

Variability in activated volume using canonical HRF or individual HRF

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Introduction. In many studies of functional Magnetic Resonance Imaging (fMRI), the existence of inter individual variability in the hemodynamic response function (HRF) has been demonstrated and influences the cortical activation detection^{1,2}. This is an issue in particular for the use of fMRI in clinical applications such as surgical planning. This study consists in evaluating the variability among healthy volunteers in terms of HRF features and its impact when an individual HRF is used in the detection of brain activation in the general linear model (GLM) analysis. A visual stimulation trial has been implemented to study activations in the visual cortex, as it is a passive task and has no external factors difficult to be controlled. Preliminary results are presented here. **Methods.** Images were acquired in a GE Signa Excite LX 1.5T equipment in Hospital Carlos Van Buren, Valparaíso, Chile, with the ethics committee authorization. 7 healthy volunteers have been studied, 2 of them male, 29.7±11.2 years, without caffeine consumption during the day of study. To acquire the individual HRF, an event-related design was performed, the stimulus was a chessboard flickering projection (8 Hz), using random Inter Stimulus Interval (23- 33 sec) and stimulus duration of 1 sec (number approximated events: 6)³. Simultaneously, 7 volumes of 7 mm thickness were acquired, GE-EPI sequence, TE/TR=60/1500 ms, matrix of 64 pix. To obtain an activation map, 10 volumes localized in the visual cortex were acquired in parallel with a block stimulation design. GE-EPI, TE/TR=60/3000 ms, matrix de 64 pix and the trial duration was 5 min, with 30 sec every period⁴. The signal used to estimate the individual HRF was extracted in first approximation from the most activated pixel detected using conventional GLM. Then, the temporal signal was cut and the events were re-aligned in time according to each stimulus onset. The mean value of temporal signal was subtracted and the entire signal was divided by the global maximum. Levenberg- Marquardt method was used to estimate the parameters of the double Gamma model⁵. A t- test was performed to assess normality in the residuals and to confirm that the model used was adequate. Time to initial dip (TID), time to peak (TTP) and time to undershoot (TTU) were obtained by Golden Section Search method. At the end, the individual HRF was inserted in GLM to obtain activation maps and to compare them with those obtained using the canonical HRF. Activation threshold of 5% was used. Canonical HRF used here is the one implemented by default in SPM8⁶. Moreover, the volume ratio was calculated to quantify differences in the activated volumes, defined as the ratio between the volume obtained with the individual HRF and the volume obtained with the canonical HRF.

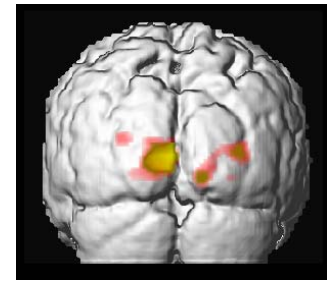


Figure 1: Activated volumes overlapping. Red: canonical HRF; yellow: individual HRF. Visual task HRF

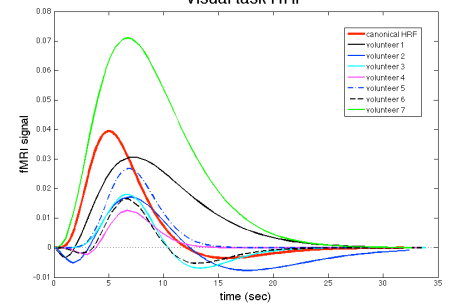


Figure 2: Individual HRF in visual task with the canonical HRF in thick red line.

Results. The goodness-of-fit have shown that the residuals of the nonlinear approximation conforms a Gaussian distribution. The protocol used in this study can detect the activated zones both event-related design and block design. Figure 1 shows a typical example of an activated volume using canonical HRF and individual HRF. Figure 2 presents the HRF of different volunteers, showing in particular presence or not of initial dip and undershoot after the main signal peak. The HRF descriptive values, expressed in Table 1, are within the values found in literature^{1,7}. Additionally our data show low variability in TTP, with a mean TTP longer than the canonical TTP. In about half of the cases, similar activation volumes are detected. In some cases whether individual HRF-based detection or canonical-based detection do not detect any activation. When focusing on the comparison of activated volumes between the two methods, all volunteers with values superior

Vol	TID (s)	TTP (s)	TTU (s)	Canonical HRF	Individual HRF	Vol. Ratio (%)
				Volume cm ³	Volume cm ³	
Canon.	None	4.97	15.75			
1	1.00	7.23	None	23.1	13.3	57.6
2	1.78	6.92	17.65	16.6	0.4	2.5
3	None	6.68	13.32	F	1.8	None
4	2.85	6.75	None	136.1	136.0	99.9
5	None	6.82	None	82.6	80.2	97.1
6	2.63	6.62	13.08	160.2	9.4	5.9
7	None	6.69	None	89.8	77.4	86.2
Mean ± Std	2.07 ± 0.85	6.82 ± 0.21	14.68 ± 2.57	84.7 ± 58.0	52.8 ± 53.8	58.2 ± 44.5

Table 1. Left. Descriptive parameters of individual and canonical HRF. Right. Activated volume obtained with the two analysis

physiological variations of the individual. The question is still open about determining a methodology to allow reducing as much as possible the inter-individual volume variability in order to provide an extension of the cortical activation so that the surgeon can take a decision with the greatest confidence possible.

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