



Chronic work stress and decreased vagal tone impairs decision making and reaction time in jockeys



Kathleen Landolt^a, Paul Maruff^b, Ben Horan^c, Michael Kingsley^d, Glynda Kinsella^a, Paul D. O'Halloran^a, Matthew W. Hale^a, Bradley J. Wright^{a,*}

^a School of Psychology and Public Health, La Trobe University, Bundoora, Victoria, 3086, Australia

^b The Florey Institute, The University of Melbourne, Parkville, Victoria, Australia

^c School of Engineering, Deakin University, Geelong, Victoria, 3216, Australia

^d Exercise Physiology, La Trobe Rural Health School, Bendigo, Victoria, 3552, Australia

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ABSTRACT

The inverse relationship between acute stress and decision-making is well documented, but few studies have investigated the impact of chronic stress. Jockeys work exhaustive schedules and have extremely dangerous occupations, with safe performance requiring quick reaction time and accurate decision-making. We used the effort reward imbalance (ERI) occupational stress model to assess the relationship of work stress with indices of stress physiology and decision-making and reaction time. Jockeys ($N = 32$) completed computerised cognitive tasks (Cogstate) on two occasions; September and November (naturally occurring lower and higher stress periods), either side of an acute stress test. Higher ERI was correlated with the cortisol awakening responses (high stress $r = -0.37$; low stress $r = 0.36$), and with decrements in decision-making comparable to having a blood alcohol concentration of 0.08 in the high stress period ($p < 0.001$). The LF/HF ratio of heart rate variability impacted the association of ERI with decision-making. Potentially, this may be attributed to a 'tipping point' whereby the higher ERI reported by jockeys in the high stress period decreases vagal tone, which may contribute to reduced decision-making abilities.

1. Introduction

Professional athletes operate in competitive, highly stressful, and often dangerous environments, where decision making and reaction time can not only mean the difference between winning and losing, but can also have implications for their personal safety. Unsurprisingly, by the nature of their occupations, elite athletes are at increased risk of injury and death at work (Bureau of Labor Statistics, 2006). Therefore, understanding the factors that precipitate and contribute to this increased risk is vitally important. One factor that may contribute to these adverse outcomes is stress. Several lines of evidence have demonstrated an inverse relationship between acute stress and decision-making (Starcke and Brand, 2012), and chronic psychosocial stress is known to be an antecedent to athletic injury (Ivarsson et al., 2014; Williams and Andersen, 1998). Unlike any previous study, we will examine this problem through the use of a validated occupational stress model, considerations of stress physiology and experimental models of decision making.

The effort-reward imbalance (ERI; Siegrist, 1996) model of

occupational stress is based on the philosophy of social reciprocity, with stress theorised to manifest when effort is not matched by reward. Adverse stress outcomes are likely when ERI ratio scores are > 1 (Siegrist, 2010). Additionally, the ERI model has an intrinsic component, overcommitment (OC), which reflects the disposition/cognitive style of the individual, and reflects poor coping and an inability to 'turn off' from work. The ERI model proposes that efforts, rewards, and OC will be associated with ill-health indices, and that the interaction of efforts and rewards (e.g., ERI ratio) will explain more than these constructs in isolation. Large prospective studies of the ERI model have shown associations with a number of disease states, maladaptive behaviours, and poor health perceptions (Eddy et al., 2016; Siegrist and Li, 2016), and in recent times this has extended to include a growing number of studies with physiological measures as outcomes (Bellingrath and Kudielka, 2016). There is support for generalising the ERI model to professional athletes, with an imbalance between the perceived costs and rewards of professional Swedish athletes related to burnout (Gustafsson et al., 2008), but to the author's knowledge, the ERI model has not been used with athletes. Similarly, little work has

* Corresponding author at: School of Psychology and Public Health, La Trobe University, Bundoora, Victoria, 3086, Australia.
E-mail address: b.wright@latrobe.edu.au (B.J. Wright).

assessed the association of ERI with short term outcomes such as cognition, and especially reduced speed and accuracy of decision-making, which is very likely related to increased workplace injury.

The relationship between acute stress and decision-making (broadly defined here as the speed and accuracy of choices), has included several acute stress and decision-making paradigms, although the findings have been inconsistent (see Starcke and Brand, 2012 for a review). Only a handful of studies however, have assessed the association between chronic stress and decision-making. For example, higher chronic stress as measured by critical life events has been associated with more errors in decision-making and faulty information processing strategies (temporal narrowing, pre-mature selection, and non-systematic scanning of potential answers to a series of multiple choice questions), but only in individuals who were more sensitive to inner sensations (Baradell and Klein, 1993). In a study of university students, those reporting higher chronic stress performed more poorly on a monetary decision-making task, with the researchers suggesting a bias towards short-term thinking in those that reported being stressed, and thus making poorer overall choices (Gray, 1999). Similarly, a study of females experiencing chronic burnout, had decreased accuracy and reaction time on a visual and auditory continuous performance test when compared with a healthy age-matched sample (Sandström et al., 2005). To our knowledge, only one study has assessed the chronic effects of stress on decision-making using physiological indices of stress. The investigators reported that lower basal levels of cortisol were related to dysfunctional decisions in a gambling task (van Honk et al., 2003). The understanding of the relationships between stress and the speed and accuracy of decision-making is compromised however, due to the heterogeneity of individual physiological reactions (Sapolsky, 2015) and issues such as self-report bias (Macleod et al., 2002), and the possible time-lag surrounding the self-report of stress (Hausser et al., 2011). These limitations can be overcome by utilizing within group designs and physiological measures of stress in combination with the ERI model.

Physiological measures of stress are important as recent experimental evidence reveals that people may exhibit physiological signs of stress well before they are subjectively aware of being stressed (Hausser et al., 2011; O'Donnell et al., 2015). Alongside the decrements reported in decision-making due to chronic stress (Starcke and Brand, 2012), cognitive impairment (e.g., reduced episodic memory, reduced perceptual learning) has also been associated with increased glucocorticoid secretion (Wolf, 2009), with suggestions that dysregulated chronic stress physiology may contribute to the relationship between perceived stress and impaired psychological functioning (Dinse et al., 2017). Another index of the chronic stress response is heart rate variability (HRV). The low frequency to high frequency ratio (LF/HF) index of HRV provides information on the interplay between the sympathetic and parasympathetic nervous system response, with a higher LF/HF ratio indicative of increased sympathetic to parasympathetic dominance, chronic stress, and future morbidity (Thayer et al., 2010; Tsuji et al., 1994).

1.1. The present study

Due to the nature of horse racing which involves managing heavy animals at high speed in close proximity to other horses, fast and accurate decision-making is required and decrements in this area can lead to poor decisions with dire outcomes. Jockeys are at high risk of injury (Cowley et al., 2007; Hitchens et al., 2009), and this may be compounded by chronic stressors that include managing their diet and weight, and working long hours, while rewards are received sporadically (Dabscheck, 2015). We will also assess decision-making either side of an acute stressor, to determine if increased physiological arousal buffers jockeys from the decrements in decision-making and reaction time anticipated for those reporting more chronic stress.

We will assess if ERI is associated with dysregulated (acute and chronic) stress physiology and impaired decision-making and reaction

time in both high and low stress periods. We also expect naturally occurring high and low stress periods to correspond with perceptions of stress and health and with objective measure of decision-making and stress physiology. Consistent with Siegrist's assertion (2010), we anticipate that ERI ratio scores > 1 will be associated with signs of dysregulated physiology and decreased decision-making. And finally, we will assess if indicators of dysregulated stress physiology moderate the association between ERI and decision-making.

2. Method

2.1. Participants

Full-time professional Australian apprentice jockeys provided data at two time-points (September $N = 42$, November $N = 32$) and were aged between 16 and 24. Males ($n = 14$, M age = 18.1 $SD = 1.5$) and females ($n = 18$, M age = 19.9 $SD = 2.3$) participated, representing 64% of all apprentice jockeys in the region. Participants self-excluded themselves from the study if they were taking any medication (other than the contraceptive pill), were presently ill, or had a chronic health, thyroidal, heart, or psychiatric condition, as these can all potentially confound the assessment of the physiological indices of stress used in the present investigation (Pruessner et al., 1997). Eligibility was confirmed via participants' self-report and no participants were excluded due to violation of the testing protocol. All participants provided informed consent and received a small financial reward on each of the two days of testing in return for their participation. Institutional ethics approval was granted for this study (FSTE 14-050).

2.2. Measures

2.2.1. Effort reward imbalance

We employed the 24-item ERI questionnaire (Siegrist et al., 2004). Six items are related to 'effort,' 11 items are related to 'reward,' and 6 items relate to 'overcommitment.' The effort and reward scales were converted into an ERI ratio by using a correction factor that accounts for the uneven number of items (ERI ratio = sum score effort scale/sum score reward scale*6/11; Siegrist et al., 2004). A ratio of 1 represents an equal exchange between efforts and rewards. Ratio scores > 1 are suggestive of elevated risk of ill-health (Siegrist, 2010). The effort (low stress $\alpha = 0.75$, high stress $\alpha = 0.88$), reward (low stress $\alpha = 0.92$, high stress $\alpha = 0.97$), and overcommitment (low stress $\alpha = 0.80$, high stress $\alpha = 0.88$) scales showed high internal consistency.

2.2.2. Short-form 12 health survey (SF-12)

The 12-item Short-Form Health Survey (Ware et al., 1996) assesses physical functioning, role limitations due to physical health problems, bodily pain, general health perceptions, vitality (e.g., energy/fatigue), social functioning, role limitations due to emotional problems, and general mental health (including psychological distress and well-being), and condenses responses to produce two composite scores for physical and mental health. Higher scores correspond with better health. Both physical (September $\alpha = 0.81$, November $\alpha = 0.78$) and mental health (September $\alpha = 0.74$, November $\alpha = 0.78$) scales showed high internal consistency.

2.2.3. Acute stress manipulation

Acute stress was induced using the Maastricht Acute Stress Test (MAST; Smeets et al., 2012). The MAST involves participants submerging their right hand into a clear plexiglass water bath of very cold water (2 °C). An electrical immersion cooler (Huber Unichiller, MPC, Offenburger, Germany) and a water circulation pump were used to maintain water temperature evenly throughout the box. The MAST incorporates a physical stressor, as well as elements of psychological stress such as unpredictability, uncontrollability, social-evaluation, and mental arithmetic. The MAST has been shown to reliably increase

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