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Measurement of olfactory threshold using an evoked potential technique*

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SUMMARY

A new device introducing brief pulses of odorised air synchronous with the inspiration of the test subject was developed . Responses to skatole were distinguishable as an evoked response by using the superimposition technique before averaging. The olfactory threshold measured by the chemosensory event-related potentials to olfactory stimulations according to our ascending method was found E-2 or E-1 and was equal to the detection olfactory threshold in each of the eight normal test subjects.

Key words : olfactory threshold, chemosensory-event-related potential, olfactory stimulation

INTRODUCTION

There have been several reports on olfactory evoked potentials published in the literature, e.g. those by Allison & Goff, 1967; Kobal & Hummel, 1991 and Tonoike & Kurioka, 1982. Constant responses evoked by odorant stimulation are not easily elicited due to problems associated with the control of the stimulus. We therefore introduced a technique of olfactory stimulation synchronised with subject's inspiration. (Wada, 1995, 1996, 1997). In this paper we will discuss a method of measuring the olfactory threshold by recording the event-related potentials to olfactory stimulation.

MATERIAL AND METHODS

The subject was instructed to lie down on his back on a bed. An EEG was recorded as upper negative from the central midline using monopolar recording by an active electrode. Other electrodes were attached to an auricle (indifferent electrode) and the forehead (earth electrode) according to the International 10-20 system. (bandpass 1-30 Hz, impedance 2-6 kOhm.) Odorant pulses were introduced by a new odorant stimulator at a flow rate of l l/min (Figure l). Each bottle contains 5 ml of a given concentration of odorant. Just prior to the onset of subject's inspiration, the tip of the stimulator was atraumatically inserted for 1 cm into the nostril (usually into the right side). After offering the odorant,. the tip of the stimulator is gently removed. The subject's respiration was used as the odorant pulse trigger. The trigger pulses were generated by a hand switch attached to the stimulator just after the start of the inspiration at a rate of once in four slow and regular respirations. An electric valve activated for 300 ms by a trigger pulse generated by a hand switch was used to introduce the odorant . After having recorded eight responses to a given concentration of odorant had been recorded, the results were averaged by a Neuropack Four Computer (NIHON KOHDEN Co.,. Japan). The analysis time was 1000 ms. The subject was asked to report at each presentation whether or not an odour was recognised and to evaluate the perceived intensity.

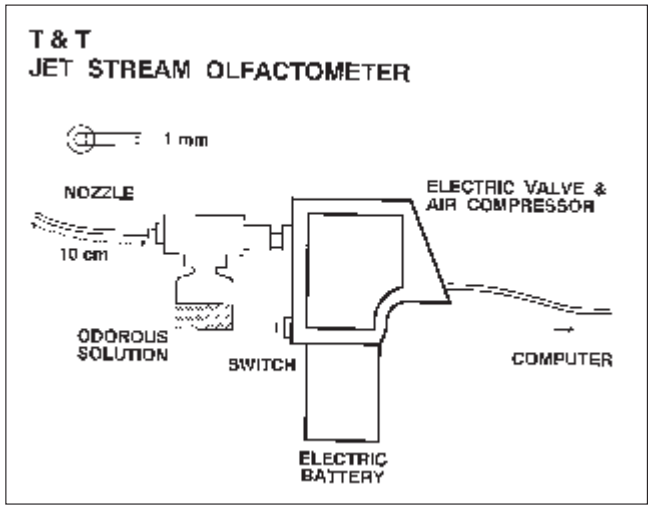

Figure 1. Schematic diagram of the stimulator.
(Nozzle: length 10 cm. inside diameter 1 mm)

Eight apparently healthy Japanese male non-smokers, aged 26-38 years were examined. Their detection olfactory threshold was within E0 when tested with a T & T olfactometer (Zusho, 1990) and their olfactory abilities were found to be normal (E0:

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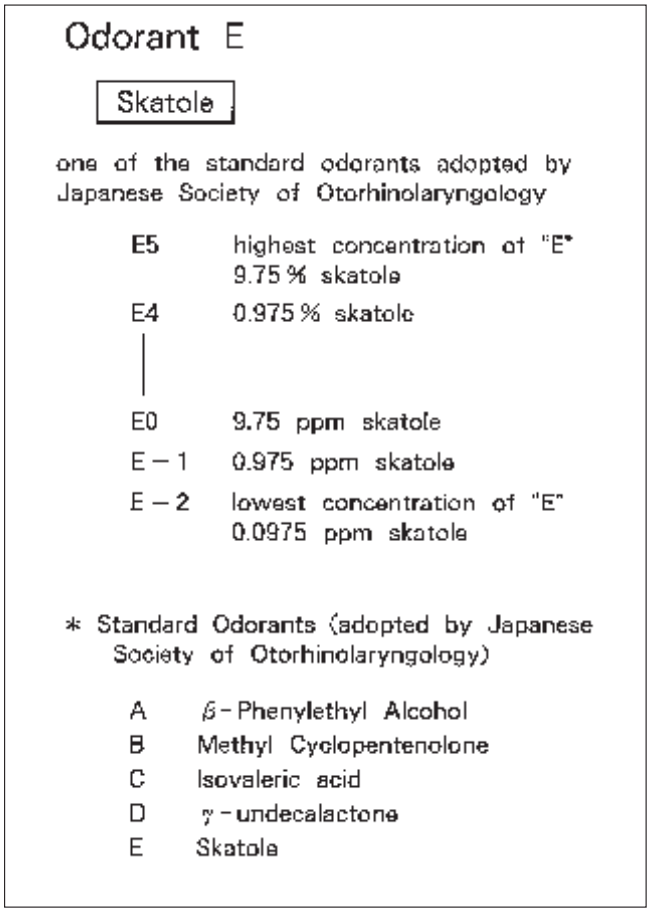

Figure 2. T & T olfactometer.
"E" indicates skatole, which is one of the standard odorants adopted by the Japanese Society of Otorhinolaryngology. E5 represents the highest concentration of skatole (9.75% skatole).

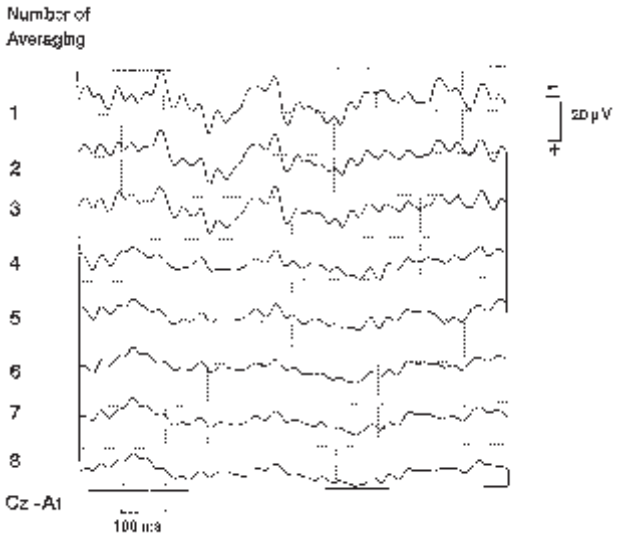

Figure 3. Responses to unscented air. Unscented air produced no response.

9.75 ppm skatole). Each individual was tested using skatole and the odorant was introduced by means of an ascending method from an undetectable level to a clearly detectable one with eight presentations of each concentration. Each new and higher concentration was presented after by an interval of fifteen minutes (Wada, 1995). Skatole is one of the standard odorants supplied with T & T olfactometer which has been adopted by the Japanese Society of Otorhinolaryngology (Figure 2), (Zusho, 1990). E5 (9.75% skatole) is the highest concentration of skatole, E4 (0.975% skatole) a 10% dilution of E5, E3 (0.0975% skatole) is 10% dilution of E4 etc. The lowest concentration of skatole offered is E-2 (0.0975 ppm skatole) (Figure 2). The environmental temperature of the test room was maintained at 21-24°C.

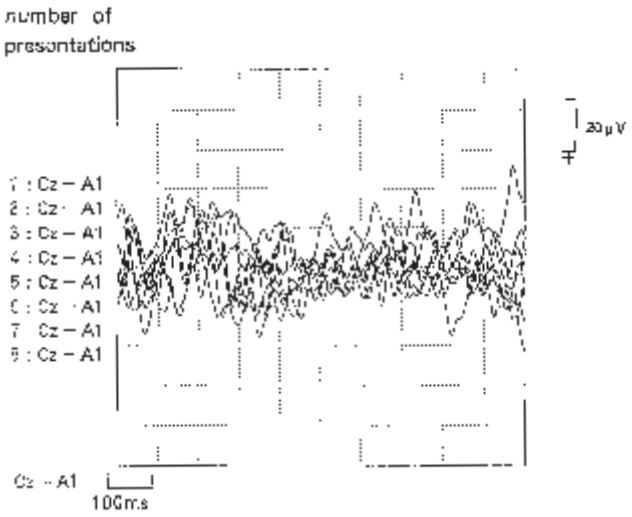

Figure 4. Evoked response to E5 (9.75% skatole) before averaging. The positive responses were detectable at a certain peak latency by the superimposition technique.

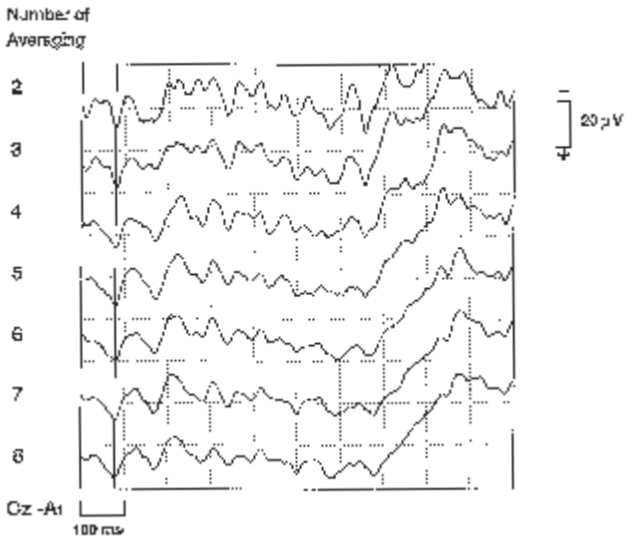

Figure 5. The averaged evoked responses to E5. The positive responses became obvious employing averaging technique. The number 8 wave represents eight times the total. Waves 4-5 show the largest amplitude.

RESULTS

There was no detectable response when the odour was absent (Figure 3). When the odorous stimulation was introduced at the end of an inspiration or during expiration, no positive evoked response was detectable. A typical pattern of an evoked response to E5 in a normal young subject before averaging is shown in Figure 4. Positive responses were detectable at a certain peak latency by using a superimposition technique. After averaging a positive response became obvious (Figure 5). In this graph wave 8 represents 8 times the total;. thus wave 4 and 5 show the largest amplitude and wave 7 or 8 represent the clearest wave. E5 evoked a positive response with a peak latency of 68 to 84 ms in these eight normal young subjects. According to our previous study, an interval of 15 minutes was sufficient to create a satisfactory response to a following and different odorant (Wada, 1995).

Figure 6 shows the evoked response to E-2 (0.0975 ppm skatole) in a normal subject. The detection threshold measured by the T & T olfactometer was E-1 (0.975 ppm skatole) in this case. As shown here, there was no positive response to E-2.Fifteen minutes later a more highly concentrated odorant, E-1, evoked a positive response with a peak latency of 81 ms (Figure 7). As a result the olfactory threshold measured by the chemosensory-event-related potentials to olfactory stimulations according to our ascending method was E-2 in 4 cases (with a peak latency of 82 to 116 ms) and E-1 in 4 cases (with a peak latency of 71 to 108 ms) and was equal to the detection olfactory threshold.

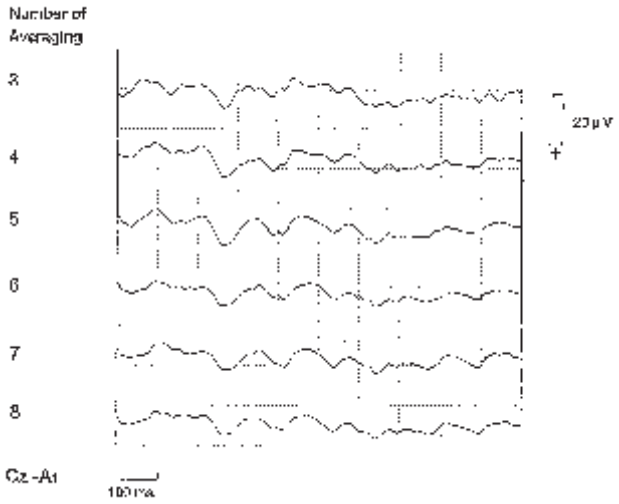

Figure 6. Evoked response to E-2 (0.0975 ppm skatole). The detection threshold measured by T & T olfactometer was E-1 in this case. No positive response was found.

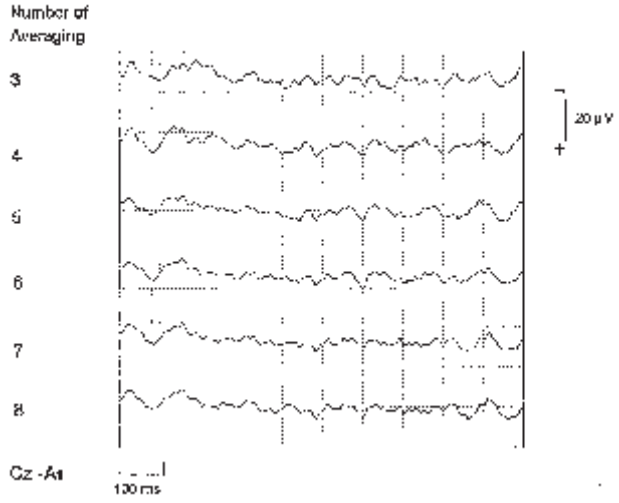

Figure 7. Evoked response to E-1 (0.975 ppm skatole). Fifteen minutes later, E-1 evoked a positive response with a peak latency of 81 ms.

DISCUSSION

Introduction of an odorant at the end of an inspiration or during expiration did not result in any detectable evoked response. In order to exclude aspecific influences, the effect of inserting a nozzle and sudden blast of an odorant, glacial acetic acid – which is thought to be a trigeminal stimulating agent – was tested in an anosmic patient. Glacial acetic acid evoked a negative response, whereas a blast of skatole E5 produced no effect. The positive responses to odorants can therefore be considered a specific result of olfactory simulation. In our study, the positive waves were made distinguishable by using the technique of superimposition before averaging. The positive wave evoked by the odorant was made clearer by averaging (Wada, 1995, 1996, 1997).In order to be able to evaluate olfactory evoked responses, it is essential to stimulate precisely at a certain time. We therefore decided to deliver the aerosolised odorant by pressurised air synchronised with the subject's inspiration. The pressurised odorous air itself does not evoke any positive responses when there is no inspiration as was shown in our previous studies (Wada, 1995, 1996, 1997). In other words, a slow and regular inspiration is necessary to deliver the odorous air to the olfactory cleft. A reproducible and stable response, as recorded by our technique is obtained by a slow respiration with a constant rhythm.

There have never been reports discussing evoked responses to olfactory stimulation by using the technique of superimposition before averaging. When we measure the peak latency of positively evoked responses or discuss adaptation, averaging of eight responses is needed. Our method results into a stable and reproducible response and saturation of responses is found after 4-5 averagings. The saturation phenomenon is related to the amplitude of the evoked potentials as well as to olfactory fatigue. Saturation or adaptation will be affected by the total amount of odorant introduced (Köster & De Wijk, 1991) and will therefore be dependent on both the strength and the duration of the preceding stimulation. Presenting several stimuli after each other will induce an adaptation. This may explain the different results of various studies as saturation will depend on the amount of odorous substance that is offered with time (Allison & Goff, 1967; Kobal & Hummel, 1991; Tonoike & Kurioka, 1982; Wada 1995, 1996, 1997).

In our ascending method, the concentration of the odorant is gradually increased from a non-detectable level until it is clearly perceived. In some cases the positive response may be influenced by a previous stimulation when an interval is too short even if the intensity of the odorant is subthreshold.

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