Physiological aspects of stress and welfare

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Content

- Introduction to concepts
- Tools & indices
  - Stress metabolites
  - Heart & respiration rate
  - Health monitoring & pain
- Conclusions & outlook

Animal welfare

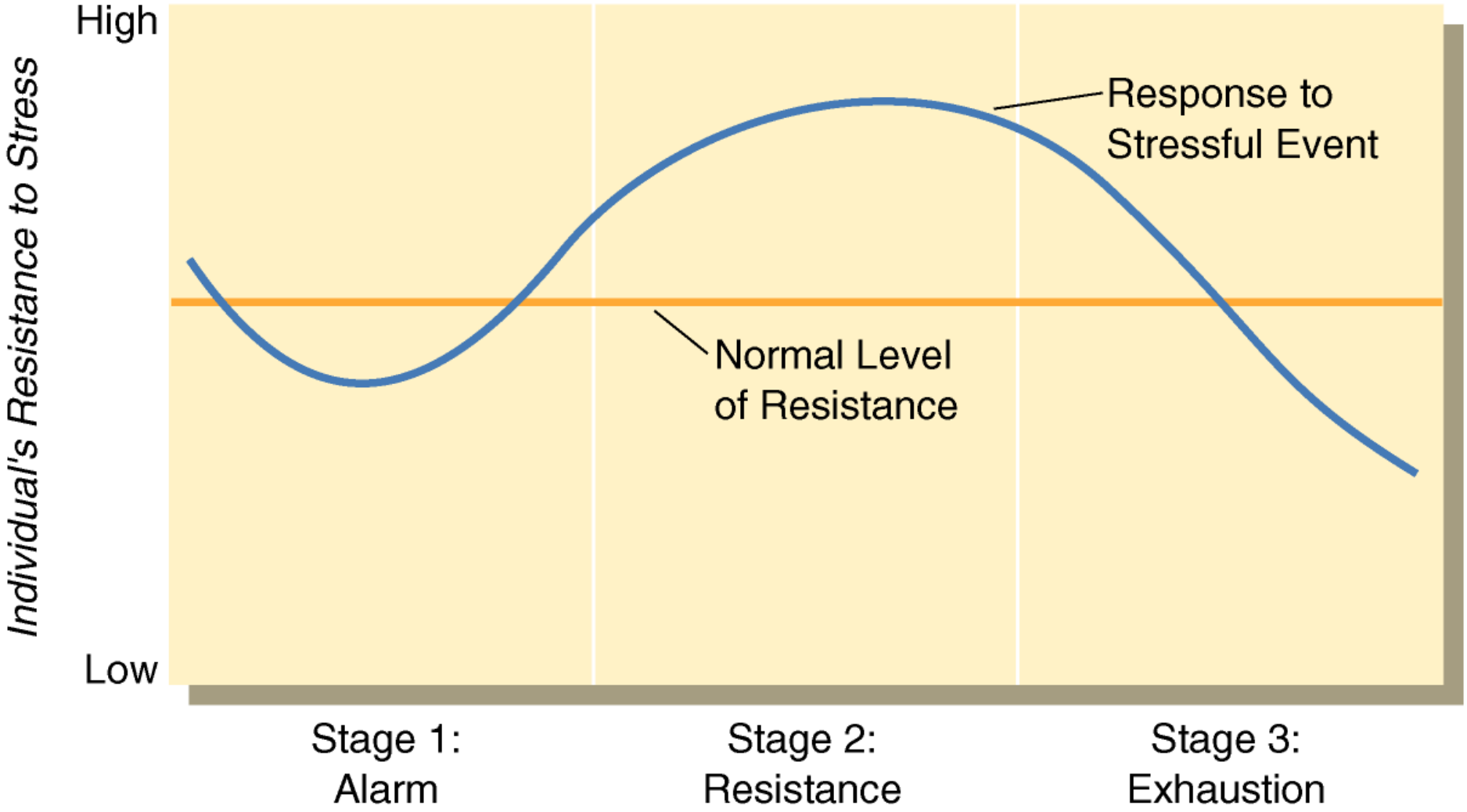
- **Physical & psychological well-being of animals**
- **Human concern for animal welfare > legislation** §

Main components:

- **biological functioning (growth performance, health & reproduction)**
- **affective states (suffering, pain, emotions)**
- **expression of „normal“ species-specific behaviours**

- **Five freedoms (from hunger & thirst, discomfort, pain, injury & disease, fear & distress, expression of normal behaviour) FAWC, 1993**

General Adaptation Syndrome (Selye, 1936)



Criticism: Exhaustion does not necessarily occur, denies mental involvement (perception) and other response factors

Fight and Flight Syndrome / Alarm Reaction (*Walter Cannon*, 1914) ADRENALIN (Stotz, 1904)

- release triggered by pain, fear etc.
- alimentary canal cease
- shift of blood flow to limbs and CNS, away from GI system
- increase cardiac vigor
- augmentation of blood sugar

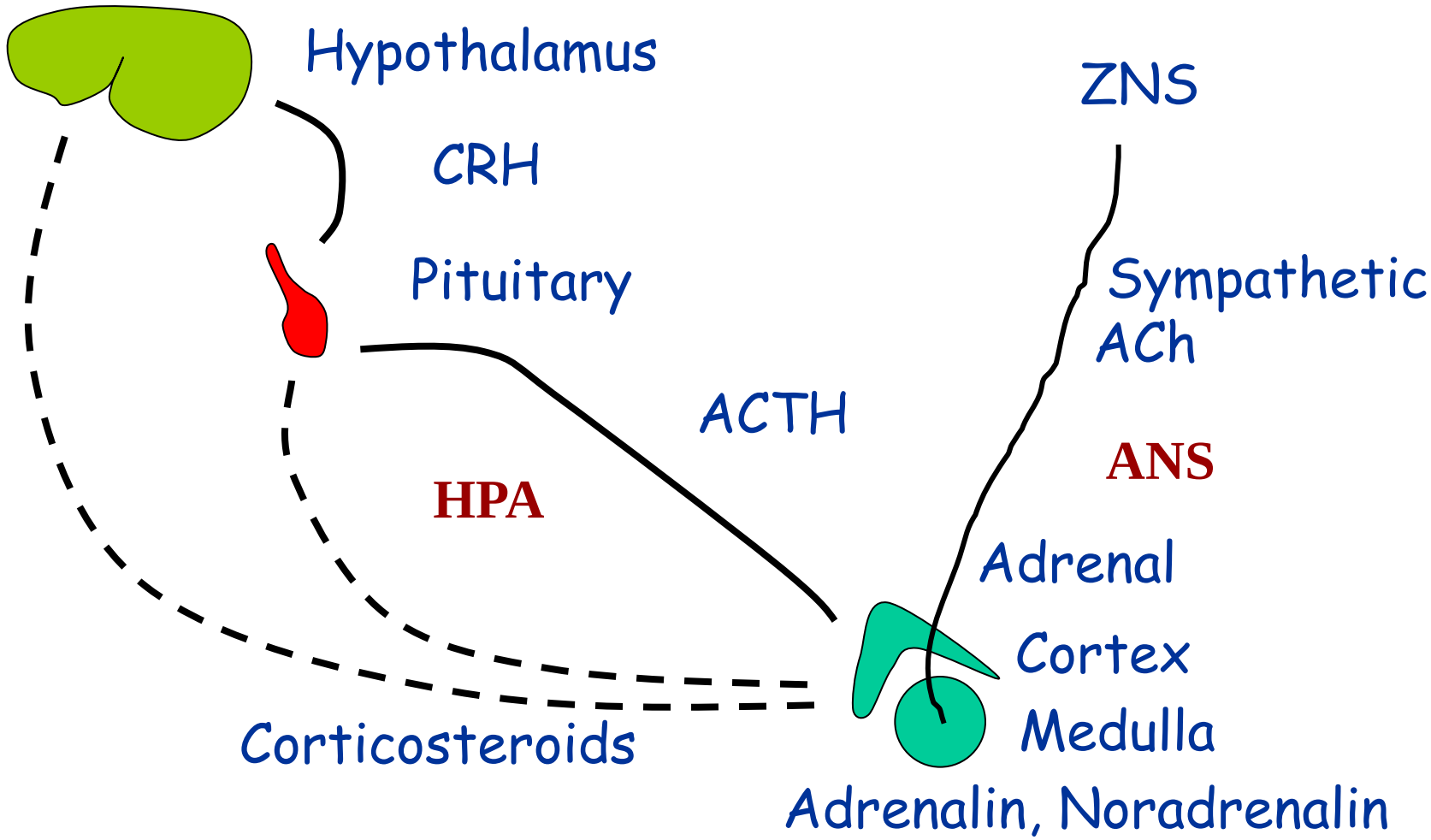
Cannon (1932): Homeostasis= Maintenance of internal stable condition

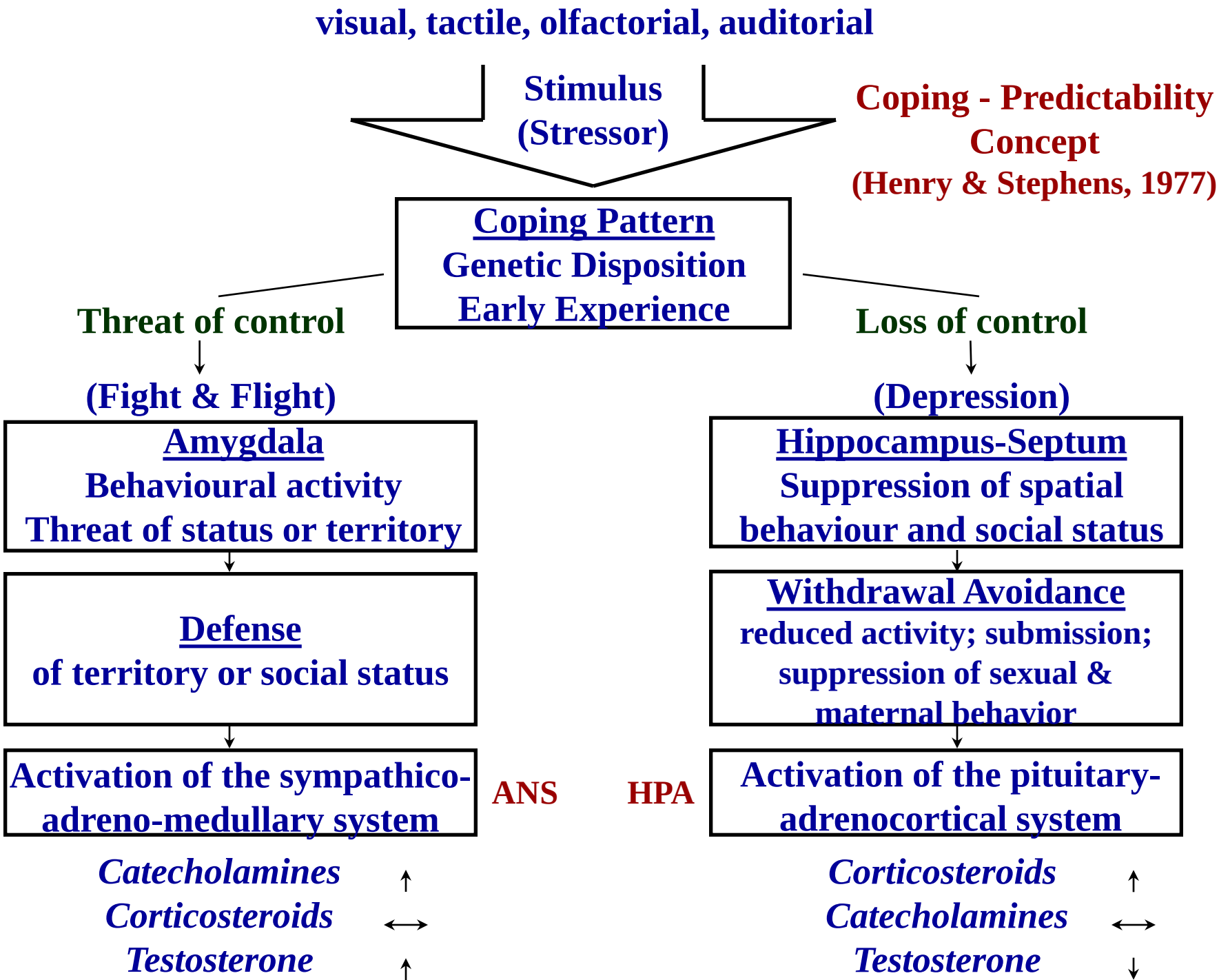
Psychophysiology

- **describes the body‘s physiology to perceived stressors suggesting that the stress response is a mind-body phenomenon (Mason 1971; Lazarus, 1974)**

  > in contrast to the Selye concept of non-specifity

Classical HPA regulation and sympathetic activation ANS




visual, tactile, olfactorial, auditorial
Stimulus
(Stressor)
Coping - Predictability
Concept
(Henry & Stephens, 1977)
Coping Pattern
Genetic Disposition
Early Experience
Threat of control
(Fight & Flight)
Loss of control
(Depression)
Amygdala
Behavioural activity
Threat of status or territory
Hippocampus-Septum
Suppression of spatial
behaviour and social status
Defense
of territory or social status
Withdrawal Avoidance
reduced activity; submission;
suppression of sexual &
maternal behavior
Activation of the sympathico-
adreno-medullary system
ANS
HPA
Activation of the pituitary-
adrenocortical system
Catecholamines
Corticosteroids
Testosterone
Corticosteroids
Catecholamines
Testosterone

Coping type

depends on individual characteristics, type and duration of stressor, predictability and controllability of the situation

Active Coping: ANS

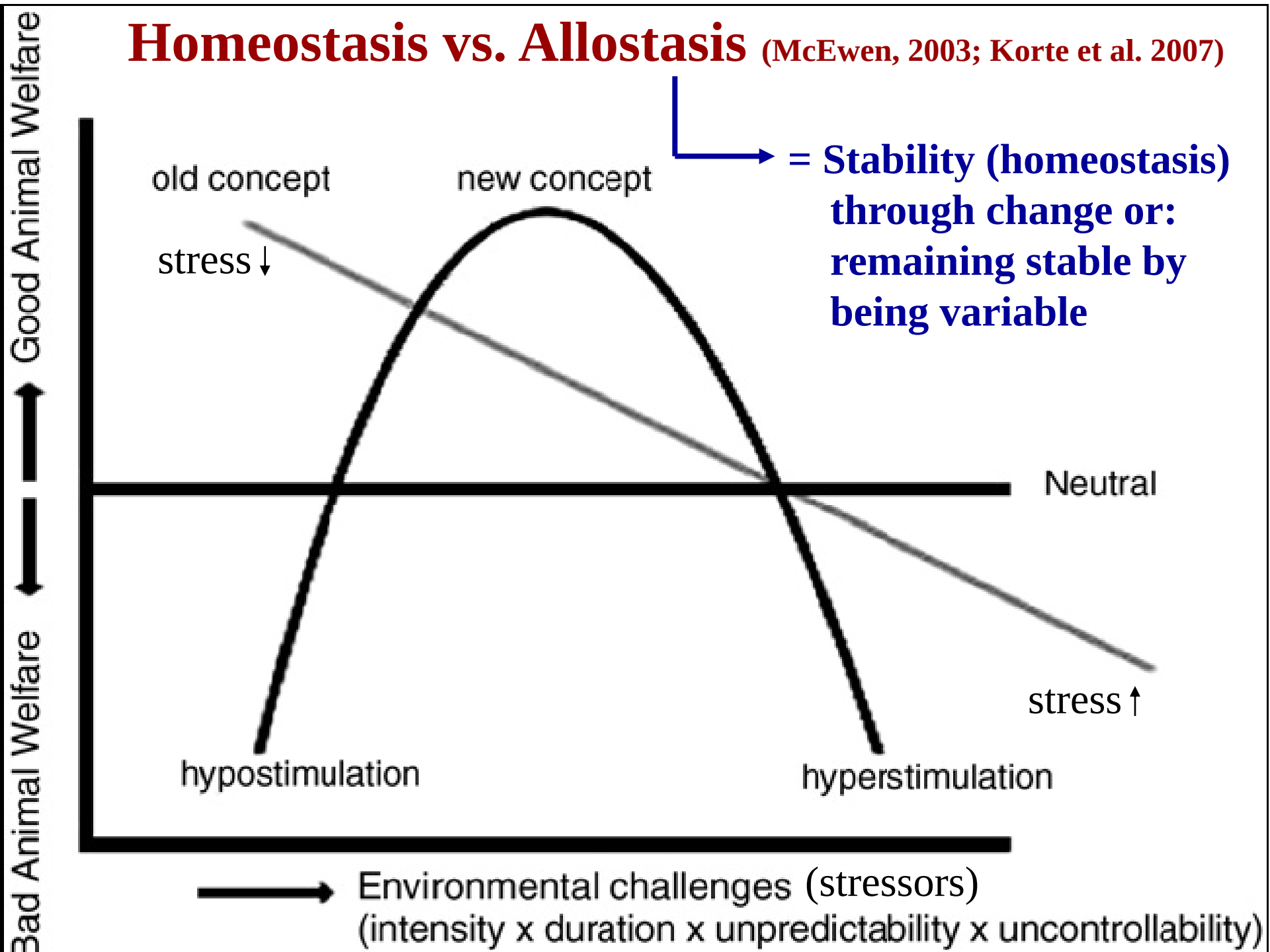
Fight & Flight Syndrome

restoration of control

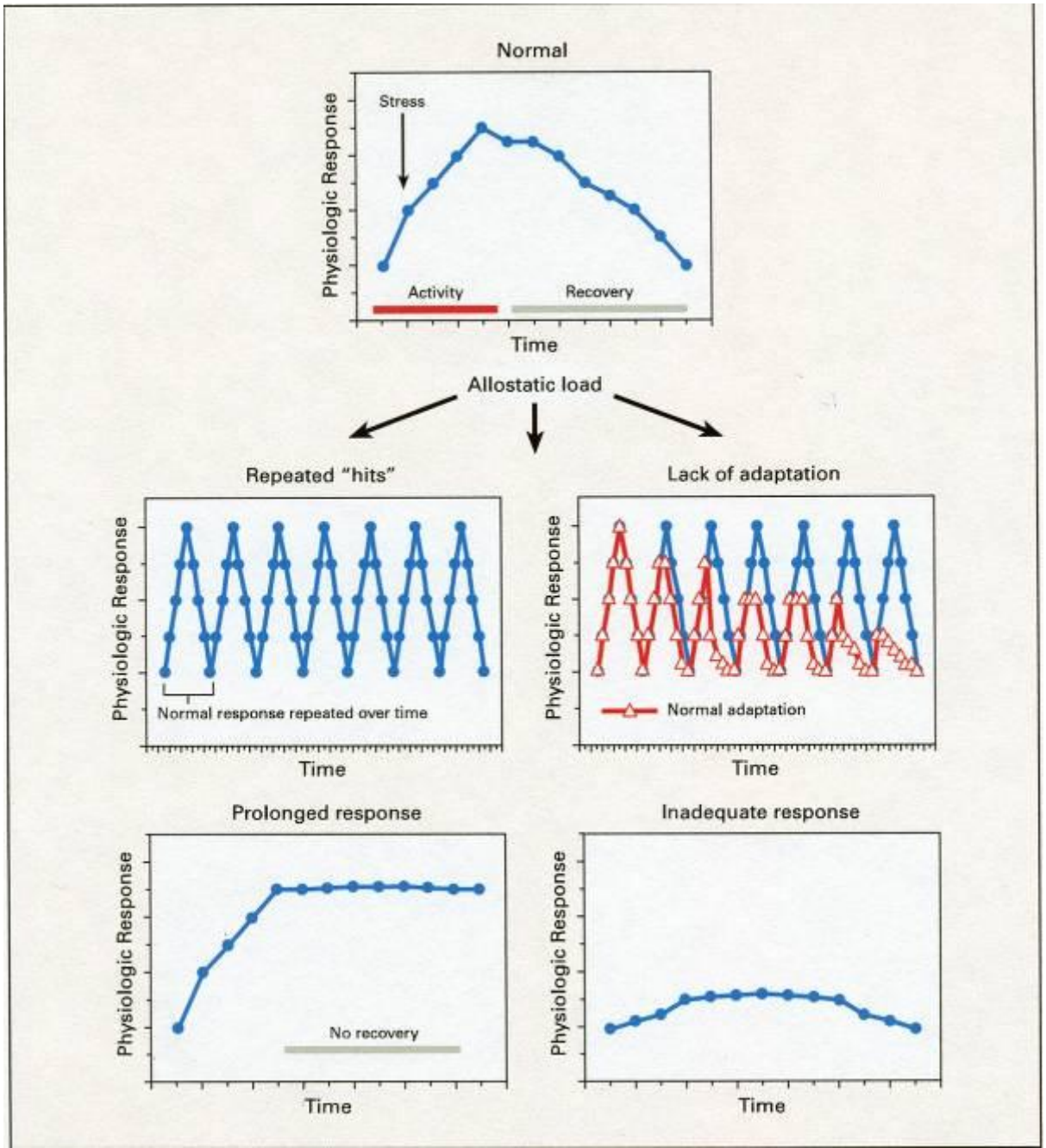
Passive Coping: HPA

inactivity, submission

Homeostasis vs. Allostasis (McEwen, 2003; Korte et al. 2007)



Allostatic Load (McEwen, 1998)



What is stress?

- **old: any condition that threatens homeostasis**

➢ **Homeostasis: maintenance of a single optimal level**

Stress response: restoration of balance

- **new: any condition that throws body out of allostatic balance**

➢ **Allostasis: range of measures appropriate for a situation**

Stress Response Components

(modified from Lazarus and Folkman, 1984)

- **Physiological component: Arousal, hormone secretion, immune response**
- **Emotional component: Anxiety, fear, excitement (positive emotion)**
- **Behavioural component: Coping strategies (both behavioural and mental) - problem focused and/or emotion-focused**

> The level of stress experienced depends mainly on the adequacy of the resources for coping and how much they will be drained by the stressful situation

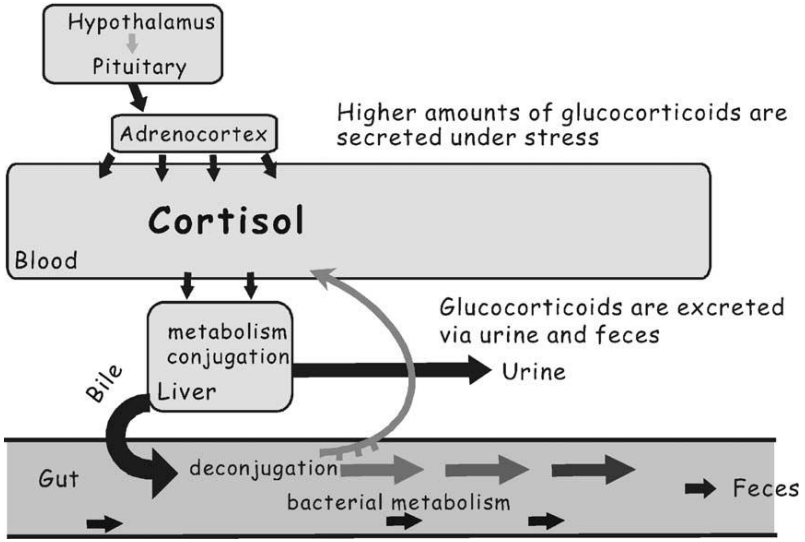
Non-invasive sampling of stress metabolites (mainly glucocorticoids)

from saliva

Swap Sampling

from Schönreiter & Zanella, 2000

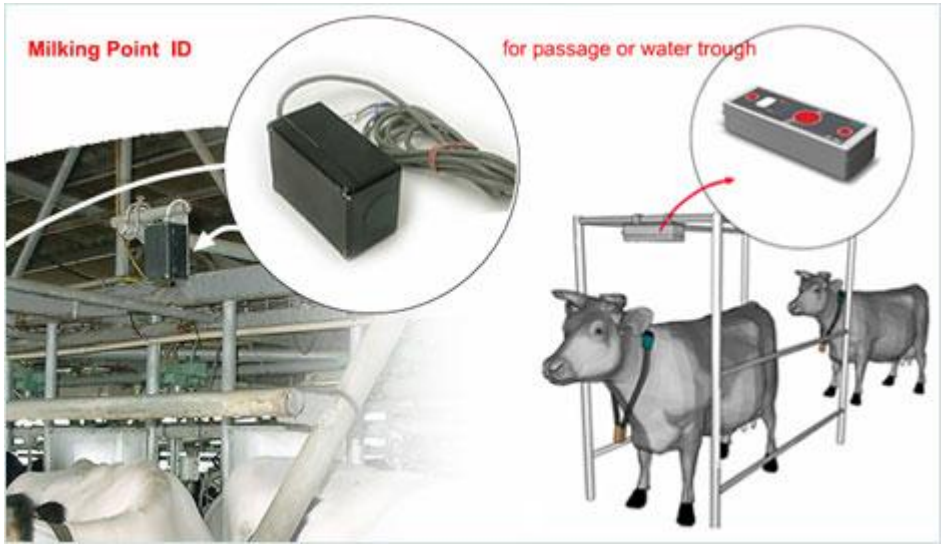
from faeces

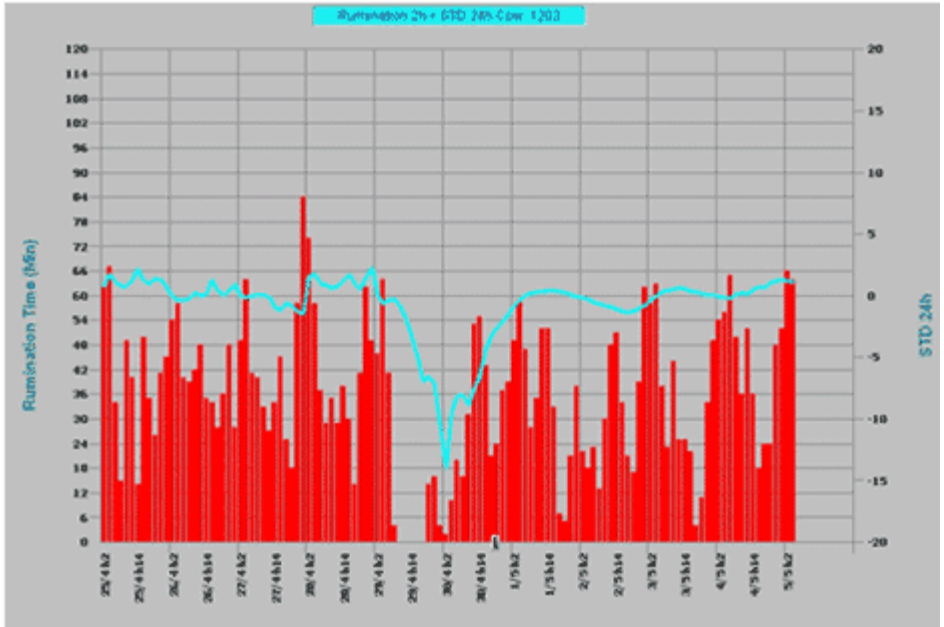


from Möstl & Palme, 2002

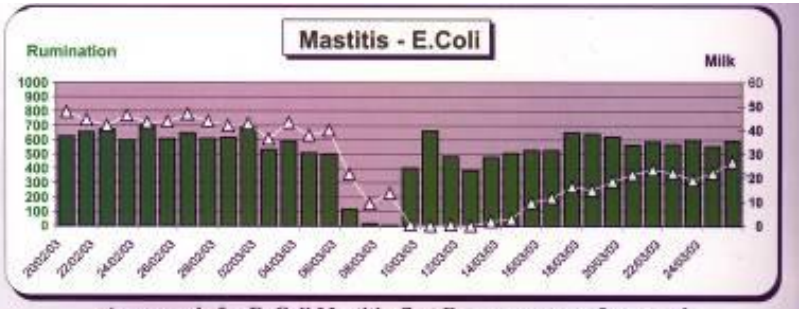
Vocal Tag® Rumination activity

Bar-Shalom et al., 2009

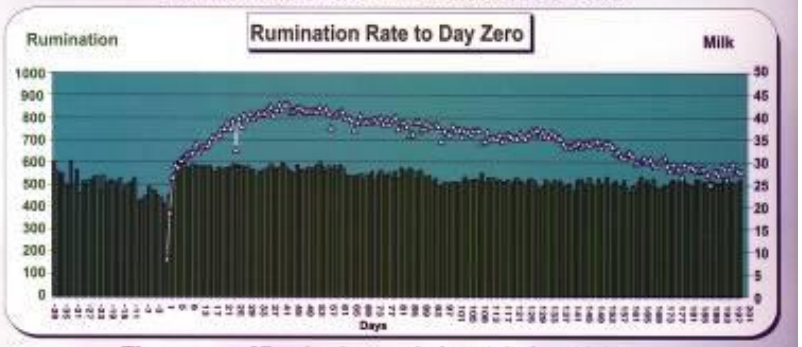




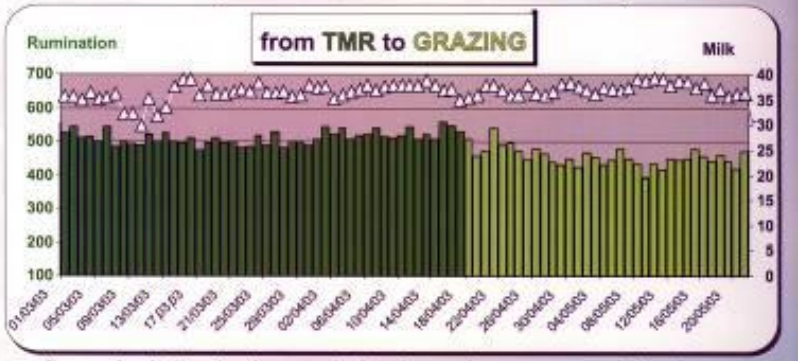
Vocal Tag® Rumination activity



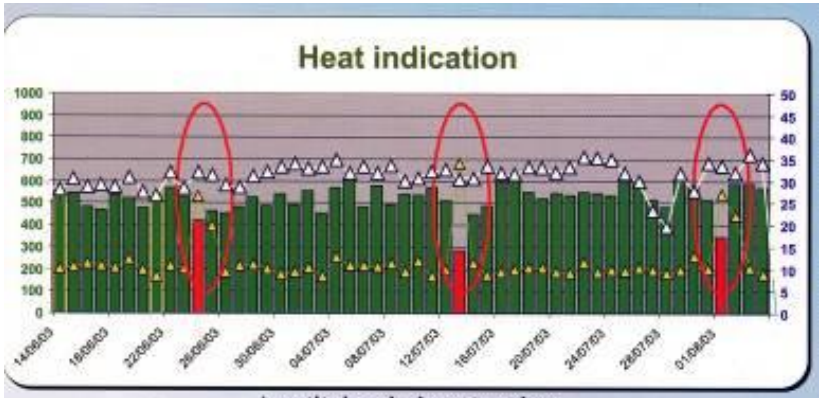
An example for E. Coli Mastitis, first Rumen response for a good treatment and later on milk production recovering



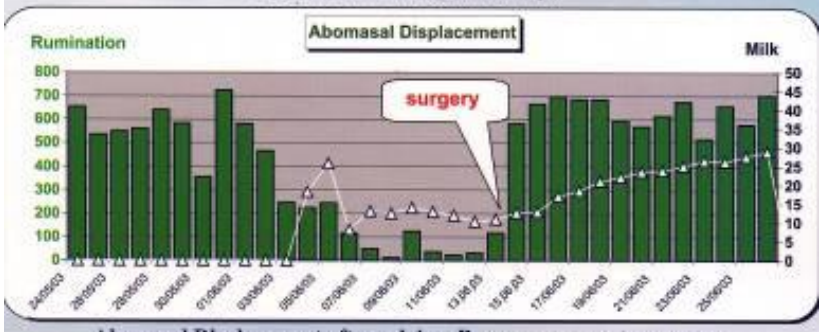
The average of Rumination rate before and after calving



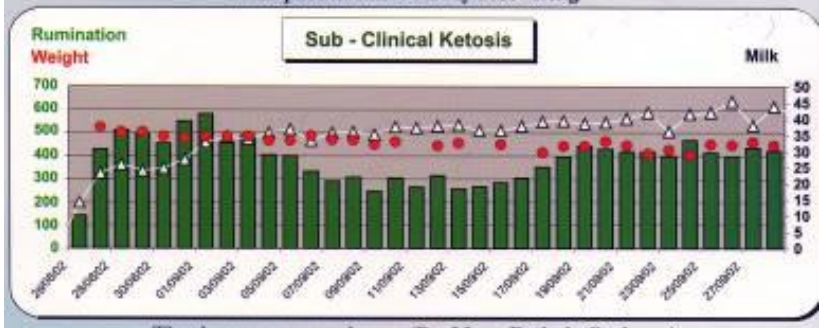
Decreasing in Rumination rate during the grazing season as an indication for a lack of effective fiber and more exposure to metabolic diseases



Appetite loss during estrus days



Abomasal Displacement after calving. Rumen response to surgery, milk production is slowly recovering



The droopy cow syndrome (Dr. Mary Beth de Ondarza)
Decreased appetite, no sign in milk production

What is pain?

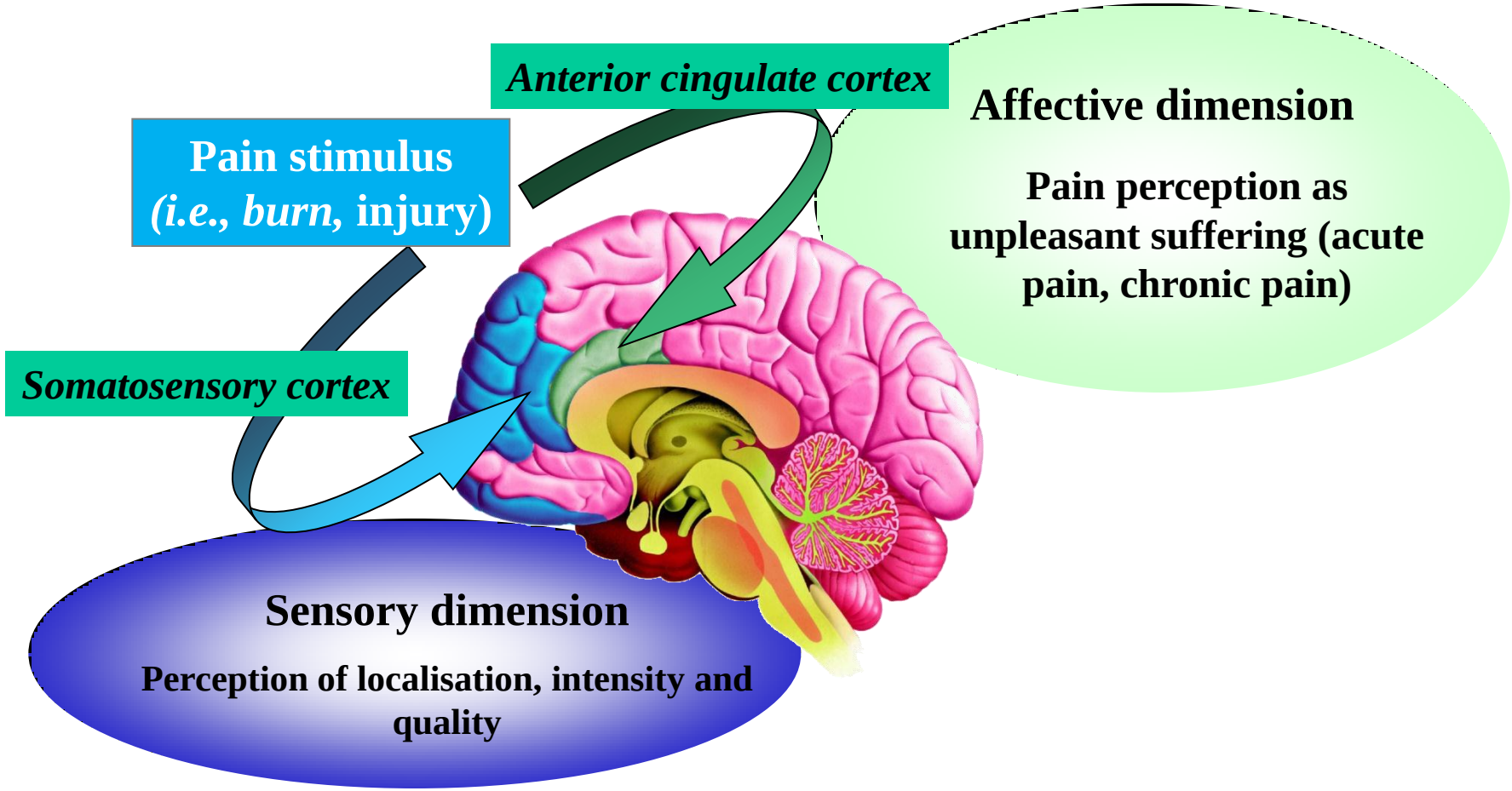
- **Pain: an unpleasant sensory or emotional experience associated with actual or potential tissue damage (IASP)**

➢ **Nociception: recognition of specific signals, originating in nociceptors and relaying information on tissue damage**

Animal Welfare – Prevention of suffering

Knocking Out Pain in Livestock (Adam SHRIVER, Neuroethics 2009)

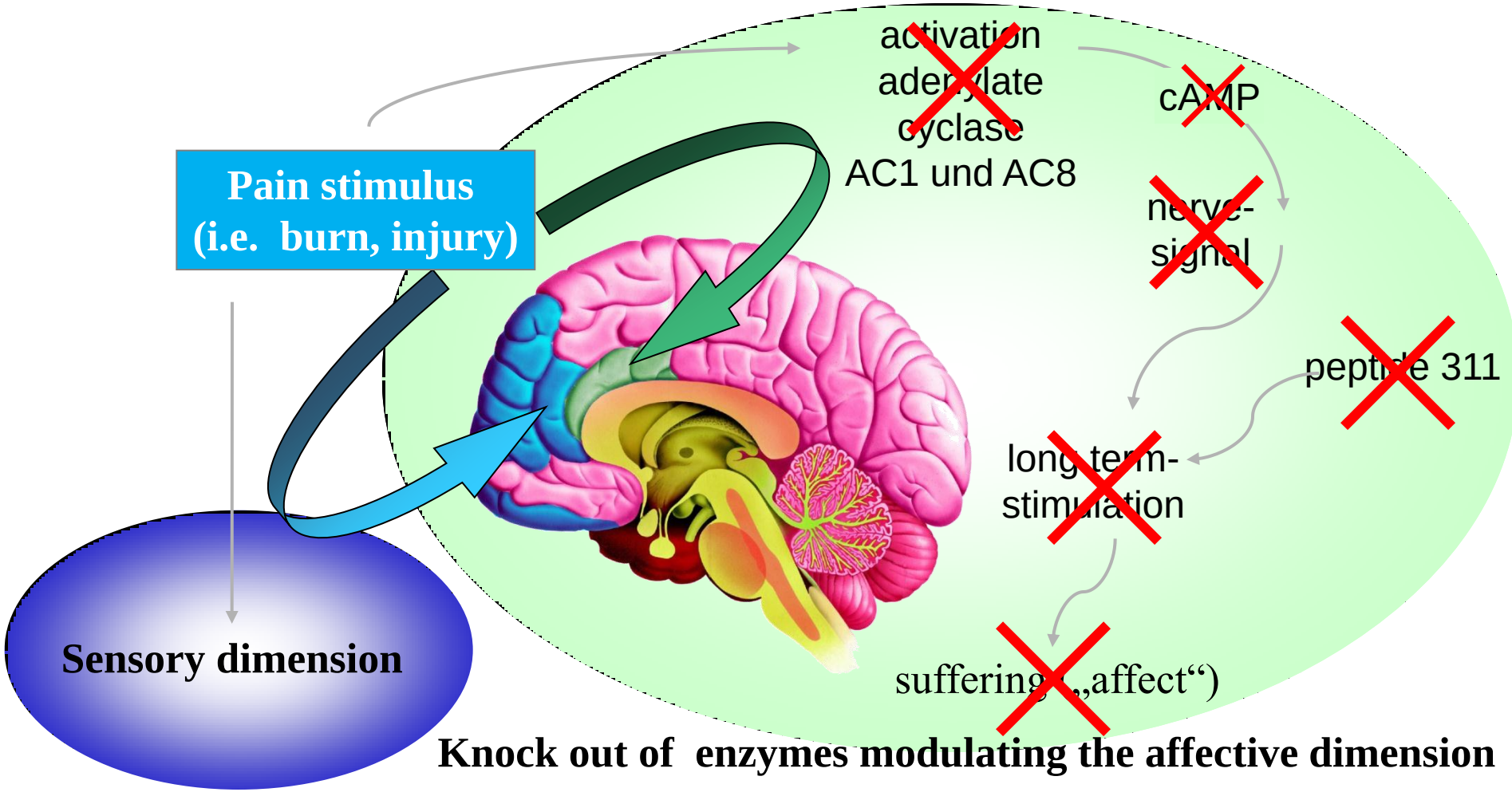
Two dimensions of pain



Source: according to Shriver, 2009; Layout: © 2010 W. Branscheid

Animal welfare – Prevention of suffering

One-dimensional pain – without suffering



Knock out of enzymes modulating the affective dimension

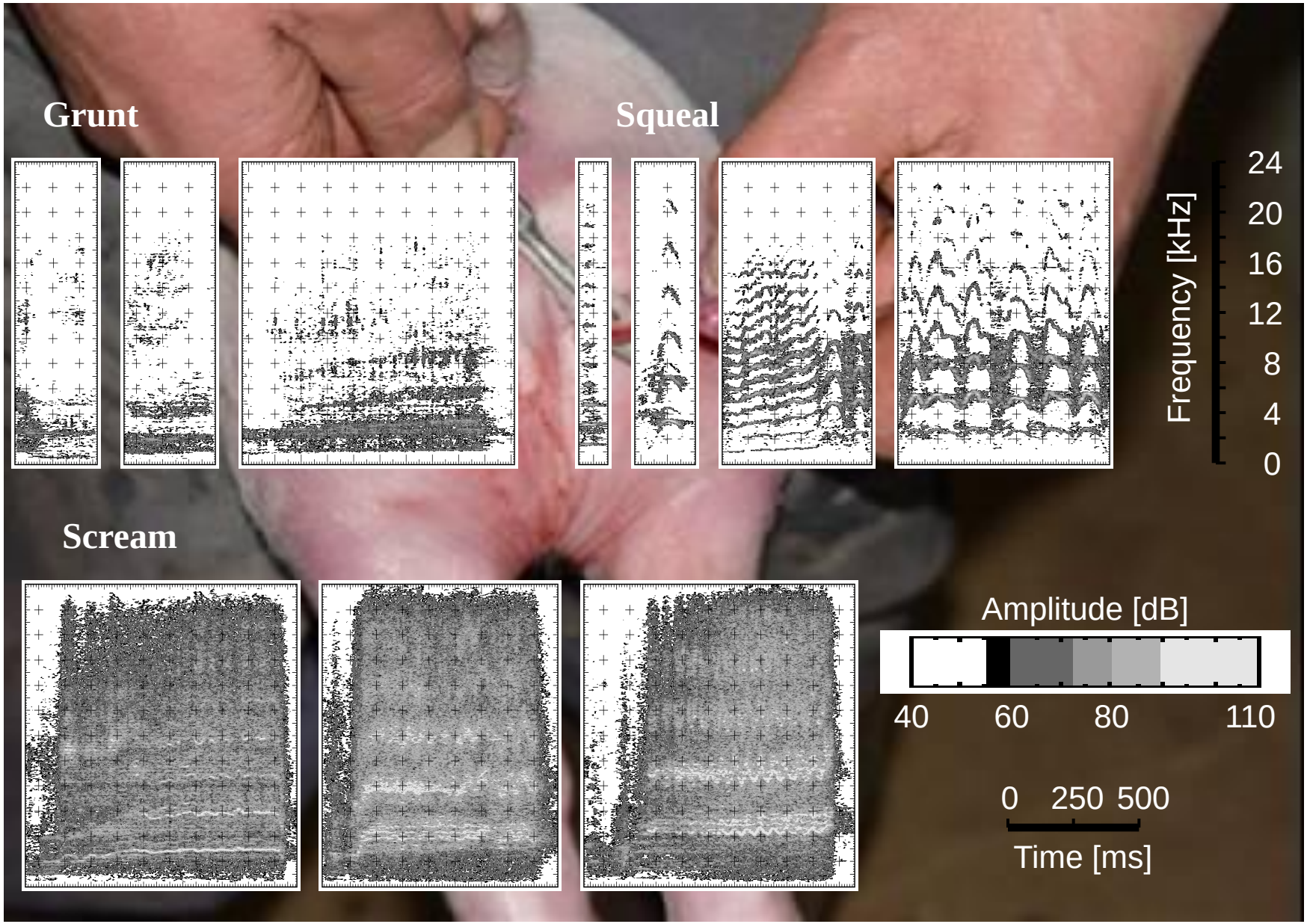
Source: according to Shriver, 2009; Layout: © 2010 W. Branscheid

Naked mole rat (*heterocephalus glaber*)

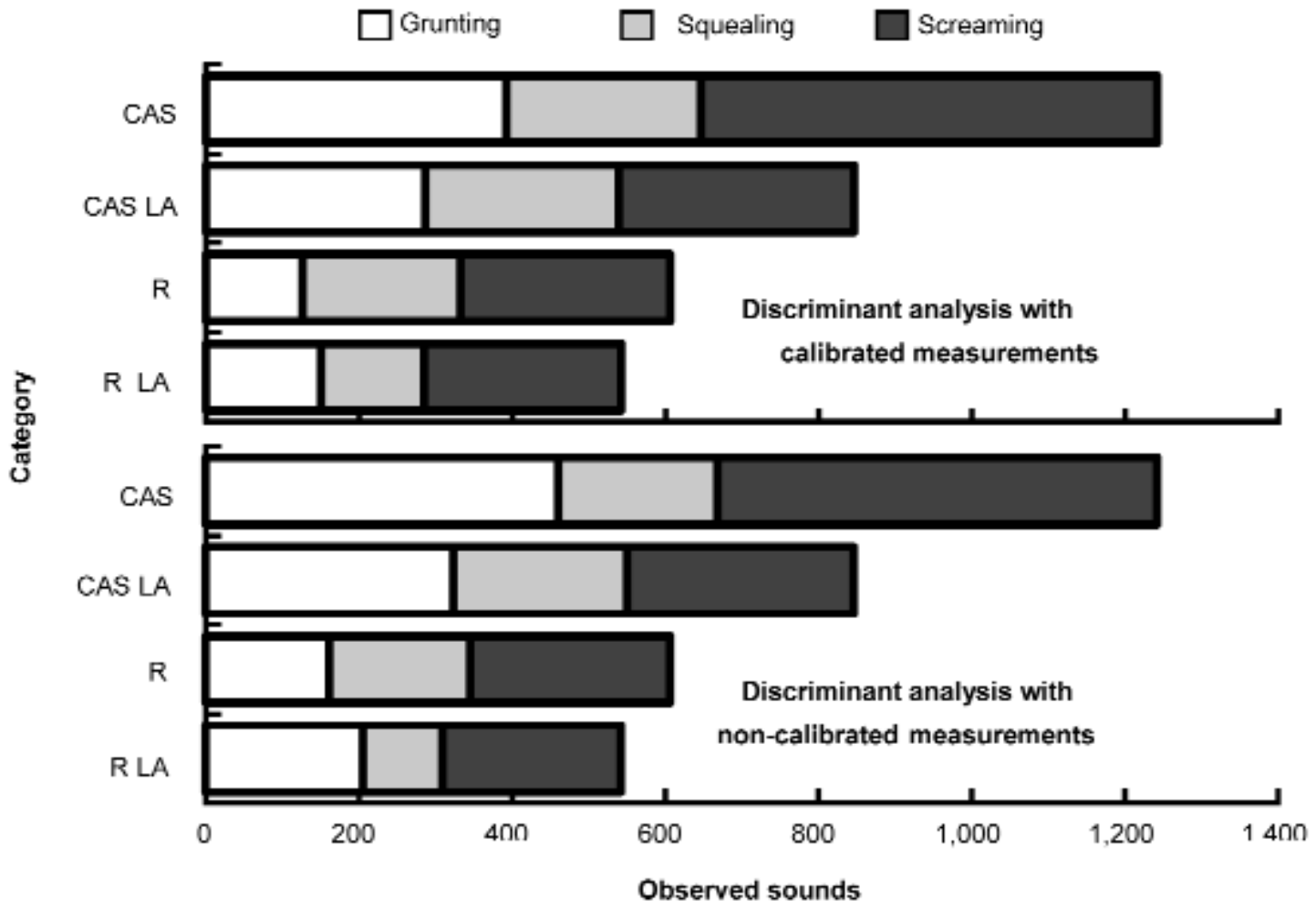
Evolutionary adaptation to underground habitat (hairless, eyes almost closed, low metabolism)

Mammals (rodents) that do not perceive pain > Skin lacks in substance P mediating pain sensation (> burn, cut)

Assessment of painful procedures?



von Borell et al., 2009

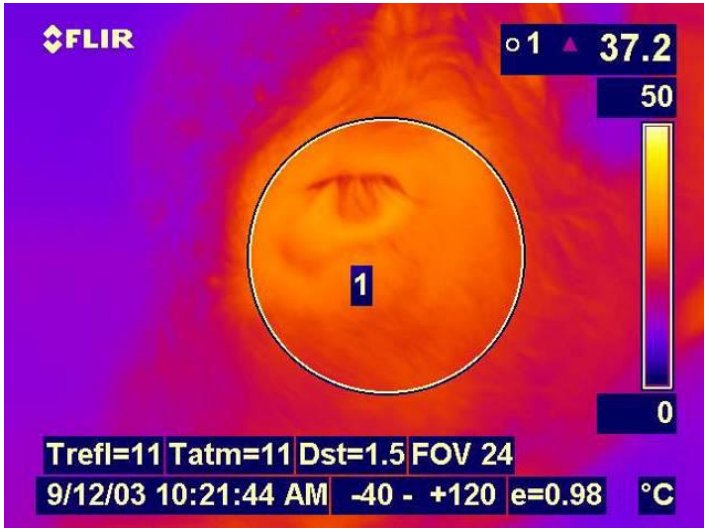


Absolute frequencies of three vocal types of piglets, classified using calibrated and non-calibrated measurements, in different stressful situations (CAS = castration, CAS LA = castration with local anaesthesia, R = restraint, R LA = restraint with local anaesthesia).

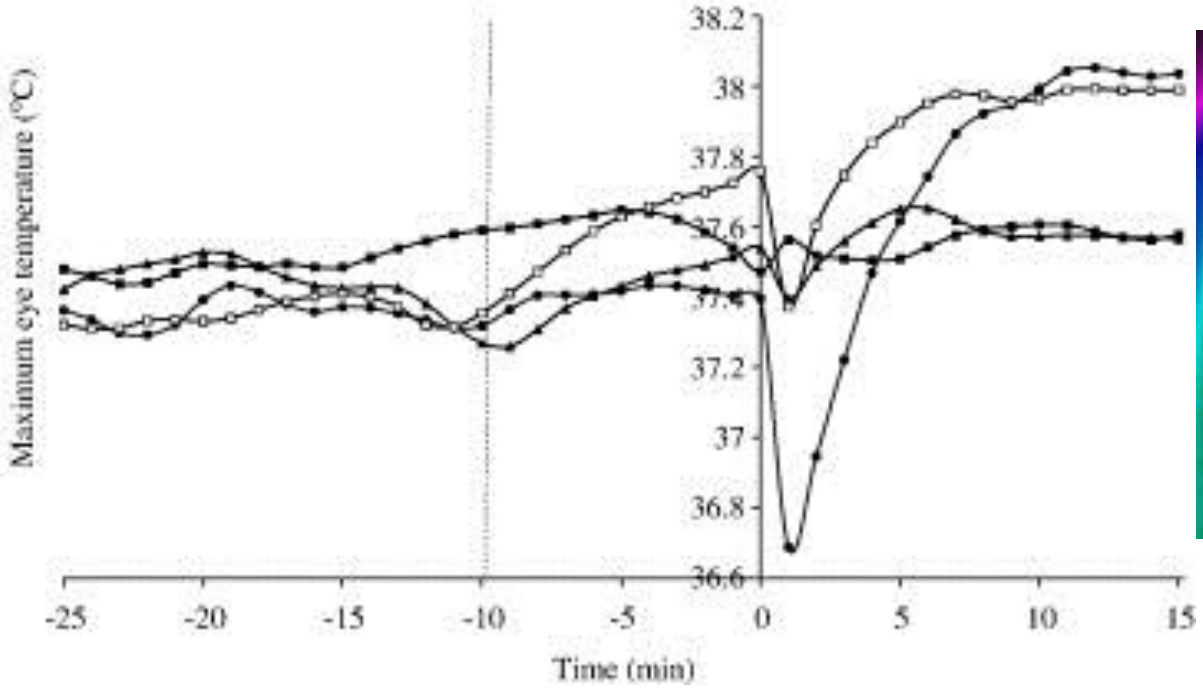
von Borell et al., 2009

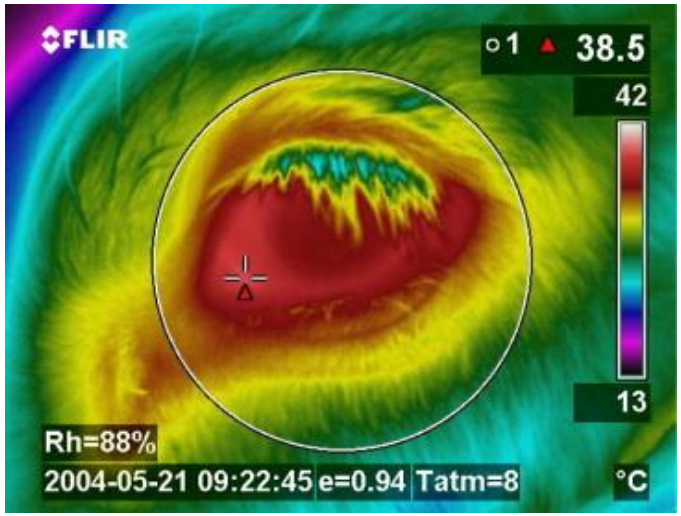
Eye temperature as a pain indicator

(Stewart, 2008)



Disbudding of calves



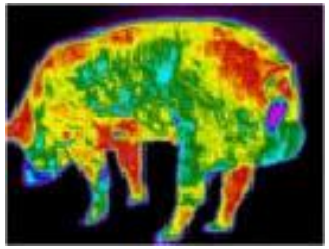


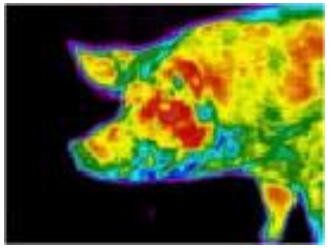
Maximum eye temperature (°C) during the 40 min sampling period for control (■, *n* = 8), local anaesthetic control (▲, *n* = 8), disbudded with local anaesthetic (□, *n* = 8) and disbudded without local anaesthetic (●, *n* = 6). Lines were smoothed using a loess smoother separately for each animal pre and post disbudding. The dashed vertical line indicates the time that local anaesthetic or the sham procedure was administered and 0 min indicates the time of treatment. (Steward et al., 2008)

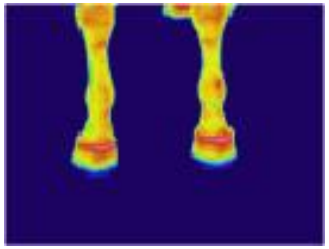
Explanation: Sympathetic Vasoconstriction

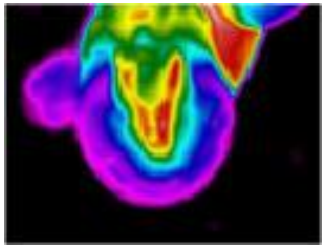
Infrared thermography

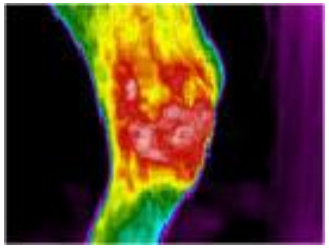
Thermal images indicate inflamed tissue, joints, skin & tissue damages, tumors, congestion, blockades









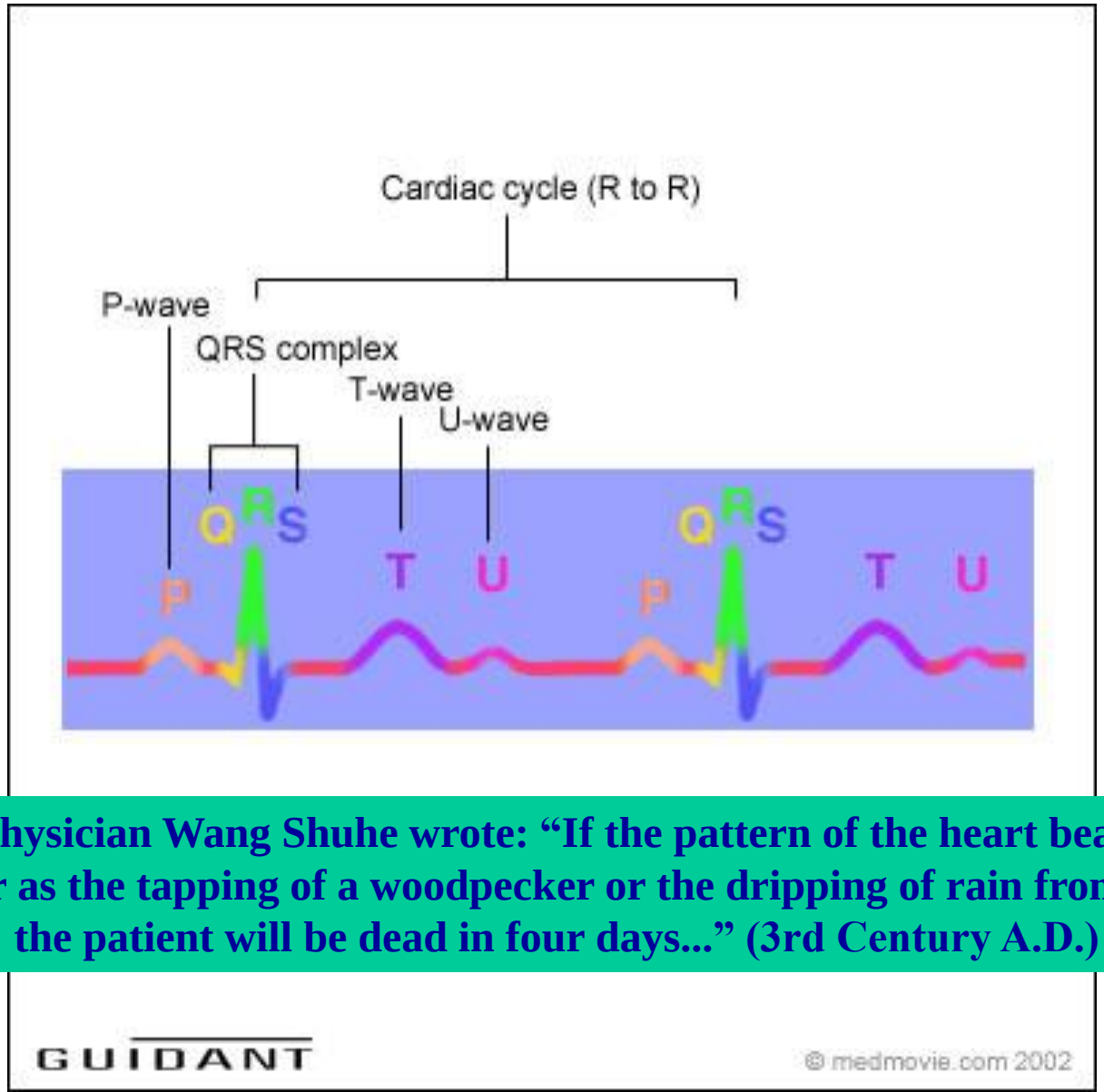


Heart Rate Variability (HRV)

- **Definition: HRV refers to the beat-to-beat alterations in heart rate**
- **Reduced HRV has been used as a marker of reduced vagal activity (parasympathetic tone)**
- **As a dynamic marker of load, HRV appears to be sensitive and responsive to acute and chronic stress**
- **Analysis of HRV offers a non-invasive method of evaluating vagal input into cardiac rhythm**

- **Allostasis: remaining stable by being variable !**

Electrocardiogram (ECG)



Chinese physician Wang Shuhe wrote: "If the pattern of the heart beat becomes as regular as the tapping of a woodpecker or the dripping of rain from the roof, the patient will be dead in four days..." (3rd Century A.D.)

HRV as a welfare indicator

- **HRV in farm animals have been related to pathological conditions, behavioural disorders, management and housing problems, training (horse), temperament and emotional states**
- **Basic understanding of cardiovascular regulation and model for human diseases**

von Borell et al., 2007

Polar Vantage® NV HR Monitor

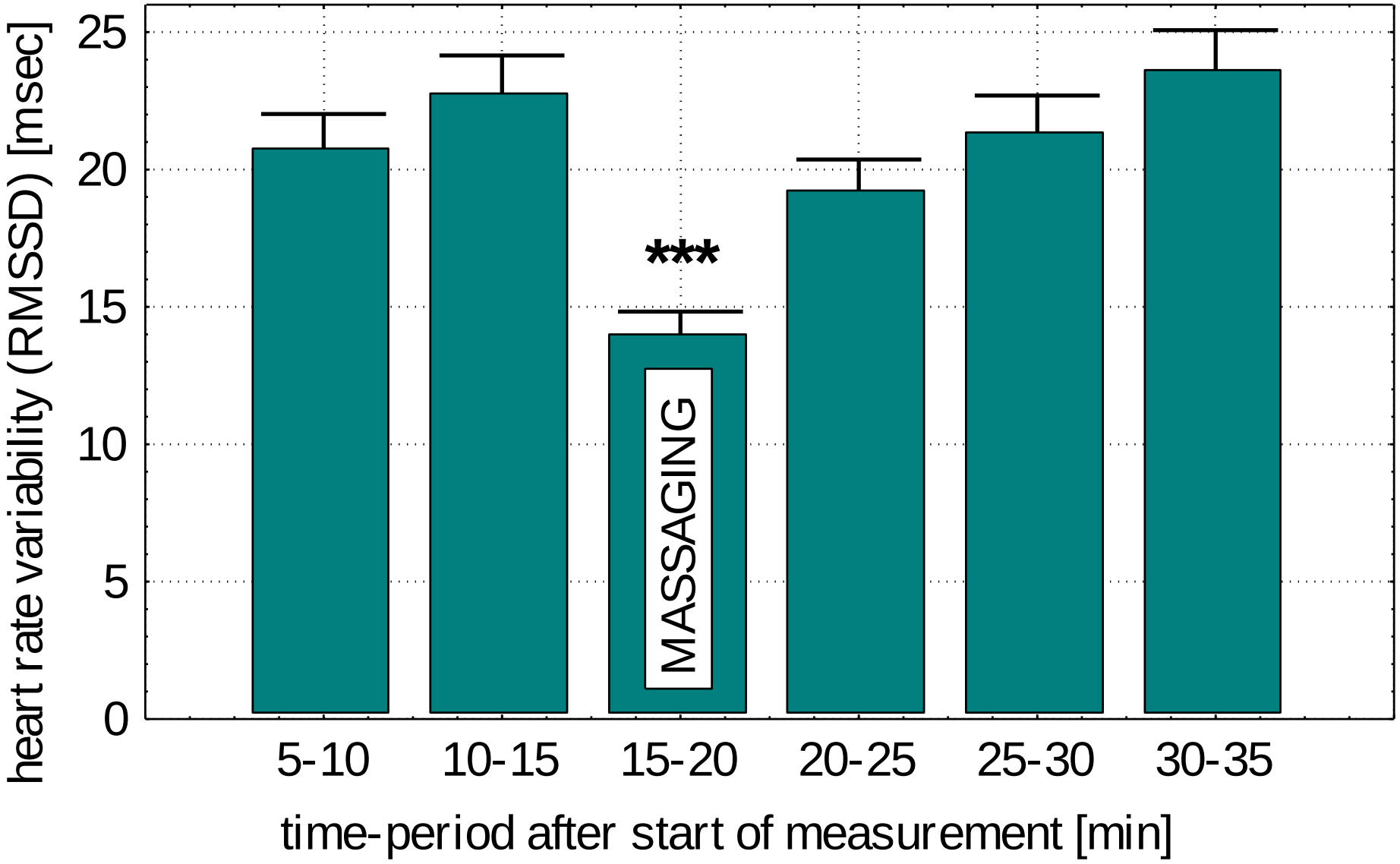
Protection vest (for pigs)

Transmitter with belt

Receiver (watch) & interface

Positive emotion (eustress)?

Hansen & von Borell, 1999



Cognitive enrichment: Call-Feeding-Stations

(Zebunke et al., 2011)

Cognitive bias as an indicator of animal emotion and welfare (Mendl et al. 2009)

- **Judgement (valence) in an ambiguous choice situation (glass half-full or half-empty) depend on emotional state**

- **Physiological correlates of emotional states? (> coping style?)**

Review on animal cognitive bias studies (Düpjan al. 2012)

negative bias induced by

- unpredictable stressors (1)
- loss of enrichment (2)
- depression (2)
- anxiety (3)
- pharmacological stress induction (1)
- 5-HT depletion (1)
- veterinary examination (1)
- individual differences (4)

positive bias induced by

- environmental enrichment (3)
- reduced anxiety (1)

Repeated social isolation in pigs did neither induce more pessimistic judgements nor changes in basal cortisol levels or acute cortisol responses (Düpjan, 2012)

Gain of knowledge and applications from stress research

- **Quality of the technical and social environment (housing & management)**
- **Interpretation of behavioural problems**
- **Adaptive and learning abilities**
- **Emotional states (positive & negative)**
- **Interrelationship with health & disease, pain and biological functioning**

Conclusions / Outlook

- **Behavioural & physiological welfare monitoring with non-invasive techniques**
- **Combined transponders / sensors (ID, body temperature, HR & activity)**
- **Acoustic monitoring (rumination, stress calls, coughing, respiration)**
- **Indicators for positive emotional states?**
- **Cognitive enrichment and eustress?**
- **Stress: (still) a concept for reevaluation**