Quantifying Post-trauma Stress in Macropods and the Polyvagal Theory and Therapy in Stress Rehabilitation

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Where traumatised wildlife can recover in safety

Overview

- Macropod Emotions
- Stress & its assessment
- Data – Bushfire, Fence Entanglement, Dog attack
- The Polyvagal theory
- Its application in rehabilitation
- The mystery of ‘shutdown’ & the question of ‘myopathy’

The emotional lives of macropods

[Ref: Garlick, S. and Austen, R. “Learning about the emotional lives of kangaroos, cognitive justice and environmental sustainability”. *Journal of Relations: Beyond Anthropocentricism*, 2014, 2 (1).]

- *Emotions are not spontaneous upwellings of arbitrary feelings. They are reactions to events. So if we can correlate emotional reactions with the events that trigger them, we can use these reactions as sources of information to help in recovery.*
- **The emotional life of an animal is just as important for recovery as is his/her physical life.**
  - The veterinarian probably can't help you with that.
  - Carers and rehabilitators spend 24/ 7 observing these emotional states

Observed Emotional & Cultural Behaviour

- A ‘Being-for’ (Bauman form of engagement.
- Six neural markers for kangaroos (joy, distress, anger, relaxation, nurturance, sexuality) seen through close engagement observation.
- Each has several behavioural indicators (see table next slide).
- Here we are interested in these neural markers as they relate to the incidence of life-threatening post-trauma stress and recovery from it.
- We want to go beyond simple observation and into quantitative assessment.
- In particular we are interested in the role of the autonomic nervous system in stress not only because it generates these neural states, but also because it also helps with the therapy and recovery process.

Observed Emotional Behaviour Markers in the Kangaroo

Neural states	Outward indicators (kangaroo)
Joy (play)	Hooning, kicking legs into the air, boxing with kin, chasing kin, eye expression.
Separation, distress (panic)	Vocal, running into objects in panic, wide eye expression, erect and extended posture, licking forearms, rapid respiratory rate, rapid pulse rate, high blood pressure, flared nostrils.
Nurturance (care)	Preening, embracing kin, body contact, protective behaviour by dominant males
Sexuality (lust)	Courtship behaviour, pairing, long-term male/female friendships
Anger (rage)	Vocal, eye expression, posture
Relaxation	Lying on back asleep, mothers relaxing pouch muscle, mothers allowing small infants to exercise outside pouch

Stress and the Autonomic Nervous System

- ANS regulates the internal environment of the body such as temperature, heart rate, respiration rate, blood pressure and digestion and comprises:
  - Sympathetic nervous system – prepares the body for ‘fight’ or ‘flight’ from a threat in the environment.
  - Parasympathetic nervous system – helps regulate the body at rest (‘rest and digest’).

Sympathetic nervous system: Effects

- Stimulates release of adrenalin – ‘adrenalin rush’
- Stimulates glucose release from liver
- Diverts blood away from GIT, kidneys and skin
- Enhances blood flow to skeletal muscles (1200%) & lungs
- Dilates bronchioles (airways) of lungs allowing better oxygen exchange
- Increases heart rate and contractility of heart cells
- Dilates cardiac blood vessels
- Dilates pupils

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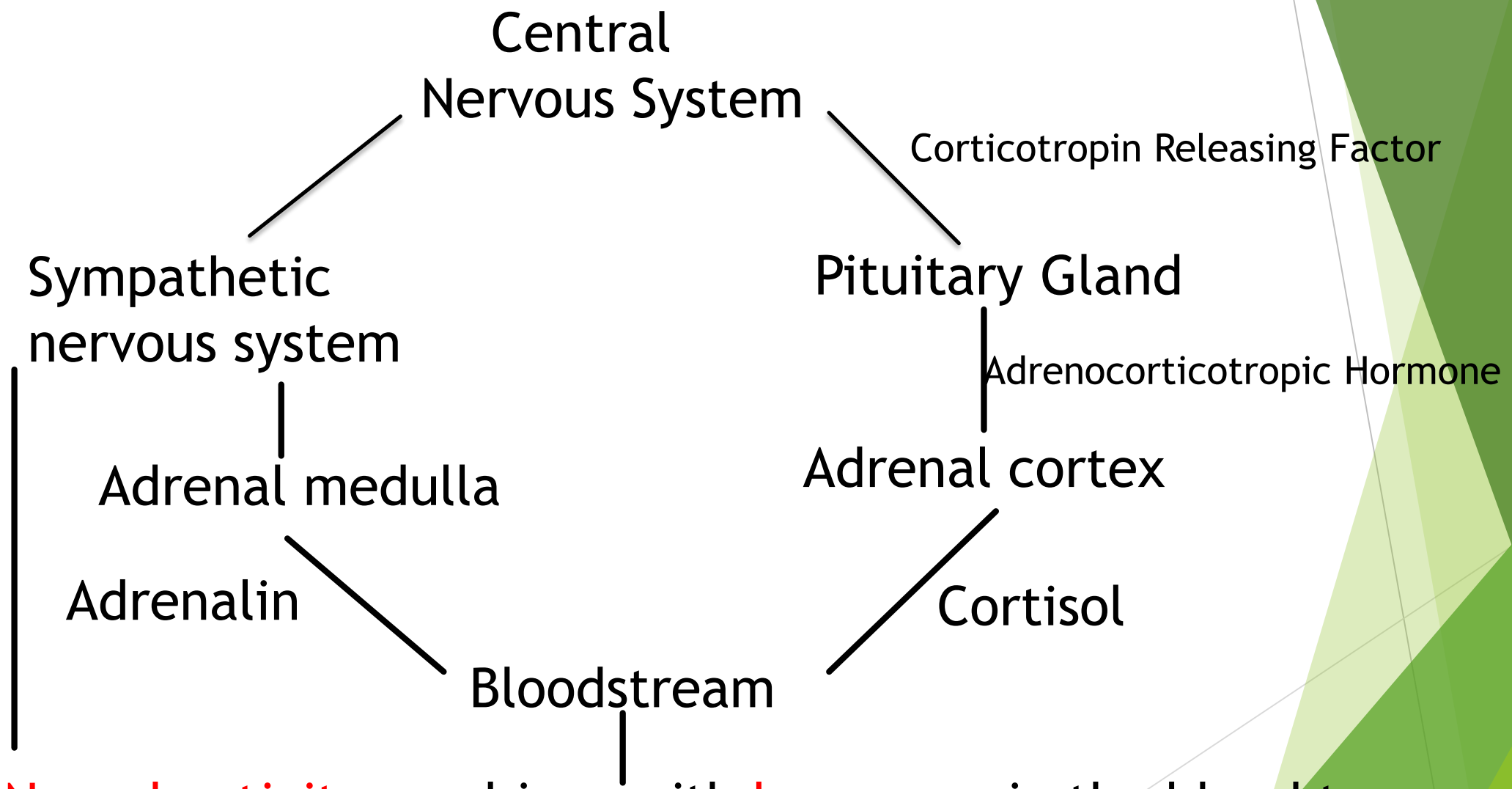
Fight or Flight Response



Neural activity combines with hormones in the blood to constitute the fight or flight response

Fear factor

Overwhelming fear & anxiety trigger the sympathetic nervous system & release of hormones such as adrenalin and cortisol

Sympathetic - fight or flight

Parasympathetic ventral vagal – rest and digest

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The Adrenalin Rush

Adrenalin contributes to the fight or flight response by:

- increasing blood flow to the muscles
- increasing output of the heart
- pupil dilation
- increasing blood glucose

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Cortisol Contribution

- Increasing blood pressure
- Increasing blood glucose
- Heightened attention
- Decreasing sensitivity to pain.

- As an analogy with respect to the fight or flight response, adrenalin puts the foot on the accelerator. As the initial adrenalin surge subsides, cortisol keeps the accelerator on. When the threat passes, the parasympathetic nervous system acts like a brake and dampens the stress response

Stress in Macropods

- Pathophysiology not well understood and a paucity of knowledge in the literature eg Ladd, “Pathology of Australian Native Wildlife”, CSIRO Publishing
- Trigger for a stress syndrome is stress caused by fear or anxiety.
- Risk of death is increased by intense physical exertion (exertional rhabdomyolysis) .
- Obvious triggers include macropod caught in a fence or chased by a motor vehicle or dogs, a joey separated from its mother, illness. Presentation after severe stress varies.
- Some triggers are more subtle eg change in carer, relocation to release site or certain noises.
- Personality of the animal also plays a role in whether significant stress develops.
- Animals with anxiety traits are more likely to develop significant stress when exposed to a stressor.

Measuring Cortisol in Wildlife for Post-trauma Assessment

Type	Advantages	Disadvantages
Blood	Cortisol data can be aligned with other biochemistry and haematology data. Sample can be correlated with the trauma circumstances.	Invasive, animal needs to be sedated for venal access. Hormonal analysis can be expensive.
Faecal	Non-invasive. Easily obtained.	May be difficult to assign sample with correct subject. Time delay in obtaining correct sample post-trauma. Frozen storage and centrifuge analysis.
Hair	Useful for chronic stress after 6 months of hair growth. Easy storage.	Not useful for acute stress. Animal needs to be captured.
Saliva	Easily obtained	Samples need to be taken throughout the day. Animal needs to be captured.
Urine	Non-invasive	Opportunistic access. Animal needs to be captured. Timing of urine collection vis a vis the stress event can be problematic. Cortisol can be influenced by urine concentration.

Exertional Rhabdomyolysis

- Prolonged, strenuous muscle activity can cause exertional rhabdomyolysis especially in hot conditions and associated with dehydration.
- The breakdown of the muscle tissue releases the muscle protein myoglobin, enzymes – creatine kinase (CK), AST/ ALT, and potassium into the blood.
- The myoglobin results in dark brown or what is known as ‘Coca Cola’ urine and can result in kidney damage and consequent renal failure.

Selected cases – Cortisol & CK data

- Being burnt in wildfires
- Being caught in wire fences
- Being chased & attacked by dogs

Black Summer Bush Fires

Name	Date	CK	Cort	Date	CK	Cort
Steff	31/1/20	6825	112	15/4/20	4867	36
Cinders	5/2/20	6097	178	25/3/20	1093	46
Sparkles	5/2/20	3872	161	15/3/20	370	24
Kenny	5/2/20	4281	170	7/2/20	11664	87
Shannon	26/1/20	2568	362	15/3/20	9965	98

CK Normal 203-6868 U/L
CORT Normal < 50nmol

Cinder's story

- One of the 30 burns cases brought to Possumwood. One of the worst burns cases.
- Cinders, 3 ½ years after rescue, treatment and her recovery from the fires.
- Like the other kangaroos rescued and treated at Possumwood after the fires, she spent her rehabilitation with others inside receiving attention
-
- Cinders has been released successfully and has had joeys.

Cinders

Observations from the burns case data

- CK approximates normal levels and generally declines further when in a safe care situation.
- Those rescued directly from the fires and brought to Possumwood generally had high cortisol levels (eg Steff, Cinders, Sparkles and Shannon).
- Those coming two months later from other triage centres with different housing and treatment protocols had higher cortisol levels.
- Cortisol levels in both cases dropped significantly while in care at Possumwood.
- The post-treatment care regime for the burns cases at Possumwood included:
  - Inside recovery
  - Group situation recovery
  - Constant engagement with Possumwood staff including physio, dressing changes, etc.

Wire Fence Entanglement

Name	Date	CK	CORT	Outcome
Kelly	2/11/21	98811	584	Died
Brooks	15/11/21	99774	337	Released
William	16/10/21	3158	202	Released
Bates	18/10/21	79651	295	Released
Cinnamon	23/7/22	57288	125	In-care
Goliath	17/8/21	9398	236	Died
McGooley	14/1/22	97164	196	Died
Tatiana	16/3/22	121722	326	Died
Gide	18/12/21	23499	347	Died
Springer	6/3/22	178210	262	Released
Timon2	5/3/22	22588	230	In-care
Ginni	15/2/22	102048	588	In-care
George	15/2/22	244716	342	Died
Basil	12/6/23	731850	152	In-care
Diego	16/9/22	122308	233	In-care

CK Normal 203-6868 U/L
CORT Normal < 50nmol

Basil's story

- Markedly elevated CK and Cort levels on rescue from fence entanglement. Caught by both legs.

- After 5 weeks in care he is doing very well. Can get up and stand for long periods, hopping.

Basil

Observations from the fence hanger data

- Both CK and Cort can be markedly elevated.
- With the right treatment and rehab, many recover and are eventually released after weeks or months depending on various factors (presence of lactic acidosis, age, severity of injuries, etc)
  - Fluids & metabolic acidosis treatment if needed
  - Antibiotics & other cover (tetanus, cocci, other parasites)
  - Wound cleaning & dressing
- Rehab conditions & program
  - Indoor shared accommodation (Isolation from others does not work and in fact can be detrimental)
  - Physio
  - Attachment (choice of roommates is important eg. stage of recovery & personality)
  - Regular communication.

Dog Attack

Name	Date	CK	Cort	Date	CK	Cort	Outcome
Boxer	28/10/21	20654	302				Released
Cherry Blossum	5/7/22	139826	242	22/7/22	705	59	Released
Woola	3/5/23	16074	349	8/5/23	4990	204	Released
Carrie		356540	525				Released
Swallow	25/3/19	82900	531	18/4/19	1829	26	Died
Big Al	26/6/18		431				Released
Rovere		216230	170				Released
Betty		17633	803				Released

CK Normal 203-6868 U/L
CORT Normal < 50nmol

Dog Attack Recovery Over Time

Cherry Blossum. Attacked by two Maremma dogs. When rescued she was suffering from exertional rhabdomyolysis (indicated by the very high CK). She was in a sympathetic flight or fight state (indicated by the very high cortisol). You can see that over time the exertional rhabdomyolysis resolves as shown by the decrease in the CK. She was housed inside with three other quiet macropods and received a lot of gentle attention from her carers. Her anxiety decreased as evidenced by the drop in cortisol (a switch from the sympathetic to the parasympathetic).

Date	CK	CORT
5/7/22	139,826	242
6/7/22	52,253	154
11/7/22	8351	96
22/7/22	705	59

CK Normal 280 – 2790 U/L
CORT Normal < 50nmol

Carrie's story

- Markedly elevated CK (356540) and Cort (525).

- A fence hanger attacked by a dog while hanging in the fence.

- She had a severe neck wound from the dog attack and broken teeth from hitting the ground when she got her feet caught in the wire fence

Carrie

Swallow

Test	21/ 03/ 2019	16/04/2019	Normal *
Cortisol (nmol/ L)	531	56	<50**
Potassium (mmol/ L)	5.7	4.6	2.2-8.2
Urea (mmol/ L)	18.8	6.9	4.3-17.1
Creatinine (umol/ L)	120	55	44-168
AST (U/ L)	3343	96	30-281
Creatine Kinase (U/ L)	82900	1829	203-6868

* Vetnostics data.

**Possumwood research.

Female Red Neck wallaby attacked by two dogs. Arm severe lacerations and fractures, bites to leg and neck. Small pinkie in pouch died.

Observations from Dog Attack Data

- Need to act quickly to rescue & treat
- Markedly elevated CK & Cort
- With treatment & rehab both CK and Cort can be significantly reduced in a short time (eg Cherry).
- Most survive to be released following rehab.

Three Stress Categories

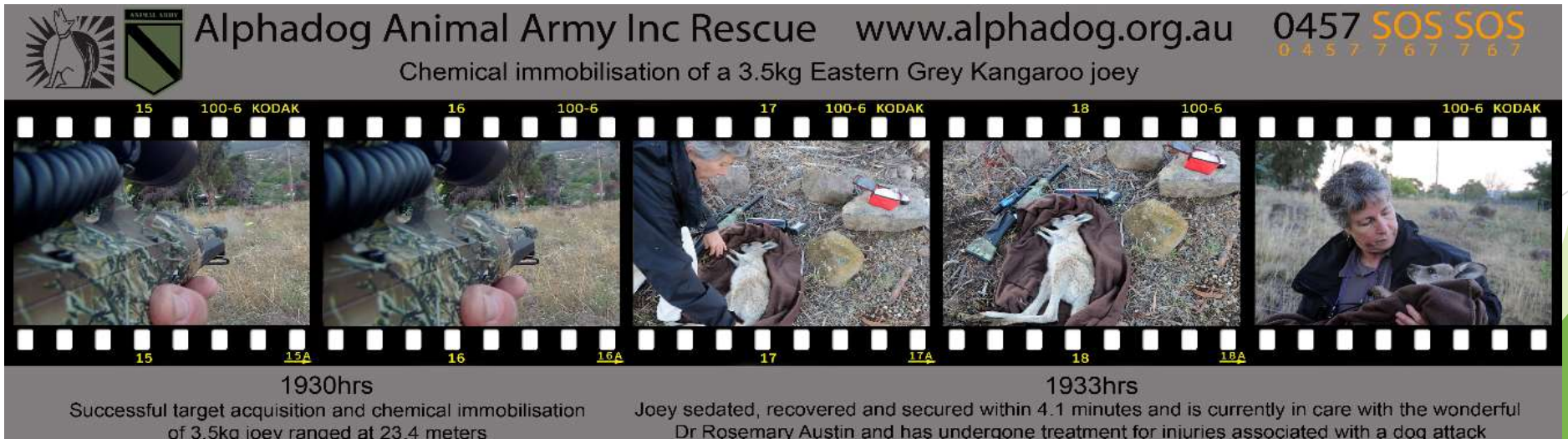
- 1. Switch from Fight or Flight to Rest & Digest
  - 1(a): High Cortisol/ Low CK, e.g. wildfire burns victims
  - 1(b): High Cortisol/ High CK, eg fence hangers and dog attack victims.
- 2: Stuck in Fight or Flight (unable to switch) - stress repeat leading to death (eg Iggy, McGooley)
- 3: Shutdown - relentless decline in vital signs (eg heart rate, respiration rate, blood pressure, temperature) with resultant respiratory arrest and death.

Stress – Category 2: The case of Iggy

- Less common
- Ongoing fight or flight state (PTSD)
- Rapid progression to death after a subsequent stress

trigger (even if mild).

Iggy. Mother euthanased, alone for three days, harassed by dogs and then darted and brought into care at 3.5kg. Always hypervigilant, thought to have PTSD. After a minor stressor, Iggy went into a trance-like state – recumbent, muscle fasciculation, respiratory arrest and death within one hour.? The shutdown state of the polyvagal theory.



Stress Category 3: The case of Toto

- We have observed that some macropods at rescue are already going into shut down. It has also been observed that some animals go into shutdown after rescue, especially if housing conditions are not ideal. These animals are under- responsive, are or are becoming hypothermic, bradycardic and bradypnoeic. They progress to respiratory arrest and death.

Name	CK	Cort	Temp	HR	RR	BP
Toto (10kg)	13009	257	32.4	60	14	102/42

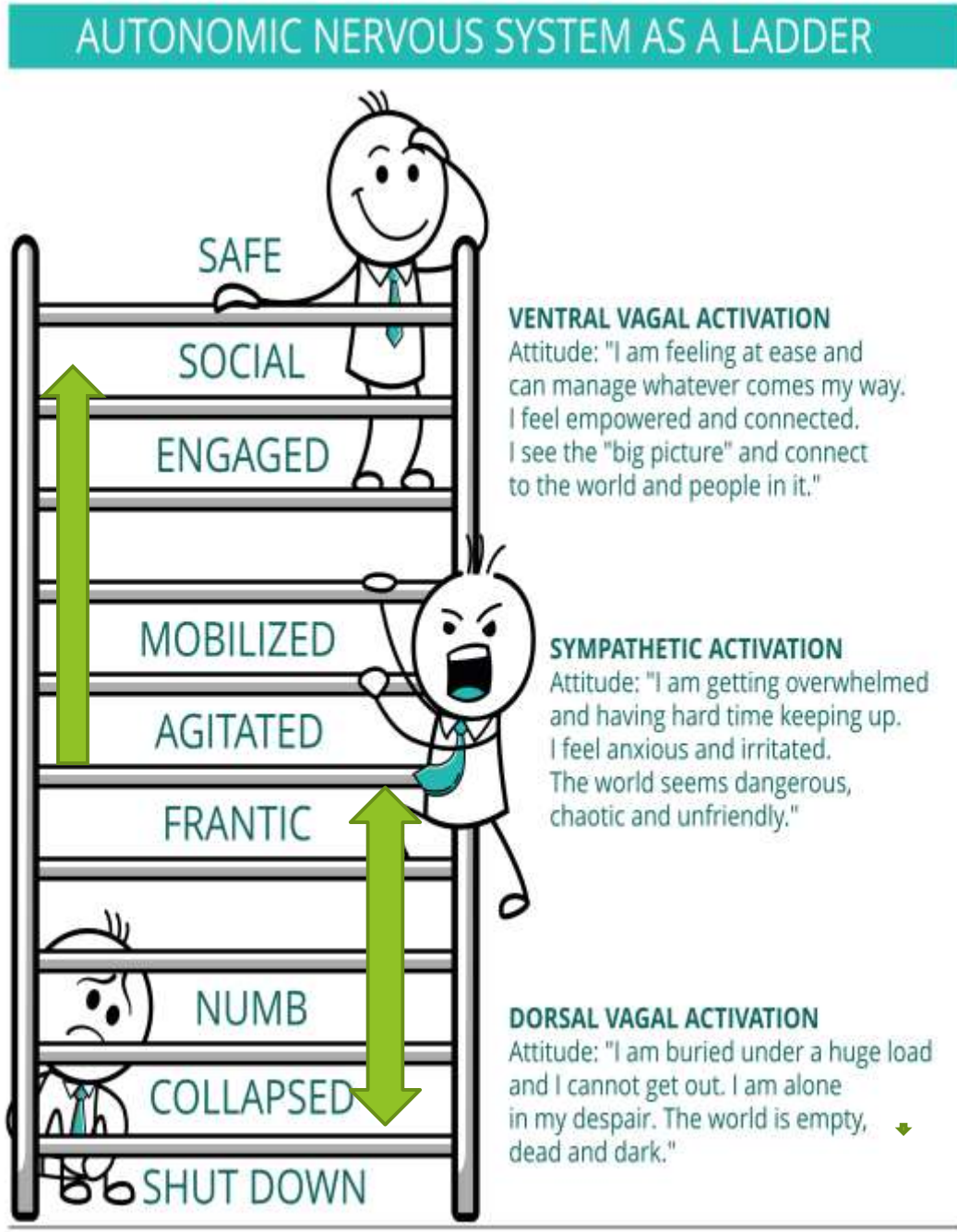
Polyvagal Theory: ANS and Vagal Nervous System

- Stephen Porges ("The Polyvagal Theory: Neurophysiological Foundations of Emotions, Attachment, Communication & Self-regulation", 2011)
- Sympathetic nervous system
- Parasympathetic Nervous System
  - Dorsal Vagal nervous system
  - Ventral Vagal nervous system
- Studies with animals

The Polyvagal Theory in Action

- The autonomic nervous system
  - Sympathetic & Parasympathetic nervous systems
- The Vagus nerves of the parasympathetic nervous system
  - Ventral vagus branch -
  - Dorsal vagus branch –
- The Polyvagal Ladder – a continuous loop of emotional &

  behavioural movement between three states
  - Rest & digest (social engagement & rest)
  - Fight or flight (mobilisation)
  - Shutdown (immobilisation) –trance-like



Adapted from *The Polyvagal Theory in Therapy* by Deb Dana

Neuroception – interpreting safety and risk

- In the ANS, Neuroception is the immediate interpretation of stimuli without conscious input from the brain.
  - Neuroception precedes perception.
  - The ANS is a surveillance system - always monitoring stimuli and asking the question ‘is this safe?’
  - Fence injured macropods – limited mobility increases the risk interpretation and consequent action.
    - Burns cases in recovery
    - Luna and Karolina (single carer)
    - Basil – changing the environment
    - Carl – housing and multiple carers.

Fight or Flight (ready for action) Sympathetic

Luna

Rest & digest (safe, socially engaged)
Parasympathetic - Ventral Vagal

Shutdown
Dorsal Vagal

Mike (CK 2272, CORT 93)

Mary

Polyvagal Rehabilitation: Self-regulation, attachment, communication & support

- Self-regulation
- Attachment
- Communication
- Environmental support (housing, group dynamic)
- Medication support?

The mystery of shutdown and the question of myopathy in macropods

- We propose the term myopathy is a misnomer. The animals don't die from muscle pathology – they die because their body functions shut down.
- How can we switch a macropod from shutdown back to fight or flight and then into rest & digest?
- This is a question we are working on at Possumwood.

Thank You