Typical results of computer-olfactometry

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SUMMARY

After pulsed peripheral olfactory impulses it is possible, under suitable testing conditions, for specific sensory potentials to be read from the surface of the skull and, after repetitions, added up (olfactorially evoked cortical potentials). Typically, there developes a so-called twin-potential containing the equivalents of the electrical activities of the nervus trigeminus and the nervus olfactorius in two peaks of the cortex equivalents. In an objective manner, in other words without intentional or vegetative influence by the test person, it is possible by the weakening or lack of one or the other or both part-potentials to obtain information about the functioning of the olfactory sense. Typical clinical examples will be presented.

FINKENZELLER, in 1966, was the first to describe the possibility of registering olfactorially evoked cortical potentials. After supraliminal pulsed olfactory stimuli he registered evoked potentials with a latency period to the given stimulus of about 500 msec.

Subsequently, reports were published by Allison and Goff (1967) as well as by Smith (1971) and his associates and also by Giesen (1970) and Alber (1972) of the Berliner Klinik am Westend and, most recently, by Gerull (1975) and associates of this group. These reports essentially confirm the original findings.

As a fundamental result of our own research, we were able, in 1972, to describe for the first time a so-called cortical twin potential in which cortical impulse potentials by the nervus trigeminus and simultaneously the nervus olfactorius are in evidence, with average latency periods in relation to the given stimulus of 250 or 500 msecs. respectively (Figure 1). This was the first time that the long-suspected duality of an olfactory impression consisting of a sensory and also perhaps mechano and/or chemo-sensory component was objectivised. (Herberhold, 1972).

We have so far prepared more than 300 computer-olfactograms for the diagnosis and evaluation of olfactory disturbances. The measuring process requires essentially the same apparatus as has been known in the field of electric response audiometry (ERA). Specifically speaking, however, the impulsecreating apparatus

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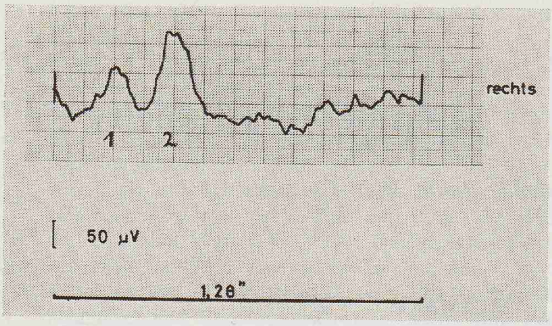


Figure 1. Normal appearance of a computer-olfactogram (cortical sum potential after 16 individual impulses of 150 msec each, Eucalyptol).
Peak 1 corresponds to cortical trigeminus, peak 2 to olfactorius activity. (Record No. CO 231).

is subject to special requirements since only olfactory impulses with rectangular characteristics are in a position to evoke cortical potentials in the desired character. In its time limits, the olfactory impulse should be clearly contrasted to the pre- and post-stimulatory atmosphere and should, in addition, be measurable quantatively and chronometrically. As a rule, we work with 16 individual impulses from a concentrated eucalyptol-gas phase lasting about 150 msecs. and containing on an average 7 x 10^{16} molecules per ml. In order to prevent adaptation effects, the impulses are added automatically and at stochastic intervals at the beginning of each inhalation phase. The appliance technology and details of the measured process have been described in detail elsewhere (Herberhold, 1973 and 1975). Some examples should serve to explain the clinical application of the process. It must be pointed out in this connection that especially a possible disassociated character of the two post-stimulatory evoked peaks provide diagnostic and also localising indications as to the nature of the sensory disturbance.

1. Traumata

Olfactory disturbances occur in about 10% of head-traumatised patients, whereby in 5 to 7% concussions show hyposmia; contusions develop anosmia in 15 to 20% of the cases. The centre of these disturbances must be sought around the

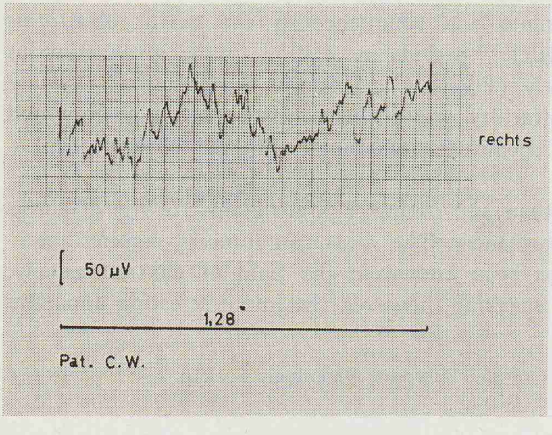


Figure 2. Condition after brainstem trauma. Computer-olfactogram 10 months after accident (Record No. CO 247). Appearance of an olfactorius peak with maximum in typical position (arrow), but heavily broadened potential-basis compared with norm. A trigeminus-related potential does not show; from [8].

third ventricle and they usually appear in conjunction with other neurological defects. Extreme cases lead to an anosmia-ageusia syndrome with additional failure of the oral-nasal trigeminus. Potential formations do not occur in the computer-olfactogram.

Brain stem contusions provide similar symptoms.

Subjectively, the patient complains about hyposmia. The computer-olfactogram shows a widened, slow-moving olfactorious oscillation (Figure 2).

In the case of mid-face injuries without major cerebral involvement, it is possible for respiratory olfactory disturbances to occur. On the other hand, isolated olfactorious failure is possible as a result of damage to the fila (Figures 3a and b). Subsequent subarachnoidal haemorrhage can also be marked by failure of the trigeminus olfactory system (Figure 4).

Aggravation and simulation must be excluded in evaluating such damage which,

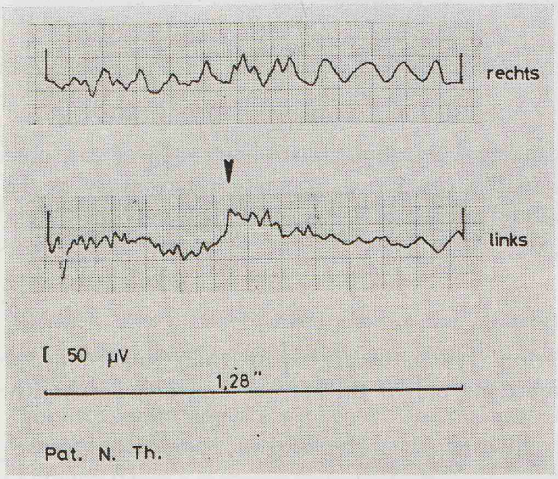
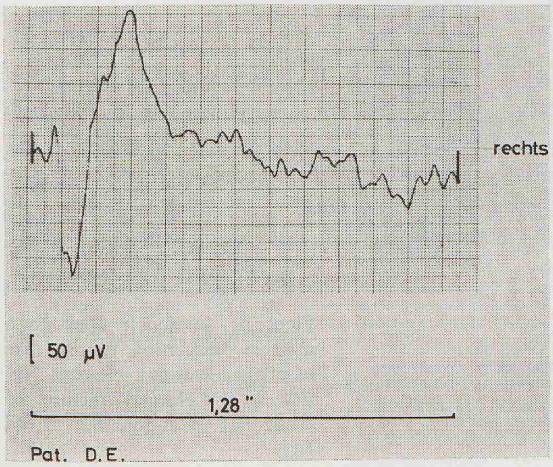


Figure 3. a) Condition after severe mid-face injury two years previously. Rhinoscopy: distinctive intra-nasal scars and lesions, heavy septum-deviation. In the computer-olfactogram (Record No. CO 232) lack of trigeminus activity on both sides; mere indication of (arrow) cortical activity of nervus olfactorius; from [8].



b) Frontal skull trauma. In the computer-olfactogram (Record No. CO 230) isolated failure of olfactorius activity (damage to fila olfactoria); from [8].

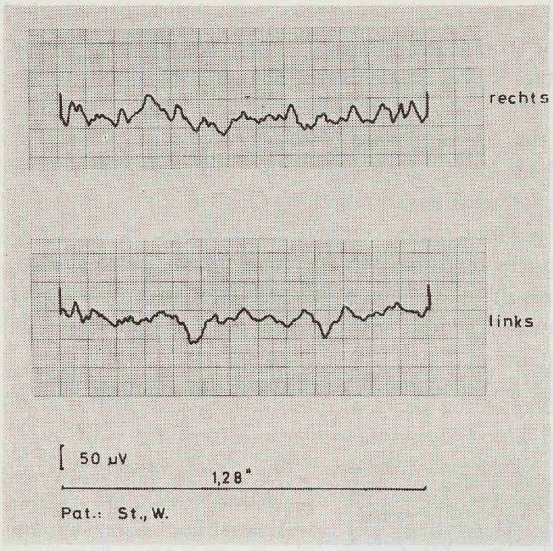


Figure 4. Condition after subarachnoidal haemorrhage. In computer-olfactogram (Record No. CO 298) complete olfactorial twin-potential fails to materialise.

according to our experience today, must be estimated at about 30% of ear, nose and throat medical evaluations. In this connection, computer-olfactometry as the so far only objective testing method of the olfactory sense helps to shed light on the case.

2. *Tumors*

Direct impairment of the olfactory system occurs, apart from tumor-induced impairments of the respiratory functions, only if the nervous structures are directly

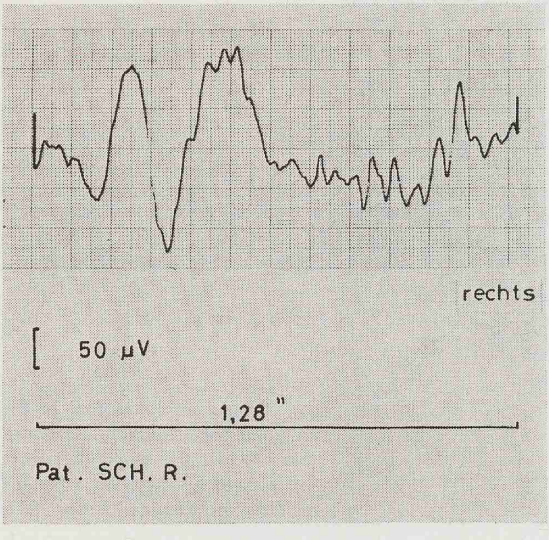


Figure 5. Computer-olfactogram used as simulation test in case of alleged anosmia (Record No. CO 227). Normal picture of olfactorial twin-potential; from [8].

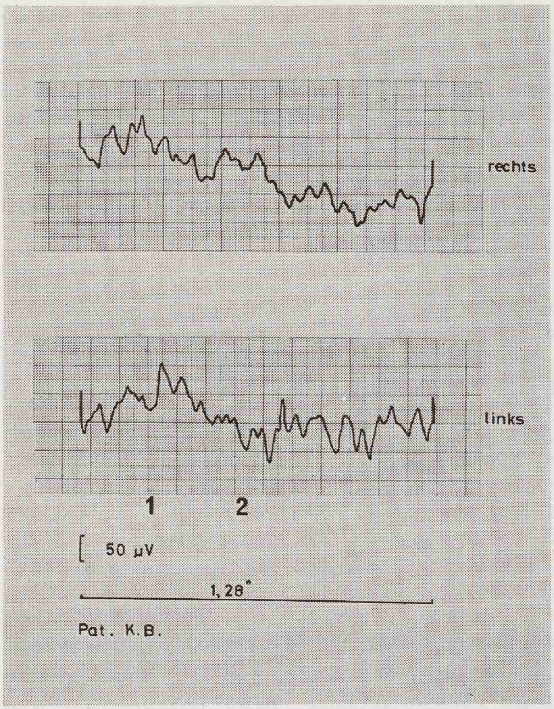


Figure 6. Condition after neuro-surgical removal of an olfactorius-meningioma. In computer-olfactogram (Record No. CO 244) weakened reaction of trigeminus-related potential (peak 1), no olfactorius activity (area 2); from [8].

affected. For olfactory meningiomas the olfactory sense cells must be considered as matrix. Functional disturbances are thus clearly understandable. Following surgical removal, the olfactory peak is obviously missing in the corticogram. The trigeminus appears weakened. The mechano and/or chemo-sensory part of the sensory perception is evidently only partially damaged by tumor of surgery. (Figure 6).

3. *Psychiatry*

In 83% of cases schizophrenics claim olfactory disturbances which must be classed as hallucinations, in other words, as spontaneous olfactory illusions. Nervously, the sensory apparatus is in no way disturbed. Accordingly, an essentially normal cortico-olfactogram occurs which, as in this case involving hebephrenia, is marked only by the influence of therapeutically administered psychopharmaka. It is remarkable that only the sensory part of the system is pharmacologically dampened (Figure 7).

4. *Hereditary disturbances*

Computer-olfactograms in cases of hereditary disturbances give rise to special discussions since they involve fundamental questions concerning the olfactory sense.

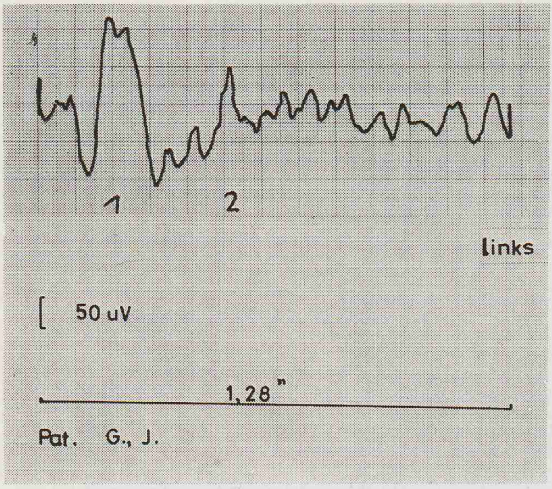


Figure 7. Hebephrenia. In computer-olfactogram (Record No. CO 275) an essentially normal twin-potential. Weakening of olfactorial peak by psychopharmaka (peak 2); from [8].

A 20-year old female patient complained about her lifelong conscious anosmia. Following repeated tests, the cortico-olfactogram provided a picture which initially seemed to show a clearly defined olfactorial peak. After anaesthetising the mucous membranes of the nose, excepting the olfactory slit, the registered peak disappeared only to form again gradually after 45 minutes.

According to the subjective olfactory test, too, in the case under discussion, the cortico-olfactogram indicated that the nasal trigeminus system must be considered in good order, only its cortical sum potential forms conspicuously late, while the olfactory representation is mising altogether. It is at present still unclear what causes this delayed potential formation. We classed this case as hereditary anosmia without having been able to differentiate any further by additional tests. (Figure 8a).

Complaints about hyp- or anosmia are possible in cases of the Turner Syndrome. In one of my own cases, a subjective test confirmed a hyposmia. In the cortico-olfactogram there developed a genuine sensible peak, while the sensory part potential registered only weakly (Figure 8b).

OUTLOOK

Computer-olfactometry is still at the beginning of its development. Taking into consideration certain technical prerequisites it can, however, now already be used clinically for diagnoses and help objectivise olfactory disturbances in insurance medicine. By means of improved evaluation possibilities of olfactorially evoked potentials we are striving for greater precision of diagnoses and reliability in evaluation.

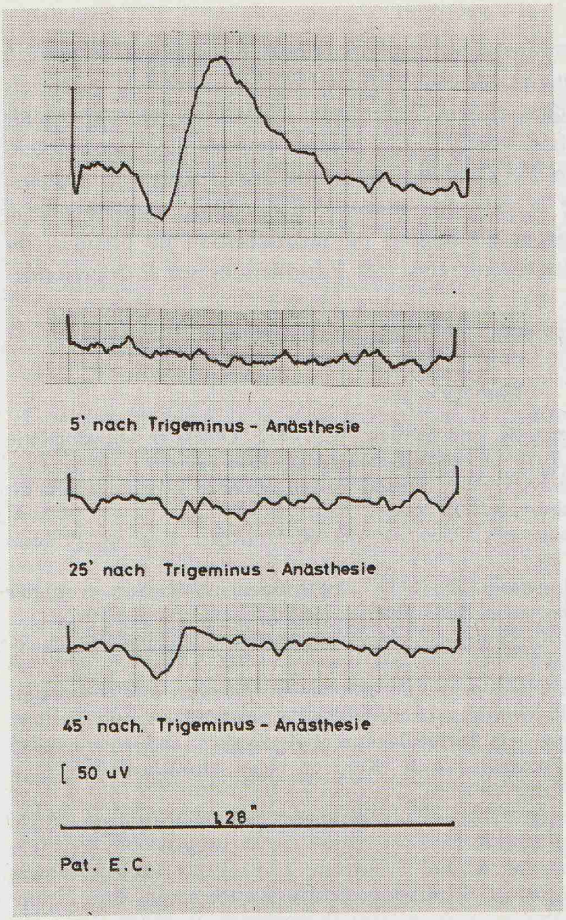
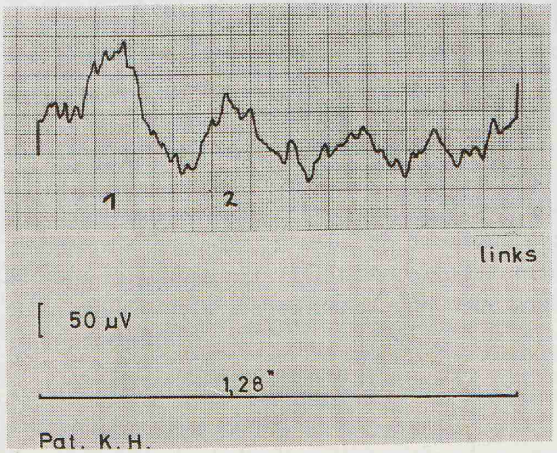


Figure 8. a) Hereditary anosmia. In computer-olfactogram (Record No. CO 254) development of a trigeminus-potential with increased latency period. Peak identified by control measurements following mucous membrane anaesthesia. The potential reappears about 45 minutes after anaesthesia (lowest curve); from [8].



b) Turner-syndrome.
In computer-olfactogram (Record No. CO 238) clear formation of a trigeminus-potential (1); mere indication of an olfactorius potential (2); from [8].

RÉSUMÉ

Après stimulation brève de l'organe olfactif périphérique, il est possible, grâce à des conditions d'examen adéquates, de faire apparaître des potentiels sensoriels spécifiques à la surface du crâne et, en répétant la stimulation, de superposer les potentiels (potentiels olfactifs évoqués). On observe typiquement deux potentiels jumelés témoignant, l'un de l'activité du trijumeau, l'autre du système olfactif. Sans l'intervention de la personne testée et donc d'une manière tout à fait objective, on peut constater la diminution ou la disparition du premier, du second ou des deux potentiels et obtenir ainsi des informations sur le fonctionnement du sens olfactif.

Des exemples cliniques typiques sont présentés.

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