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Aroma helps to preserve information processing resources of the brain in healthy subjects but not in temporal lobe epilepsy

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ABSTRACT

Purpose: Inhalation of ylang–ylang aroma has been shown to reduce the auditory P300, an event-related potential thought to reflect higher-order processing. Because olfactory function is sometimes disturbed in temporal lobe epilepsy (TLE), the objective of the present study was to determine whether the effect of ylang–ylang aroma on the auditory P300 was impaired in patients with TLE.
Method: Fourteen subjects with TLE and 14 healthy controls participated in this study. Electroencephalograms were recorded during an auditory oddball task, and ylang–ylang aroma or odorless air was delivered through a mask.
Results: We found that the ylang–ylang aroma prolonged the latencies of P300 in both groups. The ylang–ylang aroma significantly reduced the P300 amplitudes of healthy subjects as described previously. However, in TLE patients, the P300 was unaffected by the aroma.
Conclusion: The current results show that exposure to the ylang–ylang aroma reduced information processing resources in healthy subjects but had limited effects in patients with TLE. We suggest that impaired higher-order olfactory processing in TLE patients may inhibit the effects of the ylang–ylang aroma on the P300.

1. Introduction

Olfaction is an important sensory function in most animals, including humans. Recently, several studies have investigated the effects of aromas on brain function and behavior. Many researchers have examined aromas using parameters such as subjective evaluations, physiological data (e.g. heart rate, respiratory rate, blood pressure, and skin temperature), and reaction times. More recently, the influences of aromas on cognition have been examined. Moss et al.[1–3] investigated the effects on cognition of several kinds of aromas, such as those of ylang–ylang, peppermint, rosemary and species of Salvia. Other studies have applied electrophysiological methods. Hiruma et al.[4] demonstrated that the amplitudes of the contingent negative variation components were significantly larger and reaction times to the imperative stimulus were shorter under *hiba* aroma than in an odorless condition. However, there were no significant differences in the amplitudes of the mismatch negativity obtained between the two conditions. They concluded that the *hiba* odor generates a high level of arousal within the nervous system but does not have a significant effect on automatic information processing. Ishigjchi et al.[5] investigated the influence of inhaling aromas on background electroencephalogram (EEG) using lavender, peppermint, grapefruit, juniper, and ylang–ylang essential oils. They reported that these aromas increased alpha powers and lowered subjective alertness. Iino et al.[6] found that the amplitude of the auditory P300 in healthy subjects was reduced during inhalation of ylang–ylang aroma, and interpreted this finding to reflect a relaxing effect of aroma on cognition.

Based on these studies, we have developed a particular interest in the effects of ylang–ylang aroma on the brain, because among the five essential oils Ishiguchi et al. had examined, this aroma had produced the strongest effect. Ylang–ylang (*Cananga odorata*) is a

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tree with yellow flowers. Ylang–ylang essential oil, which smells sweet and exotic, is extracted from these flowers.

In the present study, we examined the effects of ylang–ylang aroma on the auditory P300. The P300 is an event-related potential (ERP) that is observed when subjects detect an expected but novel stimulus during the oddball paradigm. In the oddball paradigm, two stimuli are presented in a random order, with one occurring more frequently than the other. Infrequent-target stimuli elicit maximal P300 potentials on the parietal region dominantly that peak at approximately 300–500 ms after the stimulus onset. Since the P300 was first described in 1965,[7] it has been extensively investigated, and it has come to be accepted that it is related to higher cognitive processing in the brain. Specifically, the P300 has been interpreted to reflect the attentional allocation and context updating processes of working memory.[8,9]

It has been recognized for over a century that the temporal lobe plays a crucial role in olfaction. In 1889, Hugulings-Jackson and Beevor[10] reported a case of a patient with a right temporal lobe tumor and olfactory seizures. About 50 years later, Penfield and Jasper[11] discovered that focal electrical stimulation in the olfactory bulb, uncus, or amygdala of awake patients could induce olfactory sensations. More recently, many researchers have demonstrated that patients with temporal lobe epilepsy (TLE) or patients who received temporal lobectomy had deficits of identification[12–14] and memory[15,16] of odors.

We hypothesized that the effects of aroma on cognition might be limited in TLE. The objective of this study was to elucidate whether the effects of ylang–ylang aroma on the P300 seen in healthy subject was also observed in patients suffering from TLE.

2. Methods

2.1. Subjects

Fourteen TLE patients (mean age 33.9 ± 9.0 years old; 8 males and 6 females) and 14 healthy control (CTRL) subjects (mean age 34.3 ± 7.5 years old; 8 males and 6 females) participated in this study. Table 1 summarizes the clinical characteristics of subjects.

The subjects with TLE were recruited from Tokyo Medical and Dental University Hospital and Hara Clinic, a specialized epilepsy clinic certified as a training facility by The Japan Epilepsy Society. All of the patients had a diagnosis of partial seizures, and they had features strongly suggestive of a diagnosis of TLE. These features included simple partial seizures characterized by autonomic symptoms, psychiatric symptoms, certain sensory phenomena such as olfactory and auditory hallucinations (including illusions), and complex partial seizures beginning with motor arrest followed by oroalimentary automatism. The diagnosis was based on the combination of their clinical symptoms, EEG, and structural and functional neuroimaging data according to the Classification and Terminology of the International League Against Epilepsy in 1989.[17] Four patients presented medial temporal lobe lesions on magnetic resonance imaging (MRI) scan. Three out of these four patients had hippocampal sclerosis and one had cavernous angioma. The exclusion criteria for both groups were comorbid psychiatric disease, substance abuse or dependence, or impairments of hearing or vision. Additional exclusion criteria for the CTRL group were a history of psychiatric disease, a previous traumatic brain injury with any known cognitive consequences or loss of consciousness, previous convulsions other than simple febrile seizures, history of encephalitis or meningitis, or history of psychiatric diseases or epileptic disorders in first-degree relatives.

This study was approved by the Ethics Committee of Tokyo Medical and Dental University. Written informed consent was obtained from each participant after thoroughly describing the experiment.

2.2. Procedures

All the subjects were presented with auditory stimuli consisting of 1000 Hz frequent stimuli (80%, 200 times) and 1050 Hz rare stimuli (20%, 50 times). The stimulation frequencies were different from those recommended in the guidelines published in Clinical Neurophysiology[18] (frequent, 1000 Hz; rare, 1500 Hz), because we aimed to minimize the physical difference between the two stimuli. Although the difference between the 1000 Hz stimulus and the 1050 Hz stimulus is very small, the tones are easily distinguishable. The two types of stimuli were delivered in random order. The interstimulus interval was 900 ± 90 ms. All the participants were seated and instructed to watch silent cartoons during the recording session and to mentally count the number of rare stimuli heard via the earphones. We dropped 0.05 ml of ylang–ylang essential oil that was diluted in grape seed oil (1:10, ylang–ylang: grape seed oil) in a plastic bag. The participants inhaled air with ylang–ylang aroma or odorless air through a mask during the oddball tasks. All the participants recognized the presence of the aroma. The order in which the aromas were presented to the subjects was counter balanced. After each session, we asked the participants the number of rare stimuli they counted during the oddball task.

2.3. ERP recordings

EEG was recorded using a portable bio-amplifier recording device (Polymate AP, TEAC CORPORATION, Japan) from the Fz, Cz, and Pz scalp electrodes. The electrodes were attached according to the 10–20 international system. The tip of the nose served as the reference for the other electrodes. To monitor the electrooculogram (EOG), we placed an electrode above the left eye and an electrode below the right eye of each patient. The impedance between the electrodes and the skin did not exceed 5 kΩ. The sampling rate was 1000 Hz, and the recording bandwidth was between 0.05 Hz and 300 Hz.

Table 1
Characteristics of the subjects in the study.

Variables	CTRL ($n = 14$)			TLE ($n = 14$)			
	Mean	(SD)	Range	Mean	(SD)	Range	
Age	34.3	(7.5)	23–48	33.9	(9.0)	20–48	NS
Gender (male/female)	(8/6)			(8/6)			
Education (years)	16.7	(2.8)	14–22	14.7	(1.8)	14–18	NS
Age of epilepsy onset (years)	NA			20.1	(10.8)	0.9–45	
Side of epilepsy focus (left/right/bilateral or undetermined)	NA			5/2/7			
Seizure in the year prior to the study (−/+)	NA			6/8			
Number of AEDs	NA			1.9	(1.3)	0–4	

CTRL, controls; TLE, temporal lobe epilepsy; AED, antiepileptic drug; NA, not applicable; NS, no significant difference.