EFFECT OF SUBTHRESHOLD OLFACTORY STIMULI ON THE SENSITIVY OF THE SENSE OF SMELL IN NORMAL AND PATHOLOGICAL CONDITIONS

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The present work consists of a study of the effect of subthreshold olfactory stimuli on the sensitivity to smell in healthy and sick persons, and includes a comparative study of adaptation to smell.

METHOD

The olfactometers used(O-3, O-4, and O-5) in these investigations of the olfactory analyzer and of human higher nervous activity allowed an accurate dosage of odorous substances to be introduced into a stream of air, at concentrations ranging from subthreshold upwards.

The olfactory threshold was measured in two ways [1, 2, 3]. In the first method, after acquainting the subject with the smell, the olfactory stimulator was connected to the air stream until the smell was appreciated (not more than 20 seconds elapsed), after which there was an interval of 1-1½ minutes.

The concentration of the odorous substance was gradually reduced so that, after an interval, a weaker olfactory stimulus was used. The lowest concentration of the substance which could be perceived was taken as representing the threshold of smell.

The difference in the second method was that, starting from a subthreshold value, the concentration of the substance was gradually and continuously increased every 5 seconds, until the smell was perceived. In order to obtain a precise determination of the olfactory threshold, this procedure was repeated with a slower rate of increase in concentration.

At the beginning of the experiment, we used another method, since it allowed the threshold to be determined considerably more rapidly. However, in some subjects, it was not possible to determine the sensitivity, since with repeated determinations of threshold, very considerable fluctuations in sensitivity occurred. A further, more detailed, study of subjects showing this peculiarity of the olfactory analyzer was carried out.

It was found that determination of the threshold by the first method gives more accurate results than does the second method, where considerable variations in the threshold were found.

In these subjects, a study was made of the sense of smell by both the first and the second methods, and the rate of increase of concentration of the odorous substance in the air stream was taken into account.

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RESULTS

An analysis of the results of the investigation using the second method showed that the sensitivity of the sense of smell is greater when the concentration of the odorous substance in the air stream is increased more rapidly (0.03-0.05 mm every 5 seconds). With a slow rate of increase of concentration of the odorous substance in the air stream (0.01 mm every 5-10 seconds), the sensitivity was considerably reduced, i.e., the onset of sensation occurs only at quite a strong smell level, and sometimes there is a complete fatigue of the sense of smell.

When the strength of the olfactory stimulus is increased rapidly (0.05 mm in 5 seconds), the effect of the subthreshold stimulus is not maintained for more than 15-20 seconds. With a slow increase of concentration (0.01 mm in 5-10 seconds) the subthreshold olfactory stimulus acts on the olfactory receptor for a longer time, and may continue to do so for several minutes.

Thus, for example, in experiment No. 36, an increase in the concentration of camphor of 0.01 mm every 5 seconds corresponds to an olfactory threshold of 2.95 mm, which corresponds to a strong stimulus such as is found in cases of definite hyposmia.

TABLE 1

Results of Experiment No. 152; Subject F.N.; Peppermint Oil Used as Odorous Substance

Methods of determining threshold	Second	Second	First	First	First	Second
Time of the change in strength of the smell	5 seconds 0.02 mm	5 seconds 0.01 mm				5 seconds 0.01 mm
Smell threshold (in mm)	2.65	2.68	2.65	2.64	2.63	2.68

TABLE 2

Results of Experiment No. 160; Subject T.A.; Camphor Used as Odorous Substance

Methods of determining threshold	Second	Second	Second	First	First
Time of the change in strength of the smell	5 seconds 0.02 mm	5 seconds 0.02 mm	10 seconds 0.01 mm		
Smell threshold (in mm)	2.75	2.72	2.87	2.75 –	2.80+

The second determination of the threshold was carried out with a rapid increase in the strength of the stimulus (0.05 mm in 5 seconds), and the smell was perceived at 2.70 mm, which represented a normal sensitivity.

With a subsequent slow increase in the strength of the odor (0.02 in 5 seconds), a reduction in olfactory sensitivity was once more observed.

Consequently, when the strength of the stimulus is increased slowly from a subthreshold level, if the action of the subthreshold stimulus is continued for some time, there may be a reduction in smell sensitivity. Such a reduction may be called subthreshold inhibition.

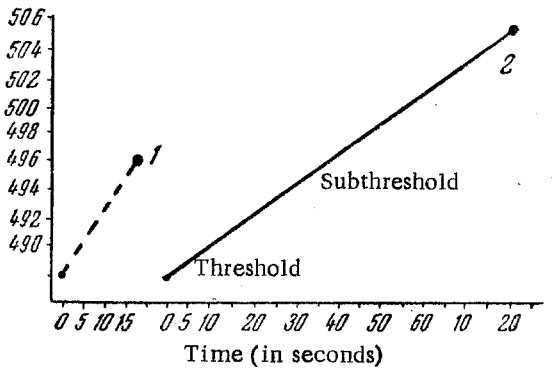

Fig. Change in olfactory threshold in an influenza patient for different rates of increase of the concentration of the odorous substance (explanation in text).

Subthreshold inhibition is found when the thresholds on the right and left halves of the nose are determined separately (Experiment No. 36).

Determination of the olfactory threshold using the first and second methods was carried out using peppermint oil (Experiment No. 152) and camphor (Experiment No. 160).

From the results obtained in experiment No. 152, it can be seen that with a slow rate of increase of concentration of the odorous substance (0.01 mm per 5 seconds), the sensitivity was reduced, and corresponded to a micrometer scale reading of 2.68 mm, while when the threshold was determined by the first method, where the concentration was increased rapidly (0.02 mm per 5 seconds), the sensitivity was high and equal to 2.65 mm.

In the third, fourth, and fifth determination of the threshold, the first method of investigation was used, and the sensitivity was found to be quite high – 2.63 mm. But in the sixth determination of the threshold by the method giving a slow increase in strength and a longer action of the subthreshold stimulus, a reduction in sensitivity down to 2.68 mm was observed.

In experiment No. 160, the gradual increase in the concentration of the odorous substance in the air stream (0.01 mm in 10 seconds) caused a marked reduction in the olfactory sensitivity, after which, as a result of adaptation brought about through the action of the subthreshold stimulus, the sensitivity remained depressed for several minutes. In some subjects this phenomenon is well shown (experiment No. 160) while in others it is less marked (experiment No. 152).

Later tests showed that people in whom this phenomenon is well developed are those with the less excitable type of nervous system.

Means were not available for determining human higher nervous activity types (temperaments), so we have had to confine ourselves to describing the inhibitory influence of subthreshold olfactory stimuli on sensitivity to smells in people with the less excitable type of nervous system.

In many tests, carried out on more than 150 persons, it was shown that the inhibitory effect of subthreshold olfactory stimuli occurred in approximately 10% of those tested.

This fact must be taken into consideration in any clinical diagnostic test.

It is thought that investigations of the sense of smell, in which the effects of subthreshold stimuli are studied, may yield results of diagnostic importance in various diseases.

The case of poisoning through the slow absorption of toxic gaseous substances from the air, which may be present at first in subthreshold concentrations, may possibly be explained in terms of the inhibitory effect of subthreshold stimuli.

In investigating olfaction in patients with influenza and severe catarrh, using an O-4 olfactometer, changes in sensitivity, as well as adaptation and subthreshold inhibition were demonstrated. Subthreshold inhibition was found both in influenza patients and in those with severe catarrh.

The figure shows a graph of the smell threshold in an influenza patient for different rates of increase of the olfactory stimulus. With rapid increase in the concentration, the threshold (1) is normal. The appreciation of the odor is indicated by a black dot (4.96). In the second determination of the threshold (2), when the strength of the smell was increased gradually, the sensitivity was reduced, the threshold value being 5.06, and this was the result of the inhibitory influence of the subthreshold stimulus; the normal individual variation was from 4.90 to 4.98 scale readings.

The results of these investigations showed that subthreshold inhibition is encountered somewhat more frequently in influenza patients than in those with severe catarrh, and also that it is found in almost 50% of the patients.

Thus, in influenza and in severe catarrh of the upper respiratory passages, subthreshold inhibition is found to occur much more often than in healthy individuals, and this evidently shows how commonly this condition occurs in these two illnesses.

In influenza and in severe catarrh of the upper respiratory passages, a rapid adaptation of the sense of smell is observed, and this is shown sometimes in the complete inability to appreciate the scent of peppermint oil after only 15-30 seconds of continuous inhalation (more often, after 1-1½ minutes), while in healthy subjects, fatigue of the sense of smell for this substance occurs, on average, after 4-6 minutes.

Since in influenza, subthreshold inhibition, as determined by the second method, is found in 50% of the cases, further investigation of olfactory sensitivity was made by a combination of the first and the second methods. At first, an approximate determination was made using the second method, and this was further refined by the first.

In carrying out olfactory tests with accurate olfactometers, subthreshold olfactory stimuli will inevitably be encountered, and it is therefore necessary to take into account the possibility of subthreshold inhibition occurring.

The results on subthreshold inhibition reported here constitute one of the proofs of the physiological effect of subthreshold olfactory stimuli.

SUMMARY

The author designed an olfactometer which enabled him to demonstrate that, in 10% of healthy persons, the olfactory sensitivity is considerably diminished under the effect of a subliminal olfactory stimulus. This phenomenon is considered to be due to the summation of the subliminal olfactory stimulation and is called "subliminal inhibition". The latter is observed in 50% of patients suffering from influenza or acute upper respiratory catarrh.

The possibility that subliminal inhibition may occur should be taken into consideration when carrying out investigations on the sense of smell.

LITERATURE CITED

[1] R.Z. Amirov, Byull. éksptl. biol. i med., 1953, volume 36, No. 8, issue 2, pp. 76-78.

[2] R.Z. Amirov, Trudy nauchno-issled. in-ta ukha, gorla i nosa. Moscow, 1954, issue 4, pp. 127-128.

[3] R.Z. Amirov, Trudy nauchno-issled. in-ta ukha, gorla i nosa. Moscow, 1956, pp. 135-146.