

# CHRONIC PAIN NEUROTECHNOLOGY NETWORK+

**Stuart Black**

**Founder, Managing Director**

**Applied Neuroscience Solutions Ltd, trading as BrainTrainUK**

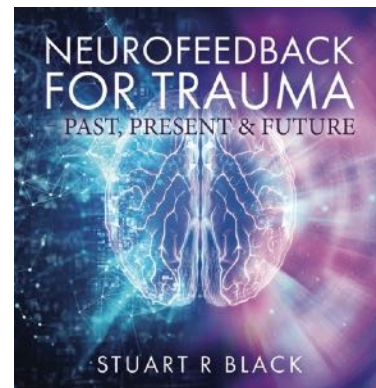
**AN INTRODUCTION TO CONTEMPORARY CLINICAL  
NEUROFEEDBACK**

# Contents

- Who are we?
- What is Neurofeedback?
- How do we explain it?
- What do we use it for?
- What does the client have to do?
- How do we plan it?
- How do we deliver it?

# Who are we?

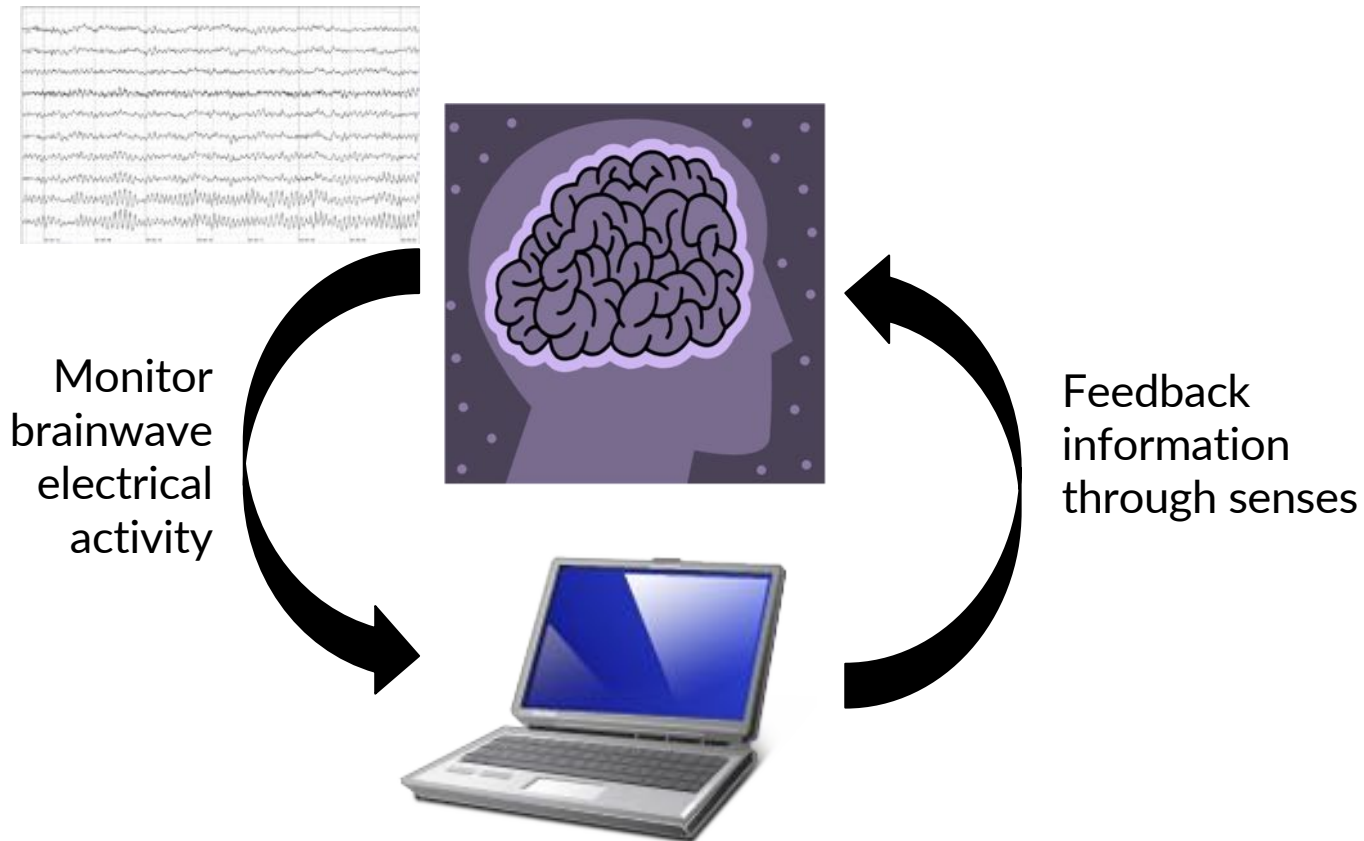
- Stuart Black BSc(Eng) MSc CEng MIET
- Applied Neuroscience Solutions Ltd
- Founded BrainTrainUK 2013
- Five clinics in UK + home-based programme
- Bournemouth doctorate industrial sponsor
- Published, peer reviewer



# What is Neurofeedback?

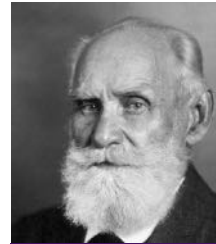
- Simple question?
- Improve brain & nervous system function through feedback-based learning on EEG rhythms
- In more detail = more complicated
- Various modalities have emerged since inception

# What is Neurofeedback?



*Neurofeedback creates an additional external feedback loop to enable learning*

# What is Neurofeedback? - lineage



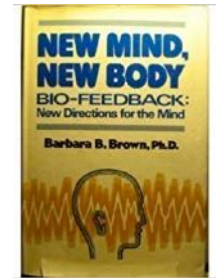
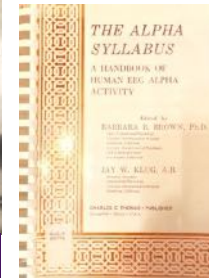
Ivan Pavlov



Jerry Konorski



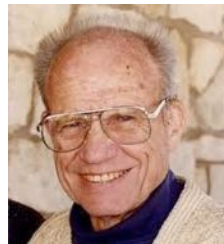
Barbara Brown



Alpha wave control



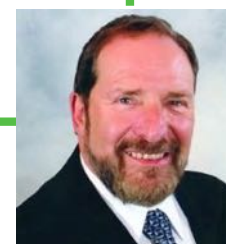
Joe Kamiya



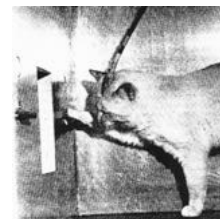
Elmer & Alyce Green



Wanda Wyrwicka

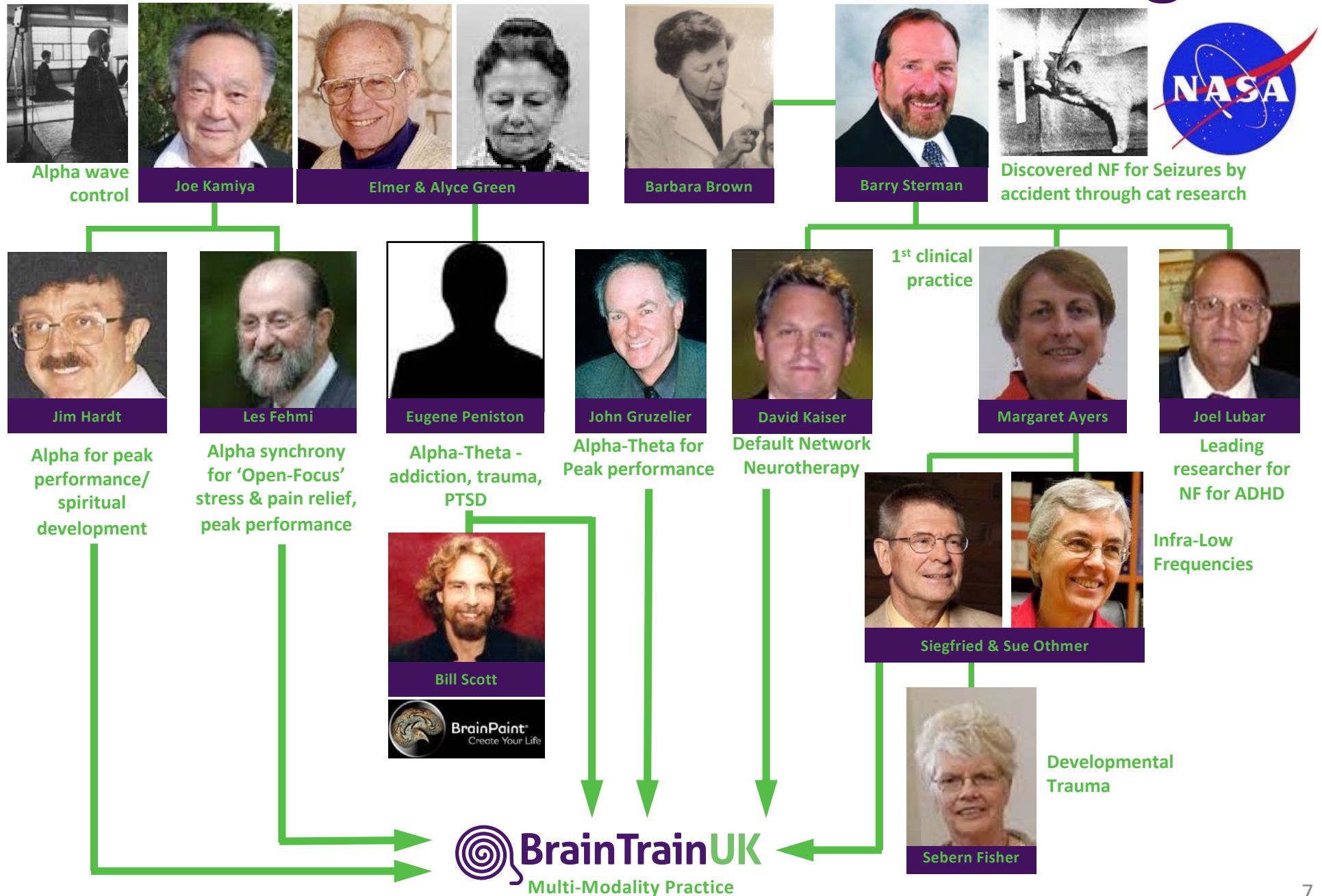


Barry Sterman

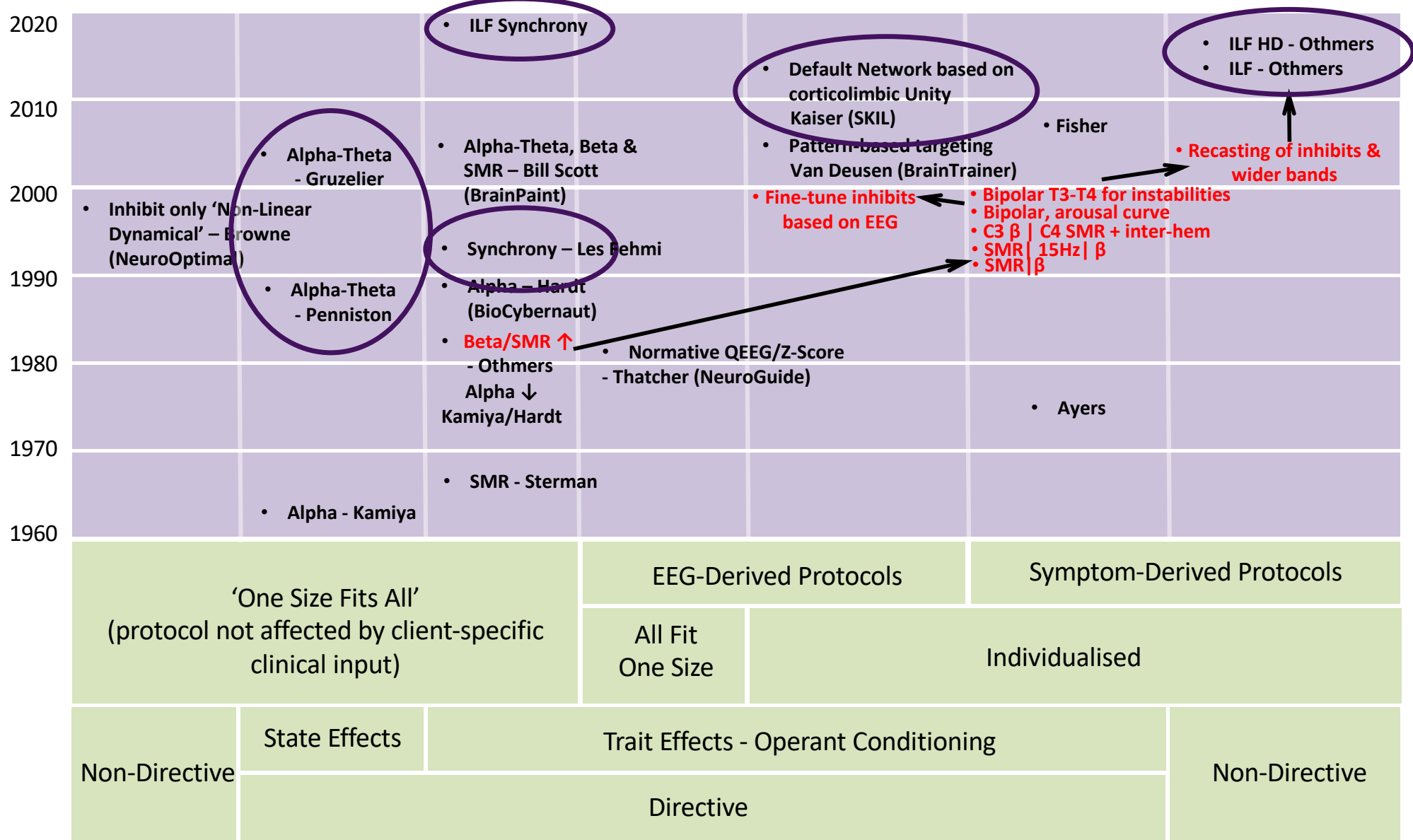


Discovered NF for Seizures by accident through cat research

# What is Neurofeedback? - lineage



# EEG Neuromodulation Modalities & History



# Endogenous Neurofeedback

- Clinical pathway bespoke to client history & symptom profile
- Clinical pathway tailored in response to client feedback
- Non-directive, unconscious learning process
- Frontiers in Human Neuroscience Research topic:

The screenshot shows the article page for "Endogenous Neuromodulation in the Infra-Low Frequency Regime" on the Frontiers website. The article is categorized under "Frontiers in Human Neuroscience > Brain Health and Clinical Neuroscience > Research Topics". It has 58.6K views, 59 authors, and 18 articles. The page features a "Impact" section with three articles:

- REVIEW** (21 September 2022): "Infra-low frequency neurofeedback and insomnia as a model of CNS dysregulation" by Paul Terrence Moore. This paper will review what is conventionally known of sleep homeostasis and focus on insomnia as a primary manifestation of brain dysregulation, whether as a solitary symptom or as part of a larger syndrome such as post-traumatic stress disorder, PTSD. It will discuss in brief behavioral/mindfulness treatments that have been used to treat neurologic diseases, as this is germane to the...
- CASE REPORT** (21 September 2022): "Infra-Low Frequency Neurofeedback rapidly ameliorates schizophrenia symptoms: A case report of the first session" by Ioannis N. Nestoros and Nionia G. Vailanitou. A 38-year-old army officer started therapy in 2020 with a four-year history of auditory hallucinations and delusions of reference, persecution and grandeur, symptoms that were...
- ORIGINAL RESEARCH** (15 September 2022): "Neurofeedback in patients with frontal brain lesions: A randomized, controlled double-blind trial" by Christine Annaheim, 4 more and Margret Hund-Georgiadis. Background: Frontal brain dysfunction is a major challenge in neurorehabilitation. Neurofeedback (NF), as an EEG-based brain training method, is currently applied in a wide...



<https://www.frontiersin.org/research-topics/24349/endogenous-neuromodulation-in-the-infra-low-frequency-regime/magazine>

# How do we explain it?

- Plasticity of brain
- Learning through feedback
- Brain's ability to make sense of information
- Brain's development by making sense of information

## The Brain Can Change - 2005



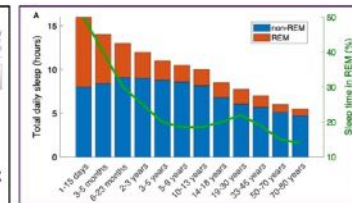
Dr. Alvaro Pascual-Leone, MD, PhD  
Harvard Medical School

Plasticity is an intrinsic property of the human brain and represents evolution's invention to enable the nervous system to escape the restrictions of its own genome and thus adapt to environmental pressures, physiologic changes, and experiences. Dynamic shifts in the strength of preexisting connections across distributed neural networks, changes in task-related cortico-cortical and cortico-subcortical coherence and modifications of the mapping between behavior and neural activity take place in response to changes in afferent input or efferent demand. Such rapid, ongoing changes may be followed by the establishment of new connections through dendritic growth and arborization. However, they harbor the danger that the evolving pattern of neural activation may in itself lead to abnormal behavior. Plasticity is the mechanism for development and learning, as much as a cause of pathology. The challenge we face is to learn enough about the mechanisms of plasticity to modulate them to achieve the best behavioral outcome for a given subject.

Neuroplasticity is real and enables development and learning, it can also be a cause of pathologies (problems)



## We Dream Because our Brain is so Plastic

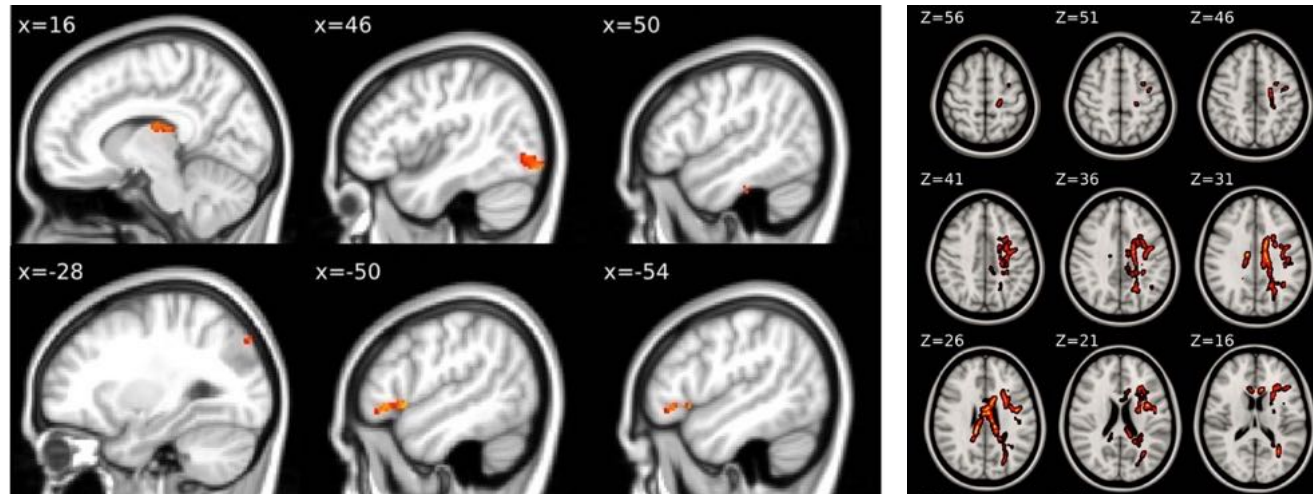


Prof. David Eagleman believes that we dream to protect our visual cortex from being 'taken over' by other senses during sleep



# How do we explain it?

## Neurofeedback Training Induces Changes in White and Gray Matter



*“increases in gray matter volume following Neurofeedback”*

Clinical EEG and Neuroscience  
00(0) 1-8  
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Society (ECNS) 2013  
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DOI: 10.1177/1550059413476031  
[eeg.sagepub.com](http://eeg.sagepub.com)



*“significant  
increase in white  
matter pathways  
following  
Neurofeedback”*

- Evidence the brain is ‘re-wired’ by Neurofeedback (NF)
- 20 sessions of NF like ‘learning to ride a bike’
- Studies on NF for ADHD show 10 year lasting effect

# How do we explain it?

|                              | Current Mental Health Paradigms                                                                                                                                                     |
|------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|                              | <b>Psychiatric paradigm</b>                                                                                                                                                         |
| <b>View of mental health</b> | Brain chemistry imbalance                                                                                                                                                           |
| <b>Approach</b>              | Medication to change brain chemistry                                                                                                                                                |
| <b>Limitations</b>           | <ul style="list-style-type: none"><li>• Limited effectiveness</li><li>• Does not address root cause</li><li>• Only works whilst being taken</li><li>• Common side-effects</li></ul> |

# How do we explain it?

Molecular Psychiatry [www.nature.com/mp](https://www.nature.com/mp)

**SYSTEMATIC REVIEW** **OPEN** [Check for updates](#)

## The serotonin theory of depression: a systematic umbrella review of the evidence

Joanna Moncrieff<sup>1,2,3</sup>, Ruth E. Cooper<sup>3</sup>, Tom Stockmann<sup>4</sup>, Simone Amendola<sup>5</sup>, Michael P. Hengartner<sup>6</sup> and Mark A. Horowitz<sup>1,2</sup>

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The serotonin hypothesis of depression is still influential. We aimed to synthesise and evaluate evidence on whether depression is associated with lowered serotonin concentration or activity in a systematic umbrella review of the principal relevant areas of research. PubMed, EMBASE and PsycINFO were searched using terms appropriate to each area of research, from their inception until December 2020. Systematic reviews, meta-analyses and large data-set analyses in the following areas were identified: serotonin and serotonin metabolite, 5-HIAA, concentrations in body fluids; serotonin 5-HT<sub>1A</sub> receptor binding; serotonin transporter (SERT) levels measured by imaging or at post-mortem; tryptophan depletion studies; SERT gene associations and SERT gene-environment interactions. Studies of depression associated with physical conditions and specific subtypes of depression (e.g. bipolar depression) were excluded. Two independent reviewers extracted the data and assessed the quality of included studies using the AMSTAR-2, an adapted AMSTAR-2, or the STREGA for a large genetic study. The certainty of study results was assessed using a modified version of the GRADE. We did not synthesise results of individual meta-analyses because they included overlapping studies. The review was registered with PROSPERO (CRD42020207203). 17 studies were included: 12 systematic reviews and meta-analyses, 1 collaborative meta-analysis, 1 meta-analysis of large cohort studies, 1 systematic review and narrative synthesis, 1 genetic association study and 1 umbrella review. Quality of reviews was variable with some genetic studies of high quality. Two meta-analyses of overlapping studies examining the serotonin metabolite, 5-HIAA, showed no association with depression (largest  $n = 1002$ ). One meta-analysis of cohort studies of plasma serotonin showed no relationship with depression, and evidence that lowered serotonin concentration was associated with antidepressant use ( $n = 1869$ ). Two meta-analyses of overlapping studies examining the 5-HT<sub>1A</sub> receptor (largest  $n = 561$ ), and three meta-analyses of overlapping studies examining SERT binding (largest  $n = 1845$ ) showed weak and inconsistent evidence of reduced binding in some areas, which would be consistent with increased synaptic availability of serotonin in people with depression, if this was the original, causal abnormality. However, effects of prior antidepressant use were not reliably excluded. One meta-analysis of tryptophan depletion studies found no effect in most healthy volunteers ( $n = 566$ ), but weak evidence of an effect in those with a family history of depression ( $n = 75$ ). Another systematic review ( $n = 342$ ) and a sample of ten subsequent studies ( $n = 407$ ) found no effect in volunteers. No systematic review of tryptophan depletion studies has been performed since 2007. The two largest and highest quality studies of the SERT gene, one genetic association study ( $n = 115,257$ ) and one collaborative meta-analysis ( $n = 43,165$ ), revealed no evidence of an association with depression, or of an interaction between genotype, stress and depression. The main areas of serotonin research provide no consistent evidence of there being an association between serotonin and depression, and no support for the hypothesis that depression is caused by lowered serotonin activity or concentrations. Some evidence was consistent with the possibility that long-term antidepressant use reduces serotonin concentration.

Molecular Psychiatry (2023) 28:3243–3256; <https://doi.org/10.1038/s41380-022-01661-0>

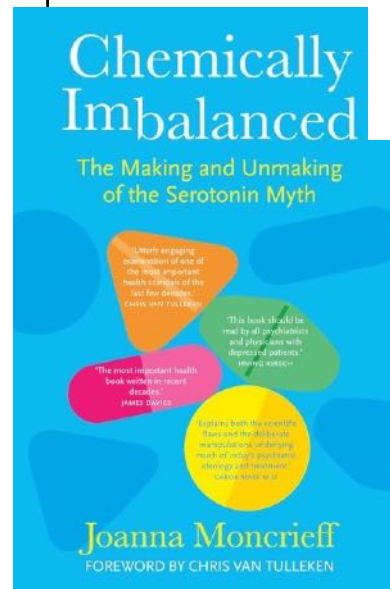
### INTRODUCTION

The idea that depression is the result of abnormalities in brain chemicals, particularly serotonin (5-hydroxytryptamine or 5-HT), has been influential for decades, and provides an important justification for the use of antidepressants. A link between lowered serotonin and depression was first suggested in the 1960s [1], and widely publicised from the 1990s with the advent of the Selective Serotonin Reuptake Inhibitor (SSRI) antidepressants [2–4]. Although it has been questioned more recently [5, 6], the serotonin theory of depression remains influential, with principal English language textbooks still giving it qualified support [7, 8], leading researchers endorsing it [9–11], and much empirical research based on it [11–14]. Surveys suggest that 80% or more of the general public now believe it is established that depression is caused by a ‘chemical imbalance’ [15, 16]. Many general practitioners also subscribe to this view [17] and popular websites commonly cite the theory [18].

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SPRINGER NATURE



Existential questions are being asked about the scientific basis of the psychiatric paradigm

# How do we explain it?

|                       | Current Mental Health Paradigms                                                                                                                                                     |                                                                                                                                                                                          |
|-----------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|                       | Psychiatric                                                                                                                                                                         | Psychotherapeutic                                                                                                                                                                        |
| View of mental health | Brain chemistry imbalance                                                                                                                                                           | Learned behaviour                                                                                                                                                                        |
| Approach              | Medication to change brain chemistry                                                                                                                                                | Unlearn behaviour through therapy                                                                                                                                                        |
| Limitations           | <ul style="list-style-type: none"><li>• Limited effectiveness</li><li>• Does not address root cause</li><li>• Only works whilst being taken</li><li>• Common side-effects</li></ul> | <ul style="list-style-type: none"><li>• Limited effectiveness</li><li>• Does not address root cause if trauma has caused physiological changes</li><li>• Inaccessible for many</li></ul> |

# How do we explain it?

## Current mental health paradigms do not address nervous system dysregulation

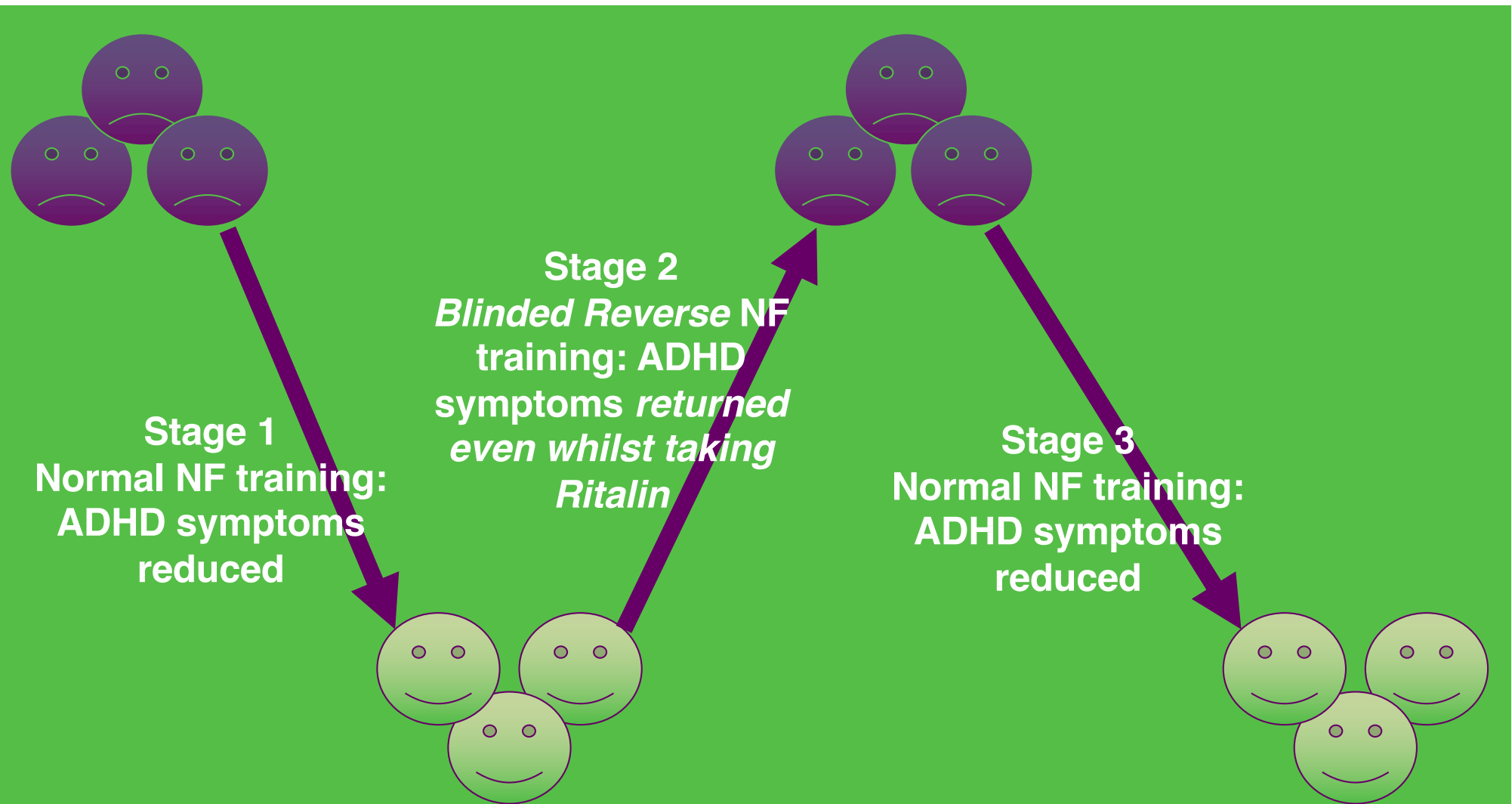
|                              | Current Mental Health Paradigms                                                                                                                                                     |                                                                                                                                                                                          |
|------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|                              | Psychiatric                                                                                                                                                                         | Psychotherapeutic                                                                                                                                                                        |
| <b>View of mental health</b> | Brain chemistry imbalance                                                                                                                                                           | Learned behaviour                                                                                                                                                                        |
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# New Mental Health Paradigm

| View of mental health | Nervous system (NS) dysregulation                                                                                                                                                                                                                                                             |
|-----------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Approach</b>       | Improve nervous system regulation using neuroplasticity                                                                                                                                                                                                                                       |
| <b>Benefits</b>       | <ul style="list-style-type: none"> <li>• No need to discuss trauma or even be able to remember it</li> <li>• Highly effective: 85-95% success rate</li> <li>• Addresses root cause</li> <li>• Builds "scaffolding" for further psychotherapeutic interventions</li> <li>• Scalable</li> </ul> |

|                              | Current Mental Health Paradigms                                                                                                                                                          |                                                                                                                                                                                              |
|------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|                              | Psychiatric                                                                                                                                                                              | Psychotherapeutic                                                                                                                                                                            |
| <b>View of mental health</b> | Brain chemistry imbalance                                                                                                                                                                | Learned behaviour                                                                                                                                                                            |
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# 'ABA' Study - Shouse & Lubar, 1979



Early study that would not be ethically approved today “reversed” the neurofeedback mechanism, blind to subjects, and reversed the effect

# What do we use it for?

1. Nervous system re-regulation
2. Processing traumatic memories
3. Exercising specific functions to make them stronger

# What do we use it for?

## Remediation of symptoms of brain dis-regulation:

- Children's ADHD
- Adult's ADHD
- Autism Spectrum Disorder
- Dyslexia/Dysgraphia/Dyspraxia
- Epilepsy
- Sleep problems
- Traumatic Brain Injury
- Acquired Brain Injury
- Stroke recovery
- Depression, Anxiety, Stress
- Migraine
- OCD
- Anger management
- Fibromyalgia Syndrome
- Chronic fatigue
- Chronic pain
- Chemo Brain
- Dementia (halt of deterioration)

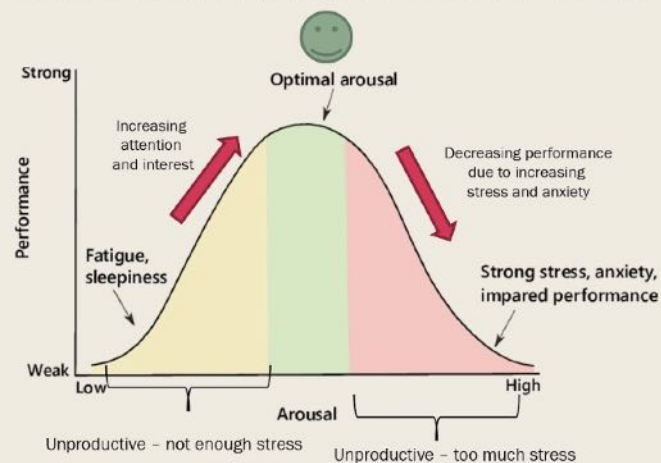
## ... and to process traumatic events/learned fears

- Post traumatic stress disorder
- Developmental trauma
- Addiction

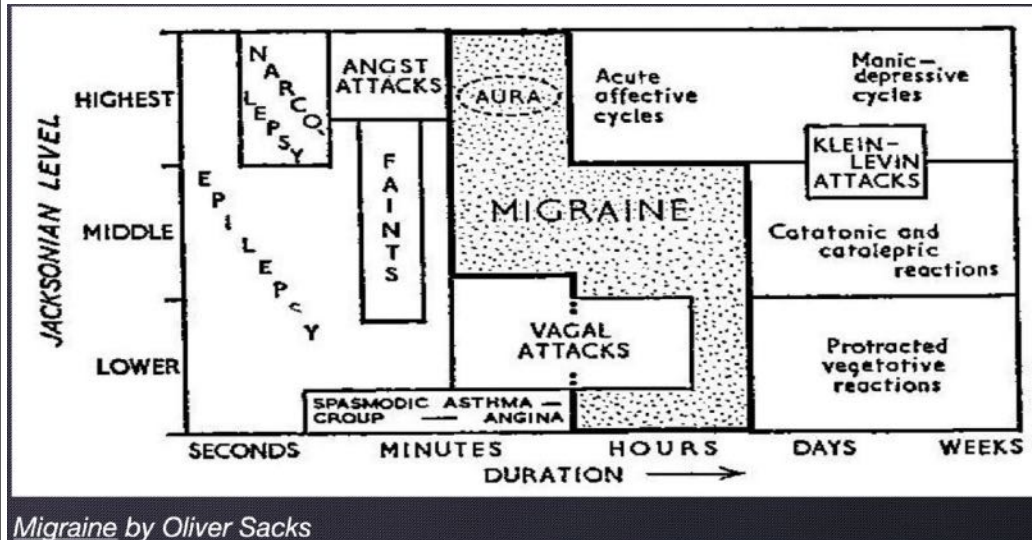
# What do we use it for? – Re-regulation

## Arousal regulation

### The Yerkes-Dodson Law: Inverted U-Model

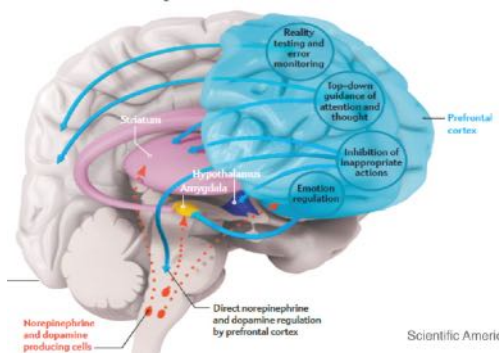


## Stability regulation

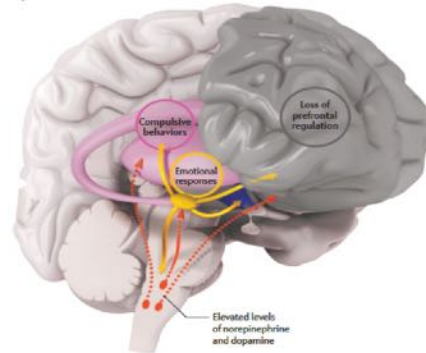


## Inhibition regulation

### Healthy Prefrontal Control



### Loss of Prefrontal Control



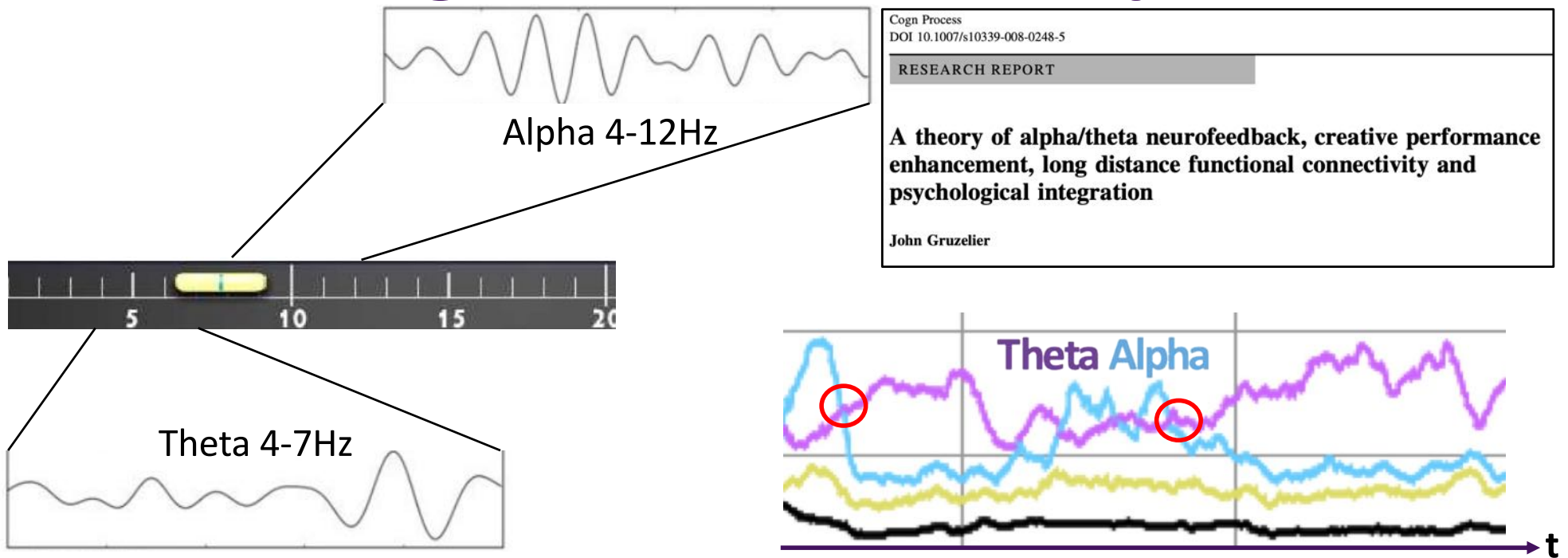
## Localised dysfunctions

- Parietal: body relaxation & awareness, spatial awareness, sensory integration
- Temporal: Emotional regulation, autonomic balance, auditory processing, object recognition, pattern recognition
- Pre-frontal: Impulse control, planning and organisation, OCD, disinhibition, fear and attachment, emotional control



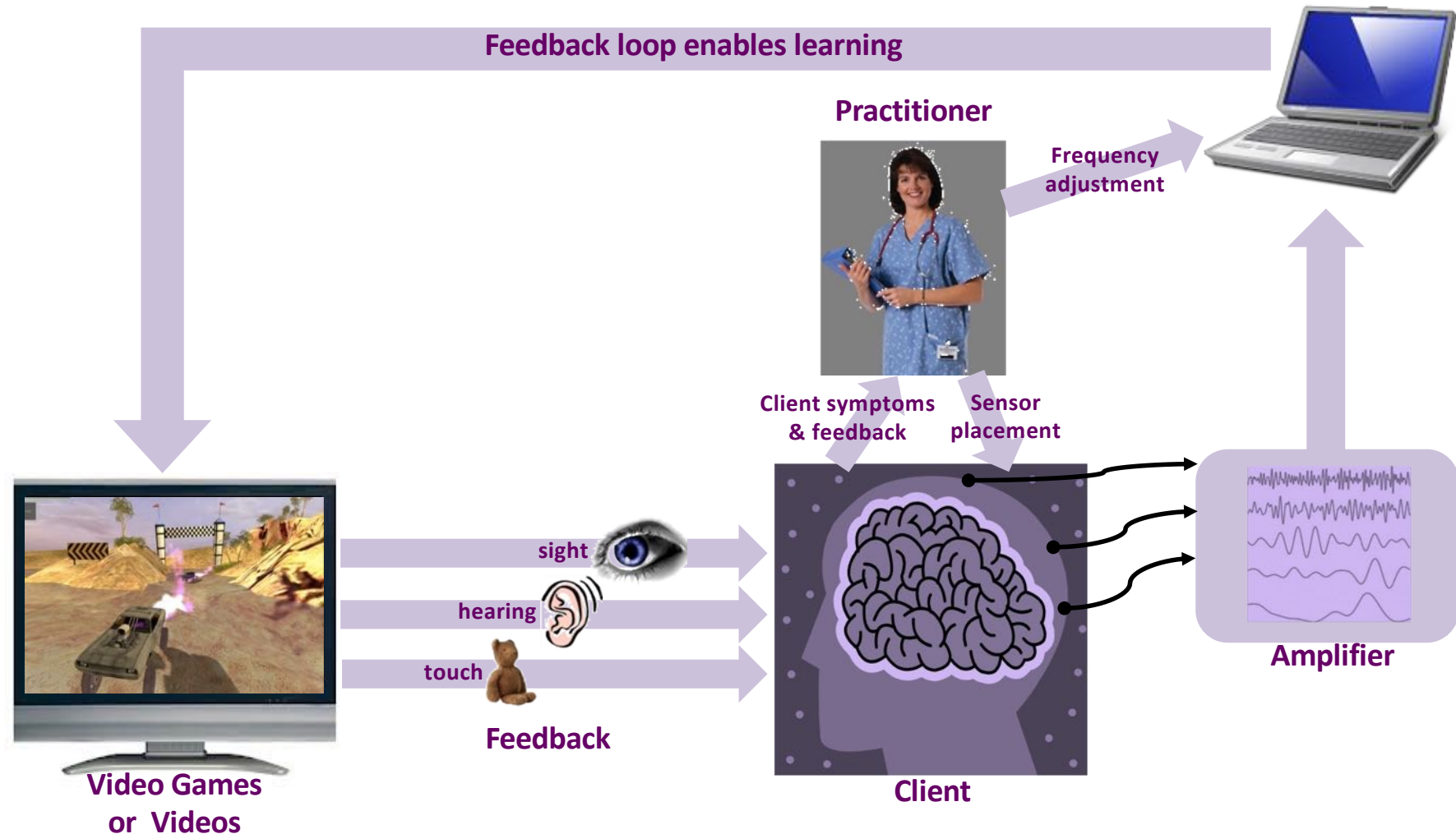
# What do we use it for?

## Processing learned fears – Alpha-Theta



- Audio operant conditioning by rewarding  $\alpha$  &  $\theta$  rhythms to elicit hypnagogic state
- State-based processing of traumatic memories
- State of deep relaxation/creativity

# What does the client have to do?



*Endogenous Neurofeedback at Infra Low Frequencies for nervous system re-regulation*

# What does the client have to do?

- **Watches video of choice**
- **Feedback delivered through 3 senses: sight, hearing, touch**
- **Endogenous, non-directive <> Operant Conditioning**
  - Visual feedback: Size of picture
  - Audio feedback: Volume
  - Tactile feedback: Vibration of cuddly toy
- **Don't use games - they are available, but dated; and come from the paradigm of operant conditioning, i.e. goal-based**
- **HOWEVER there is an inhibit function that provides negative operant conditioning feedback in response to excessive activity**
  - Visual feedback: Clouding of picture
  - Audio feedback: Dipping of volume
- **So in reality there IS an element of operant conditioning**

# How do we plan it?

Referral Medical History

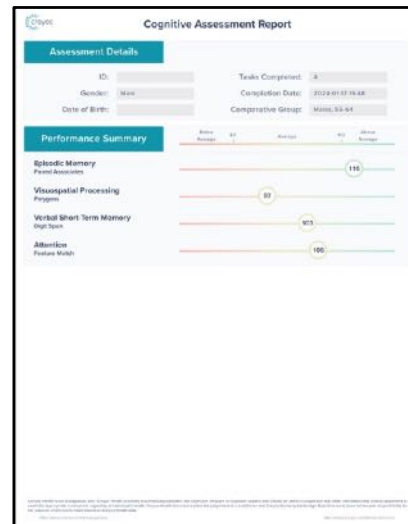
Symptom Assessment

Individual Neurofeedback Plan

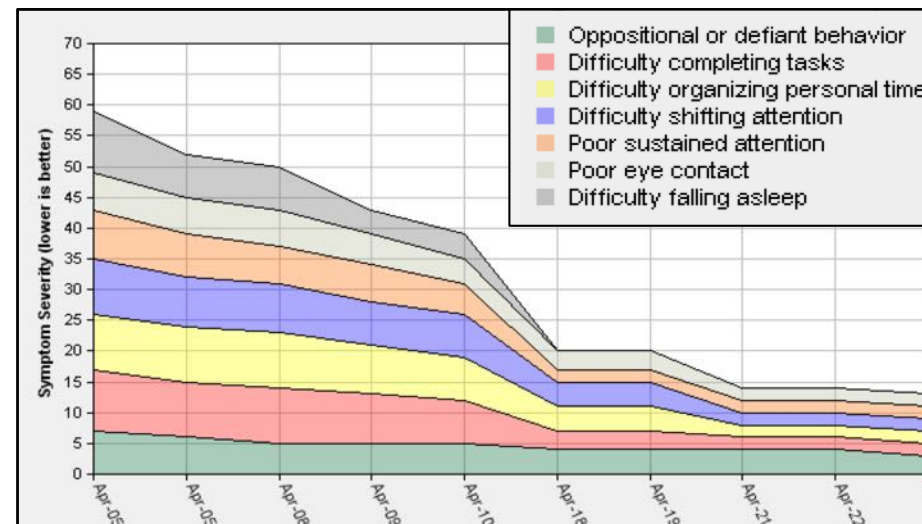
School  
LA  
CAMHS  
Self  
GP

Knowledge Base:  
Symptoms->  
Brain Functions->  
Protocols

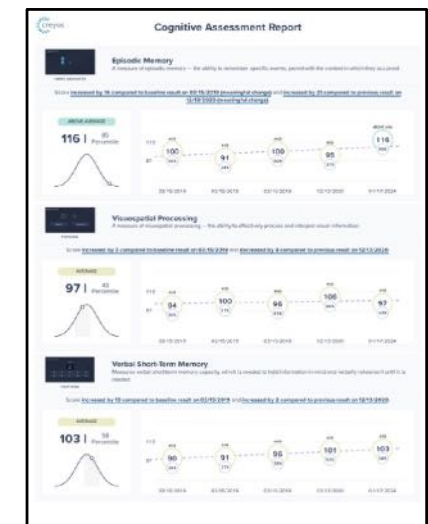
Client Feedback guides  
route through pathway



Cognitive Assessment



On-Line Symptom Tracking



Cognitive Assessment

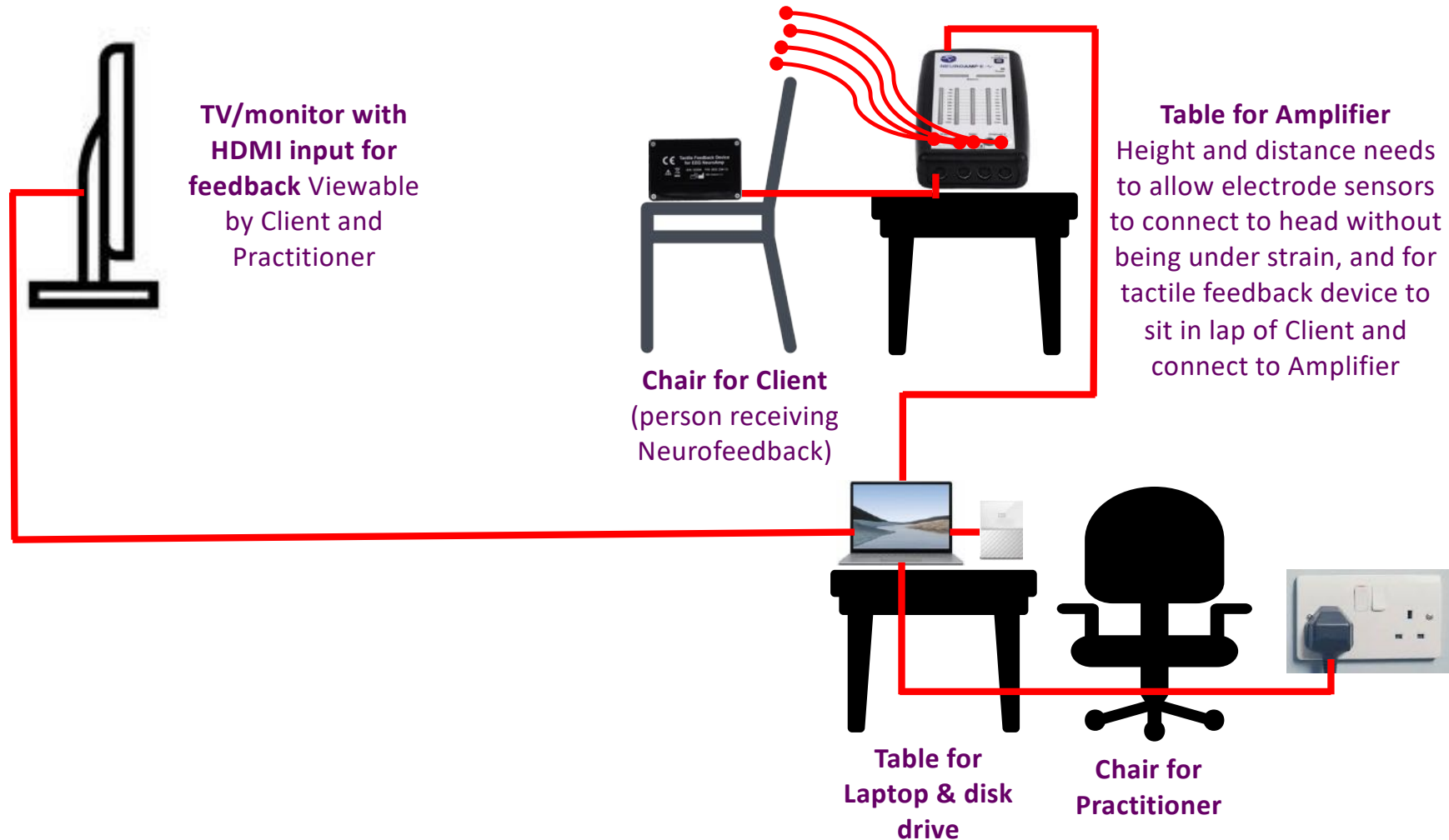
# How do we deliver it?

- Sessions nominally 30 mins
- At least weekly sessions
- Learning process
- 20 session commitment expected to deliver lasting benefits
- Stages of delivery:
  - Cognitive assessment
  - Starting protocol
  - Frequency optimisation
  - Progress through pathway, track symptom progress
  - Adjust pathway according to client feedback
  - Cognitive assessment
- Intensive programmes possible, risk that optimisation delays planned progress

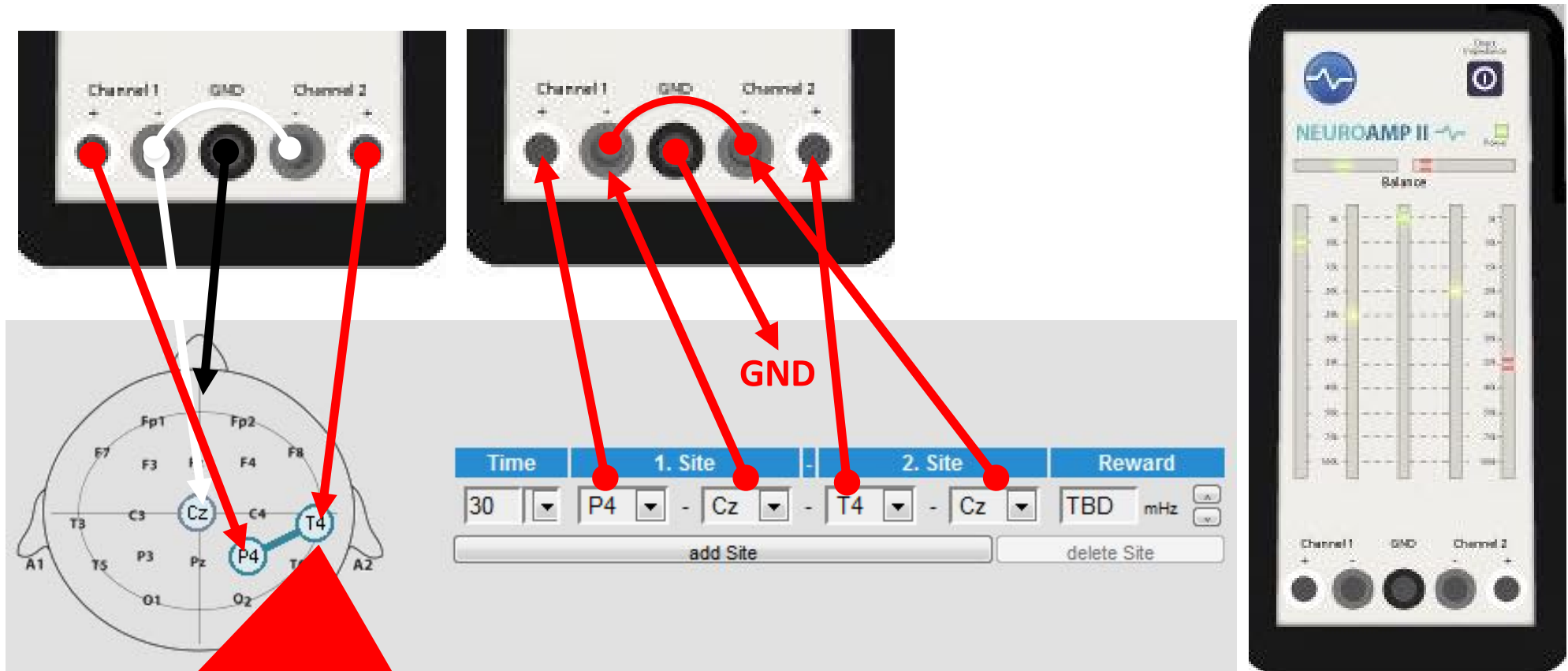
# Demonstration – Room Set-up



# Demonstration – Room Set-up



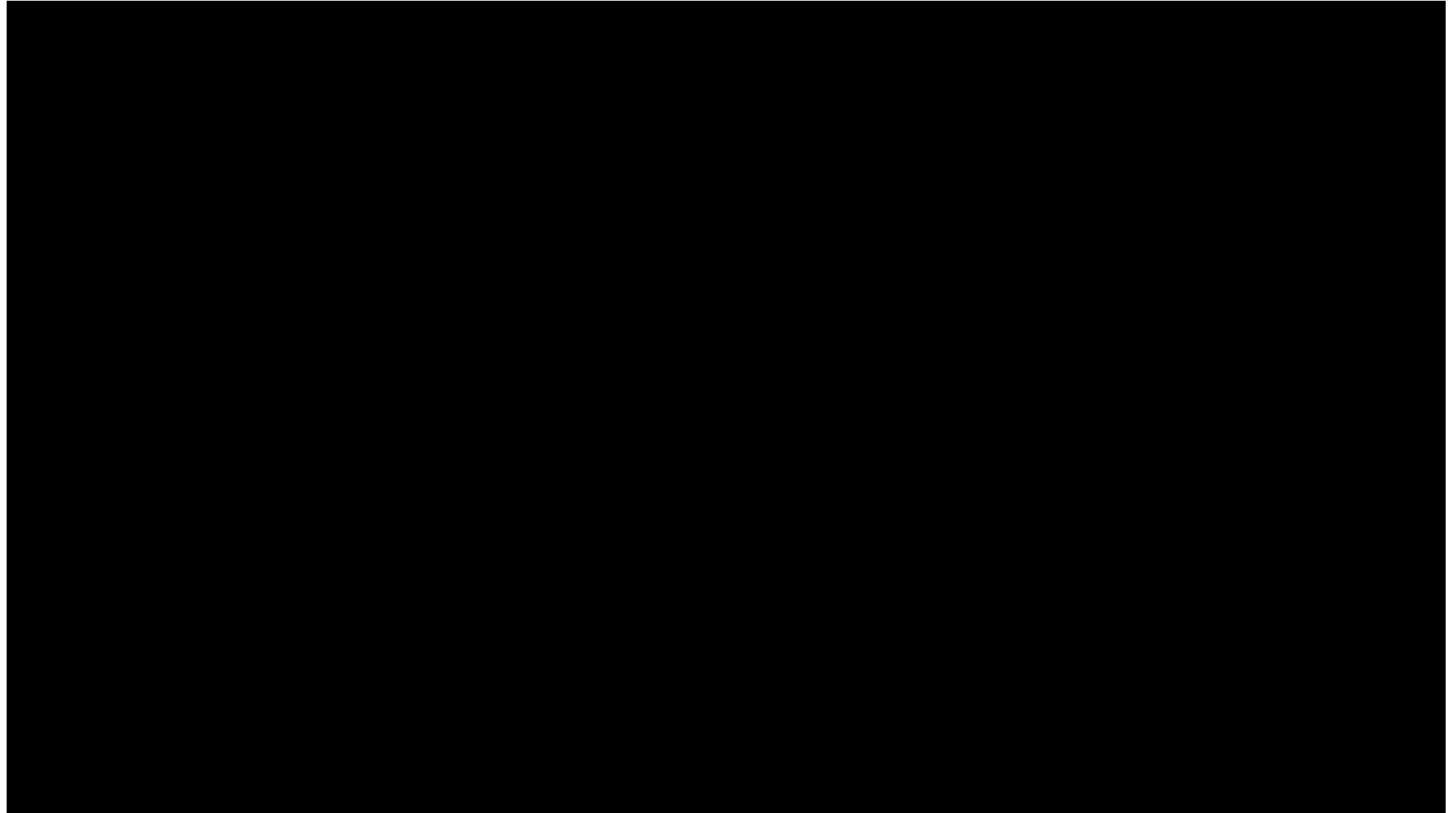
# Demonstration - Equipment



## 2 active channels

- Main feedback: Bipolar montage, referenced to Cz
- Inhibit: Summed reference to Cz

# Demonstration - Feedback



# How do we deliver it?

- Sessions nominally 30 mins
- At least weekly sessions
- Learning process
- 20 session commitment expected to deliver lasting benefits
- Stages of delivery:
  - Cognitive assessment
  - Starting protocol
  - Frequency optimisation
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- Intensive programmes possible, risk that optimisation delays planned progress

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# Questions?

[BrainTrainUK.com](https://www.braintrainuk.com)



[stuart@braintrainuk.com](mailto:stuart@braintrainuk.com)

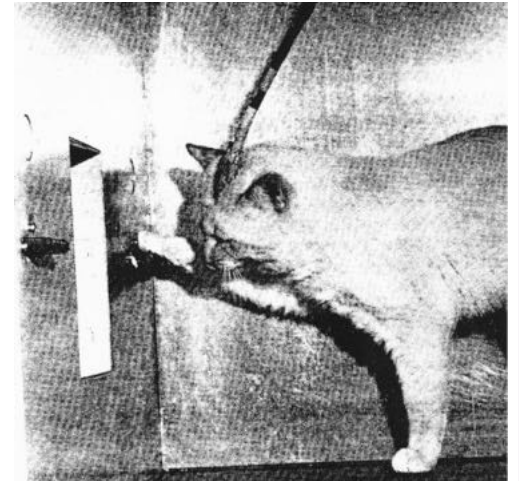


# Backup Slides

# Discovery of Clinical Neurofeedback



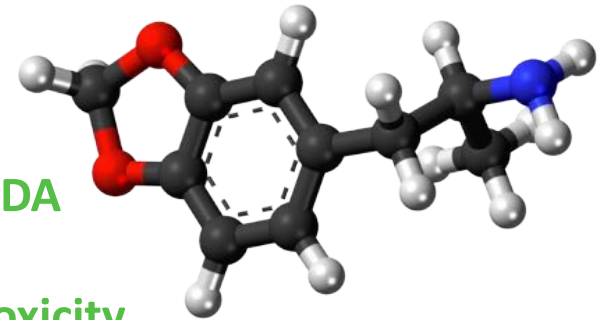
- Dr Barry Sterman – sleep researcher
- Observed particular frequency in cats' brains when they were very still
- Trained cats to generate these brainwaves at will – rewarded with food (chicken broth)



# Discovery of Clinical Neurofeedback



- Prof. Gordon Alles - Pharmacologist
- Interest in mind-altering drugs
- 1<sup>st</sup> to prepare amphetamine sulphate
- Discovered psychological effects of MDA (original Ecstasy)
- Commissioned by NASA to research toxicity of rocket fuel
- BUT tried a new compound on himself before study started



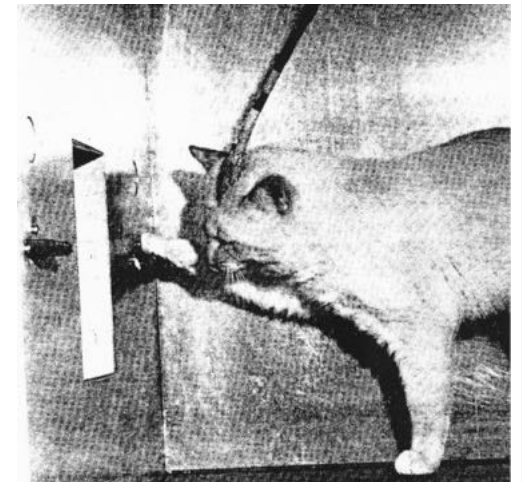
Kava



# Discovery of Clinical Neurofeedback

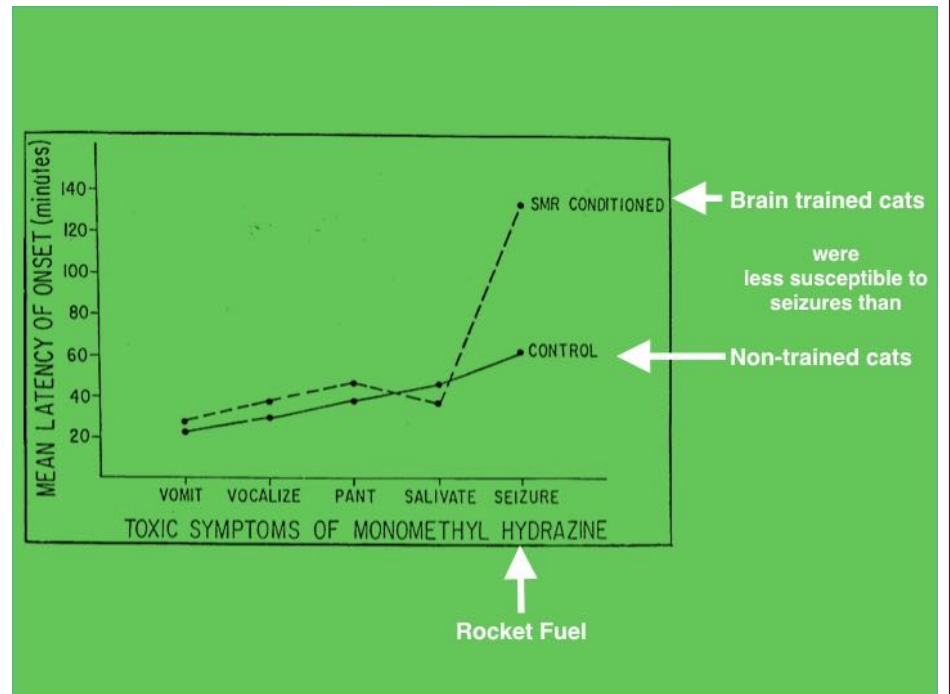


- Dr Barry Sterman – sleep researcher
- Observed particular frequency in cats' brains when they were very still
- Trained cats to generate these brainwaves at will – rewarded with food (chicken broth)

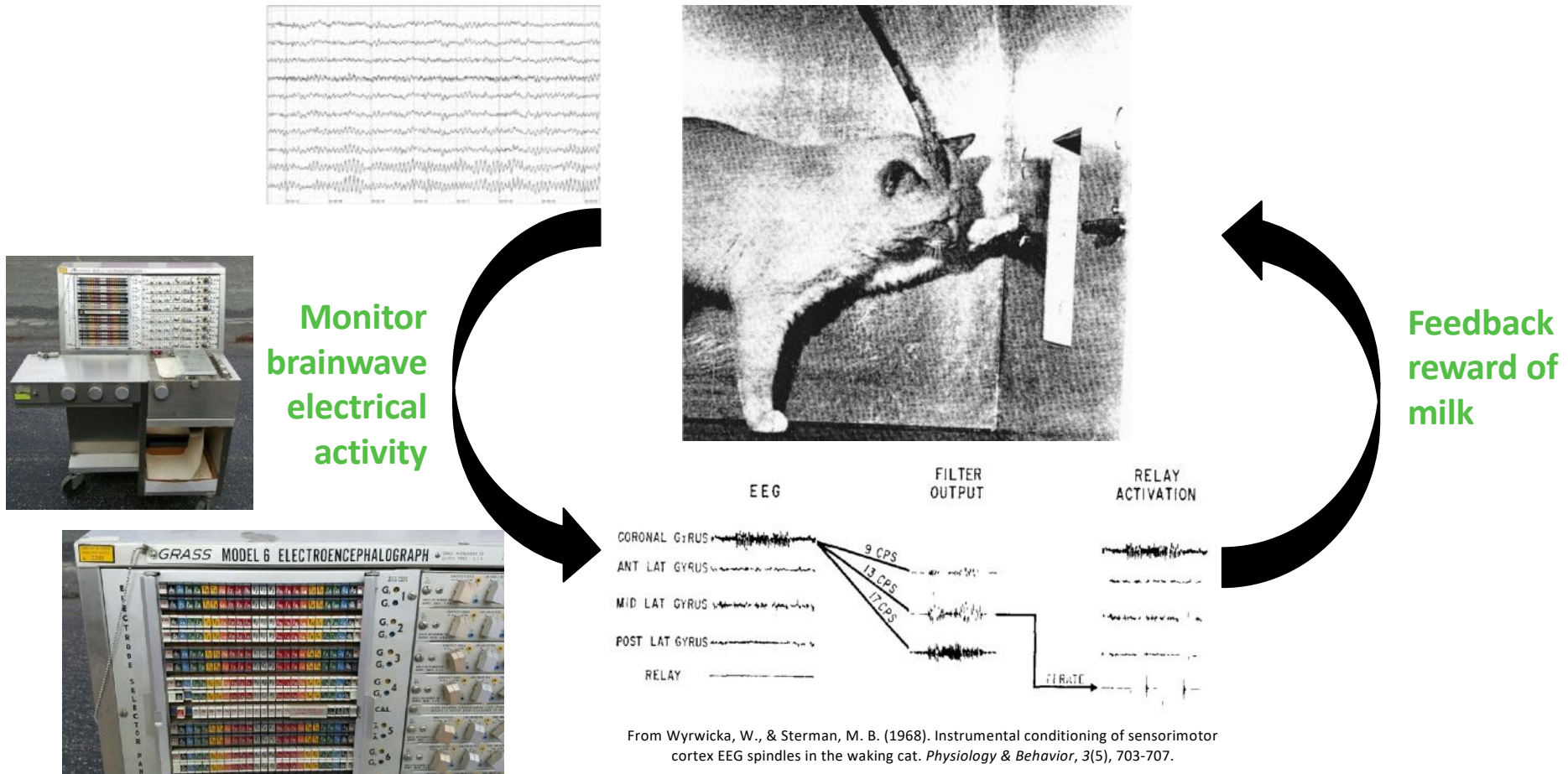


- NASA commissioned Sterman to do research on toxicity of rocket fuel

- Injected cats with rocket fuel
- Unexpected results they didn't understand
- The previously brain-trained cats were much less susceptible to seizures
- Perhaps 'the ultimate double-blind design'

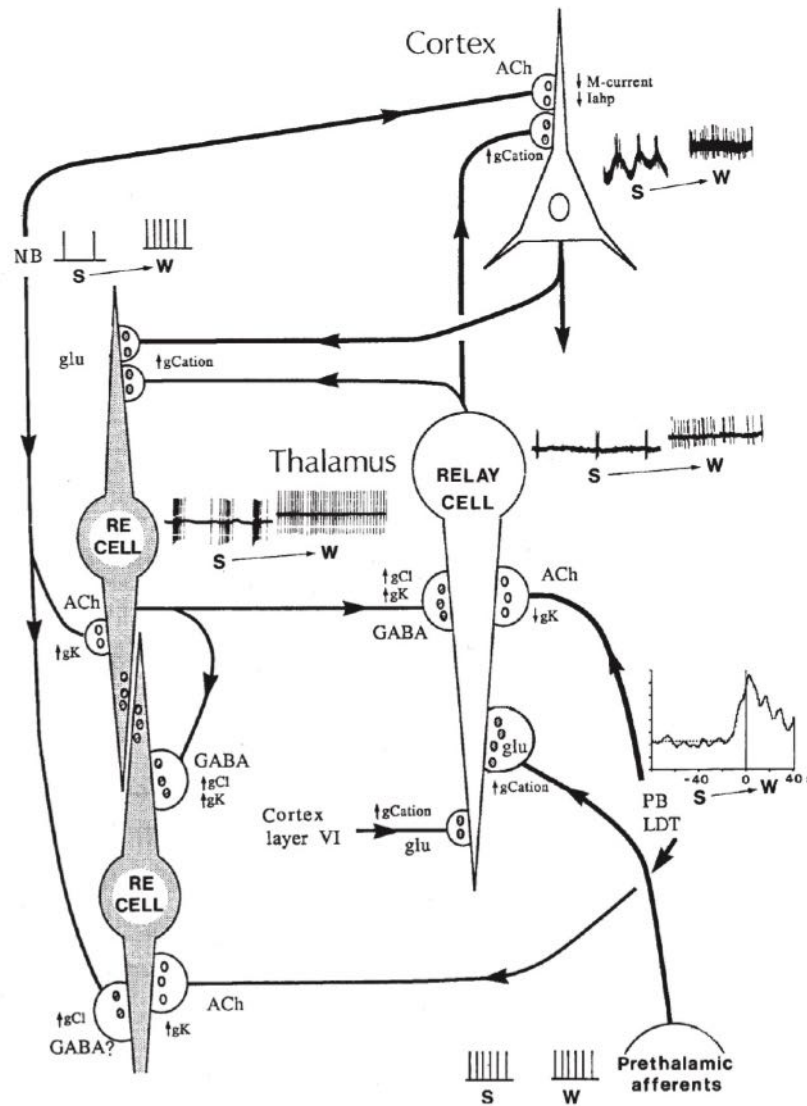


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*Cats learned to generate brainwaves in response to reward*

# Discovery of Clinical Neurofeedback



- Thalamic rhythm keeps motor cortex stable
- Rhythm dependent on GABA

Rocket fuel interfered with GABA



Stabilising rhythm reduced



Brain becomes unstable



Seizures