



Interactive Exploration of Microbial Exposure, Asthma and Allergy Using a Web-Based Tool

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Abstract

Rationale

To understand the relationship among microbial exposure, asthma and allergy, analysts need new tools that facilitate intuitive exploration of complex multivariate data.

Methods

We created a customizable web-based tool that allows analysts and investigators to compare microbial exposure among subgroups of interest using a series of linked visualizations. The tool is built using standard web technology, runs in any modern web browser and is designed to work with any microbial data set. To test the tool, we looked at the relationship of microbial exposure with atopy and wheeze in data from the Inner City Asthma Consortium (ICAC) Microbiota pilot study which included complex datasets reporting relative abundance data for 49,607 array-detected bacterial taxa in living room dusts collected from houses in which infants were resident (n=104). The allergic asthmatic status at of these children was subsequently determined at 3 years of age.

Results

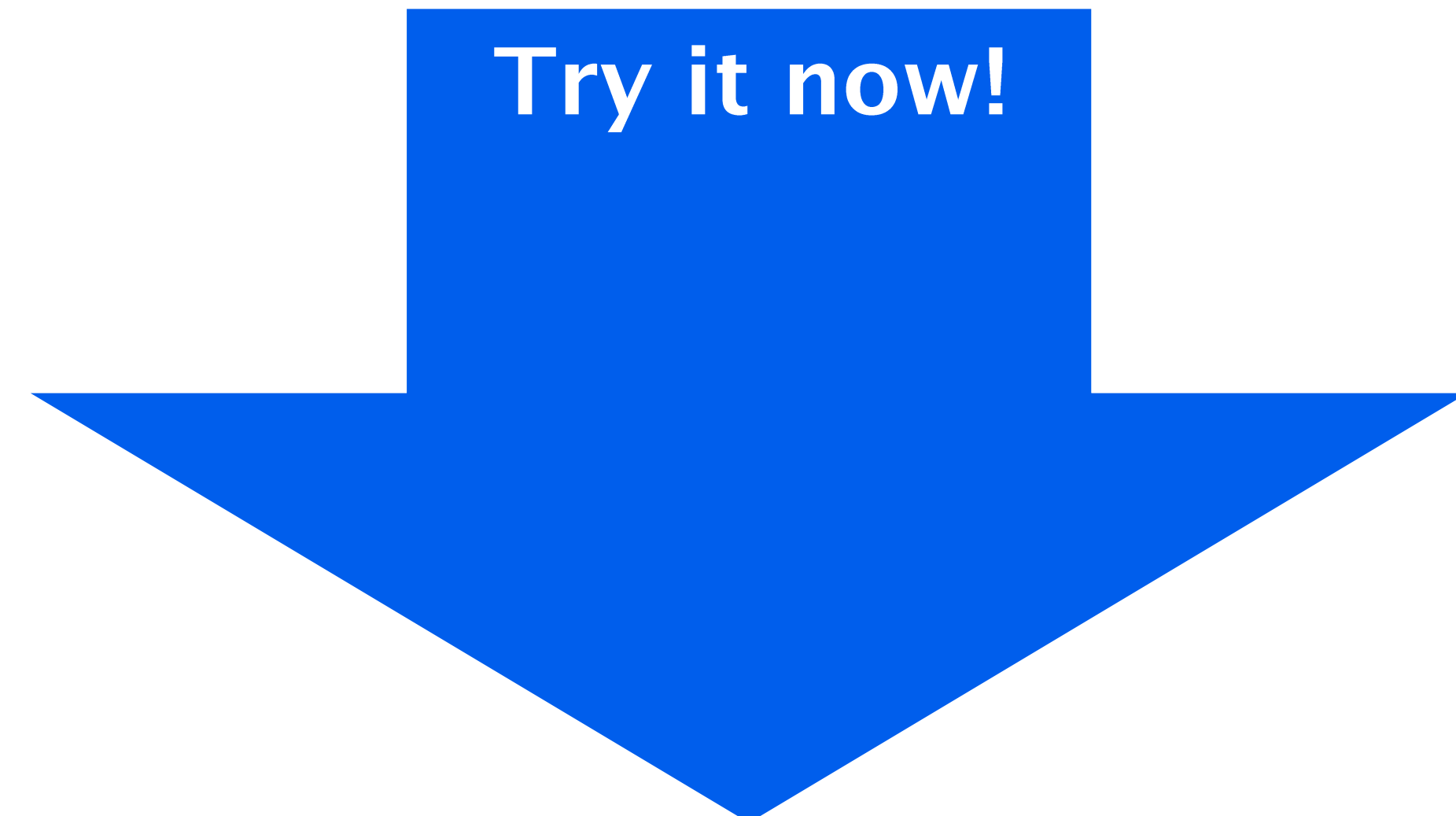
In the ICAC example, the interactive tool clearly showed an overall trend of higher microbial exposure in the first year of life in participants without evidence of atopy and wheeze at age three (full results submitted for publication). Built-in filters showed the trend to be especially strong for members of the Firmicutes and Bacteroidetes phyla, and the tool's search functionality allowed investigators to isolate specific taxa of interest.

Conclusions

This new tool provides a streamlined and intuitive user interface for a 5 million record database and facilitates investigator access to the data using rigorous statistical methods. The tool will be released for free, public use in 2014.

Live Demo

Try it now!



Microbiota Explorer - Web-Based Tool

Demo population

The online Microbiota Explorer utilizes a series of interactive plots to show the relationship between microbial exposure and participant characteristics. The tool works with any combination of study population, microbial panel and subgroups of interest.

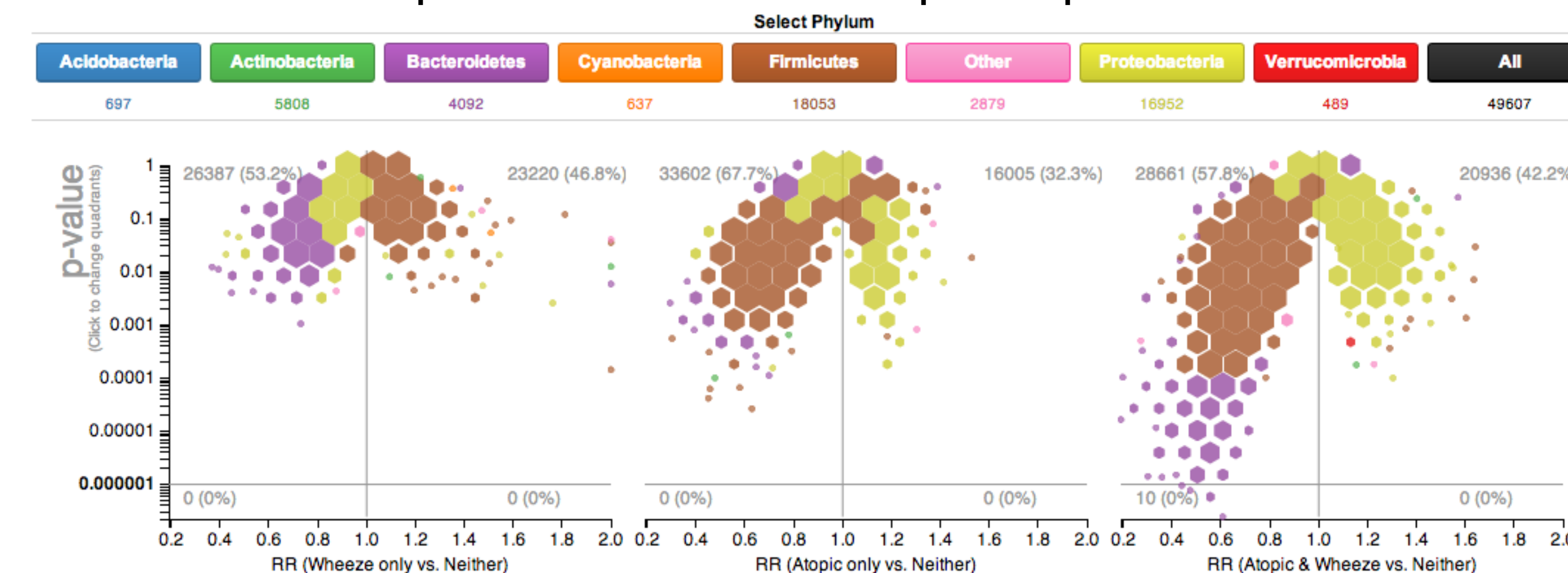
This demo shows data from 104 participants enrolled in the Urban and Environmental Childhood Asthma Study (URECA), a birth cohort in the Inner City Asthma Consortium (ICAC). Each participant had their asthma and atopic status assessed and a home dust sample was collected in the first year of life to examine early life exposure to bacterial communities in these homes.

The study participants are divided evenly among 4 subgroups:

- Evidence of Both Wheeze and Allergy
- Evidence of Wheeze only
- Evidence of Allergic Only
- Evidence of Neither Wheeze nor Allergy

Overview

The figures below show the relationships between asthma, allergy and microbial exposure in 104 URECA participants.



Each figure shows data for all 49,607 collected taxa. Unique points are plotted as circles, while similar taxa are grouped in to hexagons. The positions of the hexagons and circles are based on the ratio of the mean fluorescence intensity (i.e. the relative abundance) among groups (on the x-axis) and the associated p-value in the selected groups (on the y-axis). Hex size is based on the number of taxa present. The color of the hex is based on phylum; hex color is based on the most prevalent phylum in the hex.

Lines are drawn on each figure to divide it in 4 quadrants. Points in the quadrants can be loosely interpreted as follows:

- Upper Left - Taxa may be protective, but is not statistically significant
- Lower Left - Taxa may be protective and statistically significant
- Upper Right - Taxa may be a risk factor, but not statistically significant
- Lower Right - Taxa be a risk factor and statistically significant

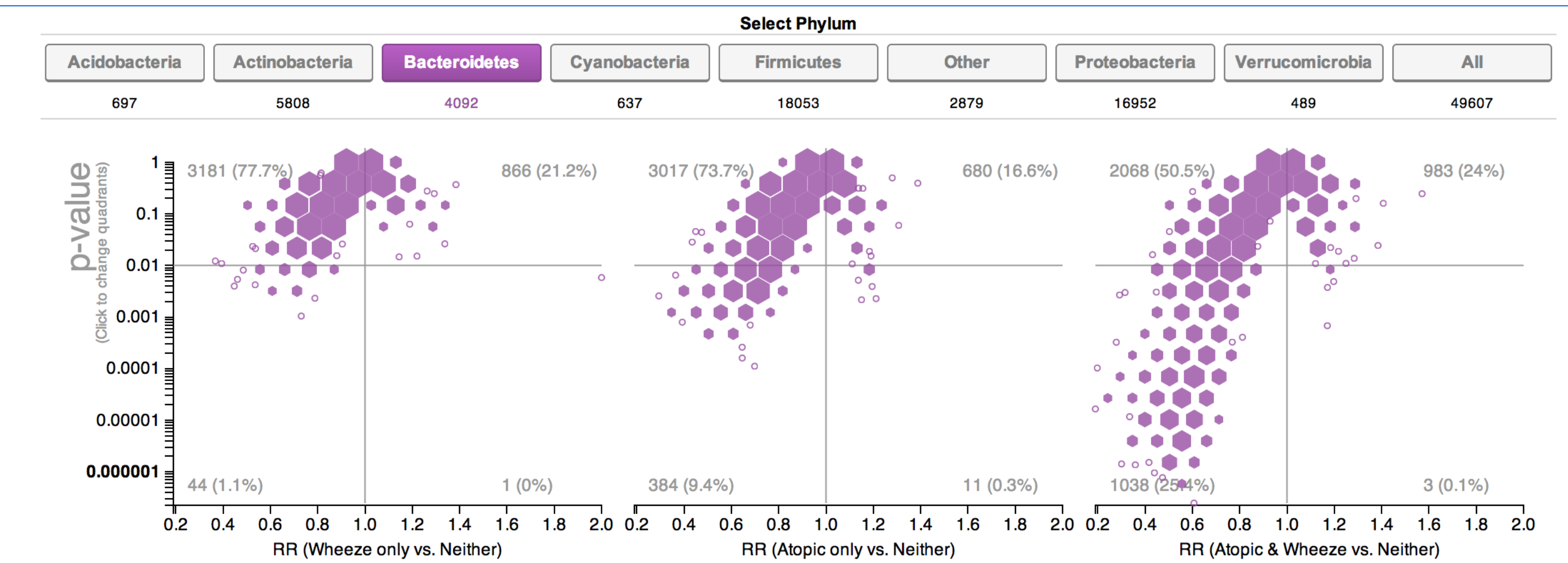
Technical Notes

The Microbiota Explorer web page runs in any modern web browser is built using standard web technologies including html, css and javascript. Graphics and data manipulation is done with the Data Driven Documents javascript library (d3js.org) and the following plug-ins and examples:

- Hexbin Package: <https://github.com/d3/d3-plugins/tree/master/hexbin>
- Hexbin Example: <http://bl.ocks.org/mbostock/4248145>
- Brushing Example: <http://mbostock.github.io/d3/talk/20111116/iris-splom.html>

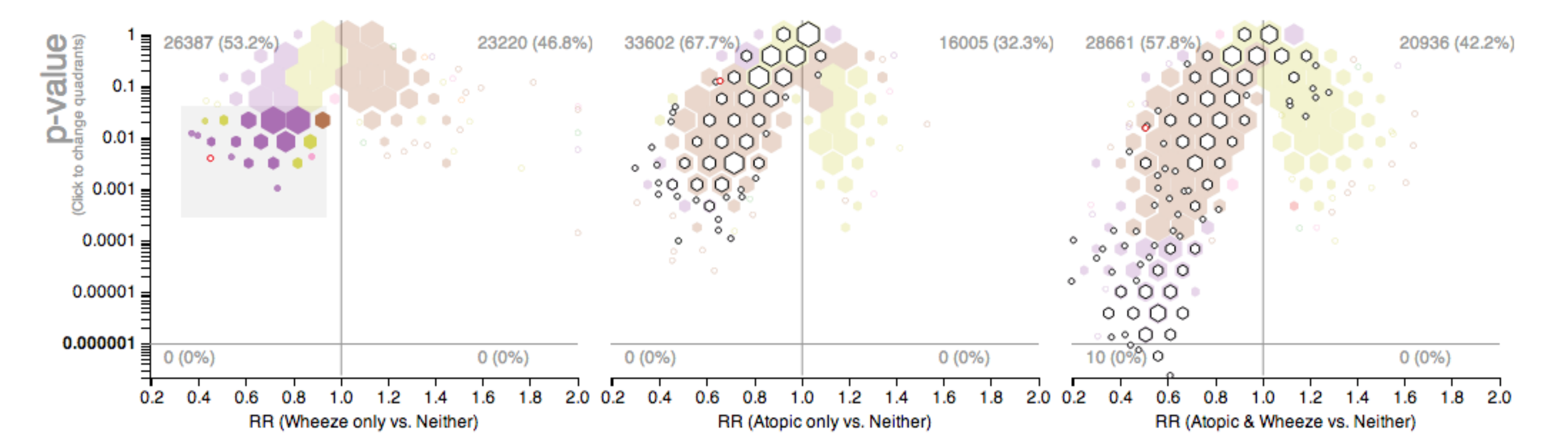
Controls

Filtering - Use the phylum buttons to filter the figures. Alt-click to select multiple phyla.



Select Taxa of Interest - Click and drag on any plot to select exposures of interest. The selected points are shown in white on the other plots and listed in a table below the plot.

Taxa-level details - Mouseover the figures or summary table to see taxa details.



Selected Taxa (n=479)

Click and drag a figure or use the search bar below to select taxa.

Search:

Phylum	Genus	Details
Bacteroidetes	Prevotella	291589 mongoose lemur feces clone ML_aa28a06
Bacteroidetes	Prevotella	300684 mongoose lemur feces clone ML_aa25f10
Bacteroidetes	Prevotella	107476 Prevotella nigrescens str. ChDC KB6
Bacteroidetes	Prevotella	585048 Microbome neonatal caves
Bacteroidetes	unclassified	353421 and White Plague Disease-Induced Changes Caribbean Coral Montastrea favosita kept aquarium 23 days clone SGUS916
Proteobacteria	Pseudoalteromonas	161247 Pseudoalteromonas elyakovii str. BS20428
Tenericutes	sfA	545311 transition and zone within nearshore anoxic basin
Actinobacteria	Actinomyces	109929 Actinomyces dentalis str. R18165
Bacteroidetes	Capnocytophaga	56144 Capnocytophaga ochracea str. ChDC OS48
Bacteroidetes	Sphingobacterium	348666 Sphingobacterium sp. str. MQL-1
Bacteroidetes	Prevotella	193335 human fecal clone RL247_aa22c11
Bacteroidetes	Prevotella	109626 Prevotella isoschellii str. NCTC 11321
Bacteroidetes	Prevotella	521915 Symbiote primary and secondary habitats Escherichia coli O157
Bacteroidetes	Prevotella	291438 mongoose lemur feces clone ML_aae88c02
Bacteroidetes	Prevotella	301191 white-faced saki feces clone Saki_aa34407
Bacteroidetes	Prevotella	295287 mongoose lemur feces clone ML_aa27d08
Bacteroidetes	Prevotella	527333 Symbiote primary and secondary habitats Escherichia coli O157
Bacteroidetes	Prevotella	120305 human rectum mucosal Biopsy clone LN69
Bacteroidetes	Prevotella	469277 Topographical and Temporal Human Skin Microbiome skin interdigital web space clone nbu107a05c1
Bacteroidetes	Prevotella	291577 mongoose lemur feces clone ML_aae87109

Details

Mouseover the figure or summary table for taxa details.

Taxa information	
OTU	67786
Phylum	Bacteroidetes
Genus	Prevotella
Family	Prevotellaceae
Details	107476 Prevotella nigrescens str. ChDC KB6
Risk Ratios	
Wheeze vs. Neither	0.45 (p=0.00398)
Atopic vs. Neither	0.65 (p=0.12555)
Both vs. Neither	0.5 (p=0.01535)

Quadrant annotations - Annotations show the number and percentage of taxa in each quadrant. Click on the numbers or ticks in the y-axis to change the p-value cut-points.

