The After-Effects of Physical Exertion on Cognitive Performance: Youth Sailors and Logical Reasoning

Gavin R. Dagley

This thesis is presented in partial satisfaction of the requirements for the degree of
Master of Arts at Massey University, Albany
1999

Abstract

Youth sailors completed four logical-reasoning test administrations to explore whether an extended-duration cognitive task might isolate a cognitive performance decrement after long-duration moderate-intensity physical exertion. The cognitive task, the 30-minute Grammatical Transformation Test (GTT), was developed from the three-minute Baddeley Logical Reasoning Test (Baddeley, 1968). Thirty-seven 16 to 20 year-old sailors completed the GTT before and after a day of on-the-water training, and a day of simulated racing ashore. Although a subjective measure indicated the sailors were more physically tired after a day of sailing than after either a day ashore, or prior to either activity, no significant test performance changes occurred due solely to the after-effects of the physical exertion. However, the number of questions correctly answered was higher on the second testing day than on the first, and higher in the afternoon administrations than in the mornings. Further, the number of correctly answered questions increased in each of the consecutive 10-minute test phases in the mornings but decreased in the afternoons. The accuracy of the responses in the first 10-minute phase of each test was lower than in the second and third phases. Also, the accuracy of responses to relatively simpler questions was lower than for complex questions. Finally there were interactions affecting the accuracy of responses between the question complexity and test time, complexity and phase, and complexity, day, time, and phase. The results are discussed in relation to a model of the relationship between fatigue and cognitive performance, and to the cognitively complex sport of sailboat racing.

Acknowledgements

I would like to extend my gratitude to Dr Jennifer Stillman for her support and effort in helping me complete this thesis. I have learned that a supervisor's job is not an easy one. Her persistence and skill is reflected in the consistent improvements that have occurred with each successive draft. I would like to thank Dr Philip Voss, Dr Mark Andersen, and Dr Harriet Speed for their patience with my outbursts of enthusiasm, and for their sound direction. Richard Mason and Harold Bennett of the Royal New Zealand Yacht Squadron were pivotal in allowing this study to occur at all, and I would like to acknowledge their assistance and enthusiasm. I am deeply grateful for the help and friendship of John Weston, youth coach at the Royal New Zealand Yacht Squadron, and previously, the Bucklands Beach Yacht Club. John, as is typical of him, went above and beyond the call of duty to help me through this project. To my family and friends, thank you for your patience and support. Finally, I am deeply indebted to the youth sailors of the Royal New Zealand Yacht Squadron and the Bucklands Beach Yacht Club for their effort in completing a series of unappealing tests, simply because they were asked too.

Contents

	Abstract		ii
	Acknowledgements		iii
	Contents		iv
	List of Tables		vi
	List of Figures		vii
1	**Background**		**1**
	1.1	Fatigue	1
	1.2	Fatigue from Physical Exertion	5
	1.3	Fatigue from Cognitive Exertion	11
	1.4	Sleep Loss and Circadian Rhythm Disruption	12
	1.5	Points of Difference in Fatigue Research	19
2	**Introduction**		**21**
	2.1	Hypotheses and Theories of Cognitive Performance	21
	2.2	Long-Duration, Moderate-Intensity Exertion	25
	2.3	Cognitive Task	26
	2.4	Factors Affecting Cognitive Performance	31
	2.5	Study of the After-Effects of Physical Exertion On Cognitive Performance	32
3	**Grammatical Transformation Test**		**36**
	3.1	Development	36
	3.2	Pilot Study	38
4	**Method**		**41**
	4.1	Participants	41
	4.2	Materials	41
	4.3	Procedure	42
	4.4	Data Analysis	45
5	**Results**		**46**
	5.1	Data Screening	46
	5.2	Tiredness and Effort Ratings Analysis	49
	5.3	Total Correct Data Analysis	51
	5.4	Proportion Correct Data Analysis	53
6	**Discussion**		**63**
	6.1	Overall Performance	63
	6.2	Simple Versus Complex Question Responses	67
	6.3	Practice and Time-of-Testing Effects	69
	6.4	Comparison with Baddeley Test	71

6.5 Model of Fatigue and Cognitive Performance 73
6.6 Implications for Racing Sailors 74
6.7 Problems and Future Directions 75

References **77**

Appendix A **81**

Appendix B **83**

List of Tables

Table 1.1	Points of Difference in Studies of the Effects of Fatigue on Cognitive Performance	4
Table 1.2	Differences in Physical Exertion Types, Durations, and Measures	20
Table 2.1	Cognitive Task Durations in Studies of the Effects of Fatigue on Cognitive Performance	28
Table 4.1	Program for Sailing Days	43
Table 4.2	Program for Lay-Days	44
Table 5.1	Means and Standard Deviations for Physical Tiredness, Mental Tiredness, and Test Effort Subjective Measures on a 7-Point Likert Scale	49

List of Figures

Figure 2.1	Model of relationship between fatigue-inducing factors and cognitive performance.	32
Figure 5.1	Interaction of day and time of test on physical tiredness.	50
Figure 5.2	Interaction of 10-minute phase and time of test on number of questions correctly answered in the GTT.	52
Figure 5.3	Interaction of chronological test day and time of test on number of questions correctly answered in first three minutes of GTT.	54
Figure 5.4	Interaction of chronological test day and time of test on response accuracy proportions in first three minutes of GTT.	57
Figure 5.5	Interaction of question type and time of test on response accuracy proportions in the GTT.	58
Figure 5.6	Interaction of question type and 10-minute test phase on response accuracy proportions in the GTT.	59
Figure 5.7	Interaction of question type and phase on response accuracy proportions in the GTT on the sailing day morning administration.	60
Figure 5.8	Interaction of question type and phase on response accuracy proportions in the GTT on the sailing day afternoon administration.	60
Figure 5.9	Interaction of question type and phase on response accuracy proportions in the GTT on the lay-day morning administration.	61
Figure 5.10	Interaction of question type and phase on response accuracy proportions in the GTT on the lay-day afternoon administration.	61