What are the prerequisites for the establishment of a pig model to investigate the mechanisms of conditioned food aversion in humans?

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UMR Livestock Production systems, Animal and human Nutrition
Feeding behaviour in human and animals
research and consumption of food and drink

• maintain vital functions: survival, reproduction

but appears to be also driven
• by pleasure: hedonic value
• by sociocultural influence

Regulation of food ingestion:

• research of high-energy foods, avoidance of toxic foods,
• sensorial characteristic of food (taste, odour, texture, visual cues),
• post-ingestive consequences associated to the sensorial characteristic of food or contextual events of intake.

➤ importance of aversion mechanisms in food selection
Socio-economic and medical context related to food aversions in humans and pigs

Feeding transition
New diets

Neophobia

Anorexia

in chemotherapy-treated patients
in hospitalised elderly patients

Aversion

Optimisation of production

Welfare improvement

Therapeutic applications

Food diversification
Pig as a model for research in human cognitive abilities

Close phylogenetically:
- Cognition: morphology / physiology
- Omnivorous feeding regimen

Comparative table:

<table>
<thead>
<tr>
<th>Species</th>
<th>Brain Weight (g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Human</td>
<td>1300 g</td>
</tr>
<tr>
<td>Primate</td>
<td>300 g</td>
</tr>
<tr>
<td>Pig</td>
<td>180 g x 4</td>
</tr>
<tr>
<td>Rat</td>
<td>10 g</td>
</tr>
</tbody>
</table>
Experimental paradigm to study conditioned food aversion

Pavlovien associative learning (Pavlov, 1927)

Conditioned stimulus SC = sensorial characteristic of food

Flavoured diet using essential oils

Unconditioned stimulus SNC = Negative ingestive consequences

Injection of emetic substance after the meal ingestion → visceral illness

Associative learning

Conditioned response evaluated by behaviour: choice test → learning brain image in anaesthetized pigs → central integration
Prerequisites for the establishment of a pig model to investigate conditioned food aversion

1/ Emetic substance?

2/ Flavoured diet?

3/ Flavour detected as isolated sensory modality?

4/ Brain activation in anaesthetized pig during flavour exposure after a conditioned aversion
1/ what emetic substance?

- Control diet supplied / meal duration: 30 min / 4 trials
- Substance: apomorphin, veratrin, erythrocyn, lithium chloride
- Injection of substance just after the end of the meal
- Behavioural recording during 1h after the injection: emetic response

**Methods**

**Emetic response after the injection of substance**

<table>
<thead>
<tr>
<th>Apomorphin</th>
<th>Veratrin</th>
<th>Erythrocyn</th>
<th>Lithium Chloride</th>
</tr>
</thead>
<tbody>
<tr>
<td>-</td>
<td>-</td>
<td>-</td>
<td>+</td>
</tr>
</tbody>
</table>

**Emetic response to LiCl injection: low vomiting latency (min)**

<table>
<thead>
<tr>
<th>g/ml saline NaCl</th>
<th>Duodenal</th>
<th>Gastric</th>
<th>Peritoneal</th>
</tr>
</thead>
<tbody>
<tr>
<td>6/150</td>
<td>5-10</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>6/50</td>
<td>5-10</td>
<td>-</td>
<td>20-30</td>
</tr>
<tr>
<td>4/50</td>
<td>&gt;30</td>
<td>&gt; 60</td>
<td></td>
</tr>
<tr>
<td>9/50</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Duodenal 6g in 50ml saline
### Three-choice tests

<table>
<thead>
<tr>
<th>Solubilised essential oil</th>
<th>Concentration % (total oil)</th>
<th>Averaged choice rank</th>
<th>Deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cinnamon</td>
<td>1</td>
<td>1.5</td>
<td>0.5</td>
</tr>
<tr>
<td>Thyme</td>
<td>5</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>Orange</td>
<td>5</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>Cinnamon</td>
<td>1</td>
<td>1.25</td>
<td>0.5</td>
</tr>
<tr>
<td>Thyme</td>
<td>2</td>
<td>1.75</td>
<td></td>
</tr>
<tr>
<td>Orange</td>
<td>2</td>
<td>1.7</td>
<td></td>
</tr>
<tr>
<td>Cinnamon</td>
<td>2</td>
<td>1.75</td>
<td>0.25</td>
</tr>
<tr>
<td>Thyme</td>
<td>5</td>
<td>1.75</td>
<td></td>
</tr>
<tr>
<td>Orange</td>
<td>5</td>
<td>2</td>
<td></td>
</tr>
</tbody>
</table>

Choice rank according to the level of the refusal weight in each trough rank: 1, 2 or 3; averaged values on 4 pigs/test

Slightest deviation of differences
3/ Flavour detected as isolated sensory modality?

Conditionned aversion by flavoured diet

flavour -> digestive troubles by injection of emetic substance.
flavour: taste and smell

Detection of flavour as isolated sensory modalities

Odour diffused in the ambiant air just above a standard diet

Two-choice test: standard diet in two troughs

• 8 pigs tested
• essential oil tested: Cinnamon, Thyme
• negative odour: air odorized with essential oil previously associated with digestive troubles

Food discrimination according to hedonic value
4/ Brain imaging results

Image acquisition -> single photon emission Tomography (SPECT)
Spatial processing and statistical analysis -> statistical Parametric Mapping

Conditioned aversion stimulus vs Control stimulus

Higher activation of specific areas:
- Medulla - Olfactory bulb - Somatosensory association cortex
- Primary visual cortex
- Perirhinal cortex - Anterior prefrontal cortex

structures related to:
- olfactogustatory sensations: perception of essential oil
- sensory associative processes: unconscious visual image of food
- contextual memory
**Conclusion**

**Behavioural approach:** establishment of clear-cut aversion for flavoured diets associated to visceral illness

**Brain imaging approach:**
differential brain activation according to experience with flavour
  ➔ unconscious cognitive dimension evoked by flavour
  ➔ sensory image of food

Pig model of conditioned food aversion

Further studies using the pig as a model in biomedical research to explore the mechanisms of food aversion and their consequences on nutrition and health.
Thank you for your attention