Differential Sensitivity in Auditory Flutter Measured by the Constant Method and the Method of Just Noticeable Difference

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journal or publication title	Tohoku psychologica folia
volume	25
number	3-4
page range	65-80
year	1967-03-30
URL	http://hdl.handle.net/10097/00122508

DIFFERENTIAL SENSITIVITY IN AUDITORY FLUTTER MEASURED BY THE CONSTANT METHOD AND THE METHOD OF JUST NOTICEABLE DIFFERENCE

By

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To inquire into the mechanism underlying the perception of auditory flutter, the differential sensitivity about it was measured by the two different psychophysical methods.

In the experiment (I), the constant method was employed and comparative judgments of the interrupted stimulus noises were stated in terms of "dense", "equal or doubtful", or "rough" under three categories. The results showed that the distribution pattern of judgments was not in good agreement with that of normal distribution curve. It was because the listeners sometimes took the category of "dense" for "rough", and vice versa, whereas they detected well the difference of two noises. These data suggested that the use of the constant method is not proper for measurement of the psychophysical constants of flutter.

In the experiment (II), the method of just noticeable differences was employed and the differential upper limens of the interrupted noises were measured. The measurements were taken in the two experimental series of ascending and descending. The results showed that the ascending series is more proper than the descending for determination of differential limens. The Weber ratios were approximately constant over the range of noise from 20 to 320 i.p.s., but it turned suddenly upward at 500 i.p.s. It was concluded from this experiment that the functional upper limit of perceiving the intermittency may lie between about 320 and 500 i.p.s.

Introduction

In the uniformity of the noise spectrum over the range of frequencies passed by a dynamic earphone, there is no radical difference between the continuous white noise and the noise interrupted at a steady rate, which can be regarded as the noise modulated 100 per cent in amplitude by a square wave. Consequently, a wave analyzer can not distinguish the two noises in the shape of spectrum. If the ear discerned a sound merely in a similar manner as the wave analyzer does and had not any other function of the perception of sound beyond it, the two noises would remain indistinguishable from each other by the listeners. On the contrary, to this expectation the listeners can notice the qualitative difference between the two nosises. One is perceived as a continuous sound, the other as "flutter" designated by Miller and Taylor (1948).

According to Miller and Taylor, the perceptual changes of flutter which occur as the

We wish to express our gratitude to Prof. S. Tsukahara (2nd Dept. of Physiology, Fukushima Medical College) for his advice of the apparatus, to Prof. S. Kitamura (Tohoku University) for his support throughout this study, and to fourteen fellow graduate students who took part in this experiment as subjects.

rate of interruption are distinguished and mark the following four stages, with an interrupted noise in which the portion of the noise bursts occupied 50 per cent of the total time (sound-time fraction: 0.5).

(1) Successive bursts: About 10 or 15 interruptions per second (i.p.s.) and below.

(2) A train of bursts having a pitch character: Over the range from about 15 to 250 i.p.s.; the distinct pitch character begins to emerge from about 40 i.p.s.

(3) A noise differing slightly in quality from continuous noise; from about 250 to 2000 i.p.s.

(4) A continuous noise: About 2000 i.p.s. and over.

On the basis of a simple resonance theory of hearing, it is difficult to explain how the flutter accompanied with pitch character is perceived, since the entire basilar membrane in the cochlea is stimulated by the continuous noise as well as periodically by the repeated bursts of noise. Then, Miller and Taylor assumed from their detailed experiments that the ear has the ability to perceive interruptions in a random noise and that it depends upon the synchronous firing of the fibers in the auditory nerve. They assumed also that this ability plays a predominant role in the perception at low-pitched sound, and the ability in the cochlea to analyze the spectral composition of sound at high pitched. The characteristics of this vibratory activity capable of perceiving the intermittency are determined through the investigation on the flutter. The investigations have been developed by Pollack (1951a, 1951b, and 1952), Symmes, Chapman, and Halstead (1954), and etc. including the study of Miller and Taylor.

Problem

The purpose of the present study is to analyze the characteristics of the ability of perceiving flutter through the measurements of differential limens by means of the two psychophysical methods.

In the experiment (I), whether or not the listeners can judge the slight change of interrupted noise into the categories "dense" or "rough" is examined, by the use of the constant method. If the distributions of judgements on "dense" or "rough" to comparison stimuli accorded well with the psychometric function, the major problem would be concerned with determining the p-functions in various interrupted noises, which show the temporal transition pattern of time error as a function of inter-stimulus interval of two compared stimuli.

In the experiment (II), the differential limens on the interrupted noise are determined over a wide range of frequencies in terms of the method of just noticeable differences, to confirm the same data obtained in the experiment (I). An increase of Weber ratio is plotted as a function of interruption rate and an upper limit is obtained, where it becomes impossible for the measurement to determine the meaningful limen. This may indicate the limit where the vibratory function of ear becomes ineffective.

(I) Measurement by the constant method

Method

Apparatus: The block diagram of apparatus is shown in Fig. 1. A voltage of amplfied random-noise from a noise generator was led to a switch circuit. The switch circuit was composed of four diodes and chopped the noise into successive bursts in the synchronization with square waves. The square waves were oscillated in two generators; one was for standard stimuli, the other for variable stimuli. The interrupted noises from the switch circuit were fed into a pair of dynamic earphones (DR–305) through the relays, of which the switchings were controlled by a timer. The timer regulated all time condition necessary for the experiments. Owing to the use of the relays, it became unavoidable that the stimulus noise was sometimes followed by clicks. All experiments were carried out in a quiet room.

Two views of the part of apparatus are shown in Fig. 2.

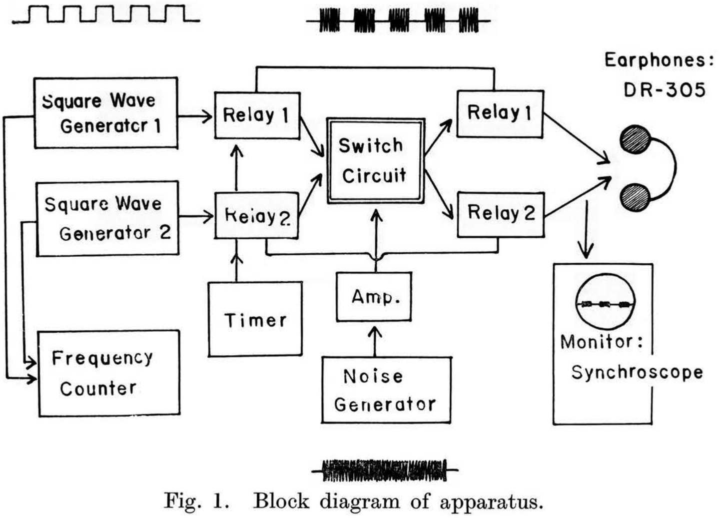
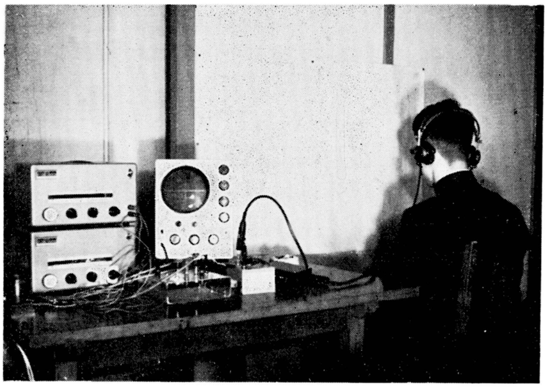


Fig. 1. Block diagram of apparatus.

Procedure: The method of complete series of the constant method was used. Standard stimuli (Ss): Three noises of 80, 220, and 320 interruptions per second (i.p.s.) having duration of 1.5 sec. were chosen. Comparison stimuli (Sc): Each of seven noises of 50, 60, 70, 80, 90, 100, and 110 i.p.s. was paired off with standard stimulus of 80 i.p.s., 130, 160, 190, 220, 250, 280, and 310 i.p.s. with 220 i.p.s., and 170, 220, 270, 320, 370, 420, and 470 i.p.s. with 320 i.p.s. The comparison stimuli were arranged with steps of equal stimulus interval, on the basis of the result of Miller and Taylor that most of the greater or less judgements might fall into both stimuli respectively. The duration of the stimuli was set up also 1.5 sec. Inter-stimulus time interval (time interval between the standard and the comparison stimulus): Four kinds of 0.0, 0.5, 2.0, and 4.5 sec. Rest time interval (time interval between two judgments):



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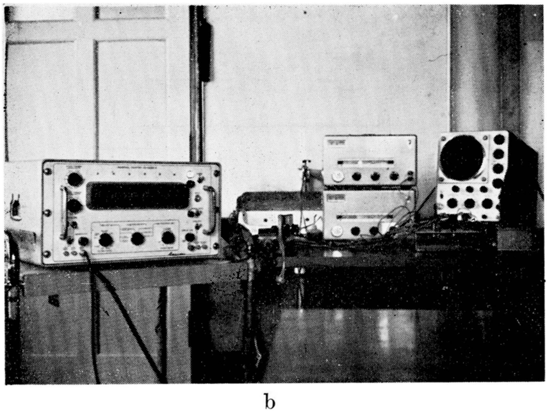

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Fig. 2. Two views of the part of apparatus.

25 sec. Six subjects: A woman graduate student R.K., and five male graduate students H.U., M.Y., H.T., Y.S., and K.M.

Total twelve series of experiment (three stimulus conditions four inter-stimulus time interval conditions) were carried out. Trial order of these series was randomly assigned to each subject. The subjects tried four series of experiment a day, and consequently it took three days for the completion of all series. In a series, the subjects were asked to express five judgments on each of seven comparison stimuli, i.e., 35 judgments in all.

After a ready signal, a standard stimulus was presented for 1.5 sec., and then a comparison stimulus was emerged with the same duration followed by a given inter-stimulus time interval. The subjects were asked to judge the comparison stimulus "dense", "rough", or "equal or doubtful" in comparing the standard stimuli (three-category judgments). The presentation of this stimulus pair was repeated every rest interval of 2.5 sec., and total 35 presentations were completed per a series. The standard stimulus was kept constant in a series, though the comparison stimulus was renewed at every presentation in haphazard sequence.

Prior to the trial in each series, the subjects were given three stimulus pairs, of which comparison stimuli were the two extremes and a median stimulus, that he might be able to understand the concept of "dense", "rough", and "equal". Though the interrupted noise was always accompanied by a definite pitch character, the subjects were instructed not to judge the pitch, but to judge the rate of interruption of the noise. All stimuli used in the experiment were the interrupted noises having sound-time fraction of 0.5 and sound pressure level of 75 db re 0.0002 dyne/cm^2 over a long period of time. The noises were given to the listeners binaurally.

Results and Discussion

1) *On specific property in the comparative judgment on the rate of interruptions of noise*: The distributions of judgments "dense", "equal or doubtful", and "rough" are shown in Table 1. The figures of the table stood for the sum of six subjects' judgments at the noise of 80, 220, and 320 i.p.s. with four inter-stimulus intervals. It may be valid for finding the general feature of distributions to pool the judgments of all subjects in this way, since the number of judgments in a subject was too few to obtain the psychometric functions, only five judgments per a stimulus pair being obtained. Thus, the total number of judgments per a stimulus pair in Table 1 is 120. Fig. 3. is the graphical presentation of the results of Table 1, i.e., the functional relationship between proportions of judgments "dense", "equal or doubtful", and "rough" and stimulus values.

As seen from Table 1 and Fig. 3, the curves of distribution function of judgments deviate considerably from those of the cumulative normal distribution. According to the results of test for normality, most of them were not proved to be normal distribution. As experimenters expected, the smallest stimuli were likely to give reports of "rough" about 100 per cent of the time, and the largest stimuli, to give reports of "dense" also about 100 per cent of the time. There occurred, however, a distortion in the judgements as to five median stimuli but the two extremities. That is, (1) the center stimuli (80, 220, and 320 i.p.s.) of comparison were judged so seldom as incorrect, that the number of judgments "equal" became extremely large at these stimuli as seen in Fig. 3. (In this experiment most answers were "equal", though the category "equal or dobutful" was provided.) The distribution curve on the judgment "dense" as well as the curve on "rough" show a steep decline at the centers of comparison stimuli, as seen in Fig. 3. And still, (2) there was a tendency that four stimuli above or below the center (e.g., 60, 70, 90, and 100 i.p.s. in 80 i.p.s. condition) were sometimes judged as the reverse category, — e.g., the stimuli of 60 and 70 i.p.s. were judged to be "dense" and 90 and 100 i.p.s. to be "rough." Thus, it may be attributed to the above two reasons that the distribution pattern of judgments was not in good agreement with that of normal distribution curve.

Table 1. Row figures and proportions of judgments "dense", "equal or doubtful", and "rough" for seven Sc compared with Ss. Ss: 80, 220, and 320 i.p.s.

Ss: 80 i.p.s.

Sc	"dense"	"equal or doubtful"	"rough"
50	0	0	120(1.000)
60	5(0.042)	14(0.117)	101(0.842)
70	17(0.132)	39(0.325)	64(0.533)
80	14(0.117)	85(0.708)	21(0.175)
90	70(0.583)	39(0.325)	11(0.092)
100	111(0.925)	6(0.050)	3(0.025)
110	119(0.992)	1(0.008)	0

Ss: 220 i.p.s.

Sc	"dense"	"equal or doubtful"	"rough"
130	0	0	120(1.000)
160	5(0.042)	1(0.008)	114(0.950)
190	8(0.067)	26(0.217)	86(0.716)
220	13(0.108)	94(0.783)	13(0.108)
250	75(0.625)	35(0.293)	10(0.083)
280	114(0.950)	5(0.042)	1(0.008)
310	119(0.992)	1(0.008)	0

Ss: 320 i.p.s.

Sc	"dense"	"equal or doubtful"	"rough"
170	0	1(0.008)	119(0.992)
220	3(0.025)	5(0.042)	112(0.933)
270	13(0.108)	33(0.275)	74(0.617)
320	16(0.133)	94(0.783)	10(0.083)
370	73(0.608)	37(0.308)	10(0.083)
420	105(0.875)	15(0.125)	0(0.000)
470	108(0.900)	10(0.083)	2(0.016)

These results show that the subjects could notice the difference between the standard and comparison noises, but that it was so difficult for them to determine the difference between "dense" or "rough", that they sometimes took "dense" for "rough", and vice versa. The difficulty in determining the difference between "dense" and "rough" was also found from subject's introspection. This is a specific property in the comparative judgment on the rate of interruptions of noise, in terms of three categories "dense", "equal or doubtful", and "rough". Although on the center stimulus of the condition of 80 i.p.s. in Fig. 3. the number of judgements "equal" was slightly fewer than in the other two stimulus conditions, it may be considered that there are no significant differences among three stimulus conditions. Thus, the property mentioned above is

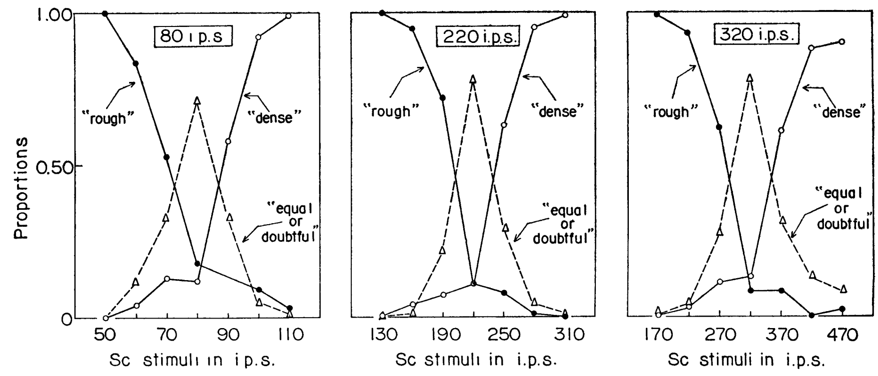

Fig. 3. Distributions of proportions of judgments "dense", "equal or doubtful", and "rough" as the function of Sc stimuli. (Graphical presentation of the data in Table 1.)

found alike throughout every stimulus condition.

Though the subjects were instructed to judge the rate of interruptions in terms of "dense" or "rough", they were to use the pitch character of the interrupted noise as another cue for the judgment of difference, since the interrupted noise which heard a train of bursts is always accompanied by the pitch character, as indicated by Miller and Taylor. Accordingly, it may be possible to change an expression of the property mentioned above as follows: When the difference of two noises is small in their rate of interruptions it becomes difficult to categorize the difference between "high" or "low". This may be attributed to the fact that the pitch of flutter is very rough, vague, and diffuse.

2) *Computations of the psychophysical constants*: In this experiment, it must be taken into consideration that the psychophysical constants computed from the data are not so meaningful, since the psychometric function for judgment on the rate of interruptions of noise did not match well the typical normal distribution.

The following two methods may be selected for the computations of the psychophysical constants: Woodworth's summation method and Pauli's method. For the use of the summation method, the judgments of six subjects were pooled together in every series. (The number of judgments per a stimulus pair became 30 at each series. This number, however, is still insufficient for the requisite number of 50 for application of the method.) In the application of the Pauli's method, the judgments were not pooled together but the computation of constants was done at every series of each subject (the number of judgments per a stimulus pair was 5 for each computation), and a representative was shown in each series in terms of a mean of six subjects. Thus, the psychophysical constants were determined through the two ways, and the differences between the two results were compared.

According to the results of comparison, however, there was no significant difference between the two methods. Consequently, only the Pauli's method was used, since the individual differences can be taken into consideration.

3) *Time error* (*p-function*) *in flutter*: The points of subjective equality (PSE) of each subject were computed at four inter-stimulus time intervals with three standard stimuli of 80, 220, and 320 i.p.s. The time error was calculated by dividing the PSE of each subject by the rate of interruptions of standard stimulus (PSE/Ss). The mean time errors of six subjects are plotted as a function of inter-stimulus time interval with three standard stimuli of 80, 220, and 320 i.p.s. in Fig. 4 (p-function).

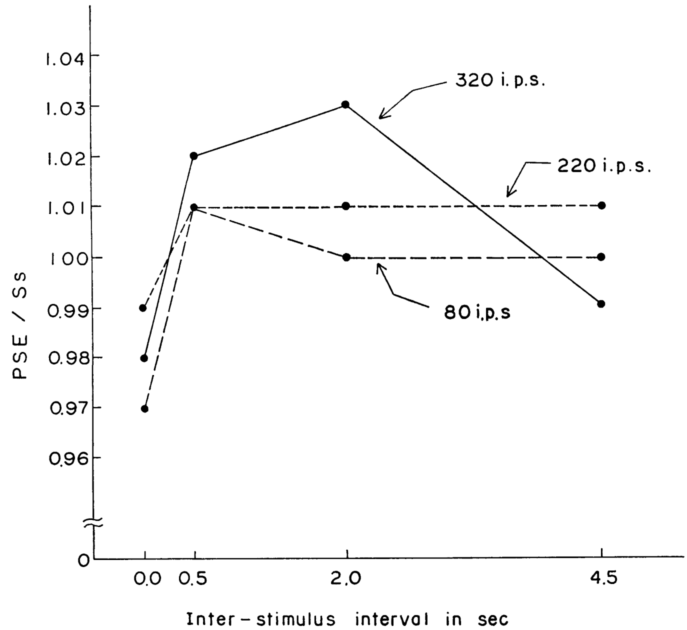

Fig. 4. Time errors as a function of the inter-stimulus time interval with three Ss conditions: 80, 220, and 320 i.p.s.

In this figure, the PSE/Ss more than 1.0 indicates the positive time error, and the one less than that the negative. The results showed that the time error seems to be negative at the inter-stimulus time interval of 0.0 sec. and positive at the intervals longer than that. But, such a tendency could not be proved as significant by statistical test owing to its large individual difference. Moreover, the difference of pattern between p-functions of 80 and 320 i.p.s. was not significant ($F_{(4,7)} = 0.0126$).

Wada (1933) has found a time error in the successive comparison of tonal pitch of sinusoidal wave. It was negative at short inter-stimulus time interval of about 1.0 sec. and positive as the interval became longer than 2.5 sec. Since a train of bursts of interrupted noise was always accompanied by the pitch character, it was pressumed that the pitch character would serve as a cue for the comparative judgment on noise.

Based on this pressumption, it was futher assumed that the *p*-function of interrupted noise would be comparable with that of Wada's results on the tonal pitch. Contrary to the expectation, however, the *p*-function of interrupted noise did not show any significant pattern as seen in the tonal pitch.

It may be concluded that a definite time error could not be found in comparative judgment on the rate of interruptions of noise, as well as on the pitch of flutter though the judgments in experiment were done not on the pitch but mere on the rate of interruptions. It may be safer to conclude, however, that the flutter is not qualified material for the research of time error.

4) *Deviation of judgments*: In Fig. 5 the mean deviation score from six subjects by Pauli's method is plotted as a function of four inter-stimulus time intervals of 0.0, 0.5, 2.0, and 4.5 sec., with three standard stimuli of 80, 220, and 320 i.p.s. The deviation score is an index to show the accuracy of judgments. The score seems to be low at the inter-stimulus time intervals of both 0.5 and 2.0 sec. However, the results of analysis of variance did not show it significantly.

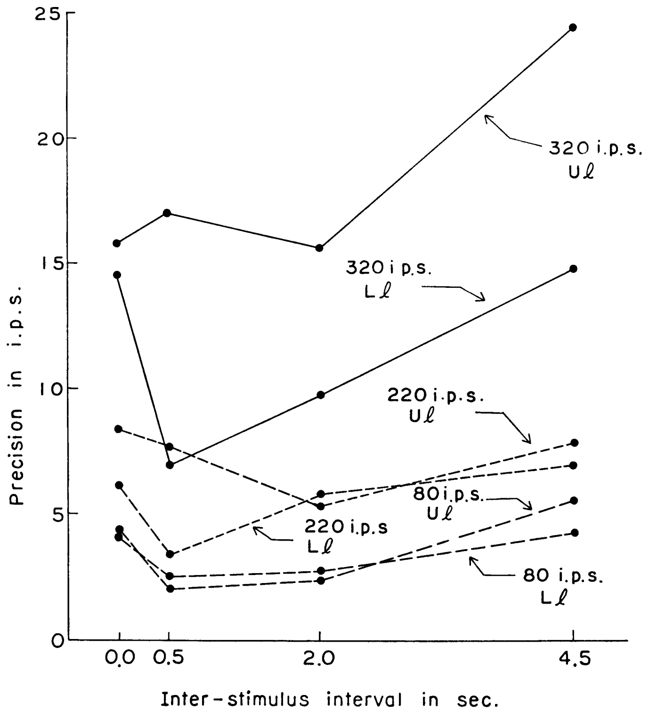

Fig. 5. Precision of judgments "dense", "equal or doubtful", and "rough" in four inter-stimulus intervals at three Ss conditions of 80, 220, and 320 i.p.s.

5) *Differential limen*: In Fig. 6 the mean upper limen from six subjects as graphically shown as a function of four inter-stimulus time intervals of 0.0, 0.5, 2.0, and 4.5

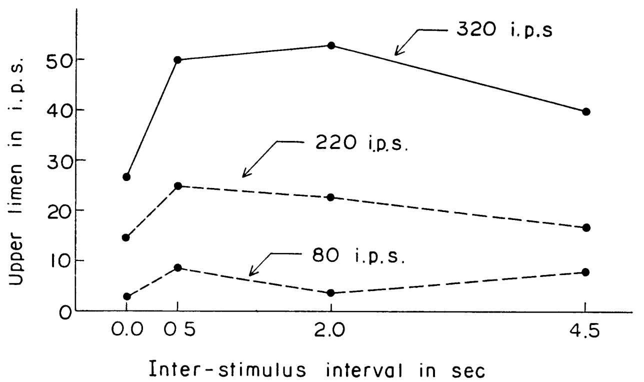

Fig. 6. Upper limens as a function of the inter-stimulus time interval with three Ss conditions: 80, 220, and 320 i.p.s.

sec., with three standard noises of 80, 220, and 320 i.p.s. It was considered significant in the figure that the upper limen decreased at the time interval of 0.0 sec. in every noise condition. At the time interval of 0.5 sec., the upper limens were 8.7, 25.0, and 50.0 i.p.s. with the noise conditions of 80, 220, and 320 i.p.s., respectively. All of these but 25.0 with 220 i.p.s. condition are comparable well with the same limens obtained in the experiment (II): 11.4, 40.0, and 59.5 i.p.s., respectively. In order to estimate the differential limen of interrupted noise precisely, however, it may not be proper to employ the constant methods, but to use the modified method of minimal change as employed in the experiment (II), where the subjects were asked to judge only the difference between standard and comparison noise disregarding whether "dense" or "rough".

(II) Determination of the Differential Limen by the Method of Just Noticeable Differences

Method

Apparatus: The apparatus used in this experiment was the same as in the experiment (I).

Procedure: The pairs of interrupted white noise — the standard (basic) and the comparison (variable) stimuli were presented at every rest interval of about 10 sec. Both of the stimuli having the duration of 1.5 sec. were separated from each other for 0.5 sec. This 0.5 sec. as inter-stimulus time interval was chosen on the basis of the result in the previous experiment (I). The discrepancy rate of interruption between the two noises was either advanced or reduced with every presentation, by means of gradual change of the comparison stimulus. In the ascending-series, the experimenter advanced the discrepancy until the subject came to notice the difference between the noises. In the descending-series, on the contrary, reduced it until he was not able to detect the difference.

The subjects were divided into two groups. One group consisted of six graduate students (one woman subject M.K., and five man subjects T.H., M.Y., F.I., M.K., and H.T.) was assigned to the ascending-series, and the other of seven graduate students (three woman subjects N.S., K.S., and H.G., and four man subjects M.O., Y.A., H.U., and H.K.) to the descending-series. The subjects were asked to report when they noticed the difference between the two noises, in terms of "equal" or "different."

Magnitude of step in change of the comparison stimuli was not constant with each subject, but varied at experimenter's option. Most subjects required seven to ten repeated presentations of the stimulus pair for a determination of threshold. When the subject was aware of the difference, the presentation was stopped and the rate of interruptions as to the comparison stimulus was measured by a digital counter and recorded as a threshold. On a standard stimulus, three to five thresholds were measured with each listener and a mean of these was taken as a representative threshold.

Eight interrupted noises of 20, 40, 80, 120, 160, 220, 320, and 500 i.p.s. (sound-time fraction: 0.5) were used as the standard stimuli. Each of these stimuli was distributed

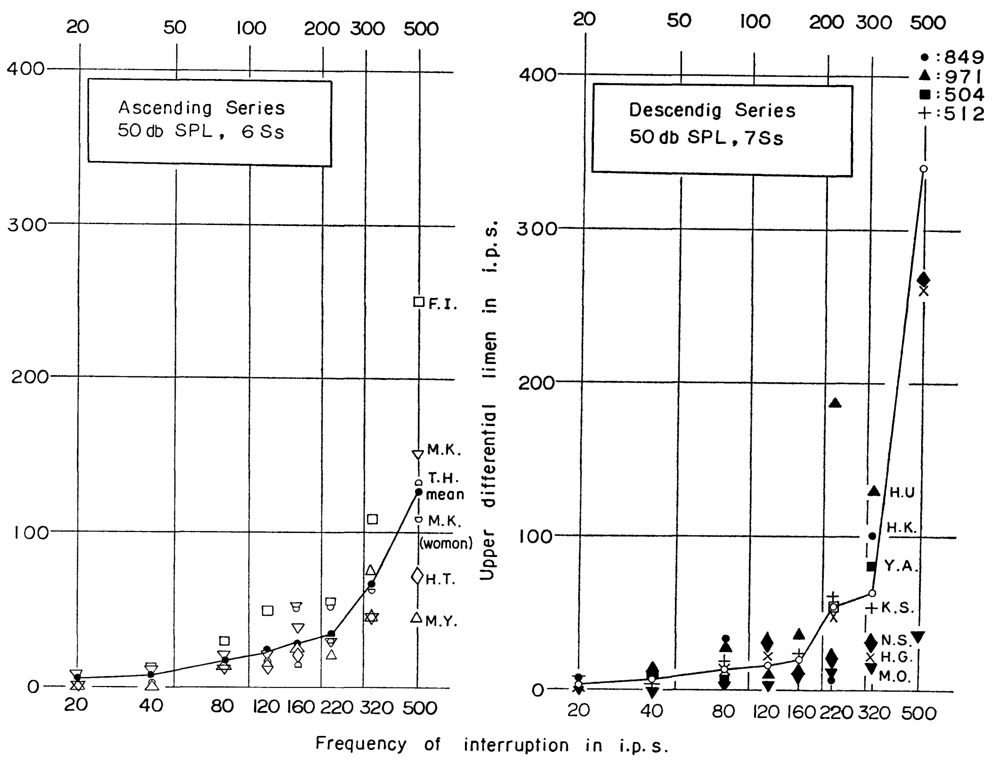

Fig. 7. Upper differential limen as a function of the standard (basic) frequency for A- and D-series.

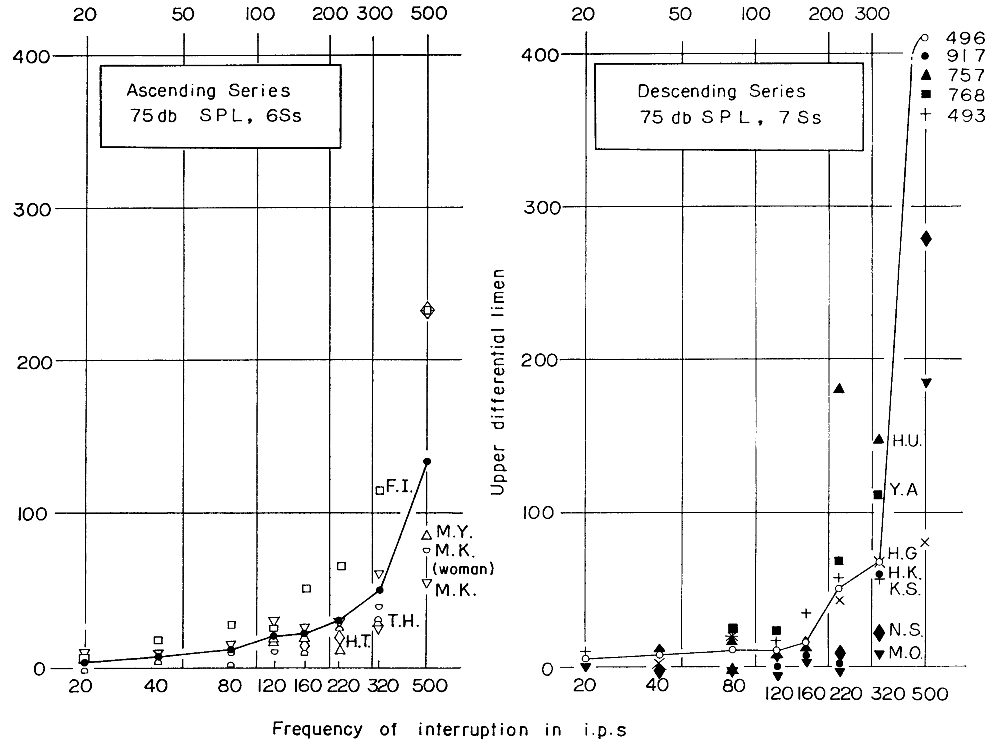

Fig. 8. Upper differential limen as a function of the standard (basic) frequency for A- and D-series.

at two grades of sound pressure level of 50 and 75 db re 0.0002 dyne/cm^2. Therefore, the total number of obtained threshold was 16 in each subject. These stimulus conditions were done in 2 hours in terms of haphazard order for each subject.

Results and Discussion

1) *Ascending-series vs. Descending-series*: The results of six listeners in ascending-series as well as of seven listeners in descending-series are shown in Fig. 7 for 50 db, and those for 75 db are shown in Fig. 8. In these figures, the differential limens of the individual listeners and the mean of them are plotted as a function of the basic (standard) stimulus on the abscissa.

The differential limens of the descending-series were significantly larger at 500 i.p.s. than that of ascending-series, in both 50 db and 75 db conditions. Although this seemed to be detected at 220 and 320 i.p.s., it may be plausible to conclude that below 320 i.p.s. there were no differences between the two ways. In the descending-series below 220 i.p.s., there were some instances, as seen from Fig. 7 and 8, that the differential limen took negative, where the subjects did not change their judgments from

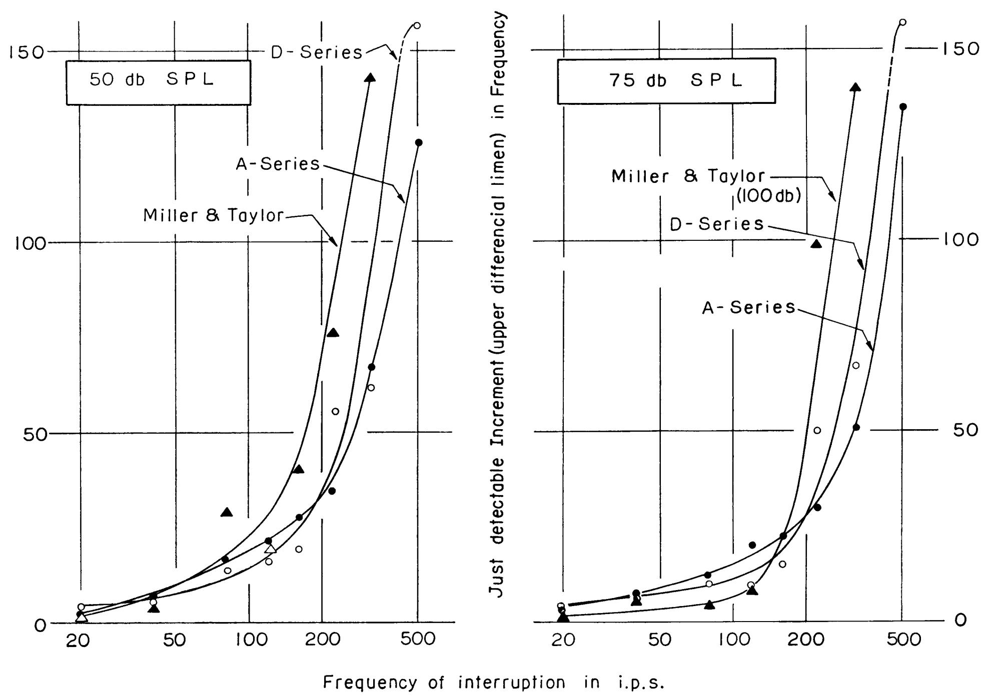

Fig. 9. The smoothed curves of the upper limen (induced from Fig. 7 and 8) and that of Miller & Taylor's study (1948).

"different" to "equal" until the variable stimulus became smaller than the standard. In the descending-series, futhermore, the deviation of limen within subject as well as the individual differences among subjects appeared larger than in the ascending-series. These results suggest that the ascending-series is more proper than the descending-series as the method for measuring the differential limen in flutter.

2) *On differential sensitivity*: Each of results in the ascending- and the descending-series of Fig. 7 and 8 is put into a smoothed curve and arranged with two sound levels of 50 db and 75 db in Fig. 9. The ordinate scale of Fig. 9 is enlarged more than that of Fig. 7 and 8, which show the just noticeable increment of the rate of interruptions in frequency, i.e. the upper differential limen.

With the results of this study, those of Miller and Taylor's are also plotted in Fig. 9.

The relative threshold at every basic stimulus can be obtained directly from Fig. 9. Fig. 10 shows the relative threshold computed from the mean differential limen of all subjects without distinction of two series. These of Miller and Taylor's are added to Fig. 10 calculated from the smoothed curves in Fig. 9.

3) *Differential sensitivity at the two levels of noise intensity*: In Fig. 9 and 10, it is seen that the differential sensitivity is higher at 75 db than at 50 db over the range

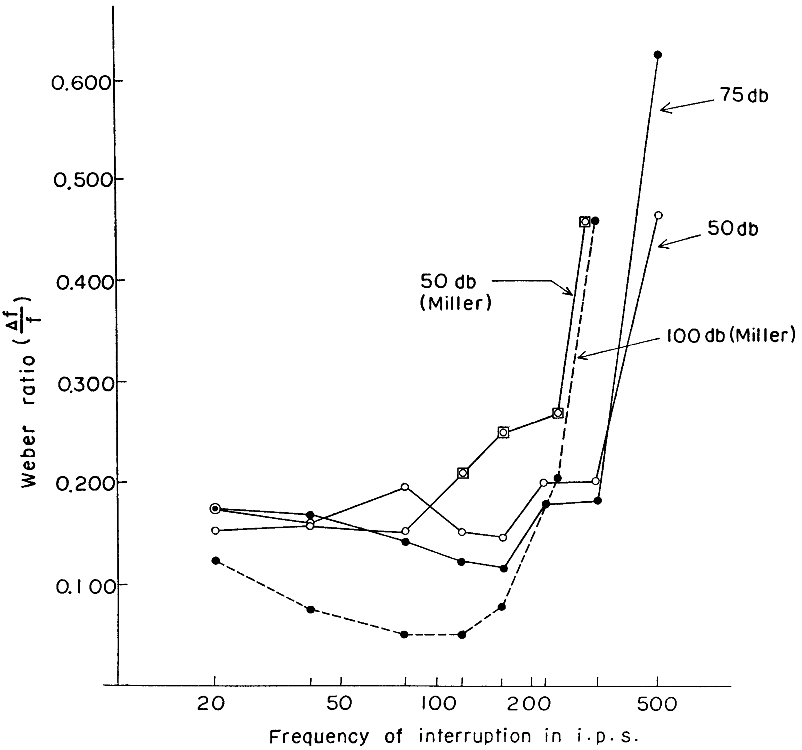

Fig. 10. Weber ratio as a function of the standard (basic) frequency.

from 80 to 320 i.p.s. In the results of Miller and Taylor, the Weber ratios in 100 db are smaller than those in 50 db distinctly. Summarizing these results, we find the differential sensitivity increases in proportion to the intensity of noise. Differential sensitivity as a function of the rate of interruptions of noise: — As seen in Fig. 10, we can not find the marked differences in the differential sensitivity over the range of noise from 20 to 310 i.p.s., at both 50 and 75 db conditions. Although the Weber ratio seems to turn downwards at the flutter frequency of 160 i.p.s., it may be plausible to consider that the differential sensitivity is approximately equal over the range of frequency from 20 to 320 i.p.s. and it increases rapidly above from between 320 and 500 i.p.s. In the results of Miller and Taylor, however, the differential sensitivity began to decrease at 240 i.p.s. and increased abruptly above 320 i.p.s. Thus, except that the flutter frequency where the differential sensitivity begins to decrease was higher in this experiment than in the Miller and Taylor's, there appeared no essential distinction between the results of two studies.

According to the introspections from subjects, the perceptual changes which occur as the rate of interruptions of a random noise can be summarized as follows: Over the range of the noises from 120 to 320 i.p.s. within the noises used in this experiment as the basic stimulus, the interrupted noises had the impression of a definite pitch character corresponding to their rate of interruptions. The pitch character was not distinct at the noises of 40 as well as 80 i.p.s., however. At 500 interruptions per second a mere qualitative difference between the interrupted noise and continuous noise could be detected, but the definite pitch character as well as the impression of successiveness as a train of bursts of noise decayed. Accordingly, at the noise of 500 i.p.s. most of subjects made difficulties in distinguishing it from the continuous noise. The individual differences among the subjects are quite striking at the 500 i.p.s. condition of Fig. 7 and 8, and a subject T.H. gave up completing the ascending-series on the noise of 500 i.p.s., 75 db. These results seem to reveal that the obtained data as to the interrupted noise of 500 i.p.s. are not meaningful.

Based on the result in experiment of (II) that the Weber ratio was approximately constant over the range from 20 to 320 i.p.s., and the one in experiment (I) that no significant difference was found in the p-function between the noises of 80 and 320 i.p.s., it may be possible to estimate that the functional ability to perceive the interruptions in a random noise is available between about 320 and 500 i.p.s. The ability to perceive the intermittency may be a function mediated by the intermittent character of the neural activity as assumed by Miller and Taylor, and the fact that the individual nerve fibers can respond up to 400 or 500 times each second is a physiological base to support the above estimation. Harris (1952) has summarized that the Weber ratio on a tonal pitch is approximately constant from about 500 i.p.s. and over, but it turns suddenly upward below 500 i.p.s. This turning may be attributed to the fact that the aspect of intermittency begins to play a role for the perception of pitches from the region about 500 c.p.s. It is thus concluded from this experiment that the functional upper limit of the ability to perceive the intermittency lies between about 320 and 500 i.p.s., whereas Miller and Taylor estimated it as about 200 and 300 i.p.s.

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(Received January 10, 1967)

Zusammenfassung

Um die Eigenheiten der Funktion, die das akustische Geflatter fasst, zu erforschen, wurde das unterschiedliche Empfindungs-vermögen für das akustische Geflatter durch zwei Methoden vermessen.

(1) Der Punkt der Gleichheitsurteile für die drei gebrochenen Geräusche von 80, 220, and 320 Unterbrechung für eine Sekunde wurde durch die Konstanzmethode vermessen. Es zeigte sich, dass die Versuchspersonen den Unterschied des untergebrochenen Verhältnisses des Vergleichreizgeräusches von dem Normalreizgeräusch merken konnten, es ihnen schwer fiel über den Unterschied das Urteil "dicht" oder "rauh" auszusprechen und dass die anhäufende Verhältnisse des Urteils "dicht," "gleich oder bedenklich" oder "rauh", nicht statisch normale Form zeigten. Die Konstanzmethode ist also nicht wirksam zu der Messung der psychophyskailischene Konstante des akustischen Geflatters.

(2) Die Überschwelle der Wahrnehmung des untergebrochenen Verhältnisses des Geräusches wurde durch die Grenzmethode vermessen. Daraus ergaben sich die Resultate, dass die relative Schwelle konstant über dem Reizgeräusche von 20 zu 320 Unterbrechung für eine Sekunde ist, aber sich im Geräusch von 500 Unterbrechung für eine Sekunde schnell vermehrt und dass die Überschwelle der Funktion, die das akustische Geflatter fasst, zwischen 320 und 500 Unterbrechung für eine Sekunde liegt.