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# Optimization of HYPR Filter for Detection of Smoking-Induced Dopamine Release in [$^{11}$C]Raclopride PET Studies

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## INTRODUCTION

- **The goal of this study is to optimize the detection of smoking-induced dopamine(DA) response.**
- For our purposes, an optimized HYPR filter will maximize the difference in the number of voxels with significant DA response between smoking and control condition.
- The problem is, at the voxel level, the dynamic PET data is generally too noisy for model fitting.
- HighlY constrained backPRojection (HYPR) is a promising image processing method for maximizing signal-to-noise ratio (SNR) of PET data without sacrificing spatial and temporal resolution (Christian et al., 2010).
- This project reports on the selection of an optimized HYPR filter to maximize the detection of DA release at the voxel level.

## METHODS

- We used [$^{11}$C]raclopride PET imaging to detect smoking-induced DA release by conducting experiments on healthy human subjects who received two B/I [$^{11}$C]raclopride scans on the HRRT: a control scan and a scan that included smoking two consecutive cigarettes while inside the PET scanner. Subjects began smoking 45 minutes after the initial tracer bolus.
- Event-by-event motion correction was incorporated into reconstruction using data from the Polaris tracking system. The dynamic data were then filtered with HYPR (Figure 1) to increase the SNR of PET TACs while preserving spatial resolution and relevant temporal behavior.
- HYPR processing was applied to the dynamic data using 4 different sizes of HYPR filters. The HYPR processed dynamic data were fitted with 'lp-ntPET' model (Normandin et al., 2012) within a dorsal-striatal mask. 'F-maps' were then created by the F-test comparing the fit of each voxel-wise TAC with lp-ntPET to its corresponding fit with the standard reference model MRTM (Ichise et al., 2003), which implicitly considers DA to be time-invariant. The F-maps were thresholded and filtered into binarized masks (Figure 2.A).
- Counts of voxels with significant dopamine response were retrieved from the binarized masks and compared between smoking and control data to get the contrast between the two scans (Figure 2.B).

### HYPR Processing Flow Chart

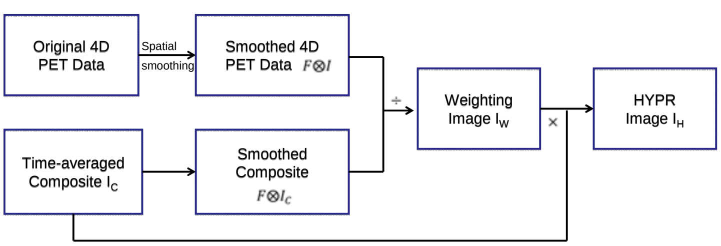


**Figure 1** The schematic of HYPR processing on dynamic PET data. The HYPR processing involves the creation of a composite image from the entire time series. The individual time frames then provide the basis for weighting matrices of the composite. The signal-to-noise ratio (SNR) of the individual time frames can be dramatically improved using the high SNR of the composite image (Christian et al., 2010).

### Image Processing Path

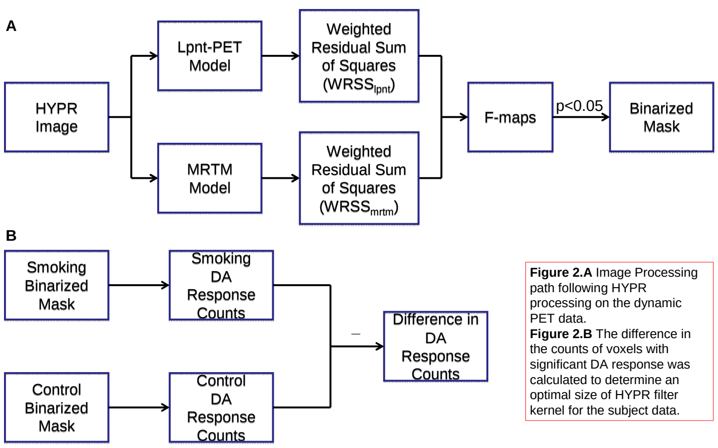


**Figure 2.A** Image Processing path following HYPR processing on the dynamic PET data.
**Figure 2.B** The difference in the counts of voxels with significant DA response was calculated to determine an optimal size of HYPR filter kernel for the subject data.

## RESULTS

- Output of HYPR processing.

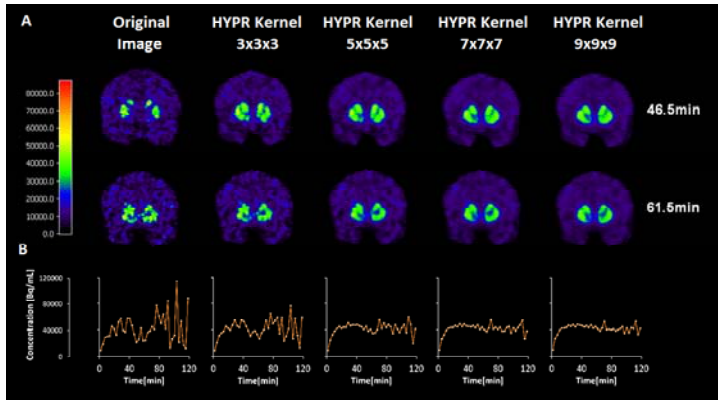


**Figure 3.A** [$^{11}$C]raclopride PET images from one subject at 46.5min and 61.5min without HYPR processing and the same data processed with 4 different sizes of HYPR kernels.
**Figure 3.B** Time-activity curves (TACs) extracted from one voxel in the left caudate of the subject using the corresponding dynamic PET data shown in Figure 3.A. The noise level of voxel-wise TACs decreased more significantly in the data processed with larger HYPR kernels. Filters with larger kernels might negatively bias the TACs by over-smoothing the image.

- Results from F-maps.

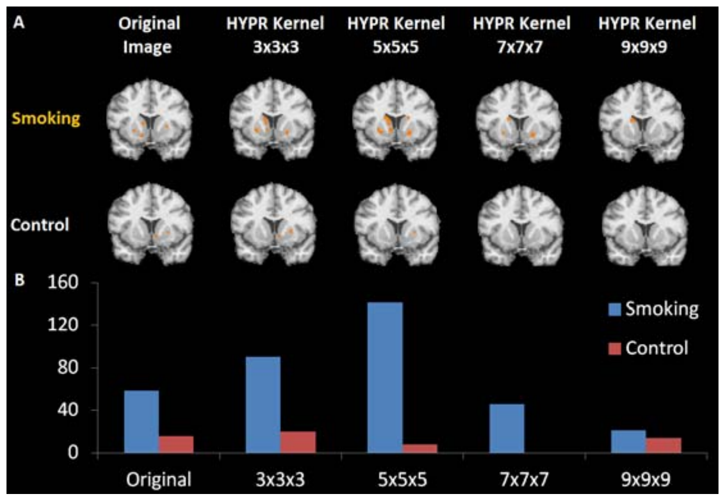


**Figure 4.A** F-maps generated from a subject's data without HYPR processing and the same data processed with 4 different sizes of HYPR filter kernels.
**Figure 4.B** The number of voxels with significant DA response counted from each F-map shown in a bar chart.

| | Smoking | Control | Difference |
|---|---|---|---|
| Original | 58 | 16 | 42 |
| HYPR Kernel 3x3x3 | 90 | 20 | 70 |
| HYPR Kernel 5x5x5 | 141 | 8 | 133 |
| HYPR Kernel 7x7x7 | 46 | 0 | 46 |
| HYPR Kernel 9x9x9 | 21 | 14 | 7 |

**Table 1** Counts of voxels showing significant DA response in F-maps generated from smoking and control data without HYPR processing and the same data processed with 4 different sizes of HYPR kernels. For this specific subject, the 5x5x5 voxels kernel produced the greatest contrast between smoking and control F-maps.

## CONCLUSION

- HYPR processing may be an effective image pre-processing method to aid in the detection of short-lived, smoking-induced DA release imaged during dynamic [$^{11}$C]raclopride PET studies. An optimal HYPR filter is useful for detecting significant deflections in striatal TACs due to DA release at the voxel level.
- There may be different optimized HYPR filters for different subjects.

## REFERENCES

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