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Decisional style, sleepiness, and online responsiveness

James G. Phillips[a], Yang-Wai Chow[b] and Rowan P. Ogeil[c]

[a]Psychology Department, Auckland University of Technology, Auckland, New Zealand; [b]Institute of Cybersecurity and Cryptology, University of Wollongong, Wollongong, Australia; [c]Eastern Health Clinical School, Monash University and Turning Point, Richmond, Australia

ABSTRACT

As sleep problems can impair quality of work, an online questionnaire was used to examine relationships between sleepiness and decision making while obtaining unobtrusive indices of performance. Participants ($N = 344$) completed the Insomnia Severity Index, Epworth Sleepiness Scale, and the Melbourne Decision Making Questionnaire in a Qualtrics survey while reporting mobile phone use. Qualtrics recorded the time and the number of clicks required to complete each page of the survey. Multiple regression indicated that insomnia was associated with daytime sleepiness and Hypervigilance, and mobile phone use before bed. Participants with moderate sleepiness required a greater number of clicks to complete the questionnaire. Greater sleepiness was associated with longer times to complete these self-assessment tasks. Clinically significant sleepiness produces changes in performance that can be detected from online responsivity. As sleepy individuals can be appreciably and quantitatively slower in performing subjective self-assessment tasks, this argues for objective measures of sleepiness and automated interventions and the design of systems that allow better quality sleep.

Practitioner summary: Work can require processing of electronic messages, but 24/7 accessibility increases workload, causes fatigue and potentially creates security risks. Although most studies use people's self-reports, this study monitors time and clicks required to complete self-assessment rating scales. Sleepiness affected online responsivity, decreasing online accuracy and increasing response times and hypervigilance.

Abbreviations: MDMQ: Melbourne Decision Making Questionnaire; ISI: Insomnia Severity Index; ESS: Epworth Sleepiness Scale; AUTEC: Auckland University of Technology's Ethics Committee; ANOVA: Analysis of Variance

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1. Introduction

Although social interactions (Argyle 1967; Welford 1966, 1987) can be supported by electronic messages, signal-to-noise ratios can be a problem (Hari 2022). Unfortunately, some messages make inappropriate requests (Hanoch and Wood 2021; Sarno and Neider 2022), and while filters are available, the human factor remains important. Heedless, ill-considered responses to phishing attacks pose security problems (Hanoch and Wood 2021). The present study specifically considers decisional style and factors germane to *human channel capacity* (namely alertness) that may influence responsiveness to messages.

While email can provide considerable benefit (Fallows 2002; Newport 2017), there are also concerns that processing email contributes to workplace overload (Bellotti et al. 2005; Dabbish and Kraut 2006; Hill et al. 2013; Kushlev and Dunn 2015; Mark et al. 2016) and stress (Akbar et al. 2019; Armstrong 2017; Blank et al. 2020). The speed of transmission and permanence of emails creates the impression that emails need to be processed immediately (Giurge and Bohns 2021; Lanctot and Duxbury 2022; Paczkowski and Kuruzovich 2016) and that this could increase susceptibility to scams and phishing attacks (Carpenter, Zhu, and Kolimi 2014; Kim et al. 2011; Rozentals 2021; Sarno and Neider 2022). There are also concerns that the processing of emails spills over into after-hours home-life (Cecchinato, Cox, and Bird 2014, 2015; Stawarz et al. 2013; Steffensen et al. 2022), with

CONTACT James Phillips jphillip@aut.ac.nz Psychology Department, Auckland University of Technology, Akoranga Campus, Auckland 0627, New Zealand

potentially adverse effects (Belkin, Becker, and Conroy 2020; Park and Haun 2018) that has raised the prospect of the 'right to disconnect' (Hanrahan, Pérez-Quiñones, and Martin 2016; Vayre, Vonthron, and Perissé 2022) in some jurisdictions. Although there is now the capacity to contact staff 24/7, an expectation that staff be responsive 24/7 may lead to performance decrements (Harrison and Horne 2000; Larue, Rakotonirainy, and Pettitt 2010).

The sleep-wake cycle is a major determinant of an organism's capacity to detect, process, and respond to stimuli (Short and Banks 2014). Adequate sleep contributes to well-being (Buysse 2014; Knutson et al. 2017), whereas sleep deprivation due to insufficient sleep quality (Lowe, Safati, and Hall 2017; Nilsson et al. 2005), or insufficient duration of a sleep episode can also impair functioning during subsequent waking hours (Walker 2008) and pose health risks (Taylor, Lichstein, and Durrence 2003). Sleep deprived individuals may be: inflexible, taking greater risks (Killgore, Balkin, and Wesensten 2006); and poorer at making critical management decisions (Harrison and Horne 2000). Indeed, driving performance when sleep deprived has been equated with intoxication above legal limits prescribed for alcohol (Dawson and Reid 1997), and an increase in errors when sleep deprived has been recognised across disciplines such as nursing (Johnson et al. 2014; Lockley et al. 2007) and law enforcement (Ogeil et al. 2018; Rajaratnam et al. 2011). Sleep deprivation has been linked to slower responding at lower levels of risk (Kovac et al. 2020; Larue, Rakotonirainy, and Pettitt 2010), and a diminished ability to utilise decisional support (Fraser, Conduit, and Phillips 2013). The present paper therefore considers relationships between sleep quality, decision-making style and electronic responsiveness.

Electronic transactions (e.g. email; file access) can potentially serve as data loggers in the same way that running wheels are used in rodent sleep research (e.g. Ciman and Wac 2019; Ellis et al. 2019; Ogeil et al. 2010; Robbins et al. 2019). Online activity could be an indicator of mental status (Khan, Nock, and Gooneratne 2015). The frequency with which emails are sent (Phillips and Reddie 2007), checked (Baker and Phillips 2007), read and replied to (Renaud, Ramsay, and Hair 2006; Shirren and Phillips 2011) can be used as event markers and indices of information processing. Whereas the sorts of messages sent (Phillips and Reddie 2007; Wyatt and Phillips 2005) and their quality (Phillips, Jory, and Mogford 2007) could also be markers of functional capacity (Phillips and Landhuis 2022) or productivity (Giurge and Bohns 2021; Lanctot and Duxbury 2022; Lim 2002; Paczkowski and Kuruzovich 2016).

Changes in information processing when sleep deprived can be interpreted using Janis and Mann (1977) Conflict Model which indicates how decision making can vary as a function of factors such as optimism (Radford, Mann, and Kalucy 1986), and resourcing (Mann and Tan 1993). When people believe they are under time pressure, they exhibit poorer decision making, canvassing fewer options and considering fewer consequences for their decisions (Janis and Mann 1977; Mann and Tan 1993). Decisional styles can be measured using the Melbourne Decision Making Questionnaire (MDMQ) (Mann et al. 1997). According to Janis and Mann (1977) a vigilant decisional style is optimal, involving a deliberate consideration of the options. Whereas Procrastinators avoid making decisions (Beswick et al. 1988) and Buckpassers defer decisions to others. Hypervigilance is associated with hasty impulsive decisions and thus potentially poses a greater susceptibility to phishing (Hanoch and Wood 2021). People with low Decisional Self Esteem know they are prone to make bad decisions (Radford, Mann, and Kalucy 1986).

Unlike traditional workplaces where sleep deprivation has been associated with an increase in work-related errors, or poorer performance (Johnson et al. 2014; Lockley et al. 2007; Ogeil et al. 2018; Rajaratnam et al. 2011), in online environments, the consequences of impaired decision making may manifest in different ways (e.g. impaired security – Carpenter, Zhu, and Kolimi 2014; Hanoch and Wood 2021; Kim et al. 2011). Defensive avoidance (procrastination or buckpassing) may manifest as a lower rate of reply to emails (Shirren and Phillips 2011), whereas Hypervigilance may manifest as frequent lower-quality messaging (Phillips, Jory, and Mogford 2007) and greater file access (Phillips and Landhuis 2022). Indeed, any such changes to decision making ability may be detectable when completing online questionnaires (Phillips and Ogeil 2022), as such the present study goes beyond subjective rating scales (Boase and Ling 2013; Coyne, Voth, and Woodruff 2023; Doliński 2018) to consider objective measurements of performance as well.

In this regard, a person's decisional style seems to contribute to their willingness to engage with electronic communications. Procrastinators may check their emails more often (Baker and Phillips 2007) or report sending more emails (Phillips and Reddie 2007), whereas the defensively avoidant may read, but not reply to emails (Shirren and Phillips 2011). Indeed, email traffic can be stressful (Armstrong 2017; Dabbish and Kraut 2006; Renaud, Ramsay, and Hair 2006; Mark et al. 2016), and defensive avoidance may also influence people's willingness to process messages, and their concerns for electronic privacy and security (Kim et al. 2011). For instance, there may be hours when workers should not be expected to reply (e.g. France's 'Right to Disconnect' – Eurofound 2014). This ability to control message traffic is important as online activity levels could be linked to mental health (Kim, Phillips, and Ogeil 2022) and susceptibility to phishing (Sarno and Neider 2022). There are known to be alterations in the activity levels of patients with mental health problems (Rogers 1985, 1992: Teicher 1995), and online activity levels have been linked to negative affect (Appel, Gerlach, and Crusius 2016).

There may also be a causal relationship between decision making ability and quality of outcomes (Ball, Mann, and Stamm 1999). Poor priorities and procrastination (Tibbett and Ferrari 2019) can waste valuable time (Janis and Mann 1977) and can detract from performance (Beswick, Rothblum, and Mann 1988). Imposed time pressure can then cause Hypervigilance and a failure to properly canvas available options (Mann and Tan 1993), leading to poorer decisions with less favourable outcomes (Herek, Janis, and Huth 1987). In particular, maladaptive decisional styles are associated with increased levels of anxiety (Filipe et al. 2020), distress (Phillips and Ogeil 2017), depression (Radford, Mann, and Kalucy 1986) and substance use (Gorodetzky et al. 2011). Indeed, maladaptive decisional styles may also influence willingness to seek further information and engage with treatment (Evans, Ogeil, and Phillips 2019; Kim, Phillips, and Ogeil 2022; Phillips and Ogeil 2015). As experiments have demonstrated that sleep deprivation can impair people's ability to make use of decisional support (Fraser, Conduit, and Phillips 2013), it could be important to examine links between decisional style, sleep quality, and electronic responsivity.

Any relationships between decisional style, sleep quality and electronic responsivity could be bidirectional (Tettamanti et al. 2020). Greater mobile phone use is also associated with reports of poorer sleep quality (Murdock, Horissian, and Crichlow-Ball 2017; Sohn et al. 2021), insomnia (Khan, Nock, and Gooneratne 2015; Tettamanti et al. 2020), and mental health problems (Liu et al. 2019; Preety, Devi, and Priya 2018; Thomée, Härenstam, and Hagberg 2011). For example, Rafique et al. (2020) reported greater mobile phone use was associated with sleep disturbance and reduced sleep duration. In particular, they found that keeping the mobile near the bed, and the use of mobile phones 30 minutes before sleep were associated with poorer sleep quality (Rafique et al. 2020). Whereas restricting mobile phone use before bedtime can confer benefits, reducing sleep latency and increasing sleep duration (He et al. 2020) and improving happiness and quality of life (Hughes and Burke 2018). Nevertheless, restricting phone use may not automatically improve mental health, as others report smaller effects of phone use on stress and depression that may be outweighed by the other benefits conferred by the use of social media (Dissing et al. 2022; Hughes and Burke 2018).

The present study therefore sought to delineate relationships between electronic messaging, sleep quality, daytime sleepiness and actual measured behaviour. Given a 24/7 availability to electronic messaging, individuals that check their phones more often, and engage in bedtime phone use are at greater risk of sleep disturbance unless they filter their calls. Previous research has reported that mobile phone use for playing, browsing or texting in bed before sleep is positively associated with insomnia (Fossum et al. 2014). Any sleep disturbance can then contribute to daytime sleepiness and impaired channel capacity as indicated by slower inaccurate responses.

Theoretically better decision-making, as indicated by greater Vigilance or higher Decisional Self Esteem (Mann et al. 1997) should predict call screening, but empirically in diary studies call screening has been linked to Defensive Avoidance (i.e. Procrastination or Buckpassing) (Shirren and Phillips 2011). Other methods of filtering messages may involve controlling the times that phones are accessed and the phone's security/privacy settings (Koohang et al. 2021; Udo 2001).

Unless messages are appropriately screened by appropriate security/privacy settings or other behavioural measures (sensible decision making as indicated by the MDMQ), it was expected that increased phone checking, and bedtime phone use would disturb sleep (as indicated by the Insomnia Severity Index), increase daytime sleepiness (as measured by the Epworth Sleepiness Scale) which then reduces online responsiveness as inferred from the time and clicks required to complete the questionnaire.

As the Insomnia Severity Index (ISI) assesses sleep disturbance it would be expected to be more sensitive to activity around bedtime, whereas the Epworth Sleepiness Scale (ESS) that assesses daytime sleepiness would be expected to be more sensitive to changes in daytime behaviour (Fossum et al. 2014). It was expected that insomnia as measured by the ISI and excessive daytime sleepiness as measured by the ESS would be associated with: a different pattern of mobile phone use; poorer decisional styles as measured by the MDMQ (i.e.

greater hypervigilance, lower vigilance and decisional self-esteem); reduced care with regards privacy/security; and slower inaccurate online responding.

2. Method

2.1. Participants

There were 344 participants (134 male, 184 female, and 26 other) (39.0% male, 53.5% female, and 7.6% other) who completed the study, ranging in age from 18 to 62 years, with a mean age of 27.65 years (SD = 9.85, SE = 0.54). Incomplete responses and shift-workers were excluded from final analyses. All procedures were approved by Auckland University of Technology's ethics committee (AUTEC 21/110).

2.2. Materials

The survey was available on Reddit from June to November and delivered online using the survey platform Qualtrics, and consisted of demographic questions, and an assessment of mobile phone use, followed by the MDMQ, the ESS, the ISI, and questions assessing security/privacy concerns. Qualtrics also allowed the unobtrusive recording of the time and the number of clicks per page of the survey.

Demographic questions asked participants their gender; age, employment status, and whether they were involved in shift work. As an index of the frequency with which participants checked their mobile phones, questions asked: 'How often do you check your mobile phone'; 'How often does your mobile phone beep'; 'How often do you use your mobile phone before you go to sleep'; 'How often does your mobile beep while you are trying to sleep'; and 'Do you turn off notifications on social media' (Boase and Ling 2013; Coyne, Voth, and Woodruff 2023).

The MDMQ was used to examine decisional style. The MDMQ has two parts (Mann et al. 1997). The first part has a Decisional Self Esteem scale that had a Cronbach's Alpha of .799 for the present study. The second part consists of Vigilance, Procrastination, Buckpassing, Hypervigilance scales. For the present study Cronbach's Alphas were: Vigilance .800; Procrastination .828; Buckpassing .863; and Hypervigilance .807.

As partial indicators of sleep health (Buysse 2014), the present study used the ESS, and the ISI. The ESS (Johns 1991; Lapin et al. 2018) assesses excessive daytime sleepiness, and consists of eight items assessing participants' propensity to doze in 8 given situations (Cronbach's Alpha .790). The ISI assesses the nature and symptoms of their sleep problems, sleep satisfaction and the extent insomnia interferes with daily functioning (Morin et al. 2011) (Cronbach's Alpha of .851).

To assess participants' concerns about their security and privacy (Kim et al. 2011), they were asked: 'How likely would you allow apps on your phone to access a series of commonly tracked outcomes?' that included: Contact information; Location tracking; Photos, media, files; Calendar and appointments; Bluetooth; Fitness sensors (e.g. heart rate, step tracking); Camera; Microphone; Usage statistics. Responses were recorded on a 4-point Likert scale (0 = would never allow; 1 = only allow for some apps; 2 = apps must ask for permission each time before use; 3 = always allow). The Security/Privacy scale had a Cronbach's Alpha of .806.

2.3. Data analysis

Relationships between variables were determined using Pearson correlation coefficients. To determine relationships between communication behaviours and sleep quality, multiple regressions were then used to determine which combination of variables were meaningfully associated with ISI scores, Phone Checking or Bedtime Phone Use. Oneway Analyses of Variance were performed to examine changes in behaviour as a function of daytime sleepiness as measured by the ESS. Analyses were performed using SPSSv27 which performs a listwise deletion of cases with missing variables.

3. Results

Participants were scored on the ESS ($M = 7.17$, $SD = 4.21$) and ISI ($M = 11.71$, $SD = 6.91$). Table 1 shows intercorrelations between the self-report scales. There were significant correlations amongst the MDMQ scales, and relationships between the ISI and the ESS. As expected, relationships were also observed between Phone use at Bedtime, ISI, and Security/Privacy, and Hypervigilance scales.

Using multiple regression, ISI scores were predicted from phone checking, phone use before bed, MDMQ, the Security/Privacy scale, Gender, Age, and ESS. The predictors accounted for a significant ($F(11, 200) = 3.407$, $p < .001$) proportion of the variance (11.2%). Hypervigilance ($t(200) = 2.721$, $p = .007$), phone use before bedtime ($t(200) = 2.454$, $p = .015$), and ESS ($t(200) = 2.757$, $p = .006$), were significantly associated with insomnia severity. Insomnia severity was associated with daytime sleepiness, hypervigilance, and phone use before bedtime. Nevertheless, these are merely self-reports and the present study allowed a consideration of some behavioural indices as well.

Table 1. Pearson correlations between Melbourne Decision Making Questionnaire, Epworth Sleepiness Scale (ESS), Insomnia Severity Index (ISI), and Security/Privacy concerns and phone use.

$N = 254+$	Phone Checking	Phone use before bed	Security/ Privacy	ISI	ESS	Hyper-vigilance	Procras-tination	Buck-passing	Vigilance
Decisional Self Esteem	−.086	.002	.063	−.156*	−.127*	−.636**	−.603**	−.689**	.092
Vigilance	.015	.019	−.051	−.036	−.056	.109	−.007	−.090	
Buckpassing	.094	.090	−.096	.108	.093	.606**	.652**		
Procrastination	.101	.134*	−.150*	.117	.146*	.688**			
Hypervigilance	.172**	.172**	−.206**	.239**	.190**				
ESS	.095	.024	−.107	.252**					
ISI	.234**	.259**	−.078						
Security/ Privacy	−.401**	−.278**							
Phone use before bed	.578**								

*$p < .05$. **$p < .01$.

Table 2. Overall questionnaire performance – Pearson correlations between total time/clicks to complete the online survey and the scores on each scale.

Pearson r $N = 251+$	DSE	Vigilance	Buckpassing	Procrastination	Hypervigilance	ESS	ISI	Security/Privacy
Log Total time	−.077	−.044	.015	.114	.104	.222**	.110	−.087
Total Clicks	−.114	−.036	.053	.058	.046	−.011	.045	−.078

*$p < .05$. **$p < .01$.

Table 3. Page analysis – Pearson correlations between scores on each scale, and the time/clicks to complete that specific page online.

Pearson r $N = 251+$	DSE	Vigilance	Buckpassing	Procrastination	Hypervigilance	ESS	ISI	Security/ Privacy
Log Page Time	.017	−.041	−.009	−.000	.028	.235**	.037	−.132*
Page Clicks	−.056	−.047	.058	.034	.041	−.020	.008	−.062

*$p < .05$. **$p < .01$.

The significant correlations between sleepiness and hypervigilance found in the present study are of interest, given concerns that sleep deprivation reduces cognitive resources (Short and Banks 2014), and hypervigilance is sometimes associated with reduced cognitive resources (Mann and Tan 1993). Table 2 shows the correlations between scores on each questionnaire and the total amount of time required to complete the survey (Log + 1 transformed). There was a significant correlation between self-reported sleepiness and the time required to complete the questionnaire.

As the total time required to complete the questionnaire tended to correlate with ESS, the times for completion of each individual page was considered to better understand the locus of such effects. As may be seen in Table 3, Sleepy people required significantly more time to complete the ESS. Whereas people that were less concerned about privacy took less time completing the Security/Privacy scale.

A more specific multiple regression considered potential predictors (MDMQ, ESS, ISI, Security/Privacy, Age, Gender, Total number of clicks) of the time involved completing the ESS page. The predictors accounted for a significant ($F(11, 200) = 2.299$, $p = .011$) proportion of the variance (6.3%). ESS scores ($t(200) = 3.221$, $p = .001$) and ISI scores ($t(200) = -2.454$, $p = .015$) were significantly associated with time taken to complete that page of the survey, while Decisional Self Esteem approached significance ($t(200) = -1.692$, $p = .092$). The multiple regression indicates that sleepy people (but not necessarily those with insomnia) were taking longer to complete this page of the survey.

Such effects may reflect concerns about privacy and sleep hygiene and behaviours at bedtime. Multiple regression entered the variables (MDMQ, ESS, ISI, Security/Privacy, Age, Gender) to predict self-reported *mobile phone checking*. The combination of variables predicted a significant proportion of the variance (16.8%) ($F(10, 201) = 5.247$, $p < .001$). ISI ($t(201) = 2.072$, $p = .04$), Age ($t(201) = -2.478$, $p = .014$), and fewer concerns about privacy ($t(201) = -4.871$, $p < .001$) were significant predictors. Younger individuals that were less concerned about their security/privacy and had trouble sleeping were more likely to be checking their mobile phones.

As phone use during or adjacent to sleep periods could contribute to insomnia, a Multiple Regression considered predictors (MDMQ, ESS, ISI, Security/Privacy, Age, Gender) of *phone use before bed time*. The combination of variables predicted a significant proportion of the variance (17.6%) ($F(10, 201) = 5.503$, $p < .001$). ISI ($t(201) = 3.153$, $p = .002$), Age ($t(201) = -2.627$, $p = .009$), Gender ($t(201) = 2.773$, $p = .006$), Decisional Self Esteem ($t(201) = 2.125$, $p = .035$), and fewer concerns about privacy ($t(201) = -2.800$, $p = .006$) were significant predictors. Young females with higher insomnia scores, that were more confident in their decision making but less interested in their security/privacy were more likely to use their mobile phone before bed-time.

3.1. Clinical significance

To address clinical significance, an ANOVA was conducted upon groups as indicated by the ESS (https://epworthsleepinessscale.com/about-the-ess/). Participants were grouped as having lower normal (ESS 0–5, $n = 98$), higher normal (ESS 6–10, $n = 102$) and excessive daytime sleepiness (ESS 11+, $n = 59$). Individuals scoring 11 or greater are more at risk of sleep disorders (Johns 2002). The total time and the number of clicks required to complete the questionnaire were subjected to separate univariate Analysis of Variance contrasting each group with the least sleepy group. As the total time to complete the questionnaire was positively skewed it was transformed (Log + 1) before analysis, but untransformed means are reported for interpretability.

There was a significant effect of Sleepiness on the time required to complete the questionnaire ($F(2,256) = 5.060$, $p = .007$, $\eta^2 = .04$). Participants scoring 6–10 on the ESS required comparable amounts of time to complete the questionnaire ($M = 307.46$s, $SE = 61.68$) ($F(1,256) = 0.725$, $p = .395$), but those scoring 11+ on the ESS ($M = 649.64$s, $SE = 79.50$) required significantly more time to complete the questionnaire than participants scoring less than 6 on the ESS ($M = 330.34$, $SE = 60.46$) ($F(1,256) = 9.861$, $p = .002$).

The number of clicks required to complete the questionnaire also varied significantly with ESS scoring bands ($F(2,256) = 6.664$, $p = .002$, $\eta^2 = .05$). Participants scoring ESS 6–10 ($M = 118.10$, $SE = 3.76$) required more clicks to complete the questionnaire than participants scoring less than 6 on the ESS ($M = 103.98$, $SE = 3.84$) ($F(1,256) = 6.903$, $p = .009$), but participants scoring ESS 11+ did not require more clicks ($M = 96.92$, $SE = 4.95$) ($F(1,256) = 1.547$, $p = .215$) when compared to the participants scoring ESS less than 6.

Those individuals scoring 11 or greater on the ESS are more likely to have a sleep disorder (Johns 2002). Figure 1 uses a Vincentizing procedure to non-parametrically depict probability distributions (Ratcliff 1979). The deciles for each ESS scoring band were calculated, and probability densities are indicated by equal area rectangles. The higher the rectangle, the greater number of individuals requiring that amount of time to complete the questionnaire. As can be seen in Figure 1, most people required between 200 to 400 seconds to complete the questionnaire. However, as ESS scores increase, a long tail of excessively long questionnaire completion times appears.

4. Discussion

The present paper assessed relationships between sleep quality, decision-making style and electronic responsiveness. Insomnia was associated with daytime sleepiness, hypervigilance and phone use before bed. Daytime sleepiness manifested behaviourally as slower completion of the overall questionnaire. The frequency with which mobile phones were checked, particularly before bedtime were linked to problems sleeping.

Apparently sleep loss associated with mobile phone use is on the increase (Oviedo-Trespalacios et al. 2019). Bedtime phone use has previously linked to sleep problems (Adachi-Mejia et al. 2014; Khan, Nock, and Gooneratne 2015; Sohn et al. 2021; Tettamanti et al. 2020). The present study reaffirms this link, but also indicates greater Hypervigilance, potentially implying other mental health issues (Filipe et al. 2020; Liu et al. 2019; Preety, Devi, and Priya 2018; Radford, Mann, and Kalucy 1986; Thomée, Härenstam, and Hagberg 2011). In particular, the present study demonstrated that such *sleepiness could manifest behaviourally as slower responses online*.

The ISI assesses sleep disturbance and was more sensitive to activity around bedtime, whereas the ESS assesses daytime sleepiness and was more sensitive to changes in daytime behaviour. The ESS has several scoring bands (https://epworthsleepinessscale.com/about-the-ess/). Not only are participants scoring greater than 10 on the ESS sleepy, but 20% appear to be requiring appreciably more time objectively to complete a self-assessment task (see Figure 1). These longer response times imply a tendency for errors of omission (Lim and Dinges 2008). In addition, moderately sleepy individuals with ESS scores of 6–10 required appreciably more clicks to complete the self-assessment task. The greater number of clicks implies a greater tendency for errors of commission (Lim and Dinges 2008). Both types of error have implications for human performance (Stepan, Fenn, and Altmann 2019), indicating that a moderate degree of daytime sleepiness can lead to more incorrect responses and at higher levels of daytime sleepiness can cause appreciable lapses of attention (see Hisler and Krizan 2019).

As the present data are *specific* to sleepiness it seems people are slower and less able to appreciate their level of alertness when they are sleepy (Costa et al. 2022; Tsai et al. 2005). Sleep deprived individuals may neither have the necessary insight (Nisbett and Wilson 1977), nor the

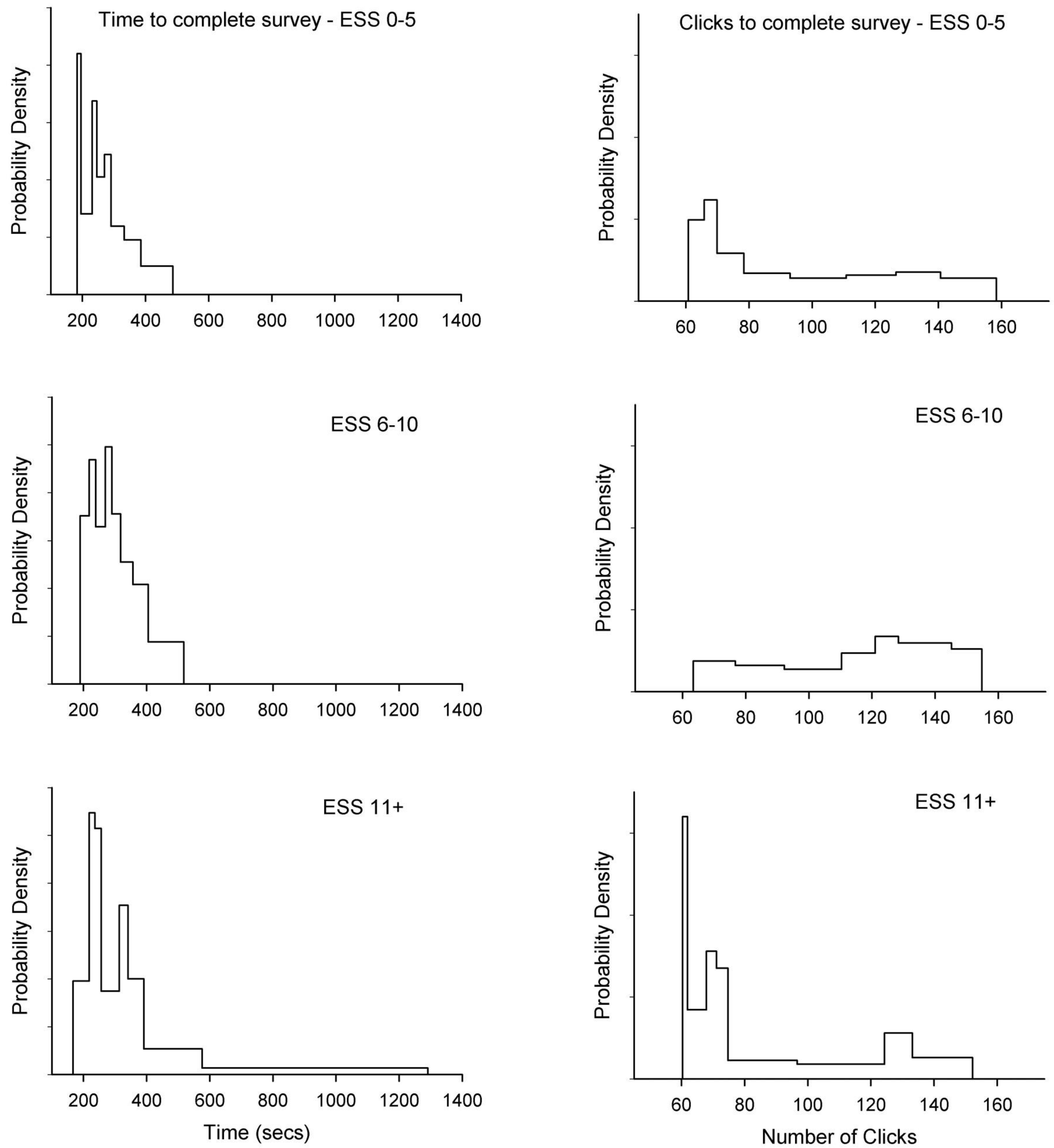

Figure 1. Non-parametric probability density functions for total questionnaire completion times and clicks required – grouped for Epworth Sleepiness Scale (ESS) scoring bands (ESS 0–5 $n = 103$, ESS 6–10 $n = 103$, ESS 11+, $n = 60$). The equal area rectangles depict distance between deciles.

access to mental processes (White 1980, 1988), be unable to remember (Ericsson and Simon 1980), or unable to introspect and report properly about their level of alertness. Even though most studies report metacognitive functions such as confidence are intact after sleep deprivation (Jackson et al. 2018), the present data indicate some *participants were taking longer to respond during self-assessment*, and this was more noticeable in those with ESS scores greater than 10, and could have implication for well-being and quality of work (Comondore, Wenner, and Ayas 2008).

As defensive avoidance has been associated with call screening (Shirren and Phillips 2011), it might be expected to to influence Privacy/Security scores and reduce checking and use of the mobile phone before bedtime. That these relationships did not occur may reflect the potentially bidirectional effects of defensive avoidance in the literature. Sometimes Procrastination predicts reading and sending messages (Baker and Phillips 2007; Phillips and Reddie 2007), but Procrastination also predicts delayed replies (Shirren and Phillips 2011).

Hypervigilance is associated with a scarcity of cognitive resources and defective decision-making (Janis and Mann 1977; Mann and Tan 1993). The present data suggest hypervigilance may also be caused by sleepiness. Indeed, insomnia has been associated with anxiety (Navarrete et al. 2017). In the present study sleepy participants demonstrated some degree of behavioural impairment, taking longer to complete the questionnaire, and this could indicate that sleepier people have a reduced cognitive capacity. However, as a hypervigilant approach to decision making can also be caused by 'time pressure' (Mann and Tan 1993), it is perhaps not surprising that increased message traffic causes hypervigilance.

Given that some people are experiencing Hypervigilance, the degree of care taken with security/privacy settings could be a concern. People's seeming lack of concerns about their security/privacy was surprising and may reflect ignorance or societal pressure (Collins and Hinds 2021; De Wolf et al. 2023; Knapova et al. 2021). Emails can be a source of stress (Armstrong 2017; Dabbish and Kraut 2006; Renaud, Ramsay, and Hair 2006; Mark et al. 2016), and it seems that 24/7 access is becoming the norm socially (Oviedo-Trespalacios et al. 2019) despite laws being enacted to provide a 'right to disconnect' (Eurofound 2014). Either people did not care, understand, or did not appreciate the potential impact of late-night messages upon their sleep. The present study implied that it was younger confident females with less interest in their privacy that were more likely to use their mobile phone before bed-time (Adachi-Mejia et al. 2014). If this is the case, a likely consequence of such indiscriminate messaging traffic (Murdock, Horissian, and Crichlow-Ball 2017) could be hypervigilance and insomnia (Taylor, Lichstein, and Durrence 2003).

4.1. Limitations

As the present study reports correlations, it is not clear as to the direction of the relationships reported. It is likely that such effects are bidirectional (Uhde, Cortese, and Vedeniapin 2009). The relationships between hypervigilance and sleepiness can indicate: (1) that a perceived scarcity of resources can contribute to poor sleep; or (2) that lack of sleep can cause problems of concentration. Moreover, although the present data is interpreted in terms of participants' sleepiness, conceivably some of the effects could reflect diurnal effects arising from the time when questionnaires were completed.

A problem using timed responses is that measurements are skewed and can range from zero to infinity (see Figure 1). In the present study, this was resolved analytically by the use of Log + 1 transforms, but this also means that the effects of longer, and potentially more indicative responses are minimised. Nevertheless, these excessively long times can be quite important (Bills 1931), and it is likely that monotonous and low risk responses would be further likely to exacerbate these tendencies (Fraser, Conduit, and Phillips 2013; Kovac et al. 2020; Larue, Rakotonirainy, and Pettitt 2010). Future studies should consider whether transformed data or nonparametric techniques would be more useful detecting functional impairments associated with sleepiness.

Although Qualtrics recorded activity on a specific webpage, our behavioural indices do not indicate the specific reason for this slowness. It is not clear whether sleepier people were indeed slower to respond to the questionnaire or if they were more likely to do something else entirely, leading to an increased response time.

4.2. Interventions

Any intervention would vary as a function of the likely cause. For instance, encouraging better sleep hygiene would be more appropriate if hypervigilance was caused by sleep loss (Adachi-Mejia et al. 2014). Whereas providing system interlocks, delays and warnings (Carpenter, Zhu, and Kolimi 2014) might be more appropriate if operators were experiencing a scarcity of cognitive resources (Janis and Mann 1977; Mann and Tan 1993) leading them to engage in error-prone or ill-considered electronic responses that could increase risk. Our data indicate that speed of response to online instruments could be a useful adjunct to such interventions.

It is a workplace requirement that employees be 'fit for work'. Indeed, there are a variety of drunk dialling apps and CAPTCHAs that potentially access mental status. Ergonomists should encourage better sleep hygiene in workers (Buysse 2014; Knutson et al. 2017) and recommend that emails only be replied to in a 'considered' way, during normal working hours (Hanoch and Wood 2021).

5. Conclusion

Sleepy individuals are more likely to report a hypervigilant decisional style, and mobile phone use before bedtime may contribute to poor sleep. Although sleepy people may believe they can respond when necessary, there is a behavioural slowness during self-assessment that can be detected during online responding. Such slowness may contribute to lack of insight and difficulty making decisions, arguing for objective measures of sleepiness and the design of systems and culture allowing people better quality sleep.

Statement of relevance

This work offers insights into the impact of 24/7 accessibility upon sleepiness and individuals' receipt and processing of messages and is thus relevant to workloads and organisational security. Although most studies use people's self-reports, this study monitors time and clicks required to complete rating scales. Sleepiness decreases online accuracy and increases response times and hypervigilance.

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ORCID

James G. Phillips http://orcid.org/0000-0002-3125-4009

Data availability statement

Data is available from the corresponding author upon reasonable request.

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