EEG Analysis of Climbers in Action

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INTRODUCTION

Rock climbing is oft described as a "mental" sport, where the ability to function at a high level through stressful stimuli is imperative. Participants may work on climbing routes for years before successful completion, referring to the successful attempt as a "breakthrough". Sport psychologists have investigated the mental processes of climbers through surveys, observations, and video analysis. Well known publications (e.g. The Rock Warrior's Way) help climbers master the psychological hurdles and achieve greater success. Perhaps nowhere are the stakes (and the stress) higher than during a climbing competition. Those who can manage their nerves and perform in this context demonstrate a high level of coping and resilience.

Research Questions:
1) What mental states are evident during a bouldering session
2) Do certain mental states at predict higher performance?

METHODS

Thirty-five climbers at the Triple Crown Bouldering competition wore Emotiv Insight EEG headsets during at least one route attempt. Each climb was captured on video and synchronized with brainwave data for post hoc analysis. Brainwaves were transformed into mental states as described in previous research (i.e. focus, motivation, excitement, meditation, relaxation). Each climb was divided into segments, based on the activity being performed at each time point. The final dataset consisted of six unique segments (i.e. epocs), including: 1) Scouting the route, 2) Overall climb, 3)Searching for holds while climbing, 4) Setup for a big move, 5) Sticking a big move, and 6) the Crux. Each segment was analyzed using principal components analysis (to determine the alignment of emotions) and Multiple Analysis of Variance (MANOVA) to determine the influence of mental states during each segment on successful route completion.

RESULTS

Significant differences were found for all independent variables, except for gender.
- The single strongest predictor of mental state during the climb was success or failure. The direction of causation is undetermined, so mental state may also predict success.
- Mental states during specific "events" of the climb were also relevant.
- Interaction effects for climbing difficulty* events and Failure/success*events were the strongest multivariate predictors, while accounting for all other variables in the model.

In sum, mental state during specific events of the climb predicted success, and the impact of events on mental state was amplified on difficult routes.
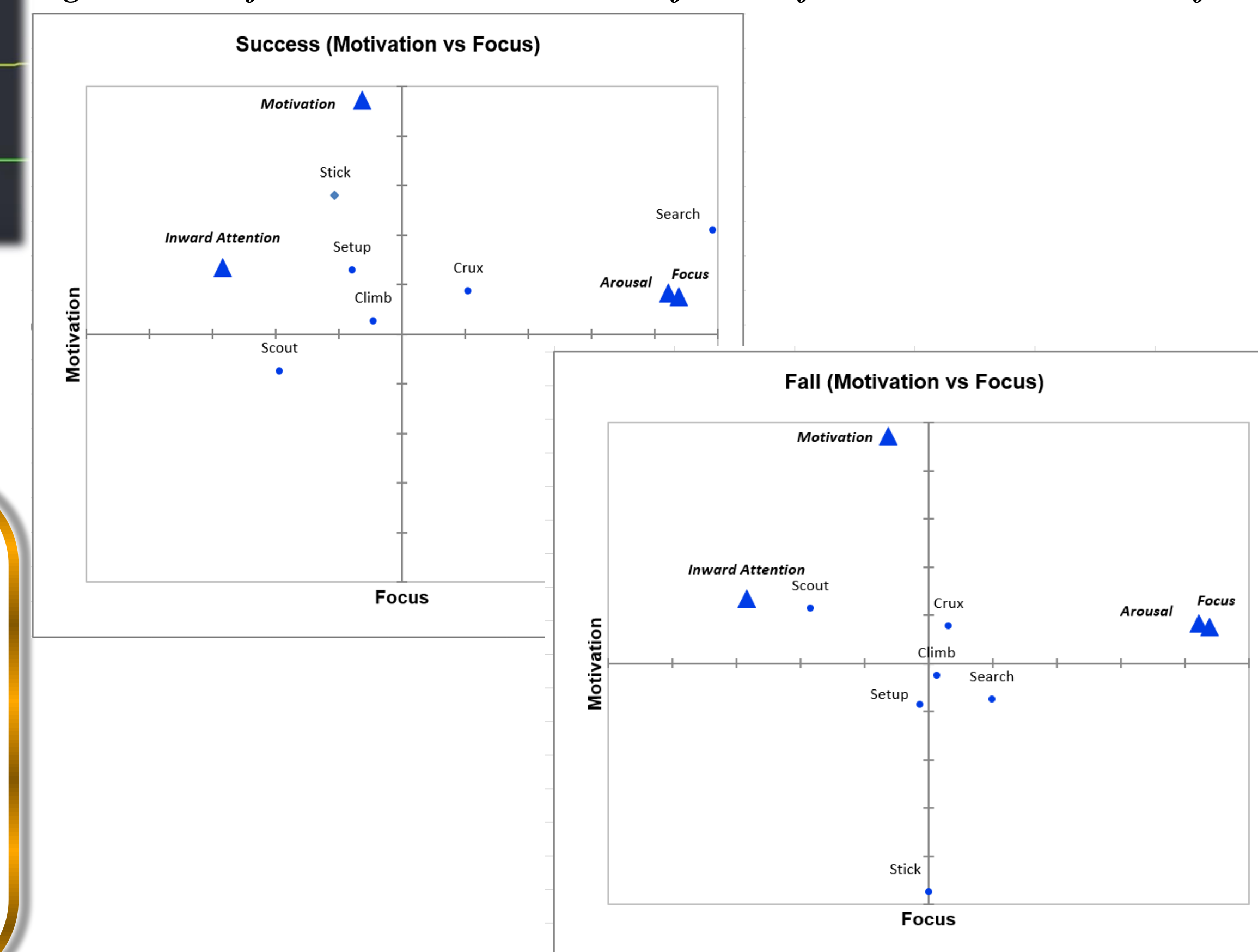
Table 1. Multivariate test results for mental states by all independent variables.

Effect	Value	F	Sig. (Wilks')	Partial Eta Squared
Gender	0.994	1.672	0.154	0.006
Difficulty	0.985	2.155	0.028	0.008
Events	0.913	4.269	0.000	0.023
Fail/Success	0.972	7.893	0.000	0.028
Gender * Events	0.980	2.79	0.004	0.010
Difficulty * Events	0.821	5.098	0.000	0.048
Difficulty * Fail/Success	0.972	8.039	0.000	0.028
Events * Fail/Success	0.821	18.883	0.000	0.064

Other Findings: Findings revealed salient insights, including significant markers of successful route completion.
- Higher focus (and lower meditative state) during the scouting phase and searching for holds while climbing predicted success by 10%.
- The strongest predictor of success (33%) was a "relaxed excitement" through the crux section, indicated by higher frontal alpha waves and gamma in the parietal and temporal zones.
  - This indicates that those who perform at the highest levels under stressful conditions can maintain a relaxed mental state throughout.

Figure 1. PCR for mental states and events of successful climbers and those who fell.

IMPLICATIONS

"You will climb only as high as your mind lets you."
--Robyn Erbesfield

Climbing is a physical and mental challenge that can improve self-efficacy, resilience, and quality of life. Many elite climbers have emphasized that mental training is equally important to physical training, for enjoyment, performance, and injury prevention. This results describe the psychological journey of a climber and identify key aspects of a climb that require mental attention. The mind is in constant flux during a climb, solving problems, filtering out anxiety and irrelevant stimulus, and directing movements based on immediate feedback. Remaining relaxed and meditative even for instantaneous stressful events can predict performance by 33%. In addition to improving athletic performance, mental training may improve resilience and coping with acute stress in various contexts.