H2 Integrated Analysis Package | Visualization Tools

# Evaluation of psychological state during work

Basic phase | Application Phase | Implementation phase

Patent: Patent Application 2021-035752, Method and device for evaluating psychological state during work, and method and device for evaluating the enjoyment of work itself

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**Easily measure KANSEI using light and visualize the enjoyment of work**

**The brain activity of the frontal region is measured using near-infrared spectroscopy (NIRS), and the psychological state (enjoyment, etc.) during work is measured. Taking advantage of the simplicity of NIRS, it is possible to objectively evaluate the psychological state during work and the enjoyment of the work itself, which is performed in a state close to nature without imposing special restrictions.**

**Application: Quantitative evaluation of work and rehabilitation load, objective evaluation of products and their sales strategies, and so on.**




《Principal investigator》

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《Laboratory introduction》

Preeminent Medical Photonics Education & Research Center, Hamamatsu University School of Medicine
Department of Innovation Photonics, Institute for Medical Photonics Research
For us, innovation means “a wide range of changes that create new value with social significance from new ideas and bring about major social changes”, not just “new technological invention” in a limited sense which is commonly referred to. We would like to conduct both basic research and applied research using optical and electronic technologies to create medically meaningful value from new ideas.


Brain activity can now be investigated in detail using electroencephalograph (EEG), fMRI, PET, and so on. These technologies have been developed to measure emotional movements in real time. However, fMRI requires a huge equipment and generates a strong magnetic field, and PET, which also needs a huge equipement, requires the injection of a radioactive drug. Thus, it is difficult to measure the KANSEI in the natural state due to the restriction of the movement.Although devices that can easily measure brain waves are appearing, there are restrictions on the environment in which measurements can be performed because they are vulnerable to electrical noise.

NIRS is easy to operate and non-invasive, does not require the subject to be restrained or restricted in position, and has the advantage of being able to measure brain function during work in a state close to daily life. In addition, due to its strong characteristics against electrical noise, portable devices have recently been developed. Hamamatsu University School of Medicine is promoting research and development of medical technology using light and is conducting research to visualize KANSEI by measuring brain activity, expanding on the technology of non-invasively measuring blood flow in muscles and brain using NIRS.

Figure 1: NIRS measurement

## Previous findings that form the premise of this study

Near-infrared (NIR) light that can be used for measurement inside the body because it is not absorbed and passes through bones and skin to some extent. NIRS is a technique for measuring blood flow and hemoglobin in the body by irradiating NIR light with a wavelength of 700 to 900 nm from the body surface into the body and detecting and analyzing the transmitted and reflected light. By utilizing the difference in light absorption characteristics between oxygen-bound oxyhemoglobin and oxygen-deprived deoxyhemoglobin, it is possible to measure tissue oxygen saturation, which is already being used in medical treatment and health management.

There are two typical measurement principals for NIRS (Fig.2). Continuous wave (CW) measurement is a simple method that measures the intensity of detected light with respect to incident light; thus, wearable devices have also been developed and are commercially available. This method is not ideal for measuring blood flow in the brain inside the skull for KANSEI measurement, because it is characterized by the detection of a large amount of light returning through shallow subcutaneous areas due to the constant irradiation of NIR light. On the other hand, time-resolved spectroscopy (TRS) measurement is a system that irradiates NIR light for an extremely short time of less than nanoseconds or less and has the feature that the detected light intensity and temporal spread can be obtained. It is possible to measure blood flow information at deeper and more localized positions than with the CW method.

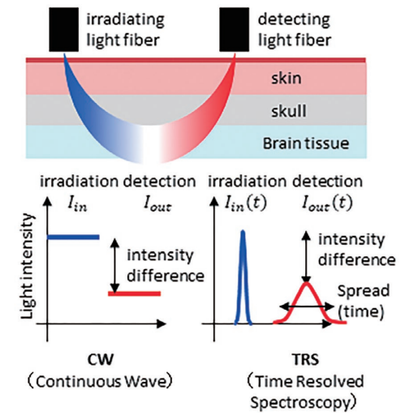


Figure 2: Comparison of NIRS measurement principals

## Experimental design and results of KANSEI measurement

In a preliminary experiment using fMRI, the frontal pole of the cerebrum (the brain at the front of the head and under the forehead), which is known to be related to KANSEI, was measured. The function of this brain region has not yet been elucidated in detail, but the following experiments confirmed the difference in blood flow changes, suggesting its role as a “window for KANSEI measurement.” The active part of the frontal pole confirmed by fMRI in advance is approximately 2 cm deep from the skin, and a 4-channel TRS measurement system (Hamamatsu Photonics K.K., Hamamatsu) was used to acquire the activity at this position (Fig.3). The TRS measurement system and the probe attached to the forehead are connected by optical fiber.

Figure 3: TRS measurement system
Hamamatsu Photonics K.K. (Hamamatsu)

### 《Experiment 1: Emotional change and frontal pole》

The participant is presented with an image via a liquid crystal display. The order of image presentation is shown in Fig. 4. The Introduction is a description of the image to evoke an emotion, and the Imagination is a presentation of the image. At this time, the images to be presented are those intended for one of three types of emotions: positive (pleasant), neutral (neutral), and negative (unpleasant), as well as those that indicate whose viewpoint is the emotion (Fig. 4). As an example, following the explanation “When I go to bed...” as an Introduction, one of the three types is shown to the participant: “I’m warm and cozy on the futon!” (positive), “I took the futon out of storage and laid it down” (neutral),” or “I can’t sleep because of a severe headache” (negative). The participants are then asked to imagine the situation as their own or someone else’s. TRS measurements were performed before and after the image presentation, which were compared with an arithmetic task that did not involve emotional changes (control). In the experiment with 35 participants, blood flow in the frontal pole was found to increase when imagining with emotional changes.

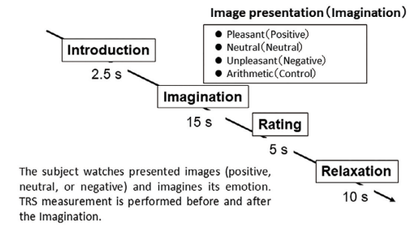


Figure 4: Frontal pole activity measurement by NIRS

### 《Experiment 2: Creative work and frontal pole》

Humans tend to work more enthusiastically when performing creative work than when performing simple work, but the difference in cerebral blood flow during creative activity and simple work is not clear. Therefore,

test the hypothesis that creative work that evokes enjoyment (work that involves changes in emotion) increases brain activity in the frontal pole, we used TRS system to measure and compare frontal pole cerebral blood flow during creative work (creating a dog using a screw toy (Neji-Block, HASHIMOTO RASHI KK, Hamamatsu (Fig.5)) and the simple task of repeating screwing and unfastening.

As a result of experiments with 23 participants, blood flow was found to increase in creative work but remained flat or slightly decreased in simple work (Fig.6). Comparing the subjective evaluation (Visual Analog Scale: VAS) performed after the experiment with cerebral blood flow, there is a relationship between positive indicators such as enjoyment and arousal and cerebral blood flow (Fig.7).

The above experiment suggested that by using TRS method, it is possible to objectively evaluate the enjoyment of the work itself by measuring the psychological state (fun, motivation, etc.) during work.

## Future Research

The idea of measuring blood flow using NIRS has already been tried; however, measuring the brain activity associated with emotion is a new challenge. The frontal pole is located just below the forehead, which is relatively easy to measure and is the most suitable part for measuring with NIRS.

In the future, we would like to advance our research to elucidate the function of the frontal pole in parallel with the development of techniques for measuring brain blood flow using the TRS method. So far, due to ethical considerations, this study has not conducted any experiments with strong negative emotions. Since cerebral blood flow is thought to increase when emotions shift, increased blood flow does not necessarily mean positive emotions. However, it is possible to evaluate and visualize the types of emotions in detail by measuring the size of emotional movement with NIRS in combination with techniques such as facial expression analysis.

Figure 5: Neji-Block
(HASHIMOTO RASHI KK, Hamamatsu)

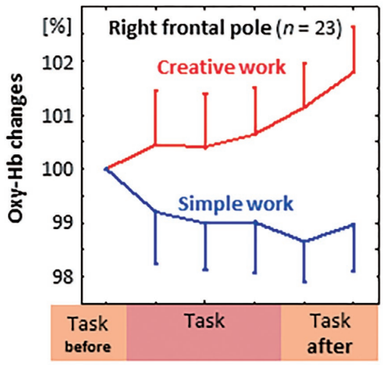


Figure 6: Changes in cerebral blood flow

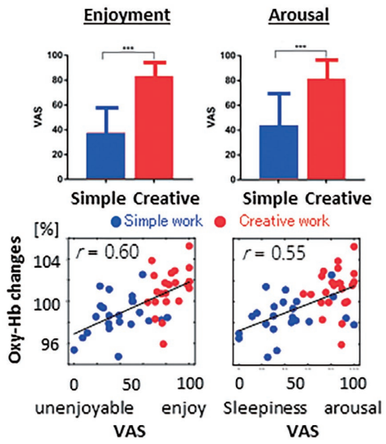


Figure 7: Relationship between experimental impressions and cerebral blood flow

# Toward social implementation

As demonstrated in the “Neji-block” experiment, it is possible to quantify the level of enjoyment and arousal during work via the amount of change in blood flow. If a hairband or glasses-type wearable device is developed, it will be possible to measure in more diverse environments. Even with the current devices, it is possible to measure without interfering with the participant's movement or thinking, as long as the task does not require significant movement.

Although there are several tools for measuring and visualizing brain activity in the Integrated Analysis Package, we believe there are many environments that can be measured only with NIRS, which uses light.

### ●In Rehabilitation

In occupational therapy for elderly people, especially those with dementia, it is sometimes difficult to find a program that they are willing to engage in. Even if a person does not (or cannot) express their likes and dislikes, measuring cerebral blood flow will help you choose a program that is suitable for them. Since it is easy to measure, it will also help select a program that suits their mood on the day.

### ●Pediatrics, psychiatry, and other medical fields

Measuring cerebral blood flow in infants who are unable to express their likes, dislikes, and emotions verbally can be useful for medical treatment and development. It is also expected to be applied to diagnosis and treatment in the field of psychiatry.

### ●In the manufacturing industry

It will be possible to evaluate work procedures and work environments that allow people to work happily and enthusiastically, and to measure individual differences in the tasks they are good at and like, so that the right people can be assigned to the right jobs.

It can also be used in technical training to develop programs that help maintain motivation.

### ●Development of products and services

When we ask consumer monitors to evaluate new products and services, we can quantify and visualize the magnitude of changes in their feelings by measuring brain blood flow using NIRS along with subjective evaluation. It is possible to visualize not only the overall evaluation, but also what part of the product or service they felt interested in.

### ●Evaluation of entertainment

By watching a movie, participating in an event, or experiencing an attraction at a theme park while wearing the measurement device, it is possible to evaluate over time which scene caused the greatest change in emotion.

Use in rehabilitation (image photo)

Use in pediatrics, etc. (image photo)

Use in manufacturing sites (image photo)

Use in product and service development (image photo)