

## PROCEEDING

# Hemodynamic changes in the prefrontal cortex during mental works as measured by multi channel near-infrared spectroscopy (NIRS)

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**Abstract :** To investigate the brain activation in the prefrontal cortex (PFC) during mental works, we examined blood oxygenation changes of healthy subjects by using multi channel near infrared spectroscopy (NIRS). It was directly confirmed that the PFC was activated during mental tasks *in vivo* and it was suggested that distribution of the activation in the PFC is different among healthy individuals. **J. Med. Invest. 52 Suppl. : 302-303, November, 2005**

**Keywords :** near infrared spectroscopy (NIRS), prefrontal cortex (PFC), the wisconsin card sorting test (WCST), the verbal fluency test (VFT), the uchida-kraepelin test (UKT)

## INTRODUCTION

The prefrontal cortex (PFC) may be involved in various higher cognitive functions such as working memory, processing of language, and reasoning (1). Moreover, the PFC has also an important role in the neurocircuitry for emotions (2). Near-infrared spectroscopy (NIRS) is an optical instrument to measure the relative concentrations of oxygenated hemoglobin ([oxyHb]) and deoxygenated hemoglobin ([deoxyHb]) with a high time resolution. The cerebral neuronal activation based on the oxygenation is observed with NIRS. We report preliminary results of the hemodynamic changes in the PFC of normal healthy individuals during mental tasks with multi channel NIRS.

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## MATERIALS AND METHODS

The Wisconsin Card Sorting Test (WCST), the Verbal Fluency Test (VFT) and the Uchida-Kraepelin Test (UKT) were adopted. The WCST is a standard neuropsychological test to evaluate the function of frontal lobe cerebral cortex. The subjects were instructed to match a response card on the basis of one of three possible categories (color, shape, number). The WCST reflects the executive function of the cognitive process for the problem solution. The VFT is a neuropsychological task, which assesses the subject's performance to retrieve series of nouns based on common criterion. On the other hand, the UKT is an aptitude test to assess working ability. Subjects were 20-30 healthy volunteers for each test. Cerebral hemodynamic changes in these subjects were monitored during these mental works. NIRS measurements were performed with a 24-channel NIRS system, ETG-4000 (Hitachi Medical Corporation, Tokyo, Japan). The probes on bilateral frontal region were measured at 12 measurement points in a 6×6 cm prefrontal area in left and right hemisphere,

respectively.

## RESULTS

The bilateral [oxyHb] was increased immediately after starting the WCST and rapidly returned to the baseline after the test in about 60% of subjects. However, 30% of subjects showed a predominant activation of either left or right side. Moreover, no [oxyHb] changes were observed in 10% of subjects even with good performances. In the VFT, [oxyHb] increases were observed in the frontal channels predominantly. However, the activation was different among individuals. In the UKT, we observed the waves in the PFC areas synchronized with the initiation and cessation of the calculation. Moreover, about 60% of subjects showed additional sporadic spindle waves in both dorsolateral PFCs in addition to these synchronized waves. The spindle waves did not seem to be related to the calculation tasks. These results were reproducible and the same pattern was seen in each subject.

## DISCUSSION

Our preliminary results suggest that there is an individual difference of the PFC activation during these tasks. There was laterality during the WCST in several subjects. The WCST contains multiple components and there may be personal differences of process and pattern of activation (3). In the VFT, there was a functional difference between letter- and category- fluency probably because the different brain areas were activated according to the type of access to the memory stores (4). In the UKT, we found oxyHb changes in the bilateral PFC synchronized with calculation. In addition to these synchronized changes, sporadic spindle waves were observed in the dorsolateral PFC bilaterally. These sporadic spindle waves may be resulted from the emotional reactions such as anxiety or unpleasant feeling for continuous

calculation because the PFC has been reported to be involved in emotion and feeling.

In conclusion, multi channel NIRS is a new reliable optical instrument to examine the hemodynamic changes of cerebral cortices and may be used to measure the PFC activation during mental tasks in each individual. The method may be useful to detect the emotional changes during stressful mental tasks.

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