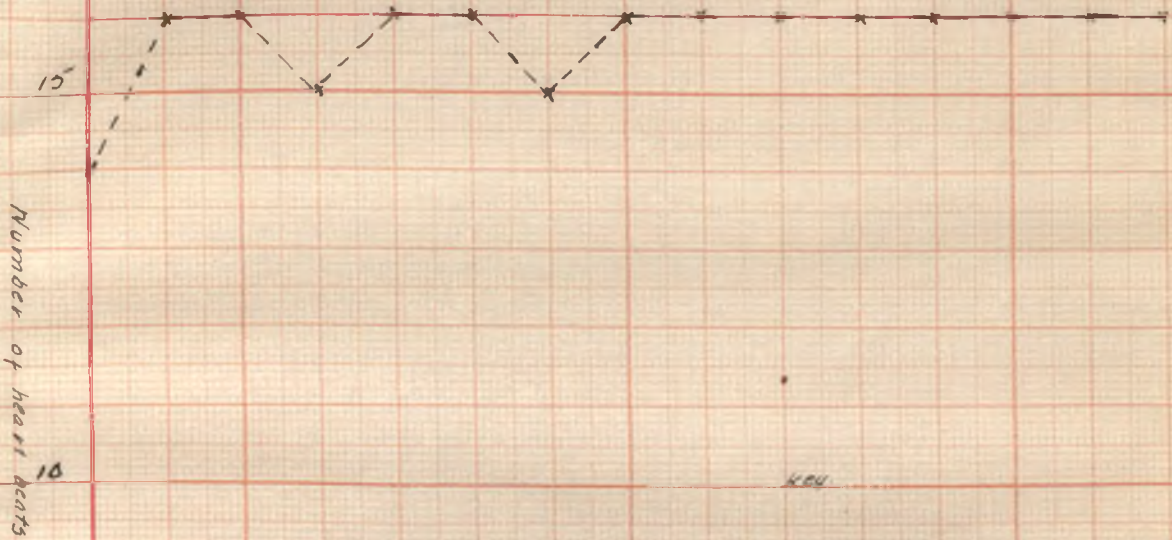
Subject G



Ten second intervals, three intervals after each stimulation

Subject H

1



KEY

— Average normal rate for 10 seconds

— x — Number of beats in 10 second intervals after stimulation

5

1 2 3 1 2 3 1 2 3 1 2 3 1 2 3

Ten second intervals, three intervals after each stimulation

Subject I

Number of heart beats

15

10

5

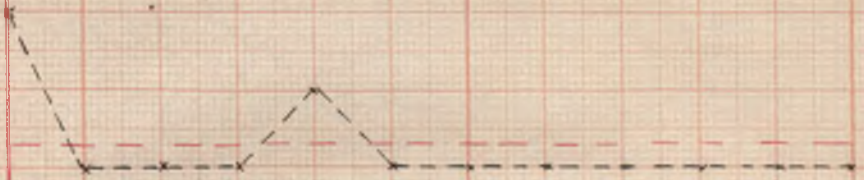
Key:

average normal rate for 10 seconds

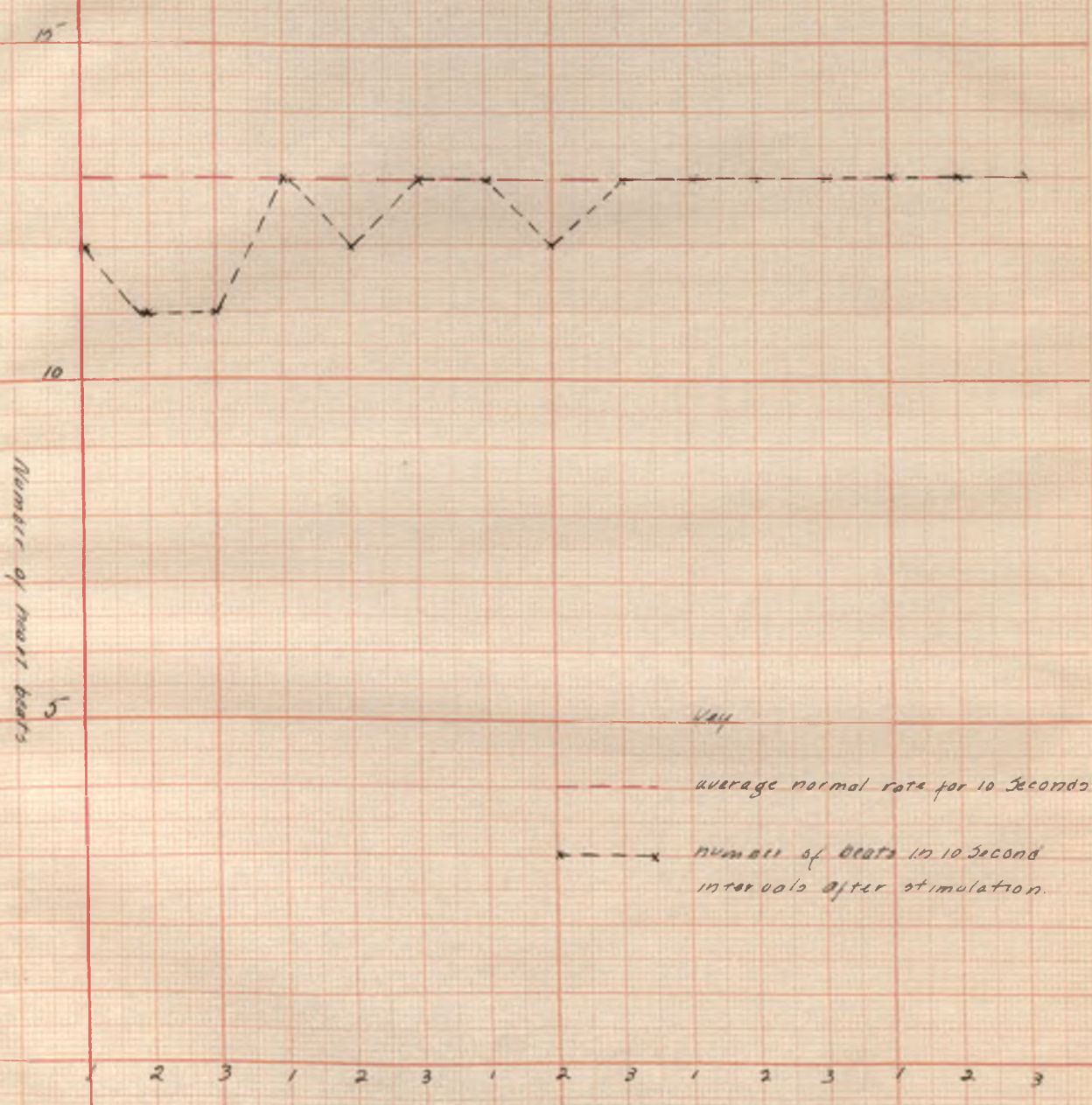
number of beats in 10 second intervals after stimulation

1 2 3 1 2 3 1 2 3 1 2 3

Ten second intervals, three intervals after each stimulation

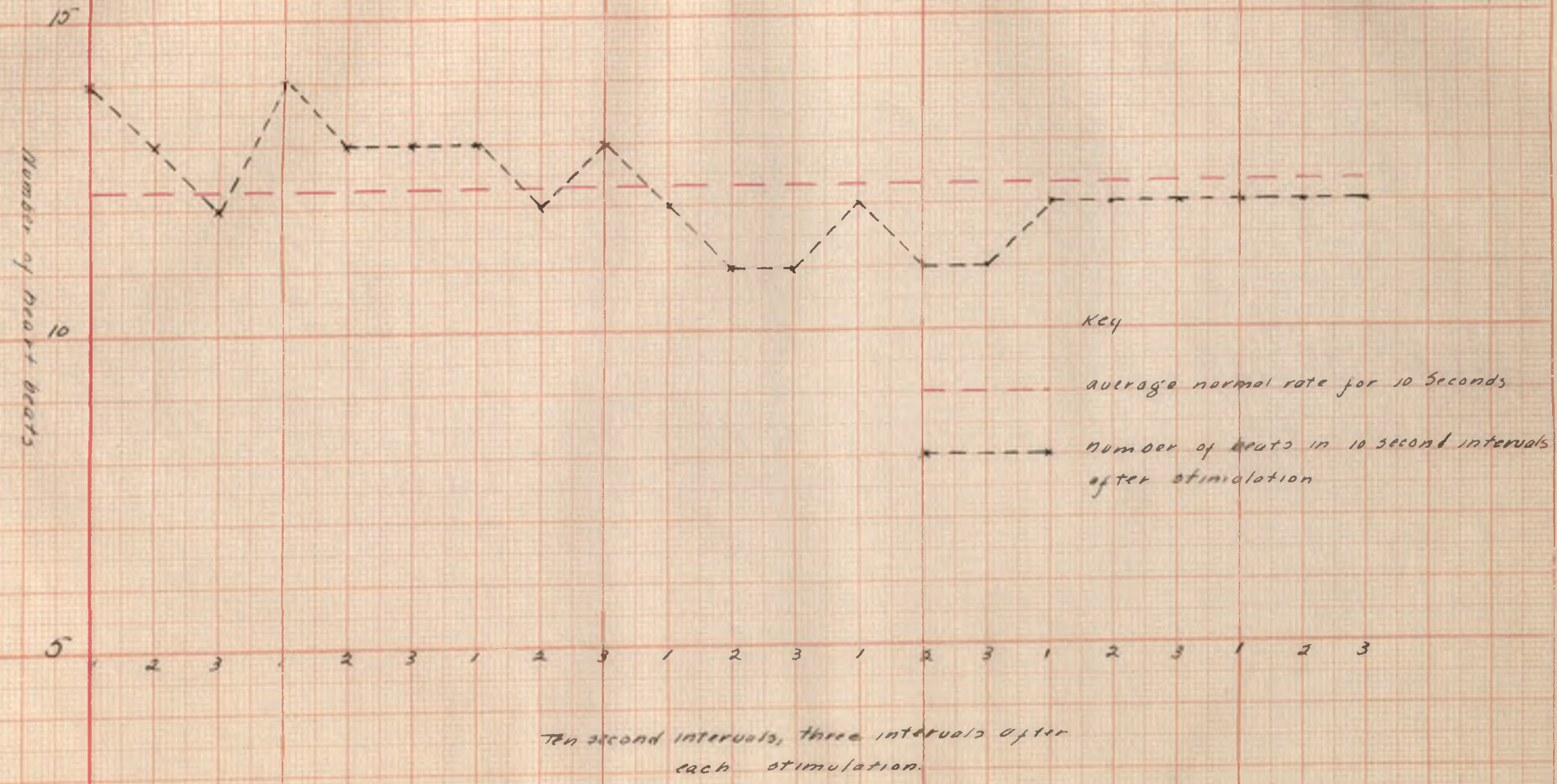


Subject J

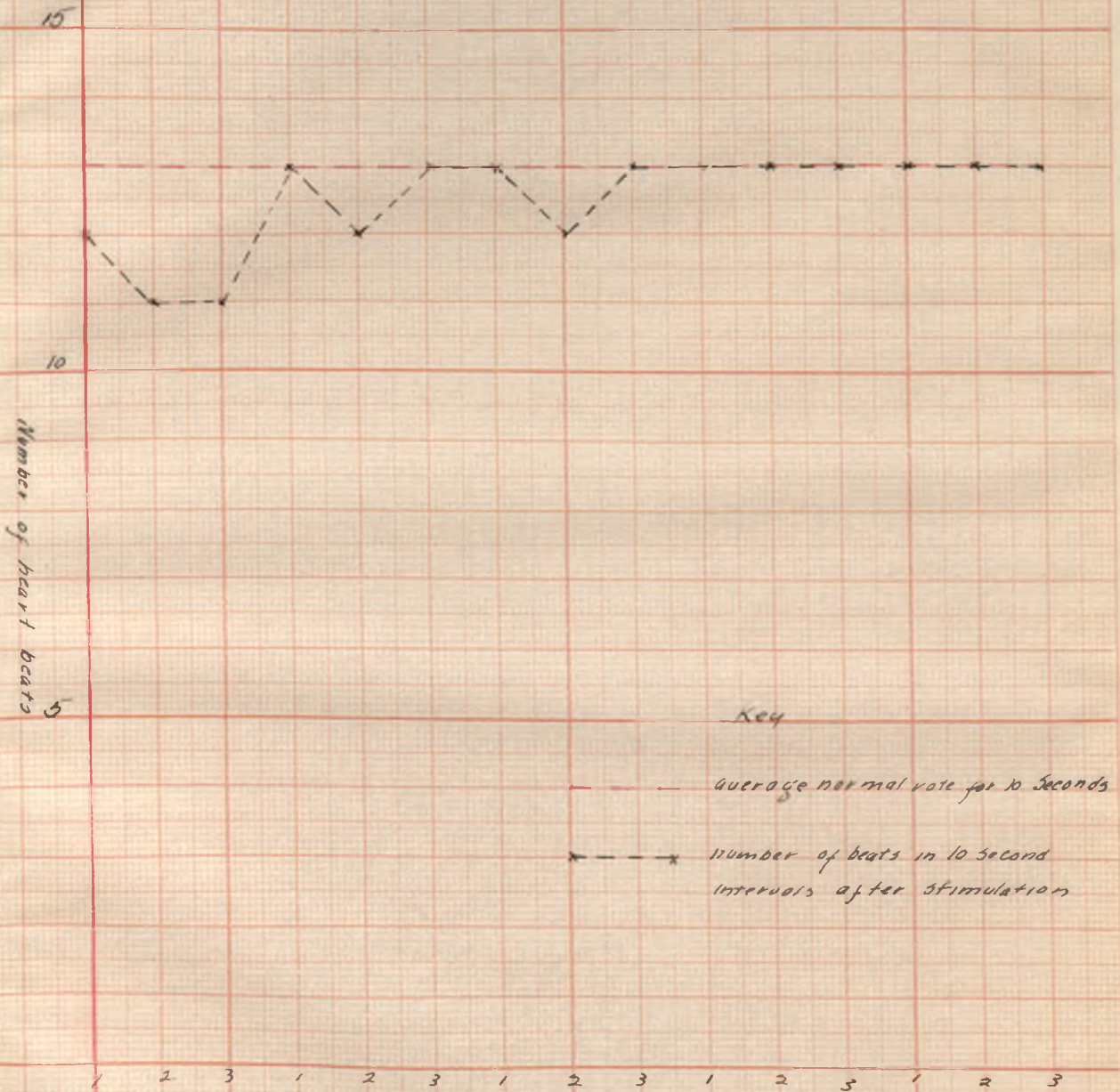


Ten second intervals, three intervals after each stimulation.

Subject K

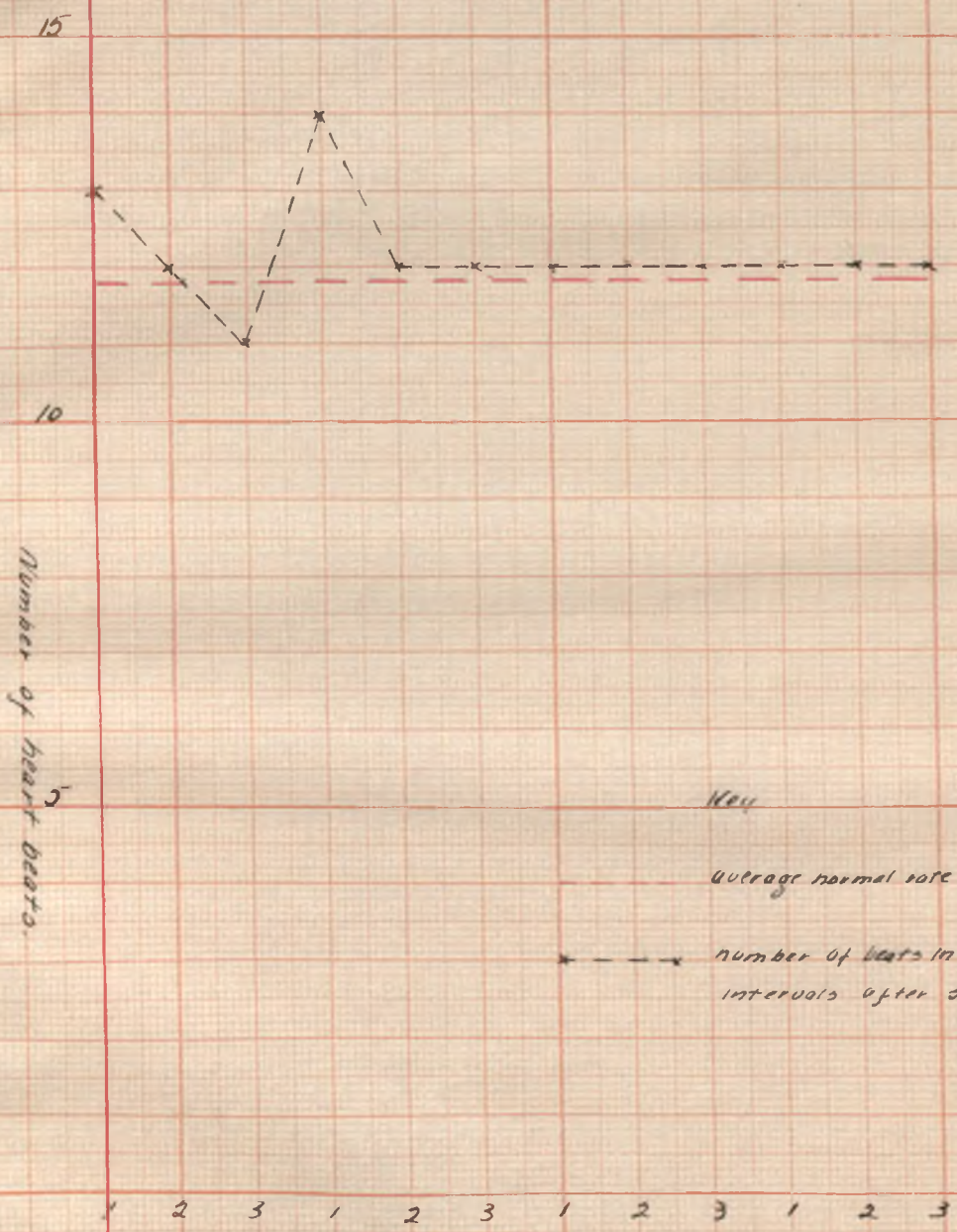


Subject L



Ten second intervals, three intervals after each stimulation

Subject M



Key

Average normal rate for 10 seconds

number of beats in 10 second intervals after stimulation

Ten second intervals, three intervals after each stimulation

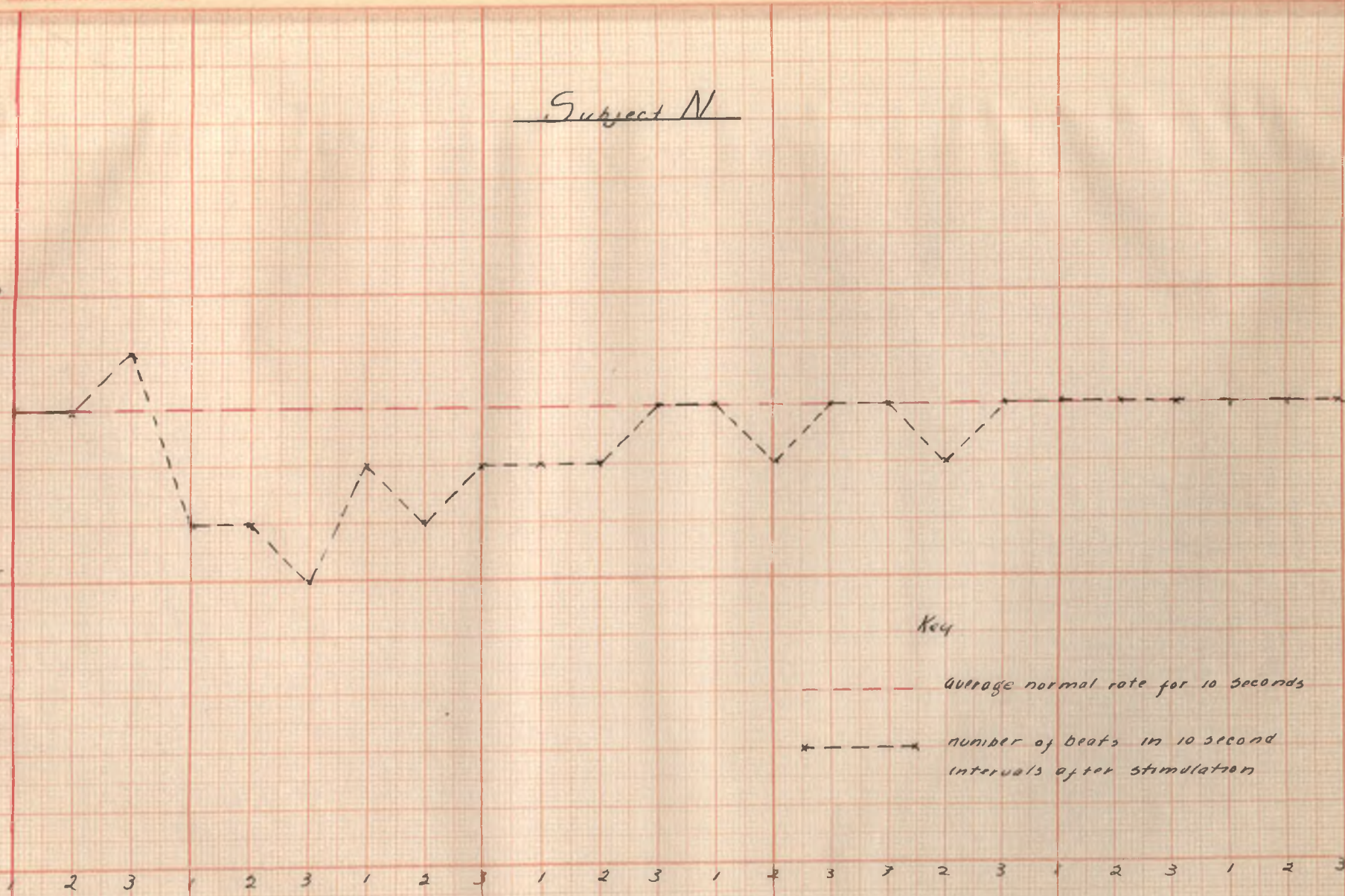
Subject N

Number of heart beats

20
15
10

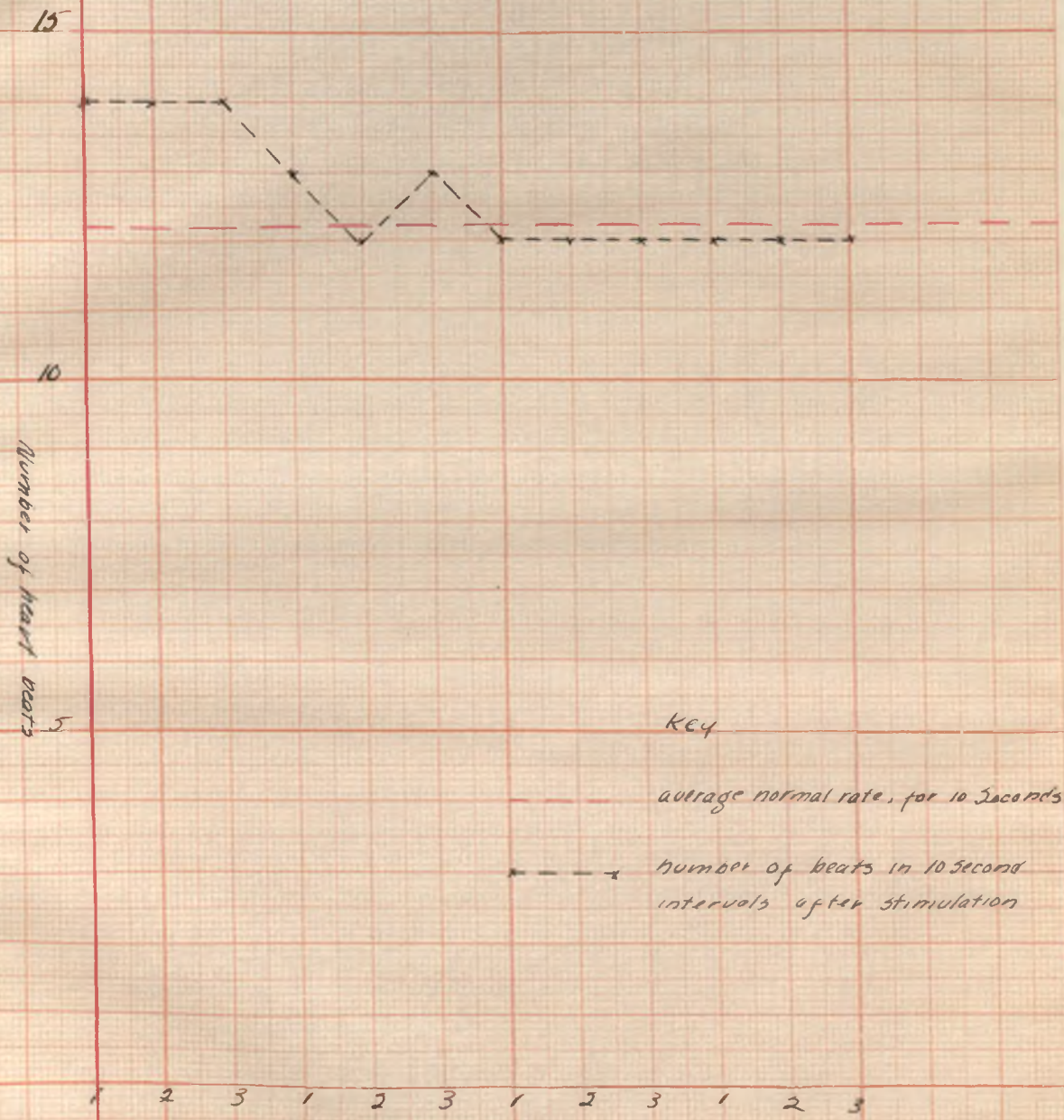
Key

- Average normal rate for 10 seconds
- * - - - * number of beats in 10 second intervals after stimulation



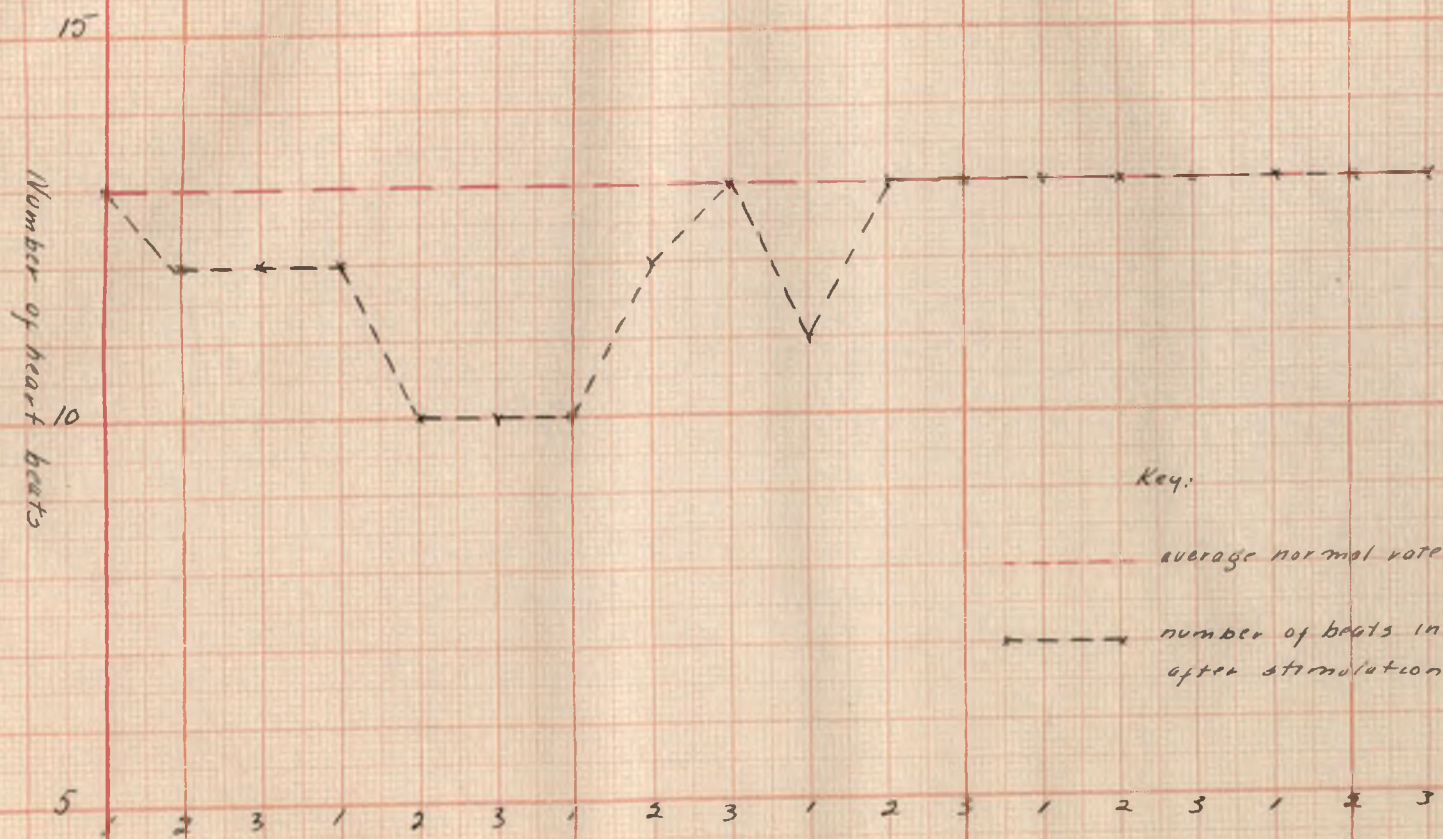
On second intervals, three intervals after each stimulation.

Subject 0



Ten second intervals, three intervals after each stimulation

Subject P

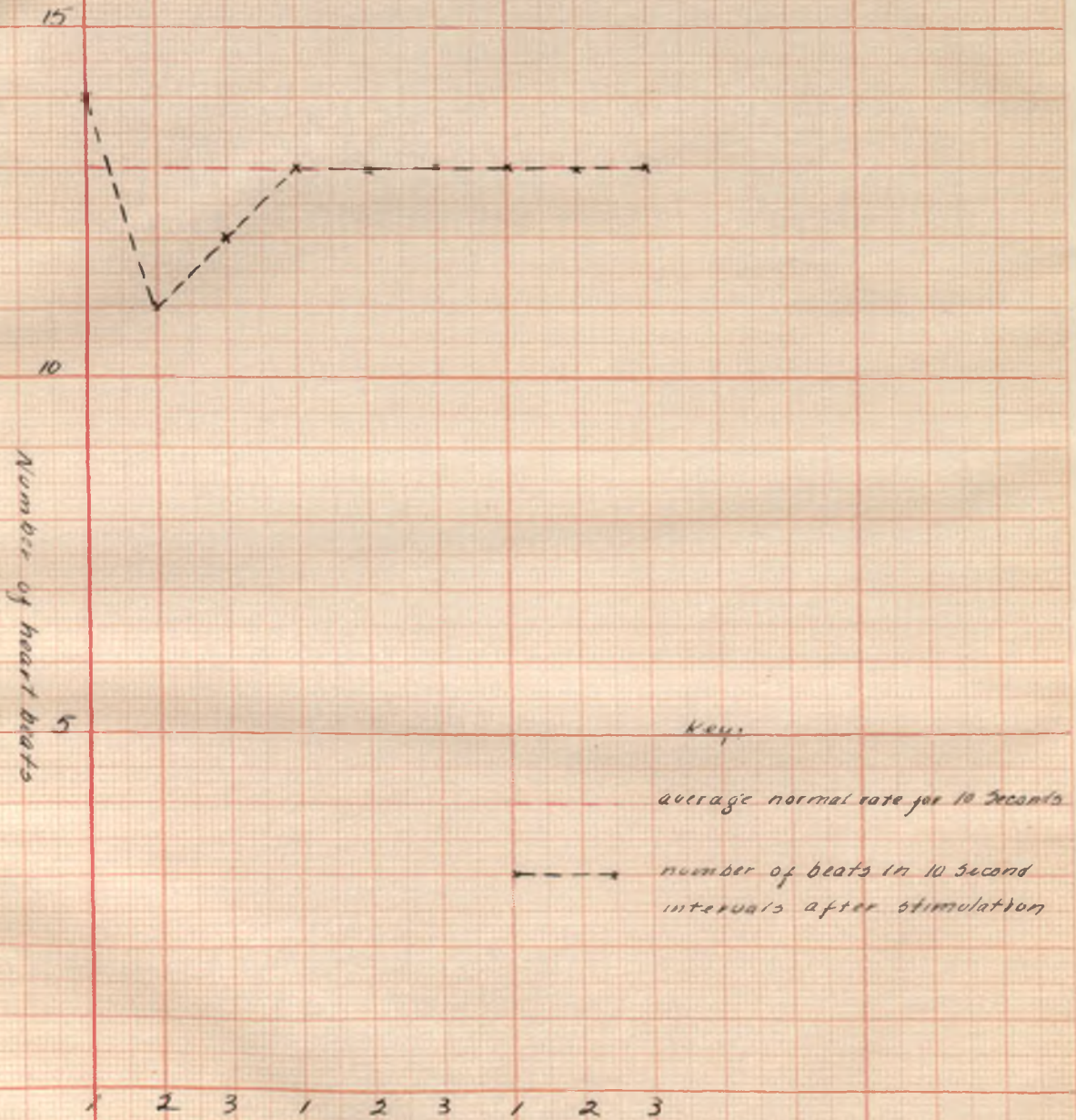


Key:

- average normal rate for 10 seconds
- number of beats in 10 second intervals after stimulation.

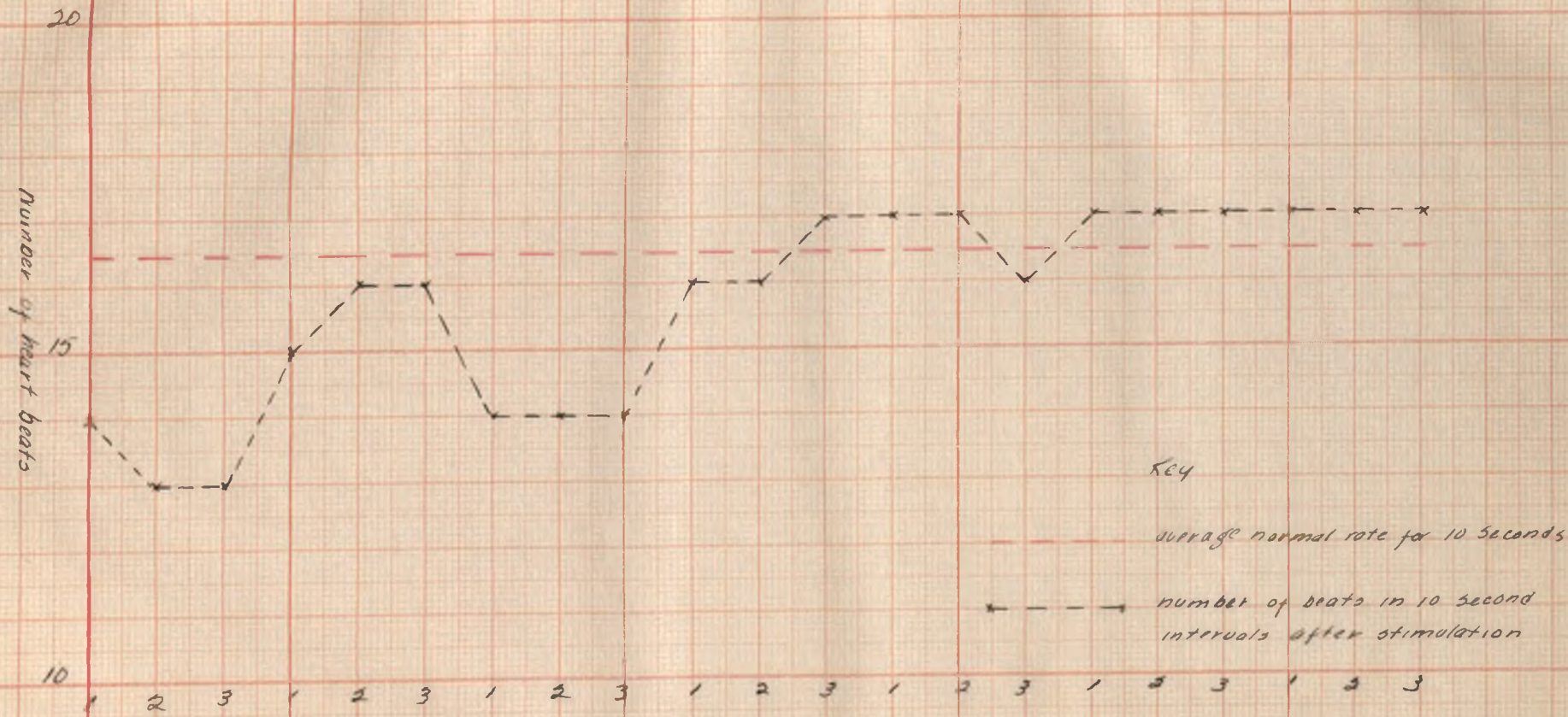
Ten second intervals, three intervals after each stimulation.

Subject Q



Ten second intervals, three intervals after each stimulation

Subject R



Key

----- average normal rate for 10 seconds

-----x----- number of beats in 10 second intervals after stimulation

Ten second intervals, three intervals after each stimulation

Subject S

15

Number of heart beats

10

5

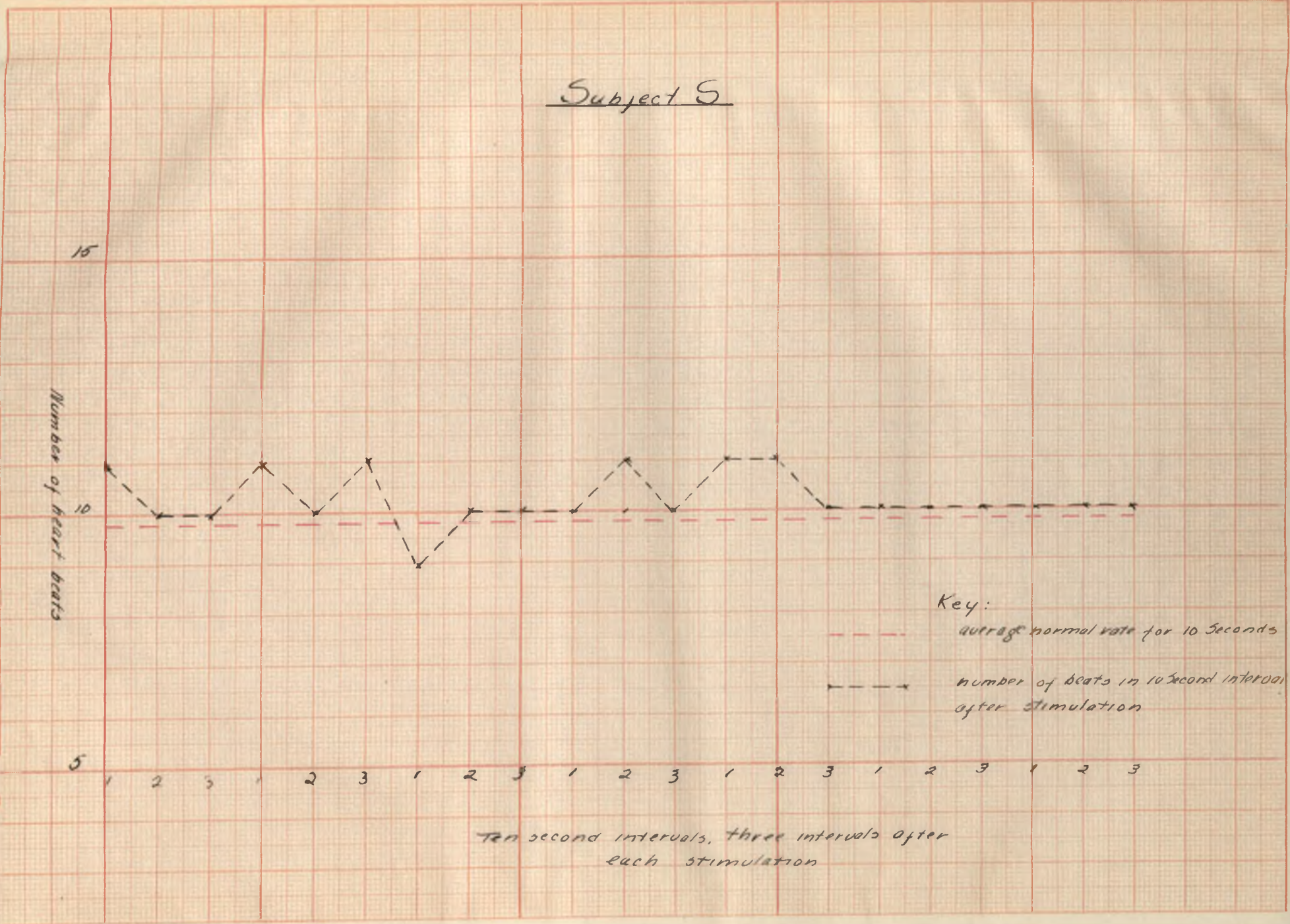
1 2 3 1 2 3 1 2 3 1 2 3 1 2 3 1 2 3

Ten second intervals, three intervals after each stimulation

Key:

----- average normal rate for 10 seconds

----- number of beats in 10 second interval after stimulation



Subject T

Number of heart beats

10

10

5

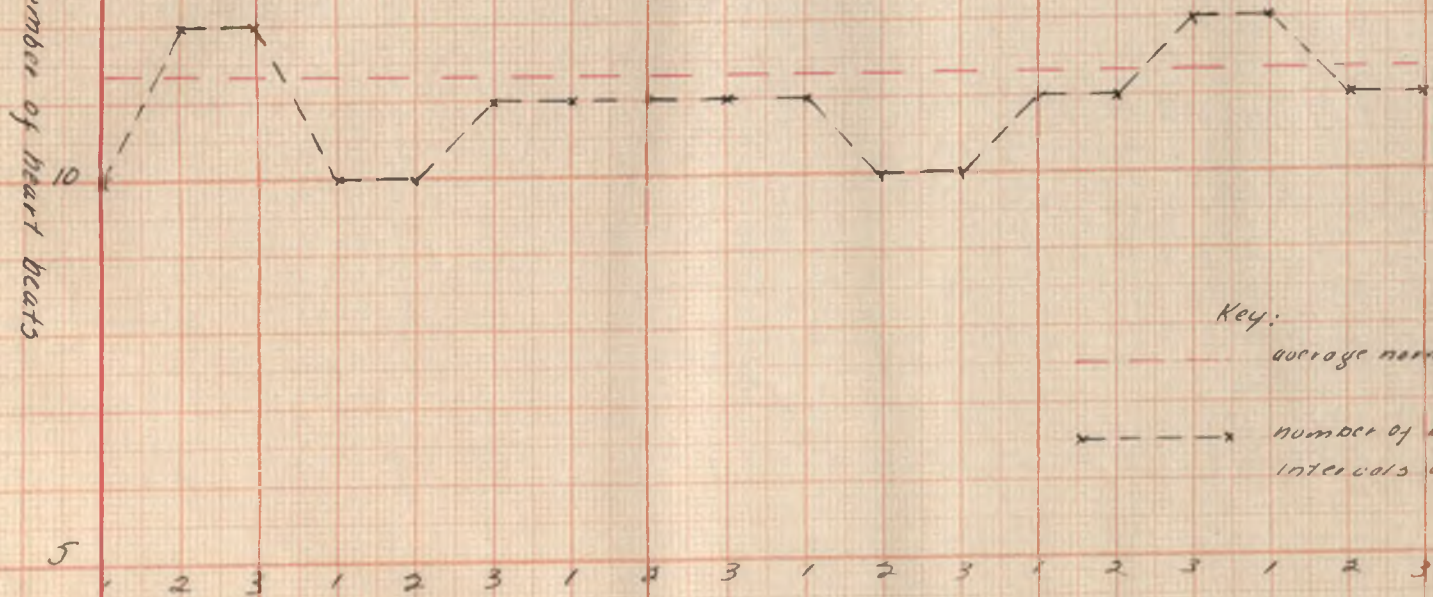
2 3 1 2 3 1 2 3 1 2 3 1 2 3 1 2 3

Key:

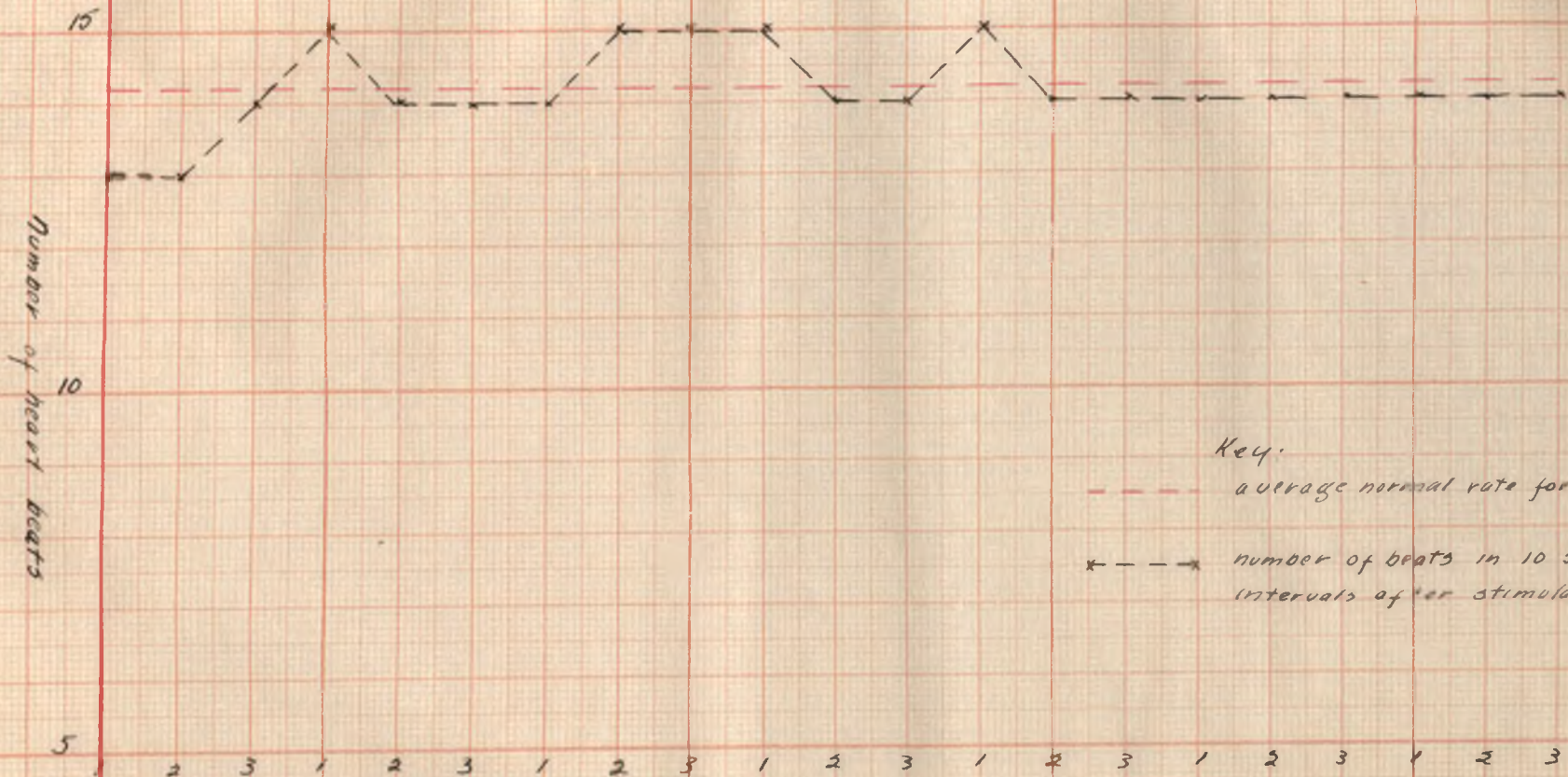
--- average normal rate for 10 seconds

x---x number of beats in 10 second intervals after stimulation

Ten second intervals, three intervals after each stimulation



Subject U



Key:
 - - - - - average normal rate for 10 seconds
 x - - - x number of beats in 10 second intervals after stimulation.

Ten second intervals, three intervals after each stimulation.

Group Average

Number of heart beats

15

10

5

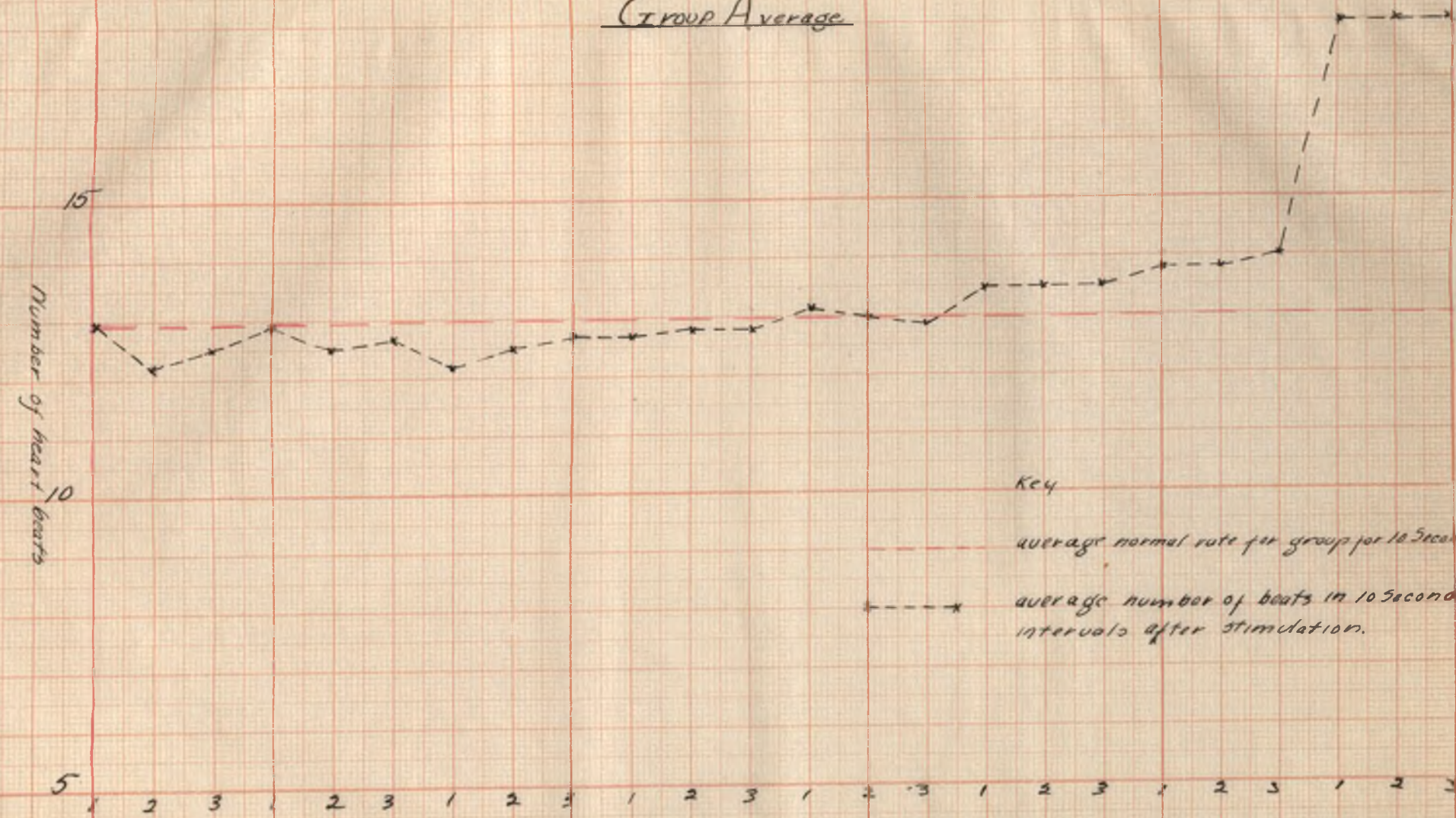
1 2 3 1 2 3 1 2 3 1 2 3 1 2 3 1 2 3 1 2 3

Key

— average normal rate per group for 10 seconds

- - - x average number of beats in 10 second intervals after stimulation.

Ten second intervals, three intervals after each stimulation.



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