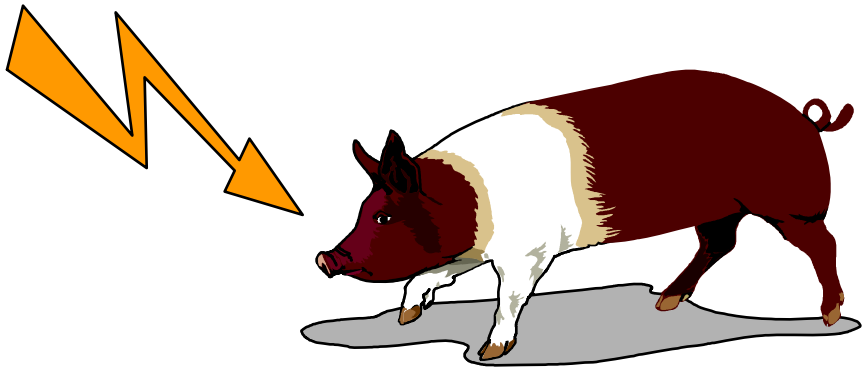
Session MPPh 16.2

Institute of Agricultural and Nutritional Sciences
Martin-Luther-Universität Halle-Wittenberg
GERMANY

Cardiac responses to stress during transport and housing of farm animals



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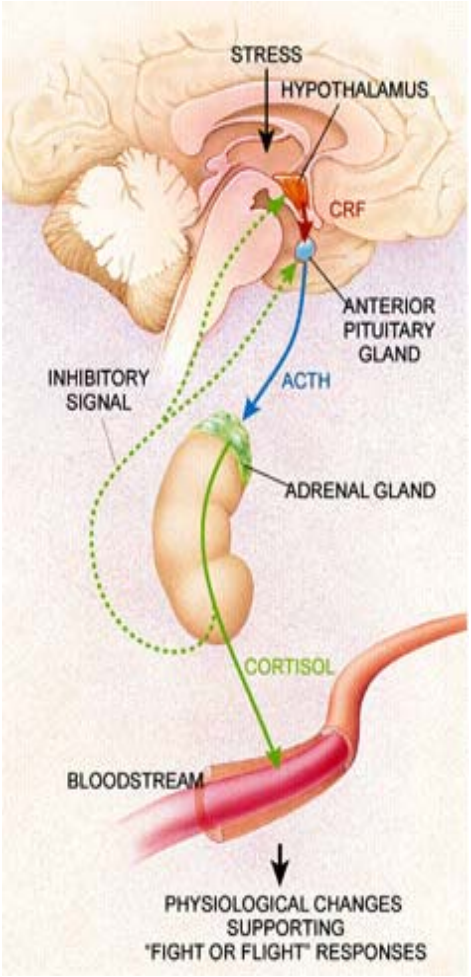
58th Annual Meeting of the EAAP, 27th August 2007, Dublin, Ireland

Content

- Stress concepts
- Measurements
- Applications
- Interpretation
- Outlook



Stress Physiology

Hans Selye (1907-1982), father of stress research developed the idea of a direct relationship between chronic stress and excessive strain and exhaustion of the body

Origination of the Stress Concept
Hans Selye (1930s)

- **injected noxious agents into rats and observed:**

  > **adrenal enlargement**
  > **thymus and lymph node involution**
  > **gastric ulceration**

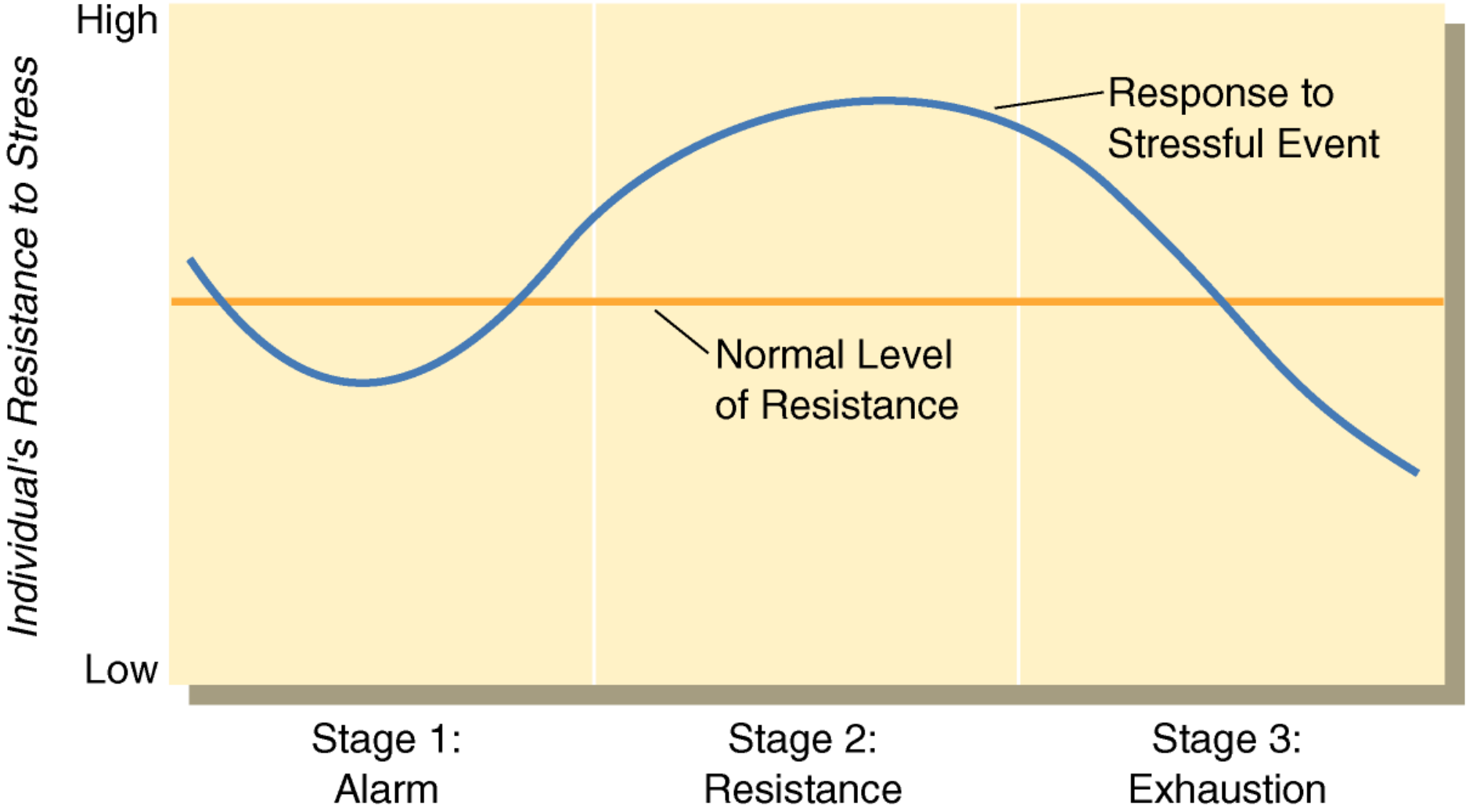
- **concluded that he had discovered a new hormone**

General Adaptation Syndrome (*Hans Selye, 1936*)

- **postulated the existence of a non-specific defense system recruited by stress**
- **called the response the GENERAL ADAPTATION SYNDROME**
- **described three phases:**
  - **alarm reaction**
  - **stage of resistance**
  - **stage of exhaustion**

- **response mediated by cortisol release from the adrenal cortex**

General Adaptation Syndrome (GAS)



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

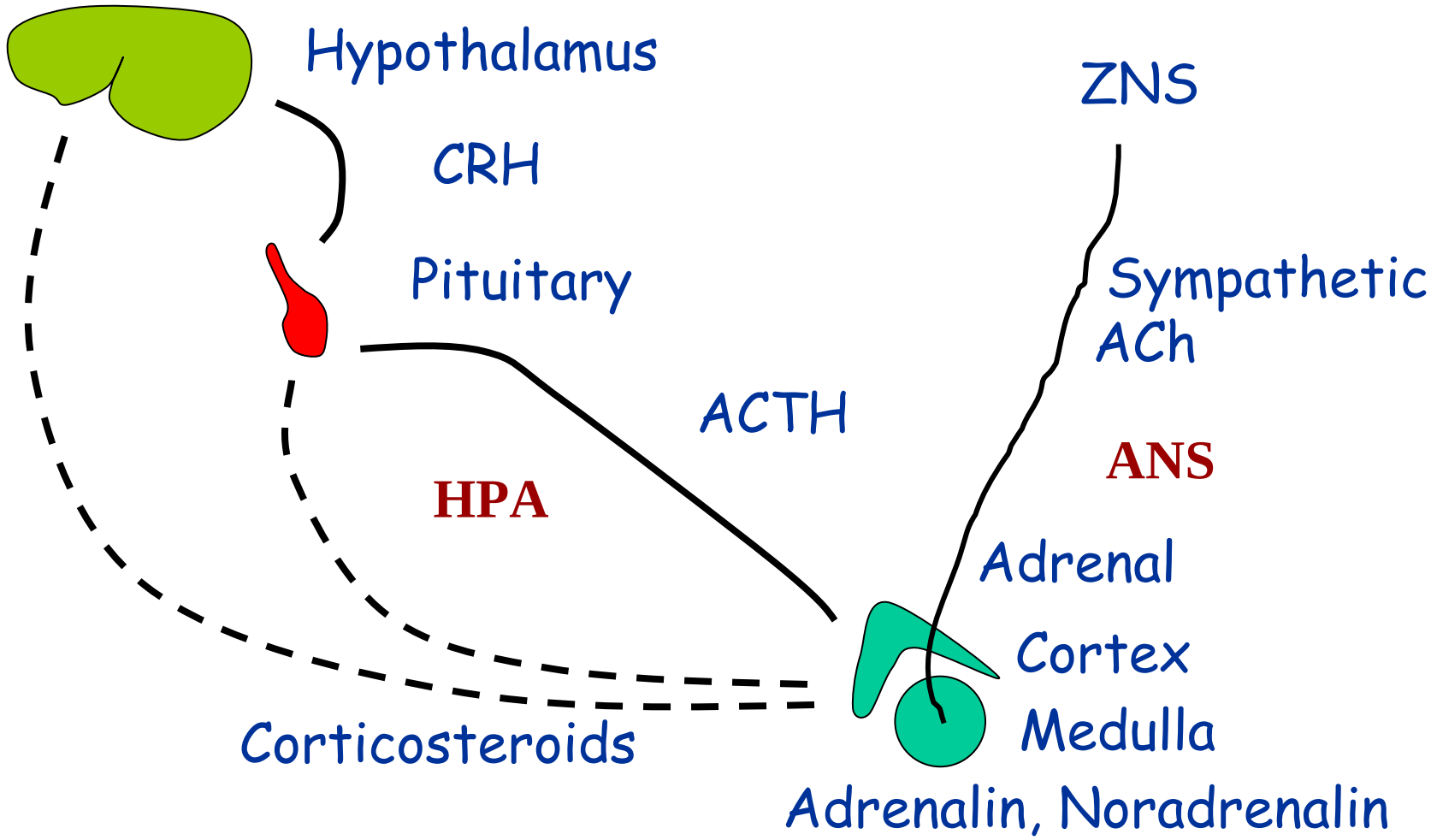
Cannon (1932): Homeostasis= Maintenance of internal stable condition

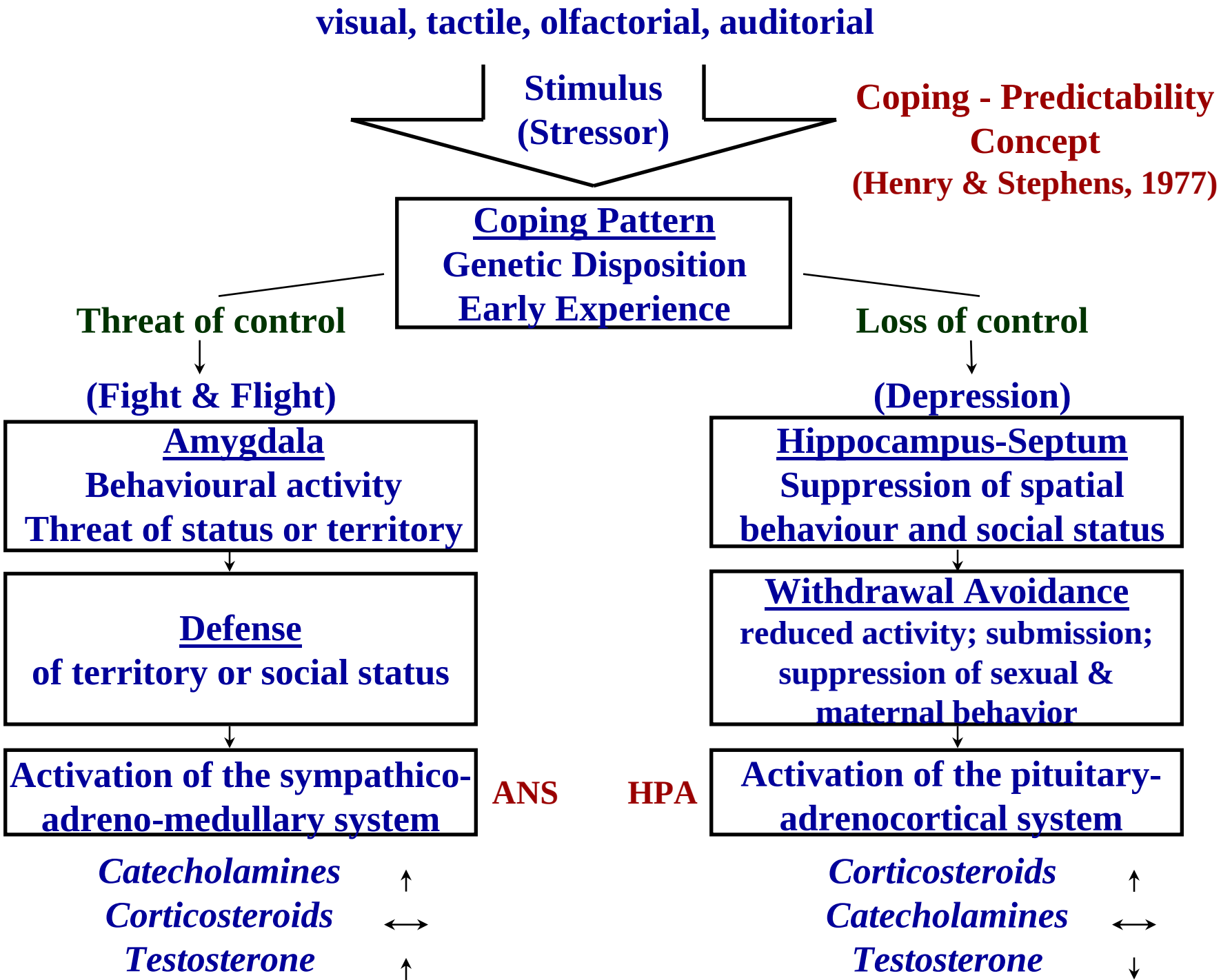
Psychophysiology

- **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

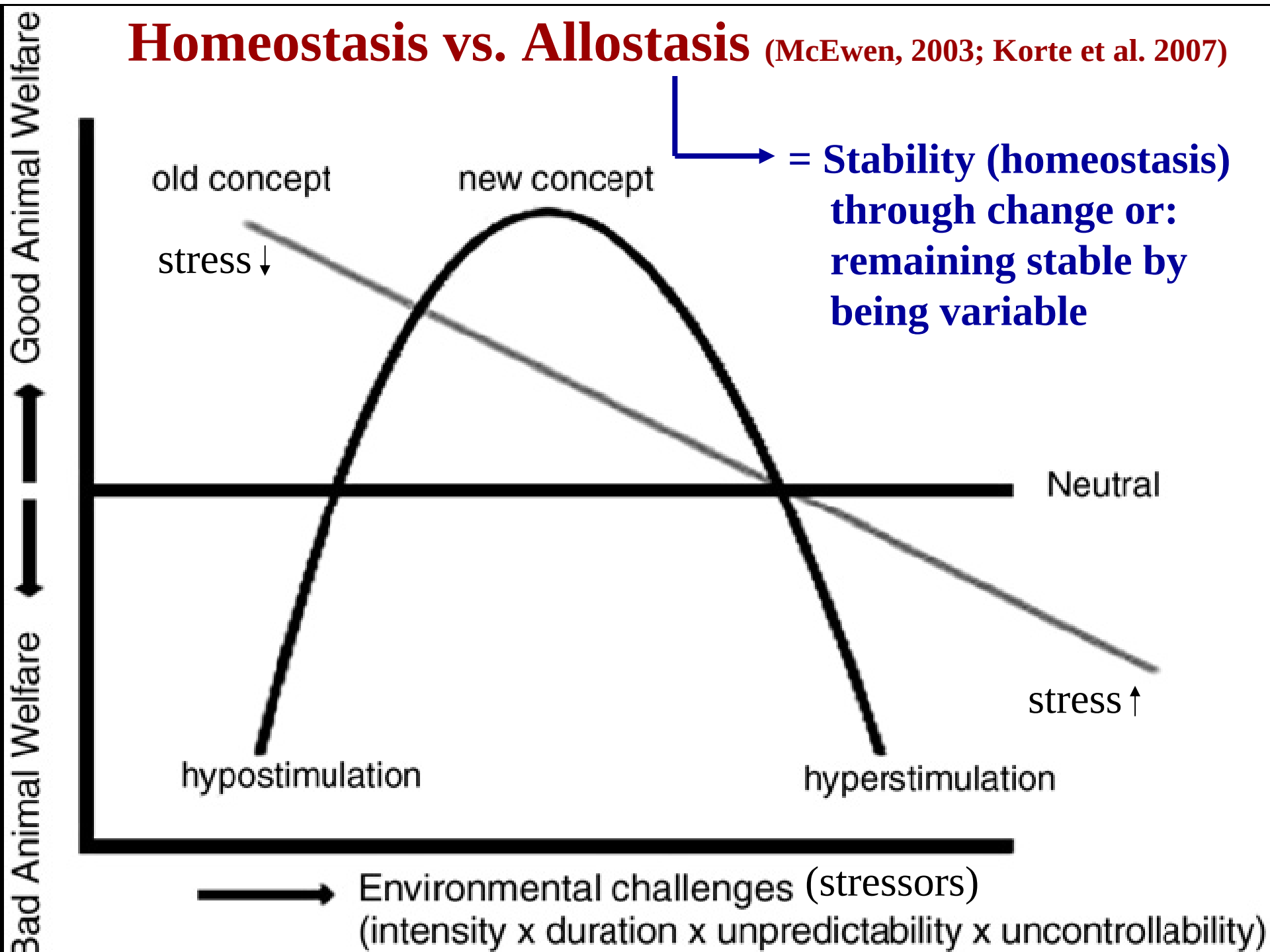
Fight & Flight Syndrome

restoration of control

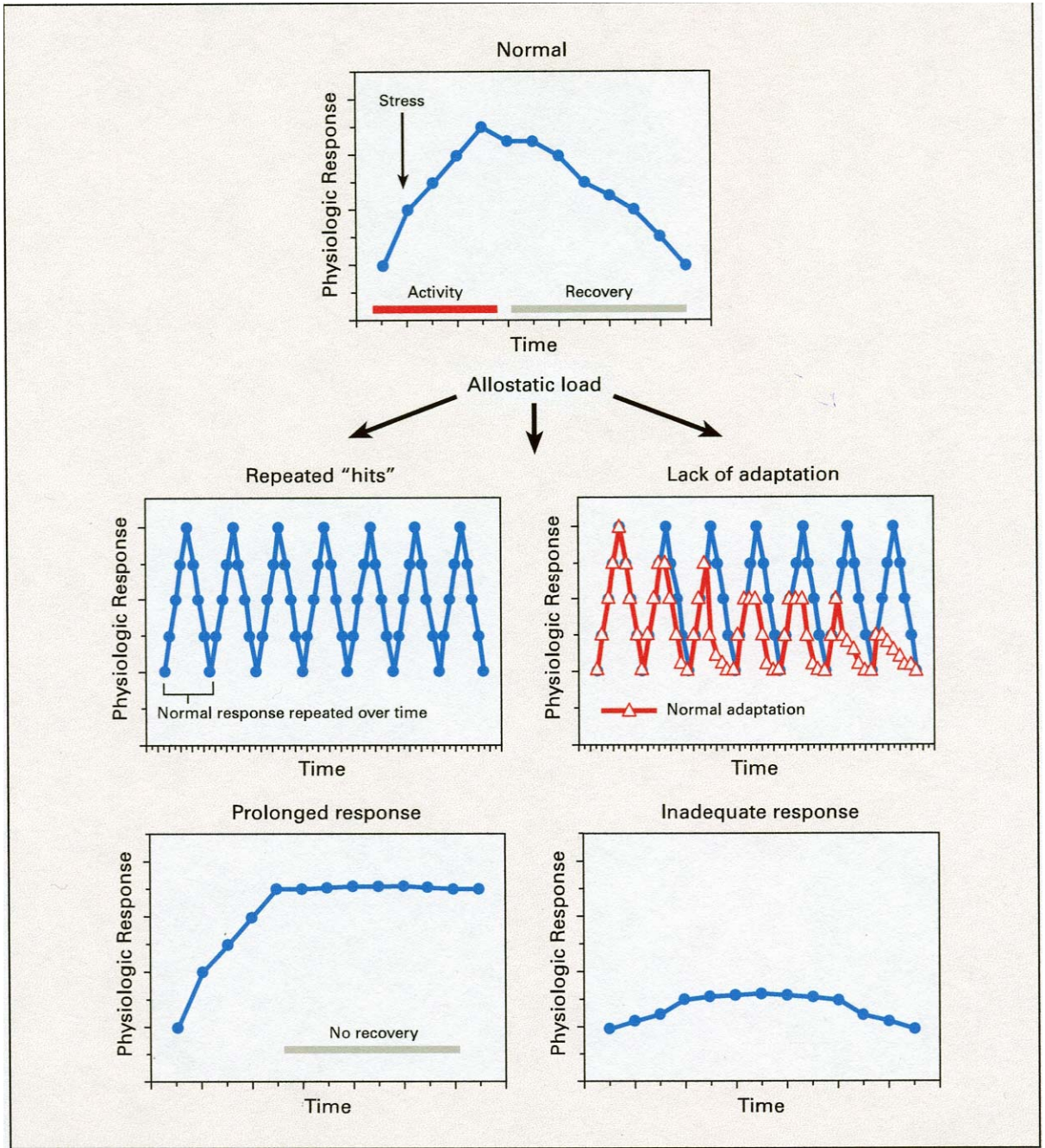
Passive Coping: HPA

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

Measuring stress in farm animals?

Typical heart rate pattern during transport

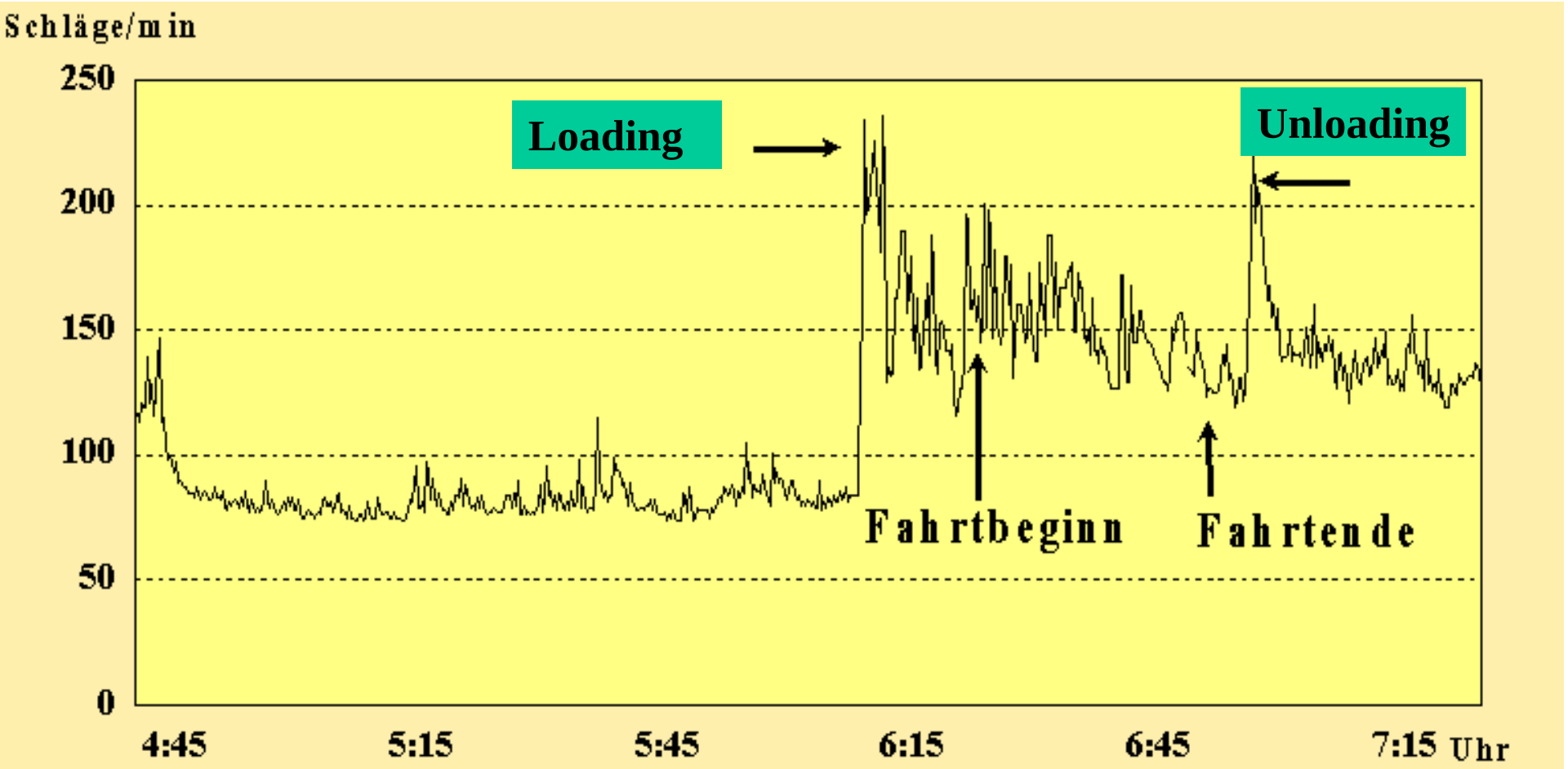


Abb. 1: "typische" Herzfrequenzkurve, Schwein 1

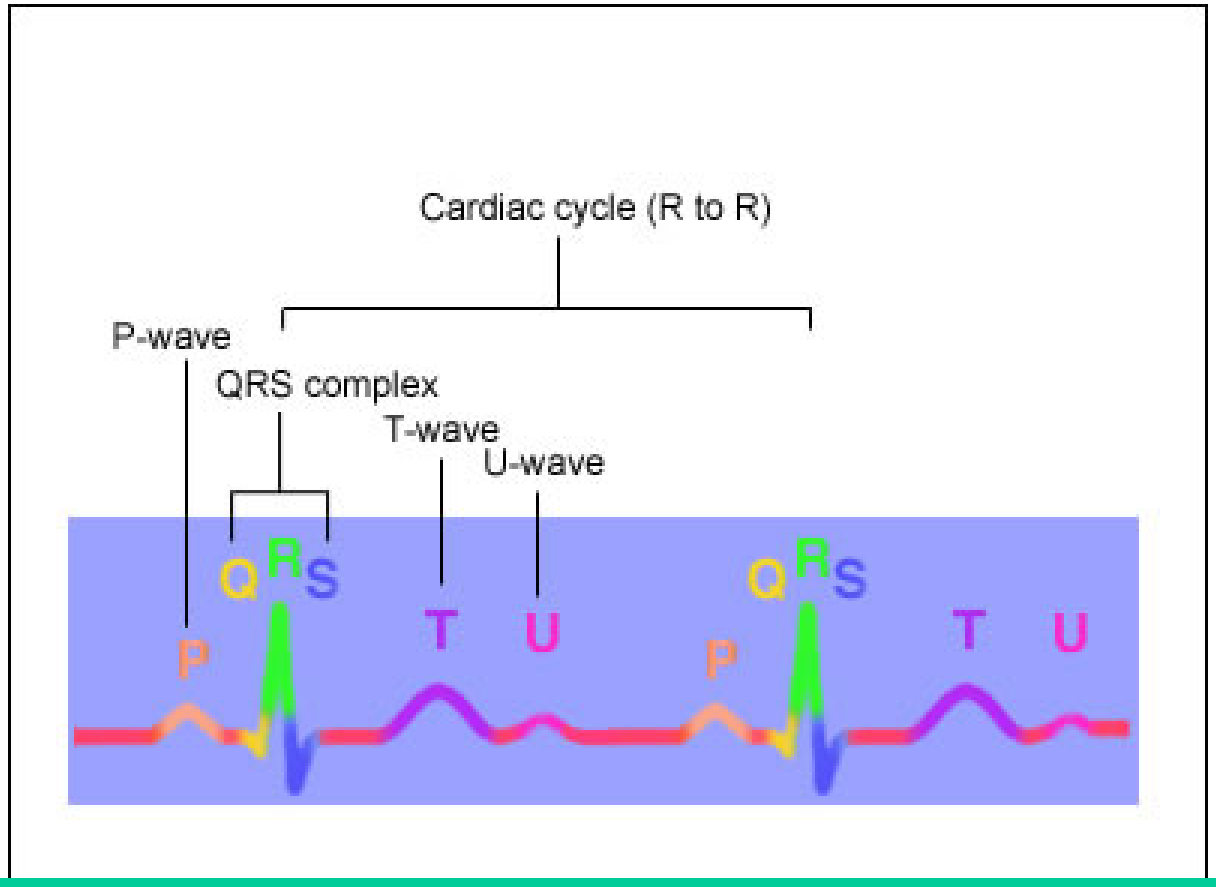
Steffens, Marahrens, Schütte and Hartung, 1998

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**

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

Electrocardiogram (ECG)

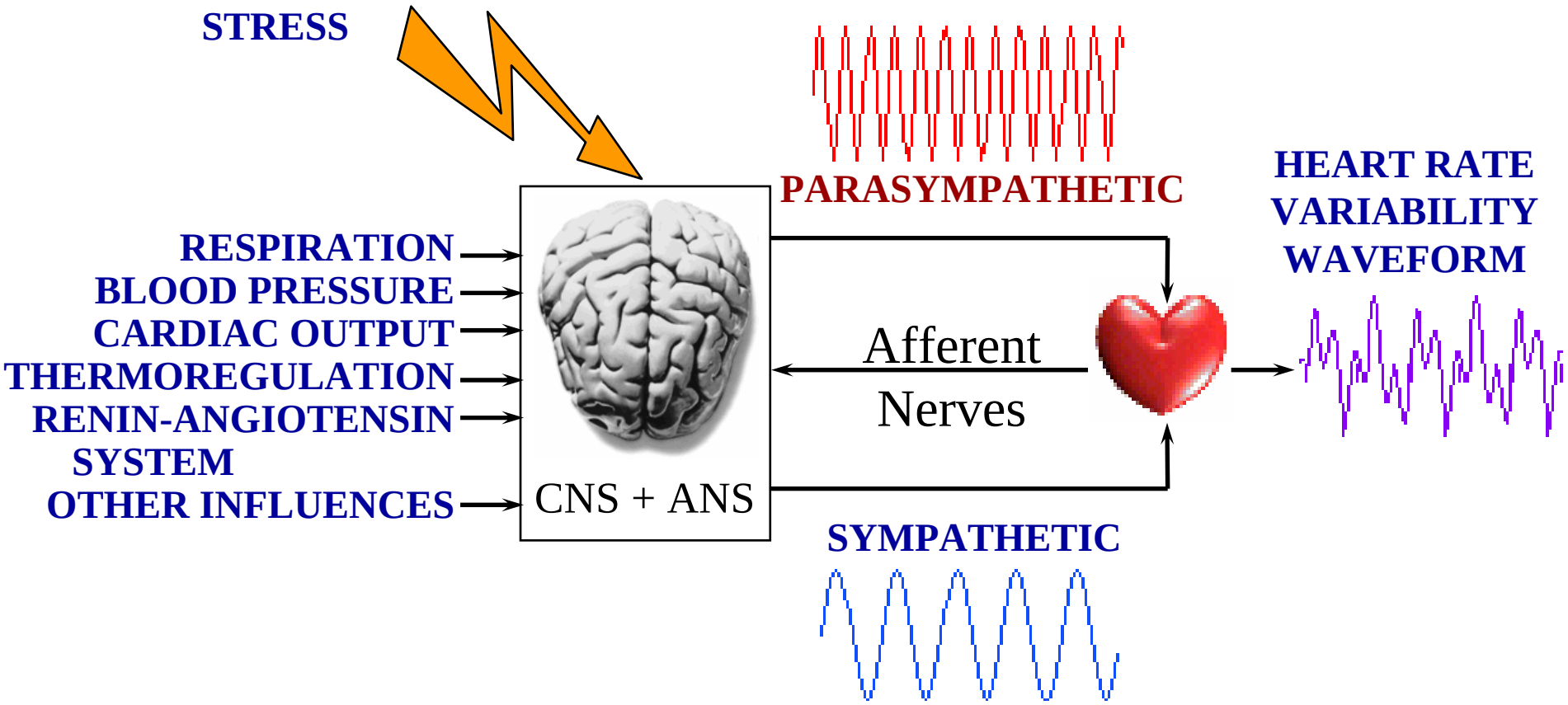


Chinese physician Wang Shuhe wrote: "If the pattern of the heart beat becomes as regular as the tapping of a woodpecker or the dripping of rain from the roof, the patient will be dead in four days..." (3rd Century A.D.)

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**

Autonomic Control of the Heart

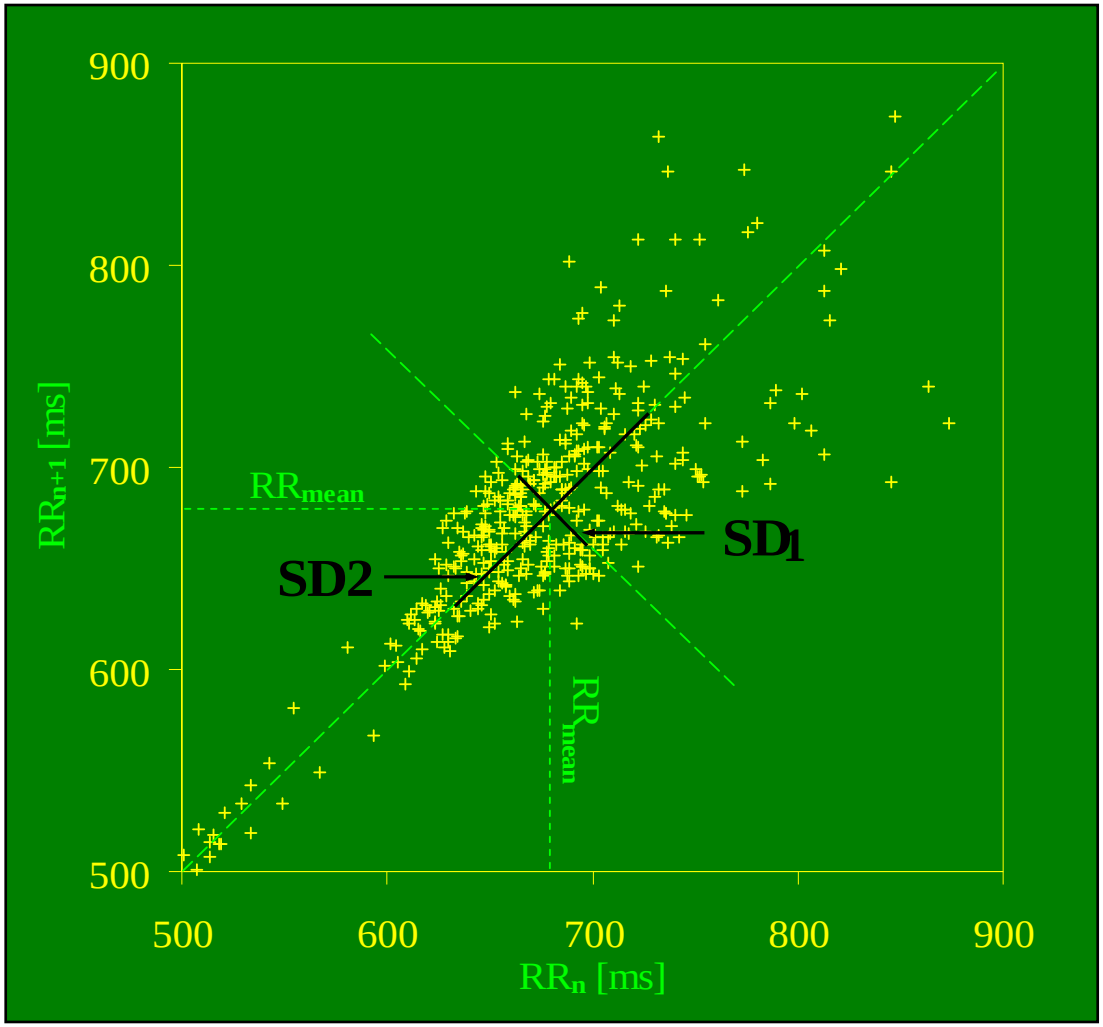


modified from McCraty & Watkins, 1996

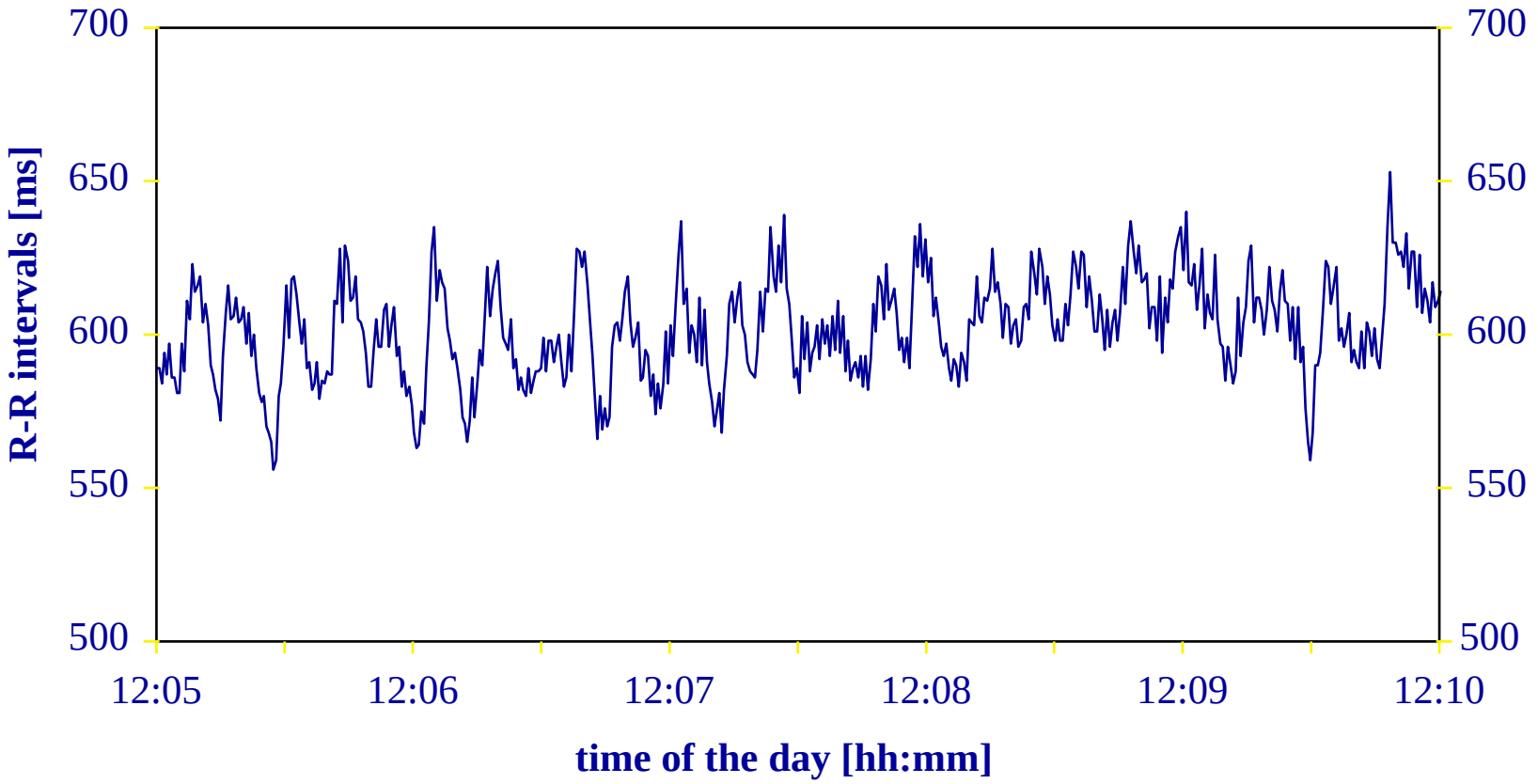
Quantitative Lorenz-Plot-Analyse der HRV Parameter SD1und SD2

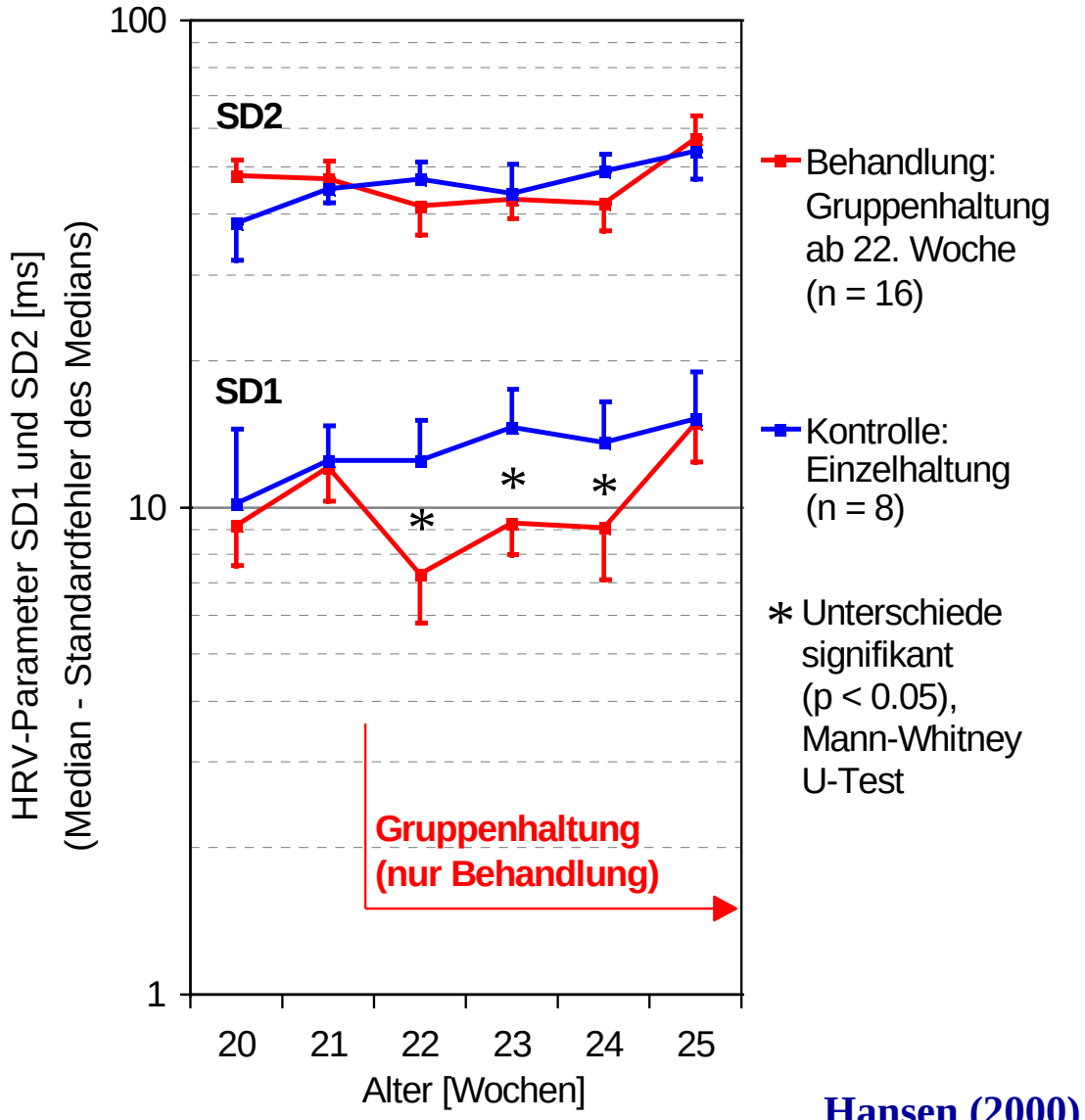
modified from
Tulppo et al. (1996)
Am. J. Physiol. 271

SD1 reflects
vagus activity



Tachogram of a pig in recumbency



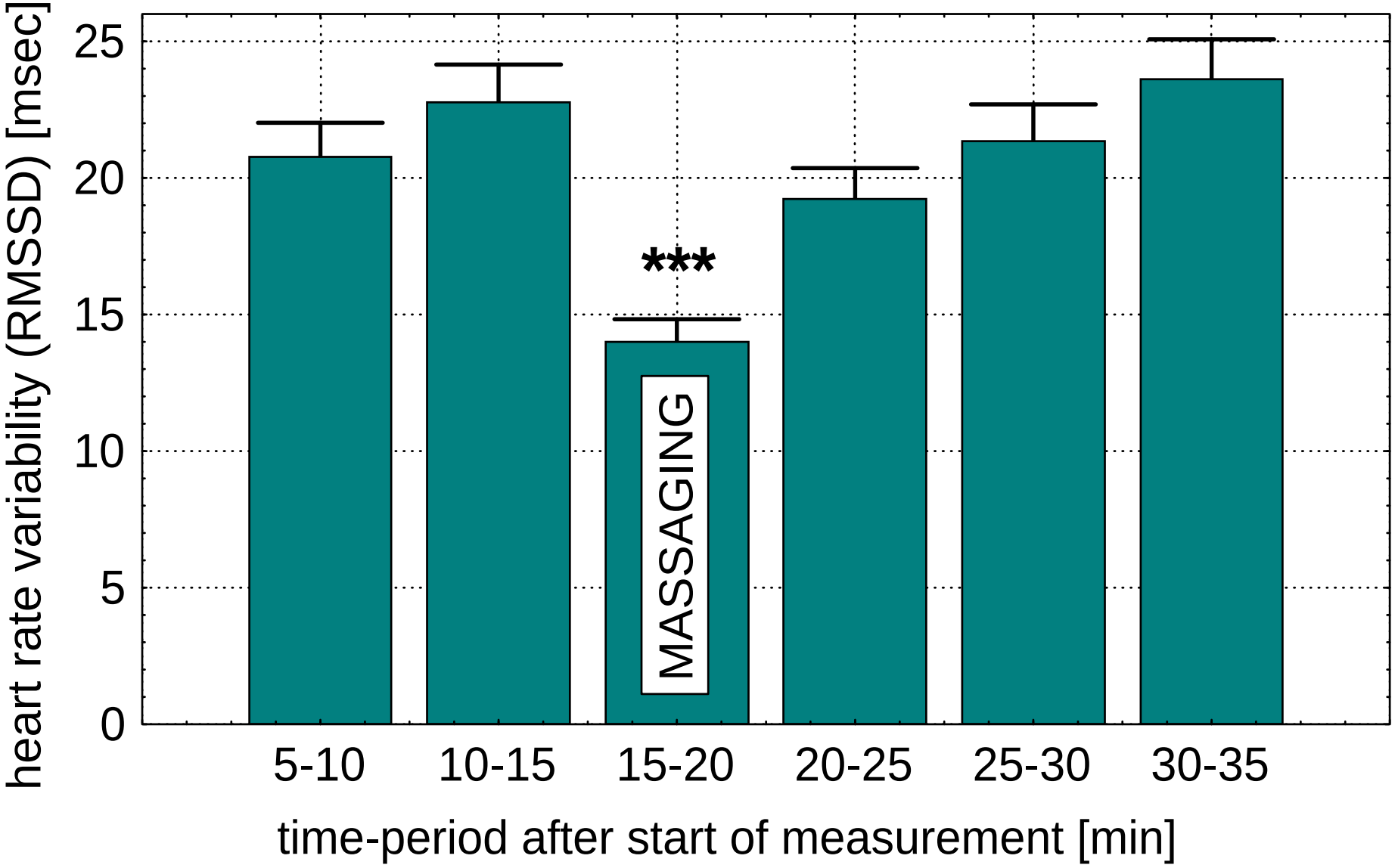


Hansen (2000)

Long Term Effect of Pig Grouping: reduces vagal tone (HRV-SD1)

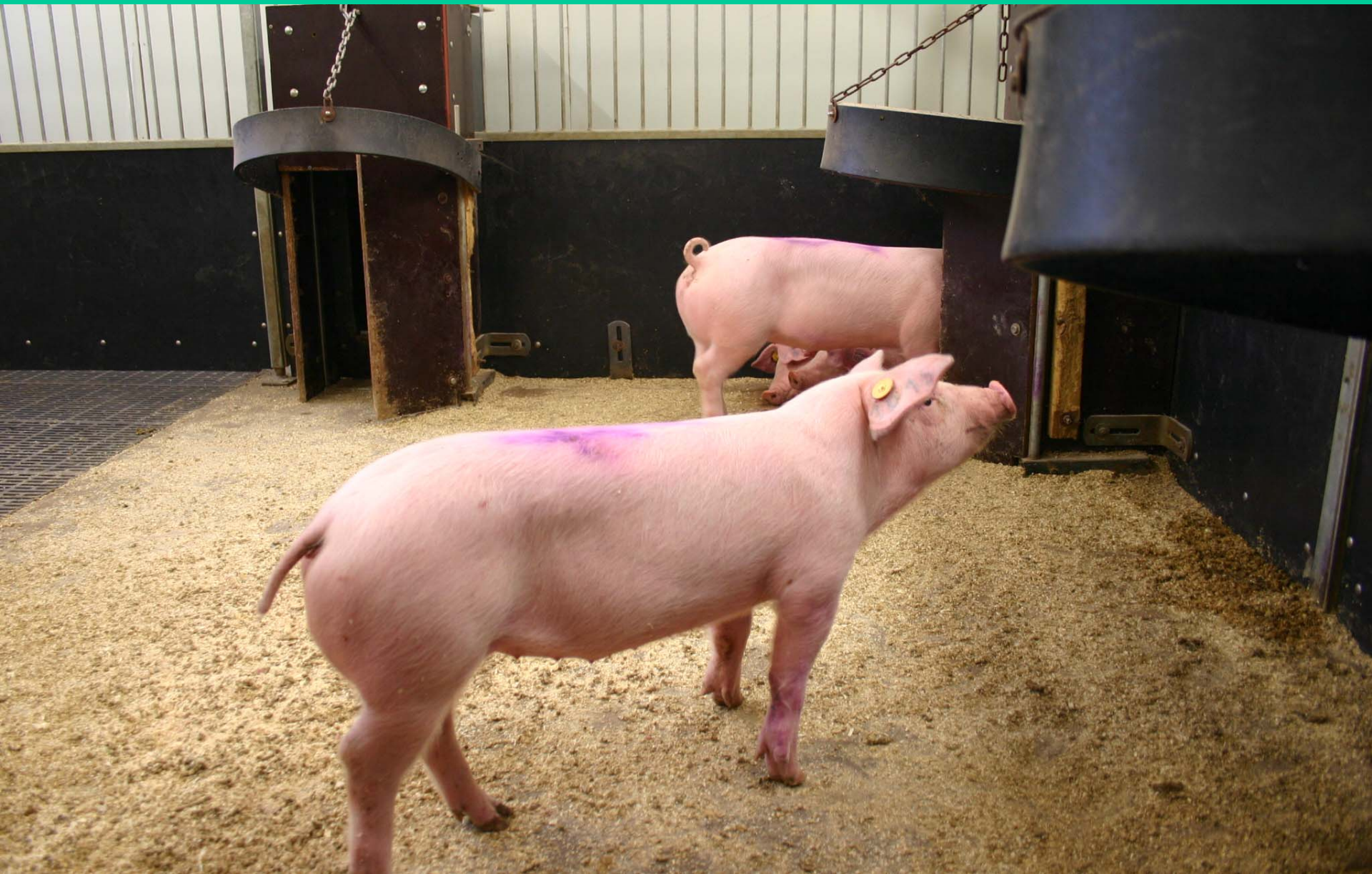
Positive Stress?

Hansen & von Borell, 1999



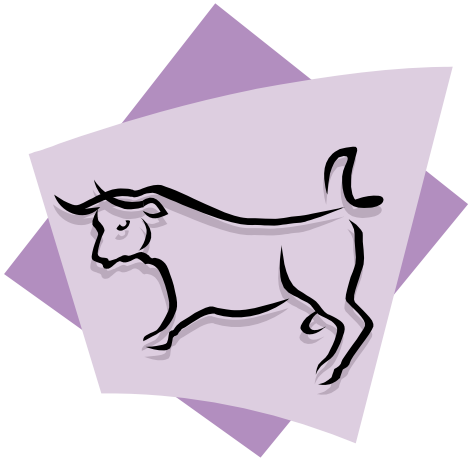
Positive Stress: Call-Feeding-Stations

(Manteuffel et al. FBN Dummerstorf)



Heart rate variability in cattle

- **HRV has been related to stress load (disease) in calves & dairy cattle (Mohr et al., 2002)**
- **HRV is reduced in cows kept in a partially forced automatic milking system (Hagen et al., 2005)**
- **HR correlates with milk yield (Weiss et al., 2004)**



New Polar Equine HR Telemetry System

Multi-Horse 6 unit system
(encoded for 200 foot range)

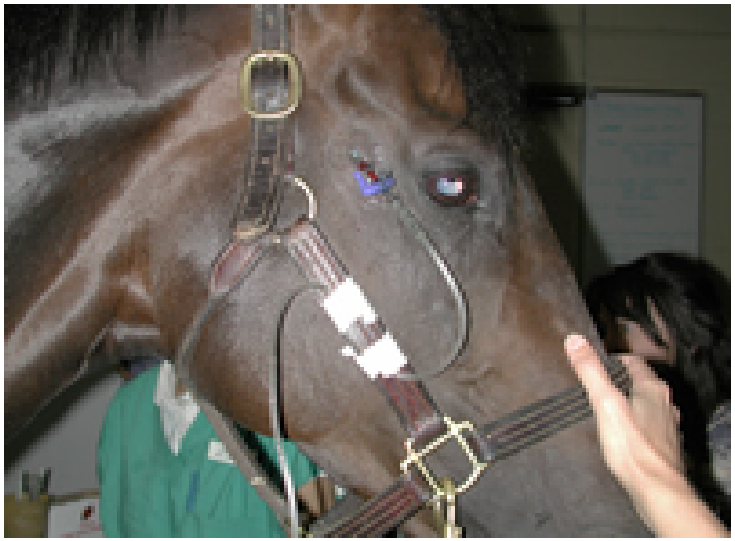
Half-Mile range system

Conclusion (HRV Task Force)

HRV is a promising approach for evaluating stress and emotional states in animals. It has the potential to contribute much to our understanding and assessment of the underlying neurophysiologic processes of stress responses and different welfare states in farm animals. (COST ACTION 846)

von Borell et al. 2007; Physiology & Behavior in press

Future: Remote monitoring of multiple indices of health and welfare such as HRV, body temperature, blood metabolites, behaviour and vocalisation



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**

Outlook

- Cognition
- Enrichment
- Motivation
- Coping
- Genetic control
- Neurobiological regulation
- Eustress & distress
- Human-animal relationship

Thanks for the support and input from the task force members of COST Action 846 „Measuring and Monitoring Farm Animal Welfare“

Special Issue on „Measuring Stress and Welfare in Farm Animals“ edited by E. von Borell and I. Veissier Physiology and Behavior, online in press