Module 3

Physiological measures of welfare

Learning objectives

• To understand the relationship between welfare and physiology
• To examine how the autonomic system (ANS) is associated with changes in welfare
• To understand how measurement of ANS responses can be used to assess welfare
• The pros/cons of different measures for assessing welfare

Summary of content

• Autonomic nervous system
• SAM & PN systems
• Measures:
  - Heart rate
  - Blood pressure
  - Respiratory rate
  - Catecholamines
  - Adrenal habituation
  - Enzymes & metabolites
• Limitations of ANS
• Conclusions

Definition of animal welfare (physical status)

“Animal welfare is the physical and psychological state of an animal as regards its attempt to cope with its environment.”

Professor Donald M Broom
Colleen Macleod Professor of Animal Welfare
University of Cambridge
UK

Change in welfare

= Change in these states
= Physiological responses
**Autonomic Nervous System (ANS) 自律神經系統**

- Sympathetic adrenal medullary system (SAM) 交感神經系統
- Parasympathetic nervous system (PNS) 副交感神經系統

---

**SAM Process 交感機制**

- CNS 中樞
- Adrenal medulla 腎上腺髓質
- Heart 心跳血壓 (sinoatrial node)
- Catecholamines 茶鹼胺

**SAM effects 交感機制之效果**

- Increased cardiac output:
  - Heart rate (Tachycardia)
  - Cardiac muscle contraction
- Increased blood to muscles:
  - Peripheral vasoconstriction
  - Contraction of the spleen
- Increased air intake:
  - Respiratory rate
  - Bronchiole relaxation

---

**PNS System 副交感神經系統**

- PNS = Regulates SAM system
  - PNS system
  - Heart (sinoatrial node)
- Reduces cardiac output: 降低心臟輸出
  - Heart rate (Bradycardia)

**Measurement of ANS 自律神經測定**

- ANS response = Acute measure 急性測定
- Pathological changes = Chronic measure 慢性測定

<table>
<thead>
<tr>
<th>Direct</th>
<th>Indirect</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heart rate</td>
<td>Adrenal habituation</td>
</tr>
<tr>
<td>Catecholamine levels</td>
<td>Adrenal enzymes</td>
</tr>
<tr>
<td>Respiratory rate</td>
<td>Blood pressure</td>
</tr>
</tbody>
</table>

---

Module 3
Measurement technique assessment

Pros and cons of measurement techniques in terms of:

- Invasiveness
  - Severity of implantation
- Restriction
  - Restraint 保定 required
- Disturbance
  - Effect of sampling on parameter

Heart rate

Indicates welfare at that point in time

Change in welfare

↑ H.R.  Tachycardia  (Active response)

↓ H.R.  Bradycardia  (Passive response)

Heart rate increase

- Sheep heart rate ↑ on exposure to:
  - Strange person (↑ 45 bpm)
  - Strange person and dog (↑ 79 bpm)

(Baldock & Sibly, 1990)

Heart rate decrease

- Rodent heart rate ↓ when disturbed by:
  - Threatening visual cue
  - Sudden noise

(Baer & Hofer, 1970)

Heart arrhythmias

Indicator of chronic welfare changes

- Tachycardia: 加強心跳
  - Repeated restraint = arrhythmias in squirrel monkeys (Corley et al., 1973)
- Bradycardia: 降低心跳
  - Repeated noise and threatening stimuli = arrhythmias in rats (Hofer, 1970)

Heart rate measurement

<table>
<thead>
<tr>
<th>Method</th>
<th>Invasive</th>
<th>Restrictive</th>
<th>Disturbing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Direct e.g. stethoscope</td>
<td>×</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Tethered e.g. polar monitor</td>
<td>×</td>
<td>✓</td>
<td>x</td>
</tr>
<tr>
<td>Telemetry</td>
<td>✓</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Remote</td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
</tbody>
</table>
**Blood pressure**

Measure of chronic welfare change
- Change in welfare = change in blood pressure (B.P.)
- Aggression = Directional B.P. in mice
  (Henry et al., 1975)
- Daily immobilisation = Directional B.P. in rats
  (Lamprecht et al., 1973)

**Catecholamines**

- The adrenal medulla releases:
  - Adrenaline (Epinephrine)
  - Noradrenaline (Norepinephrine)
- Specificity:
  - Adrenaline = Psychological stimuli
  - Noradrenaline = Physical stimuli
- Very acute measure:
  - Immediate release (Rat: 1-2 seconds)
  - Short half-life (Rat: 70 seconds)

**Catecholamine examples**

- Rat catecholamine levels with:
  - Cage door opening
  - Handling and moving between cages
  - Restraint (40 fold)
  (Kvetnansky et al., 1978)
- Defeated male guinea pigs show significantly higher catecholamine levels compared to victors
  (Sachser & Lick 1989)

**Respiratory rate**

- Assessment of present state
- Easy to observe
- Closely correlated with heart rate
- Lamb respiratory rate following:
  - Tail docking
  - Castration
  (Mellor & Murray, 1989)

**Catecholamine measurement**

- Rapid sampling required

<table>
<thead>
<tr>
<th>Method</th>
<th>Invasive</th>
<th>Disturbing</th>
<th>Restrictive</th>
<th>Variable</th>
</tr>
</thead>
<tbody>
<tr>
<td>Catheterisation</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>Urine</td>
<td>x</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Autopsy</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td></td>
</tr>
</tbody>
</table>

- Analysis: High performance liquid chromatography
Adrenal habituation

- Chronic welfare assessment
- Repeated problem leads to:
  - ø catecholamine to that stimulus (habituation)
  - × catecholamine to other stimuli (sensitisation)
- Assessment:
  - Assess levels continuously
  - Before and after stressful period

Adrenal habituation example

Repeated restraint of rats:
- Day 27 compared to day 1
  - Restraint induced ø catecholamine production
  - Different stressor induced × catecholamine production
  - (Konarska et al., 1989)

Adrenal enzymes

- Enzymes involved in catecholamine production and breakdown (post-mortem):
  - Adrenal tyrosine hydroxylase (TH)
  - Phenylethanolamine-N-methyl transferase (PNMT)
  - Monoamine oxidase (MAO)
- Social stress in mice = ø levels of TH, PNMT and MAO
  - (Henry et al., 1971)

Vanillylmandelic acid (VMA)

- Metabolite of catecholamine breakdown
  - Blood levels
  - Urine levels
- VMA levels correlate with self-report of stress in humans (Brantley et al., 1988)

Limitations to ANS - 1

1. Other factors causing changes
   - Activity
   - Metabolism
   - Timing of sample

2. Disturbance due to measurement
   - Human presence, handling, restraint and sampling method

Limitations to ANS - 2

3. Individual differences
   - High and low responders
     - Rats (Livezey et al., 1985)
   - Dominance status
     - Tree shrews (von Holst, 1986)
   - Sex
     - Rats (Livezey et al., 1985)
Conclusions

• ANS response = Acute measure
• Chronic change = Chronic measure
• Potential parameters:
  – Direct: Heart rate, blood pressure, respiratory rate and catecholamines
  – Indirect: Adrenal habituation, enzymes & metabolites
• ANS measures are limited, so care is required in their assessment