Functional imaging of welders with occupational manganese exposure using a finger tapping task

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Introduction

Mn2+ functions as a cofactor for a number of enzymatic reactions and is an essential trace nutrient for all forms of life. However, excessive accumulation of Mn in the globus pallidus(GP) is known to cause cognitive and motor deficits due to cytotoxic effect on dopamine containing neurons (Fitsanakis VA, et al, Neurochem int 2006) [1]. Human exposure to large amounts of Mn is often occupational such as manganese mine, smelting, battery and welding. Until now pallidal index(PI) in terms of T1 bright signal intensity at GP is only imaging diagnostic measure to manganism. No functional measure is currently available for motor behavior of manganese exposure in vivo. The aim of this study investigates motor behavior of manganese exposure compared to normal group using simple motor task like finger tapping task.

Subject and Methods

Twenty-eight right-handed, healthy mail participants were recruited from the general population and forty-three right-handed, Mn exposed mail participants were recruited from the welder population in this study. The welder group separated into two group with minor Mn exposure and excessive Mn accumulation. The mean age of minor Mn exposed group were 47.7 years, excessive Mn accumulated group were 47.5 years and the healthy group where 47.6 years. The fMRI task paradigm was used finger tapping task with block design. Functional magnetic resonance images were acquired using a 3.0T GE HD scanner(EPI, TR=3000ms, TE=40ms, matrix=64x64, Thickness=4.0mm, no gap). Anatomical images where acquired using 3D-FSPGR sequence(TR=7.8ms, TE=3ms, matrix=256x256, 120slices, no gap). 60volumes were acquired and fMRI raw data were analyzed by testing the BOLD differences between the active and the control task using SPM2 and group analysis was applied with random effect model.

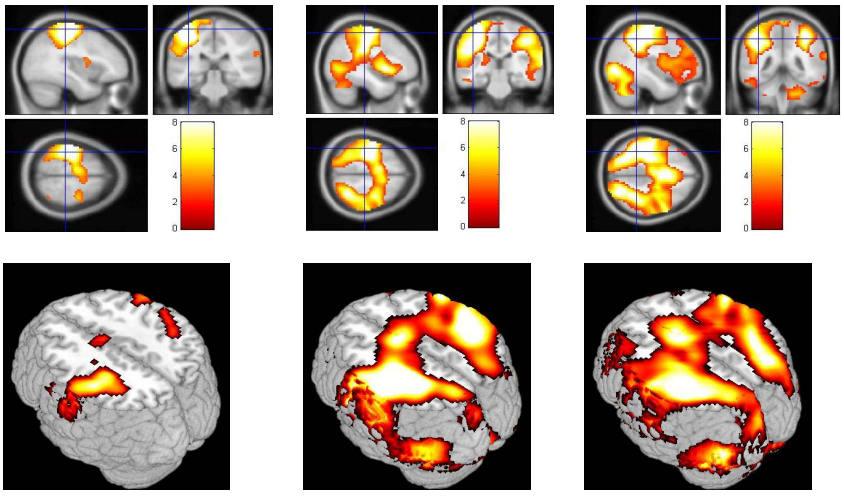
Result and Discussion

The observation that welder groups (both with and without T1 high signal at GP) show widespread motor activation suggests the change of motor network in response to Mn accumulation (Fig1). Compared to normal controls, the welder groups showed widespread activations in the supplementary motor area, cingulate motor areas and bilaterally increased activation in the parietal lobe and frontal lobe. Our result therefore demonstrated that motor fMRI is very sensitive measure to subtle functional change of motor system even for Mn exposed brains with normal PI index. One of possible interpretations on widespread involvement of motor areas is compensatory mechanism that Mn exposed brain recruits more motor areas to maintain same level of motor performance as normal subjects. It could be represented that impaired motor system is associated with a shift away from the utilization of primary motor cortex towards secondary motor networks in bilateral brain area in an effort to generate motor output for general performance(Ward,N.S.,2006) [2]. Therefore, motor fMRI is quite sensitive to change of motor network of Mn exposed brain even without T1 high signal at GP and has a great potential as functional diagnostic tool of damaged motor system in occupational exposure to Mn.

References

1. The effects of manganese on glutamate, dopamine and gamma-aminobutyric acid regulation. / Fitsanakis, Vanessa A ; Au, Catherine ; Erikson, Keith M (Neurochemistry international ,v.48 no.6/7 ,2006 ,pp.426-433)
2. Compensatory mechanisms in the aging motor system / Ward, N.S. (Ageing research reviews ,v.5 no.3 ,2006 ,pp.239-254)

Result data



(a) normal (b) welder (c) welder with PI high

Fig 1. The welder groups(b,c) show more and widespread motor activation than the healthy group(a)(p<0.05, FDR corrected).

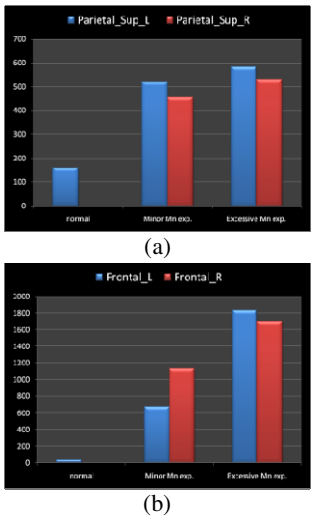


Fig 2. The welder groups were shown the bilaterally increased activation area in the parietal and frontal lobe.