Food, aroma and brain health

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Abstract: Maintaining one's brain in a healthy state is fundamentally important to maintain a rich and fulfilling mental and social life. There are numerous ways to eliminate stress and maintain the brain in a healthy condition. Some of the better methods recommended include food, aroma, and doing coloring-in. To confirm the effects of these methods, scientists have begun using new physiological methods such as brain imaging instead of conventional subjective evaluation techniques.

Methods used in brain imaging, such as analysis of EEG background activity as well as event-related potentials (ERPs) are not only safe and simple; they also excel as means of allowing long-term, chronological observations of changes in brain function. ERPs electrophysiologically display the process of cognition or of information processing that takes place in the brain. Ordinarily, ERPs are measured by means of setting "oddball task". Analysis of EEG background activity and measurement of ERPs are especially useful for assessing stress and for identifying the status of cerebral dysfunction in dementia patients. Moreover, they can be used not only to measure the effects of pharmacotherapy, but also to objectively evaluate the effects of aroma and food on stress and dementia, which until now have only been evaluated subjectively. By using both methods, we have confirmed that "luxuries" such as coffee and alcoholic beverages as well as foods such as arachidonic acid, an unsaturated fatty acid, are effective in enhancing brain health by alleviating stress and improving brain function.

Keywords: brain health, EEG background activity, event-related potentials (ERPs), EEG topography, oddball task

Introduction

Stress is a word that describes "a burden or load" or "distortion." Colloquially, it signifies psychological stress, indicating a condition in which a person is put under mental strain, inducing psychotic manifestations such as insomnia, irritability, anxiety or depression, and, in conjunction with them, sees a variety of physical disorders manifested such as headache, dizziness, anorexia, and other symptoms. As shown in Table 1, a variety of factors that exist in both the outside world and the inside world may be cited as possible stressors, meaning things that induce stress.

Psychological stress is measured by self-assessment as well as a variety of tests conducted by an observer. Immunological and physiological examinations are also used. More recently, brain imaging is also being used to evaluate stress. As shown in Table 2, there are a number of methods associated with brain imaging, including those that measure cerebral blood flow and oxygen consumption (such as PET). Of these, EEG analysis, unlike the other methods, is almost totally non-invasive. And, because long-term measurements are possible, and since the system is simple and low-priced, it is used extremely widely.

We therefore wish to briefly discuss the following subjects: (1) evaluation of stress via EEG analysis, which we have been attempting thus far, (2) the effects of aroma, foods and coloring on stress, and (3) their effects on brain function deterioration caused by aging.

1. Types and methods of EEG analyses

EEG analyses may be broadly classified into two types: those that quantitatively analyze EEG at rest, and those that
measure the changes in brain function when some sort of stimulation is provided. A typical example of the former is the analysis of frequency of EEG background activity, and that of the latter is the measurement of ERPs.

1) EEG background activity

In most cases, Fast Fourier Transformation (FFT) is used for analyzing the frequency of EEG background activity. Here, EEG, which is time domain data, is converted to data in the frequency domain to represent the amount of EEG components that occupy each frequency band. These days, it is sometimes displayed further as a topographic map, making it visually easy to understand.

2) Event-related potentials (ERPs)

Cognition is a process whereby information is extracted from the outside world and its identity clarified. Physiologically, it is a process in which sensory input that was transmitted to the brain by sensory organs is processed and refined due to the collaborative activity of the brain's numerous sites. In the past, cognition referred only to such process in which input was processed; recently, however, it has become a concept that includes even broader functions. In other words, we have come to regard ways of thinking as well as planning of activity/behavior as being included in “cognition”.

ERPs are capable of expressing (a) cognition in the narrow sense of the word as was used in the past, or, in other words, “information processing,” and (b) a course that has moved one step forward. In other words, ERPs are the electrophysiological representation of each stage of the cognition or information processin. Several components are identified that reflect each stage of those processes (Table 3). A representative example of this is P300. The significance of P300 in terms of information processing is that it represents the process of updating the cognitive context. That is to say, it reflects the process in which the flow of information processing that has been created is revised in accordance with the newly input information.

Ordinarily, P300 is a potential obtained via a stimulus presentation method called the oddball task. It was so named since healthy adults show a positive waveform which peaks about 300 milliseconds after a stimulus has been presented to them. P300 is a potential that is non-specific to sensory modality. Regardless of the type of stimulus—auditory or visual—on-the-scalp records show that, after a subject carries out an oddball task, P300 appears, parietally dominant and distributed more or less symmetrically. An oddball task entails the random presentation of different stimuli with the same sensory modality. Two types of tones with different presentation probability and frequency, e.g., 2,000 Hz and 1,000 Hz, are presented, in random order through a headset, and the subjects are asked to press a button with their right index finger when they hear sounds with a low presentation frequency (2,000 Hz). When the waveforms that correspond to each stimuli are averaged, a clear-cut P300 wave form can be obtained for the 2,000 Hz tones. On the other hand, almost no clear P300 waveform appears with respect to the 1,000 Hz tones that have a high presentation frequency and in response to which no reaction (pressing of the button) are required. In other words, P300 appears in association with the activity of switching the processing of 1,000 Hz tones, which are stimuli that occur extremely frequently, to the processing of the 2,000 Hz tones that appear on rare occasions. The amplitude of P300 represents the amount of information processing resources that are used for the process of context updating; the time to reaching peak (“latency”) is said to represent this processing rate.

2. Physiological measurement of stress via EEG analysis

Among the components of EEG background activity, alpha activity is used as the benchmark for stress. Alpha activity appears, occipital-dominant, at rest with the eyes closed but alert. If psychiatric symptoms develop in association with stress such as anxiety and irritability, alpha activity decreases. To put it the other way around, if stress is alleviated, alpha activity increases in the occipital areas. Currently, psychotropic drugs such as anxiolytics and antidepressants are primarily used to alleviate stress. Other than drugs, attempts are being made to alleviate stress by using aroma and foods. The effects of these drugs, foods and aromas have conventionally been evaluated using subjective tests. However, if the changes in alpha activity are measured, it would be possible to evaluate them in a physiological and objective fashion. For example, when we compared the amount of alpha activity induced by different coffee aromas, we found that Guatemala generated markedly greater alpha wave activity than the No Odor controls (distilled water) or Mandelberg.1) By illustrating these EEG background activities as a map and comparing them, we can visually understand with little difficulty that there are differences in
the coffee aroma's stress reduction effects according to the type of coffee bean.

EEG background activity, moreover, is extremely useful, not only for measuring alpha activity at rest with the eyes closed but also for identifying stress-related sleep disturbances and measuring the efficacy of treatment of such symptoms. In so doing, a method called polysomnography is used, which measures not only EEG but also other functions simultaneously such as an electromyogram (EMG), ocular movement (electrooculogram, or EOG), respiration, etc., during sleep.

As mentioned earlier, event-related potential P300 is an indicator of functions when the brain is vigorously engaged in an activity called cognition or information processing. If attention is hampered by stress, or if the brain cannot make full use of its information processing resources, P300 amplitude decreases. Aging also decreases P300 amplitude and extends its latency. Dementia patients manifest a marked reduction in amplitude and extension of latency, so P300 is potentially very useful as a noninvasive auxiliary diagnostic method for dementia; it is also practical for observing its degree of deterioriation. It can also be used to assess the effects of treatment and care provided to dementia patients. In our study, we provided arachidonic acid, an unsaturated fatty acid, to normal elderly individuals, and compared their results with those given a placebo in a double-blind test. We found that when arachidonic acid is consumed, the subjects showed a significantly shorter P300 latency, with a larger amplitude, than subjects given the placebo. As seen, P300 can be used as a means of objectively studying the efficacy of methods other than drugs designed to improve brain function.

Needless to say, P300 may be used not only for assessing and diagnosing aging and dementia, but also for measuring the effects of methods intended to activate brain function. As shown in Figure 1, we, too, used P300 to assess the effect of aroma on information processing, and succeeded in identifying the differences in effects. 2-4)

Lastly, we will briefly show the findings of our study on the effects of doing pictures for coloring-in, which is attracting growing interest in recent years. Figure 2 compares the P300 (using visual stimulus) between before doing coloring-in and immediately afterwards. It was revealed that P300 increased immediately after doing coloring-in, an activity requiring visuomotor cooperation. This suggests the possibility that doing coloring-in may activate brain function.

Conclusion
EEG analysis is a useful means of observing the effects of stress on brain function, and for monitoring changes in brain function caused by aging. A major advantage is seen in evaluating the effects not only of drugs but also of food and aroma that replace drugs. In the future, it is anticipated that EEG analysis will be used extensively, along with other types of brain imaging, while making use of the unique characteristics of each of these techniques.

References
食品・香りとブレインヘルス
(Food, aroma and brain health)

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要旨：豊かな心を保ち、充実した社会生活を営むには、脳を健康に保つことが基本的にお重要である。ストレスを除き、脳を健康に保つ方法は種々あるが、食品や香り、さらに香り絵なども優れた方法として推奨される。これらの効果を確認するためには、これまでの主観的な評価法に代わり、
脳機能画像をはじめとする生理学的な方法が導入されている。

脳機能画像の中で、脳波背景活動の分析や事象関連電位（event-related potential: ERP）などの方法は、安全かつ簡便であるばかりでなく、脳機能の変化を長期間定時的に観察できる手段として優れている。事象関連電位とは、認知なしが脳における情報処理の過程を電気生理学的に表出したものであり、通常は、オドボール課題により測定される。これらはとくに、ストレスの評価や認知症における脳機能障害の様態を明らかにするのに有効である。また、薬物による治療の効果測定ばかりでなく、これまで主観的な評価しか行われてこなかった香りや食品のストレスや認知症に対する効果の客観的評価にも応用することができる。両者の方法により、コーヒーなどアルコール飲料などの嗜好品、不飽和脂肪酸であるアラキドン酸などの食品などが、ストレスを軽減したり脳機能を改善することにより、ブレインヘルスを向上させる効果あることを確認した。

Keywords: ブレインヘルス、脳波背景活動、事象関連電位、脳波トポグラフ、オドボール課題