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Research Article

Genetic and Environmental Sources of Nomophobia: A Small-Scale Turkish Twin Study

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Abstract

Nomophobia is considered to be a form of behavioral addiction, namely the fear of being out of mobile phone contact. Despite many studies on the prevalence and correlates of mobile phone addiction, not much is known about its etiological nature. The purpose of this study is to reveal the extent to which nomophobia is affected by genetic and environmental factors. The participants were 125 Turkish twin-pairs. Nomophobia was measured using the Nomophobia Questionnaire (NMP-Q). The monozygotic (MZ) twin correlations were larger than the dizygotic (DZ) twin correlations in the sub-dimensions of losing connectedness (Factor 2) and giving up convenience (Factor 4), as well as for the overall questionnaire NMP-Total, showing that genetic factors affected scores on these measures. However, the MZ twin correlations were equal to or smaller than the DZ twin correlations in the sub-dimensions of not being able to communicate (Factor 1) and not being able to access (Factor 3), demonstrating that genetic factors did not play a role in the scores on these sub-dimensions. The role of both genetic and environmental factors was investigated using model-fitting analysis. The results indicate the models with best fit to be the ADE models for the sub-dimensions of losing connectedness and giving up convenience, and NMP-Total scores.

Keywords

Nomophobia • Mobile phone addiction • Smartphone addiction • Twin study • Behavioral genetics

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The world is witness to an exponential growth in the use of mobile phones with smartphone functionality. In line with this growth, some individuals have been observed to exhibit problematic or addictive behaviors related to mobile phone use, such as repetitive checking (Oulasvirta, Rattenbury, Ma, & Raita, 2012), compulsive texting (Lister-Landman, Domoff, & Dubow, 2015), ringxiety (also known as phantom ringing or vibrations; Kruger & Djerf, 2016), communifaking (the act of pretending to be involved in a call or message; Peraman & Parasuraman, 2016), and phubbing (the act of snubbing others in social interactions, instead focusing on one's mobile phone; Chotpitayasunondh & Douglas, 2016). However, mobile phones are well known to not be addictive, rather the content of the phone and/or interactive applications such as voice calling; texting; photo, video, or selfie taking and sharing; surfing the Internet; playing games; and social networking play important roles in the development of mobile phone addiction. Although mobile phones may ease the pressures of daily life, studies have shown excessive mobile phone use to appear to cause various health problems, such as sleep disturbance (Thomée, Härenstam, & Hagberg, 2011), headaches, hearing loss, eye strain, and mobile phone thumb (Acharya, Acharya, & Waghrey, 2013; Bhatia, 2008). Evidence suggests usage may also increase the risk of brain tumors (Hardell & Carlberg, 2009) and brain function disorders (Hyland, 2000). Simultaneously, researchers have tried to understand the psychological implications of mobile phone usage. In doing this, different researchers have used various labels to describe 'the problem' for instance, excessive use of mobile phones (Pourrazavi, Allahverdipour, Jafarabadi, & Matlabi, 2014), problematic mobile phone use (Billieux, Van der Linden, & Rochat, 2008; Takao, Takahashi, & Kitamura, 2009), mobile phone dependence (Toda, Monden, Kubo, & Morimoto, 2006; Toda et al., 2008), disordered mobile phone use (Billieux, Maurage, Lopez-Fernandez, Kuss, & Griffiths, 2015), cell phone addiction (Koo & Park, 2010), mobile phone addiction (Hong, Chiu, & Huang, 2012; Khang, Woo, & Kim, 2011), and smartphone addiction (Chiu, 2014).

Recently, a new term, nomophobia (no-mobile-phone-phobia), has been introduced to describe this phenomenon. Nomophobia is considered to be a type of behavioral addiction, namely "the fear of being out of mobile phone contact" (SecurEnvoy, 2012, as cited in Yildirim, 2014). Nomophobia refers to the discomfort, anxiety, nervousness, or anguish caused by being out of contact with a mobile phone (Bragazzi & Del Puente, 2014). King, Valença, and Nardi (2010) and King et al. (2013, 2014), based on their studies on nomophobia and comorbid psychiatric problems, proposed that nomophobia be regarded as a situational phobia under the category of special phobia. Addictive mobile phone use has also been suggested able to be regarded as an impulse-control disorder not involving an intoxicant and similar to pathological gambling (Bian & Leung, 2015; Leung, 2008). Thus, some scholars believe that nomophobia, or mobile phone addiction, must be seen as a common

disorder that merits inclusion under new classification systems in the *International Classification of Diseases-XI* (ICD-XI) and *The Diagnostic and Statistical Manual of Mental Disorders-V* (DSM-V) (Bhatia, 2008; Bragazzi & Del Puente, 2014; Chóliz, 2010; Yildirim, 2014).

A behavioral addiction can be defined as “a repetitive habit pattern that increases the risk of disease and/or associated personal and social problems” (Marlatt, Baer, Donovan, & Kivlahan, 1988, p. 224). Griffiths (2005) argued that all behavioral addictions share some core components such as salience, mood modification, tolerance, withdrawal, conflict, and relapse. According to Shaffer (1996, p. 465), however, “the objects of addiction cannot cause addictive behaviors; instead, it is the relationship of the addicted person with the object of their excessive behavior that defines addiction.” Although nomophobia, or mobile phone addiction, is generally accepted as a behavioral addiction, this conceptualization according to Billieux et al. (2015) is atheoretical and lacks sufficient evidence regarding its etiology. On the other hand, some researchers assert that mobile phone use might be a function of personality traits (Bianchi & Phillips, 2005; Butt & Phillips, 2008). A plethora of research exists on the correlates and predictors of mobile phone/smartphone addiction. Some of the variables that have been linked to mobile phone/smartphone addiction include anxiety (Chen et al., 2016; Bianchi & Phillips, 2005); social self-efficacy, family stress, and emotional stress (Chiu, 2014); social stress and a failure of self-regulation (van Deursen, Bolle, Hegner, & Kommers, 2015); emotional instability, materialism, and attention impulsiveness (Roberts, Pulling, & Manolis, 2015); external locus of control, social interaction anxiety, and the need for touch (Lee, Chang, Lin, & Cheng, 2014); chronotype (Demirhan, Randler, & Horzum, 2016); impulsivity (Billieux, Van der Linden, & Rochat, 2008; Billieux, Van der Linden, d’Acremont, Ceschi, & Zermatten, 2007); loneliness and shyness (Bian & Leung, 2014); lower self-esteem (Bianchi & Phillips, 2005; Hong, Chiu, & Huang, 2012); low self-control (Jeong, Kim, Yum, & Hwang, 2016); addiction proneness (Sapacz, Rockman, & Clark, 2016); and high extraversion (Bianchi & Phillips, 2005). Moreover, some studies have shown that underlying psychological/psychiatric problems such as depression (Chen et al., 2016; Thomée et al., 2011; Yen et al., 2009), social phobia (King, Valença, Silva, Baczynski, Carvalho, & Nardi, 2013), panic disorder, and agoraphobia (King, Valença, Silva, Sancassiani, Machado, & Nardi, 2014) may intensify nomophobic behaviors. Thus, learning whether nomophobia/mobile phone addiction is a distinct addiction disorder, a manifestation of an underlying psychosocial / psychiatric problem, or both has become pertinent.

From a social learning perspective, Migheli (2016) examined how siblings tend to imitate their phone use behaviors. He found the presence of clear sibling and gender effects, specifically the presence of siblings to have increased female respondents’ phone

usage, suggesting sisters to have a stronger effect than brothers. From a behavioral genetic perspective, on the other hand, only one twin study in the literature is found to have investigated heritability of mobile phone use. In this study, [Miller, Zhu, Wright, Hansell, and Martin \(2012\)](#) investigated the heritability and genetic correlates of mobile phone usage behaviors using two different Australian teenaged twins as the subject groups. They found the heritability of talk frequency to be 60% in Sample 1 and 34% in Sample 2, whereas the heritability of texting frequency to be 53% in Sample 1 and 50% in Sample 2, showing that genes matter more than family environments in predicting how often people use their mobile phones for talking and texting. Although these studies both show the genetic and environmental influences on mobile phone usage behaviors, expanding the research on nomophobia/mobile phone addiction behaviors to consider genetic and environmental contributions is still important and timely, especially within the context of different cultures. Therefore, the main purpose of this study is to quantify the relative importance of genetic and environmental influences for individual differences in nomophobia using twins as the sample.

Method

Design

In the present study, we implemented a behavioral (quantitative) genetic approach and examined the genetic and environmental sources of variation in individual differences in nomophobia. Behavioral genetic studies plan to dissect genetic and environmental influences by apportioning the observed differences between phenotypic variation into the following components: “*additive genetic influences* (a^2 or A) which represent the sum of the effects of the individual alleles at all loci that influence the trait; *non-additive genetic influences* (d^2 or D) which represent interaction between alleles at the same locus (dominance) or on different loci (epistasis); *shared environmental influences* (c^2 or C) which represent common environmental conditions such as socio-economic status and parenting style that increase similarities between twins; and *non-shared environmental influences* (e^2 or E) which represent unique environmental conditions such as differential prenatal exposure, differential parental treatment, or different social and educational experiences that make twins different from each other as well as measurement error” ([Rijsdijk & Sham, 2002, p. 120](#)). In this study, we use the classical twin design. The classical twin design compares similarities within reared-together monozygotic (identical/MZ) twin pairs to similarities within reared-together dizygotic (fraternal/DZ) twin pairs (Segal, 1990). In the classical twin design, however, testing an ACDE model that includes the effects of all variance components (additive genetic [A], shared environment [C], non-additive genetic [D], and non-shared environment [E]; [Jang, 2005](#)) is not statistically possible. Thus, researchers should limit their comparisons to sub-models

that include three of the four sources of variations: the ACE or ADE model (Franić, Dolan, Borsboom, & Boomsma, 2012). For more detailed information concerning the theoretical and methodological background of twin study designs and genetic analyses, please refer to Neale and Maes (1992).

Participants

A total of 125 convenience sampled Turkish twin-pairs ($N = 250$) participated in the study. Because Turkey has no twin registry, twin subjects were found through school enrollment records and snowball sampling, starting with the researchers' social and professional connections. There were 137 females (54.8%) and 113 males (45.2%) ranging in age from 13 to 44 ($M = 18.36$; $SD = 6.71$). Of the twins, 53 pairs (42.4%) were MZ twins (31 female and 22 male pairs), 45 pairs (36%) were same-sex DZ twins (24 female and 21 male pairs), and 27 pairs (21.6%) were opposite-sex DZ twin pairs. All twins were reared together. Zygosity was determined by the twins' self-reports. The zygosity classification of all same-sexed twins was based on answers to four questions regarding the degree of similarity between co-twins. A sample item from these questions includes "Is/was it difficult for your family and friends to tell you apart?" All participants responded to the items without communicating with their twins and reported having a mobile phone with smartphone functions. Despite using a mobile phone for an average of 5 years ($SD = 4.13$), the participants had a smartphone for an average of 2.7 years ($SD = 1.61$).

Measure

Nomophobia Questionnaire. The Nomophobia Questionnaire (NMP-Q) is a 20-item self-report scale yielding a total possible score ranging from 20 to 140. The original NMP-Q was developed by Yildirim and Correia (2015a, 2015b) in English. The NMP-Q was translated and adapted to Turkish by Yildirim, Sumuer, Adnan, and Yildirim (2016). The NMP-Q is well validated, and factor analyses show it to have a unidimensional nature. However, the NMP-Q has also shown adequate psychometric properties and consist of four factors: Factor 1, not being able to communicate (4 items); Factor 2, losing connectedness (5 items); Factor 3, not being able to access (6 items); and Factor 4, giving up convenience (5 items). The definitions for the factors of the NMP-Q are as follows (Yildirim, 2014; Yildirim & Correia, 2015a, 2015b): (1) Not being able to communicate means the feeling of losing instant communication with people and not being able to use services that allow for instant communication, as well as the feeling of not being able to contact people and to be contacted. A sample item from this factor includes "I would feel uncomfortable without constant access to information through my smartphone." (2) Losing connectedness means the feeling of losing the ubiquitous connectivity that smartphones provide and being disconnected from one's online identity. A sample item from this factor includes "If

I were to run out of credits or hit my monthly data limit, I would panic.” (3) Not being able to access means the discomfort of losing pervasive access to information through smartphones and being unable to retrieve information or search for things on smartphones. A sample item from this factor includes “I would feel nervous because I would not able to receive text messages and calls”. (4) Giving up convenience means the feeling of giving up the convenience smartphones provide, which reflects the desire to utilize the convenience of having a smartphone. A sample item from this factor includes “I would feel weird because I would not know what to do.” The items of NMP-Q are scored on a 7-point Likert-type scale (1 = strongly disagree, 7 = strongly agree). Higher scores are associated with higher levels of nomophobia. In this sample, Cronbach’s alphas were 0.78, 0.74, 0.89, 0.83, and 0.89 for the sub-dimensions of not being able to communicate, losing connectedness, not being able to access, and giving up convenience and for the entire scale, respectively.

Statistical Analyses

In the statistical analysis phase, first the means and standard deviations for sex and the zygosity of groups were calculated for the NMP-Q and its sub-scales. Next, twin similarities for the NMP-Q and its dimensions were assessed using intraclass correlations (ICC). Comparing the correlations for MZ twin with those for DZ twins provides a first estimate for variation sources regarding the individual differences in nomophobia. Biometric models for genetic and environmental influences were fitted to the covariance matrices for the nomophobia dimensions by means of maximum likelihood estimation. Models were fitted using the structural equation modelling software, OpenMx (Boker et al., 2011). In the beginning, a saturated model was fitted to calculate the correlations between twin pairs. In the model-fitting phase, the saturated model has been used as a starting-point for comparing different nested models. The fit of full and nested models have been compared using a likelihood ratio test. Goodness-of-fit has been evaluated with the Akaike Information Criterion ($AIC = \chi^2 - 2[df]$), where the model with the smallest AIC value is the best model among all specified models.

Results

Descriptive Statistics

The mean NMP-Q total score for the entire sample is 72.46 ($SD = 22.96$). Table 1 shows three categories for the NMP-Q scores and the percentage of participants within each category, indicating that 56.8% of the participants exhibited moderate levels of nomophobia whereas 13.6% of the participants exhibited severe levels of nomophobia.

Table 1

Three Categories for NMP-Q Scores and the Percentage of Participants within Each (N = 250)

NMP-Q Levels	Range	%
None to Mild	20-59	29.6
Moderate	60-99	56.8
Severe	100-140	13.6

The means and standard deviations for each of the NMP-Q sub-scales by sex and zygosity are listed in Table 2. As can be seen in Table 2, females exhibit slightly higher levels of nomophobia than males. However, no significant mean differences were found between the MZ co-twins or DZ co-twins.

Table 2

Means and Standard Deviations of the NMP-Q by Sex and Zygosity

Zygosity	Sex	MZ				DZ _{SS}				DZ _{OS}			
		Females		Males		Females		Males		Females		Males	
Measure		M	SD	M	SD	M	SD	M	SD	M	SD	M	SD
Not being able to communicate		14.66	6.39	16.70	6.02	15.70	6.19	14.83	7.09	16.14	5.69	15.66	5.34
Losing connectedness		18.54	7.77	17.47	6.15	18.02	7.65	16.33	7.05	19.77	8.42	16.81	6.55
Not being able to access		26.82	10.71	24.18	8.24	25.60	10.17	20.52	9.58	28.81	8.90	26.37	8.56
Giving up convenience		14.48	8.28	13.79	7.22	14.14	8.41	12.00	6.75	15.44	7.64	13.51	7.50
NMP-Total		74.53	23.96	72.15	19.57	73.47	25.42	63.69	21.07	80.18	24.14	72.37	20.46

Note: MZ = Monozygotic Twins; DZ_{SS} = Dizygotic Same-Sex Twins; DZ_{OS} = Dizygotic Opposite-Sex Twins

Twin Correlations

Table 3 shows the intraclass correlations and 95% confidence intervals (CI) for the NMP-Q and its sub-scales. MZ twin correlations were substantially larger than DZ_{SS} twin correlations for the sub-dimensions of losing connectedness ($r_{MZ} = .595$; $r_{DZ_{SS}} = .251$) and giving up convenience ($r_{MZ} = .409$; $r_{DZ_{SS}} = -.112$), and for the NMP-Total ($r_{MZ} = .497$; $r_{DZ_{SS}} = .215$), showing that genetic factors affect the scores on these measures.

Table 3

Intraclass Correlations and 95% Confidence Intervals for the NMP-Q and its Sub-Scales

Measure			Not being able to communicate		Losing connectedness		Not being able to access		Giving up convenience		NMP-Q Total
Zygosity	<i>n</i> ^a	<i>r</i>	95% CI	<i>R</i>	95% CI	<i>r</i>	95% CI	<i>r</i>	95% CI	<i>r</i>	95% CI
MZ _{FF}	31	.538**	[.233, .747]	.653***	[.394, .816]	.444**	[.111, .687]	.327*	[-.025, .607]	.642***	[.377, .810]
MZ _{MM}	22	.489**	[.095, .751]	.457*	[.054, .732]	.169	[-.263, .544]	.575**	[.212, .798]	.259	[-.173, .607]
MZ _{Total}	53	.524***	[.298, .695]	.595***	[.388, .744]	.321**	[.058, .542]	.409**	[.158, .610]	.497***	[.264, .675]
DZss _{FF}	24	.424*	[.034, .702]	.111	[-.298, .486]	.355*	[-.048, .658]	-.147	[-.513, .264]	.218	[-.195, .565]
DZss _{MM}	21	.631**	[.283, .832]	.458*	[.044, .738]	.211	[-.233, .582]	-.111	[-.510, .327]	.118	[-.320, .515]
DZss _{Total}	45	.534***	[.288, .714]	.251*	[-.043, .504]	.325*	[.038, .536]	-.112	[-.390, .184]	.215	[-.081, .476]
DZos _{FM}	27	.301	[-.083, .606]	.100	[-.285, .457]	.060	[-.321, .425]	.160	[-.227, .504]	.117	[-.269, .470]

^a *n* represents the number of twin pairs. * $p < .05$; ** $p < .01$; *** $p < .001$ Note: MZ = Monozygotic Twins; DZ_{SS} = Dizygotic Same-Sex Twins; DZ_{OS} = Dizygotic Opposite-Sex Twins; F = Female; M = Male.

However, correlations for the MZ twin pairs were equal to or smaller than those for DZ_{ss} twin pairs in the sub-dimensions of not being able to communicate and not being able to access, indicating that genetic factors did not play a role in the scores for these sub-dimensions. Additionally, DZ_{os} correlations tend to have much smaller than both MZ and DZ_{ss} correlations. According to Boomsma, Busjahn, and Peltonen (2002, p. 874), “If the resemblance between twins of opposite-sexes is less than expected on the basis of the heritability in males and females, then this indicates that different genes might influence the same trait in the two sexes.” However, the DZ_{os} twins in the present study were not included in the model-fitting analysis to test whether the same genes are expressed in males and females due to the small number of DZ_{os} twins.

Univariate Model-Fitting Analyses

Table 4 displays the results of model-fitting and parameter estimates of the univariate models for the aspects of nomophobia in our twin subjects. The results show the best-fitting models to be the ADE models for the sub-dimensions of losing connectedness and giving up convenience, as well as for the NMP-Q Total. For the sub-dimension of losing connectedness, the additive genetic component accounts for 36.4% of the

Table 4
Results of Model Fitting and Parameter Estimates for NMP-Q

		Parameter estimates						Fit of Model				
NMP	Model	a^2	c^2	e^2	d^2	EP	-2LL	Df	AIC	Δ_{-2LL}	Δdf	p
Losing connectedness	SATM	---	---	---	---	10	1303.521	186	931.525	---	---	---
	ADE^a	0.364	---	0.395	0.240		1305.700	192	921.700	2.18	6	.901
	ACE	0.595	0	0.404	---	4	1305.897	192	921.987	2.381	6	.881
	AE	0.595	0	0.404	---	3	1305.896	193	919.896	2.381	7	.935
	CE	0	0.430	0.570	---	3	1311.643	193	925.643	8.128	7	.321
	E	0	0	1.000	---	2	1331.643	194	943.642	28.127	8	.004
Giving up convenience	SATM	---	---	---	---	10	1344.510	186	972.510	---	---	---
	ADE^a	0.001	---	0.368	0.631	4	1351.51	192	967	6.994	6	.321
	ACE	0.310	0.001	0.689		4	1353.393	192	969.393	8.879	6	.180
	AE	0.310	0	0.690		3	1353.393	193	967.393	8.879	7	.261
	CE	0	0.168	0.832		3	1356.588	193	970.587	12.073	7	.098
	E	---	---	1.000		2	1359.414	194	971.414	14.900	8	.061
NMP-Q Total	SATM	---	---	----	----	10	1763.911	186	1391.912	---	---	----
	ADE^a	0.311	----	0.482	0.207	4	1767.660	192	1383.660	3.749	6	.710
	ACE	0.506	0	0.494	---	4	1767.801	192	1383.801	3.890	6	.691
	AE	0.506	0	0.494	---	3	1767.801	193	1381.801	3.890	7	.792
	CE	0	0	1.000	---	3	1784.849	193	1398.849	20.938	7	.003
	E	0	0	1.000	---	2	1784.849	194	1396.849	20.938	8	.007

Note: SATM; Fully Saturated Model; a^2 = additive genetic, c^2 = shared environmental, e^2 = non-shared environmental, and d^2 = dominant genetic proportion of the variance; EP = Estimated parameters; AIC = Akaike's Information Criterion.

^a Indicates the best-fitting model for each NMP-Q dimension.

variance, the dominance (non-additive) genetic component accounts for 24% of the variance, and the non-shared environment accounts for 39.5% of the variance. For the sub-dimension of giving up convenience, the dominance genetic component accounts for 63.2% of the variance and the non-shared environment accounts for 36.8% of the variance while the contribution of the additive genetic component is very low (0.01%). For the NMP-Q Total, the additive genetic component accounts for 31.1% of the variance, the dominance genetic component accounts for 20.7% of the variance, and the non-shared environment accounted for 48.2% of the variance.

Discussions

This study is the first attempt to investigate the genetic and environmental etiology of nomophobia. In the present study, we have calculated the heritability of nomophobia within the context of Turkish culture and found the most accurate model to be ADE and the heritability estimates ($a^2 + d^2$) for the sub-dimensions of losing connectedness and giving up convenience to be 60.4% and 63.2%, respectively, and to be 51.8% for the NMP-Total scores, while the remaining variances were explained by non-shared environmental factors. An Australian twin study concerning the heritability of mobile phone use behaviors revealed the most accurate model to be ACE, and the additive genetic contributions to mobile phone talking and text-messaging frequencies to range from 34% to 60%, whereas the non-shared environmental contributions range from 28% to 45% (Miller et al., 2012). Because heritability is a statistic that describes genetic contributions to the phenotypic variance of a trait within a particular population of individuals, the heritability of any given trait may not necessarily be the same for all cultures (Saudino et al., 1999). Therefore, future research should examine the heritability of nomophobia in different cultures. Cross-cultural studies can be particularly valuable for improving the understanding of the role of genetic and environmental factors on nomophobia. According to Hofstede's (1984) cultural classification, for example, "Turkish culture is classified as collectivist, hierarchical, feminine, and weak uncertainty avoidance, whereas Trompenaars (as cited in Alkis, 2013) classified Turkish people as particularistic, communitarian, diffuse, emotional, ascribed status, synchronic time oriented and outer directed". The literature shows evidence suggesting a harmony between Turkish culture and the mobile phone use behaviors of Turkish people (e.g., Alkis, 2013; Arpacı, Yardımcı-Cetin, & Turetken, 2015; Mao, Srite, Bennet-Thatcher, & Yaprak, 2005). These results indicate a need to examine whether particular national cultural features increase the probability of addictive behaviors related to technology use. This is an area of research that needs to be explored in more detail.

The results of the present study also revealed the non-shared environmental contributions for the sub-dimensions of losing connectedness and giving up convenience to be 39.6% and 36.8%, respectively, and 48.2% for the total score

on the NMP-Total scores, which shows unique environmental factors to also be important in increasing the liability to develop nomophobia. Indeed, a study by [Zhitomirsky-Geffet and Blau \(2016\)](#) showed a strong positive correlation to exist between addictive smartphone use and social-environmental factors, and younger people to be more influenced by the environment regarding smartphone use than older smartphone users. In the current study, however, the shared environmental factors do not explain a significant portion of phenotypic variation. This is not to say that shared environment may not be important in the development of nomophobia. Instead, the effect of shared (family) environment may be intertwined with the genetic sources of variance. In support of the importance of family environment, one study demonstrated that negative parenting styles significantly influence college students' smartphone addiction ([Lian, You, Huang, & Yang, 2016](#)). Therefore, subsequent research should investigate both shared and non-shared environmental contributions to nomophobia using not only the twin design but also adoption and family designs.

In the present study, $r_{MZ} = 0.595$ and $r_{DZ_{SS}} = 0.251$ for the sub-dimension of losing connectedness, and $r_{MZ} = 0.409$ and $r_{DZ_{SS}} = -0.112$ for the sub-dimension of giving up convenience, whereas for the total score for the NMP-Q, $r_{MZ} = 0.497$ and $r_{DZ_{SS}} = 0.215$, which indicates the evidence of considerable genetic non-additivity (i.e., dominance). As non-additive genetic influences involve allelic interactions, the DZ twin correlation would be less than half the MZ twin correlation if non-additive genetic influences are important for a particular trait or behavior ([Plomin, DeFries, McClearn, & McGuffin, 2008](#)). In the current study, the MZ intra-pair correlations both for the sub-dimensions of losing connectedness and giving up convenience and for the total score of the NMP-Q have double the value of the DZ_{SS} intra-pair correlations, indicating a genetic non-additivity. Thus, this provides the best estimate of total genetic influences (broad-sense heritability). However, if non-additive influences are substantial, correlation comparisons for MZ and DZ twins tend to overestimate genetic influence ([Sherman et al., 1997](#)). Therefore, future studies are needed to replicate or refute the evidence of genetic non-additivity found in this study for nomophobia, using larger and more representative twin samples.

As described earlier, the sub-dimension of losing connectedness relates to the feeling of losing the ubiquitous connectivity that smartphones provide and being disconnected from one's online identity, especially on social media, whereas the sub-dimension of giving up convenience pertains to the feelings of giving up the convenience smartphones provide and reflects the desire to utilize the convenience of having a smartphone ([Yildirim, 2014](#)). According to [Belk's \(2013\)](#) theory of extended self, people perceive their smartphones as an extension of the self and feel anxious when they are without their smartphones. On the other hand, [Billieux et al. \(2015, pp. 159–160\)](#) proposed three potential pathways that can lead to problematic

mobile phone use (PMPU). The Theoretical Pathways Models of Problematic Mobile Phone Use include: “(1) an excessive reassurance pathway (corresponding to individuals whose PMPU is driven by the necessity to maintain relationships and obtain reassurance from others), (2) an impulse-antisocial pathway (corresponding to individuals whose PMPU is driven by poor impulse-control resulting in uncontrolled urges and deregulated use), and (3) an extraversion pathway (corresponding to individuals whose PMPU takes the form of dependence-like symptoms and exaggerated use driven by a strong and constant desire to communicate with others and establish new relationships)”. These theoretical models can be useful for future behavioral genetics research in dissecting genetic and environmental contributions to nomophobia/mobile phone addiction, especially in the context of different pathways.

Furthermore, Jeong et al. (2016) asserted that determining the content types and aims of usage (study-related versus entertainment-related use) that lead to smartphone addiction would help one better understand the smartphone medium and user’s addiction to the medium. As is well-known, not all technological tools or applications are equally addictive. For example, social networking applications and games were found to be significant predictors of smartphone addiction (Darcin, Kose, Noyan, Nurmedov, Yilmaz, & Dilbaz, 2016; Jeong et al. 2016; Salehan & Negahban, 2013), whereas addicted smartphone users tend to use a smartphone because it is fun and entertaining (Vaghefi, Lapointe, & Boudreau-Pinsonneault, 2016). Bianchi and Phillips (2005) showed females to be more likely to use smartphone for social reasons, social purposes to influence habitual smartphone use, and habitual smartphone use to be an important contributor to smartphone addiction (van Deursen et al., 2015). In addition, one study has indicated informational mobile apps and the need for information to negatively correlate to smartphone addiction, while smartphone use without a specific reason to highly correlate to smartphone addiction (Zhitomirsky-Geffet & Blau, 2016). Therefore, exploring the potential relationships between the genetic/environmental etiologies of nomophobia or smartphone addiction and content types/usage aims are promising research avenues that need to be purposefully investigated.

Genetic and environmental factors on nomophobia can change throughout development. Moreover, the heritability of many psychological traits is known to tend to increase with age (Plomin, DeFries, McClearn, & McGuffin, 2001). Although studies have shown nomophobia to be prevalent among all age groups (e.g., Argumosa-Villar, Boada-Grau, & Vigil-Colet, 2017; Yildirim et al., 2016), longitudinal data are needed to determine whether genetic or environmental effects are more crucial for nomophobia in childhood, adolescence, adulthood, or aged populations.

Finally, although we did not examine sex-differences in the etiology of nomophobia in this study, several studies have shown females to be more susceptible to nomophobia

(e.g., Gezgin, Sumuer, Arslan, & Yildirim, 2017; Tavoracci, Meyrignac, Richard, Dechelotte, & Ladner, 2015; Yildirim, et al., 2016), whereas other studies have failed to show a significant relationship between gender and nomophobia (e.g., Argumosa-Villar, Boada-Grau, & Vigil-Colet, 2017; Pavithra, Madhukumar, & Mahadeva, 2015). Therefore, future behavioral genetics studies are needed to expose whether a sex-difference exists in the etiology of nomophobia.

Limitations

The main limitation of this study is its small sample-size. As mentioned earlier, Turkey has no twin registries (neither clinical nor population-based), thus finding twin subjects for this study was difficult. Hence, the results should be interpreted with caution because they may have low power attributable to the small sample-size. A smaller sample-size in twin studies can falsely lead to larger effects (Neale & Maes, 2004). Therefore, the heritability estimates for nomophobia reported here should be regarded as indicative rather than definitive. Furthermore, research with larger and more representative twin samples is needed to replicate the findings of the present study. In addition, both the concordant twin design (in which each co-twin is identified as nomophobic) and the discordant twin design (in which only one twin is identified as nomophobic) should be studied in future work. These designs would allow a comparative investigation of family features, influence from friends, personality correlates, psychosocial problems, and psychiatric comorbidities, as well as other habitual behaviors concerning nomophobia.

Conclusion

There is a growing emphasis in the literature on the need to elicit the etiology of different types of technological addictions (Kuss & Billieux, 2017). The current study was designed to examine the etiological underpinnings of nomophobia. The results indicate a considerable portion of the total variance in nomophobia to be able to be attributed to genetic factors. This does not suggest a nomophobia gene to exist. As previously demonstrated by many studies, nomophobia/mobile phone addiction is influenced by personality traits. Therefore, one should remember that some personality traits may mediate genetic contributions to nomophobia.

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