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# Electro-Gustometry

## Part 1

## Intensity Relations of Electrical Taste

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**Summary**

USING the method of single stimuli, the differential sensitivity of electrical taste was determined in 10 subjects and at three different levels of intensity. An average "just noticeable difference" of 21 per cent., a moderate deviation from Weber's law and considerable individual differences were found. On this background, it is suggested to provide the electro-gustometer with a turn-over switch for easy adjustment at 20 set stimulus intensities, each step representing a 25 per cent. increase of the intensity as measured in $\mu$A.

### Introduction

When a galvanic stimulus is applied to the surface of the tongue, a sour, metallic taste sensation is produced. The mechanism behind this phenomenon is unknown, but Krarup (1958) found a close correlation between the sensitivity to chemical taste solutions and to electrical stimulation. He developed a quantitative method of clinical taste examination, "electro-gustometry", which has several advantages compared with the semi-quantitative chemical methods.

During our clinical work with electro-gustometry, however, we have found that both the apparatus and the procedure could be further improved. In order to provide the theoretical background for these changes of the method, a series of investigations has been carried out.



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In the present study the intensity relations of electrical taste are investigated and a new calibration of the gustometer is suggested.

The physiological effect of galvanic stimulation of the taste receptors depends on the intensity of the current rather than on the voltage. On the other hand, the sensitivity of the taste receptors does not vary linearly with the intensity of the current as measured in $\mu$A. As for other sensory modalities, we would expect the sensitivity to be roughly a linear function of the logarithm of the stimulus magnitude as measured in physical units. Weber (1834) stated this general principle as $\triangle I/I = C$, where I is the intensity of the stimulus, $\Delta I$ the smallest detectable difference or just noticeable difference (jnd) in intensity and C a constant. For most sensory modalities, Weber's law has been found to apply only approximately and within a limited range of intensities, but still it expresses a fundamental feature of sense organ behaviour.

A detailed study of the intensity relations of electrical taste is not available in the literature. Krarup (1958) compared the results of chemical and electrical threshold determinations and proved that ageusia can be demonstrated with the galvanic method. He did not investigate systematically the variation of the sensitivity to electrical stimulation over the total range of intensities.

For chemical taste these problems have been studied by many authors. For a detailed review of the literature see Pfaffmann (1959). Schutz and Pilgrim (1957) determined the differential sensitivity at five levels of intensity in 10 subjects. They found an average $\triangle I/I$ for chemical taste as a whole of 0·20 and the variations over the levels of intensity tested showed only a minor deviation from Weber's law. For the present purpose, however, it is important to emphasize that differences between the four taste qualities were found significant. Thus, $\triangle I/I$ for salt was 0·15; for sweet, 0·17; for sour, 0·25 and for bitter, 0·30. Also, individuals were found to differ widely in their differential sensitivity to the basic tastes within the qualities, and in the order in which they were sensitive to the different qualities.

Krarup (1965) designed his gustometer under the assumption that a complete analogy existed between chemical and electrical taste. In accordance with Weber's law, he provided his gustometer with a logarithmic scale divided into Electric Gust Units (EGU), each unit representing an 11·57 per cent. increase of the stimulus intensity. The size of the unit was based on the average jnd of 0·20 found by Schutz and Pilgrim.

As already mentioned, it is to be expected that electrical taste does follow Weber's law, but this has never been demonstrated. Furthermore, the jnd for the four taste qualities given above vary so much (from 0·15–0·30) that a prediction as to the jnd for electrical taste seems difficult. Consequently, the present study was designed to give the differential sensitivity for electrical taste in a number of subjects and at different



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levels of intensity. In addition, a simple threshold determination was carried out for comparison with the suprathreshold discrimination.

## Method

STIMULUS: As the sense of taste shows considerable adaptation, the method of single stimuli was preferred to the method of constant stimuli. Two electro-gustometers were connected with the same 20 mm.$^2$ silver electrode which was kept in position on the left side of the tongue by means of an acrylic tongue holder (Føns and Osterhammel, 1966). One apparatus was set at the same standard stimulus intensity for one whole session, the other one adjusted at the test stimulus intensity before each application. Standard and test stimuli were both rectangular impulses of 500 msec. duration (Føns and Osterhammel, 1966), and were presented with an interval of 2 sec. Fig. 1 shows a diagram of the unit which was interposed between the manual switch and the electro-gustometers for control of the delay and the stimulus duration.

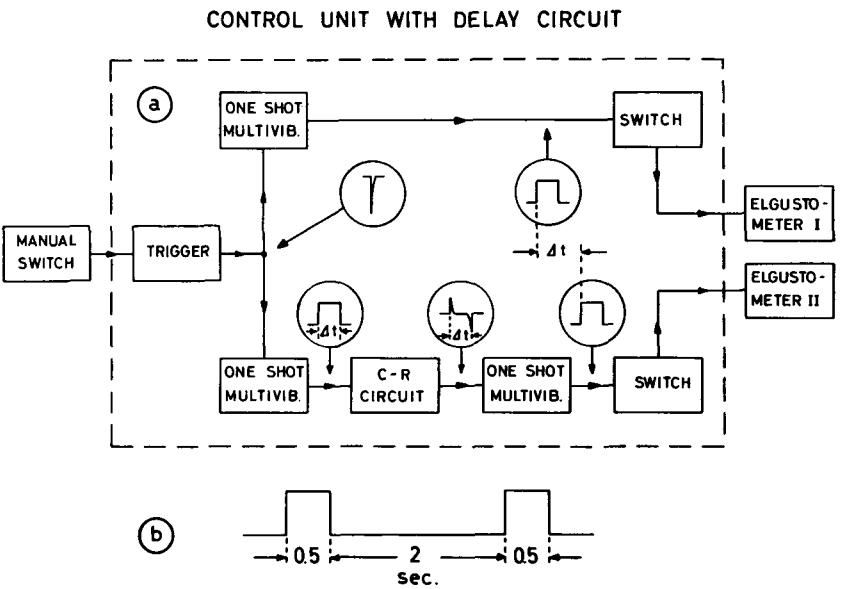



FIG. 1.

*a*. Diagram of the unit which was interposed between the manual switch and the gustometers for control of the stimulus parameters.
*b*. Graphic representation of the stimulus parameters.

SCALING: The range of intensities tested was limited at the upper extreme by the maximum intensity of 300 $\mu$A set by Krarup (1958). The lower limit had to be supraliminal to all subjects tested. The intensity



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range was then divided into logarithmic units, each representing a 20 per cent. increase of the stimulus intensity. The size of this unit was based on preliminary experiments and will be discussed later. The differential sensitivity was determined at three levels of intensities with standard stimuli ($S_o$) at 28, 84 and 208 $\mu$A. Each standard stimulus was compared with two lower and two higher stimulus intensities as shown in Table I. In 20 per cent. of the applications two identical stimuli were presented.

TABLE I.
THE STIMULUS INTENSITIES AT THE THREE DIFFERENT LEVELS.

| Level | $S_{-2}$ | $S_{-1}$ | $S_o$ | $S_{+1}$ | $S_{+2}$ |
|---|---|---|---|---|---|
| I | 19 | 23 | 28 | 33 | 40 |
| II | 58 | 70 | 84 | 101 | 121 |
| III | 145 | 174 | 208 | 250 | 300 |

PROCEDURE: Ten subjects, five male and five female, were each tested in three sessions corresponding to the three levels of intensity. In one session 100 stimulus pairs were presented. According to the forced choice procedure the subject was permitted only two replies, namely, "first one larger" or "second one larger". That is, the subject was not permitted to say that two stimuli were the same, even when they were or seemed to be.

CONTROLS: (1) The stimulus parameters were frequently checked on a direct writing recorder. (2) The influence of expectation was minimized by randomizing the order of stimulus presentations with the following two restrictions. (3) Fatigue was expected to influence the results, as the registration of discrimination data is a monotonous and time-consuming affair, each session lasting from 30–45 minutes. The first 50 of the 100 applications in a session were therefore randomized and then repeated in reverse order. (4) The so-called time order error or time error refers to the fact that the second of two equal stimuli tends to be judged larger than the first. According to Stevens (1957), the time error is small, usually only a fraction of one jnd. In our procedure it was eliminated by presenting $S_o$ first in 50 per cent. of the $S_o/S_x$-combinations. (5) It has already been mentioned that adaptation is rather pronounced in the sense of taste. It was therefore ensured in preliminary experiments that an interval of 2 seconds between two stimuli was long enough for the threshold to be restored. (6) The subjects were not informed whether their judgments were right or wrong, as learning was considered irrelevant in the present connection.



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Discrimination data are usually plotted in a diagram as shown in Fig. 2 (Luce, and Galanter, 1963). The abscissa is here a logarithmic scale, each unit representing a 20 per cent. increase of the stimulus intensity as measured in $\mu$A. The ordinate gives the proportion of times $S_x$ is judged larger than $S_o$. A total of 3,000 paired applications were registered, 1,000 at each of three intensity levels, 300 in each of 10 subjects.

The logarithmic scale permits the calculation of an average curve.

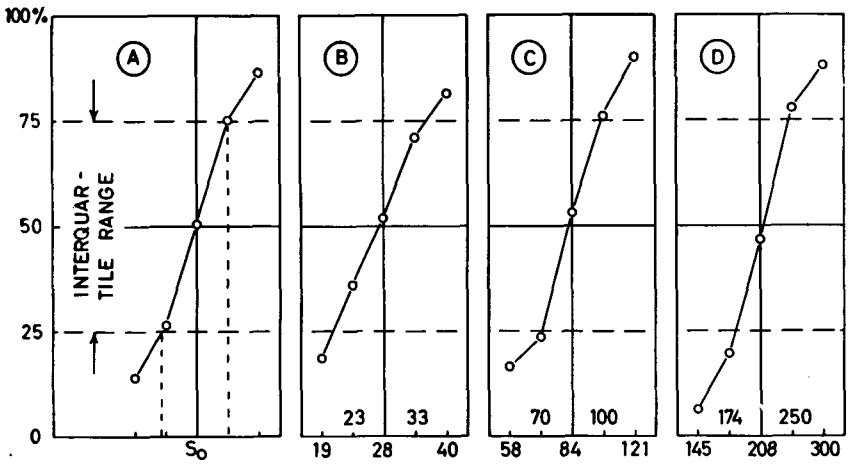



FIG. 2.

*a*. Average curve for the ten subjects and all three levels.
*b, c, d*. Average curves for each level.
Abscissa: Stimulus intensity in $\mu$A.
Ordinate: Proportion of times $S_x$ is judged larger than $S_o$.

The numerical value of the points are given in Table II. The curve has the typical S-shape of a psychometric function. Moving along the abscissa from left to right, we see that if $S_x$ is considerably smaller than $S_o$, it will rarely be judged larger than $S_o$. As the intensity of $S_x$ approaches that of $S_o$, the uncertainty of the judgments increases rapidly. When two identical stimuli are presented ($S_o$=$S_x$), the resulting point on the curve should be very close to the 50 per cent. line. As $S_x$ becomes increasingly larger than $S_o$, the function is repeated in reverse order, making the curve symmetrical around the mid-point. Within a region of 1 jnd above and below $S_o$, the psychometric function is usually very nearly a straight line. In practice a best fitting straight line is either calculated or done graphically by eye. The differential sensitivity is then determined by projecting the part of the straight line between the 25 per cent. and 75 per cent. levels (the interquartile range) on the abscissa, where it



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represents 2 jnd. Half of this value is thus equal to 1 jnd. From the results obtained in the present study, a best fitting straight line was calculated in the following way. As the $S_0$-point was merely a check on the procedure, giving no information about the discrimination ability, the line was in all cases passed through the intersection of the 50 per cent. level and the $S_0$-line. This was justified by the fact that the actual value of the $S_0$-point in the average curve (Fig. 2, *a*) was almost exactly 50 per cent. (50·5 per cent.). The slope of the straight line is a measure of the discrimination and was determined by passing the line through the $S_{-1}$ and $S_{+2}$-points or as close to them as possible. If the two points are not exactly symmetrical, an average of the two values measured as their deviation from the 50 per cent. level can be calculated.

TABLE II.

THE NUMERICAL VALUE OF THE POINTS PLOTTED IN THE AVERAGE CURVE (FIG. 2*a*).

| $S_{-2}$ | $S_{-1}$ | $S_0$ | $S_{+1}$ | $S_{+2}$ |
|---|---|---|---|---|
| 2·8 | 5·3 | 10·1 | 15·0 | 17·3 |

Fig. 2*a*, in which each point represents 600 determinations gives an average jnd of 21 per cent. The very slight asymmetry around the mid-point reflects the deviation from Weber's law which will be more evident if we look at the curves in Fig. 2*b*, *c*, *d*. The better the discrimination, the farther away all points other than $S_0$ will be from the 50 per cent. level. Our results demonstrate clearly that the discrimination is better at high intensities than at low intensities. At the three levels of intensity tested the jnd's were 27, 19 and 17 per cent. respectively.

It may be argued that the stimulus intensities within each level should have been closer to each other as only the points falling within the interquartile range are used for the calculation of the jnd. The answer to this is that all the subjects found the discrimination very difficult and felt that they were guessing rather than judging most of the time. The regular shape of the resulting curves came as a surprise to them. If a procedure had been chosen which made the judgments more difficult, the subjects would no doubt have been discouraged, and their cooperation less satisfactory. Furthermore, the points outside the interquartile range serve to demonstrate the S-shape of the curve and their distance from the 50 per cent. level give some information about the discrimination.

If we turn to the individual differences in discrimination ability, we find them rather pronounced. Fig. 3 gives a bar graph of the results in per cent. The jnd-values vary from 14 to 31 per cent. Fig. 3 includes



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the absolute thresholds determined with Krarup's method. A correlation between discrimination and threshold level is evident, but by no means very close.

The influence of adaptation and time error seems to have been eliminated. Of the 3,000 stimulus pairs presented, the second stimulus was judged larger in 1,492 cases.

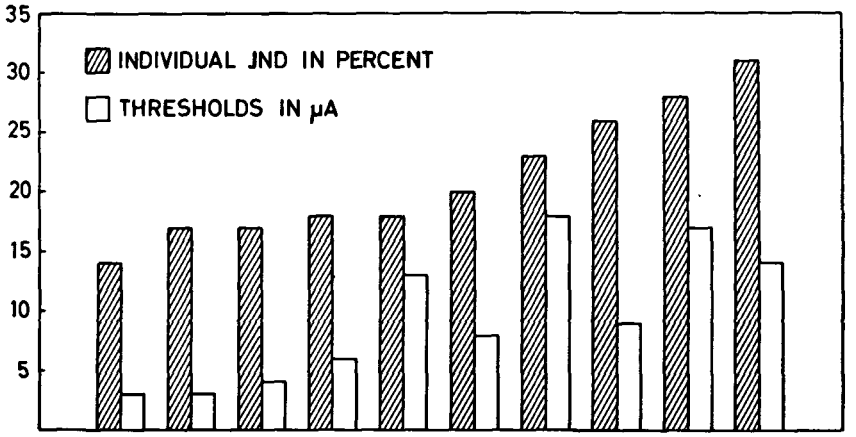



FIG. 3.
Bar graph of individual jnd's and thresholds.

## Comments

An average jnd of 21 per cent., considerable individual differences and a moderate deviation from Weber's law are, in short, the results of the present study. This could hardly have been in better accordance with the findings of Schutz and Pilgrim, who arrived at an average jnd of 20 per cent. The deviation from Weber's law is similar to what is found in other sensory modalities, e.g. hearing.

A comparison of the range of intensities tested by Schutz and Pilgrim and the one covered by our investigations (Fig. 4) discloses a remarkable difference. Schutz and Pilgrim determined the differential sensitivity at five levels of intensity, evenly distributed between the absolute threshold and a maximum intensity characterized as being "subjectively very strong". The strongest sodium chloride test solution was more than a hundred times stronger than the threshold concentration and the whole range covers about 24 average jnd's of 20 per cent. Our study covers a range of intensities from 19 $\mu$A which is just over the average threshold, up to 300 $\mu$A, a fifteen times increase in intensity or a total of fifteen 20 per cent. units. This discrepancy is connected with important differences between the two methods and between the purposes of the



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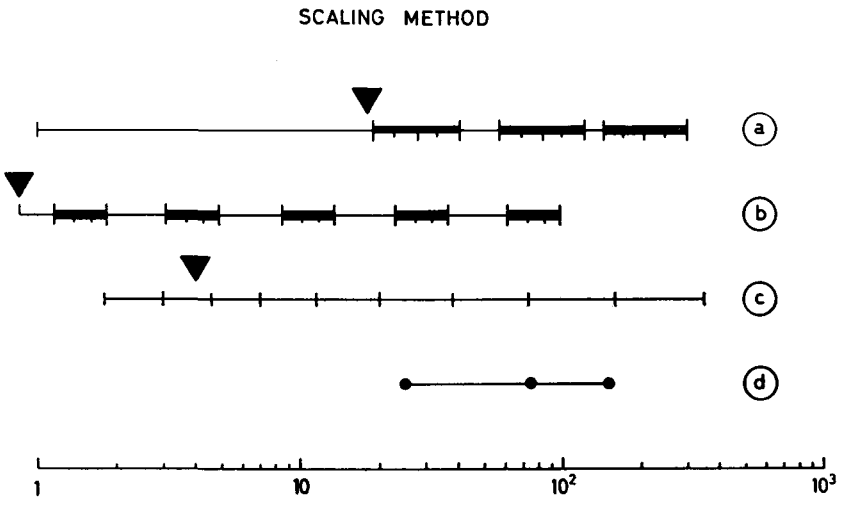



FIG. 4.
*a*. Test levels in the present study (μA).
*b*. Schutz and Pilgrim's test levels for NaCl (g% × 10).
*c*. Hinchcliffe's test solutions for NaCl (g% × 10).
*d*. Börnstein's test solutions for NaCl (g% × 10).

two studies. Schutz and Pilgrim gave the subjects 6 c.c. samples of the test solution to swirl around in their mouths, thereby stimulating the whole area of taste reception. This method imitates the physiological way of taste stimulation and the results apply to physiological conditions. In contrast, clinical taste examinations serve the purpose of testing the function of the nervous pathways involved in taste. It is therefore necessary to ensure selective stimulation of a minor tongue area, e.g. the chorda tympani area on one side. In a previous publication (Føns and Osterhammel, 1966), it was pointed out that the taste threshold improves as the size of the stimulated area is increased. Hinchcliffe (1958) designed a chemical method of clinical taste examination which is more similar to electro-gustometry. He used a "dropper-method", i.e. a few drops of a taste solution were applied to a certain tongue area. With this method he found an absolute threshold for sodium chloride of 0·4 per cent., while Schutz and Pilgrim with their "swirling method" arrived at a threshold of 0·089 per cent. As demonstrated in Fig. 4, this difference in the size of the stimulated tongue areas undoubtedly accounts for the extension of Schutz and Pilgrim's range towards the low intensities. Fig. 4 also gives the concentrations of the three test solutions used by Börnstein (1940).

The calibration of the electro-gustometer has to be designed in accordance with the intensitive relations of electrical taste as outlined



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above. Krarup's Electric Gust Unit followed Weber's law, but was met with the objection that the introduction of a new unit should be avoided, unless it was very well justified and gained universal acceptance, such as the decibel unit used in audiometry. Consequently, the gustometer used for our investigations was calibrated in $\mu$A and can be adjusted at any intensity between 0–300 $\mu$A. Our experience with this gustometer, however, has made it quite clear that a simple $\mu$A-calibration is not satisfactory for clinical use. The examiner, when moving step-wise up and down the scale, decides the absolute size of the steps as well as their variation over the different levels of intensity. If he makes the steps too small, he creates a false pretence of accuracy and makes the procedure unnecessarily complicated. On the other hand, very large steps will make the threshold determination inaccurate. If the size of the steps is not varied according to the sensitivity variation over the different levels of intensity, the procedure will be unphysiological. Under clinical circumstances, it is virtually impossible to avoid all these sources of errors.

The design of the modern audiometer suggests a simple solution of the problem. If the potentiometer is replaced by a turn-over switch, a simple and physiologically correct adjustment at a limited number of stimulus intensities can be ensured, and the $\mu$A-scale be maintained. As our results showed only a moderate deviation from Weber's law, it was decided to use a calibration in logarithmic units.

The choice of a logarithmic scale, however, does not indicate what size the unit should be. The question is, how accurately the threshold can be determined. Threshold sensitivity and differential sensitivity differ in that one concerns recognition, the other discrimination, but both depend on the same psychophysical process. The threshold is not represented by a well-defined stimulus intensity, but by an S-shaped psychometric function as for discrimination. The differential sensitivity at the threshold is usually smaller than the suprathreshold sensitivity. Furthermore, the jnd's found in the present study showed considerable individual differences. With this background, it did not seem reasonable to take the average differential sensitivity as more than a rough indication of what size the unit should be.

The electro-gustometer is meant for clinical threshold determinations in normal and pathological cases. Krarup (1958) found the individual thresholds spread over such a wide range of intensities, that no definite limit could be set between normal and pathological thresholds. On the other hand, there was a close correlation between the thresholds on the two sides. He stated that 99 per cent. of normal individuals have a difference between the sides of 2 EGU (=25 per cent.) or less.

Consequently, we have decided to calibrate the gustometer in 25 per cent. units as shown in Table III. If the threshold determination is carried out by means of a number of stimulus applications around the



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threshold level, this calibration should permit the designation of one particular adjustment as the threshold intensity, even in individuals with rather poor discrimination. It is also possible to conclude, that a threshold difference of more than one unit is, with a high degree of certainty, pathological.

TABLE III.
THE SUGGESTED CALIBRATION OF THE ELECTRO-GUSTOMETER.

| | μA | | μA |
|---|---|---|---|
| 1 | 4·3 | 11 | 40·3 |
| 2 | 5·4 | 12 | 50·3 |
| 3 | 6·8 | 13 | 62·9 |
| 4 | 8·5 | 14 | 78·7 |
| 5 | 10·6 | 15 | 98·3 |
| 6 | 13·2 | 16 | 122·9 |
| 7 | 16·5 | 17 | 153·6 |
| 8 | 20·6 | 18 | 192·0 |
| 9 | 25·8 | 19 | 240·0 |
| 10 | 32·2 | 20 | 300·0 |

## Conclusions

(1) With the procedure employed in the present study, an average jnd for electrical taste of 21 per cent. has been found.

(2) In 10 subjects the individual differences in jnd were found to be considerable.

(3) Over the levels of intensities used for electro-gustometry, only a moderate deviation from Weber's law has been found.

(4) It is suggested to provide the electro-gustometer with a turn-over switch and a limited number of set adjustments. The scale should be logarithmic, each unit representing a 25 per cent. increase in intensity.

## REFERENCES

BÖRNSTEIN, W. S. (1940) *Yale J. Biol. Med.*, **13**, 133.
FØNS, M., and OSTERHAMMEL, P. A. (1966) *Arch. Otolaryng.*, **83**, 538.
HINCHCLIFFE, R. (1958) *Acta oto-laryng.* (*Stockh.*), **49**, 453.
KRARUP, B. (1958) *Acta oto-laryng.* (*Stockh.*), **49**, 294.
——— (1965) *Kliniske smagsundersøgelser*, ed.: Store Nordiske Videnskabsboghandel, Copenhagan, thesis.
LUCE, R. D., and GALANTER, E. (1963) "Discrimination" in *Handbook of Physiology*, Sect. I: Neurophysiology, edit. by J. Field, H. W. Magoun and V. E. Hall, Washington, Vol. I, p. 507.
PFAFFMANN, C. (1959) "The Sense of Taste" in American Physiological Society, *Handbook of Mathematical Psychology*, ed.: Luce, Bush and Galanter, New York and London.



https://doi.org/10.1017/S0022215100068547 Published online by Cambridge University Press

SCHUTZ, H. G., and PILGRIM, F. J. (1957) *J. exp. Psychol.*, **54**, 41.
STEVENS, S. S. (1957) *Psychol. Rev.*, **64**, 153.
WEBER, H. E. (1834) quoted in Ruch, T. C.: "Somatic Sensation" in *Neurophysiology*, edit. by Ruch, Patton, Woodbury and Towe, Philadelphia and London 1961.

# Part 2

# The Stimulus Duration

## Summary

THE electrical method of taste examination has provided the clinician with a valuable tool in cranial nerve diagnostics. It has practical and theoretical advantages that make it superior to the semiquantitative chemical methods of taste examination. Although it has been used in the clinic for some years, a number of methodological problems remain to be solved before a complete standardization is possible.

The present study is concerned with the importance of the stimulus duration. In three subjects a complete intensity-duration curve was registered and the utilization time was found to be approximately 400 milliseconds. If the stimulus duration is either too short or too long, the threshold level will rise. Consequently, it is suggested that the manual control of the stimulus duration should be replaced by an automatic control unit, which ensures a set stimulus duration of 500 milliseconds.

## Introduction

The galvanic method of taste examination has provided the clinician with a valuable tool in cranial nerve diagnostics. As the method was first developed in this department (Krarup, 1958) it has been a natural object for us to continue the investigation of a number of theoretical and practical aspects of electrical taste.

In a previous study the intensity relations of electrical taste were evaluated and a new calibration of the electro-gustometer was suggested. It was demonstrated that this change of the apparatus ensured a physiologically correct and greatly simplified procedure.

The purpose of the present study is a similar improvement of another methodological detail concerning the duration and application of the stimulating impulse.

Until recently we have used the gustometer and procedure described by Krarup. The threshold is determined by a series of stimulations with both descending and ascending intensities. The current is turned on by a manually operated switch before the electrode is applied to the tongue surface. The stimulus is interrupted after 1–1·5 sec. by removing the electrode from the tongue.



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According to our experience a number of disadvantages are connected with this manual control of the impulse duration. Even after a long period of practice it is difficult to estimate the impulse duration with sufficient accuracy. This was shown in a preliminary experiment in which a few subjects were instructed to press the manual switch of the gustometer for 1–1·5 seconds. Graphical recording of the resulting pulse duration showed great accuracy as long as the subjects were practising with a stop-watch in front of them. When the watch was removed, the estimated stimulus duration showed considerable variation. The influence which this may have on the threshold determination will be discussed later.

The manual adjustment of the stimulus duration has some practical aspects too. As a routine method of clinical taste examination, electrogustometry should be a simple procedure which can be adopted by the whole medical staff after brief instruction. An automatic control of the stimulus duration would simplify the procedure and bring it closer to this ideal.

The duration of the stimulating impulse must be long enough to give the lowest possible threshold. Bujas (1936) tried to evaluate the relation between the intensity and the duration of the galvanic impulse by balancing two stimuli to the same subjective intensity. One of the stimuli was of a constant "long" (2·5 sec.) duration and a variable intensity, the other one of a constant intensity and a variable shorter duration. He found that the threshold of electrical taste was "built up" in approximately 1·5 sec. and that a longer duration did not lower the threshold any further. Krarup (1965) referred to Bujas' findings and added a simple experiment. In two subjects thresholds were determined using impulse durations of approximately 3/4 and 2 sec. As the same thresholds were obtained with the two different pulse durations, Krarup chose 1–1·5 sec. as the approximate stimulus duration for his procedure of clinical taste examination.

A complete registration of the intensity-duration curve for electric taste would provide a more satisfactory background for the choice of a set impulse duration. Dzendolet (1957) registered the intensity duration curve using a small reversible Ag-AgCl-Cl'-electrode on the tongue and single rectangular waves as stimuli. He found that the threshold reached a constant level in 100 msec. Unfortunately, this special reversible electrode is so different from Krarup's that we cannot be sure that the same intensity-duration curve applies to both of them. Consequently, we decided to register this curve using the circular steel electrode designed by Krarup.

## Method

Three subjects who had already some experience with taste examinations were chosen for the experiment. They had taste thresholds at



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slightly different levels, but all within the normal range of intensities. Each subject went through six sessions with at least 1 day's interval. In one session a complete intensity-duration curve was registered. Using single square wave impulses as stimuli, threshold determinations were carried out at 10 different impulse durations. At the lowest stimulus durations where the curve takes a steep course the measuring points on the abscissa were distributed at narrow intervals. The procedure was the same as Krarup's with the exception that the electrode was applied to the tongue before the current was turned on.

Only a minor change of the original gustometer was necessary in order to produce square wave impulses of variable durations. Fig. 1 shows a diagram of the unit which was interposed between the manual switch and the gustometer.

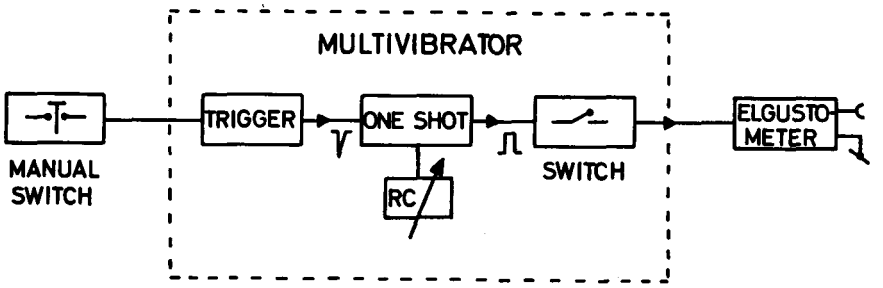



FIG. 1.

This automatic control unit was interposed between the manual switch and the gustometer.

## Results

All thresholds were registered in microamperes, converted to Electric Gust Units for calculation of mean thresholds and reconverted to microamperes. Table I gives the mean thresholds in microamperes as well as EGU for the three subjects measured at 10 different stimulus durations. A graphic representation of the results is given in Fig. 2. The three intensity-duration curves are almost identical in shape. With decreasing stimulus duration the thresholds begin to rise slowly at 500–400 microamperes, taking a steeper course at durations shorter than 150 msec. The shortest stimulus duration that gives the lowest possible threshold, generally called the utilization time, is approximately 400 msec.

## Comments

The results of the present investigation is a utilization time which is slightly longer than the one found by Dzendolet (100 msec.) but much shorter than indicated by Bujas (1·5 sec.).



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TABLE I.

MEAN THRESHOLDS FOR EACH SUBJECT MEASURED AT TEN DIFFERENT STIMULUS DURATIONS.

| Stimulus Duration | Subject I | | Subject II | | Subject III | |
|---|---|---|---|---|---|---|
| | μA | EGU | μA | EGU | μA | EGU |
| 2 | 90 | 29 | 90 | 29 | 115 | 31 |
| 6 | 65 | 26 | 65 | 26 | 80 | 28 |
| 10 | 38 | 21 | 35 | 20 | 57 | 25 |
| 13 | 23 | 16 | 26 | 17 | 52 | 24 |
| 18 | 12 | 10 | 16 | 13 | 40 | 22 |
| 46 | 7 | 6 | 12 | 10 | 30 | 19 |
| 84 | 6·5 | 5 | 8 | 7 | 18 | 14 |
| 160 | 4·4 | 1·5 | 7 | 6 | 12 | 10 |
| 456 | 4·4 | 1·5 | 6·5 | 5 | 9 | 8 |
| 995 | 4·4 | 1·5 | 6·5 | 5 | 9 | 8 |

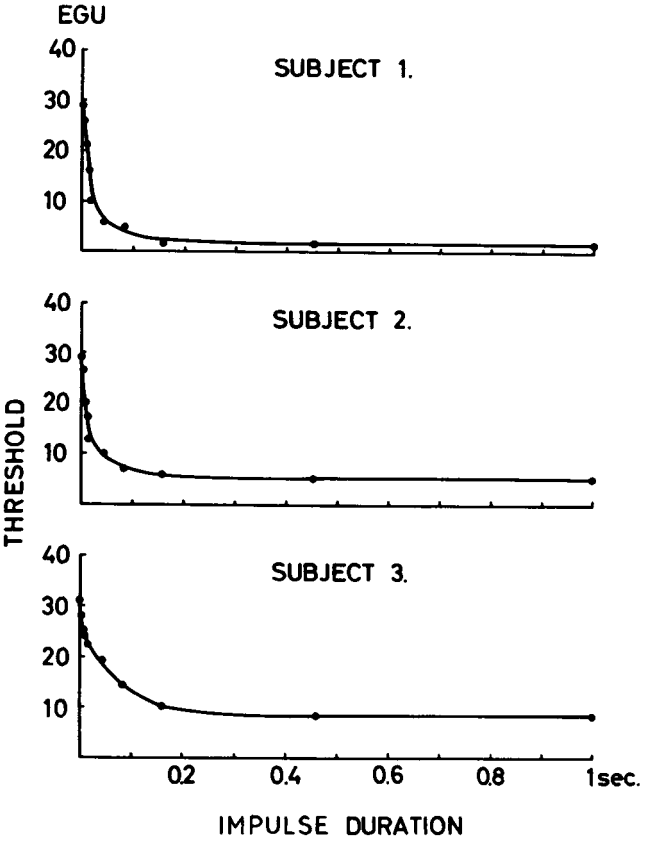



FIG. 2.

Intensity-duration curves for three normal subjects. Each point represents the mean value of six threshold determinations.

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In view of this we can now consider the risk of threshold shifts due to variable stimulus durations. If the examiner is instructed to stimulate for 1–1·5 sec., he will have to make a rather substantial misjudgment in order to get below the 400 msec. We have found this risk to be small but still not negligible.

A very long stimulus duration might not be expected to influence the threshold level at all. At high intensities, however, long lasting stimulation can cause a pronounced adaptation which may last longer than the usual interval between the applications.

Based on the results of the present study we have chosen a set stimulus duration of 500 msec. The automatic control of the stimulus duration is obtained by building the unit shown in Fig. 1 into the gustometer. By analogy with the modern audiometer the gustometer should also be fitted with an indicator visualizing the application of the stimulating impulse.

The introduction of an automatically controlled impulse duration interferes with the procedure of the threshold determination. In contrast to Krarup's procedure it will be necessary to apply the electrode to the tongue before the current is turned on. Far from being a disadvantage this seems to mean a further improvement of the method. In a previous publication on electro-gustometry (Føns and Osterhammel, 1966) it was mentioned that the intermittent application of the tongue electrode elicits a disturbing tactile sensation simultaneously with the taste sensation. If the current is turned on before the electrode is applied, even experienced subjects find it difficult to distinguish between taste and tactile sensation, especially at intensities close to the threshold. The tactile sensation elicited by the application of the electrode has two phases. As the electrode is brought into contact with the tongue surface a strong initial sensation is evoked. When kept in position by a light pressure, a weak continuous sensation follows. The suggested change of the procedure means that the electric taste stimulus is applied during the second phase of the tactile stimulation. This should make it easier to distinguish between taste and tactile sensation and a better defined threshold should be obtained. The threshold level is not affected by this difference in procedure (Føns and Osterhammel, 1966).

## Conclusions

1. The electrical method of taste examination as described by Krarup should be improved with an automatic control of the stimulus duration.

2. The choice of a set stimulus duration should be based on a complete registration of the intensity-duration curve for electrical taste.



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3. It is advocated that the gustometer should be fitted with an automatic control unit which ensures a set impulse duration of 500 msec.

4. The taste sensation is more easily distinguishable from the tactile sensation when the electrode is applied to the tongue before the current is turned on.

## REFERENCES

BUJAS, Z. (1936) *C.R. Soc. Biol.* (*Paris*), **122**, 1260.

DZENDOLET, E. (1957) *Intensity-duration relation for taste using electrical stimulation.* Thesis of Brown University.

FØNS, M., and OSTERHAMMEL, P. A. (1966) *Arch. Otolaryng.*, **83**, 538.

———, ——— (1966) Submitted for publication in *Journal of Laryng. and Otolog.*

KRARUP, B. (1958) Electro-gustometry: A method for clinical taste examinations. *Acta oto-laryng.* (*Stockh.*), **49**, 294.

——— (1965) *Kliniske smagsundersøgelser*, edited by Store Nordiske Videnskabsboghandel, Copenhagen, thesis.

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