# Compensatory recruitment after 36 h total sleep deprivation and the relationship with executive control

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## INTRODUCTION

Response inhibition is one cognitive process that requires activation of the executive control system which stops oneself from engaging in a prepotent response that reaction is not appropriate. Executive function relying on inhibition is affected by total sleep deprivation (TSD). The main purpose of this study was to investigate the influence of TSD on response inhibition using combined behavioral and functional magnetic resonance imaging (fMRI) techniques. Whether TSD would result in significantly reducing response inhibition or not and its underlying mechanism may be reflected by the changes of blood oxygenation level-dependent (BOLD) signal and behavior performance, such as brain activities, correct rates and reaction times (RTs). In order to address these problems, a visual Go/No-go task which associated with response inhibition and conflict detection were used during which BOLD signals were recorded before and after 36 h TSD.

## MATERIALS AND METHODS

***Subjects*** Fourteen healthy male undergraduate students (25.9 ± 2.3 years old) participated in the experiment as paid volunteers for the study. All subjects were given written informed consent after the experiment had been fully explained and had a typical sleep patterns ensured by 8 h of sleep. ***fMRI acquisition*** Subjects were studied with fMRI twice, once 12h after waking from a normal night of sleep (NORM) in the laboratory and once after 36h of TSD (at 20:00). The visual Go/No-go task contained five fixation blocks (resting as baseline) interleaved with four task blocks. Each task block consisted of 36 trails, with stimulus presented for 200ms with 800ms inter-stimulus interval. The fMRI scans were conducted at a GE 3.0T Signa LX scanner with an Eight-Channel-Phased-Array Head Coil. Functional images were obtained by single-shot EPI sequence (TR: 2s, TE: 30 ms, FOV: 256 mm, 3.75mm*3.75mm in-plane resolution) of twenty 6-mm axial slices covering the entire brain and measuring the BOLD signal. High-resolution radio frequency spoiled gradient recalled acquisitions (SPGR) in the steady state anatomic images were acquired after functional imaging to allow subsequent anatomical localization of functional activation. ***Data analysis*** Functional images were processed and analyzed with AFNI (Cox, 1996) in a two-step procedure: individual time-course analysis followed by group statistical analysis. A one-sample t test against the null hypothesis of no effects was performed on the percentage of the area under the curve measure for the participants performing Go/No-go task before 36 h TSD. Paired t tests comparing before and after sleep deprivation were then performed on the mean activation values for each cluster of this combined map. The threshold for *p* value was set to 0.05.

## RESULTS

False alarm rate in go/No-go task increased significantly after sleep deprivation compared with NORM situation, along with significant decrements in hit rate. 36 h TSD induced positive and negative BOLD signals (percentage of signal changes) compared with that in rested wakefulness. The activated areas of the brain include the superior prefrontal cortex, inferior prefrontal cortex, et al. Besides, there were also some brain areas showing decrease activities after sleep deprivation such as ACC, right lingual gyrus et al.

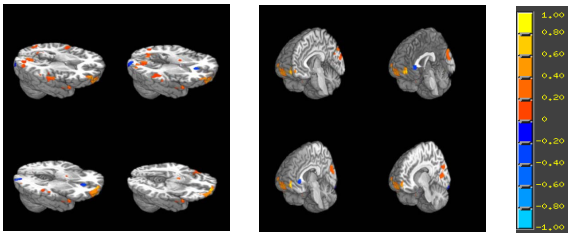


**Figure 1. Brain regions activated before and after 36 h TSD for Go/No-go tasks. Significant ACC hypoactivity was observed for Go/No-go task after 36 h TSD compared with that following a normal night of sleep. Besides, area in the right superior frontal lobe, right superior temporal gyrus and cuneus had shown elevated responsibility (P<0.05).**

## DISCUSSION AND CONCLUSION

Significant differences of hit rates and false alarm rates after 36 h TSD showed that sleep deprivation has greatly impacted people's cognitive function. Sleep deprivation lowered Go/No-go sustained, task-related activation of ACC regions. The significant activation of prefrontal lobe has shown a along with the decline performance, more attention resources are needed to perform the Go/No-go task after 36 h TSD. Compensatory recruitment is one of the particular functions of the human brain, and it is also a reason for maintaining performance when subjects are under emergency performance(Drummond et al., 2005). The results suggested that TSD were accompanied with an impact on brain functions of response inhibition and required more anti- cipation of prefrontal lobe for compensatory recruitment.

## REFERENCE

Cox RW. 1996. AFNI: software for analysis and visualization of functional magnetic resonance neuroimages. Comput. Biomed. Res. 29:162-173.
Drummond SP. 2005. Compensatory recruitment after sleep deprivation and the relationship with performance. Psychiatry Res. 140: 211-223.