

# Breath Hold Task Significantly Correlates With Cognition Across Run and Visit

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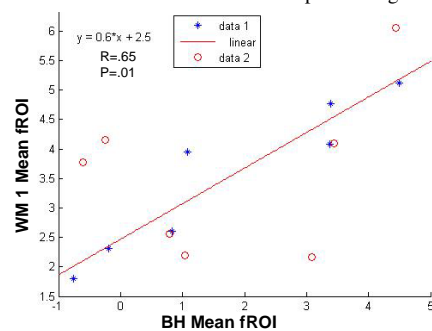
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## Introduction

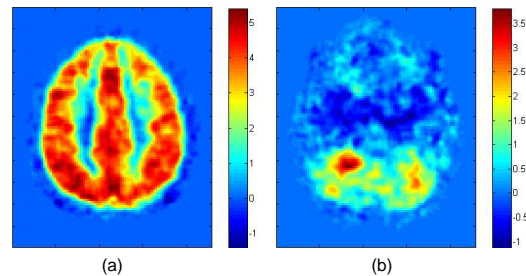
One of the fundamental challenges in multi-site fMRI is decreasing the variance among subjects, runs, visits and sites in an efficient manner. Such variables carry inherent variance that may be accounted for by establishing calibrative measures that are primarily independent of scan-specific conditions. The hypercapnic breath hold task (BH) has been shown to reduce group variance in a cognitive task using publicly available data, although demonstrated on a small sample size, at a single site and on a single visit. In preparation for a more comprehensive look at the multiple site effects on calibration it is important to validate the relationship between the BH task and cognitive tasks among different visits and runs. This study investigates the subject wise correlations that establish models for calibrating across such conditions. It is demonstrated that incorporating multiple visits into the model does not significantly alter the correlations between BH activation and working memory (WM) activation when compared to looking at single visits using multiple runs.

## Methods

The group consisted of 7 normal subjects imaged on a Siemens 3T Tim Trio System, including data from 2 visits with 2 runs of the WM task on each visit and activation from the BH task performed on the second visit. Figure 1 shows example images from the dataset. All stimulus and scanning protocols were derived from the fBIRN West Coast Traveling Subjects investigation. The BH task consisted of 8 blocks of 13.5 s normal breathing, 3 s of transitional breath holding and 13.5 s of breath holding. The WM used 4 blocks of 16 s probe and encode periods interleaved with scrambled and distractor image blocks, also 16 s long. EPI acquisition was used to acquire  $T_2^*$  weighted images (TR/TE=2000/50 ms,  $N_{acq}$ =142, MATRIX=64x64x30, Res= 3.4x3.4x5 mm). The preprocessing utilized FSL and generated z-statistic composite maps of activation. Correlation analysis was done using Matlab to draw functional ROIs (fROI) based on the cognitive task activity group results using a threshold of  $z=3.2$ . Each fROI was visually inspected for consistency and the average z-score within the fROI was averaged for each subject and task. Pearson correlation coefficients were calculated and reported. Figure 2 demonstrates the correlation found by combining two tasks on a single visit.



**Figure 2.** Mean working memory function (mean z-score, fROI) score versus breath hold activity (mean z-score, fROI). 14 fROIs across two tasks in a single visit.



**Figure 1.** Composite z-score group maps N=7, single visit. BH,(a) and WM 1 (b).

	wm1/wm2: visit 1	wm1/wm2: visit 2	visit 1/visit 2: wm1	visit 1/visit 2: wm2
All 7 Subj.	<b>0.64</b>	0.29	<b>0.67</b>	0.24
W/O Outlier	<b>0.77</b>	<b>0.63</b>	<b>0.75</b>	<b>0.60</b>

**Table 1.** Pearson correlation coefficients for all subjects before and after removal of a single outlier. Significance is denoted by bold text.

## Results

Keeping visits constant and combining data from WM 1 and working WM 2 showed significantly strong positive correlations between BH and cognition for visit 1 ( $R = .65$ ), while visit 2 did not reach significance at this threshold ( $R = .29$ ). Combining data across visits demonstrated similar results. WM task 1 was significantly correlated ( $R = .67$ ) with BH activation when combining visit 1 and visit 2 data, task 2 did not reach significance ( $R = .24$ ). Removing a single outlying subject increased the strength of each correlation, reaching significance in all four conditions. Results are summarized in Table 1.

## Discussion

The correlations found across subjects and visits demonstrates a significant relationship between the BH task, a reflection of Cerebral Blood Flow (CBF), and the BOLD signal created by the coupling of the CBF and metabolic activity. These results show that calibration is feasible across subjects when introducing the unknown factors of run and visit.

## References

1. Li TQ, Kastrup A, Takahashi AM, Moseley ME. 1998. Functional MRI of Human Brain During Breath Holding by BOLD and FAIR Techniques. *Proc. NeuroImage*. 9 243-249.
2. Thomason ME, Foland LC, Glover GH. 2007. Calibration of BOLD fMRI Using the Breath Holding Reduces Group variance During a Cognitive Task. *Human Brain Mapping*. 28 59-68.
3. Friedman, L., Stern, H., Brown, G.G., Mathalon, D., Turner, J.A., Glover, G.H., Gollub, R.L., Lauriello, J., Lim, K.O., Cannon, T., Greve, D.N., Bockholt, H.J., Belger, A., Mueller, B., Doty, M.J., He, J., Wells, W., Smyth, P.J., Pieper, S., Kim, S., Kubicki, M., Morris, S., Vangel, M., Potkin, S.G. 2007. Test-Retest and Between-Site Reliability in a Multicenter fMRI Study. *Hum Brain Mapp*. 8 958-972.

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