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Attention lapses and behavioural microsleeps during tracking, psychomotor vigilance, and dual tasks

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ABSTRACT

This study examined the incidence of attention lapses and microsleeps under contrasting levels of task complexity during three tasks: PVT, 2-D tracking and a dual task combining the two. More attention lapses per participant (median 15 vs. 3; range 1–74 vs. 0–76, $p = 0.001$), with the greatest increase with time spent-on-task ($p = 0.002$), were evident on the more cognitively-demanding dual task than on the PVT. Conversely, fewer microsleeps (median 0 vs. 0; range 0–1 vs. 0–18, $p = 0.022$) occurred during the more complex task compared to the tracking task. An increase in microsleep rate with time spent-on-task ($p = 0.035$) was evident during the tracking task but not the dual task. These results indicate that the higher cognitive load, associated with an increase in task complexity, increased the likelihood of attention lapses, while a reduction in task complexity increased the likelihood of microsleeps.

1. Introduction

Momentary lapses of responsiveness are disruptions in performance that typically last between 0.5–15 s and frequently impair sustained goal-directed behaviour (Peiris, Davidson, Bones, & Jones, 2011). Understanding the cause and impact of these lapses is important, particularly in the transport sector, such as air traffic control, and high speed train operations, where response failures can lead to fatal accidents. Such lapses are also relevant to other sectors, such as pathology laboratories, food industries, and defence. Moreover, the impact of lapses extends into everyday tasks that affect us all (Cheyne, Carriere, & Smilek, 2006).

The literature underpinning research into lapses of responsiveness has focused on attention lapses, which Mackworth (1948) originally referred to as the vigilance decrement. Attention lapses are explained by two competing theories. One

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theory is often called the mindlessness/mind-wandering hypothesis and depicts cognitive underload (Manly, Robertson, Galloway, & Hawkins, 1999; Robertson, Manly, Andrade, Baddeley, & Yiend, 1997; Thomson, Besner, & Smilek, 2015). The alternate, overload theory, suggests that lapses occur due to resource-depletion (Helton & Warm, 2008; Parasuraman, Warm, & Dember, 1987; Warm & Dember, 1998). Both accounts link the prevalence of attention lapses to task factors, albeit differentially. The underload theory holds that respondents have difficulty maintaining endogenous stimulation in the absence of exogenous support because tasks requiring attention can be monotonous and under-stimulating (Manly et al., 1999; Robertson et al., 1997). This idea proposes that participants take an automatic or "mindless" approach to the task. Conversely, the overload account holds that attention tasks are taxing and effortful, so that information processing resources become suboptimal over time due either to high demand or reduced resource allocation (Epling, Russell, & Helton, 2016; Helton & Russell, 2011, 2012; Matthews, Warm, Reinerman-Jones, et al., 2010).

The two accounts predict different outcomes with respect to task factors. For the underload theory, higher workload or more stimuli-rich tasks couple attention to the task, which results in fewer attention lapses. Conversely, the overload theory posits that high task demand and workload negatively influence attention and increases lapses. For the overload theory, then, attention lapses will increase when the task is objectively more challenging, for example, when there are multiple demands on attention or when the task is psychophysically difficult (Helton & Russell, 2011, 2012).

A facet of this debate is that there are types of performance lapses, beyond the standard attention lapse, which the literature has seldom addressed (Anderson, Wales, & Horne, 2010). One alternative lapse is the behavioural microsleep (*microsleep*) (Peiris, Jones, Davidson, Carroll, & Bones, 2006). Microsleeps are defined as brief periods of non-responsiveness (0.5–15 s), defined by transient full or partial eye closure and overt signs of drowsiness that are thought to emanate from the homeostatic drive for sleep and a complex interaction between the brain's arousal and attention systems. Microsleeps are frequently found in people who are not necessarily sleep deprived, albeit sleep restriction increases microsleep propensity (Innes, Poudel, & Jones, 2013). For example, studies have found that 53–80% of non-sleep-deprived adults experience microsleeps when undertaking a monotonous task that takes up to an hour (mean 29–79 per hour; range 0–190) (Peiris et al., 2006; Poudel, Innes, Bones, Watts, & Jones, 2014). Clearly, under certain circumstances, microsleeps make a substantial contribution to task lapses.

Another facet of the debate of underload and overload contributions to lapsing is whether task factors, such as complexity, influence the propensity for microsleeps. Altering a task to reduce vigilance decrement might reduce both attention lapses and microsleeps and we do not know whether changes in one lapse measure will come at the expense of the other. More specifically, the inter-relationship between attention lapses and microsleeps, as contextualized by task demand, is not known. Towards this, Innes et al. (2013) compared attention lapses during a psychomotor vigilance task (PVT) against microsleeps during a subsequent extended tracking task. They found no statistically significant correlation between either PVT lapses or reaction times with microsleeps. This is in itself an important result, as it indicates that attention lapses and microsleeps are separate constructs and that a single intervention is unlikely to prevent both types of lapses.

The goal of this study was to clarify the relationship between attention lapses, microsleeps, and task demands. To do this, three 30-min tasks were used: a tracking-only task, a PVT-only task, and a dual task in which the tracking task and the PVT were concurrent. Tracking allowed the measurement of instances of microsleep lapses (Poudel, Jones, & Innes, 2008), whereas the PVT provided a classic measure of attention lapses (Dinges & Powell, 1985). Of interest was the change in each of these two measures during the dual task.

Increasing task demands should increase levels of arousal and therefore reduce propensity to microsleep (Poudel et al., 2014; Smallwood & Schooler, 2006). If true, we would expect that tasks that are more demanding or more objectively challenging should result in fewer microsleeps than would less-demanding tasks. Moreover, tasks that are more demanding should, according to the underload theory of vigilance (Manly et al., 1999; Robertson et al., 1997), result in fewer attention lapses because of stronger coupling. In contrast, the overload theory would predict an increase in attention lapses because of the increase in cognitive demand mediated by the increased task complexity.

2. Methods

2.1. Participants

Twenty-three healthy non-sleep deprived participants – 12 females and 11 males – with an average age of 26.3 years (range 21–40 years) and an average Epworth Sleepiness Score of 5.1 (range 0–10) voluntarily participated in this study. Participants, recruited from the general population, reported a usual time to bed between 22:00 and 24:00, a usual time in bed of 7.0–8.5 h, and had all recorded an Epworth Sleepiness Score $\leqslant$10 from the week immediately prior to the study. No participants met the exclusion criteria, which were: a history of neurological disorders (other than headache or mild traumatic head injury), a history of psychiatric disorders (other than mild depression), sleep disorders, or the taking of any sedating or stimulating medications, or consumption of more than four cups of coffee or tea per day. Ethical approval for this study was provided by the Upper South A Ethics Committee (URA/09/11/079).