Computers in Human Behavior 114 (2021) 106555

Contents lists available at ScienceDirect

Computers in Human Behavior

journal homepage: http://www.elsevier.com/locate/comphumbeh

The effects of smartphone facilitated social media use, treadmill walking, and schoolwork on boredom in college students: Results of a within subjects, controlled experiment

Jacob E. Barkley *, Andrew Lepp

Kent State University, College of Education, Health and Human Services, Kent, OH, 44242-000, USA

ARTICLE INFO

Keywords:
Boredom
Negative affect
Social media
Smartphone
Homework

ABSTRACT

Smartphone and social media use are common leisure activities among college students. These activities are correlated with boredom in survey research, yet causality is undetermined. Using an experimental design, we assessed the effect of smartphone use and other common, free-choice activities on boredom. For this study, 40 college students completed four, 30-min conditions on separate days each in the same room: quiet sitting (Control); treadmill walking (Treadmill); utilizing a smartphone to engage with social-media (Smartphone); and completing self-selected schoolwork (Schoolwork). Participants completed three validated surveys assessing different aspects of state boredom at pre, mid, and post for each condition. A four condition by three time-point repeated-measure ANOVA compared the mean results for each measure of boredom. Both the Smartphone and Control conditions caused statistically significant ($p \leq 0.05$) increases in all three measures of boredom. The Treadmill condition led to increases in two of the measures of boredom. Conversely, Schoolwork caused a statistically significant decrease in boredom across all three measures. Thus, given a 30-min free-choice period, students should be advised that doing schoolwork or, to a lesser extent, taking a walk might better prevent boredom than social media driven smartphone use.

1. Introduction

A meta-analysis of 29 studies revealed that students commonly experience boredom (Tze, Daniels, & Klassen, 2016). Related research found that universities were the location, across many different community settings, most associated with boredom (Chin, Markey, Bhargava, Kassam, & Loewenstein, 2017). Conversely, gymnasiums, health clubs, restaurants, and the outdoors were locations associated with the least amount of boredom. The same research found that studying, doing nothing, and working were activities commonly associated with boredom; while sports, exercise, socializing, and eating were activities associated with less boredom. The prevalence of boredom on college campuses is a concern because boredom is negatively associated with academic performance (Tze et al., 2016). In addition to correlational studies, longitudinal studies covering multiple semesters indicate that boredom predicts future declines in academic performance (Pekrun, Goetz, Daniels, Stupinsky, & Perry, 2010; Pekrun, Hall, Goetz, & Perry, 2014). Therefore, a better understanding of boredom among college students is warranted as research suggests that reducing boredom could potentially improve important student outcomes.

In simple terms, boredom is the feeling of being stuck in a monotonous, unsatisfying situation of little value (Fahlman, Mercer-Lynn, Flora, & Eastwood, 2013). In this light, boredom is a negative, unpleasant emotion accompanied by a desire to engage in a more intrinsically rewarding activity but being unable to do so (e.g. Berlyne, 1960; Csikszentmihalyi, 1975). In support of this, Weissinger, Caldwell, and Bandalos (1992) found that individuals who lacked awareness of intrinsically rewarding activities experienced more boredom than individuals who were able to identify intrinsically rewarding activities. Building upon this, the control-value theory of boredom posits that boredom is likely to occur when an individual is engaged in an activity subjectively appraised as not intrinsically rewarding, i.e.: of low value (Pekrun, 2006). Additionally, the theory posits that boredom is intensified when an individual is engaged in an activity over which they have either too much or too little control of the outcome (Pekrun, 2006). The usefulness of this theory is that it explains boredom with two variables: intrinsic reward (i.e. value) and appropriate challenge (i.e., control). As such, boredom becomes likely during activities of low intrinsic value in

* Corresponding author.
E-mail addresses: jbarkle1@kent.edu (J.E. Barkley), alepp1@kent.edu (A. Lepp).

https://doi.org/10.1016/j.chb.2020.106555
Received 16 January 2020; Received in revised form 3 September 2020; Accepted 6 September 2020
Available online 7 September 2020

which the participant's skill set is not well matched to the challenge of the task at hand (e.g., Csikszentmihalyi, 1975; Pekrun, 2006). Such circumstances can lead to mental disengagement, inattention, an altered perception of time (e.g., time seems to drag on), and motivation to change the activity – in short, boredom (Fahlman et al., 2013; Pekrun et al., 2010).

Given the wide array of degree programs and free-time activities characteristic of today's college campuses, it is a bit surprising that boredom is so prevalent (Chin et al., 2017; Tze et al., 2016). Students, at least in the United States, are relatively free to choose a degree program that is intrinsically rewarding and appropriately challenging (Singh & Lepp, 2019). Likewise, students should be aware of intrinsically rewarding and appropriately challenging free-time activities thanks to the promotional efforts of campus recreation centers and similar student services. Yet boredom persists (Chin et al., 2017; Tze et al., 2016). According to control-value theory, the persistence of boredom suggests a disruption in the process by which college students identify and engage with intrinsically rewarding and appropriately challenging activities (Pekrun, 2006). As long-time college educators, and systematic observers of college students, we suspect that this disruption is partially explained by the ever-present, internet-connected cellular telephone (henceforth smartphone).

An abundance of research has established a link between smartphone use and college students' boredom. When asked to explain their smartphone use in qualitative studies, college students often identify boredom alleviation as a primary motivator (Fullwood, Quinn, Kaye, & Redding, 2017; Lepp, Barkley, & Li, 2017). Similar research, focused on younger students, has arrived at the same conclusion (Allaby & Shannon, 2019). Not surprisingly then, quantitative research has identified a positive correlation between various self-report measures of boredom and smartphone use (Biolcati, Mancini, & Trombini, 2018; Elhai, Vasquez, Lustgarten, Levine, & Hall, 2018; Ksinan, Malis & Vazsonyi, 2019; Lepp, Li, Barkley, & Salehi-Esfahani, 2015; Wegmann, Ostendorf, & Brand, 2018). However, these studies do not reveal whether smartphone use successfully alleviates boredom, only that it occurs in conjunction with boredom. Exploring the relationship more deeply, Lepp et al. (2017) found support for the following model: as intrinsic motivation decreases, boredom increases; simultaneously, as boredom increases so does smartphone use. Applying control-value theory, it may be that increased smartphone use reflects an inability to identify intrinsically valuable activities. In such situations, when an individual turns to the smartphone for boredom relief and the smartphone fails to be intrinsically rewarding and appropriately challenging, negative affect may result. Indeed, in the study by Lepp, Barkley and Li, path analysis suggested that both smartphone use and boredom led to negative affect. In sum, it may be that popular smartphone activities do not present users with sufficient challenge or value to alleviate boredom.

Research suggests that one of the most popular smartphone activities is accessing and interacting with various social media platforms (e.g., Instagram, Twitter) (Lepp et al., 2017; Vorderer, Krömer, & Schneider, 2016). Like smartphone use more generally, qualitative research reveals that students describe using social media in an effort to alleviate boredom (Flanigan & Babchuck, 2015). Social media use has also been associated with boredom in correlational studies (Sharp, Hemmings, Kay, Murphy, & Elliot, 2017; Čičević, Samčović, & Nešić, 2016; Throuvala, Griffiths, Rennoldson, & Kuss, 2019). Few studies, however, have looked beyond these associations to understand causal relationships between boredom, smartphone use, and social media use. An exception is research by Sagioglou and Greitemeyer (2014). Using a three condition between-subjects experimental design, they found that social media produced a less positive mood than the other two conditions (i.e., surf the internet, do nothing). In support of the control-value theory, participants' subjectively determined value of the activity fully mediated the relationship between social media use and mood. In other words, participants who judged their social media use to be of little value had a more negative experience. In a follow up study, published in the same paper, the researchers determined that social media users tend to overestimate the value received from social media use. This forecasting error may provide important insight into why people so often use social media (and perhaps smartphones more generally); specifically, users may overestimate the value of use. In accordance with control-value theory, when value is overestimated then boredom is more likely to occur.

There is an abundance of qualitative and correlational studies establishing a relationship between smartphone use, social media use, and boredom. Yet there is a dearth of experimental studies examining the same issues. This severely limits our understanding of causality. The study presented here represents an effort to fill that gap. We also hope to offer a partial explanation, and a potential solution, for the boredom commonly experienced on college campuses (Chin et al., 2017; Tze et al., 2016). Thus, we designed a controlled experiment to model a choice set that college students regularly face. Specifically, college students have brief periods of unobligated free time scattered throughout a school day (e.g., 30 min between classes and scheduled obligations, etc.). How students choose to spend this free time could influence boredom as well as other important variables such as academic performance, health and subjective well-being. For example, given 30 min of free time, a student could choose to study, take a walk on campus, or engage with their smartphone. Time diary research has identified smartphone use, social media use, and studying for courses as dominant free-time activities among college students (Hanson, Drumheller, Mallard, McKee, & Schlegel, 2010). Additionally, walking is the most frequent form of physical activity among US adults and is readily accessible on pedestrian friendly college campuses (Reis, Macera, Ainsworth, & Hipp, 2008). Thus, we tested the effect of each of these very common and accessible free-time choices on boredom. As a control condition for our experiment, we tested the effect of "doing nothing." "Doing nothing" is also a common free-time choice for many students and is highly associated with boredom (Chin et al., 2017). Our guiding research question was: what is the effect of 30 min of studying, walking, social media driven smartphone use, and doing nothing on state boredom?

Applying the control-value theory (Pekrun, 2006), we developed the following four hypotheses:

1. Thirty minutes of studying self-selected schoolwork should be appropriately challenging and intrinsically rewarding (i.e., adequate control, high value). Thus, boredom in this condition should be the lowest of the four conditions.
2. Thirty minutes of walking is not likely to be very challenging, however, it does have widely known health and fitness benefits (i.e., too much control, high value). Therefore, boredom in this condition should be greater than studying but less than the smartphone and the "do nothing" conditions.
3. Thirty minutes of social media driven smartphone use may provide some intrinsic rewards; however, research suggests that users may overestimate the value of this activity (Sagioglou & Greitemeyer, 2014). This activity is not likely to be very challenging. Thus, we judge it to be low challenge (i.e., too much control) and low value. Therefore, we hypothesized that boredom in this condition would be higher than the walking and studying conditions.
4. Finally, 30 min of doing nothing will likely be perceived as less challenging and less rewarding than all other conditions (i.e., too much control, very low value). Therefore, boredom would be greatest during this condition.

2. Methods

2.1. Participants

This study used a within-subjects experimental design. As such, 40 college students (n = 24 females, n = 16 males, age 21.7 ± 2.0 years) participated in four separate 30-min conditions (*smartphone facilitated social media use, walking on a treadmill, studying,* and *control*) in a random order. Each condition was completed on a separate day. Prior to participation, subjects were instructed on the benefits and risks of the study and signed informed consent and medical history forms. In this way, subjects were assessed for any contraindications to exercise (i.e., orthopedic injuries) and none were identified. Each subject then participated in all four conditions. This study was approved by the University Institutional Review Board.

2.2. Procedures

Participants reported to the Exercise Physiology Laboratory on four separate days where a special room was arranged for the experiment. The room was empty, except for a single desk and chair, and did not have a window or any decorations. During the *walking on a treadmill* condition, the desk and chair were removed and a treadmill (Quinton MedTrack CR60, Bothell, WA) was added. Subjects were alone in the room for the duration of each condition (i.e., 30 min) and monitored via closed circuit television. At the beginning of each condition (T1), students were assessed for three symptoms of state boredom (i.e.: disengagement, inattention, time perception) using previously validated measures (Fahlman et al., 2013). Students were again assessed using the same three measures after 15 min in each condition (T2), and finally at the conclusion of each 30 min condition (T3). The disengagement scale consisted of 10 items (e.g., "I am bored," "I am stuck in a situation that I feel is irrelevant") and with this sample demonstrated good internal reliability ($a = 0.92$). The inattention scale consisted of four items (e.g., "It is difficult to focus my attention," "My mind is wandering") and with this sample demonstrated good internal reliability ($a = 0.86$). The time perception scale consisted of five items (e.g., "Time is passing by slower than usual," "Time is dragging on") and with this sample demonstrated good internal reliability ($a = 0.93$).

When students arrived for the *smartphone facilitated social media use* condition, they first completed the self-assessments measuring state boredom (T1). They were then given the following instructions:

For the next 30 min you will be required to pass the time using your smartphone to access any social media platform of your choosing. You may switch between as many or as few as you would like in the provided time period. Use the social media as you would normally, you are not required to post on any site. You must stay on social media for the entire time period. Please do not listen to music, earbuds and headphones are not allowed in this condition.

After reading the instructions, students were given the opportunity to ask questions and have the instructions clarified if necessary. Students then entered the specially arranged room with only their smartphone. They remained there, using their smartphone, for 30 min. Their only interruption came at 15 min when a research assistant entered the room to administer the boredom assessments (T2). Boredom was assessed again at the conclusion of the condition (T3).

A minimum of one day before the *walking on a treadmill* condition, students were notified that they would be engaging in mild physical activity and advised to dress accordingly (e.g., exercise clothing and appropriate footwear). Upon arriving at the lab, students first completed the self-assessments measuring state boredom (T1). They were then welcomed into the specially arranged room which now contained only a treadmill. They were not allowed to bring anything into the room with them. Students then were familiarized with the treadmill and instructed to walk on the treadmill for the duration of the 30-min condition. The treadmill grade was set at zero degrees, and the speed was set at 3.1 miles/hour (i.e., typical walking speed) (Ainsworth et al., 1993, 2000). Students were instructed not to alter the grade or speed of the treadmill thereby standardizing the workload across all participants. Students were then given the opportunity to ask questions and have the instructions clarified if necessary. Once they had begun, their only interruption came at 15 min when a research assistant entered the room to administer the boredom assessments (T2). Boredom was assessed again at the conclusion of the condition (T3).

A minimum of one day before the *studying* condition, students were contacted and asked to bring study material and homework to the lab. Additionally, they were instructed to bring work that did not require the internet or a computer to complete. Upon arriving at the lab, students first completed the self-assessments measuring state boredom (T1). They were then shown into the specially arranged room which included only a desk and chair. They were only allowed to bring school books and homework into the room, smartphones were not allowed. They were instructed to spend the next 30 min studying or completing homework of their choosing. Students were then given the opportunity to ask questions and have the instructions clarified if necessary. After they began, boredom was again assessed at 15 (T2) and 30 min (T3).

When students arrived for the *control* condition, they first completed the self-assessments measuring state boredom (T1). They were again invited into the same room. They were not allowed to bring anything with them into the room (e.g., no smartphone, no books, no pen and paper). They were instructed to spend the next 30 min sitting at the desk "doing nothing." Students were then given the opportunity to ask questions and have the instructions clarified if necessary. After they began, boredom was again assessed at 15 (T2) and 30 min (T3).

2.3. Analytic plan

All data were analyzed with SPSS version 24.0 (SPSS Incorporated, Chicago, IL). A four condition (*smartphone facilitated social media use, walking on a treadmill, studying, control*) by three time point (T1, T2, T3) repeated-measure analysis of variance (ANOVA) was used to examine differences for each measure of state boredom (i.e., disengagement, inattention, time perception). During the initial testing of assumptions, Mauchly's Test of Sphericity indicated that the assumption of sphericity had not been met ($\chi^2 \geq 10.63$, $p \leq 0.005$). Therefore, the Greenhouse-Geisser correction was used to calculate a more conservative comparison of means at each time point for each condition. Post-hoc analyses for significant interactions were conducted using multiple, three time point (T1, T2, T3) repeated-measures ANOVAs for each condition separately to determine which conditions significantly altered measures of boredom. If this one-way ANOVA was significant for a given condition the Bonferroni correction was then used to determine at which time points boredom significantly changed for that condition.

3. Results

Data from the feelings of disengagement (e.g., "I am bored") measure of boredom are presented in Table 1. There was a significant ($F = 17.28$, $p < 0.001$) condition by time interaction for this variable. There were subsequent main effects of time for disengagement for the smartphone condition ($F = 9.27$, $p = 0.001$), studying ($F = 9.85$, $p = 0.001$), and the control condition ($F = 43.98$, $p < 0.001$) but not during the treadmill condition ($F = 2.09$, $p = 0.15$). In other words, treadmill walking did not significantly alter feelings of disengagement. Post hoc tests using the Bonferroni correction revealed that smartphone use caused an increase in feelings of disengagement after 30 min versus both the midpoint (15 min) and beginning (0 min) of the smartphone condition ($p \leq 0.002$). Additionally, post hoc tests revealed that studying caused a significant decrease in feelings of disengagement at 15 min ($p \leq 0.001$) and 30 min ($p = 0.05$) relative to the beginning (0 min) of the studying condition. Finally, post hoc tests revealed that the control condition (i.e., doing nothing) caused an increase in feelings of disengagement after 15 min and 30 min ($p \leq 0.001$) versus the beginning (0 min) of the control condition.

Data from the feelings of inattention (e.g., "It is difficult to focus my attention") measure of boredom are presented in Table 2. There was a significant ($F = 9.90$, $p = 0.003$) condition by time interaction for this variable. There were also subsequent main effects of time for inattention

Table 1
Repeated measures ANOVA demonstrating effect of time on Disengagement for each condition (N = 40).

Condition	Time	Mean[d]	Std. Dev.	df	F	Sig.
Control	1	3.54 [a,b]	1.14		43.975	$p < 0.001$
	2	4.69 [a]	1.06	1.3		
	3	4.88 [b]	1.24			
Treadmill	1	3.29	1.05		2.093	$p = 0.147$
	2	3.62	1.17	1.4		
	3	3.46	1.34			
Studying	1	3.35 [a,b]	0.98		9.846	$p = 0.001$
	2	2.77 [a]	0.98	1.4		
	3	2.92 [b]	1.28			
Smartphone	1	3.51 [b]	1.19		9.271	$p = 0.001$
	2	3.75 [c]	1.17	1.6		
	3	4.23 [b,c]	1.19			

Bonferroni Post Hoc Pairwise Comparisons.
[a] time 1 significantly different than time 2 ($p \leq 0.001$).
[b] time 1 significantly different than time 3 ($p \leq 0.05$).
[c] time 2 significantly different than time 3 ($p \leq 0.001$).
[d] 1 = Strongly Disagree, 4 = Neutral, 7 = Strongly Agree.

Table 3
Repeated measures ANOVA demonstrating effect of time on Perception of Time for each condition (N = 40).

Condition	Time	Mean[d]	Std. Dev.	df	F	Sig.
Control	1	3.53 [a,b]	1.26	1.5	72.418	$p < 0.001$
	2	4.22 [a]	1.22			
	3	5.65 [b]	1.30			
Treadmill	1	3.08 [a,b]	1.27	1.6	10.626	$p < 0.001$
	2	4.09 [a]	1.57			
	3	3.87 [b]	1.65			
Studying	1	3.17 [a]	1.38	1.5	3.486	$p = 0.049$
	2	2.56 [a]	1.50			
	3	2.78	1.64			
Smartphone	1	3.38 [b]	1.34	1.4	3.884	$p = 0.041$
	2	3.64 [c]	1.39			
	3	4.08 [bc]	1.72			

Bonferroni Post Hoc Pairwise Comparisons.
[a] time 1 significantly different than time 2 ($p \leq 0.05$).
[b] time 1 significantly different than time 3 ($p \leq 0.05$).
[c] time 2 significantly different than time 3 ($p \leq 0.025$).
[d] 1 = Strongly Disagree, 4 = Neutral, 7 = Strongly Agree.

for each condition (i.e., smartphone, studying, treadmill, control) ($F \geq 5.401$, $p \leq 0.012$). Post hoc tests using the Bonferroni correction revealed that smartphone use caused an increase in feelings of inattention after 30 min versus the midpoint (15 min) of the smartphone condition ($p \leq 0.001$). The treadmill condition also caused an increase in feelings of inattention after 15 min and 30 min ($p \leq 0.025$) relative to the beginning (0 min) of the condition. Conversely, studying reduced inattention after 15 min ($p \leq 0.002$) versus the beginning (0 min) of the studying condition. From the midpoint (15 min) to the end of the treadmill condition (30 min), inattention did increase significantly ($p = 0.049$) but remained less than at the beginning (0 min). Finally, the control condition (i.e., doing nothing) caused an increase in feelings of inattention after 15 min and 30 min ($p \leq 0.001$) relative to the beginning (0 min) of the control condition.

Data from the altered perception of time (e.g., "Time is passing by slower than usual") measure of boredom are presented in Table 3. There was a significant ($F = 16.56$, $p < 0.001$) condition by time interaction for this variable. There were also subsequent main effects of time for each condition (i.e., smartphone, studying, treadmill, control) ($F \geq 3.486$, $p \leq 0.049$). Post hoc tests using the Bonferroni correction revealed that smartphone use caused an increase in feelings that time is dragging on after 30 min relative to the midpoint (15 min) and the beginning (0 min) of the smartphone condition ($p \leq 0.05$). The treadmill condition caused an increase in feelings of time dragging on after 15 min and 30 min ($p \leq 0.014$) relative to the beginning (0 min) of the condition. However, studying caused a decrease in feelings of time dragging on after 15 min ($p = 0.05$) versus the beginning (0 min) of the studying condition. There was no significant difference after 30 min ($p \geq 0.495$) in the studying condition. Finally, post hoc tests revealed that the control condition (i.e., doing nothing) caused an increase in feelings of time dragging on after 15 min and 30 min ($p \leq 0.001$) compared to the beginning (0 min) of the control condition.

Table 2
Repeated measures ANOVA demonstrating effect of time on Inattention for each condition (N = 40).

Condition	Time	Mean[d]	Std. Dev.	df	F	Sig.
Control	1	3.53 [a,b]	1.33	1.4	17.206	$p < 0.001$
	2	4.57 [a]	1.30			
	3	4.75 [b]	1.36			
Treadmill	1	3.36 [a,b]	1.41	1.6	6.797	$p = 0.004$
	2	4.11 [a]	1.36			
	3	4.12 [b]	1.61			
Studying	1	3.25 [a]	1.30	1.8	7.981	$p = 0.001$
	2	2.50 [a,c]	1.39			
	3	2.87 [c]	1.50			
Smartphone	1	3.48	1.31	1.5	5.401	$p = 0.012$
	2	3.40 [c]	1.21			
	3	4.00 [c]	1.20			

Bonferroni Post Hoc Pairwise Comparisons.
[a] time 1 significantly different than time 2 ($p \leq 0.017$).
[b] time 1 significantly different than time 3 ($p \leq 0.025$).
[c] time 2 significantly different than time 3 ($p \leq 0.049$).
[d] 1 = Strongly Disagree, 4 = Neutral, 7 = Strongly Agree.

4. Discussion

These results allow us to conclude that 30 min of smartphone facilitated social media use has a statistically significant effect on state boredom. Indeed, 30 min of smartphone use caused increased feelings of state boredom for each of the three measures (i.e., disengagement, inattention, and an altered sense of time). Aside from smartphone use, only the control (i.e., doing nothing) had such a consistent adverse effect. Walking on a treadmill in an empty room also significantly increased feelings of boredom but only for two of the three measures (i.e., inattention, altered sense of time). Treadmill walking did not significantly change feelings of disengagement. In contrast, studying significantly decreased feelings of boredom as assessed by each of the three measures. Notably, studying produced a statistically significant decrease in boredom in just 15 min. The control (i.e., doing nothing) produced a statistically significant increase in boredom in just 15 min. For smartphone use, a statistically significant increase was observed after 30 min. Given these results, the hypotheses tested in this study were all supported. Thus, it appears that aspects of control (i.e., match of challenge and skill) and value (i.e., intrinsic reward) associated with an activity can be useful in predicting whether or not participation in that activity will lead to boredom (Csikszentmihalyi, 1975; Pekrun, 2006).

As such, this study informs our understanding of social media driven smartphone use. Previous research has identified a positive relationship between various self-report measures of boredom and smartphone use (Biolcati et al., 2018; Elhai et al., 2018; Ksinan, Malis & Vazsonyi, 2019; Wegmann et al., 2018). Similarly, previous research has identified a positive relationship between various self-report measures of boredom and social media use (Sharp et al., 2017; Sharp, Hemmings, Kay, Murphy, & Elliot, 2017; Throuvala et al., 2019). However, these are correlational studies and do not allow for conclusions about causality. Interview research has identified boredom alleviation as a common motivation for smartphone and social media use, implying that this behavior is often in response to boredom (Allaby & Shannon, 2019; Flanigan & Babchuck, 2015; Fullwood et al., 2017; Lepp et al., 2017). Extending this previous work, the present study concluded that 30 min of smartphone facilitated social media use caused an increase in state boredom. While 15 min of use did not produce a statistically significant effect, it should be noted that college students, as well as older adults, spend multiple hours on their smartphones accessing social media each day (Lepp, Barkley, Sanders, Rebold, & Gates, 2013; Barkley & Lepp, 2016; Fennell, Barkley & Lepp; 2019). Therefore, bouts of smartphone use longer than 15 min are likely common. Considering the collected research, the relationship between smartphone use, social media use, and boredom appears to be bi-directional. In other words, smartphone and social media use may cause and also occur in response to boredom.

This raises an important question: why might smartphone use cause boredom? According to control-value theory, boredom becomes likely during activities of low intrinsic value in which the participant's skill exceeds the challenge of the task at hand (e.g., Csikszentmihalyi, 1975; Pekrun, 2006). As evidenced here, such circumstances can lead to mental disengagement, inattention, and an altered perception of time (Fahlman et al., 2013; Pekrun et al., 2010). Thus, we suggest that popular smartphone uses, and in this specific case smartphone facilitated social media use, are not typically challenging enough to prevent boredom when used for periods greater than 15 min. Previous research found that high frequency smartphone users preferred less challenging free-time pursuits than low frequency users (Lepp et al., 2015). The same study found that high frequency smartphone users experience the most boredom. As control-value theory predicts, this preference for easy activities where an individual's skill set is overmatched for the challenge at hand is a precursor to boredom. Additionally, smartphone use may not be as intrinsically rewarding as users anticipate. In this study, smartphone use did not improve state boredom at all and eventually worsened it. In contrast, doing self-selected homework did improve (i.e., decrease) state boredom. Oddly, common perceptions maintain that homework is boring and that smartphone use is not. Such perceptions may be the result of a forecasting error, identified and described by Sagioglou and Greitemeyer (2014). They demonstrated that social media users tend to overestimate the subjective value of social media. In other words, the expected reward which motivates use may not be received in full. If true, this could partly explain the association researchers have identified between smartphone use and negative affect (Lepp, Barkley, & Karpinski, 2014; Lepp et al., 2017). Accordingly, users engage with their smartphones hoping to alleviate boredom and receive other benefits. If the rewards are overestimated as predicted by Sagioglou and Greitemeyer then negative affect can result. All in all, this collective body of work highlights the importance of control-value theory for future studies of smartphone use and boredom.

This study also has implications for college students' free time choices. This study focused on the small blocks of unobligated free time that students typically have scattered across their busy days. In such situations, students should be aware that prolonged bouts of smartphone facilitated social media use may not be as rewarding as anticipated. Indeed, this behavior may cause boredom in less than 30 min. Boredom in academic settings is significantly and negatively related to academic performance (Tze et al., 2016). Thus, it is important for students to identify and choose free time activities which can prevent or successfully alleviate boredom. The results of this study suggest that a short bout of self-selected homework is likely a better method of preventing boredom than smartphone facilitated social media use. Indeed, self-selected homework likely provides intrinsic rewards such as a sense of accomplishment and feelings of competence. It is likely perceived as valuable, meaningful and sufficiently challenging to keep an individual engaged. College campuses also tend to be pedestrian friendly. While our study found that walking on a treadmill in an empty, windowless room increased state boredom on two of three measures, abundant research demonstrates that walking outside is associated with positive affect and reduced boredom (Chin et al., 2017; Miller & Krizan, 2016; Reed & Ones, 2006). Generally speaking, control-value theory suggests that students should incorporate appropriately challenging activities which provide intrinsic rewards (e.g. feelings of competence) into their weekly leisure repertoire. Such an approach may be the best way of reducing boredom over the long term (Csikszentmihalyi, 1975). Preventing boredom and keeping students engaged while on campus could potentially improve important student outcomes such as academic performance and retention (Pekrun et al., 2010; Pekrun et al., 2014).

This study is not without limitations. First, while our interest was understanding college students, we used a convenience sample recruited from a single university. Thus, our ability to generalize these results is limited. Second, in an effort to standardize smartphone use across the sample, we limited it to social media engagement. While engaging with social media is a very common smartphone behavior, we cannot draw conclusions about other common smartphone uses (e.g., surfing the internet, playing games). Third, while we tried to model a real-life choice set faced by college students on a regular basis, our experiment was conducted in a controlled laboratory environment. Future research should endeavor to test the effect of this choice set in environments outside the laboratory (e.g., in campus green space, etc.). Fourth, there may have been individual differences in preference for social media use or the other common activities we tested. However, the within-subjects design used in this study likely reduces distortions due to individual differences. This is because each person sets their own baseline and subsequent changes are compared against that baseline. Still, we did not attempt to assess potential differences in preference for the activities tested or account for their potential influence on participants' experience of each condition. As such, we acknowledge this as a limitation of the study. Finally, while boredom alleviation is a common motivation for smartphone use, the participants in this study were not experiencing boredom at the start of each condition. In the case of smartphone use, boredom emerged as the condition extended beyond 15 min. Therefore, future researchers could extend this research by first causing boredom in their subjects and then assessing the efficacy of treadmill walking, studying, and smartphone use for alleviating that boredom.

In conclusion, this study found that using a smartphone to interact with social media for 30 min caused a significant increase in all three measures of state boredom (e.g., feelings of disengagement, inattention, and the perception of time passing more slowly). Only the "do nothing" control condition caused a similar effect across all three measures of boredom. Walking on a treadmill (in the same empty room) may have had a less negative effect as it caused a significant increase in inattention and the perception of time passing more slowly but it did not significantly increase feelings of disengagement. In contrast, focusing on self-selected schoolwork significantly decreased boredom across all three measures. Thus, contrary to what they may believe to be true, college students should be advised that doing schoolwork or, to a lesser extent, taking a brief walk during their free time might better prevent boredom than social media driven smartphone use.

CRediT authorship contribution statement

Jacob E. Barkley: Methodology, Formal analysis, Writing - original draft, Writing - review & editing. **Andrew Lepp:** Writing - review & editing.

References

Ainsworth, B. E., Haskell, W. L., Leon, A. S., Jacobs, D. R., Jr., Montoye, H. J., Sallis, J. F., et al. (1993). Compendium of physical activities: Classification of energy costs of human physical activities. *Medicine & Science in Sports & Exercise, 25*(1), 71–80.

Ainsworth, B. E., Haskell, W. L., Whitt, M. C., Irwin, M. L., Swartz, A. M., Strath, S. J., et al. (2000). Compendium of physical activities: An update of activity codes and MET intensities. *Medicine & Science in Sports & Exercise, 32*(9 Suppl), S498–S504.

Allaby, M., & Shannon, C. S. (2019). "I just want to keep in touch": Adolescents' experiences with leisure related smartphone use. *Journal of Leisure Research*. https://doi.org/10.1080/00222216.2019.1672506. online ahead of print.

Barkley, J. E., & Lepp, A. (2016). Mobile phone use among college students is a sedentary leisure behavior which may interfere with exercise. *Computers in Human Behavior, 56*, 29–33.

Berlyne, D. E. (1960). *Conflict, arousal and curiosity*. New York: McGraw Hill.

Biolcati, R., Mancini, G., & Trombini, E. (2018). Proneness to boredom ad risk behaviors during adolescents' free time. *Psychological Reports, 121*(2), 303–323.
Chin, A., Markey, A., Bhargava, S., Kassam, K. S., & Loewenstein, G. (2017). Bored in the USA: Experience sampling and boredom in everyday life. *Emotion, 17*(2), 359–368.
Čičević, S., Samčović, A., & Nešić, M. (2016). Exploring college students' generational differences in Facebook usage. *Computers in Human Behavior, 56*, 83–92.
Csikszentmihalyi, M. (1975). *Beyond boredom and anxiety*. San Francisco, CA: Jossey-Bass.
Elhai, J. D., Vasquez, J. K., Lustgarten, S. D., Levine, J. C., & Hall, B. J. (2018). Proneness to boredom mediates relationships between problematic smartphone use with depression and anxiety severity. *Social Science Computer Review, 36*(6), 707–720.
Fahlman, S. A., Mercer-Lynn, K. B., Flora, D. B., & Eastwood, J. D. (2013). Development and validation of the multidimensional state boredom scale. *Assessment, 20*(1), 68–85.
Fennell, C., Barkley, J. E., & Lepp, A. (2019). The relationship between cell phone use, physical activity, and sedentary behavior in adults aged 18 - 80. *Computers in Human Behavior, 90*, 53–59.
Flanigan, A. E., & Babchuck, W. A. (2015). Social media as academic quicksand: A phenomenological study of student experiences in and out of the classroom. *Computers in Human Behavior, 44*, 40–45.
Fullwood, C., Quinn, S., Kaye, L. K., & Redding, C. (2017). My virtual friend: A qualitative analysis of the attitudes and experiences of smartphone users: Implications for smartphone attachment. *Computers in Human Behavior, 75*, 347–355.
Hanson, T. L., Drumheller, K., Mallard, J., McKee, C., & Schlegel, P. (2010). Cell phones, text messaging, and facebook: Competing time demands of today's college students. *College Teaching, 59*(1), 23–30.
Ksinan, A. J., Mališ, J., & Vazsonyi, A. T. (2019). Swiping away the moments that make up a dull day: Narcissism, boredom, and compulsive smartphone use. *Current Psychology*. https://doi.org/10.1007/s12144-019-00228-7. published online ahead of print.
Lepp, A., Barkley, J., & Karpinski, A. (2014). The relationship between cell phone use, academic performance, anxiety, and Satisfaction with Life in college students. *Computers in Human Behavior, 31*, 343–350.
Lepp, A., Barkley, J. E., & Li, J. (2017). Motivations and experiential outcomes associated with leisure time cell phone use: Results from two independent studies. *Leisure Sciences, 39*(2), 144–162.
Lepp, A., Barkley, J. E., Sanders, G. J., Rebold, M., & Gates, P. (2013). The relationship between cell phone use, physical and sedentary activity, and cardiorespiratory fitness in a sample of U.S. college students. *International Journal of Behavioral Nutrition and Physical Activity, 10*, 79. Open Access URL: http://www.ijbnpa.org/content/10/1/79.
Lepp, A., Li, J., Barkley, J. E., & Salehi-Esfahani, S. (2015). Exploring the relationships between college students' cell phone use, personality and leisure. *Computers in Human Behavior, 43*, 210–219.
Miller, J. C., & Krizan, Z. (2016). Walking facilitates positive affect (even when expecting the opposite). *Emotion, 16*(5), 775–785.
Pekrun, R. (2006). The control-value theory of achievement emotions: Assumptions, corollaries, and implications for educational research and practice. *Educational Psychology Review, 18*, 315–341.
Pekrun, R., Goetz, T., Daniels, L. M., Stupinsky, R. H., & Perry, R. P. (2010). Bored in achievement settings: Exploring control-value antecedents and performance outcomes of a neglected emotion. *Journal of Educational Psychology, 102*(3), 531–549.
Pekrun, R., Hall, N. C., Goetz, T., & Perry, R. P. (2014). Boredom ands academic achievement: Testing a model of reciprocal causation. *Journal of Educational Psychology, 106*(3), 696–710.
Reed, J., & Ones, D. S. (2006). The effect of acute aerobic exercise on positive activated affect: A meta-analysis. *Psychology of Sport and Exercise, 7*(5), 477–514.
Reis, J. P., Macera, C. A., Ainsworth, B. E., & Hipp, D. A. (2008). Prevalence of total daily walking among US adults, 2002-2003. *Journal of Physical Activity and Health, 5*, 337–346.
Sagioglou, C., & Greitemeyer, T. (2014). Facebook's emotional consequences: Why Facebook causes a decrease in mood and why people still use it. *Computers in Human Behavior, 35*, 359–363.
Sharp, J. G., Hemmings, B., Kay, R., Murphy, B., & Elliot, S. (2017). Academic boredom among students in higher education: A mixed methods exploration of characteristics, contributors and consequences. *Journal of Further and Higher Education, 41*(5), 657–677.
Singh, S., & Lepp, A. (2019). Identity images of undergraduate college majors: Implications for hospitality and tourism education. *Journal of Teaching in Travel & Tourism*. https://doi.org/10.1080/15313220.2019.1612312. published online ahead of print.
Throuvala, M. A., Griffiths, M. D., Rennoldson, M., & Kuss, D. J. (2019). Motivational processes and dysfunctional mechanisms of social media use among adolescents: A qualitative focus group study. *Computers in Human Behavior, 90*, 164–175.
Tze, V. C. M., Daniels, L. M., & Klassen, R. M. (2016). Evaluating the relationship between boredom and academic outcomes: A meta-analysis. *Educational Psychology Review, 28*, 119–144.
Vorderer, P., Krömer, N., & Schneider, F. M. (2016). Permanently online – permanently connected: Explorations into university students' use of social media and mobile smart devices. *Computers in Human Behavior, 63*, 694–703.
Wegmann, E., Ostendorf, S., & Brand, M. (2018). Is it beneficial to use internet-communication for escaping from boredom? Boredom proneness interacts with cue-induced craving and avoidance expectancies in explaining symptoms of internet-communication disorder. *Plos one*. https://doi.org/10.1371/journal.pone.0195742. open access.
Weissinger, E., Caldwell, L. L., & Bandalos, D. L. (1992). Relation between intrinsic motivation and boredom in leisure time. *Leisure Sciences, 14*, 317–325.