#### Supplementary Materials

#### Canonical-correlation analysis (CCA) method

Given two column vectors $Y=\left[Y^{1} Y^{2} ∙∙∙ Y^{n}\right]$ and $Ŷ=\left[Ŷ^{1} Ŷ^{2} ∙∙∙ Ŷ^{m}\right]$ of random variables, CCA finds optimal weighting vectors *WY* and $W\_{Ŷ}$ such that the correlation between *WYY* and $W\_{Ŷ}Ŷ$*W* is maximized, subject to linear constraints [(Yanai and Takane, 1992)](https://paperpile.com/c/Jc9ZDg/VErB). It has been shown that the canonical vectors, *WY* and *WŶ* are the eigenvectors corresponding to the largest eigenvalues of the matrices $S\_{Ŷ}^{-1}S\_{ŶY}S\_{Y}^{-1}S\_{YŶ}$ and $S\_{Ŷ}^{-1}S\_{ŶY}S\_{Y}^{-1}S\_{YŶ}$, respectively, where $S\_{Y}=Y^{T}Y$ and $S\_{Ŷ}=Ŷ^{T}Ŷ$ are the within set covariance matrices and $S\_{YŶ}=Y^{T}Ŷ$ and $S\_{ŶY}=Ŷ^{T}Y=S\_{YŶ}^{T}$ are the cross-covariance matrices of the vectors in the Y and $Ŷ$ column vectors. Here we define *Y* as the vector of BOLD signal measurements (BOLD(*t*)), and $Ŷ$ is the column vector of the convolutions between the assumed $h(t)$. $h(t)$ here is assumed to be a single Gamma function

$h\left(t;A,τ,σ\right)=A∙\{exp\left(-t/\sqrt{σt}\right)\left(\frac{e.t}{τ}\right)^{\sqrt{\frac{τ}{σ}}}, t>0 $ (A1)

 $0, t<0 $

where σ represents the width of the peak (dispersion) and τ its location. The temporal derivatives of $h(t)$ and the stimulus pattern (e.g., PETCO2(t)), and $\hat{h}(t)$ is the initialization for $h(t)$:

$Ŷ=\left[ĥ\left(t; τ, σ\right)\*X\left(t\right), \frac{∂}{∂τ}ĥ\left(t; τ, σ\right)\*X\left(t\right), \frac{∂}{∂σ}ĥ\left(t; τ, σ\right)\*X\left(t\right)\right]$ (A2)

As mentioned, CCA finds the optimal weighting vectors ($W\_{Y}$ and $W\_{Ŷ}$) that maximize the correlation between column vectors Y and $Ŷ$,

$U=w\_{Ŷ}^{1}∙ĥ\left(t; τ, σ\right)\*X\left(t\right)+w\_{Ŷ}^{2}∙\frac{∂}{∂τ}ĥ\left(t; τ, σ\right)\*X\left(t\right)+w\_{Ŷ}^{3}∙ \frac{∂}{∂σ}ĥ\left(t; τ, σ\right)\*X\left(t\right)$ (A3)

 $V=w\_{Y}∙Y(t) $ (A4)