Transportation Research Part F 59 (2018) 203–211

Contents lists available at ScienceDirect

Transportation Research Part F

journal homepage: www.elsevier.com/locate/trf

The mediating role of smartphone addiction on the relationship between personality and young drivers' smartphone use while driving

Erez kita [a,b], Gil Luria [a,*]

[a] Faculty of Welfare and Health Sciences, Head of Department of Human Services, University of Haifa, Mount Carmel, Haifa 31905, Israel
[b] Oryarok – The Association for Safer Driving in Israel, Israel

ARTICLE INFO

Article history:
Received 24 April 2018
Received in revised form 28 August 2018
Accepted 2 September 2018

Keywords:
Personality
Big 5
Smartphone addiction
Smartphone use while driving
Young drivers

ABSTRACT

Young drivers touch their smartphone screens for a number of reasons (to access text messages, Internet, social media, games, music, videos, and more), but doing so increases the likelihood of accidents. This study discusses the relationship between personality traits and the use of smartphones by 221 young drivers (64.7% male) aged 17–22 years. It focuses on the mediation effect of smartphone addiction on the relationship between personality and smartphone use while driving, using an objective measure—the number of times young drivers touch their smartphones, measured by a unique smartphone monitoring application. Results show that participants touched their smartphones on average 1.71 times per minute while driving. They also indicate a negative relationship between participants' openness to experience and smartphone use while driving, a positive relationship between both extraversion and neuroticism and smartphone use while driving, and a mediation effect of smartphone addiction on the relationship between neuroticism and smartphone use while driving. This is the first study to identify relationships between psychological variables and smartphone use while driving based on a real-time objective measurement. The ability to predict such use may lead to a personalized intervention that will reduce addiction to the smartphone and help drivers refrain from using smartphones while driving.

1. Introduction

Smartphones are becoming ever more popular. Users regularly carry their phones everywhere and interact with them an average of 150 times per day (Meeker & Wu, 2013). Those interactions while driving present a danger to the driver and other road users. A recent study, focused on the frequency of secondary tasks in driving, found that mobile-phone-related tasks were the most frequent activities that increase driving distraction (Metz, Landau, & Just, 2014) and consequently increase the number of driving mistakes (Young & Salmon, 2012) and the risk of accidents for everyone on the road (Nemme & White, 2010). According to the U.S. National Highway Traffic Safety Administration (2013), young drivers (aged 17–24 years) are more likely to use smartphones while driving than were older drivers. Further, almost 50% of young drivers send emails or text messages while driving, compared with 18% of all drivers who participated in another survey (Tison, Chaudhary, & Cosgrove, 2011). Crash rates during the teenage years are higher than at any other age for both males and females (Williams,

* Corresponding author.
E-mail address: gluria@univ.haifa.ac.il (G. Luria).

https://doi.org/10.1016/j.trf.2018.09.001
1369-8478/

2003). Young people's use of smartphones while driving, combined with their inexperience, puts them at greater risk of being involved in car accidents (Nemme & White, 2010).

The U.S. Governors Highway Safety Association (Hedlund, 2011) presented four types of distractions that result from smartphone use while driving: visual—looking at something other than the road or in a different direction, voice—listening to something or someone not road-related, hands—touching something other than the steering wheel, and cognitive—thinking about something or someone other than road-related. A cognitive distraction can occur together with other distractions or independently, and smartphone use may generate several (sometimes all) distractions simultaneously. Caird, Johnston, Willness, Asbridge, and Steel (2014), who conducted a meta-analysis (28 experimental studies) of the effects of texting on driving, found that typing and reading text messages impaired drivers' ability to focus on the road, respond to traffic incidents, and maintain speed and lane positioning control. Thus, young adults' heavy smartphone use, combined with the increased likelihood of their involvement in road accidents, creates a significant safety issue (Nemme & White, 2010). Teen drivers crash at a much higher rate than adult drivers, and in nearly six of 10 moderate-to-severe teen crashes, distraction was identified as a factor (Carney, Harland, & McGehee, 2017).

This study adds to understanding the feature of young drivers screen touches per minute while driving and examines this risky behavior through an objective measure (a smartphone application that records drivers' real-time smartphone use). In addition, we suggest smartphone addiction as a mediator between personality and the use of smartphone while driving.

1.1. Mediating effect of smartphone addiction

Problematic smartphone use is a construct often defined by excessive use that interferes with work, school, or social interaction (Billieux, Maurage, Lopez-Fernandez, Kuss, & Griffiths, 2015). Any type of compulsive use is generally considered an addiction (Peele, 1985). In this case, excessive smartphone use is considered a technological addiction that develops when people trust technology to supply them with psychological rewards such as decreased mood swings or increased social profits (Griffiths, 1996; Shaffer, 1996). Smartphone addiction relates to where, how frequently, and with whom the smartphone is used (Kim, 2013): where—unsuitable places such as the classroom, face-to-face social interaction, and driving; frequency—obsessively throughout the day; with whom—peers for maintaining social ties.

Three personality traits (*conscientiousness*, *extraversion,* and *neuroticism*) also relate to smartphone addiction. *Conscientiousness* plays the greatest part in explaining dangerous behaviors (Friedman et al., 1995). People with a high degree of conscientiousness tend to work hard and are responsible, practical, and target oriented (Arthur & Graziano, 1996). Conversely, people with a low degree of conscientiousness tend to be lazy, careless, and irresponsible; have little self-discipline; and take an illogical approach to decision making. Kuss, Van Rooij, Shorter, Griffiths, and van de Mheen (2013) found that teenagers with a low degree of conscientiousness experience more Internet addiction because they tend to avoid tasks they perceive as challenging or less enjoyable. It can be assumed, therefore, that young people with low conscientiousness have a greater tendency towards smartphone addiction because the device serves as a convenient and accessible means to connect to the Internet. These young people may also use their smartphones more in general and specifically while driving.

Garland, Froeliger, and Howard (2014) found that social media provided a means for self-expression and not just for keeping in touch or engaging in social interactions. People with a high degree of *extraversion* are socially involved, assertive, and adventurous (Lane & Manner, 2011), whereas those with a low degree tend to be shy, introverted, and cautious. Several studies have found a significant relationship between extraversion and accident involvement (e.g., Arthur & Graziano, 1996; Clarke & Robertson, 2005). Furthermore, people with a high degree of extraversion reported greater use of apps that require typing (Lane & Manner, 2011) and thus will presumably be more likely to type while driving. They were also found to be addicted to social media such as Facebook and Instagram (Andreassen, Torsheim, Brunborg, & Pallesen, 2012), applications some young drivers use while driving. Hence, people with a high degree of extraversion will presumably tend more towards smartphone addiction and use their phones more often while driving.

People with a high degree of *neuroticism* manifest insecurity, tenseness, and anxiety, whereas people with a low degree tend to be emotionally stable and calm with high self-confidence (Lane & Manner, 2011). Neuroticism has known influences on the social dimension. For example, neurotic people tend to be highly anxious about interpersonal relations (Leary, 1983) and may prefer to keep in touch with others by using their smartphones. Such interactions are easier for them to maintain than face-to-face contact (Igarashi, Motoyoshi, Takai, & Yoshida, 2008). Neurotic people also tend to be more problematic (i.e., excessive) smartphone users due to their low self-esteem and great desire for others to perceive them in a positive light (Motoharu, 2014). For people with a high degree of *neuroticism* who adapt communication patterns to avoid face-to-face contact with others, smartphone addiction could be a means to reduce anxiety (Billieux, Van der Linden, d'Acremont, Ceschi, & Zermatten, 2007) and avoid social meetings that entail physical closeness and cause or increase anxiety.

The relevant literature suggested that smartphone addiction explains the relationship between personality and increased smartphone use. That is, young people's increased use relates to their self-identity, desire to improve their social status, and quest to boost their self-confidence, as well as to entertain and develop social and interpersonal ties (Srivastava, 2005). For example, young people who show higher degrees of extraversion and anxiety, combined with lower self-esteem, may have a greater tendency to smartphone addiction (Bianchi & Phillips, 2005). Further, the more addicted the young people are to their smartphones, the more time they may spend using them (Billieux et al., 2007).

Research has shown that smartphone addiction is a mediating factor in the relationship between smartphone use and a high degree of extraversion and anxiety combined with low self-esteem (Hong, Chiu, & Huang, 2012). We believe this may

also be the case for smartphone use while driving. Therefore, we suggest that the relationship between personality traits related to smartphone addiction and use while driving may be mediated through smartphone addiction. We hypothesize:

Hypothesis 1: Smartphone addiction will mediate the relationship between *neuroticism* and smartphone use while driving.

Hypothesis 2: Smartphone addiction will mediate the relationship between *conscientiousness* and smartphone use while driving.

Hypothesis 3: Smartphone addiction will mediate the relationship between *extraversion* and smartphone use while driving.

2. Method

2.1. Participants and procedure

Participants were 240 drivers aged 17–22 years, recruited over a 4-month period through social media and the "friends bring friends" method (Dishion, Andrews, & Crosby, 1995). They were paid approximately US$55 to participate. After completing the questionnaires online, they received a link to download a mobile app called *Protext Me* to monitor touching their smartphones while driving. The app and the online questionnaire were tested in a pilot before we started the research. The app continuously worked in the background for a month and automatically recognized when driving began and ended. It monitored the number of times the participants touched the smartphone screen while driving but provided them no feedback about their behavior. To ensure participant privacy, the data were automatically saved on a separate server to which only the research team had access. The study was approved by the Ethics Committee at the University of Haifa.

At the end of the study, data for 19 participants were deleted because they had not completed the questionnaires in full or for technical reasons (e.g., the app had not been connected to their GPS, necessary to monitor screen touches only while the participant was driving). In all, data from 221 participants (92% response rate) were analyzed. These were 143 males and 78 females aged 17–22 years (M = 19.3; SD = 1.71) who had held a driving license for at least 3 months and were legally permitted to drive without supervision. All participants owned smartphones with an Android operating system and drove at least 2 h per week.

2.2. Measures

2.2.1. Number of screen touches per minute

Protext Me (Albert & Lotan, 2018) is a smartphone app available for the Android mobile operating system (4.3 or higher) that was adjusted and configured especially for this research. The technology was tested rigorously prior to the study, and the most reliable version was used.

All participants placed a unique sticker, prepared specifically for those who participated in the research, on their car near the driver's seat to allow the app to identify the presence of the driver's phone in the car via near field communication (NFC) technology.

All drivers who participated in the research were asked to put their smartphones on the sticker before they started driving. The NFC technology detects only the smartphone that touches the sticker or is within centimeters from the sticker. In this way, it was possible to monitor with certainty the number of touches on the screen of the smartphone while driving for the drivers who participated in the study (and not passengers).

However, in case a participant did not place the phone on the sticker, the app was also equipped for smart detection of driving via several other indicators, such as Bluetooth connection and GPS. If, for some reason, the app started monitoring when the participant was not driving, then the participant was prompted to turn off the app by selecting the app's "I am not driving" function.

Pilot tests examined the reliability of this variable and ensured correct monitoring with users and safety experts. As a result of these pilot tests, not all drivers—and not all minutes monitored during the study—were included in the final sample. Journeys with at least one of the following characteristics were excluded when the variable was calculated:

1. Journeys when neither the GPS nor an alternative navigating app was activated,
2. Journeys lasting less than 3 min,
3. Journeys in which the participant stopped the monitoring app manually (because he or she was not the actual driver during that specific journey), or
4. The last minute of each journey was erased from the data because the app continued to monitor smartphone touching after the drive ended (i.e., when smartphone use was considered safe).

2.2.2. Personality traits

Participants were asked to complete a questionnaire about their Big Five personality traits, measured on the International Personality Item Pool scale (Frederick, Lucas, & Bairo, 2006). Due to its size, we selected the short (20-item) version, adapted to digital transmission media more suitable for the younger population.

Participants rated their degree of agreement or disagreement with each item on a Likert scale from 1 (strongly disagree) to 5 (strongly agree). Pilot tests with potential participants from the target population were successful, and the items were divided into the five categories of the Big Five personality traits model. Each category represented a different personality trait and contained four items. Cronbach's alpha for extraversion was $\alpha = 0.69$; for agreeableness, $\alpha = 0.79$; conscientiousness, $\alpha = 0.75$; neuroticism, $\alpha = 0.70$; and openness to experience, $\alpha = 0.74$. This questionnaire has been used in many studies that reached similar reliabilities as in this study (Andreassen et al., 2014; Laverdiere, Morin, & St-Hilaire, 2013; Li, Sang, Wang & Shi, 2012; Wittek et al., 2016).

2.2.3. Smartphone addiction

Participants completed the Smartphone Addiction Scale questionnaire (Kwon, Kim, Cho, & Yang, 2013). In order to increase instrument reliability and validity, we conducted a pilot in which we tested the scale with a group of participants from the target population. Potential participants found eight of the 10 items to be clear and did not comment on them. The other two questions ("feeling impatient and fretful when I am not holding my smartphone" and "I will never give up using my smartphone even when my daily life is already greatly affected by it") were removed based on participant comments.

The eight remaining items encompassed a wide range of addiction indicators, such as lengthy use of the smartphone and disruptions due to smartphone use in class, while doing school assignments, or at work. The participants rated their degree of agreement or disagreement with each item on a Likert scale from 1 (strongly disagree) to 5 (strongly agree). The eight items were highly reliable, with a Cronbach's alpha of 0.79, which resembles the reliability reported in other studies that used the 10-item questionnaire (De Pasquale, Sciacca, & Hichy, 2017; Hartanto & Yang, 2016; Yuchang, Cuicui, Junxiu, & Junyi, 2017).

2.2.4. Demographic questionnaire and self-reporting

Participants were asked to complete a questionnaire on personal details, such as age, address, and gender.

3. Results

Descriptive statistics and relationships between the variables are presented in Table 1. Smartphone addiction had the strongest relationship with smartphone use while driving ($r = 0.233$, $p < 0.01$). Negative correlations were found between smartphone use while driving and three personality traits: *consciousness* ($r = -0.148$, $p < 0.05$), *agreeableness* ($r = -0.138$, $p < 0.05$), and *openness to experience* ($r = -0.208$, $p < 0.01$). A positive correlation existed between *neuroticism* ($r = 0.186$, $p < 0.01$) and smartphone use while driving.

The bootstrap process (Hayes, 2012) was used to test the study's hypotheses (Fig. 1 presents the model). The procedure can indicate direct relationships between personality traits and smartphone use while driving (Fig. 1, Path c') and can test the mediation effect of addiction (Fig. 1, Path c'i). One advantage to bootstrapping is that the inference is based on an estimate of the indirect effect itself and makes no assumptions about the shape of the sampling distribution of the indirect effect (Hayes, 2009).

The bootstrapping technique compares 5000 random samples and assesses the significance through the bootstrap range. Thus, if the range is from below zero to above zero, the relationship is not significant (results are presented in Table 2). Sections A and B of the regression table show the direct relationship between the independent variables (the five personality traits) and the dependent variable (smartphone use while driving) and the direct relationship of the control variables with smartphone use while driving. Section C shows the mediating (indirect) effect of addiction. The hypotheses were tested after controlling for income, age, and number of journeys driven.

Results of the regression analyses are shown in Table 2.

The first hypothesis, that smartphone addiction would mediate the relationship between neuroticism and smartphone use while driving, was supported. The bootstrap range from lower limit (LLCI) to upper limit (ULCI) excluded zero; thus, the indirect effect was significant [bootLLCI 0.01–bootULCI 0.18]. The second hypothesis, that smartphone addiction will mediate the relationship between conscientiousness and smartphone use while driving was not supported and the indirect

Table 1
Descriptive statistics and correlation matrices.

	M	*SD*	1	2	3	4	5	6	7
1. Neuroticism	2.52	0.79	–						
2. Extraversion	3.22	0.82	0.009	–					
3. Agreeableness	4.04	0.78	−0.014	0.365**	–				
4. Conscientiousness	3.55	0.88	−0.248**	−0.006	0.236**	–			
5. Openness to experience	3.80	0.80	−0.093	0.106	0.255**	0.130	–		
6. Smartphone addiction	2.68	0.72	0.312**	0.079	0.060	−0.148*	−0.072	–	
7. Smartphone use while driving	1.71	1.45	0.186**	0.119	−0.138*	−0.148*	−0.208**	0.233**	–

Note: N = 221.
* $p < 0.05$.
** $p < 0.01$.

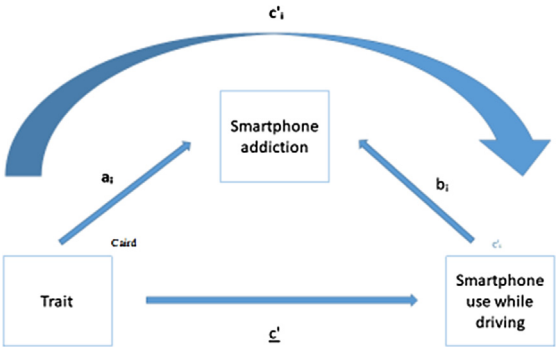

Fig. 1. The indirect effect of smartphone addiction on the relationship of the five personality traits and smartphone use while driving.

Table 2
Regression results: relationships between personality traits and smartphone using while driving and the mediation effect of addiction.

Variable	β	*SE*	bootLLCI[a]	bootULCI[b]
Direct relationship[c]				
A. Big five personality trait[d]				
Openness to experience	−0.31*	0.11	−0.55	−0.07
Conscientiousness	−0.09	0.11	−0.31	0.13
Agreeableness	−0.24	0.14	−0.51	0.03
Neuroticism	0.29*	0.12	0.05	0.52
Extraversion	0.36**	0.12	0.10	0.56
B. Control factor				
Income	−0.16*	0.07	−0.30	−0.03
Age	−0.04	0.05	−0.15	0.06
Journeys driven	0.00	0.00	−0.00	0.00
C. Indirect relationship (addiction mediator)[e]				
Openness to experience			−0.10	0.02
Conscientiousness			−0.10	0.00
Agreeableness			−0.00	0.12
Neuroticism			0.01	0.18
Extraversion			−0.01	0.08

Note: $N = 221$.
R^2 (direct) = 0.14; R^2 (indirect) = 0.16.
[a] Hayes's (2012) bootstrap lower limit/confidence interval.
[b] Hayes's bootstrap upper limit/confidence interval; bootLLCI – bootULCI signifies mediation if neither interval crosses zero.
[c] The full findings, with all paths regarding the indirect effect of addiction between the five personality traits and smartphone use while driving are presented in Table A.1.
[d] See path c' in Fig. 1.
[e] See path c'i in Fig. 1.
* $p < 0.05$.
** $p < 0.01$.

effects were nonsignificant [bootLLCI −0.1–bootULCI 0.00]. The third hypotheses, that smartphone addiction would mediate the relationship between extraversion and smartphone use while driving, was not supported. The indirect effects were non-significant [bootLLCI −0.01–bootULCI 0.08].

4. Discussion

Previous studies were based on participants' self-reports of their smartphone use while driving (Dahlen, Edwards, Tubré, Zyphur, & Warren, 2012; Herzberg, 2009; Jovanović, Lipovac, Stanojević, & Stanojević, 2011; Tison et al., 2011). As such, one of the current study's contributions is that it overcomes those earlier single-source biases by means of a new, objective measure to facilitate understanding of the relationship between personalities and smartphone use while driving. The *Protext Me* app enables passive, real-time monitoring of the number of times drivers touch their smartphone screens, whether to access text messaging, the Internet, social media, games, music, videos, or other reasons. No matter the objective, when young, novice drivers touch their smartphone screens while driving, they automatically avert their eyes from the road—putting themselves and others at risk of a road accident (Nemme & White, 2010).

An additional contribution of this study lies in understanding the process that links personality traits with smartphone use while driving. So far, studies have focused on only the relationship between personality and smartphone use while driving (Demirhan, Randler, & Horzum, 2016; Sween, Ceschi, Tommasi, Sartori, & Weller, 2017) or between personality and

smartphone addiction (Bianchi & Phillips, 2005; Elander, West, & French, 1993; Phillips, Butt, & Blaszczynski, 2006). This study, however, adds examination of the mediation effect of addiction on the relationship. It also identifies which relationship addiction mediates (neuroticism) and which personality traits directly affect smartphone use while driving (extraversion, neuroticism, and openness to experience).

4.1. Relationship between personality traits and smartphone use while driving

This research combined two separate bodies of knowledge that could help explain the relationship between personality and smartphone use while driving. The first addresses the relation between personality and safety; the second, the relation between personality and communication (or other social constructs). In their studies, Beus, Dhanani, and McCord (2015) and Phillips et al. (2006) found a positive relationship between unsafe workplace behavior, extraversion, neuroticism, and excessive phone use—similar to our finding of a positive relationship between extraversion, neuroticism, and smartphone use while driving (i.e., unsafe driving behavior). However, our research did not replicate those author's other findings, possibly due to the unsafe behavior under examination. That is, the smartphone use while driving tested in the current study is an example of unsafe behavior specifically while driving, whereas "unsafe workplace behavior" encompasses a variety of unsafe behaviors. Moreover, the first-time objective measurement tool used in our study may have eliminated relationships that resulted from previous single-source bias.

Our results demonstrate a positive relationship between extraversion and smartphone use while driving. It is important to note that the direct relationships were not strong; personality explained only 14% of the variance in the use of smartphone while driving. However, these existing relationships align with other studies regarding these traits. People with a high degree of extraversion tend to be risk-takers (Arthur & Graziano, 1996; Clarke & Robertson, 2005) and to make greater use of typing apps (Lane & Manner, 2011); therefore, they tend to use their smartphones more while driving. However, our hypothesis that smartphone addiction would be a mediating factor between extraversion and using smartphone while driving was not supported. A possible explanation is that extraverted people tend to make greater use of smartphone social media apps as a means of self-expression rather than as a means to keep in touch or interact socially (Garland et al., 2014). Their lack of need for social interaction via smartphones may explain the lack of a relationship between extraversion and smartphone addiction.

Studies have shown that people who have a high degree of neuroticism also tend to be dangerous drivers (Beus et al., 2015; Jovanović et al., 2011; Leary, 1983; Sümer, Lajunen, & Özkan, 2005) and problematic smartphone users (Ehrenberg, Juckes, White, & Walsh, 2000; Igarashi et al., 2008; Joinson, 2004; Motoharu, 2014). Similar to the abovementioned studies, the current study found a direct relationship between neuroticism and smartphone use while driving, and smartphone addiction to be a mediating factor between them. Young drivers with a high degree of neuroticism are more prone to develop addiction to their smartphones, leading them to use their phones while driving.

The results of the current research regarding the mediating role of smartphone addiction and that addiction's strong relationship to smartphone use while driving demonstrate the importance of this variable to road-safety research. When driving, young people need to focus solely on the road; however, social interactions through smartphones distract them, interfering with safe driving and increasing the likelihood of an accident. These social interactions occur continually and place a great demand on the drivers' resources. Young drivers with a tendency towards smartphone addiction stay close to their phones in order to maintain social ties (Kim, 2013). The results of this study confirm that while driving, young people with smartphone addiction will find it hard to overcome the temptation to use their devices and will probably take their eyes off the road and their hands off the wheel to touch their screens.

Our hypothesis that conscientiousness would negatively relate to smartphone use while driving was based on previous studies (Arthur & Graziano, 1996; Clarke & Robertson, 2005; Oltedal & Rundmo, 2006; Sümer et al., 2005). Similarly, we found significant negative correlations between conscientiousness and both smartphone addiction and use while driving. However, our findings did not show a relationship between conscientiousness and smartphone use while driving in a model combined with other personality traits. This aligns with Ross et al. (2009), who found no relationship between conscientiousness and the use of Facebook, and who stated that further research was required. Our results indicate that conscientiousness does not explain smartphone use while driving directly or indirectly, beyond the variance explained by other traits. Intercorrelations with extraversion and openness to experience apparently reduced the variance explained by conscientiousness.

4.2. Limitations and future research

The dependent variable measure used in this study is unique because it measures real-time smartphone use while driving and replaces self-reporting. The app does not identify whether people look at (check/monitor) their phones (without touching the screen) while driving, a behavior other studies reported as highly prevalent (Caird et al., 2014; Lipovac, Đerić, Tešić, Andrić, & Marić, 2017).

The app provides information only about the number of times drivers touch their smartphone screens while driving and not about the smartphone usage (i.e., which apps they are using, how fast they are driving, or whether they use the smartphone to only read or to watch a video). Nor does it provide information about the setting, such as if additional passengers are in the car, whether the driver was stopped at a traffic light, and so forth. Such information could offer additional insights

into young drivers' use of smartphones while driving. Generalizing the findings to entire populations is also limited because the study analyzed data only for young drivers aged 17–22 years.

Our cross-sectional study provided data on relationships among smartphone use while driving, personality traits, and addiction. Conclusions cannot be drawn about the factors that may cause people to use or not use smartphones while driving. To that end, an experimental cause-and-effect study would be necessary. Moreover, a mixed-method qualitative and quantitative study would benefit further understanding of young people's smartphone use patterns while driving. Such research could shed light on drivers' motivations, preventive mechanisms, and means to help young people avoid using smartphones while driving, thereby enhancing their safety.

4.3. Conclusions

This research used objective techniques that measured how many times novice drivers touched their smartphones while driving. The result—1.7 times per minute—indicates that their hands were not on the steering wheel while driving, a behavior that places novice drivers and other road users at serious risk. We indicate that the tendency to touch the mobile phone while driving relates to smartphone addiction and demonstrate that addiction serves as a mediator between neuroticism and the use of smartphone while driving.

4.4. Practical implications

Interventions proven effective in treating addictions (Bowen, Chawla, & Witkiewitz, 2014; Marlatt, Baer, Donovan, & Kivlahan, 1988) can be used for young drivers who suffer from smartphone addiction and thus reduce their risk of operating smartphones while driving. Apps have the potential to help people in their daily lives. The literature provides evidence for using apps to improve mental health (Donker et al., 2013), reduce stress (Economides, Martman, Bell, & Sanderson, 2018), and reduce smoking (Iacoviello et al., 2017). Although personality supposedly is comprised of stable traits that are not easily amenable to change, the ability to predict—directly or through mediation—their effect on behavior may help practitioners create personalized intervention tools that consider personality and help drivers refrain from the dangerous behavior of using smartphones while driving. A body of research deals with applying different interventions for different personality types to treat addictive behaviors such as alcohol misuse (Conrod, Stewart, Comeau, & Maclean, 2006; O'Leary-Barrett, Mackie, Castellanos-Ryan, Al-Khudhairy, & Conrod, 2010), drug use (Conrod, Castellanos-Ryan, & Strang, 2010), and so forth. Likewise, interventions that consider personality can be developed to reduce the dangerous habit of using smartphones while driving.

Acknowledgements

Special thanks are due to Tsippy Lotan and Gila Albert. Thanks to the research team from The Ran Naor Foundation: Oren Musicant, Ilit Oppenheim, Sasha Harel, Yael Nave, and Ofra Bigger. Thanks also to Shai Tal and Zvika Beer from Or Yarok. Many thanks to the Israeli Association of the Insurance Companies for the financial support. Exceptional thanks are due to Tomer Chen and Vika Beckerman for their effort, support, and cooperation in managing the technical issues.

Appendix. A

See Table A1.

Table A1
Indirect effect of smartphone addiction on the relationship of personality traits and smartphone use while driving.

Trait	a_i Trait and smartphone addiction β (*SE*)	b_i Smartphone addiction and use while driving β (*SE*)	c' Direct effect β (*SE*)	c'$_i$ Indirect effect [bootLLCI–bootULCI][a]
Openness to experience	−0.05 (0.06)	**−0.29*** (0.04)	**−0.31*** (0.12)	[−0.09 to 0.01]
Conscientiousness	−0.08 (0.06)	**0.31*** (0.14)	−0.09 (0.11)	[−0.09 to 0.00]
Agreeableness	0.10 (0.07)	**0.31*** (0.14)	−0.24 (0.14)	[−0.00 to 0.12]
Neuroticism	**0.25***** (0.06)	**0.31*** (0.14)	**0.29*** (0.12)	**[0.01** to **0.18]**
Extraversion	0.06 (0.06)	**0.31*** (0.14)	**0.36***** (0.12)	[−0.01 to 0.08]

Note: N = 221.
R^2 = 0.16.
$^{*}p < 0.05$; $^{**}p < 0.01$; $^{***}p < 0.001$.
[a] The range between Hayes's (2012) bootleg lower limit/confidence interval (bootLLCI) and upper limit/confidence interval (bootULCI) indicates the significance of mediation.

Appendix B. Supplementary material

Supplementary data to this article can be found online at https://doi.org/10.1016/j.trf.2018.09.001.

References

Albert, G., & Lotan, T. (2018). How many times do young drivers actually touch their smartphone screens while driving? *IET Intelligent Transport Systems, 12*, 414. https://doi.org/10.1049/iet-its.2017.0208.

Andreassen, C. S., Griffiths, M. D., Hetland, J., Kravina, L., Jensen, F., & Pallesen, S. (2014). The prevalence of workaholism: A survey study in a nationally representative sample of Norwegian employees. *PLoS ONE, 9*(8), e102446. https://doi.org/10.1371/journal.pone.0102446.

Andreassen, C. S., Torsheim, T., Brunborg, G. S., & Pallesen, S. (2012). Development of a Facebook addiction scale 1, 2. *Psychological Reports, 110*, 501–517. https://doi.org/10.2466/02.09.18.PR0.110.2.501-517.

Arthur, W., Jr., & Graziano, W. G. (1996). The five-factor model, conscientiousness, and driving accident involvement. *Journal of Personality, 64*, 593–618. https://doi.org/10.1111/j.1467-6494.1996.tb00523.x.

Beus, J. M., Dhanani, L. Y., & McCord, M. A. (2015). A meta-analysis of personality and workplace safety: Addressing unanswered questions. *Journal of Applied Psychology, 100*, 481. https://doi.org/10.1037/a0037916.

Bianchi, A., & Phillips, J. G. (2005). Psychological predictors of problem mobile phone use. *CyberPsychology & Behavior, 8*, 39–51. https://doi.org/10.1089/cpb.2005.8.39.

Billieux, J., Maurage, P., Lopez-Fernandez, O., Kuss, D. J., & Griffiths, M. D. (2015). Can disordered mobile phone use be considered a behavioral addiction? An update on current evidence and a comprehensive model for future research. *Current Addiction Reports, 2*, 156–162. https://doi.org/10.1007/s40429-015-0054-y.

Billieux, J., Van der Linden, M., d'Acremont, M., Ceschi, G., & Zermatten, A. (2007). Does impulsivity relate to perceived dependence on and actual use of the mobile phone? *Applied Cognitive Psychology, 21*, 527–537. https://doi.org/10.1002/acp.1289.

Bowen, S., Chawla, N., & Witkiewitz, K. (2014). Mindfulness-based relapse prevention for addictive behaviors. In R. A. Baer (Ed.), *Mindfulness-based treatment approaches* (2nd ed., pp. 141–157). London, United Kingdom: Academic Press. https://doi.org/10.1016/B978-0-12-416031-6.00007-4.

Caird, J. K., Johnston, K. A., Willness, C. R., Asbridge, M., & Steel, P. (2014). A meta-analysis of the effects of texting on driving. *Accident Analysis & Prevention, 71*, 311–318. https://doi.org/10.1016/j.aap.2014.06.005.

Carney, C., Harland, K. K., & McGehee, D. V. (2017). Examining teen driver crashes and the prevalence of distraction: Recent trends, 2007–2015. *Journal of Safety Research, 64*, 21–27. https://doi.org/10.1016/j.jsr.2017.12.014.

Clarke, S., & Robertson, I. T. (2005). A meta-analytic review of the Big Five personality factors and accident involvement in occupational and non-occupational settings. *Journal of Occupational & Organizational Psychology, 78*, 355–376. https://doi.org/10.1348/096317905X26183.

Conrod, P. J., Castellanos-Ryan, N., & Strang, J. (2010). Brief, personality-targeted coping skills interventions and survival as a non-drug user over a 2-year period during adolescence. *Archives of General Psychiatry, 67*, 85–93. https://doi.org/10.1001/archgenpsychiatry.2009.173.

Conrod, P. J., Stewart, S. H., Comeau, N., & Maclean, A. M. (2006). Efficacy of cognitive–behavioral interventions targeting personality risk factors for youth alcohol misuse. *Journal of Clinical Child and Adolescent Psychology, 35*(4), 550–563. https://doi.org/10.1207/s15374424jccp3504_6.

Dahlen, E. R., Edwards, B. D., Tubré, T., Zyphur, M. J., & Warren, C. R. (2012). Taking a look behind the wheel: An investigation into the personality predictors of aggressive driving. *Accident Analysis & Prevention, 45*, 1–9. https://doi.org/10.1016/j.aap.2011.11.012.

De Pasquale, C., Sciacca, F., & Hichy, Z. (2017). Italian validation of smartphone addiction scale short version for adolescents and young adults (SAS-SV). *Psychology, 8*, 1513. https://doi.org/10.4236/psych.2017.810100.

Demirhan, E., Randler, C., & Horzum, M. B. (2016). Is problematic mobile phone use explained by chronotype and personality? *Chronobiology International, 33*, 821–831. https://doi.org/10.3109/07420528.2016.1171232.

Dishion, T. J., Andrews, D. W., & Crosby, L. (1995). Antisocial boys and their friends in early adolescence: Relationship characteristics, quality, and interactional process. *Child Development, 66*, 139–151. https://doi.org/10.1111/j.1467-8624.1995.tb00861.x.

Donker, T., Petrie, K., Proudfoot, J., Clarke, J., Birch, M. R., & Christensen, H. (2013). Smartphones for smarter delivery of mental health programs: A systematic review. *Journal of Medical Internet Research, 15*(11). https://doi.org/10.2196/jmir.2791 e247.

Economides, M., Martman, J., Bell, M. J., & Sanderson, B. (2018). Improvements in stress, affect, and irritability following brief use of a mindfulness-based smartphone app: A randomized controlled trial. *Mindfulness, 1–10*. https://doi.org/10.1007/s12671-018-0905-4.

Ehrenberg, A. L., Juckes, S. C., White, K. M., & Walsh, S. P. (2000). Personality and self-esteem as predictors of young people's technology use. *CyberPsychology & Behavior, 11*, 739–741. https://doi.org/10.1089/cpb.2008.0030.

Elander, J., West, R., & French, D. (1993). Behavioral correlates of individual differences in road-traffic crash risk: An examination of methods and findings. *Psychological Bulletin, 113*, 279–294. https://doi.org/10.1037/0033-2909.113.2.279.

Frederick, K. L., Lucas, R., & Bairo, B. M. (2006). The mini scales: Tiny-yet- effective measures of the Big Five factors of personality. *Psychological Assessment, 18*, 192–203. https://doi.org/10.1037/1040-3590.18.2.192.

Friedman, H. S., Tucker, J. S., Schwartz, J. E., Martin, L. R., Tomlinson-Keasey, C., Wingard, D. L., & Criqui, M. H. (1995). Childhood conscientiousness and longevity: Health behaviors and cause of death. *Journal of Personality and Social Psychology, 68*, 696. https://doi.org/10.1037/0022-3514.68.4.696.

Garland, E., Froeliger, B., & Howard, M. (2014). Mindfulness training targets neurocognitive mechanisms of addiction at the attention-appraisal-emotion interface. *Frontiers in Psychiatry, 4*, 173. https://doi.org/10.3389/fpsyt.2013.00173.

Griffiths, M. (1996). Behavioural addiction: An issue for everybody? *Employee Counselling Today, 8*(3), 19–25. https://doi.org/10.1108/13665629610116872.

Hartanto, A., & Yang, H. (2016). Is the smartphone a smart choice? The effect of smartphone separation on executive functions. *Computers in Human Behavior, 64*, 329–336. https://doi.org/10.1016/j.chb.2016.07.002.

Hayes, A. F. (2009). Beyond Baron and Kenny: Statistical mediation analysis in the new millennium. *Communication Monographs, 76*, 408–420. https://doi.org/10.1080/03637750903310360.

Hayes, A. F. (2012). Process: A versatile computational tool for observed variable mediation, moderation, and conditional process modeling. Retrieved from <http://www.afhayes.com/public/process2012.pdf>.

Hedlund, J. (2011). Distracted driving: What research shows and what states can do. Washington, DC: Governors Highway Safety Association. Retrieved from <http://www.ghsa.org/html/files/pubs/sfdist11.pdf>.

Herzberg, P. Y. (2009). Beyond "accident-proneness": Using five-factor model prototypes to predict driving behavior. *Journal of Research in Personality, 43*, 1096–1100. https://doi.org/10.1016/j.jrp.2009.08.008.

Hong, F. Y., Chiu, S. I., & Huang, D. H. (2012). A model of the relationship between psychological characteristics, mobile phone addiction and use of mobile phones by Taiwanese university female students. *Computers in Human Behavior, 28*, 2152–2159. https://doi.org/10.1016/j.chb.2012.06.020.

Iacoviello, B. M., Steinerman, J. R., Klein, D. B., Silver, T. L., Berger, A. G., Luo, S. X., & Schork, N. J. (2017). Clickotine, a personalized smartphone app for smoking cessation: Initial evaluation. *JMIR mHealth and uHealth, 5*(4), e56. https://doi.org/10.2196/mhealth.7226.

Igarashi, T., Motoyoshi, T., Takai, J., & Yoshida, T. (2008). No mobile, no life: Self-perception and text-message dependency among Japanese high school students. *Computers in Human Behavior, 24*, 2311–2324. https://doi.org/10.1016/j.chb.2007.12.001.

Joinson, A. N. (2004). Self-esteem, interpersonal risk, and preference for e-mail to face-to-face communication. *CyberPsychology & Behavior, 7*, 472–478. https://doi.org/10.1089/cpb.2004.7.472.

Jovanović, D., Lipovac, K., Stanojević, P., & Stanojević, D. (2011). The effects of personality traits on driving-related anger and aggressive behaviour in traffic among Serbian drivers. *Transportation Research Part F: Traffic Psychology and Behaviour, 14*, 43–53. https://doi.org/10.1016/j.trf.2010.09.005.

Kim, H. (2013). Exercise rehabilitation for smartphone addiction. *Journal of Exercise Rehabilitation, 9*, 500–505. https://doi.org/10.12965/jer.130080.
Kuss, D. J., Van Rooij, A. J., Shorter, G. W., Griffiths, M. D., & van de Mheen, D. (2013). Internet addiction in adolescents: Prevalence and risk factors. *Computers in Human Behavior, 29*, 1987–1996. https://doi.org/10.1016/j.chb.2013.04.002.
Kwon, M., Kim, D. J., Cho, H., & Yang, S. (2013). The Smartphone Addiction Scale: Development and validation of a short version for adolescents. *PLOSOne, 8* (12), e83558. https://doi.org/10.1371/journal.pone.0083558.
Lane, W., & Manner, C. (2011). The impact of personality traits on smartphone ownership and use. *International Journal of Business and Social Science, 2*(17), 22–28.
Laverdiere, O., Morin, A. J., & St-Hilaire, F. (2013). Factor structure and measurement invariance of a short measure of the Big Five personality traits. *Personality and Individual Differences, 55*, 739–743. https://doi.org/10.1016/j.paid.2013.06.008.
Leary, M. R. (1983). Social anxiousness: The construct and its measurement. *Journal of Personality Assessment, 47*, 66–75. https://doi.org/10.1207/s15327752jpa4701_8.
Li, Z., Sang, Z., Wang, L., & Shi, Z. (2012). The mini—IPIP Scale: Psychometric features and relations with PTSD symptoms of Chinese earthquake survivors. *Psychological Reports, 111*, 641–651. https://doi.org/10.2466/16.12.15.PR0.111.5.641-651.
Lipovac, K., Đerić, M., Tešić, M., Andrić, Z., & Marić, B. (2017). Mobile phone use while driving-literary review. *Transportation Research Part F: Traffic Psychology and Behaviour, 47*, 132–142. https://doi.org/10.1016/j.trf.2017.04.015.
Marlatt, G. A., Baer, J. S., Donovan, D. M., & Kivlahan, D. R. (1988). Addictive behaviors: Etiology and treatment. *Annual Review of Psychology, 39*, 223–252. https://doi.org/10.1146/annurev.ps.39.020188.001255.
Meeker, M., & Wu, L. (2013). Internet trends 2013 (Kleiner Perkins Caufield Byers Technical report). Retrieved from <https://www.slideshare.net/kleinerperkins/kpcb-internet-trends-2013/52-Mobile_Users_Reach_to_Phone>.
Metz, B., Landau, A., & Just, M. (2014). Frequency of secondary tasks in driving: Results from naturalistic driving data. *Safety Science, 68*, 195–203. https://doi.org/10.1016/j.ssci.2014.04.002.
Motoharu, T. (2014). Problematic mobile phone use and Big Five personality domains. *Indian Journal of Community Medicine, 39*, 111–113. https://doi.org/10.4103/0970-0218.132736.
Nemme, H. E., & White, K. M. (2010). Texting while driving: Psychosocial influences on young people's texting intentions and behaviour. *Accident Analysis and Prevention, 42*, 1257–1265. https://doi.org/10.1016/j.aap.2010.01.019.
O'Leary-Barrett, M., Mackie, C. J., Castellanos-Ryan, N., Al-Khudhairy, N., & Conrod, P. J. (2010). Personality-targeted interventions delay uptake of drinking and decrease risk of alcohol-related problems when delivered by teachers. *Journal of the American Academy of Child & Adolescent Psychiatry, 49*, 954–963. https://doi.org/10.1016/j.jaac.2010.04.011.
Oltedal, S., & Rundmo, T. (2006). The effects of personality and gender on risky driving behaviour and accident involvement. *Safety Science, 44*, 621–628. https://doi.org/10.1016/j.ssci.2005.12.003.
Peele, S. (1985). *The meaning of addiction: Compulsive experience and its interpretation*. Lexington, MA: Lexington Books/DC Heath.
Phillips, J. G., Butt, S., & Blaszczynski, A. (2006). Personality and self-reported use of mobile phones for games. *CyberPsychology & Behavior, 9*, 753–758. https://doi.org/10.1089/cpb.2006.9.753.
Ross, C., Orr, E. S., Sisic, M., Arseneault, J. M., Simmering, M. G., & Orr, R. R. (2009). Personality and motivations associated with Facebook use. *Computers in Human Behavior, 25*, 578–586. https://doi.org/10.1016/j.chb.2008.12.024.
Shaffer, H. J. (1996). Understanding the means and objects of addiction: Technology, the internet, and gambling. *Journal of Gambling Studies, 12*(4), 461–469. https://doi.org/10.1007/BF01539189.
Srivastava, L. (2005). Mobile phones and the evolution of social behavior. *Behaviour and Information Technology, 24*, 111–129. https://doi.org/10.1080/01449290512331321910.
Sümer, N., Lajunen, T., & Özkan, T. (2005). Big Five personality traits as the distal predictors of road accident involvement. In G. Underwood (Ed.), *Traffic and transport psychology: Theory and application* (pp. 215–227). Bingley, United Kingdom: Elsevier Science and Technology.
Sween, M., Ceschi, A., Tommasi, F., Sartori, R., & Weller, J. (2017). Who is a distracted driver? Associations between mobile phone use while driving, domain-specific risk taking, and personality. *Risk Analysis, 37*, 2119–2131. https://doi.org/10.1111/risa.12773.
Tison, J., Chaudhary, N., & Cosgrove, L. (2011). National phone survey on distracted driving attitudes and behaviors (U.S. Department of Transportation Report DOT HS 811-555). Retrieved from <https://ntl.bts.gov/lib/45000/45700/45720/811555.pdf>.
U.S. National Highway Traffic Safety Administration. (2013). Traffic safety facts, research note: Distracted driving 2011 (U.S. Department of Transportation Summary of statistical findings DOT HS 811 737). Retrieved from <https://crashstats.nhtsa.dot.gov/Api/Public/ViewPublication/811737>.
Williams, A. F. (2003). Teenage drivers: Patterns of risk. *Journal of Safety Research, 34*, 5–15. https://doi.org/10.1016/S0022-4375(02)00075-0.
Wittek, C. T., Finserås, T. R., Pallesen, S., Mentzoni, R. A., Hanss, D., Griffiths, M. D., & Molde, H. (2016). Prevalence and predictors of video game addiction: A study based on a national representative sample of gamers. *International Journal of Mental Health and Addiction, 14*, 672–686. https://doi.org/10.1007/s11469-015-9592-8.
Young, K. L., & Salmon, P. M. (2012). Examining the relationship between driver distraction and driving errors: A discussion of theory, studies and methods. *Safety Science, 50*, 165–174. https://doi.org/10.1016/j.ssci.2011.07.008.
Yuchang, J., Cuicui, S., Junxiu, A., & Junyi, L. (2017). Attachment styles and smartphone addiction in Chinese college students: The mediating roles of dysfunctional attitudes and self-esteem. *International Journal of Mental Health and Addiction, 15*, 1122–1134. https://doi.org/10.1007/s11469-017-9772-9.