The neurophysiological regulation of temperament in sheep

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Abstract

This thesis examines the neurophysiological underpinning mechanisms which may be pertinent for understanding temperament and its relationship to fearfulness in sheep. In the dose response experiment conducted in chapter 3, administration of diazepam (GABA agonist) and m-CPP (5-HT agonist) gave the most consistent physiological responses in the arena test and isolation box test, which aligned with extrapolated data. The interpretation of the behavioural responses was less clear.

We designed a psychological challenge (the fear potentiation model) to induce fear utilizing a line of sheep selected for calm and nervous temperament. The final model consisted of two prior exposures to an isolation and dog challenge, and a final exposure to isolation only. Manipulation of the fear response was achieved with a potentiated fear state, causing the sheep to respond to the final isolation exposure with a marked reduction in the behavioural response, similar to freezing behaviour, which was still evident after a long period of time. This implies memory of the situation resulting in a behaviourally potentiated fear response. Physiologically, the isolation and dog challenge caused only a slight potentiated response. Additionally, sheep were able to perceive the dog's presence without visual or auditory cues, suggesting possible olfactory detection.

We employed the use of selected pharmacological treatments to target neurotransmitter pathways to investigate their role on fearfulness and temperament whilst exposed to the challenge test, however the role of the pathways targeted (GABA and 5-HT) and influence upon temperament was not obvious. The selected pharmacological treatments did convey effects on behavioural and physiology; however this was not evident in observing differences in the temperament selection lines. The primary observation was that of a divergent behavioural response whilst the physiological response between calm and nervous was fairly inconsistent. The marked divergence in behaviour and limited divergence of the physiological response was consistent throughout the experiments using the selection line. It appears that selection has mostly resulted in common characteristics that differentiate the line behaviourally and not physiologically, whilst the physiological data for the selection line is not tightly linked to the behavioural responses during the challenge periods.

Certification

I certify that the substance of this thesis has not already been submitted for any degree and is not currently being submitted for any other degree or qualification.

I certify that any help received in preparing this thesis, and all sources used, have been acknowledged in this thesis.

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Kelly Anne Drake

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Abbreviations

ACh	acetylcholine
ACTH	adrenocorticotrophine
AMS	Australian Merino Society
ANS	autonomic nervous system
BZP	benzodiazepine
Ca^{2+}	calcium ion
cAMP	cyclic adenosine monophosphate
CBG	corticosteroid binding globulin
CBZ	central benzodiazepine
CCK	cholecystokinin
Cl^-	chloride
CNS	central nervous system
CRH	corticotropin releasing hormone
CSF	cerebrospinal fluid
DA	dopamine
DAT	dopamine transporter
DOPA	3,4-dihydroxyphenylalanine
DOPAC	3-4-dihydroxyphenlacetic acid
DRN	dorsal raphe nuclei
GABA	γ-amino-*n*-butyric acid
EPM	elevated plus maze
GABA-T	γ-amino-n-butyric acid-transaminase
GAD	glutamate decarboxylase
GC	glucocorticoid
GI tract	gastro-intestinal tract
GR	glucocorticoid receptor
HPA axis	hypothalamic-pituitary adrenal axis
IBT	isolation box test
IUPHAR	International Union of Pharmacology
K^+	potassium ion
LDH	lactate dehydrogenase

LS means	least square means
LH	luteinising hormone
MAO	monoamine oxidase
MR	minerolocorticoid receptor
MRN	medial raphe nuclei
m-CPP	*m*-chlorophenylpiperazine
NA	noradrenaline
NT	neurotransmitter
Na^+	sodium ion
PAG	periaquaductal grey
PBS	phosphate buffered saline
PNS	peripheral nervous system
RIA	radioimmunoassay
RU-486	Mifepristone
QTL	Quantitative trait loci
SAM axis	sympatho-adrenal medullary system
SIH	stress-induced hyperthermia
SNPs	single nucleotide polymorphisms
SSA	succinic semi-aldehyde
SSRI's	selective serotonin re-uptake inhibitors
SUCC	succinic acid
TBPS	*t*-butylbicyclophosphorothionate
UWA	University of Western Australia
5-HT	5-hydroxytrptamine (serotonin)
5-HTP	($_L$-5-hydroxytryptophan)
5-HIAA	5-hydroxyindoleacetic acid
8-OH-DPAT	8-hydroxy-2-(di-*n*-propylamino) tetralin
γ MSH	gamma melanocyte stimulating hormone

Working definitions for thesis

Temperament:

Is the inherent fearfulness of an animal in response to a variety of situations, including the response to humans or to strange, novel or threatening situations. This has also been referred to in the literature as emotional reactivity, emotionality and reactivity.

Fearfulness:

Is a temperament trait that incorporates the general susceptibility of an animal to react to a variety of potentially threatening situations. Fearfulness helps to motivate an animal to avoid a potentially averse or threatening situation and facilitates a learned response.

Fear potentiation:

Prior exposure to a more severe stressor will increase or potentiate the fear response on a subsequent exposure to a different challenge. For example, exposure to an Isolation and dog challenge will potentiate the fear response to a subsequent presentation of Isolation only.

Stress:

Stress is a very broad term, which implies a threat to an animal, in which it needs to adjust.

Stressor:

Intrinsic and extrinsic factors, both real and perceived that alter an animal's homeostatic balance, activating behavioural, physiological and neurophysiological systems of the body.

Anxiety:

A normal and pathological state, however in this instance it is considered more of a psychological state and can be caused by real and/or imagined threats