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It's all in the mind: The relationship between mindfulness and nomophobia on technology engagement while driving and aberrant driving behaviours

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ABSTRACT

This study investigated the relationship between mindfulness and nomophobia on technology engagement while driving and aberrant driving behaviours. Nine hundred and ninety participants completed an online survey (Female: 68.6%; Age: M = 51.2 years, SD = 15.7, Range = 18.0–84.0 years) that assessed mindfulness, nomophobia, technology engagement while driving, aberrant driving behaviour, and self-reported crashes and infringements during the past two years. Structural equation modelling (SEM) was used to examine the relationships between mindfulness and nomophobia, on one hand, with self-reported engagement with technology while driving and general aberrant driving behaviours (combination of errors, lapses and violations) on the other. The results of the SEM showed that, as expected, mindfulness shared negative relationships with nomophobia, engagement with technology and aberrant driving behaviours, while all other relationships were positive. In terms of engagement with technology, there were direct and indirect paths between nomophobia and mindfulness and engagement with technology. The results of this study demonstrate the positive influence mindfulness can have on nomophobia, engagement with technology while driving, and dangerous driving behaviours that have been associated with crash risk. Mindfulness practices may reduce the effect of nomophobia on engagement with technology while driving and increased dangerous behaviours as a result. This will be increasingly important as modern work and social practices encourage people to increasingly use the phone while driving, and the technology within smart devices, and connectivity of these to the vehicle, increase. More research is needed to understand whether mindfulness-based interventions can reduce nomophobia, and thereby improve driving behaviours and reduce crash rates.

1. Introduction

Distraction and inattention are increasingly emerging as a leading cause of crashes, especially amongst younger age groups (Bingham, 2014; World Health Organization, 2018). Distraction can be caused by external factors (i.e., engaging in tasks secondary to driving such as smartphone use) (Huemer et al., 2018; Young et al., 2018), or emerge from internal factors (i.e., mind-wandering

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distracting from the act of driving) (Yanko & Spalek, 2014).

In-vehicle distractions caused by technology, such as on-board and portable devices, increase the likelihood of visual and cognitive impairment and risks associated with poor driver performance and attention. The ubiquity of smartphones worldwide has led road safety agencies to introduce varying restrictions on mobile phone use, however, high daily use and growing problematic dependency are leading to an increased likelihood of using the device in various problematic and dangerous circumstances, such as while crossing a road or while driving (Kaviani et al., 2020a). More insidiously, even if a driver avoids engaging with their technological devices while driving, merely having a mobile phone in the vehicle (even while it is off) decreases attention toward the driving task (Toch et al., 2020). Indeed, simply having a smartphone within eye-shot was enough to reduce performance on a whole range of measures of cognitive performance (Ward et al., 2017). In short, smartphone presence has been shown to increase the likelihood and frequency of engagement with the smartphone, and therefore, aberrant driving behaviours.

Aberrant driving behaviours include unintended errors or lapses in attention, and deliberate violations of driving rules. These can increase crash risk (Parker et al., 1992). These behaviours have been captured in the Driving Behaviour Questionnaire (DBQ), developed by Reason et al. (1990) to measure drivers' engagement in various risky driving behaviours. The DBQ has since been adapted in terms of item numbers and factor structure to better capture a variety of road user cohort behaviours. A common version contains 28-items that sit within four broad types of dangerous driving behaviours known to increase crash risk, including: 1) violations, 2) aggressive violations, 3) errors, and 4) lapses (Lawton et al., 1997; Parker et al., 1995; Stephens & Fitzharris, 2016). While errors and lapses originated mostly from driver inattention, violations coincide with deliberate transgressions (Stephens & Fitzharris, 2016). Whether a result of intentional risk-taking or habitual behaviour, the DBQ captured both internal and external factors. Mindfulness, a practice of being actively attentive and aware of one's present moment, has been shown to reduce the likelihood of these aberrant behaviours (Koppel et al., 2018).

Mindfulness has its origins in ancient Eastern and Buddhist philosophy, with roots also in other wisdom traditions (Trousselard et al., 2014). During the early 2000s, after decades of increasing disenchantment (Mackinnon, 2001), stress, poor mental health and distraction in many Western countries (Turner, 2011), mindfulness has grown in popularity and scope (Baer, 2003). This was largely driven by the development of mindfulness-based cognitive therapy (MBCT; Segal et al., 2001) and subsequent *meta*-analyses showing mindfulness is efficacious for improving mental health in clinical (Khoury et al., 2013) and nonclinical (Querstret et al., 2020) settings. In clinical settings, various models of mindfulness-based were shown to be efficacious (Kabat-Zinn, 2003) in reducing a range of psychological ailments, in particular depression, stress and anxiety.

Within the context of road safety, conceptualisations of mindfulness were adopted that enhanced self-awareness and were concerned with increasing and sustaining attention and awareness towards one's environment and behaviour. A recent systematic review found that mindfulness can play a significant role in improving aspects of road safety by increasing situational awareness (Kass et al., 2011). Other studies have shown mindfulness may be effective in reducing driving violations (Koppel et al., 2018), and aggression (Deffenbacher et al., 2016; Stephens et al., 2018, 2020) and, ultimately, reducing crashes (Koppel et al., 2019). Studies revealed that higher levels of mindfulness were also associated with lower levels of engagement with distracting technology while driving (Regan et al., 2020; Young et al., 2019) which may be a major contributing factor to reduced crash rates. Specifically, mindfulness has been shown to reduce distraction caused by smartphones (Throuvala et al., 2020), with degrees of success varying between male and female drivers (Kita & Luria, 2020). As such, mindfulness techniques and programs were considered effective interventions for increasing attention toward the driving task and potentially improving driving performance (Reynaud & Navarro, 2019). Studies often encouraged further research into pertinent psychological traits that may impact the effectiveness of mindful techniques as an intervention for preventing distracted driving.

Recent research has identified a phenomenon associated with smartphone users that may be confounding the psychosocial dynamic between mindful driving and technology engagement. 'Nomophobia'—the fear of being without a mobile phone—is an emergent condition impacting the behaviour of smartphone users globally (Rodríguez-García et al., 2020; Yildirim & Correia, 2015), with a recent study revealing that over 99.2% of Australians experience some form of nomophobia (Kaviani et al., 2020). Studies have demonstrated that nomophobia can lead to poor decision making (Márquez-Hernández et al., 2020), is associated with negative

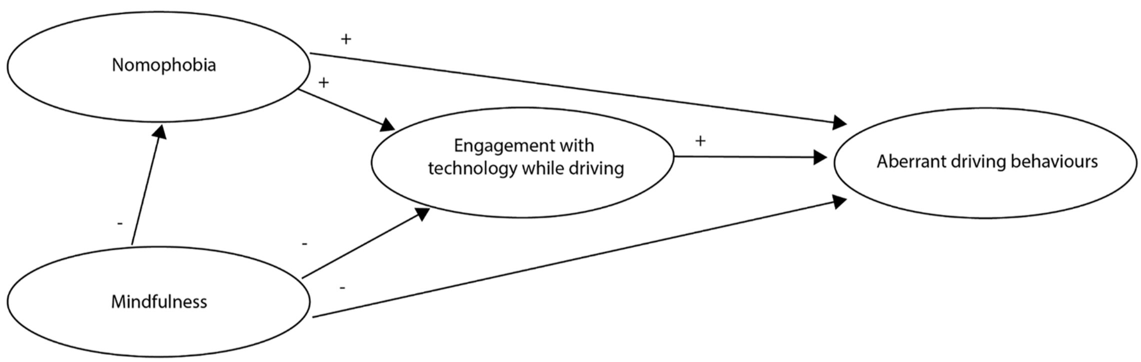

Fig. 1. Proposed relationships between mindfulness, nomophobia, engagement with technology and aberrant driving behaviours (+ and − indicate hypothesised direction of the relationship).

lifestyles and other psychological conditions (Gonçalves et al., 2020), increases distraction among employees and students (Gutiérrez-Puertas et al., 2019; Mendoza et al., 2018; Osorio-Molina et al., 2021; Wang & Suh, 2018), and increases the likelihood of problematic smartphone behaviours such as dependent, dangerous, and anti-social use (Kaviani et al., 2020a). Indeed, nomophobia has been shown to increase smartphone use while driving, with the fear of being without information predicting the likelihood of illegal use (Kaviani et al., 2020b). Recent systematic reviews showed that nomophobia particularly impacts women, younger people, and people that spend more time on their devices (León-Mejía et al., 2021; Notara et al., 2021). Mindfulness is also linked to decreased nomophobia (Arpaci et al., 2019), while psychological resilience — defined as the ability of individuals to withstand and continue evolving in the face of adversities (Fletcher & Sarkar, 2013) — had a mediating effect on the success of mindfulness as an intervention for nomophobia (Arpaci & Gundogan, 2020). Although mindfulness has been shown to improve driving performance and reduced the likelihood of nomophobia or engaging with technology while driving, there has been no research exploring the relationships between mindfulness, nomophobia, technology engagement while driving, and aberrant driving behaviour.

The aim of the current study was to address this gap. Fig. 1 demonstrates the proposed relationships between mindfulness, nomophobia, engagement with technology and aberrant driving behaviours based on the theoretical reasoning provided above. This figure builds upon Arpaci et al. (2017) by considering relationships between mindfulness and nomophobia, on one hand, with self-reported engagement with technology while driving and general aberrant driving behaviours (combination of errors, lapses and violations) on the other. As can be seen in this figure, and based on the literature above, mindfulness is expected to share negative relationships with nomophobia, engagement with technology and aberrant driving behaviours (i.e., mindfulness reduces nomophobia etc.), while positive relationships are expected between the other latent variables. That is, a higher frequency of aberrant driving behaviours is expected to be explained by a combination of lower levels of mindfulness, higher levels of nomophobia and engagement with technology while driving.

2. Methods

2.1. Participants

Participants were eligible to participate in the current study if they: a) were aged 18 years and older; b) had a valid driver's licence; c) were an 'active' driver (i.e., at least once per week in the pre-COVID19 period), d) used a smartphone, and e) lived in Australia. The demographics of participants who completed the survey are described in the Results.

2.2. Materials

Participants completed an online survey (taking approximately 25 min) which is described below.

2.3. Socio-demographic characteristics

Participants were asked to provide information about their: age, sex, residential state, highest level of completed education, and current annual household income.

2.4. Driving and licensing characteristics

Participants were asked to provide information on their pre-COVID19: annual mileage, frequency of driving (where: 1 = Daily; 5=<once per week). They were also asked to provide information on their: licensing history, previous motor vehicle crash involvement, and/or driving infringements.

2.5. Aberrant driving behaviours

Participants' aberrant driving behaviour was measured using the Driver Behaviour Questionnaire (DBQ) (Reason et al., 1990). A common version of the DBQ contains 28-items which relate to four broad types of dangerous driving behaviours that have been associated with an increased motor vehicle crash risk: 1) violations, 2) aggressive violations, 3) errors, and 4) lapses (Lawton et al., 1997; Parker et al., 1995; Stephens & Fitzharris, 2016). For each DBQ item, participants were asked to indicate how frequently they had engaged in each behaviour on a six-point Likert response scale (where: 0 = Never, 5 = Always). Higher DBQ subscale scores represent more frequent aberrant driving behaviours. The DBQ has good internal consistency (Composite reliabilities ranging from 0.79 to 0.89) (Stephens & Fitzharris, 2016).

2.6. Mindfulness

Participants' trait mindfulness, or their awareness of and attention to what is occurring in the present moment, was measured using the Mindful Awareness and Attention Scale (MAAS) (Brown & Ryan, 2003). The MAAS contains 15-items related to mindful attention and awareness. For each MAAS item, participants were asked to indicate how frequently they experienced each situation on a 6-point Likert response scale (where: 1 = Almost always, 6 = Almost never). Higher MAAS scores equate to higher levels of mindful attention and awareness. The MAAS has good internal consistency (Cronbach's $\alpha = 0.87$; Brown & Ryan, (2003)).

2.7. Nomophobia

Participants' nomophobia, or their fear of being without their mobile phone, was measured using the Nomophobia Questionnaire (NMP-Q; Yildirim & Correia, 2015). The NMP-Q contains 20-items which are broadly related to: 1) not being able to communicate, 2) losing connectedness, 3) not being able to access information, and 4) giving up convenience. For each NMP-Q item, participants were asked to indicate their level of agreement on a 7-point Likert scale (where: 1 = Strongly disagree, 7 = Strongly agree). Total nomophobia scores were calculated by summing item responses (Range: 20–140), where higher scores represent a higher level of nomophobia severity (where: scores < 20 = 'absence' of nomophobia; scores between 21 and 59='mild' level of nomophobia; scores between 60 and 99='moderate' level of nomophobia; and scores > 100 = 'severe' level of nomophobia. The NMP-Q has excellent internal consistency (Cronbach's $\alpha = 0.95$) (Yildirim & Correia, 2015).

2.8. Engagement with technology while driving

Engagement with technology was measured with ten technology-related activities (modified from Young et al., (2019). Given the focus on nomophobia, these activities focussed primarily on technology-related tasks, including: 1) Talked on your smart phone (handheld); 2) Read a text message on your smart phone (handheld); 3) Wrote a text message on your smart phone (handheld); 4) Accessed social media (e.g., Twitter, Facebook, Instagram etc.) on your smart phone (handheld); 5) Taken a photo or video on your smart phone (handheld); 6) Used an App on your smart phone (handheld); 7) Entered a new destination into a route navigation system on your smart phone (handheld); 8) Accessed the Internet on your smart phone (handheld); 9) Wore headphones while listening to your smart phone (handheld); 10) Interacted with your smart watch (e.g., Apple Watch, Fitbit etc.). For each activity, participants were asked to indicate how frequently they engage in each while driving using a five-point Likert scale (where: 0 = Never, 4 = Always). Participants were also provided with a "not applicable" option for each item. A total average engagement with technology while driving score was calculated on frequency of use across only applicable items.

2.9. Procedure

The study was approved by the Monash University Human Research Ethics Committee (MUHREC). Participants were recruited through a range of online and social media advertising; including the MUARC Facebook page and Twitter feed, the Monash University Insider newsletter etc. The advertising directed participants to an online survey link. To improve recruitment, participants who completed the online survey were able to opt into a draw to win one of five $100 gift vouchers. The online survey was administered from July–August 2020.

2.10. Data analysis

Descriptive statistical analyses were conducted to describe the sample. Bivariate correlations explored the relationships between demographic characteristics and DBQ, MAAS, and NMP-Q scores. Mann-Whitney U tests were conducted to explore the relationships between DBQ and MAAS, NMP-Q scores and self-reported crashes and speeding infringements.

Factor analysis was conducted to determine the most appropriate factor structure for the engagement with technology while driving items. Principal axis factoring was used, with direct oblimin rotation to consider correlated factors. Kaiser-Meyer-Olkin (KMO) measure or sampling adequacy and Bartlett's Test of Sphericity were used as measures of appropriateness determined by KMO values$>$0.70 (Kaiser, 1974) and significant test of sphericity ($p < 0.05$). The number of factors retained were determined by the scree plot. The factor analysis confirmed a unidimensional one factor structure with all items having loadings above 0.45, except for interacting with a smart watch and wearing headphones (loadings of 0.20). Bartlett's test of sphericity was significant $p < 0.001$ and KMO = 0.91. Cronbach's α was 0.87 indicating good reliability.

Structural equation modelling was conducted to test the model proposed in Fig. 1. Latent variables for mindfulness (MAAS), nomophobia (NMP-Q) and engagement with technology while driving were constructed from parcelled items. Three parcels were made for each variable combining items specific to that scale. This helped to reduce the number of observed variables in the model (Little et al., 2002). Two models were tested. First a measurement model, containing the latent variables only, followed by a full structural model with endogenous latent variables. Model fit was determined by a combination of fit statistics. These included the Comparative Fit Index (CFI) (values > 0.90 are considered good fit; (Hu & Bentler, 1999) and the Root Mean Square Error of Approximation (RMSEA) (values < 0.06 are considered to be good fit, while values between 0.06 and 0.08 are considered fair fit; (Browne & Cudeck, 1992)). The 90 percent confidence intervals around the RMSEA were also included. The Chi-Square ($\chi 2$), degree of freedom and significance are also reported, however not used as a measure of fit given the large size of the sample. A Maximum Likelihood estimation was run and Bollen-Stine bootstrapping on 2000 samples was also used to account for violations of multivariate normality. All statistical analyses were conducted using IBM SPSS v. 28 and AMOS version 27.

3. Results

3.1. Participants' socio-demographic characteristics

Nine hundred and ninety participants completed the online survey. As shown in Table 1, most commonly participants: were aged between 56 and 65 years (26.1%; M = 51.2 years, SD = 15.7, Range = 18.0–84.0 years); were female (68.6%); had completed an undergraduate or postgraduate university degree (28.7%, 30.6%, respectively); lived in the Australian state of Victoria (42.4%), and had a yearly household income ($AUD) of between $50,001 and 75,000 before tax (15.9%).

3.1.1. Driving and licensing characteristics

All participants reported that they held a valid driver's licence and most reported that they did not have a conditional or restricted licence. As shown in Table 2, most participants drove between 10,001 and 15,000 km per year and drove daily. Most participants had not been involved in a crash or received a traffic infringement notice in the previous two years.

3.1.2. Aberrant driving behaviours

Participants' self-reported aberrant driving behaviours, as measured using the DBQ, are presented in Table 3.

3.1.3. Mindfulness

Participants' mean MAAS score was 3.94 (SD = 0.88, Range = 1.00–6.00) and their responses to this scale had excellent internal consistency (Cronbach's α = 0.92).

3.1.4. Nomophobia

Most participants were classified as having a 'moderate' level of nomophobia (49.1%; see Table 4). The mean nomophobia score was 72.4 (SD = 26.5, Range = 20.0–140.0) and participants' responses to this questionnaire had excellent internal consistency (Cronbach's α = 0.96). Approximately one percent of participants had an 'absence' of nomophobia (1.1%), while 16.9 percent of participants were classified as having a 'severe' level of nomophobia.

3.2. Engagement with technology while driving

Table 5 shows the self-reported frequency of engaging in technology while driving. As can be seen, the majority of participants reported that they 'never' talked on a handheld device while driving, or interacted with their device for social media, internet or other

Table 1
Socio-demographic characteristics.

Socio-demographic characteristics	% (n)
18–25	8.8 (87)
26–35	11.6 (115)
36–45	13.3 (132)
46–55	19.9 (197)
56–65	26.1 (258)
66–75	17.4 (172)
76+	2.9 (29)
Male	30.2 (299)
Female	68.6 (679)
Other	0.6 (6)
Prefer not to say	0.6 (6)
Primary/Intermediate (Year 10 equivalent)	5.3 (52)
High (Year 12 equivalent)	9.9 (98)
Technical/Trade (incl. apprenticeship)	12.2 (121)
Diploma	13.3 (132)
Undergraduate degree	28.7 (284)
Postgraduate degree	30.6 (303)
<$25,000	10.2 (101)
$25,001–$50,000	14.8 (147)
$50,001–$75,000	15.9 (157)
$75,001–$100,000	11.4 (113)
$100,001–$125,000	7.6 (75)
$125,001–$150,000	7.7 (76)
$155,001–$175,000	5.1 (50)
$175,001–$200,000	4.1 (41)
$200,001–$250,000	3.1 (31)
>$250,001	2.9 (29)
Prefer not to say	17.2 (170)
ACT	3.5 (35)
NSW	22.0 (218)
NT	0.4 (4)
QLD	14.2 ()
SA	6.4 (63)
TAS	3.8 (38)
VIC	42,4 (420)
WA	7.2 (71)

Table 2
Driving characteristics.

Driving characteristics		% (n)
Frequency of driving	Daily	41.1 (407)
	4–6 times per week	31.1 (308)
	2–3 times per week	20.0 (198)
	Once per week	7.8 (77)
Estimated kms driven in their vehicle over the past year	≤5,000 km	22.6 (224)
	5001–10,000 km	22.5 (223)
	10,001–15,000 km	25.5 (252)
	15,001–20,000 km	14.0 (139)
	20,001–25,000 km	8.2 (81)
	>25,001 km	7.2 (71)
Involved in a crash while driving (including minor crashes) in the past two years?	No	85.7 (848)
	Yes	14.3 (142)
Involved in an at-fault crash while driving (including minor crashes) in the past two years	No	93.4 (925)
	Yes	6.6 (65)
Over the past two years, cited for failing to stop at a stop sign or traffic signal (including red light cameras)	No	97.0 (960)
	Yes	3.0 (30)
Over the past two years, cited for speeding	No	84.7 (839)
	Yes	15.3 (151)
Over the past two years, cited for other driving offences such as using a mobile phone illegally while driving	No	97.1 (961)
	Yes	2.9 (29)

Table 3
Self-reported aberrant driving behaviours.

Participants' responses	N	Cronbach's α	Mean (SD)	Range
DBQ: Errors (Max = 55)	990	0.91	0.42 (0.51)	0.00–5.00
DBQ: Lapses (Max = 30)	990	0.77	0.98 (0.66)	0.00–5.00
DBQ: Aggressive violations (Max = 15)	990	0.67	0.69 (0.71)	0.00–5.00
DBQ: Violations (Max = 40)	990	0.82	0.75 (0.65)	0.00–5.00

Table 4
Nomophobia severity level.

Severity level	% (n)
Absence (≤20)	1.1 (11)
Mild (21–59)	32.9 (326)
Moderate (60–99)	49.1 (486)
Severe (100–140)	16.9 (167)

functions. However, 31 percent reported reading text messages on their handheld device while driving.

3.3. Relationships between mindfulness, nomophobia, engagement with technology and aberrant driving behaviours

The relationships between mindfulness, nomophobia, engagement with technology while driving, and aberrant driving behaviours are presented in Table 6.

Age was negatively correlated with DBQ violation scores, with older participants reporting lower levels of violations. Age was positively correlated with MAAS scores, with older participants reporting higher levels of mindful attention and awareness in everyday life and in generalized situations. MAAS scores were negatively correlated with all DBQ subscales, however the relationship between MAAS scores and lapse and error subscale scores were strongest. That is, participants with lower levels of mindful attention and awareness in everyday life were more likely to report higher levels of errors and lapses. Gender was not significantly related to DBQ or MAAS scores. Based on high correlation between DBQ violations and aggressive violations, these factors were combined for the structural model.

Both the measurement model and the structural model showed good fit to the data. The measurement model showed that all indicator variables significantly loaded onto their factors, with standardised regression weight > 0.64. The composite reliability for each factor was good with Rho greater than 0.70 (MAAS and NMP-Q = 0.97, Engagement with technology = 0.76; DBQ = 0.86) demonstrating construct reliability. Convergent reliability was also good with average variance explained (>0.50 for all variables). The full structural goodness of fit statistics were: $\chi^2(48) = 279.38$, Bollen-Stine $p < 0.001$; CFI = 0.98, RMSEA = 0.07; 90% CI = 0.06–0.08. Sex, age, and annual mileage were initially included in the model, however, were removed due to lack of significant loading onto aberrant driving behaviours (sex, annual milage) and poor performance (age which did not increase the variation explained in the model).

Fig. 2 shows the final full model. As expected, mindfulness shared negative relationships with nomophobia, engagement with

Table 5
Participants' engagement with technology while driving.

Activity	n*	M (SD) Range 0–4	Never	Occasionally	Sometimes	Often	Always
Talked on smart phone (handheld)	963	0.35 (0.76)	81.3 (783)	3.7 (36)	14.1 (136)	0.5 (5)	0.3 (3)
Read text message on smart phone (handheld)	968	0.60 (0.93)	68.5 (663)	5.2 (50)	24.5 (237)	1.3 (13)	0.5 (5)
Wrote text message on smart phone (handheld)	968	0.33 (0.78)	83.1 (804)	2.6 (25)	12.8 (124)	1.0 (10)	0.5 (5)
Accessed social media (e.g., Twitter, Facebook, Instagram) on smart phone (handheld)	928	0.21 (0.68)	90.1 (836)	1.2 (11)	6.9 (64)	1.0 (9)	0.9 (8)
Taken photo or video on smart phone (handheld)	931	0.26 (0.71)	87.1 (811)	2.1 (20)	9.1 (85)	1.2 (11)	0.4 (4)
Used App on smart phone (handheld)	945	0.37 (0.82)	81.3 (768)	3.0 (28)	13.8 (130)	1.3 (12)	0.7 (7)
Entered new destination into a navigation system on smart phone (handheld)	962	0.74 (0.99)	58.9 (567)	13.2 (127)	23.1 (222)	4.3 (41)	0.5 (5)
Accessed Internet on smart phone (handheld)	965	0.29 (0.76)	86.1 (831)	1.7 (16)	10.1 (97)	1.6 (15)	0.6 (6)
Wore headphones while listening to smart phone (handheld)	930	0.26 (0.74)	87.3 (812)	3.2 (30)	6.7 (62)	1.9 (18)	0.9 (8)
Interacted with smart watch (e.g., iWatch, Fitbit etc.)	655	0.03 (0.76)	83.2 (545)	4.6 (30)	9.9 (65)	1.8 (12)	0.5 (3)
Total Average	982	0.04 (0.55)					

*Number of participants for whom this was applicable.

Table 6
Correlation matrix for participants' demographic characteristics (age and gender), DBQ subscale scores, MAAS average scores, NMP-Q total scores, and engagement with technology while driving.[1]

		1	2	3	4	5	6	7	8	9
1	Age									
2	Gender	−0.208**	–							
3	DBQ: Errors	−0.223**	0.055	–						
4	DBQ: Lapses	−0.225**	−0.069*	0.723**	–					
5	DBQ: Violations	−0.257**	−0.137**	0.534**	0.658**	–				
6	DBQ: Aggressive Violations	−0.093**	−0.086**	0.391**	0.533**	0.532**	–			
7	MAAS	0.361**	−0.080*	−0.518**	−0.402**	−0.344**	−0.232**	–		
8	NMP-Q	−0.321**	0.131**	0.274**	0.319**	0.190**	0.196**	−0.382**	–	
9	Engagement in Technology while Driving	−0.241**	−0.064*	0.403**	0.464**	0.517**	0.329**	−0.283**	0.208**	–

[1] Gender codes were male = 1; female = 2; * = $p < 0.05$, ** = $p < 0.01$, *** = $p < 0.001$.

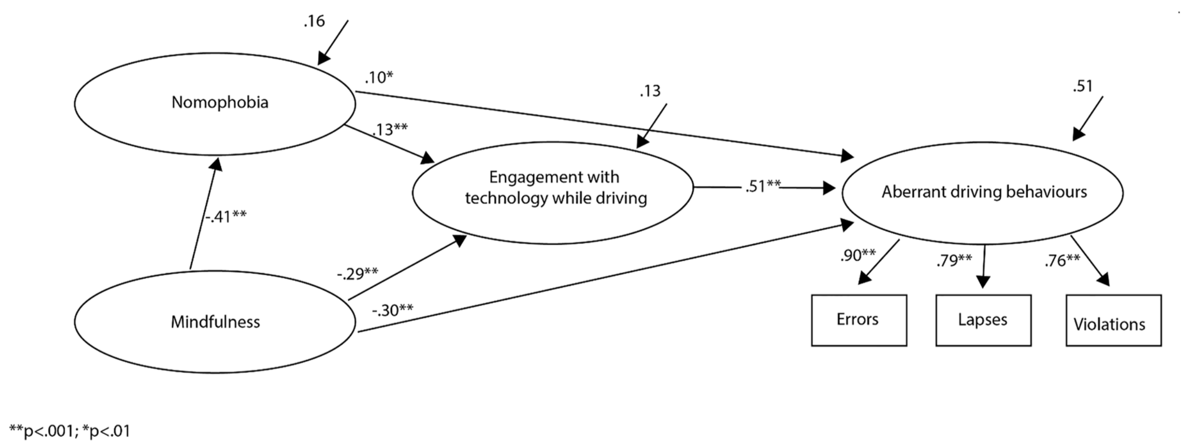

Fig. 2. Final full model of relationship between mindfulness, nomophobia, engagement with technology and aberrant driving behaviours.

technology and aberrant driving behaviours, while all other relationships were positive. In terms of engagement with technology, there were direct paths between nomophobia and mindfulness and also with engagement with technology. The combination of the nomophobia and mindfulness explained 13% of the variance in engaging with technology. Overall, the combination of mindfulness, nomophobia and engagement with technology explained 51 percent of the variance in aberrant driving behaviours.

Mann-Whitney U tests were also conducted to explore the relationships between mindfulness, nomophobia, engagement with technology while driving, aberrant driving behaviours and self-reported crashes (see Table 7). Although self-reported crashes were unable to be included in the structural model, it is important to understand if relationships exist between these variables.

Table 7 shows that there was a significant relationship between aberrant driving behaviours and self-reported crashes; Drivers who had been involved in a crash reported significantly more errors, lapses and violations than drivers who had not been involved in a crash. Mindfulness was also related to self-reported crashes; Drivers who had been involved in a crash had significantly lower levels of mindfulness than those who had not been involved in crash. While there was no significant relationship between nomophobia scores and self-reported crashes, drivers who had been involved in a crash reported significantly higher levels of engagement with technology while driving compared to drivers who had not been involved in a crash.

4. Discussion

The current study explored the relationships between mindfulness, nomophobia, technology engagement while driving, and aberrant driving behaviour. Although previous research revealed how mindfulness reduces aberrant driving behaviours, no research to date has evaluated whether mindfulness can still improve driving performance when the fear of being without a mobile phone is considered.

Nomophobia was the focus for this study because the fear of being without a mobile phone has been shown to increase the likelihood of poor decision making (Márquez-Hernández et al., 2020), distraction (Gutiérrez-Puertas et al., 2019; Mendoza et al., 2018; Osorio-Molina et al., 2021; Wang & Suh, 2018), dangerous, risky, and more frequent smartphone engagement (Kaviani et al., 2020a), and illegal smartphone use while driving (Kaviani et al., 2020b). Previous research has shown that higher levels of mindfulness are associated with less nomophobia (Arpaci et al., 2019; Arpaci & Gundogan, 2020). Further, higher levels of mindfulness are also related to less errors, lapses and violations and fewer self-reported crashes (Koppel et al., 2018). In this study, the relationship between mindfulness and nomophobia was explored to determine the aggregate impact on engagement with technology and aberrant driving behaviours, including the direct link between nomophobia and aberrant driving behaviours. Understanding these dynamics may allow for the development of mindfulness interventions that take into consideration the possible confounding impact of nomophobia on engagement with technology and resulting aberrant driving behaviour.

As expected, participants with higher mindfulness reported less nomophobia, less frequent engagement with technology while driving, and less frequent aberrant driving behaviours. Regarding nomophobia, the results of this study showed 98.9 percent of participants experienced some level of nomophobia. This aligns with previous studies that found nomophobia impacted 99.2 percent of Australian drivers that own a smartphone (Kaviani et al., 2020a). Although previous studies also showed nomophobia increased the likelihood of illegal smartphone use while driving (Kaviani et al., 2020b), the current study is unique in that it illustrated a direct relationship between higher levels of nomophobia and more frequent aberrant driving behaviours such as errors, lapses, and violations. Although no significant relationship between nomophobia and crashes were established, aberrant driving behaviours have been shown to increase crash risks (Lawton et al., 1997; Parker et al., 1995; Stephens & Fitzharris, 2016). Given a recent systematic review (León-Mejía et al., 2021) found nomophobia is prevalent across the world, with severe levels impacting women and younger individuals more than older individuals and males, this finding has global implications for already at-risk drivers. Additionally, COVID-19 has increased the need to always be with our devices to show vaccination status, check into venues, or maintain social connection while in isolation or lockdowns (David & Roberts, 2021).

As expected, participants with higher trait mindfulness reported less nomophobia, less frequent engagement with technology while driving, and less frequent aberrant driving behaviours. Despite mindfulness reducing nomophobia—a finding that is consistent with previous research (Arpaci et al., 2019)— nomophobia increased engagement with technology. This is consistent with previous studies that found individuals with higher levels of nomophobia are more likely to use their smartphones illegally while driving (Kaviani et al., 2020a; Kaviani et al., 2020b). Higher mindfulness was, however, associated with a reduced overall impact of nomophobia on engagement with technology. Regarding nomophobia's direct relationship with aberrant driving behaviours, this study found nomophobia was related to the tendency to report more frequent errors, lapses, and violations (although a distinction should be drawn between complex multitasking (i.e., non-driving related phone use such as making phone calls while driving) and driving-related phone use which is not multitasking (e.g., using the phone for navigation while driving). This may be due to both internal (i.e., mind-wandering) and external (i.e., secondary task engagement) factors. Indeed, research has shown that, even if an individual does not engage with their smartphone while driving, its mere presence, even while switched off, can still negatively impact attention (Chee et al., 2021). As such, when employing mindfulness as an intervention for mitigating engagement with technology while driving, an understanding of a driver's reasons for needing to be with their smartphones should be developed and considered. Nomophobia should be understood as a common and conditioned response to the modern world, where the perceived negative consequences of a missed phone call may be significant. Formal attention training through mindfulness meditation along with training in the informal practice of mindfulness (maintaining attention on-task while engaged in an activity) may be particularly helpful for drivers to be more conscious of where their attention is focused while driving, and to be more able to redirect it when it is distracted from the driving task.

Examining the impact of mindfulness on engagement with technology while driving, the findings were consistent with previous research that demonstrated mindful drivers were more likely to focus their attention on the primary task of driving rather than

Table 7
Medians (IQRs) for DBQ subscale scores, MAAS average scores, NMP-Q total scores, and engagement with technology while driving across self-reported crashes in previous two years.

	Self-reported crashMedian (Q1, Q3)		Significance
	Yes (n = 139)	No (n = 822)	
DBQ: Errors	0.364 (0.18, 0.73)	0.273 (0.11, 0.55)	$U = 45472.00, z = -3.87, p < 0.001$
DBQ: Lapses	1.00 (0.67, 1.50)	0.833 (0.50, 1.33)	$U = 49006.50, z = -2.70, p < 0.01$
DBQ: Violations	0.818 (0.45, 1.10)	0.546 (0.27, 0.91)	$U = 45728.00, z = -3.78, p < 0.001$
MAAS: Average	56.00 (48.00, 65.00)	61.00 (51.00, 68.00)	$U = 48522.00, z = -2.85, p < 0.01$
NMP-Q: Total	76.00 (57.00, 94.00)	71.50 (50.00, 90.25)	$U = 52078.00, z = -1.67, p = 0.095$
Engagement with technology while driving: Average	2.50 (1.33, 3.67)	2.00 (1.00, 3.00)	$U = 48620.00, z = -2.82, p < 0.01$

engaging with technology, especially smartphones (Regan et al., 2020; Throuvala et al., 2020). Additionally, mindful drivers had less frequent driving-related errors, lapses, and violations, a finding that was consistent with previous research (Koppel et al., 2018). In contrast, a higher frequency of aberrant driving behaviours was explained by a combination of lower levels of mindfulness and higher levels of nomophobia and engagement with technology while driving. This study also found the average mindfulness scores among drivers who self-reported being involved in a crash over the past two years were lower than those who reported that they had not been involved in a crash. This finding is supported by previous studies that reported that drivers with greater trait mindfulness were less likely to be involved in a crash over the same timeframe (Koppel et al., 2018). It is important to note that while this study cannot suggest lower crash rates are due to trait mindfulness, the consistent relationship between mindfulness and safe driving practices are found across the literature and should therefore be the focus of further research for developing mindfulness-based interventions designed toward reducing crash rate.

Several limitations should be noted. Firstly, the findings regarding mindfulness, nomophobia, aberrant driving behaviours, distracted driving and crashes are based on self-report. Previous research has suggested that participants tend to minimise the extent or frequency of their behaviours if they are not considered to be socially acceptable (e.g., distracted driving; Adams et al., 2005). However, underreporting of socially unacceptable behaviours is likely to have been reduced for the online survey given that participants were assured of confidentiality and anonymity. Further, DBQ scores obtained in this study were similar to those reported in previous research (Stephens & Fitzharris, 2016). While the current study investigated the simultaneous relationships between the MAAS and the DBQ, because the MAAS has been widely used in the area of driving behaviour, this analysis considered mindfulness as a single construct - whereas previous research has suggested that mindfulness may be better conceptualised as a multidimensional construct (Baer et al., 2006; Bishop et al., 2004). Future research should specifically explore these relationships with mindfulness when viewed as a multidimensional construct. Finally, the findings from the current study are based on a convenience sample and may be the result of a volunteer bias (i.e., individuals who agreed to participate in the online survey may be more interested in driving or road safety more generally). Future research should validate the self-reported responses with more objective measures such as those collected through naturalistic driving study (NDS) methodology.

5. Conclusion

In summary, the results of this study demonstrate the positive influence mindfulness can have on nomophobia, engagement with technology while driving, and dangerous driving behaviours that have been associated with crash risk. Mindfulness practices may reduce the effect of nomophobia on engagement with technology while driving and increased dangerous behaviours as a result. This will be increasingly important as modern work and social practices encourage people to increasingly use the phone while driving, and the technology within smart devices, and connectivity of these to the vehicle, increase. More research is needed to understand whether mindfulness-based interventions can reduce nomophobia, and thereby improve driving behaviours and reduce crash rates.

CRediT authorship contribution statement

Sjaan Koppel: Conceptualization, Methodology, Formal analysis, Writing – original draft, Writing – review & editing, Project administration. **Amanda N. Stephens:** Formal analysis, Writing – original draft, Writing – review & editing. **Fareed Kaviani:** Formal analysis, Writing – original draft, Writing – review & editing. **Sujanie Peiris:** Writing – original draft, Writing – review & editing. **Kristie L. Young:** Writing – review & editing. **Richard Chambers:** Writing – review & editing. **Craig Hassed:** Writing – review & editing.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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