NIR Imaging of Prefrontal Activation by Anagram Solutions

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Continued studies in cognitive function in problem solving of graded difficulty (1) has now proceeded through several thousand tests of high school students in a six weeks period last summer. The optical imager uses 9 sources and 23 detectors operated in time multiplex to give an image of the prefrontal region in several seconds. Thus, the image can be acquired in the state prior to activation, during and following activation. The images are acquired at two wavelengths, 750 and 850 nm, from which the changes of blood concentration (blood pooling) and relative oxygenation/deoxygenation state (metabolic activity) can be obtained and with suitable calibrations converted into micromolar changes of total Hb concentration and fractional changes of oxygenation, respectively. The imager has a flexible, wearable pad applied to the forehead and the electronics presents the running average of the two quantities mentioned above in the 16 voxels which cover the prefrontal region. The protocol involves a scanning through multi-letter anagrams of graded difficulty which include problems ellicitating maximal activation (>3 solutions in the 30 sec test interval) or are to easy, or too difficulty. Anagrams are presented in a sequence of three, four, five letter anagrams of to the maximal level of difficulty and back to the starting point. Each anagram is displayed for approximately one minute. Computer scanning of the results gives histograms of the several hundred tests per individual in the "training" interval (for three weeks) and in the post training interval (3 weeks). Usually two or three complete trials per day were achieved with the result that the group of 7 students produced over 2600 test results. The histogram displays were studied to determine a) the most fruitful voxels, b) the approximate of the total tests that appeared in those voxels and c) the maximum signal level observed in the histogram display in units of micromolar hemoglobin. The product these two was taken as the Figure of Merit and their displays of the 16 voxels gave patterns for trained and untrained responses. The preliminary conclusions of this study were: a) that the training effect was very large, pre-training exhibited a chaotic voxel distribution for all difficulty levels while trained students gave a higher output and activated only one or two of the 16 voxels. If the tests was too easy, too hard, i.e., an ability/difficulty mismatch, frustration or disattention gave similar chaotic patterns; b) a match between difficulty and ability activated only one or two voxels in similar locations for the group. Since attention and success measure appear to be of interest in school room studies, a wearable imager with local LCD display is being supplied to the Senior class of the local high school for those individuals who have already had last Summer's training in anagrams. It is concluded that wearable NIR measurements of metabolic activation and blood flow may be a useful educational aid.

(1) Chance, B. Anday, E., Nioka, S., Zhou, S., et al. (1998) A Novel Method for Fast Imaging of Brain Function, Non-Invasively, with Light. Optics Express 2:411-423.

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Abstract

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