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Research Article

Predicting Patterns of Problematic Smartphone Use among University Students: A Latent Class Analysis

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University students are consistently ranked among the highest users of smartphones. As such, recent research has focused on examining the antecedents and consequences of problematic smartphone use among university students. While this work has been instrumental to our understanding of the risk and protective factors of developing problematic smartphone use, it has been largely variable-centered and thus fails to recognize the diversity with which problematic smartphone use is experienced among university students. As such, this study employed a person-centered approach (i.e., latent class analysis) to classify individuals based on patterns of problematic smartphone use feature/symptom cooccurrence among a sample of 403 Canadian university students. The relationships between these subgroups (or classes) and potential covariates (i.e., self-regulation, attachment anxiety, and attachment avoidance) were then examined to gain a more complete understanding of university students' experiences of problematic smartphone use. Three classes of problematic smartphone use were identified: (1) "connected" displaying the features/symptoms of problematic smartphone use associated with being constantly connected to smartphones; (2) "problematic" displaying all of the features/symptoms of problematic smartphone use; (3) "distracted" displaying the features/symptoms associated with being distracted by smartphones. Findings indicate that attachment anxiety and avoidance were significantly associated with membership in the most pathological (i.e., "problematic") class, suggesting that this may be an especially important risk factor for developing problematic smartphone use among university students. Moreover, self-regulation was significantly related to membership in the least pathological class (i.e., "connected") suggesting that this may function as an important protective factor in developing more concerning patterns of problematic smartphone use. Findings from this work provide empirical evidence of a heterogeneity in patterns of problematic smartphone use associated with distinct individual-level risk factors. This has important implications for conceptualizations of problematic smartphone use and the development of intervention and prevention efforts.

1. Introduction

With the widespread prevalence of smartphones in modern culture, there has been increased interest in understanding the effects and behaviours related to smartphone use. Despite a lack of consensus regarding definition and standard measure [1, 2], research in this area has largely focused on evaluating the addictive features of smartphone use, often referred to as problematic smartphone use (see [3], for a systematic review). Problematic smartphone use is broadly defined as the compulsive use of the smartphone which can result in negative consequences that interfere with daily functioning [1, 4–6] and is more prevalent among people who are young, female, and highly educated [3]. As such, many studies have examined the antecedents and consequences of problematic smartphone use among university students (e.g., [7, 8]). While this work has been instrumental in identifying the potential risk and protective factors of developing problematic smartphone use, it has been largely variable-centered (i.e., looking at the relationship between constructs) and thus fails to recognize the distinct patterns with which features of problematic smartphone use may be experienced at the individual level. Thus, an emerging body of work has begun to investigate problematic smartphone

use using person-centered approaches (i.e., looking at possible subgroups characterized by different sets of parameters), such as latent class analysis (e.g., [7, 9]) and latent profile analysis (e.g., [10]), to better understand the distinct patterns underlying the experience of problematic smartphone use among university students. The current study contributes to this growing literature by investigating latent classes of problematic smartphone use among university students and their relationship with empirically established predictors. Specifically, given that a recent systematic literature review identified control (e.g., self-regulation) and emotional health (e.g., attachment dimensions) as important predictors of problematic smartphone use [3], this study examines the role of these constructs in predicting university students' distinct patterns of problematic smartphone use feature/symptom cooccurence.

Despite not being in the fifth edition of the *Diagnostic and Statistical Manual of Mental Disorders* (DSM-V; [11]), problematic smartphone use is generally conceptualized as a subset of behavioural addictions, similar to drug addiction, where the addiction is to the behaviour, or the feelings experienced through acting out the behaviour, instead of to a substance [8, 12–14]. In this way, it is believed to include the core components of addictive behaviours (e.g., cognitive salience, loss of control, mood modification, tolerance, withdrawal, conflict, and relapse; [15, 16]) and has been theorized to function according to the principles of operant conditioning [17], such that when an individual experiences enjoyment or happiness from an activity with their smartphone (e.g., playing a game), they are more likely to engage in that particular activity again (i.e., positive reinforcement). Thus, increased use of the smartphone is conceptualized to drive problematic smartphone use [18, 19], such that those who spend more time engaging with their smartphone are at increased risk for developing problematic smartphone use. Given that university-aged students are among the highest users of smartphones, both in terms of frequency of use and prevalence of ownership [2, 20, 21] and that problematic smartphone use tends to be negatively correlated with age [3], this demographic may be particularly vulnerable to developing problematic smartphone use. Indeed, though partly due to convenience sampling and ease of access, extant research has focused on examining problematic smartphone use among university students (e.g., [4, 10, 22–24]), with an emerging body of work acknowledging the need for person-centered approaches (i.e., looking at possible subgroups characterized by different sets of parameters) to understand the distinct patterns underlying these experiences. To date, the latter have examined the relationship between latent classes of problematic smartphone use and psychopathology constructs (e.g., depression, anxiety, stress [9, 10], anger, and worry; [7]). Specifically, Elhai and colleagues [7] and Yue and colleagues [9] both identified three latent classes of problematic smartphone use severity among university students through latent class analysis of the smartphone addiction scale [25]. Findings from Elhai and colleagues [7] indicated that membership in more severe classes of problematic smartphone use was predicted by worry and anger, when controlling for age and sex, while findings from Yue and colleagues [9] indicated that negative emotional variables (e.g., depression) were significantly correlated with smartphone addiction proneness. Moreover, Hong and colleagues [10] identified four latent classes of problematic smartphone use among university students in China through latent profile analysis of the mobile phone addiction index scale. Findings from this work indicated that gender and depression were significant predictors of "higher risk" classes. While this work has identified classes of problematic smartphone use severity, there has yet to be a study specifically examining symptom/feature cooccurrence. Additionally, to date, no studies have examined the role of self-regulation and attachment dimensions in predicting latent classes of problematic smartphone use—a conspicuous knowledge gap given the theoretical and empirical relevance of these constructs [3].

The notion of self-regulation or "control" is central to current understandings of how problematic smartphone use emerges, with several studies suggesting that deficiencies in an individual's ability to self-regulate their smartphone use can contribute to the development of problematic smartphone use over time. Indeed, problematic smartphone use is commonly defined as a preoccupation with using the smartphone that is characterized by a loss of control [24, 26], and it has been theorized that individuals who develop problematic smartphone use may have an inability to control their smartphone use. For example, individuals with less self-regulation may be more likely to respond to notifications as soon as they appear, thus creating a habitual dependence on their smartphone, marked by frequent checking behaviours, that become increasingly problematic over time (LaRose et al. [27]). Self-regulation is broadly defined as the conscious or unconscious adaptation of cognition, emotion, and behaviour to accomplish one's goals or to adapt to the requirements of a particular situation [28–30]. Given that individuals often have more than one desired outcome or goal in mind simultaneously, self-regulation requires an ability to prioritize [31] and focus on predetermined goals despite distractions [32]. As such, maladaptive outcomes of self-regulation, such as compulsive use of the smartphone despite negative consequences (as in the case of problematic smartphone use), are often associated with poor goal prioritization [29]. In fact, extensive work has identified deficits in self-regulation as an important risk factor to the development of problematic smartphone use (e.g., [19, 33]). For example, a study by van Deursen and colleagues [19] found that lower levels of self-regulation were responsible for increased risks of problematic smartphone use, and a study by Jeong and colleagues [26] concluded that individuals lacking skills in self-regulation were more likely to display problematic smartphone use. Inversely, several studies have revealed a link between higher self-regulation and healthy patterns of social media use [34, 35].

Stemming from work with other behavioural addictions, attachment theory has also been extensively examined as a paradigm for understanding problematic smartphone use. Specifically, it has been theorized that individuals with insecure attachments may develop problematic smartphone use as a means of coping with the perceived unreliability of close

others [36]. According to Bowlby [37], interactions with responsive and available attachment figures promote a sense of attachment security and facilitate the optimal functioning of the attachment system. However, when attachment figures are not reliably available and supportive, defensive secondary attachment strategies develop through either hyper- or deactivation of the attachment system. These strategies reflect the two dimensions of attachment: (1) anxiety (i.e., compulsively seeking proximity and protection, accompanied by a hypersensitivity to signs of possible rejection or abandonment; [38]) and (2) avoidance (i.e., maximizing autonomy and distance from others and avoiding intimacy; [38]). These dimensions have been conceptualized as inner resources that guide individuals' coping behaviours and exert strong effects on how individuals respond to life stressors [37]. In this way, individuals with insecure attachment dimensions may develop problematic smartphone use due to difficulties in responding to stress, and as an alternative to overcoming difficulties in their relationships. Specifically, Kim and colleagues [36] theorize that the relationship between insecure attachment dimensions and problematic smartphone use results from an individual's use of the smartphone as an alternative for their lack of a secure attachment. Indeed, the link between attachment insecurity (i.e., anxiety or avoidance) and problematic smartphone use has been demonstrated in several studies (e.g., [39–42]).

Despite an emerging body of work examining distinct patterns of problematic smartphone use among university students, there has yet to be an investigation into the role of self-regulation and attachment dimensions in predicting these patterns. Rather, while extant literature has demonstrated the importance of these two constructs in contributing to problematic smartphone use, no studies have examined these relationships using a person-centered approach. Whereas variable-centered approaches examine the relationships between "averaged" parameters across individuals, person-centered approaches examine possible subgroups characterized by different sets of parameters [43]. In this way, this approach provides a means of examining the heterogeneity underlying the symptomology of problematic smartphone use to gain a better understanding of individual differences in its manifestation. As such, the objective of this study was to (1) use latent class analysis (LCA, see [44]) to classify students based on patterns of problematic smartphone use feature/symptom cooccurrence and (2) to subsequently examine the relationship between these subgroups (or classes) and proximal covariates (i.e., self-regulation, attachment anxiety, and attachment avoidance) to gain a more complete understanding of university students' experiences of problematic smartphone use.

2. Methods

2.1. Sample and Participant Selection. This study involved a total of 403 participants: 202 students recruited from a large, public, research university in Western Canada and 201 students recruited from a large, public, research university in Eastern Canada. The majority of participants (76.6%) self-identified as women, and the mean age was 20.40 (sd = 1.75, range = 18 to 25). Just under half of the sample (44.3%) self-reported their ethnicity as White, while 27.6% indicated East Asian, 16.7% indicated South Asian, 3.7% indicated Southeast Asian, 3.2% indicated Black, 1.7% indicated East Asian, 0.7% indicated Indigenous, and 3.7% indicated an ethnicity classified as "Other" (e.g., Canadian, European, Middle Eastern, and North African). Participants from the university in Western Canada were recruited through posters, Facebook advertisements, and in-person recruitment at highly frequented spaces on campus. Participants from the university in Eastern Canada were recruited through an undergraduate psychology student participant pool. All participants had to be university students between 18 and 25 years old and own a smartphone with at least one active social media account. This criterion reflects previous findings that accessing the internet (i.e., for social media) is one of the major reasons for smartphone use among university students [8, 17]. Thus, by including this criterion, we ensured that our sample only included participants who were active smartphone users (i.e., for whom smartphone engagement featured as a relevant part of daily life).

2.2. Measures. Demographic information (e.g., age, gender, and ethnicity) was collected via self-report questionnaires.

2.2.1. Adult Attachment. Adult attachment was measured using the revised version of the Experience in Close Relationships Scale (ECR-R; [45]). This scale is one of the most commonly used self-report measures of adult attachment and measures attachment dimensions in terms of individuals' relationships with a current or past romantic partner. Though adult attachment targets can also include parents and peers [37], Hazan and Shaver [46] asserted that in adulthood, romantic partners almost exclusively assume the role of primary attachment target. As such, for the sake of clarity and consistency, participants were asked to respond to questionnaire items in relation to a current or past romantic relationship. The ECR-R is a 36-item questionnaire that asks the participants how much they agree with each item on a 7-grade Likert scale (i.e., from 1 = "strongly disagree" to 7 = "strongly agree"). Responses to the negatively worded items were reversely coded, and the scale scores for attachment anxiety and attachment avoidance were computed by taking the mean of the items for each subscale. In this sample, Cronbach's alpha coefficient was 0.88 for attachment anxiety and 0.68 for attachment avoidance (see Table 1).

2.2.2. Self-Regulation. Self-regulation was measured using the Self-Regulation Scale (SRS; [47]). This scale is a 10-item self-report measure that assesses participants' self-regulation in relation to the pursuit of a goal, while focusing on attention and emotion regulation with items such as "I stay focused on my goal and don't allow anything to distract me from my plan of action" and "If an activity arouses my feelings too much, I can calm myself down so that I can continue with the activity soon". Previous research has demonstrated the reliability and validity of this measure, evidencing it as an appropriate measure of self-regulation among young

Table 1: Descriptive statistics for measures.

Variables	N	M	SD	Range	α	# items
Attachment anxiety (ECR-R)	377	3.74/7	1.06	1-6.72	0.879	18
Attachment avoidance (ECR-R)	376	2.89/7	1.01	1-6.22	0.683	18
Self-regulation scale	372	2.65/4	0.45	1.40-4	0.892	10
Problematic Mobile Phone Use Scale	375	2.85/5	0.57	1-4.56	0.863	18

adults (i.e., 19 to 39 years; [48]). Participants were asked to rate each item on a 4-point Likert scale, ranging from "not at all true" to "exactly true." Responses to negatively worded items were reversely coded prior to analysis. In this sample, Cronbach's alpha coefficient was 0.89 (see Table 1).

2.2.3. Problematic Smartphone Use. Problematic smartphone use was measured using the Problematic Mobile Phone Use Scale (PMPUS; [22]). This scale was developed by Güzeller and Coşguner [22] to reflect the core components of addictive behaviours (i.e., cognitive salience, loss of control, mood modification, tolerance, withdrawal, conflict, and relapse; [15, 16]). Participants were asked to rate each of the 18 items of the scale in terms of how often it applied to them on a 5-point Likert scale. Responses to the negatively worded items were reversely coded prior to analysis. For the latent class analysis, the original 5-point responses to each item were dichotomized into a binary indicator variable (i.e., presence = 1 or absence = 0 of a feature/symptom). A feature/symptom was considered present if the response categories of *Sometimes (3)*, *Almost Always (4)*, or *Always (5)* were chosen and considered absent if *Never* or *Almost Never* were chosen. This dichotomization was consistent with other work as reflecting the presence of a symptom [49, 50], and other work examining technological addictions (e.g., [51–53]). In this sample, Cronbach's internal consistency reliability for the overall scale was 0.86 (see Table 1).

2.3. Statistical Analysis. LCA was conducted in Mplus 8 [54] using maximum likelihood estimation. LCA is a statistical method that uses a set of observed indicators to identify latent classes (a discrete latent variable) that represent distinct patterns of item responses. That is, individuals are assigned to the latent classes based on their observed item response patterns. These classes can be thought of as unobserved "subgroups" or "typologies" that characterize heterogeneity in a population with respect to a given phenomenon [55]. In the present study, classes were identified based on 18 dichotomous indicators (i.e., presence or absence of a feature/symptom) of problematic smartphone use. Participants with similar response patterns to the items on the Problematic Mobile Phone Use Scale were grouped together to form latent classes. In this way, LCA is a "person-centered" approach to creating empirically derived typologies, in contrast to the more dominant "variable-centered" tradition that generally requires arbitrary cutoffs on the continuous latent variable for classifying or differentiating among individual cases [56]. Thus, LCA was used to identify the minimally sufficient K number of classes that accounted for the response dependence among the problematic smartphone use features/symptoms. That is, after controlling for individuals' latent class memberships, their item responses are considered to be independent (i.e., the local independence assumption; [55]). The number of classes K to retain was determined through a process called "class enumeration" in which several LCA models with differing numbers of latent classes were fit to the data. This iterative procedure began by fitting a one-class model to the items of the Problematic Mobile Phone Use Scale. Successive models with an increasing number of classes were then fit to the same data to assess whether the addition of one more class resulted in statistically superior model fit indices.

Information-based measures of Bayesian information criterion (BIC), sample adjusted Bayesian information criterion (SABIC), and Akaike's information criteria (AIC) were used to compare and select the best-fitting model, with a smaller value indicating a superior fit. Moreover, the Vuong-Lo-Mendell-Rubin likelihood ratio test (VLMR-LRT) was used. A statistically significant p value for this test indicates that a model with K classes improved significantly from that of a model with $K - 1$ classes ([55]; see Table 2). On top of the fit indices, the number of classes for the selected model considered the interpretability and utility of the results [55].

Preliminary analyses were conducted including demographic factors (i.e., age and gender), attachment dimensions (i.e., attachment anxiety and attachment avoidance), and self-regulation as proximal covariates. Age and gender were not significant factors contributing to class membership, and the removal of these variables was not associated with a significant drop in the model's deviance (i.e., chi-square ratio test of the overall -2 log-likelihood). Thus, the final model included attachment anxiety, attachment avoidance, and self-regulation as proximal covariates of problematic smartphone use latent class membership (see Figure 1). Multinomial logistic regression analysis was used for regressing the latent class variable on the covariates. As per Vermunt [57], the latent class variable was estimated based on posterior probabilities and regressed onto the covariates while taking into account misclassification from posterior probability estimation using Mplus' three-step method (see [58, 59]).

3. Results

3.1. Descriptive Statistics. The scores for attachment anxiety and attachment avoidance averaged 3.74, sd = 1.06 (i.e., "somewhat agree"), and 2.89, sd = 1.01 (i.e., "Neither agree nor disagree"), respectively. Self-Regulation Scale scores averaged 2.64 (sd = 0.45). The average score for the Problematic Smartphone Use Scale was 2.85 (sd = 0.57). A correlation matrix of these variables is presented in Table 3.

Table 2: Goodness-of-fit statistics for 1 to 5 class solutions.

# of classes	Log-likelihood	AIC	BIC	SABIC	Entropy	VLMR-LRT (p value)
1	-3812.447	7660.893	7731.578	7674.469		
2	-3389.783	6853.567	6998.863	6881.472	0.837	<0.001
3	-3269.728	6651.456	6871.364	6693.690	0.847	0.003
4	-3222.752	6595.505	6890.024	6652.069	0.857	0.076
5	-3194.555	6577.109	6946.240	6648.003	0.848	0.645

Note. AIC = Akaike information criterion; BIC = Bayesian information criterion; SABIC = sample-adjusted Bayesian information criterion; VLMR-LRT = Vuong-Lo-Mendell-Rubin adjusted likelihood ratio test.

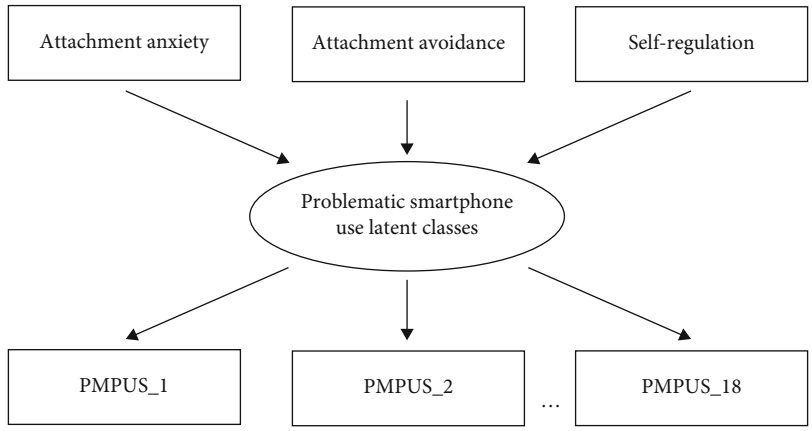

Figure 1: Structural model of the latent class analysis with covariates. Note. PMPUS = Problematic Smartphone Use Scale.

3.2. Primary Latent Class Results. Table 2 presents the fit indices for the latent class analysis (without covariates) from 1 to 5 classes. The results of the Vuong-Lo-Mendell-Rubin LRT show that the model fit did not statistically improve after 3 classes, indicating that the 3-class model was sufficient. Evidence for the 3-class model was also supported by this model having the lowest BIC value. Furthermore, there was a precipitous drop in SABIC after a 2-class model but plateaued after 3 classes. Based on consideration of the fit indices and the interpretability (to be discussed below), the 3-class solution was chosen. The entropy (i.e., classification reliability) for the 3-class model was 0.847, which was higher than the commonly accepted cut-off of 0.80 for using class membership as a categorical variable in further analyses [60, 61].

Table 4 displays the class proportions and the conditional item probabilities estimated by the 3-class model. The conditional item probability was the probability of a feature/symptom being present for a given latent class [62]. Based on these conditional item probabilities, the meaning of a class was inferred, and a label was assigned. For interpretation convenience, a probability greater than 0.60 was regarded as being high, between 0.15 and 0.59 as being moderate, and below 0.15 as being low [62].

Class 1 (28%) was characterized by constant connectivity and responsiveness to smartphones (labelled "connected"). As can be seen in Figure 2, the "connected" class evidenced a high probability for the presence of the features/symptoms of problematic smartphone use pertaining to being constantly connected and responsive to smartphones (e.g., "I frequently check my missed calls and text messages"), with probabilities of endorsing each of these items at over 68%. Moreover, the "connected" class was characterized by a moderate probability (i.e., between 17 and 41%) of endorsing most of the features of problematic smartphone use related to being distracted or disrupted by smartphone use (e.g., "I can't do my homework or study because of mobile phones") and a low probability (i.e., less than 15%) for items related to the negative impacts of excessive smartphone use (e.g., "Others complain about my using my mobile phone too much"). Thus, the distinguishing feature for the "connected" class was a high probability for only the problematic smartphone use features/symptoms related to being constantly connected and responsive to smartphones.

Class 2 (22%) was characterized by a high probability of experiencing all of the features/symptoms of problematic smartphone use. This class was labelled the "problematic" class. Beyond also displaying a high probability (i.e., over 82%) of being constantly connected and responsive to smartphones, the "problematic" class also had a high probability (i.e., over 80%) of being distracted or disrupted by their smartphone use, along with a high probability (i.e., over 77%) of experiencing compulsive features (e.g., "When I can't use my mobile phone, I am exasperated") or negative consequences (e.g., "I feel pain in my head, eyes, thumbs, and hands because of using my mobile phone"). What distinguished this class from the other two classes was the high probability for the presence of compulsive features/symptoms of problematic smartphone use and their associated negative consequences.

Class 3 (50%) was characterized by being distracted or disrupted by smartphone use (labelled "distracted").

Table 3: Correlation matrix for variables of interest.

Variable	1	2	3
(1) Attachment anxiety			
(2) Attachment avoidance	0.281***		
(3) Self-regulation scale	-0.296***	-0.048	
(4) Problematic Smartphone Use Scale	0.286***	0.035	-0.309***

Note. $^{*}p < 0.05$; $^{**}p < 0.01$; $^{***}p < 0.001$.

Table 4: Conditional item probabilities by class membership.

		Conditional item probabilities		
		Class 1 *Connected*	Class 2 *Problematic*	Class 3 *Distracted*
1	I cannot do my homework or study because of mobile phone use.	0.220	**0.923**	**0.882**
2	I am often late for appointments because I'm engaged on the mobile phone when I should not be.	0.023	**0.803**	0.179
3	I find myself occupied on my mobile phone when I should be doing other things, and it causes problems.	0.252	**0.896**	**0.948**
4	Using a mobile phone causes a decline in my school success.	0.169	**0.868**	**0.712**
5	I cannot concentrate on learning because of sending and receiving text messages, or playing games with my mobile phone.	0.110	**0.919**	**0.713**
6	I worry about mobile phone charges.	0.360	**0.897**	0.387
7	There are times when I would rather use the mobile phone than deal with other more pressing issues.	0.410	**0.939**	**0.836**
8	I feel pain in my head, eyes, thumbs, and hands because of using my mobile phone.	0.139	**0.771**	0.202
9	I immediately answer calls and reply to text messages.	0.730	**0.824**	**0.835**
10	I always carry my mobile phone.	0.933	**0.928**	**0.996**
11	I never turn off my mobile phone during the day.	0.818	**0.889**	**0.916**
12	I frequently check my missed calls and text messages.	0.771	**0.921**	**0.903**
13	I use my mobile phone any time I can.	0.675	**0.925**	**0.905**
14	I tried to cut down on mobile phone use but failed.	0.149	**0.892**	0.509
15	Others complain about me using my mobile phone too much.	0.085	**0.886**	0.230
16	I think life without mobile phones is boring and futile.	0.351	**0.868**	0.445
17	I say to myself "just a few more minutes" when using my mobile phone (talking, sending, or receiving text messages, playing games, watching TV, and so on).	0.336	**0.932**	**0.825**
18	When I cannot use a mobile phone, I am exasperated.	0.106	**0.944**	0.373

Specifically, this class had a high probability of smartphone use that was disruptive to daily life (e.g., "I find myself occupied on my mobile phone when I should be doing other things, and it causes problems"). Similar to the other two classes, the "distracted" class had a high probability (i.e., over 84%) of endorsing the items related to being constantly connected and responsive to smartphones. This class was also characterized by a high probability (i.e., over 71%) for being distracted or disrupted by smartphone use. This class also had a moderate probability (i.e., between 18 and 51%) of endorsing items related to the compulsive or negative features of problematic smartphone use (e.g., "I tried to cut down on mobile phone use, but failed"). Thus, what distinguished this class from the other two classes was the high probability of endorsing items related to being constantly connected and distracted by smartphones, and a moderate probability of endorsing items about the compulsive use or negative effects of smartphone use.

3.3. LCA Covariates. Results of the multinomial logistic regression analysis regressing the latent class variables on the proximal covariates are presented in Table 5. In this analysis, the "problematic" class served as the reference class (this class was used as the reference class as it had the overall highest probability of endorsing all of the symptoms/features of problematic smartphone use and was thus the most problematic). Results indicated that lower attachment anxiety was predictive of membership in the "connected" (vs. the "problematic") class but did not significantly predict membership in the "distracted" (vs. the "problematic") class,

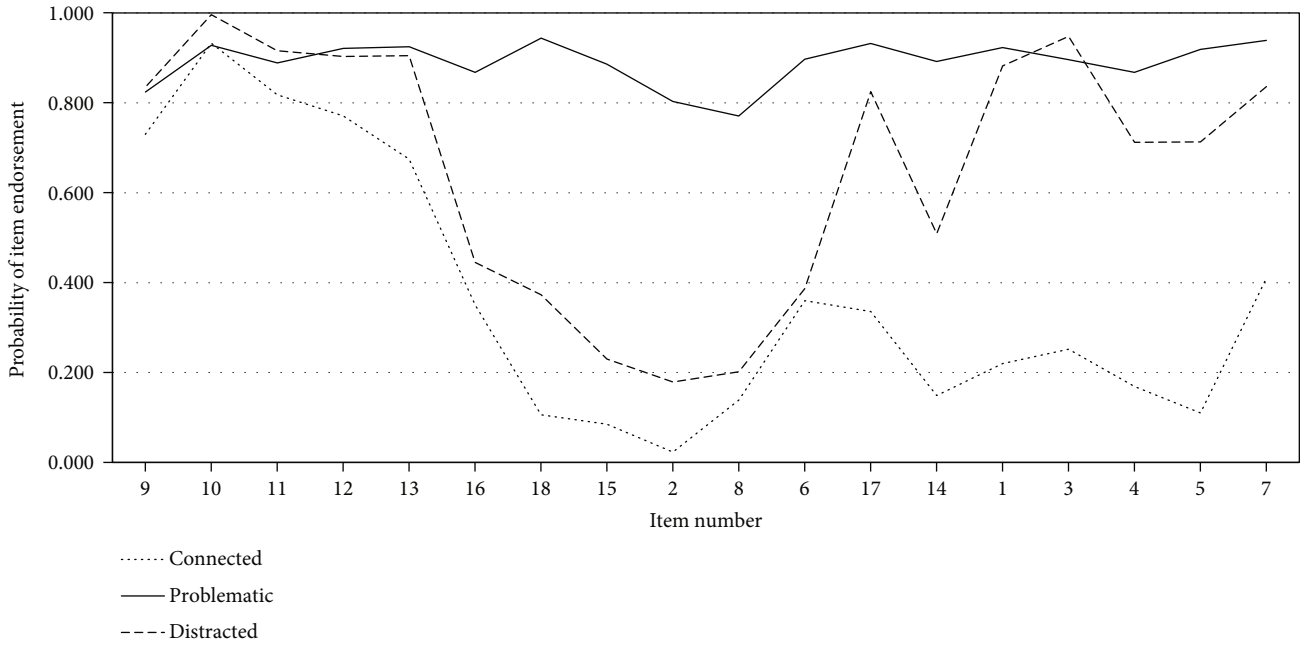

Figure 2: Conditional item probabilities by class membership.

Table 5: Multinomial logistic regression predicting latent class membership.

(a)

Class 1 (connected) compared to class 2 (problematic)			
Covariate	*B*	*SE*	*p value*
Attachment anxiety	-0.611	0.176	0.001
Attachment avoidance	-0.047	0.182	0.796
Self-regulation	1.730	0.421	<0.001

(b)

Class 3 (distracted) compared to class 2 (problematic)			
Covariate	*B*	*SE*	*p value*
Attachment anxiety	-0.280	0.155	0.071
Attachment avoidance	-0.384	0.130	0.003
Self-regulation	-0.222	0.390	0.570

while taking into account the influence of the other covariates. Lower attachment avoidance predicted membership in the "distracted" (vs. the "problematic") class but did not significantly predict membership in the "connected" (vs. the "problematic") class. Higher self-regulation predicted class membership in the "connected" (vs. the "problematic") class but did not significantly predict membership in the "distracted" (vs. the "problematic") class, while taking into account the influence of the other covariates.

To examine whether the covariates predicted membership of "distracted" classes (vs. the "connected" class), the analysis was repeated, however, using the "connected" class as the reference class. The results indicated that being higher in terms of attachment anxiety ($B = 0.331$, SE = 0.163, $p = 0.043$) and lower in terms of self-regulation ($B = -1.952$, SE = 0.388, $p < .001$) predicted membership in the "distracted" (vs. the "connected") class, while taking into account the influence of the other variables. However, attachment avoidance ($B = -0.337$, SE = 0.185, $p = 0.068$) was not a significant predictor of membership to the "distracted" (vs. the "connected") class.

4. Discussion

This study empirically examined typologies of problematic smartphone use in a sample of Canadian university students along with their relationship to theoretically and empirically informed covariates (i.e., attachment dimensions and self-regulation). Three latent classes were identified based on distinct patterns in problematic smartphone use feature/symptom cooccurrence. These latent classes labelled "connected," "problematic," and "distracted" were predicted by differing levels of attachment anxiety, attachment avoidance, and self-regulation, thus providing empirical evidence of a heterogeneity in patterns of problematic smartphone use associated with distinct individual-level risk factors. Findings from this work have important implications for understanding distinct patterns of problematic smartphone use feature/symptom cooccurrence among university students and their associated risk factors. Notably, attachment anxiety and avoidance were significantly associated with membership in the most pathological (i.e., "problematic") class, suggesting that this may be an especially important risk factor for developing problematic smartphone use among university students. Moreover, self-regulation was significantly related to membership in the least pathological class (i.e., "connected") suggesting that this may function as an important protective factor to developing more concerning patterns of problematic smartphone use.

The first class was labelled the "connected" class since members of this class displayed a high probability of being constantly connected and responsive to their smartphone. This was also observed for the other two classes, reflecting the quasinormalized phenomenon of constant connectivity to smartphones in modern culture [21, 63, 64]. What distinguished the "connected" class from the other two classes was the low and moderate probabilities of compulsive or disruptive use, respectively. Given that all participants had a high probability of constant connectivity to smartphones and that this was not a clinical sample, this aspect of problematic smartphone use may not be accurately capturing a "problematic" feature of smartphone use—at least not among active smartphone users (i.e., those with at least one social media account). Rather, this feature may be capturing a more functional dependence on smartphones intricately rooted in the social necessities of modern culture (e.g., using social media to keep up and connect, with others). This has important implications for conceptualizations, and measures, of problematic smartphone use that currently include this constant connectivity to smartphones as a central feature. Rather, this work suggests that constant connectivity may actually represent a normalized, quasiunanimous behaviour among young people. In this way, measures and conceptualizations of problematic smartphone use should account for this new norm of human behaviour so as to not overestimate the prevalence of a problematic and/or pathological use of smartphones. In further support of this normalized pattern of use, in this analysis, belonging to the "connected" class was predicted by lower levels of attachment anxiety, a well-established risk factor for problematic smartphone use, and higher levels of self-regulation, which appears to function as a protective factor.

The second class was labelled the "problematic" class because members in this class had a high probability of compulsive and negative features/symptoms of problematic smartphone use. That is, beyond the normalized features/symptoms discussed in the previous paragraph, membership in this class was predicted by the more pathological and disruptive features of problematic smartphone use, such as disruptive use (e.g., "I find myself occupied on my mobile phone when I should be doing other things, and it causes problems"), and use resulting in negative outcomes (e.g., "I feel pain in my head, eyes, thumbs, and hands because of using my mobile phone"). Despite problematic smartphone use (or smartphone addiction) not being a current diagnostic category in the DSM-V [11], the items on the Problematic Mobile Phone Use Scale [22] were developed to capture the key features of addictive behaviours [15, 16]. Thus, the high probability of endorsing each feature/symptom by this class suggests that these students were experiencing all of the key features of addictive behaviours in relation to their smartphones—and so qualified for some degree of problematic smartphone use (or smartphone addiction). As such, these students may be more susceptible to some of the negative psychological consequences associated with problematic smartphone use, such as anxiety [19, 42], depression [9, 36, 42], and loneliness [14, 36]. Importantly, this group contained 22% of the sample, which is in contrast to other recent studies which have found prevalence rates of 52-68% for problematic smartphone use among university students (e.g., [65–67]). This discrepancy in findings emphasizes the importance of person-centered work which allows for a more nuanced investigation of the heterogeneity of symptom/feature cooccurrence and thus avoids overpathologizing behaviours which have become largely normative.

The third class was labelled the "distracted" class since members in this class had a high probability of being distracted and disrupted by their smartphone use. Specifically, some of the high probability items were related to having difficulty focusing on or successfully accomplishing tasks due to smartphone use. Of note, many of these features related to disruptions in academic tasks (e.g., "I can't do my homework or study because of mobile phone use"), an aspect of problematic smartphone use that may be particularly relevant given that the sample consisted entirely of university students. In this way, it is not surprising that this class held the highest percentage of participants as it may be reflective of a particularly salient aspect of problematic smartphone use among university students.

4.1. Attachment Dimensions and Problematic Smartphone Use. Attachment dimensions were distinguishing predictors between the three classes, with those in the "problematic" class reporting significantly more attachment anxiety compared to those in the "connected" class, and significantly more attachment avoidance than those in the "distracted" class. Put simply, participants who were more likely to endorse all of the features/symptoms of problematic smartphone use tended to be higher in attachment anxiety, and attachment avoidance, than those in the "connected" and the "distracted" classes. This is in line with previous work linking problematic smartphone use with insecure attachment dimensions [39–42]. Indeed, in line with the theorizing of Kim et al. [36], these students may be using their smartphones as an alternative for their lack of a secure attachment. That is, for those higher in attachment anxiety, their smartphones may function as a tool for employing strategies that help reduce their uncertainty about close others (e.g., voyeurism on social media and constant texting/calling), or as an alternative attachment target (see [23, 68–70]). In this way, attachment anxiety could be seen as a risk factor that distinguishes those with potentially more functional dependence on their smartphones (i.e., in the "connected" class) from those with a more concerning pattern of use (i.e., in the "problematic" class).

By contrast, those higher in attachment avoidance may be engaging in smartphone use as a means of disengaging with some of the fear and discomfort they experience around forming new relationships. This use of the smartphone as a means of avoiding relational stress appears to distinguish more concerning profiles of problematic smartphone use (i.e., "problematic") from those merely exemplifying disruptive/distracted patterns of use (i.e., "distracted"). Thus, there may be something about using the smartphone to disengage or escape negative feelings around forming and/or maintaining relationships that propel individuals into a more

problematic use of their device. Overall, this analysis suggests that those with less secure attachment dimensions (i.e., higher in attachment anxiety and attachment avoidance) are more likely to be in the higher risk class of problematic smartphone use that includes compulsive use (e.g., an inability to reduce or control smartphone use) and use resulting in negative consequences (e.g., physical pain as a result of technology overuse).

4.2. Self-Regulation and Problematic Smartphone Use. Self-regulation was also a significantly distinguishing factor between classes, with those in the "connected" class reporting higher self-regulation than those in both the "distracted" and the "problematic" classes. That said, there was no difference in self-regulation between the "distracted" and the "problematic" classes. Specifically, being higher in self-regulation appeared to function as a protective factor against experiencing any of the features/symptoms of problematic smartphone use that extend beyond what has largely been considered a more normative use (i.e., the features/symptoms related to constant connectivity and responsiveness to smartphones; [63]). This is in line with the theorizing of LaRose and Eastin [71] who argue that an individual's lack of self-regulation may cause their media usage to increase in a way that could subsequently become an addiction and is in line with an extant body of work indicating that deficits in self-regulation are a key contributing factor to problematic smartphone use among university students [8, 19]. Moreover, the fact that lower self-regulation differentiated the "distracted" from the "connected" class suggests that higher self-regulation may serve as a protective factor to more habitual and absent-minded patterns of smartphone use.

4.3. Limitations and Future Directions. There are several limitations to the conclusions that can be drawn from this study. First, the cross-sectional nature of LCA precludes any causal conclusions. Second, the use of a cutoff for feature/symptom presence vs. absence ignores potential variations in the "amount" of feature/symptom present for each class. Though, for this study, this dichotomy allowed for the observation of classes distinguished by feature/symptom cooccurrence—thus providing an important contribution to the current literature—future work should consider using latent profile analysis to get a more nuanced understanding of the class characteristics. Third, although gender was not significantly associated with class membership, it is important to note that the majority of participants self-identified as women. Thus, future studies that include a more gender-balanced sample are needed to determine the extent to which gender differentially predicts patterns of feature/symptom comorbidity. It is also important to note that our study only included participants who owned a smartphone with at least one active social media account. While this ensured that we investigated the experience of problematic smartphone use among active smartphone users, this may have excluded the small proportion of university students who actively use their smartphones but do not own a social media account. Moreover, adult attachment was measured in relation to participants' current or past romantic relationships and did not take into account participants who had never been in a romantic relationship. Thus, it is unclear how these participants responded to the items within the Experiences in Close Relationships Scale. Additionally, attachment avoidance measure had somewhat low reliability (Cronbach's alpha = 0.68), which could have impacted the pattern of findings. Additionally, data was collected using self-report measures and was thus susceptible to misclassification due to recall bias, as well as participants' biased use of rating scales. Specifically, research has shown that people have different ways of filling out rating scales which naturally produces differences in scores between participants that reflect something other than what the questionnaire was designed to measure [72]. Though this remains a limitation for this study, the sample was relatively large and data for all key measures was normally distributed, suggesting that this was not a major concern for this sample. Finally, recent work suggests that problematic smartphone use may develop in adolescence, as adolescents' developmental social goals drive increased smartphone engagement [73]. Thus, future work should examine the heterogeneity of problematic smartphone use among this demographic.

5. Conclusion

Through using LCA to identify distinct subgroups of problematic smartphone use symptom/feature cooccurrence and their relationships with self-regulation and attachment dimensions, this study contributes to the emerging body of work using person-centered approaches to investigate problematic smartphone use among university students. This is in contrast to the extant literature examining the relationships between these constructs using variable-centered approaches (see [3]). While these previous studies have been instrumental to identifying the influence of these variables on problematic smartphone use, they have focused on understanding relationships with problematic smartphone use as a cohesive unit and have thus failed to examine the heterogeneity with which it is often experienced. Since problematic smartphone use has yet to adopt a cohesive definition and standard measurement [3] or be accepted as an addictive disorder (DSM-V; [11]), exploration into the heterogeneity underlying its symptomology is an important contribution to work in this area. Indeed, this study offers a more nuanced understanding of the patterns and experiences of problematic smartphone use, and their relationship with self-regulation and attachment dimensions, by examining how features/symptoms cooccur together within individuals.

Findings from this work have important implications for conceptualizations of problematic smartphone use. First, results suggest that some of the features/symptoms of problematic smartphone use reflect "normative" behaviours of constant connectivity to smartphones among active smartphone users. Moreover, findings suggest that attachment anxiety and attachment avoidance may be particularly relevant risk factors to the presence of problematic smartphone use symptomology and that self-regulation may act as an important protective factor. This has important implications for the development of intervention and prevention programs targeting problematic smartphone use, as it suggests

that these programs should focus on promoting self-regulation and increasing attachment security.

Data Availability

The quantitative data used to support the findings of this study are restricted by the University of British Columbia Ethics Board in order to protect participants' privacy. Data are available from Dr. Jennifer Shapka and Natasha Parent (natashaparent@gmail.com) for researchers who meet the criteria for access to confidential data.

Conflicts of Interest

The authors have no conflicts of interest to declare.

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