PSYC305

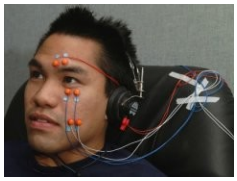
Applied Cognition & Neuroscience

- Psychophysiology
- Some Methods of Investigation in Applied Research

Psychophysiology

Allessandri's definition (1998)

Psychophysiology is the study of relations between psychological manipulations and resulting physiological responses, measured in the living organism, to promote understanding of the relation between mental and bodily processes.




From www.psychphys.com

Some Psychophysiological dependent variables

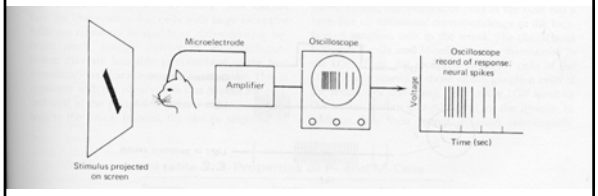
❑ Brain Activity	- (EEG) (PET,MRI,CAT)	Electroencephalography
❑ Brain Potentials in response to spec. stimuli	- (ERP)	Event related potentials
❑ Heart muscle activity	- (ECG)	Electrocardiography
❑ Heart beat frequency		
❑ Eye movements	- (EOG)	Electro- oculography
❑ Eye tracking		
❑ Sweat gland activity	- (EDA,GSR)	Electrodermal activity or Galvanic skin response
❑ Blood volume in the finger		Plethysmography
❑ Blood pressure		
❑ Respiration		

Psychophysiology Research Applications

❑ Research in **Brain and Behaviour Relationships**

1) Single cell recording
2) MRI, PET, CT (Visualizing the living brain)
3) EEG (e.g., sleep research)
4) Eye movement research
5) Event related potentials

1) Single cell recording



3) EEG (e.g., Sleep Research)

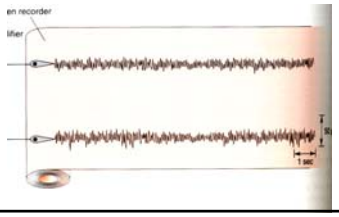
In 1930, Hans Berger developed the method of

ELECTROENCEPHALOGRAPHY

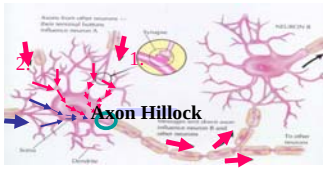
- **Electrical activity of the brain that is being measured**
- **Referring to head and brain**
- **Method is using a recording instrument**

Terminology:

..graphy: method
..gram: the recording (the output)
..graph: equipment

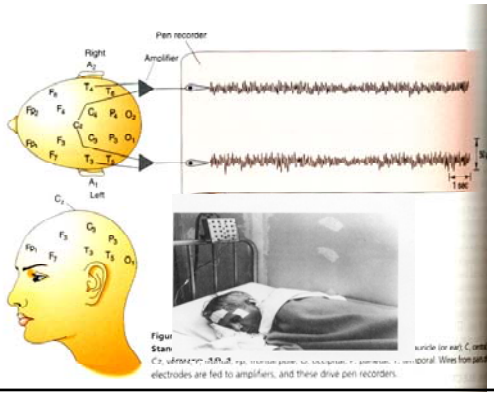


EEG measures the currents that flow during synaptic excitation of the dendrites of many pyramidal neurons in the cerebral cortex, which lies right under the skull and makes up 80% of the brain's mass.

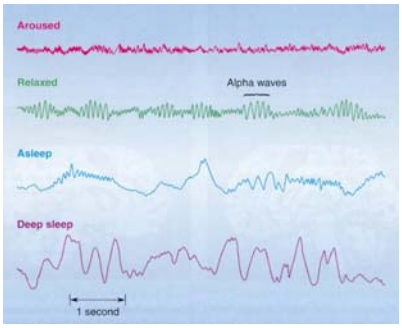


But the electrical contribution of any single cortical neuron is exceedingly small, and the signal must penetrate several layers of non-neural tissue, including the meninges, fluid, bones of the skull, and skin, to reach the electrodes.

EEG (or more informally, "brain waves")



ELECTROENCEPHALOGRAPHY



ELECTROENCEPHALOGRAPHY

Four different brain waves:

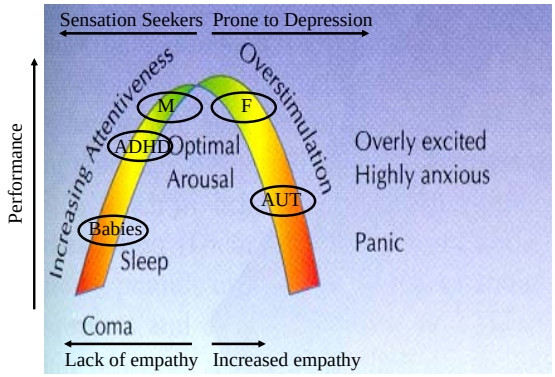
Beta Waves: Highly desynchronised, mostly low-amplitude waves of 13-30 Hz, correlated with cognitive processes.

Alpha Waves: Moderately synchronised, 8-12 Hz, relaxed state and the visual parts of the cortex are not particularly busy.

Theta Waves:
Synchronised, 3.5-7.5 Hz, transition between sleep and wakefulness.

Delta Waves:
Highly synchronised, 1-4 Hz, unconscious, either asleep or in coma. Large group of neurons are being driven to fire roughly in step with one another rather than being allowed to participate in small networks assumed to underlie individual thoughts

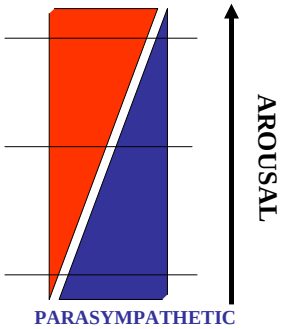
Decreased arousal - Brain waves: lower amplitude, more synchronised



Resting Arousal Levels

The Yerkes Dodson law

SYMPATHETIC ACTIVITY (Energy expenditure)



PARASYMPATHETIC ACTIVITY (Energy conservation)

Arousal (optimal level):

A condition of increased alertness, focused attention, and bodily activation

Arousal (Optimal level)
Experientially, it is an alteration of consciousness in the direction of becoming more alert with increased concentration on selected stimuli.

Arousal (Optimal level)
Behaviorally, it is an orientation reaction.

- Pupillary dilatation for better vision
- Temporary decrease in auditory threshold
- Increased respiration
- Temporary slowing of heart rate
- GSR increase

Arousal (High level)
In terms of brain waves
- it is desynchronisation

EEG Applications, e.g.,

- **Arousal Level Modification**
  e.g., Neuro-feedback
- **Sleep research**
  e.g., investigating different sleep stages
- **Seizure and mental disorder Diagnostics**

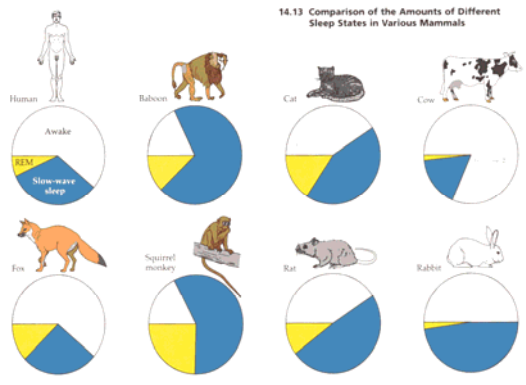
Why do we sleep?

Habituation Theory

Sleep as an Adaptive Response (Evolutionary Theory)

Sleep as a part of the brain's Circadian Rhythm

Sleep as a Restorative Process



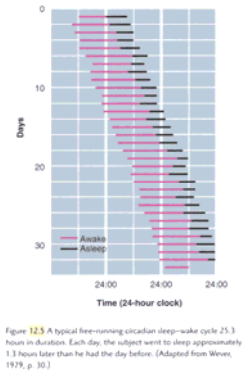
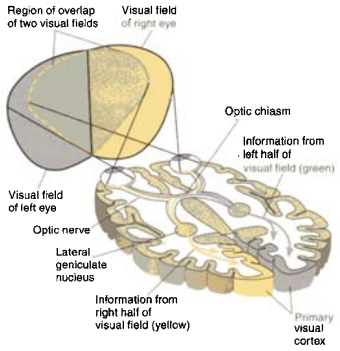
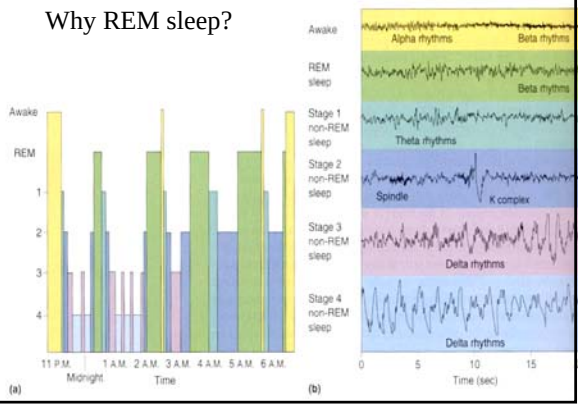


Figure 12.5 A typical free-running circadian sleep–wake cycle 25.3 hours in duration. Each day, the subject went to sleep approximately 1.3 hours later than he had the day before. (Adapted from Wever, 1979, p. 30.)

Suprachiasmatic nucleus (SCN) = biological clock responsible for organizing many of the body's circadian rhythms, including the timing of sleep cycles.



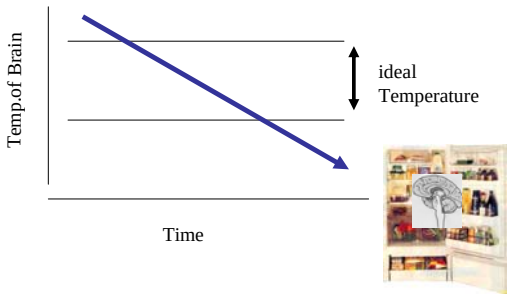
Why REM sleep?



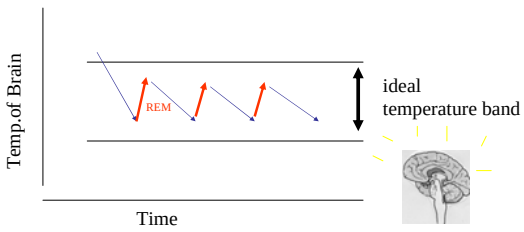
Why REM SLEEP??

1. Consolidation of memory contents with emotionally related information
2. Flush useless information from memory
3. Important for brain development
4. Integrating learned and instinctive behaviour
5. Helps temperature regulation of the brain

SLOW WAVE SLEEP:
Metabolic rate of neurons decreases
Cerebral blood flow decreases
=Brain Temperature decreases



REM SLEEP:
Metabolic rate of neurons increases
Cerebral blood flow increases
= Brain temperature increases
keeping the temperature of the brain in the ideal band



EEG Applications, e.g.,

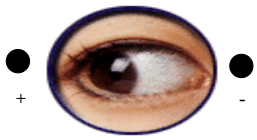
- **Arousal Level Modification**
  e.g., Neuro-feedback
- **Sleep research**
  e.g., investigating different sleep stages
- **Seizure and mental disorder Diagnostics**

Psychophysiology Research Applications

- Research in **Brain and Behaviour Relationships**

1) Single cell recording
2) MRI, PET, CT (Visualizing the living brain)
3) EEG (e.g., sleep research, seizure and mental disorders diagnostics)
4) Eye movement research
5) Event related potentials

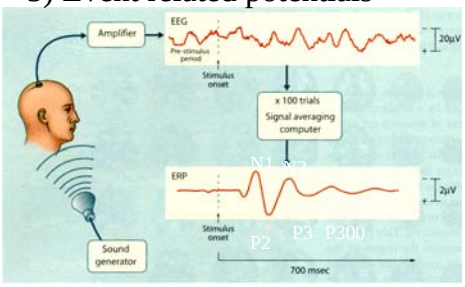
4) Eye Movement Behaviour



Electro-oculography (EOG)

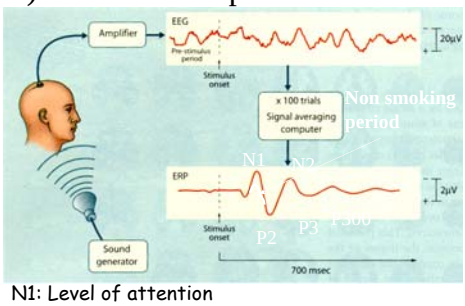
Eye-tracking

5) Event related potentials



N1: Level of attention
P2: Level of signal processing (deep or shallow)
P3: Level of anticipation
P300: familiar stimuli; Yes: large No: small

5) Event related potentials



N1: Level of attention
P2: Level of signal processing (deep or shallow)
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Psychophysiology Applications

- **Behavioural Assessment**
  (e.g., anxiety disorders, antisocial personality disorders, OCD)

Psychophysiology Applications

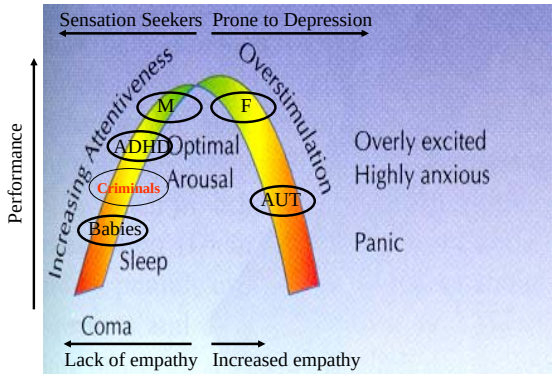
- **Lie detection**

(method was used so far in more than 3 million court cases in the US)

Psychophysiology Research Applications

- **Biofeedback and Self-control**

Providing immediate and continuous feedback regarding physiological, processes, e.g., EEG - control over theta waves, GSR - control over sweat gland activity (anxiety and relaxation therapies, pain and stress management etc.,)
Control over breathing patterns



Resting Arousal Levels

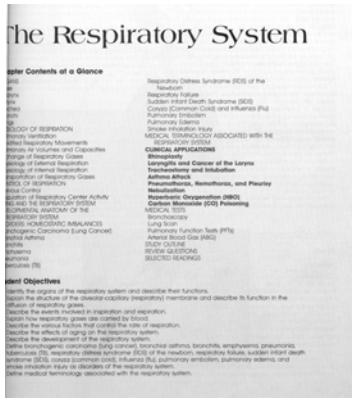
The Yerkes Dodson law

Psychophysiology Research Applications

- **Biofeedback and Self-control**

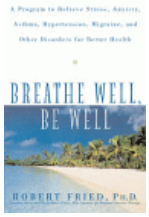
Providing immediate and continuous feedback regarding physiological, processes, e.g., EEG - control over theta waves, GSR - control over sweat gland activity (anxiety and relaxation therapies, pain and stress management etc.,)
Control over breathing patterns (HRV)

Breathing is the only automatic vital function we can voluntarily control, and therefore we can cause it malfunction.

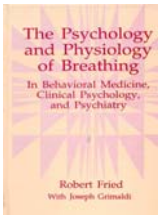

The Respiratory System

Voluntary reading

Breathe Well, Be Well: A Program to Relieve Stress, Anxiety, Asthma, Hypertension, Migraine, and Other Disorders for Better Health



Robert Fried



The Psychology and Physiology of Breathing : In Behavioral Medicine, Clinical Psychology, and Psychiatry (The Plenum Series in Behavioral Psychophysiology)

Breathing: The Master Key of Self Healing

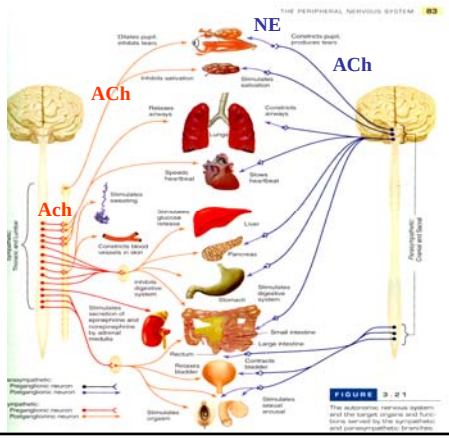
"I have come to believe that I would choose correct diaphragmic breathing if we had to share one tool or technique for maximally improving health" (Patricia Norris, 1995)

An average adult takes approx. 23-24,000 breaths per day.

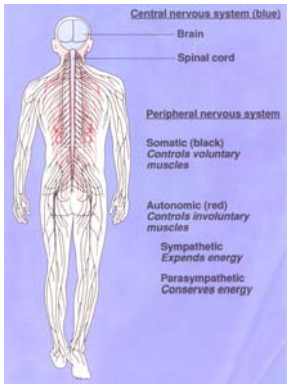
Effects of breathing:

Inhalation → stimulates → **Sympathetic N. S** → - Speeds heartbeat -Constricts blood vessels in skin -Increases blood pressure -Inhibits digestive system etc.

Exhalation → stimulates → **Parsympathetic N. S** → -Slows heartbeat - Decreases bloodpressure -Stimulates digestive system etc.



From Carlson, N. 4e



Please read 'The Peripheral Nervous System" in Carlson, 4e., pages 80-85

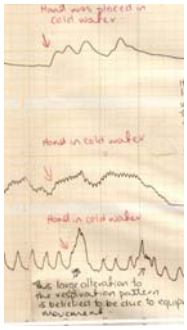
Behaviour that influences breathing patterns:
"small mistakes"

Coughing	A long-drawn and deep inspiration followed by a complete closure of the glottis, which results in a strong expiration that suddenly pushes the glottis open and sends a blast of air through the upper respiratory passages. Stimulus for this reflex act may be a foreign body lodged in the larynx, trachea, or epiglottis.
Sneezing	Spasmodic contraction of muscles of expiration that forcefully expels air through the nose and mouth. Stimulus may be an irritation of the nasal mucosa.
Sighing	A long-drawn and deep inspiration immediately followed by a shorter but forceful expiration.
Yawning	A deep inspiration through the widely opened mouth producing an exaggerated depression of the lower jaw. It may be stimulated by drowsiness, fatigue, or someone else's yawning, but precise stimulus–receptor cause is unknown.

← "Barrel breathing"

More small 'mistakes'

Sobbing	A series of convulsive inspirations followed by a single prolonged expiration. The glottis closes earlier than normal after each inspiration so only a little air enters the lungs with each inspiration.
Crying	An inspiration followed by many short convulsive expirations, during which the glottis remains open and the vocal cords vibrate; accompanied by characteristic facial expressions and tears.
Laughing	The same basic movements as crying, but the rhythm of the movements and the facial expressions usually differ from those of crying. Laughing and crying are sometimes indistinguishable.
Hiccuping	Spasmodic contraction of the diaphragm followed by a spasmodic closure of the glottis to produce a sharp inspiratory sound. Stimulus is usually irritation of the sensory nerve endings of the gastrointestinal tract.



BIG mistakes:

- Regularly holding your breath: (once a minute)
  -> irregular heartbeats
- Toracic (Chest) Breathing:

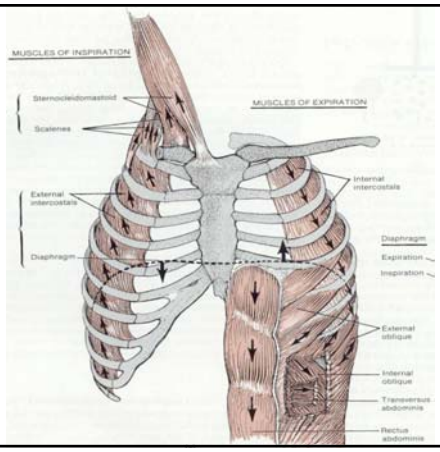
Shallow breathing using only the accessory respiratory muscles -> may produce many symptoms (it's all in your mind…) such as dyspnea, fatigue, headache, muscle tension in upper chest, anxiety, and panic

- Hyperventilation:

Breathing beyond what the body needs to meet the immediate needs for oxygen and removal of carbon dioxide -> produce an astonishing array of sensory, affective and physical symptoms.

Accessory

Principal



Breathing helps to regulate the acid-base balance in the body:

PH = 7.4 (slightly basic)

Excess O_2 is toxic and damaging to the body, but homeostatic mechanisms prevent an overload. Insufficient O_2 (hypoxia) threatens life.

Excess CO_2 is also toxic and may cause anesthesia, narcosis (depression of neuronal excitability), and death.
Insufficient CO_2 may cause
PH to rise toward alkalosis

Lack of CO_2:

Inhibiting brain respiratory centers, constricting brain and peripheral arteries and arterioles, reducing brain blood flow and altering the capacity of hemoglobin to bind and to release O_2.

- Anxiety, panic and depression
- Hypertension, migraine and colitis
- Can compound the symptoms of disorders with organic basis heart arrhythmias, asthma related problems or seizure thresholds

Hyperventilation:
Dyspnea, hypocapnia or respiratory alkalosis
->
Lack of CO_2 →

Central Neurological
Dizziness, faintness, light headedness, blurred vision, concentration impairment, Disturbances of consciousness

Peripheral Neurological:
Numbness (tongue, face, hands feet, coldness (general, hands or feet) paresthesia (tingling), pins and needles, Tetany (spasm twitching, and cramps)

Musculoskeletal:
Muscle tension, tremor, muscle pain (cramping) stiffness (fingers, arm, and legs)

Cardiovascular:
Heart racing-tachycardia, heart palpitation (pounding) arrhythmias, precordial pain

Hyperventilation:
Dyspnea, hypocapnia or respiratory alkalosis
->
Loss of CO_2 →

Gastrointestinal
Nausea, vomiting, diarrhea, epigastric pain, bloating, stomach cramps

Other somatic:
Dry mouth and throat, headache, sweating, weakness, fatigue.

Respiratory:
Shortness of breath, suffocating feeling, unable to breathe deeply,
chest pain (around heart), chest tightness, yawning/sighing

Affective:
Apprehension, fear of inability to breathe, panic, tension, crying
fits without reason

Anxiety (Greek) → to choke

Criteria for Panic Attack

Note: A Panic Attack is not a codable disorder. Code the specific diag which the Panic Attack occurs (e.g., 300.21 Panic Disorder With Agor [p. 402]).

A discrete period of intense fear or discomfort, in which four (or n the following symptoms developed abruptly and reached a peak 10 minutes:

(1) palpitations, pounding heart, or accelerated heart rate
(2) sweating
(3) trembling or shaking
(4) sensations of shortness of breath or smothering
(5) feeling of choking
(6) chest pain or discomfort
(7) nausea or abdominal distress
(8) feeling dizzy, unsteady, lightheaded, or faint
(9) derealization (feelings of unreality) or depersonalization (being detached from oneself)
(10) fear of losing control or going crazy
(11) fear of dying
(12) paresthesias (numbness or tingling sensations)
(13) chills or hot flushes

Compare these symptoms with those of hyperventilation

Just take a deep breath…!

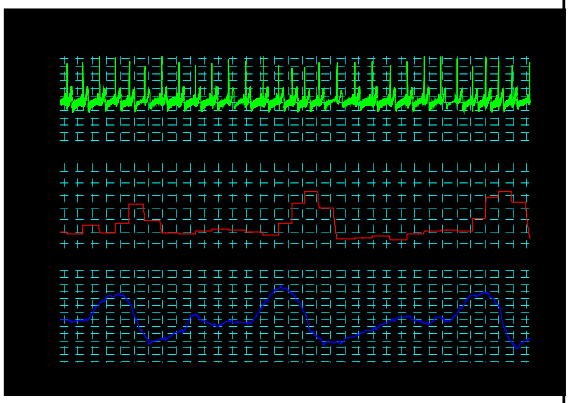
This usually results in stimulating the Sympathetic Nervous System:
increasing heart rate,
blood pressure…. etc.

Correct Breathing:

Diaphragmatic Breathing:
- 5-8 respirations per minute
- 750-2000ml of air per inhalation
- Exhalation phase is longer than the inhalation phase
- Pause after exhalation

→ Respiratory Sinus Arrhythmia (RSA)

RSA: Variation in heart rate that accompanies breathing. Heart rate increases during inhalation and decreases during exhalation.



Correct Breathing:

- Increased blood flow to brain
- Increased blood flow to the periphery
- Decreased blood pressure
- Higher grade of vitality
- Improved digestion

Psychophysiology Research Applications

❑ **Biofeedback and self-control**

Providing immediate and continuous feedback regarding physiological, processes, e.g., EEG - control over alpha waves, GSR - control over sweat gland activity (anxiety and relaxation therapies, pain and stress management etc.,)

Control over breathing patterns

Breathing Therapy

Before

After

Today

- Psychophysiology
- Methods of Investigation in Applied Research

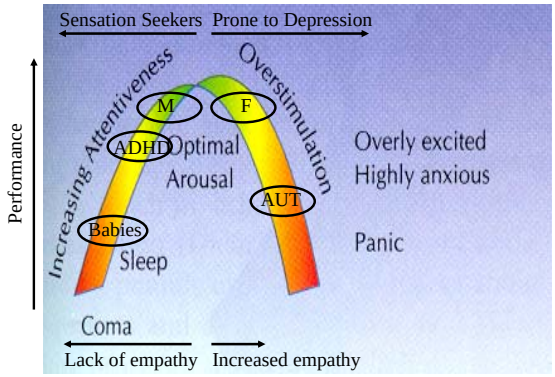
Examples of Methods of Investigation in Human Performance Research

Psychophysiology:
Heart rate variability as predictor of cognitive performance
(Laboratory exercise 3)

Education:
Effect of Self-Assessment

Road Safety:
Older Driver Behaviour at rural T-intersections
Frontal lobe study
Data Brake evaluation study
Conspicuity of road workers

Effect of heart rate variability.... on cognitive functions



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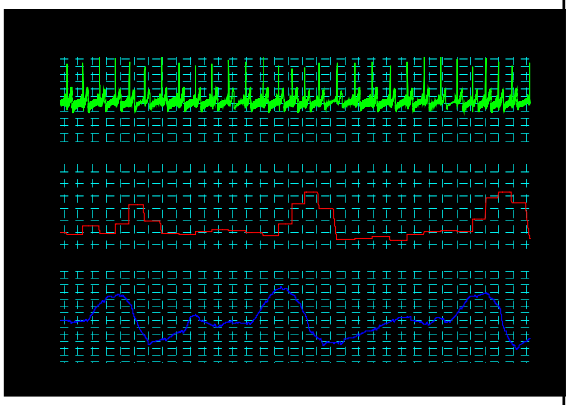


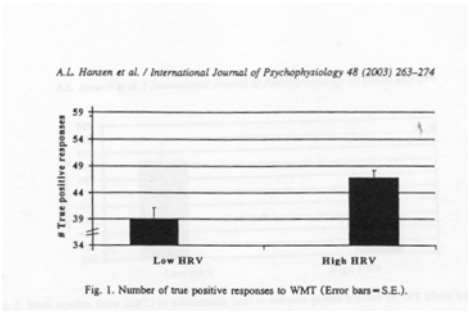


Fig. 1. Number of true positive responses to WMT (Error bars = S.E.).

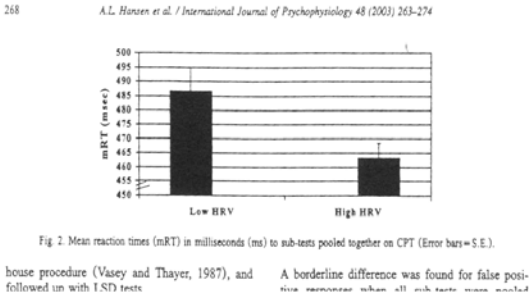
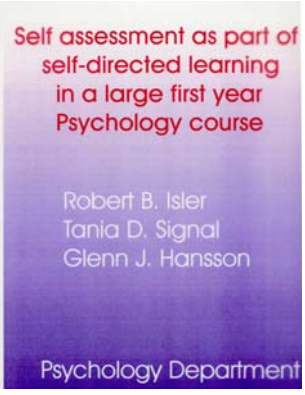
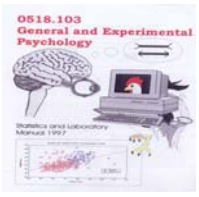


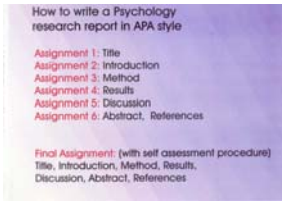
Fig. 2. Mean reaction times (mRT) in milliseconds (ms) to sub-tests pooled together on CPT (Error bars = S.E.).

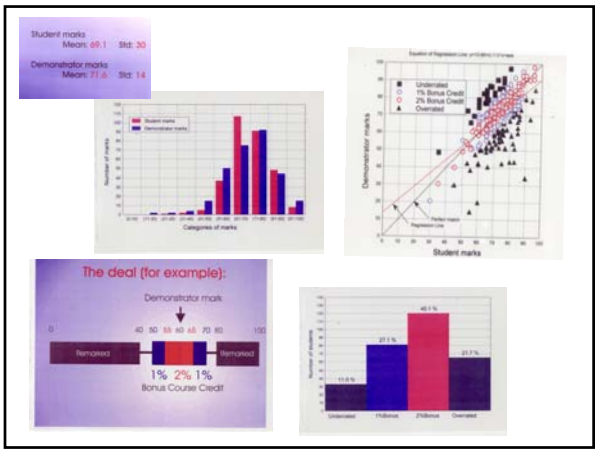
house procedure (Vasey and Thayer, 1987), and followed up with LSD tests.

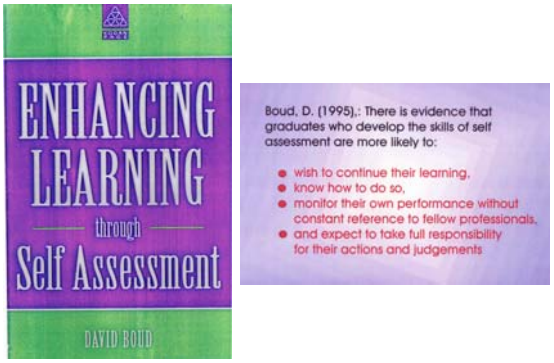
A borderline difference was found for false posi-











Older Driver Behaviour at rural T-intersections

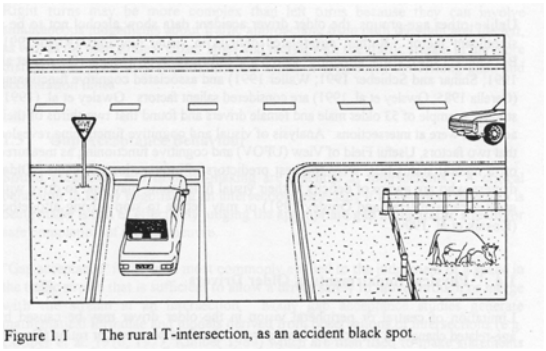


Figure 1.1 The rural T-intersection, as an accident black spot.

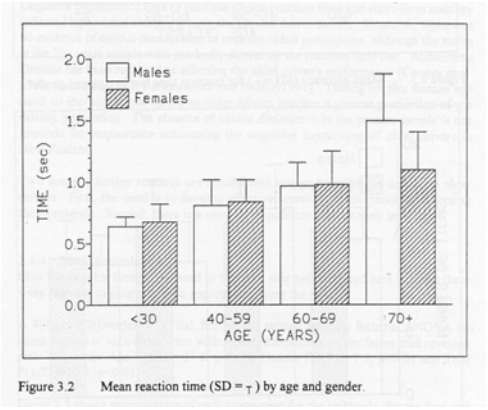


Figure 3.2 Mean reaction time (SD = $_T$) by age and gender.

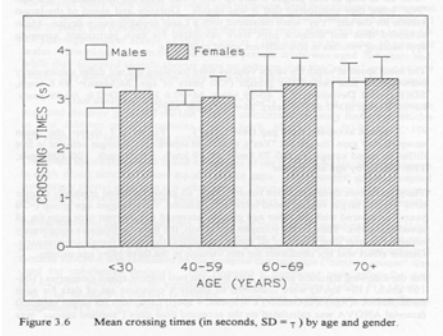
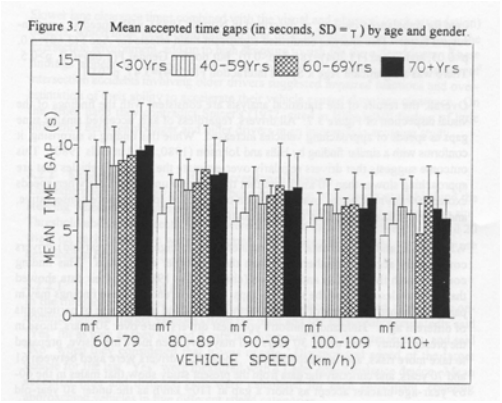


Figure 3.6 Mean crossing times (in seconds, SD = $_T$) by age and gender.

Figure 3.7 Mean accepted time gaps (in seconds, SD = $_T$) by age and gender.



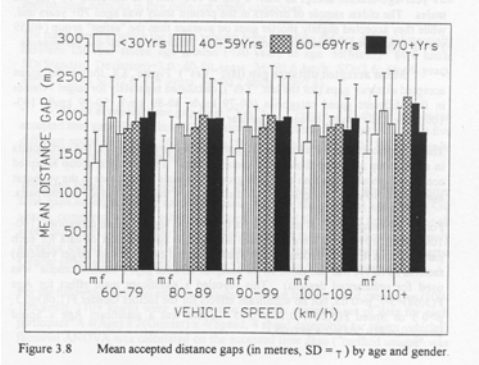


Figure 3.8 Mean accepted distance gaps (in metres, SD = τ) by age and gender.

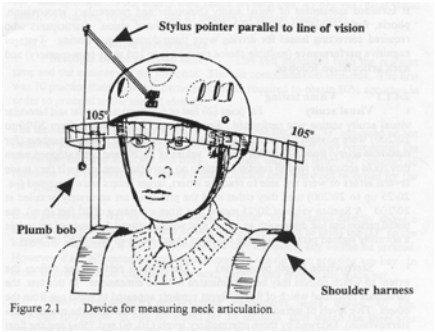


Figure 2.1 Device for measuring neck articulation.

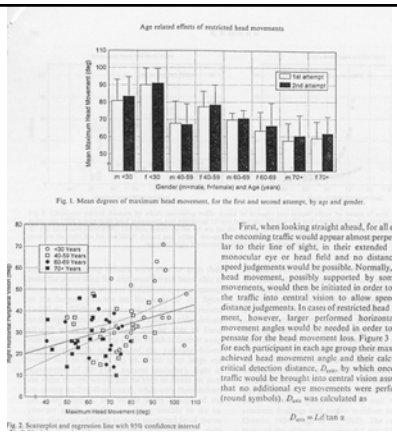


Fig. 1. Mean degrees of maximum head movement, for the first and second attempt, by age and gender.

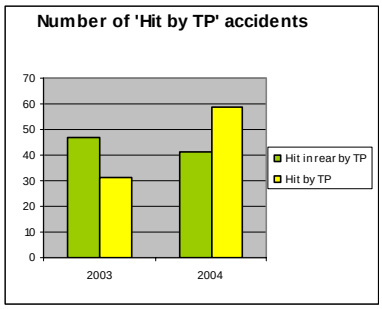
Fig. 2. Scatterplot and regression line with 95% confidence interval

Data Brake Evaluation Field Study

700 taxis in Auckland

Data Brake Evaluation Study

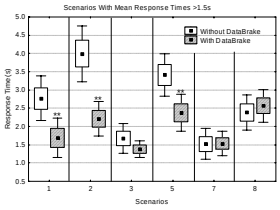
700 taxis in Auckland

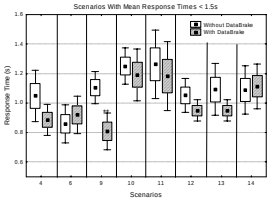


Data Brake Evaluation Laboratory Study

Research Design:

Baseline	Time A (6 months)	Time B (6 months)
No DataBrake Control	Control	Test Group2 (DB)
Test Group1	Test Group1 (DB)	Test Group1 (DB)





Conspicuity of road workers....

Figure 15a. Condition R12: Rural background with test-garment in position 12.

THE 'FRONTAL LOBE' PROJECT 2006

Driver Education Foundation

LTNZ, NZ Army, Porirura City Council, Taupo Police, Taupo City Council, Toyota NZ, Morrel Motors Taupo, AMS Training Group Huntly, Taupo Road Safety Co-ordinators, Taupo-Nui-A-Tia College

A double blind, randomized controlled study of the effectiveness of higher level skills training to improve frontal lobe (executive) function related driving performance in young drivers.

Aims of the study

- 1. To determine if the level of frontal lobe functioning in young drivers is related to their driving performance.

Issues:

Sample size
Double blind study
Reliability of main outcome measure
Method of statistical analysis
'Second week'
'Bias' in introduction

1. PRE - ASSESSMENT

Extensive Psychometric testing included:
Frontal lobe executive function (D-KEFS), General Ability, Depressive and Anxiety tendencies

Driving skills assessment

Visual Search - Speed choice - Directional control

Baseline

Professional driver assessors

Aims of the study

- 2. To determine the effects of 'higher level' and 'vehicle control' skills training on displayed and self reported driving behaviour, self rated confidence level and driving skills.

2. Training

Red: **Higher level skills**
Blue: **Vehicle control skills (traditional)**
Yellow: **Control**

Red Group: Higher Level Driving Skills Training (low risk)

Road commentary

Self assessment

Group work

Video based hazard perception training

Blue Group: Car Control Skills Training (high risk)

Steering

Manoeuvering

Braking

Parking

Yellow Group: Control – off sightseeing (very low risk)

Driving skills assessment

Visual Search - Speed choice - Directional control

post-training

Professional driver assessors

3. Post-training driving evaluation

Fortnightly diaries:
36 frontal lobe participants versus 36 controls

- Number of near hits, failures and successes, errors, lapses, traffic fines, and possibly crashes
- Frequency of speeding, unsafe following distance, cell phone while driving, text messaging etc.

3. Post-training driving evaluation

Piloting a GPS based telemetric data tracking system to evaluate post training real driving behaviour of young drivers

- **Speeding**
- **Average speed**
- **G force**
- **Distance travelled**

What next:

Frontal lobe project - second serving

60 participants 60 controls - 120 data trackers to evaluate post training effects