Olfactory Brain Evoked Potentials to Odorant Stimulations: Effects of Age on Smell Sensitivity

Byung Chan Min*, Chul Jung Kim*, Se Jin Park*, Ki Woong Bae**, Jin Soo Kim**, Jin

Kyu Kang**, Dong Hyung Lee**, Masashi Wada***, and Kazuyoshi Sakamoto****

* *Ergonomics Lab., Korea Research Institute of Standards & Science(KRISS), Taejon, Korea*

** *Dep. of Industrial Engineering, Taejon National Univ. of Technology, Taejon, Korea*

*** *Dep. of Otorhinolaryngology, National Center of Neurology and Psychiatry, Japan*

**** *Ergonomics Lab., The University of Electro-Communications, Tokyo, Japan*

1. Introduction

The sense of smell has played an important role in developing human life. Smell initially served mankind in a protective role to warn of approaching dangers and identified harmful substances. Yet, the utility of smell has expanded beyond these basic practical concerns into various facets of everyday life, and even to the esoteric. For the instance, certain odoriferous scents are currently commercially exploited for their unique capacity to be noble feel. Consequently, smell has become an indispensable component of our cultural life. Even so, studies of human olfactory functionality, like those of taste, lag far behind similar research endeavors in the other senses, namely, the somatosensory, visual, and auditory sense. Anatomical changes associated with aging have been detected in both peripheral olfactory structures, e.g., olfactory epithelium (Dodson and Bannister, 1980), and central olfactory pathways, e.g., olfactory bulb (Hinds and McNelly, 1981). However, their relative contributions to the age-related functional deficits are unknown. Olfactory evoked potentials offer an objective and quantitative method for studying changes in olfactory function due to aging in humans. A number of investigators have been able to record olfactory evoked potentials from the scalp in response to odorant stimuli in normal human subjects (Allison and Goff 1967, Kobal and Hummel 1991, Tonoike and Kurioka 1982), although stable, constant responses evoked by odorant stimulations are not easily elicited due to problems associated with control of the stimulus. Murphy et al (1994) has examined the effects of age showing a decline in the amplitude of odorant EP with increasing age. The purpose of this study is to further define the age effect on the olfactory evoked potential.

2. Materials and Methods

2.1. Subjects

Olfactory evoked potentials were recorded from 10 "young" subjects (males, aged 22-28 years), and 10 "old" ones (males, aged 60-78 years). All subjects reported a normal sense olfactory sensens. All subject were non-smokers and were instructed to restrain from drinking or eating for at least one hour prior to the measurement.

2.2. Odorant

Each was tested using several odors, including skatole and vanillin. Their olfactory abilities were determined to be normal by testing them with a T&T olfactometer (Zusho 1990), which has been adopted as a standard by the Japanese Society of Otorhinolaryngology. Skatole is one of the standard odorants supplied with the T&T olfactometer (Zusho 1990).

2.3. Olfactory Evoked Potentials (OEPs)

EEG was measured in a quiet electrically shielded chamber with good air circulation. The rest time for a minute was taken between sequential tests, so that the results were not affected by fatigue of olfactory sense or adaptation. The temperature of the measurement chamber was kept at 21-24°C and the time for the measurement was from 2:00 to 5:00 in the afternoon. The EEG was recorded from the central midline by an active electrode using a monopolar recording. Other electrodes were attached to a ear lobe (in different electrode) and the forehead (earth electrode) according to the International 10-20 system (bandpass 1-30 Hz, impedance 5 k Ω). Trigger pulses were generated by hand switch just after the start of inspiration and were determined by visual inspection of the subject's abdominal movement at a rate of once in four slow, regular respiration. After eight responses have been recorded, the results were averaged by a Biopac system. An electric valve introducing the odorous stimulation was activated for 20 ms by a trigger pulse. The analysis time was 1000 ms. Within these late nearfield potentials the peak-to-peak amplitudes P1N1 and N1P2, and the latencies of P1, N1 and P2 (in relation to stimulus onset) were measured.

3. Results and Discussion

When the odorous stimulation was introduced at the end of inspiration or during the expiration, the evoked response was undetectable. Also, there was no detectable response in the absence of the odor (Fig. 1), distilled water being used as the control.

Fig. 1. Absent responses to uncented air in a test subject using distilled water as the control.

Fig. 2. Typical pattern of evoked potentials to odorant simulations demonstrating evoked responses to skatole before averaging. As seen here, the responses showed good reproducibility. Before the averaging, the positive responses were detectable at a certain peak latency by the superimposition technique.

A typical pattern of an evoked response to skatole was shown in Fig.2 before averaging. In this Figure, the number 8 wave represented typical pattern waves 4 or 5 showed the largest amplitude and wave 7 or 8 represented the clearest wave. With the total number of stimulations exceeding 8, peak amplitude decreased and waveforms decayed. Similar results were obtained from all subjects tested. Post hoc analysis showed that this was primarily due to longer latencies in the "old" group than in the "young" subject group (Fig.3). Changes in age do not have a significant effect on the amplitudes of N1 and P2 (Fig.3). The results of this study showed that both young and old were significant factors affecting the latency of olfactory evoked potentials to skatole. Age increase associated with a prolongation of the P2 peak latency at about 35 msec for between young and old groups. Changes by aging in evoked potentials amplitudes of both N1 and P2 were not affected by odor.

Fig.3 Mean peak latencies(+S.E.) of latencies at P2 and N1-P2 interpeak amplitudes(+S.E.) by function and age group. The number of data points in each group is represented by n at the base of each bar. As for the age, the significant differences for only latencies was recognized by 1% significant level.

Since the generators of the olfactory evoked potential are unknown, it is not clear whether the age-related changes observed in this study are due to alterations peripherally at the receptor or more centrally in the brain. The correlation of P2 latency with odor identification scores suggests an intimate relationship between the generation of P2 and olfactory processing. Since age increase is associated with prolongation in latency of the later components (N1 and P2) and not the earlier components (P1 and N1), age is possibly related to alterations in central olfactory structures contribute disproportionately to the decline in olfaction typically seen in the elderly. The results of the present study emphasize the importance of subject parameters (i.e., young and old) as a source of variability in the olfactory evoked potential measures.

4. References

- [1] Dodson, H.C. and Bannister, L.H. (1980) "Structural aspects of ageing in the olfactory and vomeronasal epithelia in mice." In: H. Van der Starre (Ed.), *Olfactory and Taste VII*. IRL, London, pp. 151-154
- [2] Hinds, J.W. and Geisser, S. (1959) "On method in the analysis of profile data." *Psychometrika*, 24: 67-164
- [3] Murphy, C., Nordin, S., et al., (1980) "Olfactory evoked potentials: assessment of young and elderly, and comparison to psycho-physical threshold." *Chem. Sense*, 19: 47-56
- [4] Allison T and Goff W.R., (1967) "Human cerebral evoked potential to odorous stimuli", *Electroencephalogr Clin Neurophysiol* 14, 331-343
- [5] Kobal G, and Hummel T, (1991) "Human electro-olfactograms and brain responses to olfactory stimulation", *The human sense of smell*, Springer, Berlin Heidelberg New York, pp. 135-151