Effects of retronasal smelling, variety and choice on appetite and satiety

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**Subject Summary**

Completed: 8 control subjects (6 non-exerciser and 2 unmatched)  
8 exerciser subjects (from the non-testosterone pool)

Average age: 34 ± 6 years

Subjects undergo:  
35 combined nasal patency and odorant identification tests (10 tests on BR1 & 2)  
7 commercial ‘scratch and sniff’ smell tests,  
Complete a food acceptability survey for every meal (~300),  
Daily mood and health surveys (~100),  
Dietary Assessment Questionnaire (DAQ)  
Entry survey, and Exit survey
Four principal areas

Nasal Patency

  Measure nasal tissue swelling and airflow in BR and compare this to PreBR baseline and PostBR recovery

  Ask subjects to self-assess nasal congestion at each test to compare with Astronaut self-assessment

Odorant Identification

  Measure subject’s ability to recognize odorants obtained from food samples taken from FARU menu and compare this with recognition of food odors not available on FARU

  Compare subject assessed ratings of odorant intensity and food liking with nasal airflow measurements to determine effect of fluid shift on smell ability
Four principal areas

**Meal acceptability**

Determine the onset and progression of reported ‘menu fatigue’ during BR

Determine whether decreased nasal airflow or smell ability are factors in ‘menu fatigue’

**Daily Mood and Health**

Record mood changes during study and compare with meal acceptability and smell ability
Nasal volume, nasal cycle, nasal airflow

- Nasal volume changes over test days, with a focus on left and right nostril volumes.
- Nasal airflow also varies over test days, with specific patterns observed.
- Graphs showing resistance and volume changes with time, indicating correlation coefficients of $R^2 = 0.91$ and $R^2 = 0.95$. 
Total Nasal Volume in BR and post-BR
Grouped by Control and Exerciser

Control = 8 subjects  Exerciser = 8 subjects

- NVTotal compared to Pre-BR
- Days
- Control
- Exerciser
Total Nasal Airflow in BR and post-BR
Grouped by Control and Exerciser

Control = 8 subjects  Exerciser = 8 subjects
Self-assessed congestion

Astronauts (60%)

Pillownauts (56%)

N = 664

N = 16

All Pillownauts had measurable nasal congestion!
Odorant Identification (OID)

- 20 odorants are presented at each OID session
- Odorants are drawn from the FARU menu and food sources not present in the FARU
- Odorants are smelt either retronasally or orthonasally or both
- Odorants are repeated 10 times over the course of the study
- Odorants are randomly assigned to each OID session and randomly ordered
Changes in retronasal and orthonasal smell ability

A change in smell ability is measured by tracking subject perception of 35 odorants from admission to the FARU through to dismissal.

The odorants are divided into three categories:

<table>
<thead>
<tr>
<th>Menu</th>
<th>Off-menu</th>
<th>Calibrates</th>
</tr>
</thead>
<tbody>
<tr>
<td>Apple sauce</td>
<td>Chipotle</td>
<td>Banana</td>
</tr>
<tr>
<td>Bacon</td>
<td>Chocolate</td>
<td>Coconut</td>
</tr>
<tr>
<td>Cheesecake</td>
<td>Cilantro</td>
<td>Flowers</td>
</tr>
<tr>
<td>Cranberry Sauce</td>
<td>Coffee</td>
<td>Peppermint</td>
</tr>
<tr>
<td>Egg Salad</td>
<td>Cilantro</td>
<td>Soap</td>
</tr>
<tr>
<td>Mac&amp;Cheese</td>
<td>Garlic</td>
<td></td>
</tr>
<tr>
<td>Mustard</td>
<td>Gingerbread</td>
<td></td>
</tr>
<tr>
<td>Oatmeal</td>
<td>Hazelnut</td>
<td></td>
</tr>
<tr>
<td>Orange Juice</td>
<td>Lime</td>
<td></td>
</tr>
<tr>
<td>Peanut Butter</td>
<td>Olive Oil</td>
<td></td>
</tr>
<tr>
<td>Potato Chips</td>
<td>Parmesan</td>
<td></td>
</tr>
<tr>
<td>Salsa</td>
<td>Raspberry</td>
<td></td>
</tr>
<tr>
<td>Salmon Cake</td>
<td>Root Beer</td>
<td></td>
</tr>
<tr>
<td>Spaghetti Sauce</td>
<td>Soy Sauce</td>
<td></td>
</tr>
<tr>
<td>Sweet&amp;Sour Sauce</td>
<td>Vinegar</td>
<td></td>
</tr>
</tbody>
</table>
Assessing retronasal and orthonasal smell ability

After smelling the odorant from the front or back of the nose, subjects rate the character of the smell:

Intensity, Familiarity, Pleasantness, Food or not Food, Like to eat.

And identify the smell from a list of descriptors
Odorant Identification results

Self-assessed Intensity

Orthonasal

Retronasal
Only 3 subjects show a slight correlation between change in airflow and odorant intensity.

Have much to do to analyze this data:
- Compare individual odorants in groupings (aromatic, trigeminal, etc.)
- Compare menu odorants with menu items
- Determine odorant response in extreme cases: First day of BR, first day of head up, etc.
- Determine how well subjects identify the odorant and change over time.
Menu Fatigue
Tracked using daily meal questionnaires

**Breakfast**

<table>
<thead>
<tr>
<th>Meal Item</th>
</tr>
</thead>
<tbody>
<tr>
<td>Scrambled egg</td>
</tr>
<tr>
<td>Sausage</td>
</tr>
<tr>
<td>Waffle</td>
</tr>
<tr>
<td>Syrup</td>
</tr>
<tr>
<td>Strawberries</td>
</tr>
<tr>
<td>Milk</td>
</tr>
<tr>
<td>Orange juice</td>
</tr>
</tbody>
</table>

Meal items are scored on a Likert scale

### Appearance and Acceptability

<table>
<thead>
<tr>
<th>Scale</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Dislike extremely</td>
</tr>
<tr>
<td>2</td>
<td>Dislike very much</td>
</tr>
<tr>
<td>3</td>
<td>Dislike moderately</td>
</tr>
<tr>
<td>4</td>
<td>Dislike slightly</td>
</tr>
<tr>
<td>5</td>
<td>Neither Like nor Dislike</td>
</tr>
<tr>
<td>6</td>
<td>Like Slightly</td>
</tr>
<tr>
<td>7</td>
<td>Like moderately</td>
</tr>
<tr>
<td>8</td>
<td>Like very much</td>
</tr>
<tr>
<td>9</td>
<td>Like extremely</td>
</tr>
</tbody>
</table>

### Interest in Consuming Food

<table>
<thead>
<tr>
<th>Scale</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Extremely reluctant to eat it</td>
</tr>
<tr>
<td>2</td>
<td>Very reluctant to eat it</td>
</tr>
<tr>
<td>3</td>
<td>Moderately reluctant to eat it</td>
</tr>
<tr>
<td>4</td>
<td>Slightly reluctant to eat it</td>
</tr>
<tr>
<td>5</td>
<td>Neither interested in it nor reluctant</td>
</tr>
<tr>
<td>6</td>
<td>Slightly interested to eat it</td>
</tr>
<tr>
<td>7</td>
<td>Moderately interested to eat it</td>
</tr>
<tr>
<td>8</td>
<td>Very interested to eat it</td>
</tr>
<tr>
<td>9</td>
<td>Extremely interested to eat it</td>
</tr>
</tbody>
</table>

### Satiety

<table>
<thead>
<tr>
<th>Scale</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>-3</td>
<td>Extremely hungry</td>
</tr>
<tr>
<td>-2</td>
<td>Hungry</td>
</tr>
<tr>
<td>-1</td>
<td>Semi-hungry</td>
</tr>
<tr>
<td>0</td>
<td>No particular feeling</td>
</tr>
<tr>
<td>1</td>
<td>Semi-satisfied</td>
</tr>
<tr>
<td>2</td>
<td>Satisfied</td>
</tr>
<tr>
<td>3</td>
<td>Extremely full</td>
</tr>
</tbody>
</table>

Meals are repeated every 11 days
During the study, a subject will eat the same meal up to 9 times, with a serving of every meal presented during pre- and post-bed rest.
General Menu Fatigue

“Interest in consuming” meals drops by 2 points during the study
Specific Menu Fatigue

“Interest in Consuming” meal items drops by 2 points during the study.
Summary

Menu Fatigue
Spectrum of Response

N5803 N6877 N6319 E8713
Specific

* *

N7750

* *

N7574 N6546 E7548
General

N8936 E7152 No Menu Fatigue

Menu Fatigue
Onset

N546 E8713
Early

N7750 E7548 N7574 N5803
Middle

N6877 N6319
Late

N6947 E5160

E8010
# Daily Mood and Health

<table>
<thead>
<tr>
<th>How you feel right now</th>
<th>Rated on a scale of 1 - 7</th>
</tr>
</thead>
<tbody>
<tr>
<td>Elated/Depressed</td>
<td></td>
</tr>
<tr>
<td>Unsure/Confident</td>
<td></td>
</tr>
<tr>
<td>Hostile/Agreeable</td>
<td></td>
</tr>
<tr>
<td>Composed/Anxious</td>
<td></td>
</tr>
<tr>
<td>Confused/Clear-headed</td>
<td></td>
</tr>
<tr>
<td>Tired/Energetic</td>
<td></td>
</tr>
<tr>
<td><strong>Today's High Point</strong>, if any:</td>
<td>Text description required</td>
</tr>
<tr>
<td><strong>Today's Low Point</strong>, if any:</td>
<td></td>
</tr>
<tr>
<td><strong>Usual State of Health (USH)</strong></td>
<td>Choose one state, if &lt; 5 note symptoms on next page</td>
</tr>
<tr>
<td>7. Unusually healthy and vigorous</td>
<td></td>
</tr>
<tr>
<td>6. Somewhat better than usual</td>
<td></td>
</tr>
<tr>
<td>5. In typical health for me</td>
<td></td>
</tr>
<tr>
<td>4. Not quite 100%</td>
<td></td>
</tr>
<tr>
<td>3. Not feeling well, but able to eat my meals and complete tasks</td>
<td></td>
</tr>
<tr>
<td>2. Missed test/activity or a meal due to a health issue</td>
<td></td>
</tr>
<tr>
<td>1. Need medical care outside of FARU</td>
<td></td>
</tr>
</tbody>
</table>
Daily Mood and Health Results

Change of Mood

Most subjects remained in positive mood throughout the study.
Daily Mood and Health Results

Usual State of Health

Most subjects chose “typical health” (5) throughout the study, and chose “not quite 100%” (4) in the early and post-BR phase.
Daily Mood and Health Results

High and Low Points

Low compliance may be due to the phrase “if any”
Daily Mood and Health Results

High points
Talking with wife, or family visits
Workouts
Food
Going outside
Massage
Showers
Ice cream
Visitors (astronauts, BBC)
Reconditioning
Getting own room
Social interactions
Birthday
Personal achievements
Specific tests (MRI, FTT, NP/OID)
None

Low points
Biopsy
Muscle soreness
Headache
Food
Irritation with staff
Bad news from outside
Changes in posted schedule
Waking up early
Hunger
Specific tests (MRI, Tilt tests, NP/OID)
None
Data Sharing

Gianmarco Vizzeri
Intraocular pressure
and nasal tissue swelling

Rachael Seidler
Anatomical images of
nasal passages
Data Analysis and Data Sharing

What we have but haven’t processed

- **Odorant Identification data**
  - Much to do to understand the response to individual odorants and which parts of this data will benefit food manufacturing for space environments

- **Nasal Patency data**
  - Understanding the deeper nasal response: MRI anatomical data makes this possible.
  - How the nasal response fits into the whole head response to fluid shift (VIIP).
Data Analysis

What we have but haven’t processed

• **Menu Fatigue** and DMH data
  • Understanding the factors that precipitate Menu Fatigue: Mood? Physiology? Environment? Can onset be defined?
  • More robust data about mood change would be appreciated
HISEAS Mars Exploration Analog

- **HISEAS data**
  - A crew of six were isolated for four months in 2013
  - We have data on Nasal Patency, Odorant Identification, and Menu acceptability as a control data set for the BR subject data
  - HISEAS offers opportunities for external research projects
  - Currently nearing the end of HISEAS 2 (4 month mission started in April this year), and have an 8 month and 12 month mission funded for 2014 and 2015
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