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ORIGINAL ARTICLE

Nomophobia in Late Childhood and Early Adolescence: the Development and Validation of a New Interactive Electronic Nomophobia Test

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Abstract
The widely spread dependence on smartphones by children, adolescents, and adults has shoved researchers to assess its impact on the wellbeing of individuals. Nomophobia, the fear of being out of cellular contact, was typically assessed by self-report measures or proxy measures in adolescents and older adults. The goal of the current study was to examine nomophobia in late childhood and adolescence using scenario-based vignettes that are interactively presented and mediated by computers. To fulfill this goal, the Interactive Electronic Nomophobia Test (IENT), comprising of five scenario-based vignettes, was developed and administered to 1211 students aged between 10 and 18 years and enrolled in grades 5–12. The IENT psychometric properties were examined using a series of confirmatory factor analysis and structural equation modeling. Additionally, the study examined the clustering nomophobia symptoms in a nationally representative sample of Omani students and explored the association of these Nomophobia symptoms with both students' grade and gender. Results of the study provided evidence of the four-pronged structure of the IENT, and an overall all composite nomophobia score, with strong associations found among the subscales, and between each of the four subscales and Nomophobia composite score. Invariance tests found significantly different model results by gender in all cases. Finally, cluster analysis revealed two to three clusters, with significant associations between gender, class, and cluster type. Implications of the study are discussed in view of previous literature on the assessment of nomophobia and smartphone addiction.

Keywords Nomophobia · Mobile phone addiction · Test development · Children · Oman

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Mobile phone has gradually occupied a major part of the techno-culture across the globe since it was first introduced. The increasing utilization and pervasion of the mobile phone, the new smart technology, and virtual communication tools including computers, tablets, and smartphones have influenced peoples' daily routines (Bragazzi & Puente, 2014). A huge revolution in mobile phone technology is smartphones that allow individuals to do more than just communication with others. A variety of daily tasks are now easily performed by smartphones including calling, texting, sending e-mails, scheduling appointments, communicating socially, surfing the internet, and gaming (Park et al., 2013). Kang and Jung (2014) proposed that the use of smartphones has gone beyond communication. They identified five basic needs that using smartphones fulfill for individuals in the USA and Korea: (a) physiological needs, (b) safety, (c) belongingness, (d) self-esteem, and (f) self-actualization.

The absence of face to face communication and the excessive use of new technologies may arguably cause negative behaviors and feelings. It may result in social isolation, alienation, stress, and economic and financial problems (Bragazzi & Puente, 2014). More importantly, there is research evidence that smartphones can cause addictive behavior, compulsive checking habits, distress, and pressure (e.g., Matusik & Mickel, 2011; Oulasvirta et al., 2012). Additionally, nomophobia negatively impacts the individual's physical and mental health, leading undesirable outcomes in personality, stress, self-esteem, and academic performance (Rodríguez-García et al., 2020). The term nomophobia stands for "no mobile phobia," and was first coined in 2008 in a study conducted by SecurEnvoy Company to examine anxiety that mobile phone users in the UK suffer from. The study defined nomophobia as "the fear of being out of mobile phone contact" (SecurEnvoy, 2012, Par 1).

Recently, nomophobia has received considerable attention by numerous researchers who investigated this type of phobia referring to it as a psychosocial neurosis (Bragazzi & Puente, 2014). The first aspect of investigating nomophobia involved the development of different measures for the assessment of the different aspects of the construct. To date, the majority of the developed measures which attempted to capture the construct were in the form of self-report questionnaires that are used with adolescents and older adults (e.g., Billieux et al., 2008; Buctot et al., 2020; Gao et al., 2020; Olivencia-Carrión et al., 2018; Yildirim & Correia, 2015). To date, no measures were specifically designed to assess nomophobia in children and adolescents. The current study, therefore, aimed to develop a new measure for nomophobia that is specifically designed to assess nomophobia in childhood and adolescence. To avoid the limitations linked to the use of self-report measures, the new nomophobia measure in the current study takes an electronic form and utilizes scenario-based vignettes and written responses to capture nomophobia among children and adolescents.

Nomophobia: a Succinct Review

Nomophobia or mobile phone addiction is recently perceived as a psychological disorder resulting from the excessive use of new technology and virtual communication. Nomophobia refers to "discomfort, anxiety, nervousness, or anguish caused by being out of contact with a mobile phone or a computer" (Bragazzi & Puente, 2014, p. 156). Some scholars have proposed to include nomophobia in DSM-V as a type of specific phobia which is known as “an anxiety disorder that represents unreasonable and irrational fear prompted by a specific stimulus” (Bragazzi & Puente, 2014, p. 155).

Numerous studies have investigated the negative consequences of the excessive use of smartphone and nomophobia symptoms (Augner & Hacker, 2012; Gezgin et al., 2018a; Kateb, 2017; Park et al., 2013). Smartphone users expressed responsiveness pressure, “the expectation a user will respond quickly to a message after receiving it,” and accessibility pressure, “the expectation that a user will make time to check and respond to messages” whether the user has that time or not (Matusik & Mickel, 2011, p. 1010). Furthermore, Kateb (2017) found that smartphone involvement factors (e.g., not being able to communicate, losing connectedness, access information disability, and giving up convenience) significantly correlated with depression, anxiety, and stress.

The addictive and excessive use of mobile phone might be provoked by several factors. Park et al. (2013), for example, suggested that users show increased dependency on smartphones when they perceive them useful and easy to use. A number of studies examined the predictors and antecedents behind nomophobia, mobile phone addiction, or dependency. Some of these predictors include individual or demographic-related factors while some of them are psychological factors (Augner & Hacker, 2012; Gezgin et al., 2018a; Villar et al., 2017). With regard to psychological factors, Bianchi and Phillips (2005) indicated that extraverted users tended to make more calls on a regular basis and spent longer time using the phone during the week days and weekends. Moreover, the findings revealed that extraversion and low self-esteem were predictors of problematic mobile phone use. In a similar vein, other studies found that self-esteem, extraversion, and other personality factors (such as conscientiousness, agreeableness, and neuroticism) had different predictive effects on mobile phone use and nomophobia (Augner & Hacker, 2012; Lee et al., 2014; Villar et al., 2017). Loneliness significantly correlated with nomophobia (Gezgin et al., 2018a). Motivation for social inclusion and instrumental use of smartphones were two important factors for increasing users’ perceptions of smartphones’ perceived usefulness and perceived ease of use. Also, feeling of innovativeness while using smartphone had great impact on users’ intentions to keep using smartphones (Park et al., 2013).

For demographic variables, age and gender were frequently reported as the most common predictors of nomophobia or some other related problems such as internet or smartphone addiction. Several surveys and studies suggested that adolescents aged between 18 and 25 years are more prone to nomophobia or smartphone addiction because they are more frequently use smartphones than other age groups (Kateb, 2017). Furthermore, in a study on a sample of Turkish school students aged between 10 and 18 years’ smartphone addiction and nomophobia were shown to increase with age and that high school students had higher level of nomophobia (Yildiz Durak, 2018). Age was negatively associated with problematic mobile phone use in a sample of 17–35-year-old Austrian students (Augner & Hacker, 2012). This means that younger students are involved more in problematic mobile phone use than older students. Alternatively, Al-Balhan et al. (2018) found that age was not a significant predictor for nomophobia scales.

The findings on the effect of gender on nomophobia are inconclusive. A number of studies found male users more addicted to smartphones than females (AlBarashdi et al. 2014a, b; Yildiz Durak, 2019). In contrast, other studies showed that female users were more addicted and involved with smartphones than males (Augner & Hacker, 2012;

Kateb, 2017; Kwon et al., 2013). However, Al-Balhan et al. (2018) indicated that gender was not a significant predictor of nomophobia. In a recent study on the effect of age and gender on the prevalence of nomophobia among young people in Spain, Moreno-Guerrero and colleagues surveyed 1743 students between 12 and 20 years and found that women showed higher rates of nomophobia than men. Additionally, they reported no significant differences between age groups, concluding that nomophobia affects all ages equally (Moreno-Guerrero et al., 2020b). In a similar study, Moreno-Guerrero and colleagues used the NMP-Q to examine nomophobia in 849 future teaches in Early Childhood and Elementary Education. Overall, they found average levels of nomophobia, with higher prevalence of anxiety and fear in relation to the inability to communicate. Additionally, nomophobia was most prevalent in those who reported they sacrificed their rest time to use their mobile phones (Moreno-Guerrero et al., 2020b).

Prevalence of Mobile Phone Use and Nomophobia

Mobile phones and internet use have become pervasive across countries. International Telecommunication Union (2018) demonstrated that 51.2% of the global population (3.9 billion people) are using the internet. Furthermore, the total global mobile-cellular subscriptions was 8 million and 160 by the end of 2018. In Oman, The National Center for Statistics and Information in Oman (2018) reported that the number of sim cards used for mobile phones was 6,440,889 in 2018. Also, the number of people benefiting from the internet by the end of 2011 was 2,168,049.

Some researchers attempted to examine the prevalence of smartphone addiction or nomophobia. In a study conducted on Saudi undergraduate students, Kateb (2017) showed that more than half of the participants (63. 3%) use their phone more than 4 h daily and 61.2% check their phones more than 10 times each day. In addition, AlBarashdi et al. (2014b) reported that the casual level of smartphone addiction was the highest among undergraduate Omani students (42.3% of the sample) followed by heavy level (30.8%) and finally moderate level (26%). In a study conducted on Turkish undergraduates, the highest percentage (32.6%) revealed using their smartphones more than 49 times daily and the findings indicated a moderate level of nomophobia among the participants (Gezgin et al., 2018a). Among Kuwaiti users, Al-Balhan et al. (2018) showed that 18% of participants presented mild level of nomophobia, 56.2% showed moderate level, and 25.8% exhibited severe level of nomophobia. Using the NMP-Q, Moreno-Guerrero and colleagues explored nomophobia among Spanish students aged 12–20 years and found that the most prevalent rates of nomophobia were found in relation to the inability to communicate and contact others immediately (Moreno-Guerrero et al., 2020a).

Measurement of Nomophobia

As a response to the increasing prevalence of nomophobia across countries, different instruments were developed to assess it among individuals across cultures. Although not all the instruments were specifically designed to measure nomophobia, they measure some related phenomena such as smartphone involvement, addiction, or dependency. Table 1 provides a summary of some existing measures in the literature.

NMP-Q is the only questionnaire that assesses nomophobia based on a robust theoretical structure and psychometric properties (Lin et al., 2018). Yildirim and Correia (2015) conducted a mixed method study that involved both qualitative and quantitative data. The qualitative phase focused on the exploring nomophobia construct using interviews and generating items for the NMP-Q. Nine college students (four males, five females) who had been identified—through previous online questionnaire—as heavy dependents on smartphone were interviewed. Four dimensions of nomophobia were generated from the interview's results: (1) not being able to communicate, (2) losing connectedness, (3) not being able to access information, and (4) giving up convenience. NMP-Q items were generated based on these dimensions. In the quantitative phase, the psychometric properties of the questionnaire were examined. The questionnaire was administered to 300 college students (mean age = 20) and principal component analysis (PCA) was utilized. The initial analysis showed four factors with eigenvalues greater than one. A second analysis with varimax rotation was run. The four factors explained 22.9%, 18.5%, 14.3%, and 13.9% of variance respectively. All item loadings were above 0.45. Cronbach's alpha values ranged from 0.81 (giving up convenience) to 0.93 (not being able to communicate).

Numerous studies examined the psychometric properties of NMP-Q in different cultures and used it to examine the level of nomophobia in individuals (e.g., Buctot et al., 2020; Gao et al., 2020; Gezgin et al., 2018a; Lin et al., 2018; Rangka et al., 2018, Tams et al., 2018). Two studies were conducted in Arabic speaking countries. First, Al-Balhan et al. (2018) examined the psychometric properties of the NMP-Q in a sample of undergraduate students in Kuwait University. They used confirmatory factor analysis (CFA) to examine the four-factor structure proposed by Yildirim and Correia (2015). Fit indices were not completely satisfactory. Based on an exploratory factor analysis (EFA) with varimax rotation, however, the findings showed a four-factor structure as supported, with the eigenvalue and the scree plot explaining 57.24% of the variance. The four factors included (1) "not being able to communicate," (2) "losing connectedness," (3)"not being able to access information," and (4) "giving up convenience" and explained 18.73%, 15.58%, 14.24%, and 8.68% of variance respectively. All items loaded on their respective factors similar to the original structure of the questionnaire.

Second, Albarashdi and Alldhafri (2020) investigated the psychometric properties of the NMP-Q in a sample of university students in Oman. Using EFA, the findings suggested a three-factor structure of the questionnaire named as (1) "fear of losing connectedness," (2) "fear of not being able to communicate," and (3) "fear of network outage." The three factors explained 65.6% of the total variance and showed good internal consistency (0.83, 0.91, and 0.87 respectively). Additionally, CFA was used to confirm the three-factor structure and the results showed excellent goodness of fit indices which support the questionnaire structure. In a recent systematic review of 42 recent nomophobia studies, Rodríguez-García and colleagues concluded that the most commonly used instrument for the assessment of nomophobia is the NMP-Q (Rodríguez-García et al., 2020).

Table 1 Summary of nomophobia and smartphone addiction measures

No.	Measure	Author(s)	Participants	Dimensions
1	Cellular Phone Dependence Questionnaire (CPDQ)	(Toda et al. 2004)	168 female university students (mean age = 21.7)	–
2	Problematic Mobile Phone Use Questionnaire (PMPU-Q)	Billieux et al. (2008)	430 volunteer participants from the community (ages: 20–35 years old)- Switzerland	1. Prohibited/dangerous use of the mobile phone. 2. Financial problems due to mobile phone use. 3. Dependence on the mobile phone.
3	Mobile Phone Involvement Questionnaire (MPIQ).	(Walsh et al. 2010)	946 youth aged 15–24 years (M= 18.27) - Australia	One factor
4	Smartphone Addiction scale (SAS)	Kwon et al. (2013)	540 participants (mean age = 14.5)- Korea	Long version: 1. daily-life disturbance 2. positive anticipation 3. withdrawal 4. yberspace-oriented relationship 5. overuse 6. tolerance Short version: One factor scale, 10 items
5	Smartphone Addiction Questionnaire (SAQ)	(AlBarashdi et al. 2014a)	140 undergraduate students (ages: 18–27 years)- the Sultanate of Oman	1. disregard of harmful consequences 2. preoccupation 3. inability to control craving 4. productivity loss 5. feeling anxious and lost
6	Nomophobia Questionnaire (NMP-Q)	Yildirim and Correia (2015)	300 college students (mean age = 20)- USA	1-not being able to communicate 2-losing connectedness 3-not being able to access information 4-giving up convenience
7	Young Adult Attachment to Phone Scale (YAPS)	Trub and Barbot (2016)	955 participants (ages 18–29 years)- USA	1. Refuge 2. Burden
8	Questionnaire to Assess Nomophobia (QANIP)	Olivencia-Carrión et al. (2018)	968 respondents from different institutions (ages: 17–55, (M = 23.19)-Spain	1-Mobile Phone Abuse 2-Loss of Control 3-Negative Consequences 4-Sleep Interference

The Current Study

One of the characteristic differences between today's children and adults in using mobile phone is the longer exposure of children in their lifetime (Chiu et al., 2015; Fadzil et al., 2016). Children begin using mobile phones and other technologies at an early stage of their life. Tablets, computers, and the internet are introduced to children as early as they begin their preschool, thereby predisposing them to nomophobia which may affect their health and wellbeing (Zheng et al., 2015). Several studies have asserted various symptoms that can be detected among nomophobic users. Examples of these symptoms include trembling, anxiety, respiratory alternation, agitation (Bhattacharya et al., 2019), spending much time using the phone, processing more than one phone and keeping chargers always around, and frequently checking the screen (Bragazzi and Puente, 2014); which are associated with health related outcomes such as stress and depression (Kateb, 2017). Nomophobia diagnosis among adolescents and adults received considerable attention by scholars. It is equally essential, however, to identify nomophobia among children given their increasing exposure to mobile phones and other technological devices. Betoncu and Ozdamli (2019) pointed out that individuals aged 12–18 are more vulnerable to "digital disease" such as nomophobia. Based on aforementioned review, it seems that instruments available to assess nomophobia for children are not available. A few studies examined nomophobia, smart phone, or internet addiction among young children aged 10 and above (e.g., Yildiz Durak, 2018; Gezgin et al., 2018a; Leung, 2017, Wang et al., 2017).

The current study utilizes Yildirim and Correia (2015) Nomophobia Questionnaire (NMP-Q) model as a theoretical framework to develop the new Interactive Electronic Nomophobia Test. The aim of the current study, therefore, is threefold: (1) develop and validate a new instrument, namely the Interactive Electronic Nomophobia Test (IENT), that can be used to assess nomophobia in children and adolescents aged 10–18 years using innovative format other than self-report written questionnaires, (2) examine the construct validity of the IENT using CFA and gender invariance, (3) analyze the representation of nomophobia characteristics in relation to gender and grades, using structural equation modeling and cluster analysis.

Method

Participants

Data for the current study was collected as part of a lager research project, which examined psychological outcomes associated with nomophobia among children. Schools were contacted to have access to students for data collection. Information on the study aims and procedures was sent to enable access to data collection and allow for students' participation in the study. Participants of the study were recruited from the different regions in the Sultanate of Oman using cluster random sampling method. In total, 1211 students aged between 10 and 18 years and enrolled in grades 5–12 participated in the study. The number of participants in each grade ranged between 131 and 164. A number of research assistant were trained on administering and scoring the IENT. The IENT was administered to the participants in learning support rooms in schools which included a number of computers with internet access.

Ethical Considerations

Prior to data collection, the study was approved by the Institution Review Board (IRB), the Humanity Research Ethics Board (HREB) at Sultan Qaboos University, and the Ministry of Education Technical Office for Research and Development (MoE-TORD). Because our study included participants at early and late childhood stages, we obtained participants' consent in two different ways. For early childhood participants, the paper and electronic consent forms were sent for schools to have them signed by students' parents. For late childhood participants asked them to sign the consent forms by themselves. Consent forms included information on the overall goals of the research study.

Instrument

The IENT was developed based on Yildirim's and Correia's Nomophobia Questionnaire (NMP-Q) model. Hence, the IENT includes four dimensions: (1) "Not being able to communicate" which refers to "the feelings of losing instant communication with people and not being able to use the services that allow for instant communication," (2) "losing connectedness" which refers to "feelings of losing the ubiquitous connectivity smartphones provide, and being disconnected from one's online identity, especially on social media," (3) "not being able to access information" which reflects "discomfort of losing pervasive access to information through smartphones, being unable to retrieve information through smartphones and search for information on smartphones," and (4) "giving up convenience" which relates to "the desire to utilize the convenience of having a smartphone" (Yildirim & Correia, 2015, pp. 133–134).

The IENT (see Appendix) used five nomophobia animated vignettes that depict real situations in real-life contexts. The video clips portray school children acting in different situations in which they lose their phones, chargers, or the internet connections, or excessively use the phone without marking the time they spent doing so. The respondents are then asked about how would they react or feel if they went through the same experience. For each question, four responses are provided that reflect the four aforementioned dimensions. Examples of the responses are as follows: "I would feel uncomfortable because I can't use the phone," or "I would feel anxious because I will not be able to complete my favorite game." Responses are scored on five-point Likert scale ranging from *strongly disagree (1) to strongly agree (5).* The time duration of each video clip ranges between 47 and 63 s. Scenario 1 for example shows a child using iPad, and a wall clock is placed behind him. One hour, two hours, and three hours pass and the child still indulges in using the device without noticing the time lapse. Suddenly, the child notices that the device battery is draining and the iPad is about to die. The child looks for the charger everywhere but never finds it.

Statistical Analysis

A series of statistical analyses were conducted in order to explore the data and the associations between the IENT sub-scales. The four subscales are referred to by the letters A, B, C, and D; the total score is referred to as Nomophobia. The full list of items is presented in the Appendix. Initially, descriptive statistics and a set of CFAs conducted on Nomophobia score and the four subscale scores. This included reliability analyses, which incorporated measures of Cronbach's alpha. Item statistics were also calculated and reported for each of the individual items, with these statistics consisting of the mean, standard deviation, skew, kurtosis, the corrected item-total correlations, measures of alpha if the item was deleted, and the CFA congeneric loadings. Then, invariance tests were conducted on Nomophobia and all four subscales on the basis of respondent gender, which were conducted through the use of multiple group analysis using structural equation modeling. Pearson's correlations were also conducted between Nomophobia and all subscales, along with a structural equation model in which gender and class were used to predict the factor of Nomophobia. Finally, cluster analysis was conducted on Nomophobia and the four subscales, with Pearson's chi-square used in order to determine whether there were significant associations between cluster number, gender, and class for both analyses. In addition to the commonly used chi-square statistic, we used several goodness of fit indices in order to assess the model fit, including Comparative Fit Index (CFI), the Tuker-Lewis Index (TLI), and the root mean square error of approximation (RMSEA) (Harrington, 2009). All analyses were conducted in IBM Amos 23.

Results

Confirmatory Factor Analyses, Item Statistics

CFAs were conducted on Nomophobia and the four subscales. The results are presented in Table 2. Path estimates are presented along with standardized path estimates in parentheses. Among the four subscales A through D, all standardized path estimates were found to be above 0.30, with all path estimates found to achieve statistical significance at the .001 alpha level. Similarly, all standardized path estimates were above 0.30, with all path estimates similarly found to achieve statistical significance at the .001 alpha level in the CFA conducted on the full Nomophobia scale. These results suggest appropriate factor structures with regard to all four subscales as well as for Nomophobia. Cronbach's alpha values were found to be acceptable, or marginal with regard to all four subscales. Regarding Nomophobia, a Cronbach's alpha of .893 was found, indicating very high reliability.

With respect to measures of model fit, the chi-square and degrees of freedom are presented in the notes of Table 2, along with the normed chi-square, TLI, CFI, RMSEA and its associated significance, and the 90% confidence interval associated with the RMSEA. The .05 and .01 Hoelter sample sizes are also presented. These results indicated acceptable to marginal model fit among these five models.

Table 3 presents the means and standard deviations associated with the individual items, along with their skew and kurtosis. For the reliability analyses conducted on the four subscales, the corrected item-total correlations are presented, along with the alpha measure if the item was deleted, and the CFA congeneric loadings. Means were found to range

Table 2 CFA factor loadings and Cronbach's alpha for all measures used in the study

Item	A[1]	B[2]	C[3]	D[4]	Nomophobia[5]	Cronbach's α
Item 1	.601*** (.534)			.603*** (.535)		.654
Item 2	.660*** (.615)			.571*** (.532)		
Item 3	.576*** (.478)			.579*** (.481)		
Item 4	.595*** (.548)			.513*** (.473)		
Item 5	.500*** (.447)			.616*** (.551)		
Item 6		.685*** (.620)		.633*** (.573)		.733
Item 7		.698*** (.599)		.703*** (.603)		
Item 8		.855*** (.781)		.726*** (.663)		
Item 9		.296*** (.322)		.325*** (.354)		
Item 10		.730*** (.654)		.774*** (.693)		
Item 11			.336*** (.339)	.345*** (.348)		.666
Item 12			.757*** (.664)	.725*** (.636)		
Item 13			.721*** (.649)	.645*** (.580)		
Item 14			.375*** (.385)	.404*** (.415)		
Item 15			.692*** (.621)	.738*** (.661)		
Item 16				.662*** (.543)	.706*** (.578)	.656
Item 17				.693*** (.615)	.693*** (.616)	
Item 18				.617*** (.545)	.547*** (.482)	
Item 19				.419*** (.448)	.387*** (.414)	
Item 20				.582*** (.483)	.700*** (.581)	

***$p < .001$; [1] $\chi^2(5) = 52.308$, $p < .001$, $\chi^2/df = 10.462$, TLI = .868, CFI = .934, RMSEA = .088, 90% CI = [.068, .111], $p < .01$, Hoelter .05 = 257, Hoelter .01 = 349; [2] $\chi^2(5) = 12.618$, $p < .05$, $\chi^2/df = 2.524$, TLI = .988, CFI = .994, RMSEA = .035, 90% CI = [.011, .060], $p = .811$, Hoelter .05 = 1062, Hoelter .01 = 1447; [3] $\chi^2(5) = 26.637$, $p < .001$, $\chi^2/df = 5.327$, TLI = .947, CFI = .973, RMSEA = .060, 90% CI = [.039, .083], $p = .205$, Hoelter .05 = 503, Hoelter .01 = 686; [4] $\chi^2(5) = 52.867$, $p < .001$, $\chi^2/df = 10.573$, TLI = .869, CFI = .934, RMSEA = .089, 90% CI = [.068, .111], $p < .01$, Hoelter .05 = 254, Hoelter .01 = 346; [5] $\chi^2(170) = 1703.281$, $p < .001$, $\chi^2/df = 10.019$, TLI = .774, CFI = .798, RMSEA = .086, 90% CI = [.083, .090], $p < .001$, Hoelter .05 = 144, Hoelter .01 = 154

A, giving up convenience; B, being able to communicate; C, not being able to access information; D, losing connectedness

between approximately 2 and 3.5, with standard deviations generally approximating one. The standard deviations were of almost equal or close to equal whereas means are variant. Regarding skewness and kurtosis, none of four subscales was found to have substantial skewness or kurtosis. Corrected item-total correlations were generally found to be moderate or strong, with alphas if the item was deleted found to be marginal in relation to subscales C and D, and higher but still generally marginal in relation to subscales A and B. The majority of CFA congeneric loadings were above .50, suggesting good fit between the models and the data.

Correlations and Gender Invariance

A series of zero-order correlations were conducted among the four subscales, and between these four subscales and Nomophobia. The results are presented in Table 3. As shown from

Table 3 Item statistics

Item	*M*	SD	Skew kurtosis	Corrected item-total correlation	α if item deleted	CFA congeneric loading	
A1	2.799	1.128	−.262	−1.393	.408	.601	.534
A2	2.983	1.074	−.506	−1.161	.454	.580	.615
A3	2.636	1.205	−.059	−1.573	.397	.607	.478
A4	3.175	1.084	−.897	−.698	.407	.601	.548
A5	1.961	1.120	.880	−.651	.370	.618	.447
B1	2.808	1.106	−.224	−1.395	.526	.675	.620
B2	2.566	1.165	.048	−1.489	.502	.685	.599
B3	2.704	1.096	−.056	−1.403	.631	.632	.781
B4	3.373	.920	−1.259	.396	.276	.757	.322
B5	2.571	1.117	.079	−1.393	.543	.668	.654
C1	3.246	.991	−.962	−.419	.292	.668	.339
C2	2.663	1.141	−.064	−1.458	.516	.567	.664
C3	2.735	1.111	−.148	−1.399	.496	.578	.649
C4	3.329	.973	−1.156	−.012	.333	.651	.385
C5	2.547	1.116	.113	−1.380	.462	.595	.621
D1	2.437	1.221	.181	−1.551	.427	.595	.543
D2	2.834	1.126	−.318	−1.363	.471	.573	.615
D3	2.932	1.133	−.467	−1.293	.431	.593	.545
D4	3.424	.935	−1.434	.774	.339	.633	.448
D5	2.246	1.205	.439	−1.367	.380	.618	.483

Table 3, all correlations were found to be strong, positive, and significant at the .001 alpha level. These results indicate strong associations between the subscales themselves, as well as between each of these four subscales and Nomophobia.

Additionally, the invariance tests were conducted on the four subscales, along with Nomophobia on the basis of respondent gender. The analyses were conducted as multiple group analyses in IBM Amos, which tested for significant moderation on the basis of respondent gender. Difference in chi-squared tests was also conducted in order to determine whether significant differences in the calculated estimates were present on the basis of gender. As shown in Table 4, the results found that the unconstrained model, in which completely separate models were estimated for males and females, is preferred for subscales A through C and Nomophobia. In the case of subscale D, the constrained measurement weights model would be preferred, though with measurement residuals not constrained.

Structural Equation Model

A structural equation model was specified and run examining the relationships between gender, class, and Nomophobia. A dummy variable representing female respondents was created and included in this model as well as dummy measures representing class, with class 5 omitted from this analysis as the comparison category. Nomophobia was specified as being composed of the separate A, B, C, and D subscales, with covariances

Table 4 Invariance tests by gender for Nomophobia and subscales

Model	$\chi^2(df)$	χ^2/df	TLI	CFI	RMSEA	Hoelter .05	.01
A							
Unconstrained	58.742*** (10)	5.874	.867	.934	.063 [.048, .080]	378	479
Meas. weights	88.347*** (15)	5.890	.867	.900	.064* [.051, .077]	344	420
Meas. Resid.	142.456*** (20)	7.123	.833	.833	.071** [.060, .082]	268	320
B							
Unconstrained	15.649 (10)	1.565	.991	.995	.022 [.000, .041]	1416	1795
Meas. weights	29.795* (15)	1.986	.984	.988	.029 [.013, .044]	1016	1242
Meas. Resid.	54.852*** (20)	2.743	.972	.972	.038 [.026, .050]	694	830
C							
Unconstrained	22.622* (10)	2.262	.970	.985	.032 [.014, .050]	980	1242
Meas. weights	44.029*** (15)	2.935	.954	.965	.040 [.027, .054]	688	841
Meas. Resid.	60.662*** (20)	3.033	.952	.952	.041 [.029, .053]	628	750
D							
Unconstrained	49.282*** (10)	4.928	.893	.947	.057 [.042, .073]	451	571
Meas. weights	56.827*** (15)	3.788	.924	.943	.048 [.035, .062]	533	652
Meas. Resid.	70.791*** (20)	3.540	.931	.931	.046 [.035, .058]	538	643
Nomophobia							
Unconstrained	1914.927*** (340)	5.632	.770	.794	.062*** [.059, .065]	244	256
Meas. weights	1970.301*** (360)	5.473	.778	.789	.061*** [.058, .063]	250	262
Meas. Resid.	2089.850*** (380)	5.500	.776	.776	.061*** [.058, .064]	248	260
Zero-order Pearson's correlations between Nomophobia and subscales							
Measure	A	B	C	D			
B	.643***						
C	.648***	.675***					
D	.686***	.685***	.702***				
Nomophobia	.857***	.867***	.867***	.885***			

*$p < .05$, **$p < .01$, ***$p < .001$; $df = 1209$

specified between all four errors associated with these subscales. This model's path diagram is presented in Fig. 1.

Table 5 presents the regression weights associated with this structural equation model. Significant, negative paths were found between gender and Nomophobia, with positive, significant paths found between grades 7 through 11 and Nomophobia. No significant paths were found between grade 6 or grade 12 and Nomophobia. Additionally, significant positive paths were found between Nomophobia and subscales B through D. No significance test was conducted on the path between Nomophobia and subscale A as this path was constrained to be equal to zero.

With regard to gender, this result found that females had an estimated value on Nomophobia that was .202 units lower as compared with male respondents. With regard to grade, grade 5 was omitted from this model as the comparison category. Compared with grade 5 respondents, those in grade 7 had expected values on Nomophobia that were increased by .250 units, with those in grade 8 having expected values on Nomophobia that

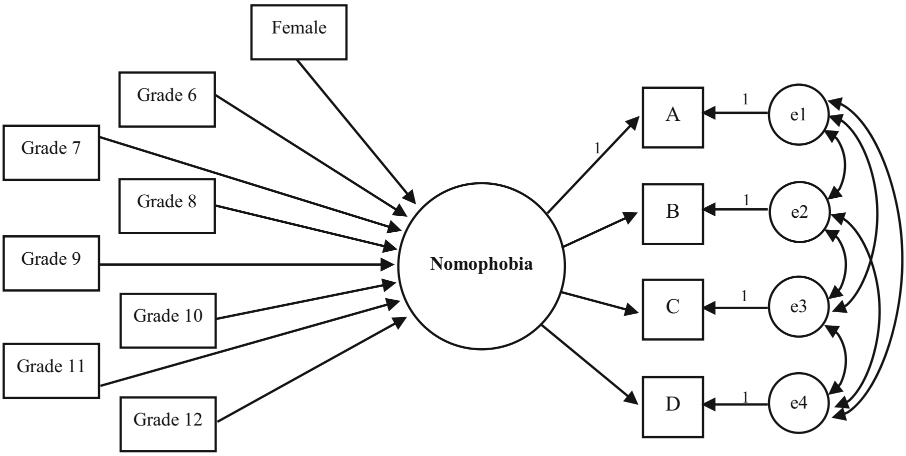

Fig. 1 Path diagram of structural equation model conducted with nomophobia

were increased by .249 units. Next, those in grade 9 had expected values that were increased by .516 units, with those in grade 10 having expected values that were increased by .109 units. Finally, those in grade 11 had expected values that were increased by .118 units. Regarding the paths between Nomophobia and the four subscales, all paths were found to be reasonably close to one. The estimate between Nomophobia and the B subscale was 1.046, slightly higher than the path between Nomophobia and subscale A, which was constrained to be equal to one. Estimates were slightly lower than one in the two remaining cases, with the path between Nomophobia and subscale C found to be .864, and with the path between Nomophobia and D found to be .918. Regarding measures of model fit, these results indicated marginal model fit.

Table 5 presents the covariances and correlations associated with this structural equation model. In this model, covariances were specified between all errors, which are related to all subscales. As shown, all covariances were found to range between .3 and .35, with correlations found to range between .6 and .7. These indicate strong correlations between these specified errors.

Cluster Analysis

Two two-step cluster analyses were conducted. These analyses specified the optimal number of clusters to be automatically determined. The initial cluster analysis incorporated all four subscales, along with Nomophobia, with the second cluster analysis incorporating these four subscales but omitting Nomophobia. The results indicated good cluster quality in the initial cluster analysis, with two clusters saved, while the second cluster analysis indicating fair to good cluster quality, with three clusters being saved.

Regarding the initial cluster analysis conducted in which two factors were saved, additional chi-square analyses were conducted in order to determine whether there were significant associations between cluster number and respondent gender and grade. A significant association was found with gender, $\chi^2(1) = 19.974$, $p < .001$. Within cluster one, 53.8% were male, while within cluster two, 59.3% were female. A significant association was also found with grade, $\chi^2(7) = 49.164$, $p < .001$. The results found

Table 5 Regression weights from structural equation model

Path	Estimate (standardized)	Path covariance	Correlation		
Female → nomophobia	−.202*** (−.435)		e1↔e2	.319***	.619
Class 6 → nomophobia	.026 (.037)		e2↔e3	.326***	.656
Class 7 → nomophobia	.250*** (.359)		e3↔e4	.334***	.687
Class 8 → nomophobia	.249*** (.368)		e1↔e3	.301***	.628
Class 9 → nomophobia	.516*** (.693)		e2↔e4	.347***	.667
Class 10 → nomophobia	.109* (.159)		e1↔e4	.336***	.668
Class 11 → nomophobia	.118* (.170)				
Class 12 → nomophobia	.074 (.106)				
Nomophobia → A	1.000 (.312)				
Nomophobia → B	1.046*** (.315)				
Nomophobia → C	.864*** (.281)				
Nomophobia → D	.918*** (.285)				

***$p < .001$; $\chi^2(170) = 1703.281$, $p < .001$, $\chi^2/df = 10.019$, TLI = .774, CFI = .798, RMSEA = .086, 90% CI = [.083, .090], $p < .001$, Hoelter .05 = 144, Hoelter .01 = 154

grades seven through nine to be over-represented in cluster one, with grades five, six, and ten through 12 to be over-represented in cluster two.

Next, with regard to the second cluster analysis, which omitted Nomophobia, significant associations were again found with gender, $\chi^2(2) = 12.484$, $p < .01$, and grade, $\chi^2(14) = 71.618$, $p < .001$. Regarding gender, the percentage of males was highest in cluster one (53.1%), followed by cluster two (43.0%), and cluster three (40.2%). With respect to grade, cluster one was found to have the highest percentage of grades 8 and 9, with cluster two found to have the highest percentage of grades 10 through 12. Finally, cluster three was found to have the highest percentage of grades 5 through 7.

Discussion

Review of previous studies showed that nomophobia was assessed by self-report measures in adolescents and older adults (AlBarashdi et al., 2014b; Olivencia-Carrión et al., 2018; Trub & Barbot, 2016; Yildirim & Correia, 2015). Investigation of nomophobia among children is limited and was also based on self-report or proxy measures rather than direct testing using a question-and-answer format (Sturgess et al., 2002). Previous research on psychological testing of children's behavior shows that the use of story-based vignettes is an objective method for the assessment of various aspects of their children's health behavior (Liu et al., 2018). We, therefore, developed five nomophobia vignettes that could elicit information from children regarding the behavioral pattern in using mobile phones. To ensure that their responses to the questions following each scenario are not biased, the test was computer generated in a self-administered form. Each vignette was followed by four responses that reflect the four dimensions of nomophobia reported by Yildirim, Correia (2015), which gained empirical ground. For validation purposes, data was collected on a representative sample from Oman to examine its validity, reliability and authenticity.

The result of the employed statistical analyses indicated marginal to adequate reliability among the four nomophobia subscales, with very high reliability found in the total score of Nomophobia. Previous studies showed that the four dimensions suggested by Yildirim and Correia (2015) were reliable across different cultures (Galhardo et al., 2020; González-Cabrera et al., 2017; Lin et al., 2018; Ma & Liu, 2018). Our findings, therefore, provide further evidence to the utility of the four dimensions even though we used a different testing technique. The CFA results indicated appropriate factor structure, while measures of model fit varied, commonly indicating marginal to acceptable model fit. Invariance tests found significantly different model results by gender in all cases, with strong correlations indicated between all subscales, as well as between all subscales and Nomophobia. The results, therefore, provide further support to the four factors reported by Yildirim and Correia (2015), which were examined in different cultures (Galhardo et al., 2020; Lin et al., 2018; González-Cabrera et al., 2017; Ma & Liu, 2018). More specifically, Ma & Liu (2018) reported that the CFA provided support to the four dimensions of the NMP-Q on a sample of 966 Chinese college students. Using EFA, González-Cabrera et al., (2017) reported a similar four-dimension structure of the NMP-Q in a Spanish sample of 306 students aged 13–19 years. Galhardo et al. (2020) examined the NMP-Q scale structure among 500 Portuguesa subjects aged 18–59 years. Testing three models of the NMP-Q factor structure, they reported that one higher order factor (global nomophobia) with four lower order factors revealed a good fit to the data.

Invariance tests found significantly different model results by gender in all cases, with strong correlations indicated between all subscales, as well as between all subscales and Nomophobia. This result suggests that conclusions about differences in all subscales and Nomophobia do not generalize over the set of items used in the IENT for both males and females. Previous studies on NMP-Q provided support for gender invariance, reflecting that scores are comparable between both genders (Lin et al., 2018; Moreno-Guerrero et al., 2020a; Yildirim & Correia, 2015). Given that the gender measurement model of IENT does not hold across males and females, real differences in the structure of nomophobia may exist between both groups, differences in observed scores may not be directly comparable, and some measurement bias could arise when nomophobia is assessed by the IENT. Therefore, the true differences across groups may be mixed with the measurement bias of assessment.

With regard to the third aim, the structural equation model conducted found significant relationships between gender, grade, and Nomophobia, as well as significant paths between Nomophobia and the associated subscales. The results of the cluster analysis revealed two to three clusters, with significant associations between gender, class, and cluster type. For the two-cluster solution, the first cluster was slightly more heavily weighted by males, grades 7–9, and higher means on A–D and Nomophobia. Alternatively, the second cluster was slightly more heavily weighted by females, grades (5–6, 10–12), and lower means on A–D and Nomophobia. In the three-cluster solution, the first cluster was slightly more heavily weighted by males, grades 7–9, and the highest means on A–D and Nomophobia. The second cluster was slightly more heavily weighted by females, (5–6, 10–12), and moderate means on A-D and Nomophobia. The third cluster slightly more heavily weighted by females, grades (5–7, 10–11), and the lowest means on A–D. Previous research studies found similar clusters of severe, moderate, and mild nomophobia levels in individuals with different psychological distress and psychiatric disorders (Adawi et al., 2019), and in college students (Dasgupta et al., 2017). Additionally, nomophobia was shown to increase in late adolescence as compared to adolescence (Yildiz Durak, 2018; Gezgin et al., 2018b; Kateb, 2017; Yildirim & Correia, 2015) and in males compared to females (AlBarashdi et al., 2014a, b; Yildiz Durak, 2019).

Limitations of the Study

The current study has a number of limitations that warrant discussion. First, the data did not include any information on the duration the participants used their smart phones. This means that claims on the participants' exposure to their mobile phones could not be made. Second, the study did not collect any data on the participants' other psychological problems whether from their parents or their teachers in school. It could be expected that some of the participants had some type of psychological problems or psychiatric disorder, including anxiety, depression, and obsessive compulsive disorder particularly in older participants in high school. These psychiatric problems could have comorbid effects with nomophobia. Third, all participants were indigenous Omani students and, therefore, our findings need to validated in other cultures whether in Asia or in Europe. Third, there was no data collected on whether the electronic administration of the vignettes had any effect on the participants' responses. Further investigation is needed to examine participants' responses on the written paper and pencil format of the test. Fourth, no evidence was collected on the concurrent or criterion validity of the test with other available instruments that assess nomophobia, including proxy and self-report measures. Further studies may explore concurrent validity with such measures and other qualitative measures that could provide in depth information on the utility of the test and what it actually captures.

Implications of the Study

The study offers a number of theoretical and practical implications. Given that nomophobia research is at incipient phase, more empirical research is needed on testing the validity of various assessment methods. To date, proxy and self-report measures represent the most widely used methods for measuring nomophobia. The current study provided preliminary evidence that using scenario-based vignettes may provide a more flexible novel way of assessing nomophobia in children. Future research needs to replicate this method with samples from different age groups. The cluster analysis findings provide further evidence that the effect of age and gender on nomophobia is salient but inconclusive. These results may inform teachers and families when they consider children's interaction with smart phones. This is equally important as a new reality has been shaped following the break out of COVID-19 pandemic during which the demarcation of advantages and risks associated with the use of smart phones has disappeared. The recent emergence of the dependence on technology as the sole mode of education during disruptive time has provided compelling evidence that children's vulnerability is confirmed. Anticipating the negative consequences of nomophobia requires credible, authentic, and valid assessment that can inform the design of possible context-bound intervention (e.g., home, school) and which are informed by cultural values.

Conclusion

Despite the study limitations, the findings of the current study indicated that the IENT is a valid and reliable measure to assess nomophobia children aged 10–18 years. The findings provided further evidence on the four-pronged structure of nomophobia which gained ground through the use of NMP-Q in different cultures. The IENT has some psychometric properties that warrant revision in future investigation, particularly with regard to gender invariance. Overall, our results showed that the IENT could be a promising measure of nomophobia in children that health professionals, school psychologists, and other professionals in clinical settings can use for various purposes.

Appendix

Scale Items

Table 6 Description of the Nomophobia Scale items

Scale, item number	Item
A, 1	I would feel uncomfortable because I could not use the device.
A, 2	I would constantly check my device to make sure if the network is back.
A, 3	I could not concentrate on studying my lessons because I think a lot about my device and my desire to use it.
A, 4	I would feel uncomfortable and I would start looking for the phone everywhere.
A, 5	I would refuse to get out, and I would start shouting when they do not allow me to take the device with me.
B, 1	I would feel nervous because my connection with my friends would be broken.
B, 2	I would be annoyed because I could not play with the others.
B, 3	I would feel bad because I could not communicate with my friends.
B, 4	I would feel worried because my family would not be able to reach me.
B, 5	I would feel nervous because I could not receive text messages from my friends.
C, 1	I would be annoyed because I could not search for the information I need.
C, 2	I would feel nervous because I could not browse my device.
C, 3	I would feel nervous because I could not know events around me.
C, 4	I would feel afraid of losing the information stored in my phone.
C, 5	I would feel annoyed because I could not follow updates on news.
D, 1	I would feel worried because I could not complete the game I love.
D, 2	I would be annoyed because I could not use social media.
D, 3	I would feel bored because I would not know what to do.
D, 4	I would feel nervous that I lost my device somewhere.
D, 5	My brain would be busy and I would not enjoy the picnic with my family.

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Declarations

Conflict of Interest The authors declare no competing interests.

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[4] Ministry of Education, Muscat, Oman