Involvement of the Cerebellum in Early Proceduralization and Speeded Performance in adult TBI

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Introduction

Previous research has demonstrated that activation in the right inferior and bilateral superior cerebellar hemispheres is load dependent in verbal working memory (WM) tasks and is partially dissociable across WM conditions in healthy adults (Chen and Desmond, 2004; Desmond et al., 1997; Kirschen et al., 2005). It has been demonstrated that activation in the bilateral superior and right inferior cerebellum increases following task practice in verbal WM. Correlations were found between RT and the right inferior cerebellum after task practice during motor tasks in pediatric traumatic brain injury (TBI). A study of practice effects on cerebellar involvement in WM tasks and its relationship to the DLPFC has not been conducted in an adult neurologically impaired sample. The current study examined the role of the cerebellum in modulating new learning before and after practice in a N-back WM paradigm during BOLD fMRI acquisition in a sample of adults with TBI.

Materials/Participants

Participants:

- Nine adults with moderate to severe TBI as defined by the Glasgow Coma Scale (at least one year post-injury)
- Six age and education matched healthy controls.

Data Acquisition and Processing

- Siemans 3T Magneton Trio
- SPM5
- MarsBar region of interest toolbox
- SPSS 16.0
- Talairach Demon

Methods

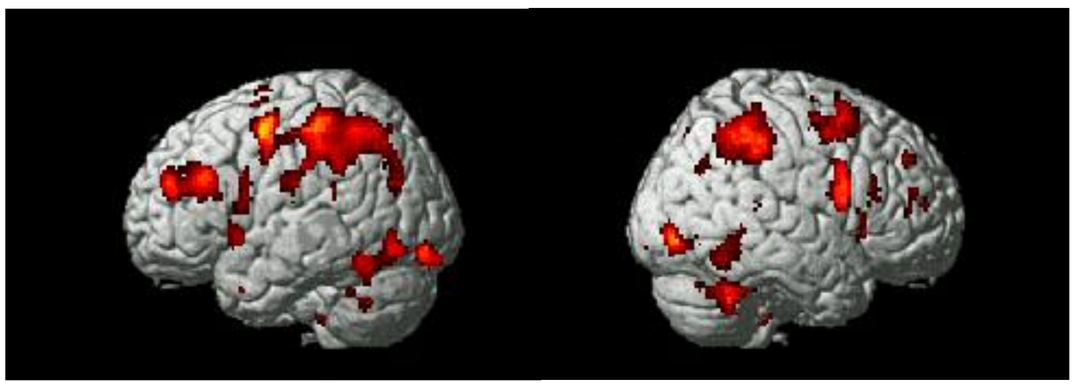
- Participants performed eight blocks of the 2-back task before practice, exited the scanner and engaged in task practice, and then re-entered the scanner and repeated 8 blocks of this WM task.
- All EPI data were realigned, coregistered to a 150-slice MPRAGE, spatiallly normalized and smoothed.
- SPM5 was used for data preprocessing and all group level analyses
- % signal change extracted with MarsBar from DLPFC and right cerebellum
- RT and BOLD relationships explored with SPSS 16.0

Hypotheses

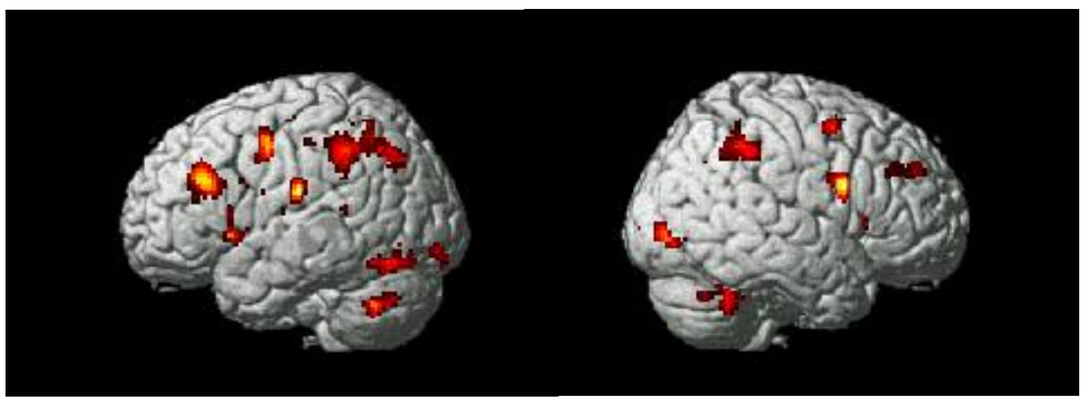
In the TBI sample:

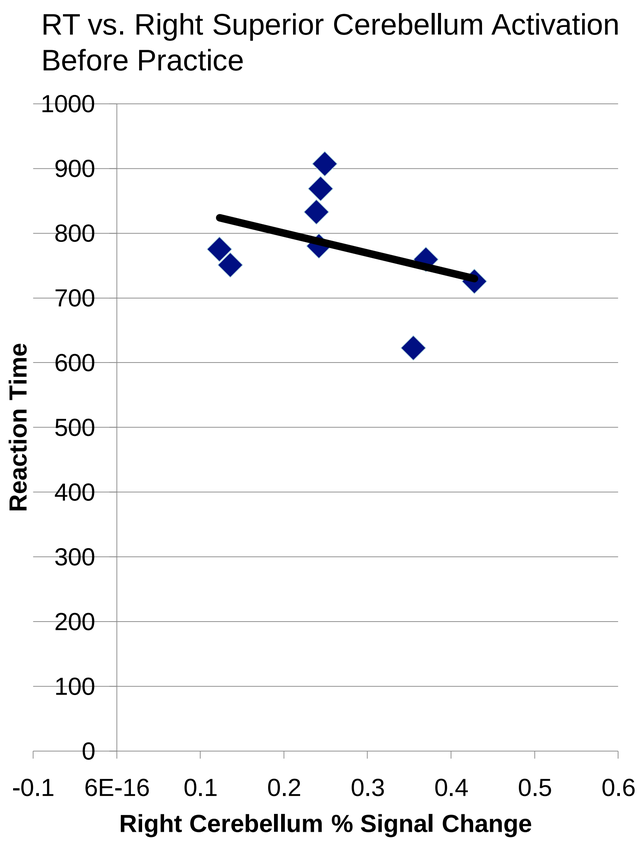
1) The bilateral superior and right inferior cerebellum will be active during the 2-back
2) Cerebellar recruitment will be positively related to RT before and after practice
3) Cerebellar activation's correlation with RT will increase after practice
4) Cerebellar activation will correlate with the DLPFC before and after practice, but this relationship will diminish after practice.

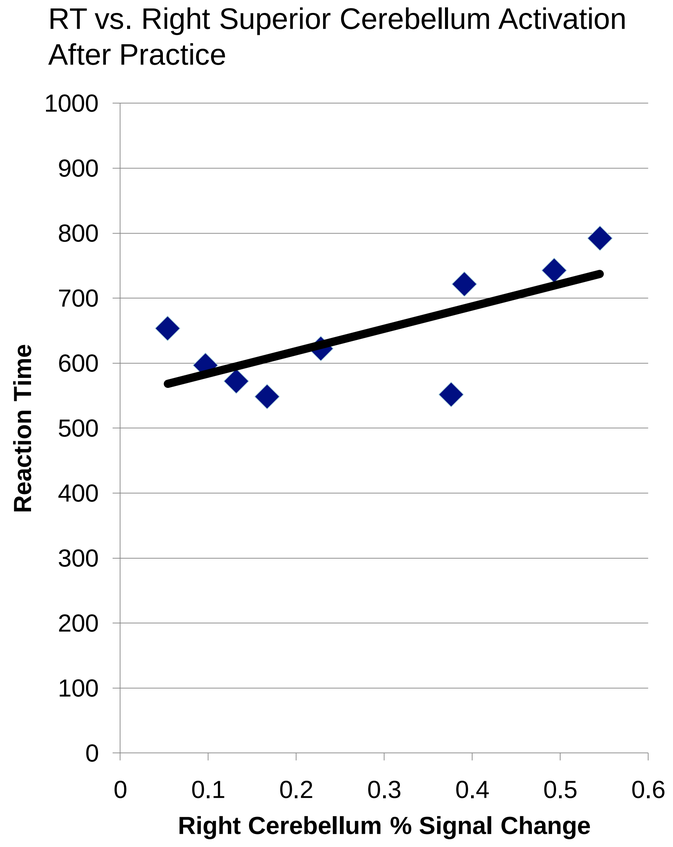
TBI Before Practice



TBI After Practice







Results

1) The bilateral superior cerebellum was active at $p<.001$
2) The right (non-significant, $R^2=.14$) and left superior cerebellum (non-significant, $R^2=.20$) exhibited weak trends toward negative correlation with reaction time before practice
3) The right ($R^2=.39$, $p=.09$) and left ($R^2=.18$, $p=.261$) superior cerebellum were positively correlated with RT after practice.
4) the right ($R^2= .64$, $p=.016$) and left ($R^2=.79$, $p=.001$) superior cerebellum were highly correlated with the left DLPFC before practice
   - The correlations between DLPFC and right ($R^2=.29$, $p=.131$) and left ($R^2=.36$, $p=.09$) superior cerebellum decreased after practice.

Discussion

The right cerebellum's role early during a task may qualitatively shift from task proceduralization in conjunction with the DLPFC to a consolidated role that responds to challenges to performance during verbal working memory in TBI. The right superior cerebellum may serve a mediating role between the contralateral DLPFC and other critical processing regions during task performance.

Future research:

-Blockwise regression of reaction time with percent signal change within runs, before and after practice in both samples.

- Analyses to detect latencies in signal amplitude change between regions

References

Chen, S.H.A., & Desmond, J.E. (2004). Cerebrocerebellar networks during articulatory rehearsal and verbal working memory tasks. *NeuroImage, 24,* 332-338.

Desmond, J.E., Gabrieli, J.D.E., Wagner, A.D., Ginier, B.L., Glover, G.H., (1997). Lobular patterns of cerebellar activation in verbal working memory and finger tapping tasks as revealed by functional MRI. *Journal of Neuroscience, 17*, 9675– 9685.

Kirschen, M.P., Chen, S.H.A., Schraedley-Desmond, P., Desmond, J.E. (2005). Load- and practice- dependent increases in cerebro-cerebellar activation in verbal working memory: an fMRI study. *NeuroImage, 24,* 462-472.