The Relation Between Smartphone Use and Everyday Inattention

by

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Author's Declaration

This thesis consists of material all of which I authored or co-authored: see Statement of Contributions included in the thesis. This is a true copy of the thesis, including any required final revisions, as accepted by my examiners.

I understand that my thesis may be made electronically available to the public.

Statement of Contributions

Jeremy Marty-Dugas was the primary author of the manuscript, conceived the smartphone questionnaires, and analyzed the data.

Brandon Ralph assisted with the creation of the smartphone usage questionnaires and writing the manuscript.

Jonathan Oakman provided assistance in conducting and interpreting the data analysis of the present study.

Daniel Smilek guided the research process, including the creation of the smartphone questionnaires, data analysis, and presentation of the findings in written format.

Abstract

In two studies, we explored the relation between subjective reports of smartphone use and everyday inattention. We created two questionnaires that measured general smartphone use (i.e. how frequently people send and receive texts, use social media, etc), and absent-minded smartphone use (i.e. how frequently people use their phone without a purpose in mind). In addition, participants completed four scales assessing everyday attention lapses, attention-related errors, spontaneous mind wandering and deliberate mind wandering, which were included in order to measure everyday inattention. The results of both studies revealed a strong positive relation between general and absent-minded smartphone use. Furthermore, we observed significant positive relations between each of the smartphone use questionnaires and each of the four measures of inattention. However, a series of regression analyses demonstrated that when both types of smartphone use were used as simultaneous predictors of inattention, the relation between inattention and smartphone use was driven entirely by absent-minded use. Specifically, absent-minded smartphone use consistently had a unique positive relation with the inattention measures, while general smartphone use either had no relation (Study 1) or a unique negative relation (Study 2) with inattention.

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Dedication

To my parents for all their love and support. Thank you for fostering my curiousity, tenacity, and interest in learning about the world. Thank you as well for all the accidental calls and texts I receive on a daily basis. Hopefully, this research will convince you to go back to a rotary phone.

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Introduction

In the 21st century, smartphones have become a near constant fixture in our daily lives. In the United States, for instance, smartphone ownership has jumped from 35% to 68% between 2011 and 2015 (Anderson, 2015). One likely reason for this increase is that smartphones confer a great deal of utility; they provide a portable means by which we can connect with friends and family, capture and share high quality photographs, listen to music, navigate our environment, and access a great deal information via the internet.

Despite the numerous benefits that smartphones might confer, there is reason to believe that smartphones might be associated with a variety of negative outcomes. For example, research on general mobile phone use, ranging from mobile devices with only talking and texting capabilities to modern smartphones, has shown that such devices are a serious distraction to drivers. Indeed, mobile devices have been implicated in approximately 27% of all auto accidents in the United States (National Safety Council, 2013), as well as recent rail disasters (Reuters, 2008; The Guardian, 2016). As a secondary task that serves to divide attention, mobile phone conversations impair performance on a variety of behaviours critical for accident avoidance (Strayer, 2015; Strayer, Drews, & Johnston, 2003; Strayer & Johnston, 2001). Perhaps most troubling, the effect of using a cellular phone while driving appears to be just as detrimental as driving drunk, when directly compared in a driving simulator (Strayer, Drews, & Crouch, 2006).

Distraction via mobile phones has also become a primary concern in other real-world contexts. In the medical industry, for instance (see Gill, Kamath, & Gill, 2012), there have been claims that patient lives have been endangered by doctor inattention caused by smartphone use (Halamka, 2011). A recent survey found that among medical professionals performing cardiopulmonary bypass, a situation in which vigilance is critical for patient safety, 56% have admitted to using their cellphone during surgical procedures (Smith, Darling, & Searles, 2011). When it comes to academic performance, the available evidence suggests that students who use their mobile phones to text or talk while completing schoolwork have poorer educational outcomes than those who do not (Junco & Cotten, 2012), and that ringing phones during a lecture can divide attention and result in poorer recall of lecture material (Shelton, Elliot, Lynn, & Exner, 2009). Furthermore, researchers have demonstrated that participants who were more reliant on their smartphones for information, also used less analytical thinking when completing reasoning tasks (Barr, Pennycook, Stolz, & Fugelsang, 2015). Mobile phones even seem to impair everyday behaviours such as walking, by dividing attention and making people less aware of their surroundings (Hyman, Boss, Wise, McKenzie, & Caggiano, 2010). There are consequences to this lack of awareness, whether it means failing to notice a unicycling clown (Hyman et al., 2010), or falling from a cliff while playing pokemonGO (CNN, 2016). As mobile phones become 'smarter' and grow in functionality and sophistication, it seems reasonable to assume that distraction and inattention caused by these devices will increase as well.

In the current investigation, we further explored the relation between smartphone use and daily inattention using an individual differences approach. Individual differences in daily inattention are often measured through subjective report scales that assess experiences such attention lapses, everyday foibles related to episodes of inattention, and mind-wandering. Here, we briefly describe four distinct measures of inattention used in the present study. The Mindful Attention Awareness Scale – Lapses Only variant (MAAS-LO; Brown & Ryan, 2003; Carriere, Cheyne, & Smilek, 2008) is a commonly used measure of attention lapses, which contains items such as: "I find myself doing things without paying attention." Everyday attention-related foibles are typically indexed by the Attention-Related Cognitive Errors Scale (ARCES; Cheyne, Carriere, &

Smilek, 2006), which requires participants to respond to items such as: “I have gone to the fridge to get one thing (e.g. milk) and taken something else (e.g. juice).” Finally, two forms of mind-wandering in everyday life, unintentional and intentional mind-wandering, can be indexed by the Spontaneous and Deliberate Mind-Wandering questionnaires (MWS and MWD, respectively; Carriere, Seli, & Smilek, 2013), containing items such as: “I mind-wander even when I’m supposed to be doing something else” and “I allow myself to get absorbed in pleasant fantasy.” It is important to keep in mind that the foregoing are all general measures of inattention in everyday life which do not directly inquire about smartphone related activity.

Why might smartphone use be related to such experiences of general inattention in everyday life? One set of answers to this question concerns the *frequency* of general smartphone use (e.g., receiving notifications from apps, emails, or texts). For instance, using a smartphone more frequently may create more *opportunities* for attention to be divided, thereby leading to more attention-related errors. Furthermore, it could be that frequent interruptions from a myriad of notifications, or continuously using smartphones to multi-task (and thereby divide attention), may erode one’s ability to sustain attention on a single task for extended periods of time. Indeed, it has been suggested in the media multitasking literature, that those who readily multitask with media (such as smartphones) might have altered attentional mechanisms compared to light media multitaskers (Cain and Mitroff, 2011; Lin, 2009; Ophir, Nass, & Wagner, 2009; Ralph, Thompson, Cheyne & Smilek, 2014); the fact that heavy media multi-taskers reportedly have less gray matter volume in the Anterior Cingulate Cortex seems to support this idea (Loh & Kanai, 2014). Alternatively, it is possible that frequent smartphone use has no detrimental effect on the attention system, but that individuals who use their smartphones more frequently simply develop a preference for engaging with the world in short temporal windows of focal attention. Whether frequent smartphone use leads to more situations of divided attention, degrades the attention system, or simply changes personal preferences for distributing attentional resources, one would expect that individuals who frequently engage in general smartphone-related behaviours (e.g., more texting, more emailing, or more use of the calendar to organize oneself) will also report more frequent episodes of general inattention in their everyday life.

Another interesting possibility, which we explore in the current paper, is that it is not the frequency (i.e., amount) of *general* smartphone use that matters, but rather the specific way people use their smartphones. Particularly, it seems reasonable to hypothesize that individuals who often use their smartphone specifically in an *absent-minded* manner may also experience more episodes of inattention and attention-related errors. Indeed, most smartphone users have experienced using their phones for longer than they intended to, scrolling through information without a goal in mind, or finding themselves repeatedly checking their phones without even realizing it–all of which may be categorized as absent-minded behaviours. Indeed, previous research has indicated that checking behaviours occur frequently, despite often being an annoyance to the user (Oulasvirta, Rattenbury, Ma, & Raita, 2012). Along these lines, absent-minded smartphone use might reflect and even strengthen one's overall tendency to be absent-minded, which would manifest in more absent-mindedness and inattention in everyday life.

To adjudicate between general and absent-minded smartphone use, we constructed two questionnaires called the Smartphone Use Questionnaire: General (SUQ-G) and the Smartphone Use Questionnaire: Absent-Minded (SUQ-A). The SUQ-G assesses the frequency of a variety of basic smartphone behaviours, such as how often individuals send and receive text messages, or use their phone to browse the web. The SUQ-A, on the other hand, focuses on the frequency of absent-minded behaviour such as using the smartphone for longer than intended, repeated unconscious checking, or engaging in various phone-functions without noticing that one is doing so (see Appendix A for the full questionnaires).

In what follows, we report two studies wherein we investigated the relation among general and absent-minded smartphone use and everyday experiences of inattention using an individual differences approach. In both studies, we included measures of general smartphone use (SUQ-G) and absent-minded smartphone use (SUQ-A) as well as the four self-reported scales of everyday inattention described below (MAAS-LO, ARCES, MWS and MWD). Study 1 was conducted using a sample of undergraduate university students. In Study 2 we sought to replicate our findings from Study 1 with a more diverse sample of participants. We anticipated that increased general smartphone usage would be related to increased frequency of absent-minded smartphone usage, which would be reflected in a positive correlation between the SUQ-G and the SUQ-A. Second, we expected that both forms of smartphone usage would be positively related to inattention, but that absent-minded use in particular would be related to inattention more strongly. Finally, our third goal was to explore the unique contributions of general smartphone use and absent-minded smartphone use when predicting the various measures of inattention.

Study 1

Method

Participants. One hundred and eighty-five undergraduates from the University of Waterloo participated in exchange for partial course credit. Our goal was to collect as many participants as possible prior to the end of term. Of these, 25 participants failed to complete at least one of the measures and were thus removed from the sample before data analysis. As our scales were included with a series of other scales, participants were not explicitly required to own a smartphone to participate. We investigated smartphone ownership by looking at responses to the question "How often do you have your smartphone on your person?". Only one participant indicated "1 – Never" (in fact, this was their response to every smartphone related question) and was removed, leaving data from 159 participants (85 females) for analysis. Participant age ranged from 18 – 33 years old, with a mean of 20.42 (SD = 2.25). Three participants declined to provide their age.

Measures.

Smartphone Use Questionnaires (SUQ-G and SUQ-A). To distinguish between frequent general use of a smartphone and frequent absent-minded use of a smartphone, we developed two new questionnaires – the Smartphone Use Questionnaire: General (SUQ-G) and the Smartphone Use Questionnaire: Absent-Minded (SUQ-A). Both questionnaires contain 10 items that participants respond to using a 7-point scale ranging from 1 (Never) to 7 (All the time). The full questionnaires are presented in Appendix A. The SUQ-G was designed to measure the frequency with which participants engaged in a broad range of smartphone-related behaviours, such as how often they send and receive text messages, use social media, or browse the web on their smartphone, containing items such as "When you get a notification on your phone, how often do you check it immediately?” and “How often do you check social media apps such as snapchat, facebook, or twitter?” On the other hand, the SUQ-A was designed to assess the frequency with which individuals engaged their phones absent-mindedly. For example, the SUQ-A contains items such as “How often do you find yourself checking your phone without realizing why you did it?” and “How often do you lose track of time while using your phone?” In each of the experiments presented here, items from these two questionnaires were intermixed and presented together in a random order in an attempt to reduce the potential impact of social desirability on responses to questions about absent-minded use.

Mindful Attention Awareness Scale - Lapses Only (MAAS-LO). The MAAS-LO (Brown & Ryan, 2003; Carriere et al., 2008) is a 12-item scale that assesses the frequency with which individuals behave in a mindless or absent-minded fashion. Participants respond to items such as “I snack without being aware that I’m eating” and “I rush through activities without being really attentive to them” on a 6-point Likert scale ranging from 1 (almost never) to 6 (almost always). The MAAS-LO has been demonstrated to have good internal consistency (i.e. above .8) (Carriere et al., 2008; Ralph et al., 2014)

Attention Related Cognitive Errors Scale (ARCES). The ARCES is a 12-item self-report measure designed to assess the frequency of everyday performance errors that result from lapses in sustained attention. Participants indicate responses to statements such as “I have gone into a room to get something, got distracted, and left without what I went there for” on a 5-point Likert scale ranging from 1 (never) to 5 (very often). The ARCES has been demonstrated to be both a reliable and valid scale, such that higher scores on the ARCES predict poorer performance on the Sustained Attention to Response Task (SART; Cheyne et al., 2006). The ARCES has been consistently demonstrated to have high internal consistency (Cheyne et al., 2006; Ralph et al., 2014).

Spontaneous and Deliberate Mind-Wandering (MWS and MWD). The Spontaneous Mind-Wandering Scale (MWS) and Deliberate Mind-Wandering Scale (MWD) are 4-items subjective reports that inquire about the tendency to experience unintentional / spontaneous episodes of mind-wandering (MWS), and the tendency to experience intentional / deliberative episodes of mind-wandering (MWD). On the MWS, participants respond to statements such as "I find my mind wandering spontaneously", whereas on the MWD, participants respond to statements such as "I allow my thoughts to wander on purpose". On both scales, participants respond to statements using a 7-point scale with respond options ranging from 1 (Rarely) to 7 (A lot). Previous research has found spontaneous and deliberate mind-wandering to be positively correlated (Carriere et al., 2013; Seli, Carriere, & Smilek, 2015), but they have also been shown to be dissociable as well (for a review, see Seli, Risko, & Smilek, 2016). Each of these scales has been demonstrated to have high reliability (Carriere et al., 2013).

Procedure. Participants were provided with a link to an online version of the questionnaires. The questionnaires of interest were presented together with 11 other questionnaires, both of our own and from other researchers, that were unrelated to the current study. After providing informed consent participants completed the measures, including the two newly developed questionnaires of smartphone use, along with four scales measuring inattention: the Attention-Related Cognitive Errors (ARCES), the Mindful Attention Awareness Scale - Lapses Only (MAAS-LO), as well as the spontaneous (MWS) and deliberate mind-wandering (MWD) scales. The smartphone and inattention measures were presented in random order and the order of the questions within each scale was randomized as well.[1]

[1] The inattention measures were used in a separate study that ran concurrently during Study 1. We visually inspected the data to ensure that Study 1 only included those participants who were answering the inattention scales for the first time.

Results

The results of the present study are described in three sections. In the first section we describe the psychometric properties of our measures, with a specific focus on the new measures of smartphone use (SUQ-G and SUQ-A) that we developed. In the second section we analyze the relation between the smartphone use questionnaires and the measures of inattention (MAAS-LO, ARCES, MWS, MWD). In the third section, we assess the unique contributions of each type of smartphone use to the understanding of inattention by conducting a series of regression analyses using the smartphone questionnaires (SUQ-A and SUQ-G) as simultaneous predictors of each inattention measure.

Psychometrics. The descriptive statistics corresponding to each of the measures are shown in Table 1. Both of the new smartphone questionnaires were found to have a good Cronbach's alpha (SUQ-G = .78, SUQ-A =.91), indicating the questionnaires had internal consistency. The questionnaires also had reasonable values for skewness and kurtosis, indicating a relatively normal distribution of scores (i.e. skewness < 2 and kurtosis < 4; see Kline, 1998). Item statistics for each of the smartphone use questionnaires are presented in Table 2.

Table 1 Descriptive statistics for Study 1 (n = 159)

Scale	Mean	SD	Skew	Kurtosis	α
SUQ-A	4.55	1.15	-.05	-.27	.90
SUQ-G	4.73	.88	-.05	-.24	.77
MAAS-LO	3.43	.72	-.01	.68	.85
ARCES	3.02	.63	.54	.70	.89
MWS	4.62	1.28	-.44	.12	.90
MWD	4.90	1.30	-.18	-.49	.91

Skew S.E. = .19 Kurtosis SE = .38

The MAAS-LO, ARCES, MWS, and MWD have been demonstrated to have acceptable psychometric properties in the past, and were each found to have acceptable psychometric properties in the current sample as well.

Table 2 Item Statistics for general smartphone use (SUQ-G) and absent-minded smartphone use (SUQ-A; *n* = 159)

Item	Mean	SD	Corrected Item-Total Correlation	Item	Mean	SD	Corrected Item-Total Correlation
SUQ-G1	6.13	1.11	.281	SUQ-A1	4.78	1.56	.326
SUQ-G2	4.86	1.38	.536	SUQ-A2	3.55	1.47	.534
SUQ-G3	4.51	1.72	.521	SUQ-A3	4.86	1.51	.746
SUQ-G4	4.90	1.42	.623	SUQ-A4	4.81	1.55	.788
SUQ-G5	4.89	1.52	.553	SUQ-A5	5.11	1.43	.777
SUQ-G6	2.97	1.64	.240	SUQ-A6	4.32	1.69	.696
SUQ-G7	5.02	1.25	.472	SUQ-A7	4.04	1.67	.625
SUQ-G8	4.35	1.71	.323	SUQ-A8	4.62	1.52	.754
SUQ-G9	5.03	1.60	.532	SUQ-A9	4.93	1.54	.690
SUQ-G10	4.62	1.67	.422	SUQ-A10	4.52	1.76	.691

Smartphone Use and Daily Inattention. A full correlation table showing the relations among each of the measures is presented in Table 3. In line with our expectations, there was a strong positive relation between general (SUQ-G) and absent-minded (SUG-A) smartphone use $r(157) = .71$, $p < .01$, indicating that the more frequently individuals use their smartphones, the more frequently they use their smartphones in an absent-minded fashion. Next we examined the relations between these two measures and the four measures of inattention (i.e., the MAAS-LO, ARCES, MWS, and MWD). As can be seen in Table 3, both of the smartphone use measures (SUQ-G and SUQ-A) showed a positive relation with each of the inattention measures. In addition, Table 3 shows that the relations between the inattention measures and absent-minded smartphone use (SUQ-A) were nominally of greater magnitude than the relations between the inattention measures and the measure of general smartphone use (SUQ-G).

Table 3
Smartphone use and inattention measures (*n* = 159)

	1	2	3	4	5
1 SUQ-A					
2 SUQ-G	.710**				
3 MAAS-LO	.419**	.264**			
4 ARCES	.473**	.265**	.597**		
5 MWS	.404**	.315**	.438**	.511**	
6 MWD	.257**	.122	.321**	.247**	.544**

** $p < .01$ (2-tailed)

To test whether the magnitude of the correlations between the inattention measures with SUQ-A and the inattention measures with SUQ-G were significantly different, we used a Fisher's r to z transformation (Lee & Preacher, 2013). The correlation between the MAAS-LO and the SUQ-A was found to be significantly larger than the correlation between the MAAS-LO and the SUQ-G (Z = 2.75, $p = .006$). The correlation between the ARCES and the SUQ-A was also found to be significantly larger than the correlation between the ARCES and the SUQ-G (Z = 3.77, $p < .001$). For the mind-wandering measures the correlation between the MWD and the SUQ-A was significantly larger than the correlation between the MWD and the SUQ-G (Z = 2.27, $p = .023$). However, the difference in magnitude between the MWS and the SUQ-A, and the MWS and SUQ-G was non-significant (Z = 1.59, $p = .11$). In general, these findings demonstrated that absent-minded smartphone use was significantly more correlated with everyday inattention than general smartphone use.

Unique Contributions of Smartphone Use. To further investigate the relation between inattention and the two types of smartphone use we conducted a series of regression analyses. We predicted each of the inattention measures (MAAS-LO, ARCES, MWS, MWD) using the SUQ-A and SUQ-G as simultaneous predictors in a linear regression model. Collectively, these two smartphone measures predicted a significant amount of the variance in each of the measures of inattention (see Table 4).

Table 4 Multiple regression predicting everyday inattention measures by general smartphone use, and absent-minded smartphone use (*N* = 159)

DV	IV	β	*t*	*p*	Zero-order	Partial
MAAS-LO						
	SUQ-G	-.10	-.97	.333	.247	-.077
	SUQ-A	.48	4.52	.001	.405	.339
			R = .411, $F(2, 157)$ = 15.97, SE = .659, $p < .001$			
ARCES						
	SUQ-G	-.18	-1.75	.830	.251	-.138
	SUQ-A	.59	5.75	.001	.460	.417
			R = .476, $F(2, 157)$ = 22.97, SE = .557, $p < .001$			
MWS						
	SUQ-G	-.02	-.18	.858	.249	-.014
	SUQ-A	.37	3.37	.001	.353	.260
			R = .354, $F(2, 157)$ = 11.22, SE = 1.21, p = .001			
MWD						
	SUQ-G	-.09	-.811	.418	.165	-.065
	SUQ-A	.35	3.14	.002	.284	.243
			R = .291, $F(2, 157)$ = 7.25, SE = 1.26, p = .001			

As can been seen in Table 4, when the SUQ-A and the SUQ-G are entered as simultaneous predictors of each of the inattention measures, it is only the SUQ-A that significantly predicted inattention. That is, the unique relation between absent-minded smartphone use and each of the inattention measures was positive, but this was not the case for general smartphone use, which showed a unique non-significant negative relation to the inattention measures. Furthermore, this pattern held across all four measures of inattention, suggesting that the relationship between smartphone use and inattention is driven by absent-minded use, rather than by smartphone use *per se*.

Thus far we have shown that absent-minded smartphone use (SUQ-A) is uniquely associated with each of the inattention measures. However, it is worth considering whether these relations just reflect an underlying construct of 'absent-mindedness' that is related to all measures. Indeed, previous research has demonstrated that attention lapses (as measured by the MAAS-LO, which is sometimes construed as a measure of absent-mindedness) are related to measures of everyday attention errors (Cheyne et al., 2006), as well as deliberate and spontaneous mind-wandering (Carriere et al., 2013; Ralph et al., 2014). To address this issue we conducted a set of hierarchical regressions, using the MAAS-LO and the SUQ-A as predictors of the remaining inattention measures (ARCES, MWS and MWD). First, we sought to determine whether the SUQ-A uniquely predicted scores on the ARCES (over and above the variance accounted for by the MAAS-LO, construed as a measure of absent-mindedness). In Step 1 we used scores on the MAAS-LO to predict scores on the ARCES, and found that it was a significant predictor of attention-related errors (see Table 5). In Step 2 we added the SUQ-A, which predicted unique variance in the ARCES, above and beyond that predicted by the MAAS-LO (see Table 5). Using the same hierarchy, we predicted scores on the MWS and the MWD. The SUQ-A accounted for unique variance in the MWS (see Table 6), but fell short of predicting unique additional variance in the MWD (see Table 7). Thus, scores on the SUQ-A were found to explain unique additional variance in the ARCES and MWS, indicating that the frequency of absent-minded smartphone use, as measured by the SUQ-A, predicted daily errors of attention independently of individual differences in absent-mindedness as measured by the MAAS-LO.

Table 5 Hierarchical regression predicting scores on the ARCES, using the MAAS-LO, and SUQ-A (*n* = 159)

Predictor	R^2	ΔR^2	F	SE	β	t	*p*
Step 1	.356		86.79**	.509			
MAAS-LO					.597	9.32	.001
Step 2	.416	.060	16.07**	.486			
MAAS-LO					.484	7.18	.001
SUQ-A					.270	4.01	.001

** $p < .001$

Table 6 Hierarchical regression predicting scores on the MWS, using the MAAS-LO, and SUQ-A (*n* = 159)

Predictor	R^2	ΔR^2	F	SE	β	t	*p*
Step 1	.192		37.29**	1.15			
MAAS-LO					.438	6.12	.001
Step 2	.251	.059	12.25*	1.11			
MAAS-LO					.326	4.27	.001
SUQ-A					.267	3.50	.001

** $p < .001$ * $p < .01$

Table 7 Hierarchical regression predicting scores on the MWS, using the MAAS-LO, and SUQ-A (n = 159)

Predictor	R^2	ΔR^2	F	SE	β	t	*p*
Step 1	.103		18.10**	1.23			
MAAS-LO					.321	4.25	.001
Step 2	.121	.018	3.21	1.23			
MAAS-LO					.259	3.214	.002
SUQ-A					.148	1.79	.075

** $p < .001$

In summary, these results demonstrated that each of the newly developed smartphone measures had strong psychometric properties, which allowed us to assess the relation between these scales and the measures of inattention with confidence. We observed a strong, positive correlation between the scores on the SUQ-G and the SUQ-A, indicating that those who use their smartphone more often also tend to use it more absent-mindedly. Additionally, both types of smartphone use were found to be positively correlated with four distinct measures of inattention. Nevertheless, the correlations with absent-minded smartphone use were generally of significantly greater magnitude, suggesting this behaviour may be a more important variable for understanding everyday inattention. Further, the correlation between smartphone use and inattention appears to be driven by absent-minded use, rather than smartphone use in general, as demonstrated by our first set of regressions. Importantly, the frequency of absent-minded smartphone use predicted everyday attention errors and spontaneous mind-wandering independently of individual differences in absent-mindedness, confirming that our measure of absent-minded smartphone use was not simply redundant with our measure of general absent-mindedness.

Study 2

In Study 2 we sought to replicate the results of Study 1 in a more diverse sample, particularly with a greater age-range of participants. Younger populations tend to be more engaged with smartphones and new technologies in general, compared to older adults, and recent data from the Pew Research Centre (Poushter, 2016) indicates that this trend has continued. Furthermore, previous research has demonstrated improvements in sustained attention as people age, both behaviourally (showing slower RTs and fewer errors on the SART) and via self-report (Cheyne et al., 2006; Carriere, Cheyne, Solman, & Smilek, 2010; Cheyne, Carriere, & Smilek, 2013), as well as reductions in mind-wandering and daydreaming in daily life (Giambra, 1979-80) and in the laboratory (Maillet & Rajah, 2013; Jackson & Balota, 2012; Giambra, 1989). Replicating our findings in a larger and more diverse sample allows us to be more confident our results will generalize across smartphone users.

Method

Participants. Two hundred and fifty participants were recruited from Amazon Mechanical Turk, and provided with 60 cents for completing a survey approximately five minutes in length. There was a relatively even distribution of males and females. Participant age ranged from 19 to 72 years, with mean age of 36.15 (SD = 11.61), thus satisfying our desire to have a broader age range than is typical in student samples (see Appendix B for additional demographic information). Following data collection, we ran a script to remove any participants who had not completed the survey. Seven participants were removed from the dataset after failing an attention check (see below for details), while eight participants were removed after indicating that they had responded randomly during the survey, and an additional four were removed for both reasons. Two participants were removed because they indicated they did not own smartphones.

Three participants who did not indicate their age were removed as well, leaving us with a total of 226 participants (128 Males)[2].

Measures. All measures (SUQ-G, SUQ-A, MAAS-LO, ARCES, MWS, MWD) were included and used as per Study 1.

Demographic Survey. In Study 2 participants were also asked to complete a brief demographics survey following their completion of the other measures. Participants were asked to fill out questions regarding their age, education level and status, income, smartphone ownership, employment status, English fluency, and gender.

Attention Check Questions. In Study 2 we included two attention check questions at the end of the survey. The first asked participants how they spent their spare time, and presented a list of hobbies. Participants who read to the end of the question instructions would know to select 'other' and type "I have read the instructions". The second attention check asked participants to indicate whether they had answered any part of the survey randomly. Participants were assured their answer would not affect whether they received their remuneration.

Procedure. After participants provided informed consent, they completed the SUQ-A, SUQ-G, ARCES, MAAS-LO, MWS, and MWD. The questionnaires, and the items within them, were presented in a randomized order to each participant. Following completion of these measures participants were asked to fill out the demographics survey (see Appendix 2). Prior to completion of the survey, participants were presented with an attention check question, and asked to indicate (without penalty) whether they had responded randomly during the course of the experiment.

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2 Three participants indicated the same value for their age and gender (i.e. "Age in Years: 29" "Gender: 29"). These participants were included in all analyses, as Gender was not one of the variables of interest.

Results

Psychometrics. We conducted reliability analyses on each of the measures included in the experiment. The smartphone questionnaires were once again highly reliable in this sample (SUQ-G = .83, SUQ-A = .93). Each of the inattention measures was once again demonstrated to have good psychometric properties and good reliability, with Cronbach's alpha ranging from .90 to .93. Full statistics for each measure are presented in Table 8, and statistics for the individual items of the SUQ-G and SUQ-A are presented in Table 9.

Smartphone Use and Daily Inattention. We first conducted a correlational analysis to replicate the results of Study 1, now controlling for each measures' relation with age. As can be seen in Table 10, controlling for age did not change the pattern of correlations between smartphone use and inattention. In either case, the correlations showed the same pattern as in Study 1. SUQ-A and SUQ-G were once again shown to be highly positively correlated, and both showed a significant positive correlation with each of the inattention measures. As in Study 1, the correlations between inattention and absent-minded smartphone use were larger than those with general smartphone use. We compared the magnitude of the correlations between each

Table 8 Descriptive statistics for Study 2 (*n* = 226)

	Mean	SD	Skew	Kurtosis	α
SUQ-A	3.83	1.42	.08	-.90	.94
SUQ-G	4.38	1.04	.04	-.43	.83
MAAS-LO	2.68	.94	-.04	-.77	.92
ARCES	2.51	.64	.17	.25	.90
MWS	3.51	1.53	.06	-.59	.91
MWD	4.12	1.51	-.33	-.50	.93

Skew SE = .16 Kurtosis SE = .32

Table 9 Item Statistics for general smartphone use (SUQ-G) and absent-minded smartphone use (SUQ-A; *n* = 226)

Item	Mean	SD	Corrected Item-Total Correlation	Item	Mean	SD	Corrected Item-Total Correlation
SUQ-G1	5.56	1.39	.392	SUQ-A1	4.58	1.62	.534
SUQ-G2	4.58	1.43	.624	SUQ-A2	3.31	1.59	.682
SUQ-G3	3.87	1.85	.584	SUQ-A3	4.04	1.86	.867
SUQ-G4	4.52	1.50	.662	SUQ-A4	3.91	1.83	.891
SUQ-G5	3.92	1.77	.578	SUQ-A5	4.40	1.71	.804
SUQ-G6	3.98	1.90	.326	SUQ-A6	3.49	1.84	.759
SUQ-G7	4.83	1.39	.580	SUQ-A7	3.26	1.73	.781
SUQ-G8	3.99	1.72	.433	SUQ-A8	3.72	1.83	.844
SUQ-G9	4.15	1.73	.630	SUQ-A9	4.14	1.70	.750
SUQ-G10	4.43	1.59	.512	SUQ-A10	3.47	1.72	.748

inattention measure and the SUQ-A with the magnitude of the correlations between each inattention measure and the SUQ-G, controlling for age, using a Fisher's r to z transformation (Lee and Preacher, 2013). The correlation between the MAAS-LO and the SUQ-A was significantly larger the correlation between the MAAS-LO and the SUQ-G ($Z = 6.025$, $p < .001$, 2-tailed). The correlation between the ARCES and the SUQ-A was significantly larger than the correlation between the ARCES and the SUQ-G ($Z = 5.087$, $p < .001$, 2-tailed). Further, the correlation between the MWS and the SUQ-A was also significantly larger than the correlation between the MWS and the SUQ-G ($Z = 6.007$, $p < .001$, 2-tailed). Finally, the correlation between the MWD and the SUQ-A was significantly larger than the correlation between the MWD and the SUQ-G ($Z = 2.424$, $p < .05$, 2-tailed). These findings replicated the pattern from Study 1 and demonstrated that absent-minded smartphone use was significantly more related to daily inattention than was general smartphone use.

Table 10 Smartphone use and inattention measures (*n* = 226)

		1	2	3	4	5	6
1	SUQ-A	-	.782**	.424**	.452**	.469**	.272**
2	SUQ-G	.789**	-	.176**	.246**	.227**	.168*
3	MAAS-LO	.465**	.212**	-	.678**	.621**	.298**
4	ARCES	.463**	.262**	.682**	-	.562**	.361**
5	MWS	.513**	.266**	.646**	.569**	-	.528**
6	MWD	.332**	.209**	.343**	.377**	.563**	-

** $p < .01$ (2-tailed)

Note. Values on the right of the diagonal represent the correlations controlled for age.

Unique Contributions of Smartphone Use. Using scores on the SUQ-A and the SUQ-G, as well as participant age, we performed a linear regression to predict a significant proportion of the variance in each one of the inattention measures (MAAS-LO, ARCES, MWS, MWD), with the proportion of variance explained ranging from 38% to 57% (see Table 11). In general, the results of these regressions followed the same pattern of results that we observed in Study 1, namely, that absent-minded smartphone use was a significant predictor of inattention when controlling for age and general smartphone use. Interestingly, in Study 2 we observed a suppression effect between general and absent-minded smartphone use. For each of the MAAS-LO, ARCES, and MWS, general smartphone use was a significant negative unique predictor. That is, when controlling for absent-minded smartphone usage, more general smartphone usage was associated with relatively less inattention in daily life. Notably, the beta coefficients for these predictors showed the same (negative) direction in Study 1 (although those betas were not significant). General smartphone use was not a significant predictor of scores on the MWD, though the direction of the relation remained negative, as was the case in Study 1. Unlike the other inattention measures, scores on the MWD were found to be significantly negatively predicted by participant age. This result is in line with previous research suggesting that mind-wandering decreases with age (Giambra, 1977-78, 1979-80; Maillet & Rajah, 2013).

Table 11 Multiple regression predicting everyday inattention by general smartphone use, absent-minded smartphone use, and participant age (*n* = 226)

DV	IV	β	*t*	*p*	Zero-order	Partial
MAAS-LO						
	Age	-.08	-1.41	.160	-.240	-.09
	SUQ-G	-.40	-4.29	.001	.212	-.277
	SUQ-A	.75	7.88	.001	.465	.468
			R = .535, $F(3, 222)$ = 29.70, SE = .798, $p < .001$			
ARCES						
	Age	.04	0.71	.480	-.117	.047
	SUQ-G	-0.28	-2.95	.003	.262	-.194
	SUQ-A	.70	7.10	.001	.463	.430
			R = .495, $F(3, 222)$ = 24.00, SE = .600, $p < .001$			
MWS						
	Age	-.11	-1.82	.070	-.272	-.121
	SUQ-G	-.35	-3.90	.001	.266	-.253
	SUQ-A	.76	8.15	.001	.513	.480
			R = .569, $F(3, 222)$ = 35.45, SE = 1.27, $p < .001$			
MWD						
	Age	-.18	-2.76	.006	-.271	-.182
	SUQ-G	-.11	-1.12	.262	.209	-.075
	SUQ-A	.37	3.50	.001	.332	.229
			R = .383, $F(3, 222)$ = 12.75, SE = 1.41, $p < .001$			

As in our analyses of Study 1, we next conducted a hierarchical regression to determine whether the SUQ-A could predict scores on inattention measures (ARCES, MWS, MWD) above and beyond the MAAS-LO, as was the case in Study 1. The MAAS-LO has previously been demonstrated to be predictive of scores on the other measures of inattention. To remind, the purpose of these analyses was to determine whether the SUQ-A is just an alternative measure of absent-mindedness, or whether there is a unique contribution of absent-minded smartphone use, over and above absent-mindedness in general. In the first step we predicted inattention using the MAAS-LO, the second step added participant age, as both these measures have been previously established to relate to attention. In step three we included the SUQ-A. For each of the criterion variables (ARCES, MWS, MWD) the SUQ-A was found to explain a significant amount of variance above and beyond the MAAS-LO and participant age, as indicated by the change in R^2 value (see Tables 12-14). This suggests that absent-minded smartphone use is independently related

Table 12 Hierarchical regression predicting scores on the ARCES, using the MAAS-LO, participant age, and SUQ-A (*n* = 226)

Predictor	R^2	ΔR^2	F	SE	β	t	*p*
Step 1	.465		194.37**	.469			
MAAS-LO					.68	13.94	.001
Step 2	.467	.002	0.95	.469			
MAAS-LO					.69	13.76	.001
Age					.049	.97	.33
Step 3	.499	.033	14.44**	.456			
MAAS-LO					.61	11.23	.001
Age					.092	1.84	.067
SUQ-A					.21	3.80	.001

** $p < .001$

Table 13 Hierarchical regression predicting scores on the MWS, using the MAAS-LO, participant age, and SUQ-A (*n* = 226)

Predictor	R^2	ΔR^2	F	SE	β	t	*p*
Step 1	.417		160.05**	1.17			
MAAS-LO					.646	12.65	.001
Step 2	.431	.014	5.67*	1.16			
MAAS-LO					.616	11.84	.001
Age					-.124	-2.38	.018
Step 3	.479	.048	20.31**	1.11			
MAAS-LO					.510	9.26	.001
Age					-.072	-1.40	.163
SUQ-A					.253	4.51	.001

*** $p < .001$ *$p < .05$

Table 14 Hierarchical regression predicting scores on the MWD, using the MAAS-LO, participant age, and SUQ-A (*n* = 226)

Predictor	R^2	ΔR^2	F	SE	β	t	*p*
Step 1	.114		29.96***	1.43			
MAAS-LO					.343	5.47	.001
Step 2	.148	.038	9.99**	1.40			
MAAS-LO					.295	4.66	.001
Age					-.200	-3.16	.002
Step 3	.169	.024	6.49*	1.38			
MAAS-LO					.221	3.19	.002
Age					-.163	-2.54	.012
SUQ-A					.180	2.55	.012

*** $p < .001$ ** $p < .01$ *$p < .05$

to everyday attention-related errors and lapses, as well as spontaneous and deliberate forms of mind-wandering, over and above trait differences in absent-mindedness.

Discussion

The results of Study 2 replicated and extended the findings from Study 1. We observed a strong positive correlation between the scores on the SUQ-G and the SUQ-A, once again indicating that those who use their smartphone more often also tend to use it more absent-mindedly. Further, while both types of smartphone use were positively correlated with inattention and attention-related errors, regressions analyses suggest that this relationship is driven by absent-minded, rather than general, smartphone use. Of particular interest was the suppression effect. While greater absent-minded smartphone use predicted relatively more daily inattention, smartphone use in general predicted relatively *less* daily inattention, when controlling for absent-minded use. Absent-minded smartphone use also predicted additional unique variance in the three measures of daily inattention independently of individual tendencies toward absent-mindedness. Thus, in Study 2 the results followed a similar pattern as was observed in Study 1. This occurred despite having a wider age range.

Concluding Comments

A review of the smartphone-use literature certainly paints a negative picture of how these devices might influence cognition (Hyman et al, 2009; Strayer, 2015; Gill et al, 2012; Barr et al., 2015). Indeed, it seems reasonable to suspect that one's general propensity to use smartphones might be related to one's propensity to experience episodes of inattention in everyday situations. For example, perhaps smartphones create more opportunities for distraction, erode our attentional mechanisms, or acclimatize us to preferring brief windows of engagement. Given that much prior work has focused on in-the-moment consequences of smartphone use (i.e., state-level measures; e.g., while using a driving simulator; Strayer & Johnston, 2001; Strayer et al., 2003; Strayer et al., 2006), here we adopted an individual differences approach to investigate the relation between the frequency of smartphone use and everyday experiences of attention (at a broader, trait-level). At the same time, we explored whether it is the frequency of general smartphone use that predicts experiences of inattention, or a particular type of use that explains the relation with inattention – namely, absent-minded use of a smartphone.

Our approach led us to four interesting findings: (1) at the trait-level, the overall tendency to use smartphones more generally, as well as absent-mindedly, positively predicts the likelihood of experiencing episodes of inattention in everyday situations (i.e., not constrained to in-the-moment dual-task costs); (2) the relation between absent-minded smartphone use and experiences of inattention was consistently larger than that of general smartphone use with inattention; (3) when controlling for the shared variance between general and absent-minded smartphone use, the general propensity to use smartphones either has no relation with inattention (Study 1), or negatively predicts experiences of inattention (Study 2). That is, in at least one of our samples we found that when controlling for absent-minded use, individuals who use their smartphone more also reported experiencing less inattention in everyday situations. Lastly, (4) when controlling for the shared association between general and absent-minded smartphone use, the tendency to use smartphones absent-mindedly had a pervasively strong and unique positive relation with all of our measures of inattention. Thus, findings from Studies 1 and 2 support a more nuanced conceptualization of the link between smartphone use and inattention than the one presented by construals of smartphone use as a unitary construct. That is, it is the absent-minded use of smartphones that drives the apparent relation between smartphone use and experiences of inattention.

Findings presented here highlight the importance of distinguishing between different types of smartphone-use behaviours. Often, researchers have inquired about the overall tendency to use smartphones, and how this general use is related to a variety of other behaviours such as reasoning (Barr et al., 2015), impulse control (Wilmer & Chein, 2016), and even mental illness such as depression (Becker, Alzahabi, & Hopwood, 2013). Like our initial finding that general smartphone use predicted experiences of inattention, it is possible other previously documented relations may be better explained, or even reversed (as in our Study 2), once a particular type of smartphone behaviour (like absent-minded use) is taken into account.

Our finding that absent-minded smartphone use is the driving force relating smartphone use to inattention is open to two possible causal interpretations. On the one hand, a troubling possibility is that using smartphones absent-mindedly may make us interact with other aspects of the world in an absent-minded fashion. According to this view, absent-minded smartphone use increases our propensity to experience other episodes of inattention in daily life, possibly by causing the deterioration of top down mechanisms that support sustained attention. possibly through causing the deterioration of top down attention control mechanisms. If this is the case, then despite the rather bleak association between absent-minded smart phone use and attention problems, there may yet be a silver lining. Those wishing to mitigate the supposed attention damage caused by smartphones only need to curtail a particular behaviour, their absent-minded usage, rather abandon their smartphone entirely. On the other hand, a much more benign explanation is that absent-minded people simply engage with the world, and therefore devices in the world, absent-mindedly. Whether it be a smartphone, a laptop, or a pocket-watch, absent-minded use of any particular device may reflect an underlying general propensity of that individual to be absent-minded. If this second possibility is the case, then the relation between smartphone use and inattention observed in the present study, suggest that such devices may be a poor choice for absent/inattentive individuals. Imagine the absent-minded individual who purchases a smartphone to get organized and become more efficient, yet has instead simply enabled themselves to behave absent-mindedly in a new domain. An interesting possible avenue for future research may be to examine how the design of smartphone apps and operating systems may interact with certain personality variables to reduce or promote absent-minded usage. These two possibilities reflect an important element in the broader debate as to whether technology is eroding or somehow shaping our cognitive mechanisms. Indeed, similar concerns have arisen in other areas as well, for example, whether media multitasking is leading to poorer executive functions (Loh & Kanai, 2014; Ophir et al., 2009), or whether computers and access to the internet is causing us to be mentally lazier than we were before their mainstream use (Carr, 2010).

Future directions for this work include investigating which of these two causal interpretations may better explain the relation between absent-minded smartphone use and inattention in everyday life. One way to shed light on the causal direction may be through longitudinal studies. Examining inattention across time among those adopting their first smartphone may provide insights into whether smartphone use may lead to greater inattentiveness in general. Such approaches have been advocated before, with the acknowledgement that the window of opportunity for conducting such studies is shrinking (Barr et al, 2015). If the number of adults using smartphones in the United States is any indication (Anderson, 2015), researchers may find that this window has already closed. Another possibility may be a longitudinal study of child populations. Such studies would require a control group to account for the confounding variable of biological maturation, and maintaining the 'smartphone-free' control group may not be feasible. A more fruitful strategy may be to observe whether any attentional *benefits* are conferred by the reduction of smartphone use, and of absent-minded use in particular, rather looking for increases in inattentiveness following the adoption of a smartphone. One such example of this approach would be an intervention study that examines whether the promotion of mindful smartphone use (i.e one aimed at reducing absent-minded smartphone use specifically) leads to a corresponding reduction in inattentiveness in everyday life.

We end by summarizing our work in the context of a recent claim made in the popular press – that smartphone use has caused the human attention span to shrink, such that "…even a goldfish can hold a thought for longer" (Watson, 2015). On the surface, by looking at the raw correlation between smartphone use and inattention, one might incorrectly believe statements such as these to be true. However, when considering a more nuanced perspective, that different ways of engage with smartphones might matter, we arrive at a very different conclusion. Here, we conclude that it is not the general use of a smartphone per se that is linked with inattention. Rather, it is the propensity to use smartphones in an absent-minded manner that predict the tendency to experience other forms of inattention.

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Appendix A

The Smartphone Usage Questionnaire

The following statements are about smartphone usage and certain experiences that you may have while using your smartphone. We are interested in how frequently you have these experiences on **a typical day.**

SUQ-G1. How often do you have your cellphone on your person?

|———————————————————|

1. Never 7 All the Time

SUQ-G2. How frequently do you send and receive text messages or emails?

|———————————————————|

1 Never 7 All the Time

SUQ-G3. To what extent do you have push notifications enabled on your phone?

|———————————————————|

1 Never 7 All the Time

SUQ-G4. How often do you find yourself checking your phone for new events such as text messages or emails?

|———————————————————|

1 Never 7 All the Time

SUQ-G5. How often do you use the phone for reading the news or browsing the web?

|———————————————————|

1 Never 7 All the Time

SUQ-G6. How often do you use sound notifications on your phone?

|———————————————————|

1 Never 7 All the Time

SUQ-G7. When you get a notification on your phone, how often do you check it immediately?

|———————————————————|

1 Never 7 All the Time

SUQ-G8. How often do you use the calendar (or similar productivity apps?)

|———————————————————|

1 Never 7 All the Time

SUQ-G9. How often do you check social media apps such as snapchat, facebook, or twitter?

|———————————————————|

1 Never 7 All the Time

SUQ-G10. How often do you use your phone for entertainment purposes (i.e. apps and games)?

|———————————————————————|

1 Never 7 All the Time

SUQ-A1. How often do you open your phone to do one thing and wind up doing something else without realizing it?

|———————————————————————|

1 Never 7 All the Time

SUQ-A2. How often do you check your phone while interacting with other people (i.e. during conversation)?

|———————————————————————|

1 Never 7 All the Time

SUQ-A3. How often do you find yourself checking your phone “for no good reason”?

|———————————————————————|

1 Never 7 All the Time

SUQ-A4. How often do you automatically check your phone without a purpose?

|———————————————————————|

1 Never 7 All the Time

SUQ-A5. How often do you check your phone out of habit?

|———————————————————————|

1 Never 7 All the Time

SUQ-A6. How often do you find yourself checking your phone without realizing why you did it?

|———————————————————————|

1 Never 7 All the Time

SUQ-A7. How often have you realized you checked your phone only after you have already been using it?

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1 Never 7 All the Time

SUQ-A8. How often do you find yourself using your phone absent-mindedly?

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1 Never 7 All the Time

SUQ-A9. How often do you wind up using your phone for longer than you intended to?

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1 Never 7 All the Time

SUQ-A10. How often do you lose track of time while using your phone?

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1 Never 7 All the Time

Appendix B

Demographic Information for Study 2

Education

What is the highest level of education you have completed?

	Frequency	Percent	Cumulative Percent
Less than Highschool	1	0.44	0.44
Highschool/GED	24	10.62	11.06
Some College/University	64	28.32	39.38
Undergraduate Degree	82	36.28	75.66
Some Graduate School	10	4.42	80.09
Graduate Degree or Higher	45	19.91	100.00
Total	226	100	

Employment

Are you currently employed (outside of mechanical turk)?			
	Frequency	Percent	Cumulative Percent
Yes - Full Time	147.00	65.04	65.04
Yes - Part Time	33.00	14.60	79.65
No	46.00	20.35	100.00
Total	226.00	100.00	

Language

Are you fluent in English?			
	Frequency	Percent	Cumulative Percent
Yes and English is my 1st language	206	91.15	91.15
Yes	19	8.41	99.56
No	1	0.44	100.00
Total	226	100	

Income

Approximately, what is your combined annual household income?			
	Frequency	Percent	Cumulative Percent
Less than 30,000	61	26.99	26.99
30,000 - 39,999	32	14.16	41.15
40,000 - 49,999	25	11.06	52.21
50,000 - 59,999	30	13.27	65.49
60,000 - 69,999	18	7.96	73.45
70,000 - 79,999	21	9.29	82.74
80,000 - 89,999	11	4.87	87.61
90,000 - 99,999	8	3.54	91.15
100,000-109,000	7	3.10	94.25
110,000 - 119,999	1	0.44	94.69
120,000 - 129,000	3	1.33	96.02
130,000 - 139,000	4	1.77	97.79
140,000 - 149,000	2	0.88	98.67
More than 150,000	3	1.33	100.00
Total	226	100	

Current Education Status

Are you currently in School?			
	Frequency	Percent	Cumulative Percent
Yes	23	10.18	10.18
No	203	89.82	100.00
Total	226	100	

Smartphone Ownership

How long have you owned a smartphone?			
	Frequency	Percent	Cumulative Percent
3 months or less	3	1.33	1.33
1 year	18	7.96	9.29
2 years	38	16.81	26.11
3 years	31	13.72	39.82
4 years	31	13.72	53.54
5 years or more	105	46.46	100.00
Total	226	100	