

LINE BISECTING TEST REVEALS RELATIVE LEFT BRAIN  
HEMISPHERIC PREDOMINANCE IN HIGHLY SKILLED ATHLETES:  
RELATIONSHIPS AMONG CEREBRAL LATERALITY, PERSONALITY  
AND SPORT PERFORMANCE

A Dissertation

Presented to the Faculty of Saybrook Graduate School and Research Center

in

Partial Fulfillment of the Requirements for the Degree

Doctor of Philosophy in Psychology

By

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(Ph.D. conferred May, 21, 2001)

May 2001

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## Abstract

### Line-Bisecting Test Reveals Relative Left Brain Hemispheric Predominance in Highly Skilled Athletes: Relationships among Cerebral Laterality, Personality and Sport Performance

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#### Introduction and Purpose

The main purpose of this dissertation was to document the performance of highly skilled athletes on a neuropsychological and behavioral measure of cerebral laterality (line-bisecting test) and compare it with that of a control group of age-matched non-athletes, as well as determine if athletes' relative tendencies in cerebral laterality were consistent with select neurophysiological findings in athletes.

This research also attempted to ascertain if repressive coping, neuroticism, absorption, and relative brain hemispheric predominance were associated interactively or separately and to what extent they were related to performance. An ancillary goal of this dissertation was to advance an original model of performance, the *Theory of Critical Moments*, in which the above measures were used help explain the influence of and unconscious ability to avert negative intrusive thoughts during critical moments of competition. Norms for repressive coping, absorption, and neuroticism in athletes were also established.

### Review of the Literature and Hypotheses: A Brief Overview

The line-bisecting test is a clinical and research instrument used to assess basic cortical functioning. Its origin can be traced to the phenomenon of hemispatial neglect as first documented by Brain [8], who observed that certain neurologically impaired patients when asked to bisect a line in half consistently divided it well to the right of the true center. By contrast, the majority of neurologically intact persons tended to make bisecting errors to the left of center, exhibiting what came to be termed pseudoneglect, or left-side underestimation. Pseudoneglect is thought to reflect a bias in processing power in favor of the contralateral hemisphere when attempting or contemplating to bisect a line [34, 63].

Rightward error in line bisecting error (neglect) in intact persons has been associated with left-hemisphere based personal optimism, risk-taking behavior, and positive affect [34, 35].

Based on previous research identifying situational left-brain hemispheric predominance or an *Athlete's Profile* of left-cortical functioning [38, 72, 92], as well as findings on line bisecting [34, 35] and left-hemisphere localized repressive coping [110] and right-hemisphere-localized neuroticism [26], this study hypothesized that highly-skilled athletes would make more rightward errors on the line-bisecting test than non-athletes. This study also predicted that greater magnitude of rightward error on the line-bisecting test and high repressive coping, a personality measure associated neurophysiologically with the ability to functionally inhibit the interhemispheric transfer of negative affect from the right

to the left hemisphere [110], would be correlated with better performance. It was also hypothesized that most athletes would exhibit a personality profile consisting of low absorption, low neuroticism, and high repressive coping.

### Sample<sup>1</sup> and Method

Four hundred and eighty five (485) highly skilled NCAA division I and II athletes from 7 sports and a non-athlete control group (n = 60 right-handers) were administered a line-bisecting test. Two hundred and fifty (250) strongly right-handed athletes (Edinburgh Handedness Inventory [82] score of >59) were identified and evaluated regarding tendencies in cerebral laterality.

Singular and interactive relationships among repressive coping, neuroticism, absorption and line-bisecting and performance were investigated using various instruments including the Marlowe Crowne Scale [23], Eysenck Personality Inventory [41], Tellegen Absorption Scale [107], and by analyzing multi-season sport specific performance statistics. In addition, normative data on the aforementioned personality measures were generated for the initial total sample of athletes (n = 485) and compared to various age-matched control groups (n = 800 to 2000).

### Analysis of the Data

The *t*-test for independent samples was used to analyze the line-bisecting data. Multiple and simple regression statistical procedures were used to examine relationships among the above predictor and criterion variables. T-tests were also used to compare personality measures in the total sample of athletes (n = 699) with the control group(s).

## Results

The main hypothesis that highly skilled athletes would make more and greater magnitude rightward errors in line bisecting than non-athletes was confirmed. The resulting t statistic was highly significant and more importantly was associated with a large effect size and a stable confidence interval ( $t = 8.96$ ,  $p < .001$ ;  $d = 1.28$ ; Mean Difference 21.27, CI = 16.87 – 26.47).

Although multiple regression and tests for interactions were not revealing, significant independent linear relationships emerged including that rightward error on line bisecting (left-cerebral predominance) was significantly correlated with performance in male athletes (but not in female athletes). Repressive coping was also significantly correlated with performance in male athletes (but not in female athletes). In women, neuroticism and absorption were significantly negatively correlated with performance.

T-tests also revealed that athletes ( $n = 699$ ) were significantly lower in absorption than non-athletes and over 89% of athletes were low in this trait compared to about 30% of non-athletes. Athletes were also significantly lower in neuroticism than non-athletes. Although athletes did not differ from non-athletes in repressive coping it should be noted that both samples were higher in this trait than non-student samples and that more than 2/3s of athletes exhibited the predicted profile of high repressive coping, low absorption, and low neuroticism.

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<sup>1</sup> Reasons for variations in sample sizes are explained in the full dissertation.

## Discussion

This study demonstrated that highly skilled right-handed athletes made more rightward errors when line-bisecting than non-athletes, indicating relative predominance of left-brain functioning. Although it was predicted that athletes would make more rightward errors than non-athletes it was not expected that over 90% of athletes would exhibit this tendency. The robustness of this finding strongly suggests that highly skilled athletes have a state-induced neurophysiological response system that is different from and more efficient than that of novices or non-athletes relative to athletic performance and learning of novel motor skills. Evidence supporting this contention includes studies showing that highly skilled athletes learned new motor skills faster than non-athletes, a process that was associated with relative left-hemispheric predominance [38]. In addition, it has been demonstrated that elite athletes allocated cortical resources more efficiently than non-athletes when attempting to learn a motor skill they had not engaged in previously [45].

Rightward error on the line-bisecting test may also reflect a stable longitudinal neuropsychological trait and behavioral correlate of the predominantly left-hemisphere EEG profile that certain athletes appear to develop as a function of learning and exhibit when engaging in sport-specific tasks [38, 72, 92]. Evidence supporting that tendencies in line bisecting may reflect a stable trait include studies reporting that rightward error was associated with positive affect, personal optimism, and risk-taking (left-hemisphere based personality traits) [34, 35]. Line bisecting and personality/behavior relationships have also

been found to be stable (i.e., reliable) over a 60-day test-retest period [35]. Drake [124] maintains that line bisecting appears to reflect a trait-like propensity, stating that he would expect athletes to be high in positive affect, personal optimism, risk-taking behavior, and other left-based personality measures that have been investigated in the context of the line-bisecting paradigm, including feelings of being strong, dominant, determined, powerful, and mighty. In fact, there is evidence indicating that athletes are higher in many of these and related characteristics than non-athletes [24, 36, 43, 53, 66, 81, 83, 85].

The finding that magnitude of rightward error was significantly correlated with performance, indicating that variability in the degree of left-hemispheric predominance exists even among highly skilled athletes, with the best performers appearing to be the most left-predominant, suggests that trait levels of relative hemispheric predominance may play an important role in mediating performance.

The fact that repressive coping was associated with better performance in males appears consistent with this measure's hypothesized potential protective function in suppressing negative intrusive thoughts, thereby facilitating performance. However, female athletes appeared not to benefit from repressive coping. Instead, absorption and neuroticism were negatively correlated with performance, suggesting that female athletes may be more vulnerable to intrusive thoughts associated with neuroticism especially if they are high in absorption, an explanation that is consistent with Wickramaskera's *High Risk Model of Threat Perception* [118].

The finding that athletes were overwhelmingly low in absorption suggests that the kind of focus, involuntariness, and peak experiences associated with high absorption may not facilitate performance in athletes and that approaches to the enhancement of performance using imagery or visualization should consider an athlete's level of absorption.

#### Contribution to Science and Practice

This dissertation revealed numerous first time data and results in a large and representative sample including the finding that highly skilled athletes were overwhelmingly left brain predominant and low in absorption and that they exhibited a general profile of low absorption and neuroticism and high repressive coping. These results may have important implications for our understanding of relationships among and between cortical organization and personality measures in this study that have been associated with attention, physiological reactivity, intrusive thoughts and their relevance to performance. Basic descriptive knowledge of these predictive variables in a large sample is crucial to advancing models of peak performance and developing efficacious and individualized intervention protocols to enhance the performance of athletes. Moreover, the findings on cerebral laterality extended and quasi-replicated EEG studies involving very small samples [38, 49, 55, 56, 72, 92] and strongly suggests that a simple, valid and reliable measure of cortical functioning, the line-bisecting test, can be used in the field to assess basic brain states in large samples of athletes. These findings further indicate that interventions designed to manipulate brain states could be used to activate the left hemisphere to facilitate positive affect and keep negative intrusive thoughts from

being manifested, in a manner similar to what has been demonstrated in research and clinical settings [33, 78, 94].

The fact that line-bisecting error (i.e., cerebral laterality), repressive coping, neuroticism, and absorption were associated with longitudinal measures of performance also suggests that micro-operationalizations of dependent/criterion measures of performance may be the key to better isolating (i.e., explaining more variance) the influence of psychological or personality variables on performance, especially during critical moments, consistent with the driving theory of this dissertation, the *Theory of Critical Moments*, as well as the *High Risk Model of Threat Perception* [118].

The first time data on repressive coping and absorption also offers new perspectives into the role negative and intrusive thoughts may play during competition and how repressive coping, in concert with absorption and neuroticism may affect the cognitions and performance of athletes.

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