

Study of Chemotopic Representations of Glomeruli in the Rat Olfactory Bulb

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Summary

The olfactory bulb (OB) receives input from the Olfactory Receptor Neurons through a neuropil layer composed of glomeruli. Each glomeruli is able to detect certain molecular properties of the odorant and similar properties seem to be detected by nearby glomeruli. As a consequence, the presence of certain molecular properties shows in the activation of zones in the OB which are sometimes called "modules" (Hildebrand and Shepherd 1997, Mori et al. 1999, Leon and Johnson 2003). We analyzed experimental image data of the rat olfactory bulb in order to determine where representational sites of properties are located. Using c-means clustering we partitioned the bulb into different zones, from which we wanted to determine those which could qualify as modules.

- Experimental data (Johnson et al. 2006).
- Each rat was exposed to a particular odorant.
- They imaged 2DG uptake in rat olfactory bulb.
- Images of olfactory bulb activations: 308 images · 1800 pixels.
- For each image we have a list of chemical properties and hedonistic descriptors corresponding to odorant.

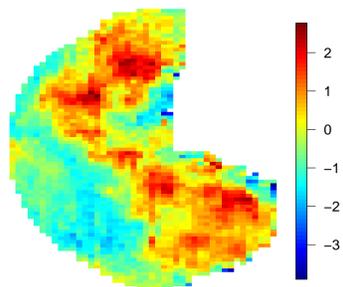


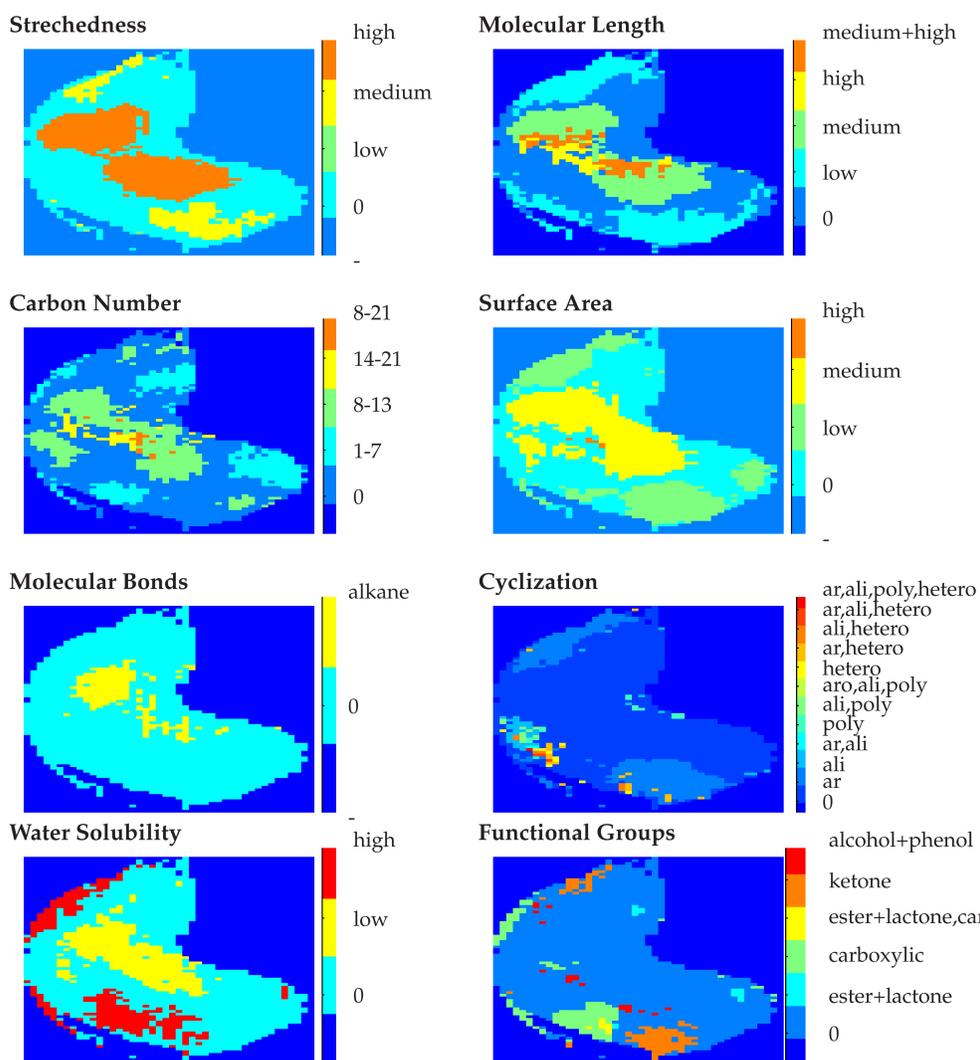
Figure shows example of glomular responses to an odorant (1-octene). Units in z-scores.

We wanted to investigate relationships between chemical properties and situation of representation in the olfactory bulb (OB).

- We calculated centroids of activations for each image by the weighted mean of activations, ... and the shift on vertical (dorsal-ventral) and horizontal (rostral-caudal) axes from the center.
- We then calculated correlations between properties and these distances.
- Here we display shifts of significant and at least medium correlations ($|\rho| \geq 0.2$).

dorsal-ventral axis	rostral-caudal axis
-molecular length	-stretchedness
-stretchedness	+vapor pressure
-freely rotatable bonds	-waxy(flavor)
-surface area	-sweaty(flavor)
+aromatic	-carboxylic acid
+vapor pressure	-carbon number
-molecular weight	
-carbon number	
+aromatic(flavor)	
-fatty(flavor)	
"+" ventral shift, "-" dorsal shift.	"+" caudal shift, "-" rostral shift.

- For each pixel, we tested whether activations were representative of a certain chemical property.
- We compared activations on images, where a property was given, with activations on images, where property was not given.
- Wilcoxon Signed-Rank test, significance level: 0.05.



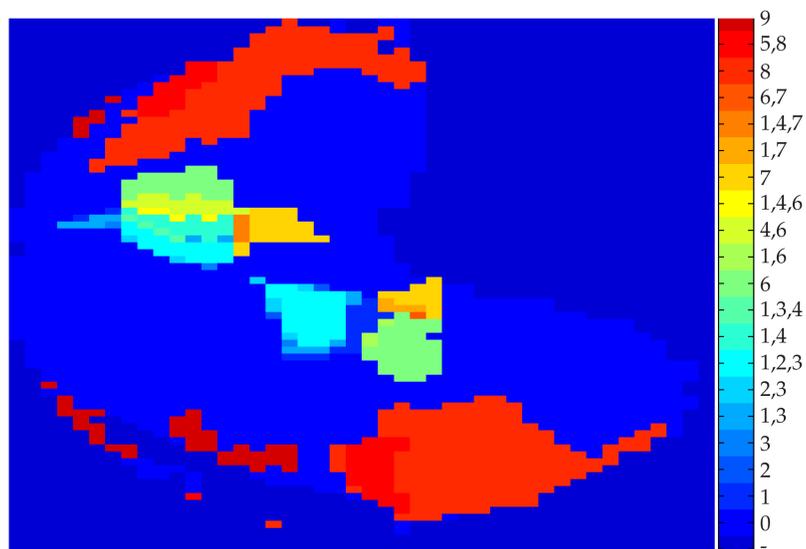
Finding Modules

What is a module?

A module has distinctive response behavior and there is a set of properties P , for which the module has elevated responses to. These properties are best represented within the region of the module.

- We applied fuzzy c-means clustering for partitioning pixels by their activations.
- We created partitions with $k = 2, \dots, 40$ clusters.
- We ran an algorithm that searched for modules within all $2 + 3 + \dots + 40 = 819$ clusters.
- For each cluster:
 - We created a list of properties with respect to which activations showed significant differences.
- For each property p
 - If there was more than one cluster found for p , for all such pairs of clusters, we tested
 - * if they had overlap,
 - * if they had significant differences with respect to property response behavior.
 - If true, we removed the property from the list of the cluster that showed less significant responses.
- We removed clusters that had empty lists and joined clusters which had exactly the same lists.

Modules



- MODULE 1 (k=21)**
high molecular length
- MODULE 2 (k=33)**
medium surface area
- MODULE 3 (k=25)**
medium molecular length
- MODULE 4 (k=35)**
medium carbon number
- MODULE 5 (k=38)**
low surface area
- MODULE 6 (k=29)**
low water solubility
- MODULE 7 (k=34)**
medium molecular length
high stretchedness
- MODULE 8 (k=6)**
few freely rotatable bonds
- MODULE 9 (k=28)**
high water solubility

- For some properties there are clear shifts in representational sites.
- We confirmed that for certain properties representational sites are clustered in zones.
- We found significant representations in clustered glomeruli for several properties.
- We explored zones which could classify as modules.

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- M. Leon and B. A. Johnson, "Olfactory coding in the mammalian olfactory bulb," *Brain Research Reviews*, vol. 42, no. 1, pp. 23-32, 2003.
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