

## Current trends and the future progression of psychophysiology in climbing research

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I would like to briefly discuss with you psychophysiology research in climbing. In particular:

- **Key definitions of terms**, particularly those often used synonymously.
- **Outline our current understanding** from research completed to date.
- Present an **impression of the future of climbing psychophysiology research**.

## Psychophysiology

*“the study of relations between psychological manipulations and resulting physiological responses... to promote understanding of the relation between mental and bodily processes”*

Andreassi (2006; p1)

### In climbing:

- Quantify the impact of stressors.
- Monitor athletes to preempt choking and performance slumps.
- Assess the effectiveness of interventions
- Understand stress-performance relationship

Psychophysiology is particularly relevant to climbing as it allows us to:

- **Quantify the impact of stressors** on individual climbers psychology, physiology and behaviour.
- **Monitor athletes stress and arousal and their interpretation of their symptoms;** allowing coaches and athletes the opportunity to preempt choking and slumps in performance.
- **Assess the effectiveness of interventions** with the aim of reducing negative perceptions of stressors and improving performance.
- Finally it allows coaches and researchers to better **understand the stress-performance relationship** in sport.

# Key terms

## Stress

"an ongoing process that involves individuals transacting with their environments, making appraisals of the situation they find themselves in, and endeavouring to cope with any issues that may arise" (Fletcher et al. 2009)

## Climbing Stressors

The task and environment demands (Stimuli) associated with climbing performance

## Arousal

"complex multifaceted blend of physiological and psychological activity in the organism that varies on a continuum from deep sleep to intense excitement" (Gould et al. 2002)

## Anxiety

"feelings of insecurity which result because of a perceived inability to cope" (Spielberger, 1966)

Terms which are often used synonymously, these are: stress, stressors, arousal and anxiety:

### Stress:

- Individuals transacting with the environment, making appraisals and endeavouring to cope.
- Key to stress is that it is a continuous process that is **neither inherently positive nor negative**.

### Stressors:

- Task and environmental demands associated with climbing performance.
- Experienced, perceived and interpreted by the individual.
- Again neither inherently positive nor negative.

### Arousal

- Depending on individuals Perception of Demand, there may be a change in arousal.
- multifaceted blend of physiological and psychological activity
- varies on a continuum from deep sleep to intense excitement
- Again neither inherently positive nor negative.

### Anxiety:

specific negative emotional response

feelings of insecurity which result because of a perceived inability to cope

**State anxiety** is a state of heightened emotions that develop in response to a particular situation. Whilst, **Trait anxiety** is a general level of stress, characteristic of an individual, the individual's personality.

**Anxiety is multidimensional**, experienced as **Somatic**, or Physiological anxiety, experienced with sweaty palms, increased heart rate, butterflies in the stomach.

**Cognitive** anxiety, experienced as fear and negative emotions. **Pijper also proposed that anxiety manifests at a Behavioural level** and individuals will experience changes in movement performance.

# Climbing specific stressors

Route knowledge

Route difficulty

Height above ground

Style of ascent

There are **numerous acute stressors in the climbing** environment.

**Stressors should not be assumed to be anxiety inducing**, this is down to the individual's interpretation.

These stressors **do not describe a single environmental demand**, which may be isolated and describe on its own, many are a amalgamation of several stressors.

## Psychological and psychophysiological measures

Competitive state anxiety inventory (CSAI-2R)

Rock climbing anxiety inventory (RCAI)

Pre Climb Heart rate

Plasma Cortisol

### Competitive State Anxiety Inventory (CSAI-2R):

- **Self-report tool** for anxiety by Martens et al. (1990) and refined by Cox et al. (2003).
- Most common measure of anxiety in research.
- **measure of individual's perception of multidimensional anxiety, measuring cognitive and somatic anxiety and self-confidence.**

### Rock Climbing Anxiety Inventory (RCAI):

- **Development of the scale used by Hardy and Whitehead (1984).**
- RCAI also **measures cognitive and somatic anxiety**, as well as activation.
- Not commonly used

### Pre climb heart rate:

- Attributed to **increased psychological arousal in preparation for the climbing task** (Hardy & Martindale, 1982).
- **Anticipatory heart rate.**

### Plasma cortisol concentration:

- Cortisol was **first used by Hodgson et al. (2009)** and has been used in numerous studies since.
- Cortisol is **secreted by the adrenal cortex under the influence of the HPA axis** in response to psychological and/or physiological stress (Wittert et al., 1996).
- **Measured pre climb and compared between pre to post values.**

## Route knowledge

On-sight vs. Red-Point

Draper et al. (2008)

Hardy & Hutchinson (2007, Study 3)

- *Reduced cognitive and somatic anxiety in both.*
- *Draper: decrease in climb time & blood lactate.*
- *Hardy: reduced heart rate, perceived exertion and an increase in the belayers rating of performance.*

### Route Knowledge:

**Draper et al. the second red-point was completed on the lead.**

**Hardy and Hutchinson a top-rope.**

The differences with a repeat ascent is **likely to be at least partially due to learning effect, resulting in a reduction in effort required, which also results in a reduction in perception of anxiety.**

# Route difficulty

Hardy & Whitehead (1984), Janot et al. (2000)

Hardy & Hutchinson (2007, Study 1)

- *Increased heart rate with difficulty in all three.*
- *Hardy (1984): no difference in cognitive or somatic anxiety.*
- *Hardy (2007): greater cognitive and somatic anxiety and reduced activation.*

## Route Difficulty:

Hardy's two studies looked at differences up to a climber's lead limit.

Janot compared two studies of differing difficulty.

**With an increase in difficulty there is an increase in the effort required.** It would also appear from the work of Hardy & Hutchinson that an increase in anxiety may be expected. Although this is not entirely clear.

# Height above ground

Pijpers et al. (2003; 2005; 2006)

Nieuwenhuys et al. (2008)

- *Increased climbing and hold grasp time and slower moments.*
- *Increased number exploratory movements with hands and feet.*
- *Increase in number and duration of gaze fixations.*

## Height above the ground:

Resulting in a **significant difference between high and low conditions as measured by a single dimensional anxiety thermometer and heart rate.**

**In all cases the climbers were still able to complete the task in the high condition, but they experienced changes in performance representative of reduction in processing efficiency.**

# Style of ascent

| Grade        | Author & Date                 | CSAI-2R       |               |                 | Heart Rate | Cortisol      |                  |
|--------------|-------------------------------|---------------|---------------|-----------------|------------|---------------|------------------|
|              |                               | Somatic       | Cognitive     | Self-Confidence | Pre        | Pre           | Delta (Pre-Post) |
| Lower Grade  | Aras & Akalan (2011)          | Lead          | Lead          | Top-Rope        | -          | -             | -                |
|              | Dickson (2013)                | Top-Rope      | Top-Rope      | No Difference   | Lead       | Lead          | Lead             |
| Intermediate | Hardy & Hutchinson (2007, S3) | Top-Rope      | Lead          | -               | -          | -             | -                |
|              | Draper et al. (2011a)         | Top-Rope      | Lead          | Lead            | -          | Top-Rope      | Lead             |
|              | Dickson (2013)                | Top-Rope      | Top-Rope      | Small Diff      | Small Diff | Top-Rope      | Lead             |
|              | Fryer (2013)                  | Top-Rope      | Lead          | Small Diff      | Small Diff | Top-Rope      | Lead             |
|              | Hodgson et al. (2009)         | Lead (Sig)    | Lead          | Top-Rope (Sig)  | -          | -             | Lead (Sig)       |
|              | Draper et al. (2010)          | Lead          | Lead          | Top-Rope        | Lead       | -             | -                |
|              | Fryer et al. (2012)           | Lead          | Lead          | Lead            | Lead       | No Difference | -                |
| Advanced     | Dickson (2013)                | Small Diff    | Lead          | No Difference   | Lead       | Top-Rope      | Lead             |
|              | Dickson et al. (2012)         | No Difference | No Difference | Top-Rope        | Top-Rope   | Top-Rope      | -                |
|              | Fryer (2013)                  | Top-Rope      | Small Diff    | Top-Rope        | Small Diff | Top-Rope      | Lead             |

Top-Rope > Lead  
Lead > Top-Rope

## Style of ascent:

- **Either top-rope, lead**, or in the case of Hodgson et al. and Aras & Akalan a contrived top-rope with trailing lead rope. With lower-grade, intermediate and advanced climbers.
- Group these have been **ordered by the approximate mean ability of the participants**.
- **Grades have been normalised** using Draper et al.'s (2011) guidelines, for ease of comparison.
- Red denotes greater value in top-rope, green in the lead.

## Hodgson et al. (2009):

- Significantly **elevated somatic anxiety and reduced self-confidence**
- **Pre to post plasma cortisol concentration was also found to be significantly elevated.**

## In the remaining studies:

- no significant difference were found in any of the measures.
- **Cognitive anxiety greater in lead condition**
- **Self-confidence greater in top-rope**
- **Pre climb cortisol greater before top-rope.**
- **Delta values cortisol pre to post greater in lead**

# Issues with experimental control

Environment

Difficulty of route

Route knowledge

Ability of participants

Timing of administration of scales

Comparisons between the previous studies is **difficult because of issues with experimental control**.

To take the style of ascent as an example:

- Different environments used
- Changes in difficulty of the route relative to climbers maximum ability.
- Some climbers completed familiar routes, whilst others completed them on-sight
- The ability of the participants was not given in some studies
- Scales such as CSAI administered at different times.

Tighter experimental control is **necessary, in order to reduce competing explanations**. Particularly with stressors that are known to interact, as seen previously.

## Further issues with methods & measures

Grouping of participants

Intra vs. inter individual measures

Possibility of report bias

Limited use of performance measures

Ecological validity

Trait anxiety

### Summary of key issues with methods and measures:

- The **broad grouping and grading of participants, may account for some of the variation has been seen in results**, as shown by the large standard deviation found in the previous discussed papers and the lack of significance seen in results.
- **A move from comparisons of inter-individual to intra-individual differences would help reduce the significant variation seen in results.** Particularly within scales such as the CSAI-2R and biochemical markers such as Cortisol. This also has **direct implications for the sport science support of athletes.**
- The **Possibility of Report Bias, should be considered, especially due to reporting social desirability of results**, particular in males not wanting to display weakness and signs of anxiety. There is also possibility that the **scales are not representative of the emotions** that the participants are actually experiencing.
- **There has been generally limited use of fine grain performance measures, like those found in the work of Pijper and Nieuwenhuys.** A move to integrate existing measures of performance such as geometric entropy, accelerometers and instrumented holds, with well controlled psychophysiology methods is necessary.
- **Extending the ecological validity, of the results** with the comparison of different environments, particularly indoors and outdoors and compassion settings with training sessions would be of great interest.

## The future

Stressors

Psychophysiological techniques

Performance measure

**The future,** I will briefly consider three areas which may be addressed in future research:

- Overlooked stressors
- Psychophysiological techniques
- Performance measures

# Further stressors

## Acute:

- Competition environment
- Climbing with an audience
- Indoor vs. Outdoor
- Environment (temp, humidity etc.)

## Chronic:

- Poor previous performances
- Pressure from sponsors.
- Injuries
- Accidents

Several **obvious climbing stressors have not been considered, including the competitive environment, climbing with an audience, indoor vs. outdoor.**

**Chronic and trait anxiety has also not been considered,** with the likes of Poor previous performances, Injuries and previous Accidents

# Potential psychophysiological measures

Heart rate variability

Leucocyte coping capacity

EEG

Skin Conductance

## Heart Rate variability:

- Non-invasive measurement technique, which **reflects the beat-to-beat variation between two R waves of a QRS complex on an ECG.**
- The **spectral analysis of heart rate variability data using fast Forian transformation**, is a method of observing the controlling influence of the sympathetic and parasympathetic pathways of the autonomic nervous system.

## Leucocyte Coping Capacity:

- Uses the bodies **leucocytes as bio-indicators.**
- Many receptors **sensitive to stress including changes in the HPA axis and the sympathetic nervous system.**
- Leukocytes which have been exposed to stressors within the body will have a **reduced capacity to produce reactive oxygen species in response to an external stimulator.**

*We have been involved in a **proof of concept, in collaboration with Coventry University**, exploring the use HRV and LCC for quantifying stress in climbing. It has been possible to demonstrate a difference pre to post climb with both the LCC and the HRV, although a large amount of variation in response was found, likely largely due to the range of abilities of participant's that were used. **There is defiantly potential for these measures in climbing research.***

## Electroencephalography (EEG):

- The **EEG allow the measurement of the brains electrical activity at the scalp.**
- As with HRV spectral analysis of the electrical activity allows changes to be quantified.

*We have been working with the **psychology team who's research focuses on anxiety and using EEG to assesses levels and changes in brain activity.** They have been **using inspired CO2 to manipulate anxiety**, one of the first studies within my PhD will be working with the psychology team to explore changes in anxiety and performance. There may be **potential in this technique to better define anxiety and to assess how and why it is occurring.***

## Skin conductance:

- **Indicate psychological and physiological arousal** as it is mediate by the sympathetic nervous system.
- Galvanic skin resistance measures **changes in resistance** between two points.

## Performance measures

### Global:

- Success vs. failure
- Climbing time

### Specific:

- Instrumented holds
- Geometric index of entropy
- Movement behaviour
- Gaze tracking

There is a real **need to move away from the crude global performance measures**, if we want to truly understand the individual climber.

Global measures **do not account for variations in individual performances.**

Specific measures of performance provide us with **tools that allow us to quantify the performance of the climber.** These should be **combined with the individuals assessment of their own performance and that of a coach. These comparisons should be made over time.**

## The future of psychophysiology in climbing...

Four factors to develop climbing psychophysiology research:

- A better understanding of the stress process.
- Manage experimental control in ecologically valid context.
- The development/ employment of discreet non-invasive psychophysiological markers.
- Multi-disciplinary teams approach.

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- A better understanding of the stress process.
- Manage experimental control in ecologically valid context.
- The development/ employment of discreet non-invasive psychophysiological markers.
- Multi-disciplinary approach to research development.

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