Smartphone Against Smartphone: An IT-Enabled Social Network Activation for Reducing Smartphone Overuse

Student: Shaokang Yang

Readers: Idris Adjerid; Jiayi Liu

Key words: social network activation, social capital, smartphone overuse, healthcare analysis

---

1. Introduction

Nowadays, smartphones have become ubiquitous, with their overuse prevalent around the world. As of 2024, 91 % Americans own a smartphone. [1]. In 2024, Americans spent 279 minutes on smartphones per day on average [2]. This is equivalent to 14 years of an individual's lifetime, accounting for the life expectancy of the U.S. Smartphone overuse often results in decreased life quality and health outcomes. Evidence suggests that excessive smartphone use exacerbates work-life balance challenges, leading to poor physiological, psychological, and relational well-being (Magni et al. 2023).

Current strategies for combating digital overuse primarily rely on access restrictions and incentives, which can be effort-consuming and costly (Allcott et al. 2022). A cost-effective and sustainable alternative is to enhance real-life social engagement, a process in which smartphones themselves can play a facilitating role (Chang et al. 2022). First, smartphones are highly portable and support instant communication anytime and anywhere, minimizing the barriers of social interaction. Building on this, smartphones also facilitate the formation and activation of social networks, fostering the organizing and sustaining of group social activities. Here, we define social network activation as the process of initiating communication with contacts within one's social network. In this study, we examine whether and how smartphone-enabled social network activation paradoxically reduces overall smartphone use. We hypothesize that contacts embedded in cohesive groups of a social network have a stronger influence than periphery contacts on promoting downstream social engagement, leading to a reduction in smartphone use when properly activated.

To test this hypothesis, we leverage data sets collected from a series of longitudinal studies that tracked participants' smartphone use, social networks, and physical activities. We construct the K-Core, a metric that captures a node's centrality while also considering the cohesion of the group in which the node sits. We identify social network activation in real-time and track its evolution for each participant, combining self-reported social network structure information and real-time mobile communications. Our results show that a one-standard-deviation increase in the K-Core of the activated contacts leads to a 6.46-minute reduction in daily screen time, representing a 3.68 % decrease in total smartphone use. The results remain robust after controlling for non-topological social factors, including social intimacy, trust, relation length, and personality. Moreover, mediation analysis suggests that activating high-K-Core contacts reduces individuals' smartphone use by improving the steps walked, resulting in reduced digital use.

Our study contributes to the literature on combating digital addiction by providing a novel, cost-effective strategy for reducing smartphone overuse that does not require significant finance and effort input. Our findings suggest that strategically activating social ties via smartphones can reduce overall screen time, even though the process itself requires screen time. We also contribute to the literature that studies the impact of social interaction on human behavior and well-being. Prior research heavily relies on social interaction volume as the social engagement metric, little attention has been paid to the structure of social networks. We demonstrate that activating different parts of a social network has heterogeneous effects on human behavior and well-being. Specifically, activating contacts within cohesive social groups helps curb smartphone overuse, potentially because these contacts foster broader group social engagement. Our findings also have practical implications for healthcare interventions and lifestyle enhancement strategies, offering insights for practitioners aiming to promote healthier digital behaviors and social engagement.

2. Literature

2.1. Smartphone Overuse

Modern smartphones support rich tasks including gaming, live streaming and video-watching, which can be addictive. Smartphone overuse, also known as "smartphone addiction" or " problematic smartphone use ", is characterized by excessive or compulsive use of smartphones, which results in negative health and quality of life. First, smartphone overuse can cause negative impacts on users' physical health. Evidence shows that constant smartphone use can cause computer vision syndrome (CVS) including eye fatigue, dryness, blurred vision and other eye-related discomforts (Choi et al. 2018). Excessive use of digital devices at bedtime can also reduce sleep duration and quality and increase daytime sleepiness (Carter et al. 2016). Second, smartphone overuse can detrimentally affect mental health. Benefiting from the portability and connectivity of the mobile platform, smartphones can facilitate the use of social media, whose misuse can cause damage to mental health. For example, by studying the staggered introduction of Facebook in US colleges, Braghieri et al. (2022) find that using Facebook has significant and negative effects on student mental health due to the social comparison on the online community. Another study using cross-sectional survey examined the relationship between smartphone overuse and overall mental health with 655 participants. The results show that excessive smartphone use is associated with higher levels of depression, anxiety and stress (Khan et al. 2023). Third, smartphone overuse can impose challenges on cognitive capability, negatively impact productivity. Alotaibi et al. (2022) find that overusing smartphone can increase cognitive load, limiting engagement in productive activities and negatively impacting academic and work performance.

Researchers and software developers have designed various approaches to help users reduce digital overuse, a process named "digital detox". Existing digital detox strategies primarily rely on access restrictions and incentives. Using a randomized experiment, Allcott et al. (2022) find that either providing users with incentives or allowing users to set limits on screen use can effectively reduce social media use, suggesting that digital overuse is a habit forming as well as a self-control problem. Others recommend using applications for limiting the time and managing the types of digital use. For example, Schmuck (2020) find that digital detox applications (apps; e.g., iOS Screen Time) can reduce smartphone overuse and its consequences on well-being that originate from the misuse of social networking sites (SNSs). Although the above strategies are proven to be effective in reducing digital use, they typically require considerable effort or financial input.

2.2. Social Engagement

Humans are inherently social beings. Appropriate social engagement has significant benefits for individuals' physical and mental health, contributing to a higher quality of life (Umberson &

Karas Montez 2010). Social engagement refers to the participation in social activities that encompasses interacting with others, forming and maintaining social relationships, and playing meaningful roles within a community.

Social engagement enhances physical health. First, engaging in social groups can result in interpersonal competition and social influence, which have been shown to be effective at motivating individuals to walk more steps, fostering physical health by reducing sedentary life styles (Hydari et al. 2022). Moreover, the received social support has been shown to be positively associated with physical activity levels, where social support is exchanged through interpersonal social interactions (Lieber et al. 2024).

Social engagement improves mental health. First, social engagement provides individuals with companionship, emotional support, and information support, contributing to one's mental health conditions (Yan & Tan 2014). In contrast, a constant lack of engagement may lead to social isolation. When individuals are socially isolated, they usually have no or little regular social interaction or sufficient contacts to connect with. Evidence suggests that the lack of social engagement is highly associated with many negative health consequences such as anxiety, depression, and suicide (Garnett F. & Curtin C. 2023).

A cost-effective and sustainable alternative is to enhance real-life social engagement, a process in which smartphones themselves can play a facilitating role (Chang et al. 2022).

1. Access Restrictions
2. Incentives
3. Engaging in Real-life Activities

3. Hypothesis Development

3.1. How Smartphones-Enabled Social Interaction (not necessarily Social Network Activation) Reduces Screen Time (Enhances Real-Life Activity Engagement)

1. Smartphones are highly portable and support instant communication anytime and anywhere, minimizing the barriers of social interaction.

2. Smartphones also facilitate the formation and activation of social networks, fostering the organizing and sustaining of group social activities.

Hypothesis 1 *Using smartphones to activate contacts reduces screen time.*

3.2. How Activating High-K-Core Contacts Reduces Screen Time

Contacts embedded in cohesive groups of a social network have a stronger influence than periphery contacts on promoting downstream social engagement, leading to a reduction in smartphone use when properly activated.

Hypothesis 2 *Using smartphones to activate contacts with a high-K-core in a social network reduces screen time.*

4. Model

4.1. Specification for Smartphone Screen Time

The primary objective of our model is to estimate the impact of social network features on an individual's smartphone overuse scale as measured by the screen use time $ScreenTime_{it}$. Therefore, our interested independent variables are the $Social\ Network\ Features_{it}$ which captures the characteristics of contacts that are activated by smartphone users. Nevertheless, the activation of social networks is triggered by the happening of communication events, which is part of smartphone screen time that we will estimate. This may violate the assumptions of econometric regressions such as homoscedasticity. In order to rigorously examine the relationship between network features and smartphone use, we examine the impact of social network features on different types of screen time use separately. We first focus on non-communication screen time $Non-COMM_{it}$ by subtracting the communication screen time $COMM_{it}$ from the total screen time $Total_{it}$. The time of network activation refers to the communication time one takes to build a connection, which is the time one spends on calls and messages (SMS, MMS, and WhatsApp). Therefore, the non-communication screen time is calculated as follows:

$$\begin{aligned} NonCOMM_{it} = TotalTime_{it} - Call\ Duration_{it} - TextMessageCharacters_{it} \div TextingSpeed_{it} \\ + Non - Text\ Message \times Time\ of\ one\ Message_{it} \end{aligned}$$

In this equation, $NonCOMM_{it}$ refers to the non-communicative screen time; $Call_{it}$ is the number of calls for participant i on day ; $TextMessageCharacters_{it}$ is the total characters for individual i on the day t; $TextingSpeed_{it}$ measures how many characters a user can text in one minute, which is based on preset assumptions (the default $TextingSpeed_{it}$ in our case is 60 characters per minute.) $Non - Text\ Message$ represents the types of the non-text messages including MMS and WhatsApp messages.$Time\ of\ one\ Message_{it}$ is a parameter that indicates how much time a $Non - Text\ Message$ takes, which is based on artificial assumption. We exclude the communication time from the total screen time to differentiate the communication screen time and non-communication screen time. Fortunately, the data sets in the communication study record the starting time and ending time of calls so that we can precisely measure the $Call\ Time_{it}$. However, instant messaging does not capture the texting time. To measure the message time, we set the parameter $TextingDuration_{it}$ as 0.15 minutes to proximate the texting time. Hereafter, we take $NonCOMM_{it}$ as our main dependent variable, which captures the non-communication screen time. Considering the studies in the project are all longitudinal, we build a fixed effect model to estimate non-communication screen time:

$$\text{Screen Time}_{it} = \beta_0 + \beta_1 \cdot \text{Social Network Features}_{it} + \alpha \cdot X_{it} + \theta_i + \lambda_t + \varepsilon_{it} \tag{1}$$

$Social\ Network\ Features_{it}$ represents our main independent variable, which is the degree centrality and core number on the day t in our study. X_{it} refers to control variables, θ_i is individual fixed effect and λ_t represents weekly time fixed effect. Since the the activation of social networks is facilitated by mobile communication which accounts for part of smartphone use, it is crucial to probe non-communication and communication smartphone use independently. Thus, we exclusively investigate communication-driven smartphone use $COMM_{it}$.

4.2. Logistic Model for Smartphone Addiction

In the previous section, we discussed the impact of the characteristics of social networks on general mobile phone adoption. In this section, we focus on the impact of the characteristics of social networks on mobile phone addiction. To the best of our knowledge, there is no definitive metric for the measurement of smartphone overuse. Therefore, we identify the observations with extremely high screen time and label them as smartphone addictions. Specifically, we define that an individual i is addicted to their smartphone on day t if $ScreenTime_{it}$ is above the top 10% of an individual's total observations. Then we create a dummy variable $Addiction_{it}$ for each observation. Thereafter, we estimate the probability of smartphone overuse with a logistic model using the above two metrics for smartphone overuse:

$$\ln\left(\frac{\Pr(\text{ Addiction }_{it}=1|\boldsymbol{X}_{it})}{1-\Pr(\text{ Addiction }_{it}=1|\boldsymbol{X}_{it})}\right) = \beta_0 + \beta_1 \cdot \text{Social Network Features}_{it} + \alpha \cdot X_{it} + \theta_i + \lambda_t + \varepsilon_{it} \tag{2}$$

Table 1 Impact of Social Engagement Volume on Smartphone Use

VARIABLES	(1) NoComm.	(2) Comm.	(3) Total	(4) NoComm.	(5) Comm.	(6) Total	(7) NoComm.	(8) Comm.	(9) Total
TotalContacts	-3.601***	6.831***	-0.649***						
	(0.292)	(0.280)	(0.222)						
InNetwork-Contacts				-6.793***	15.603***	-0.659	-7.620***	16.357***	-0.922
				(0.690)	(0.876)	(0.660)	(0.951)	(1.163)	(0.909)
OutNetwork-Contacts				-3.194***	5.838***	-0.646***	-3.125***	5.773***	-0.617***
				(0.305)	(0.257)	(0.217)	(0.301)	(0.255)	(0.214)
Trust							0.884	-0.961	0.033
							(0.967)	(1.056)	(0.829)
Close							-4.025*	5.406**	-1.483
							(2.437)	(2.725)	(2.090)
Position							0.865***	-1.282***	0.484**
							(0.260)	(0.274)	(0.194)
Duration							1.024***	-1.277***	0.473***
							(0.166)	(0.169)	(0.136)
Constant	241.852***	43.417***	264.713***	244.372***	39.654***	265.547***	241.837***	42.287***	264.712***
	(5.694)	(4.760)	(5.155)	(5.722)	(4.609)	(5.220)	(5.609)	(4.498)	(5.154)
Observations	105,370	105,370	105,370	105,370	105,370	105,370	105,370	105,370	105,370
R-squared	0.198	0.223	0.044	0.197	0.231	0.043	0.199	0.237	0.044
Number of egoid	457	457	457	457	457	457	457	457	457
Communication	Full	Full	Full	Full	Full	Full	Full	Full	Full
Unit F.E.	YES	YES	YES	YES	YES	YES	YES	YES	YES
Day F.E	YES	YES	YES	YES	YES	YES	YES	YES	YES

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Notes. TotalContacts = InNetwork-Contacts + OutNetwork-Contacts

$Addiction_{it}$ measures whether a user i is addicted to a smartphone on a given day t. $Pr\left(\text{ Addiction }_{it}=1 \mid \boldsymbol{X}_{it}\right)$ refers to the conditional probability that $Addiction_{it}$=1 when the independent variables are taking the values of X. Our objective is to examine whether activating contacts with particular network features could curb smartphone addiction. We estimate the probability of smartphone addiction with specification 2. It should be noted that we try multiple criteria for smartphone addiction as robustness checks.

5. Results: Effects of Social Network Features on Smartphone Overuse

Our results demonstrate how the degree centrality and core number of an activated social network cluster impact smartphone screen time (see Table 3). In the review of our analysis, we categorize overall smartphone use into three groups: non-communication, communication, and the overall groups. As shown in the descriptive statistics, the general screen time used was 209.72 minutes, of which 29.242 minutes were spent on communication and the remaining 180.478 minutes were spent on non-communication activities. We separately estimate the effects of social network features on smartphone use behaviors with corresponding equations 1 and 2. Overall, we observe stark differences in the impact of degree centrality vs. core number, where the two features measure the characteristics of social networks from different perspectives. We find a slight but significant positive effect of degree centrality on communication-driven smartphone use but not on non-communication use. In contrast, the core number has strong and substantive effects on reducing both communication and non-communication smartphone use, with the latter being more impacted: one standard deviation increase in core number (SD =3.724) is associated with an 8.41-minute decrease in non-communication use or a 1.51-minute decrease in communication use.

Specifically, in Table 3, we first probe the impact of social network features on non-communication screen use estimated in equation (1), which are shown in columns 1-3. Column 1 focuses solely on social network variables, while column 2 adds physical activity and sleep variables that can be associated with smartphone use. Lastly, the column 3 introduces interpersonal relationship variables. The results suggest that the degree centrality does not impact non-communication smartphone use. In contrast, the core number represents significant reduction effects in non-communication smartphone use. That is probably because the activated cluster with

Table 2 **Impact of Social Network Embeddedness on Screen Time**

VARIABLES	(1) NoComm.	(2) Comm.	(3) Total	(4) NoComm.	(5) Comm.	(6) Total
InNetwork-Contacts	-6.550***	16.053***	-0.124	-7.658***	16.305***	-0.984
	(0.750)	(0.970)	(0.694)	(0.946)	(1.156)	(0.899)
OutNetwork-Contacts	-3.200***	5.827***	-0.657***	-3.129***	5.766***	-0.623***
	(0.305)	(0.255)	(0.216)	(0.301)	(0.254)	(0.213)
K-Core	-0.564	-1.028*	-1.237**	-1.054*	-1.318**	-1.723***
	(0.566)	(0.594)	(0.498)	(0.572)	(0.627)	(0.490)
Trust				0.971	-0.851	0.176
				(0.948)	(1.050)	(0.808)
Close				-2.882	6.833**	0.385
				(2.556)	(2.868)	(2.062)
Position				0.888***	-1.252***	0.523***
				(0.259)	(0.269)	(0.192)
Duration				0.999***	-1.307***	0.431***
				(0.166)	(0.171)	(0.136)
Constant	244.964***	40.765***	266.845***	242.063***	42.561***	265.081***
	(5.711)	(4.520)	(5.196)	(5.606)	(4.498)	(5.143)
Observations	105,370	105,370	105,370	105,370	105,370	105,370
R-squared	0.197	0.232	0.043	0.199	0.237	0.044
Number of egoid	457	457	457	457	457	457
Communication	Full	Full	Full	Full	Full	Full
Unit F.E.	YES	YES	YES	YES	YES	YES
Day F.E	YES	YES	YES	YES	YES	YES

Robust standard errors in parentheses
*** $p<0.01$, ** $p<0.05$, * $p<0.1$

Notes. TotalContacts = InNetwork-Contacts + OutNetwork-Contacts.

a high core number has more capacity to initiate and organize group-level social activities, which reduces the time one spends on smartphones. Activated cluster with solely high degree centrality do not necessarily have the capacity as the core number does; therefore, it does not influence non-communication screen time.

Since the activation of social networks is triggered by mobile communication events, which is part of screen time. This may cause some disturbance in our estimation. To address the concern, we look exclusively into the effect of social network features on communication-driven smartphone use (see Table 3, columns 4 - 5). Columns 4 - 6 show the estimation for communication screen use for equation (1). Column 4 presents the results focusing on social network measurements, while column 5 includes two additional sets of variables: physical activity and social relationships. From these two columns of results, we find significant but opposite effects of the two social network features on communication screen time. Column 6 is our preferred model as it controls the physical activity level (steps) and sleep duration, which can be associated with communication use. It suggests that degree centrality does not show a significant impact on communication-driven screen use. However, we observe that one standard deviation increase in core number (SD =3.724) is associated with a 1.52-minute decrease in communication use. Moreover, we find that the increase of activated contacts regardless of whether they are in or out of the network significantly contributes to communication screen use.

After estimating non-communication and communication smartphone use independently, we turn to the impact of social network features on overall smartphone use, which is the sum of the previous two. Columns 7-9 represent the results for overall screen use. We cumulatively add IVs of social network features, activity as well as social relationships, and mobile communication from columns 7 to 9. The results suggest that degree centrality has no impact on smartphone use. While core number significantly and consistently shows a reductive effect in overall screen time.

Table 3 Results with Lagged Independent Variables

VARIABLES	(1) NonComm.	(2) NonComm.	(3) NonComm.	(4) Comm.	(5) Comm.	(6) Total Screen	(7) Total Screen	(8) Total Screen
Lagged Degree Centrality	2.729	3.448	4.893	6.333***	3.972**	9.062	7.420	4.895
	(5.292)	(5.224)	(5.138)	(1.819)	(1.615)	(5.582)	(5.268)	(5.138)
Lagged Core Number	-1.062**	-1.115**	-1.374***	-0.625***	-0.505***	-1.687***	-1.620***	-1.375***
	(0.501)	(0.500)	(0.485)	(0.185)	(0.178)	(0.503)	(0.490)	(0.485)
In-Network Nodes	-1.526***	-1.624***	-0.434	4.527***	4.627***	3.002***	3.003***	-0.484
	(0.377)	(0.396)	(0.451)	(0.189)	(0.190)	(0.425)	(0.436)	(0.451)
In-Network Inactive Nodes	-0.556***	-0.519***	-0.458**	1.136***	1.151***	0.580***	0.632***	-0.466**
	(0.175)	(0.175)	(0.205)	(0.075)	(0.075)	(0.170)	(0.171)	(0.204)
Out-Network Contacts	-0.362	-0.395	-0.756	-0.666***	-0.839***	-1.029	-1.234	-0.741
	(0.659)	(0.823)	(0.824)	(0.169)	(0.190)	(0.671)	(0.834)	(0.823)
Edges	0.061	0.053	0.100	0.097***	0.118***	0.159	0.171	0.099
	(0.114)	(0.122)	(0.124)	(0.028)	(0.029)	(0.116)	(0.126)	(0.124)
Steps		-0.183***	-0.194***		-0.033***		-0.216***	-0.195***
		(0.019)	(0.019)		(0.007)		(0.020)	(0.019)
Sleep Relation Length		-0.078***	-0.083***		-0.012***		-0.090***	-0.083***
		(0.008)	(0.008)		(0.004)		(0.008)	(0.008)
Trust		0.099	0.209		0.061		0.160	0.212
		(0.947)	(0.920)		(0.474)		(0.964)	(0.920)
Social Closeness		-1.747	-1.316		1.477		-0.271	-1.337
		(2.316)	(2.279)		(1.033)		(2.362)	(2.279)
Contact Position		0.689***	0.558***		-0.464***		0.225	0.559***
		(0.223)	(0.214)		(0.080)		(0.220)	(0.214)
Relation Length		0.432***	0.530***		-0.081		0.351**	0.523***
		(0.152)	(0.143)		(0.070)		(0.146)	(0.143)
In-Network Comm.Freq.			-0.013					0.137***
			(0.013)					(0.013)
Out-Network Comm.Freq.			-0.011					0.140***
			(0.017)					(0.017)
Call Time			-0.685***					0.309***
			(0.044)					(0.044)
Constant	156.588***	221.354***	237.243***	27.337	37.821*	183.925***	259.175***	237.301***
	(45.787)	(44.890)	(41.393)	(19.828)	(20.251)	(49.725)	(48.801)	(41.378)
Observations	81,823	81,823	81,823	81,823	81,823	81,823	81,823	81,823
R-squared	0.027	0.035	0.063	0.111	0.116	0.026	0.037	0.059
Number of egoid	445	445	445	445	445	445	445	445
Communication	Full	Full	Full	Full	Full	Full	Full	Full
Unit F.E.	YES	YES	YES	YES	YES	YES	YES	YES
Day F.E	YES	YES	YES	YES	YES	YES	YES	YES

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Notes. Columns 1-3 represent the results for non-communication smartphone use estimated in equation 1; Columns 4-6 represent the results for communication-driven smartphone use (communication variables In-COMM and Out-COMM are not included as they comprise DV: communication use time); Columns 6-9 represent the results for overall smartphone use .

5.1. Moderating Effects of Physical Activity

In this subsection, we explore whether activating social networks has heterogeneous effects on groups with different physical activity levels. Evidence suggests that physical activity could negatively impact the time people spend on smartphones (Precht et al. 2023). We divide participants into sedentary, medium, and active categories based on their average daily steps walked.The descriptive statistics are summarized in Table 5. The "Sedentary" group comprises the participants with the lowest 25% average daily steps; the "Medium" group represents the participants whose average daily steps rank from 25% to 75% among the complete cohort of participants; and the "Active" group refers to the participants whose average daily steps rank above the top 25%. Overall, we observe that the three groups daily steps are negatively associated with screen time, indicating that physically active individuals spend less time on their smartphones. Building on the descriptive results, we evaluate whether the impact of network features is influenced by physical activity level.

Table 12 shows the estimation results for the moderating impact of physical activity on network features. Columns 1-3 show how network features impact screen time as physical activity increases. We observe that the effectiveness of the core number in curbing smartphone overuse decreases with physical activity levels. The core number is particularly impactful in curbing screen time for people who live a sedentary lifestyle. Specifically, one standard deviation in core number (SD = 3.724) leads to a 9.41-minute decrease in total screen time. The effectiveness of the core number diminishes for the medium-active group and becomes insignificant for the active group.

Table 4 Moderating Effects of Physical Activity (Steps)

Pysical Level	Sedentary		Medium		Active	
Indicator	Steps	Screen Time(min)	Steps	Screen Time(min)	Steps	Screen Time(min)
count	28563	28563	57351	57351	19456	19456
mean	9293	228.26	11800	211.32	15513	178.08
std	44.28	139.86	49.96	130.02	60.80	113.44
min	2.60	0.00	4.58	0.00	11.30	0.00
25%	60.80	126.32	83.62	118.47	112.68	102.02
50%	90.21	207.85	114.26	191.58	149.39	158.02
75%	119.60	309.29	147.24	284.99	191.04	234.17
max	488.87	1010.48	455.20	1043.59	642.26	1072.86

Table 5 Moderating Effects of Physical Activity (Steps)

Pysical Level	Sedentary		Medium		Active	
Indicator	Steps	Screen Time(min)	Steps	Screen Time(min)	Steps	Screen Time(min)
count	28563	28563	57351	57351	19456	19456
mean	9293	228.26	11800	211.32	15513	178.08
std	44.28	139.86	49.96	130.02	60.80	113.44
min	2.60	0.00	4.58	0.00	11.30	0.00
25%	60.80	126.32	83.62	118.47	112.68	102.02
50%	90.21	207.85	114.26	191.58	149.39	158.02
75%	119.60	309.29	147.24	284.99	191.04	234.17
max	488.87	1010.48	455.20	1043.59	642.26	1072.86

This might be due to the limited space for reduction for the active group, as the screen time of the active group is significantly lower than that of the sedentary and medium groups, see Table 12). The Moderating Effects of physical activity level for communication-driven and total smartphone use are shown in columns 4-6 and 7-9, respectively. We find a similar diminishing effect of the core number in the estimations for total screen time, which could be driven by that found in non-communicative screen time as it accounts for 86.06% of total screen time, see Table 5. In conclusion, the results of this section indicate that the impact of the network feature (core number) is influenced by physical activity. Activating contacts with high core numbers is particularly effective for curbing smartphone overuse for those who live a sedentary lifestyle.

Table 8 shows the estimation results for the moderating impact of physical activity on network features. Columns 1-3 show how network features impact screen time as physical activity increases based on activation threshold of 1 communication event. We observe that the effectiveness of the core number in curbing smartphone overuse decreases with physical activity levels. The core number is particularly impactful in curbing screen time for people who live a sedentary lifestyle. Specifically, one standard deviation in core number (SD = 3.724) leads to a 14.12-minute decrease in total screen time. The effectiveness of the core number diminishes for the medium-active group and becomes insignificant for the active group. This might be due to the limited space for reduction for the active group, as the screen time of the active group is significantly lower than that of the sedentary and medium groups, see Table 6. We utilize alternative activation threshold in columns 4-6 and set feature borrowing limitation in columns 7-9, the estimation results are similar to those in columns 1-3. In conclusion, the results of this section indicate that the impact of the network feature (core number) is influenced by physical activity. Activating contacts with high core numbers is particularly effective for curbing smartphone overuse for those who live a sedentary lifestyle.

5.2. Moderating Effects of Communication Levels

In order to evaluate potential heterogeneity in the impact of social network features by mobile communication level, we further estimate Equation 1 on participants sampled by communication

Table 6 Moderating Effects of Physical Activity (Steps)

VARIABLES	(1) NonComm.	(2) NonComm.	(3) NonComm.	(4) Comm.	(5) Comm.	(6) Comm.	(7) Screen Time	(8) Screen Time	(9) Screen Time
Degree Centrality	21.101	-2.580	-1.847	9.088	7.748***	2.872	21.124	-2.547	-1.907
	(14.355)	(9.108)	(11.505)	(8.139)	(2.982)	(4.302)	(14.354)	(9.112)	(11.517)
Core Number	-2.527*	-1.705**	-1.590	-0.624	-0.864***	-0.545	-2.526*	-1.711**	-1.591
	(1.503)	(0.790)	(0.959)	(0.746)	(0.293)	(0.336)	(1.504)	(0.790)	(0.963)
Actived Nodes	-0.499	-1.085	0.829	4.108***	4.231***	3.080***	-0.525	-1.122	0.779
	(1.900)	(1.123)	(1.945)	(0.886)	(0.381)	(0.512)	(1.898)	(1.122)	(1.945)
Inactive Nodes	-0.203	-0.581	0.468	-0.497	-0.819***	-0.996**	-0.187	-0.564	0.468
	(1.617)	(0.991)	(1.642)	(0.699)	(0.258)	(0.407)	(1.616)	(0.990)	(1.643)
Out-Network Contacts Activated	-1.083**	-0.607***	0.517	0.984***	1.221***	1.197***	-1.097**	-0.616***	0.516
	(0.467)	(0.210)	(0.559)	(0.213)	(0.080)	(0.101)	(0.467)	(0.209)	(0.560)
Network Edges	0.221	0.056	0.057	0.081	0.142***	0.119***	0.219	0.054	0.057
	(0.290)	(0.134)	(0.234)	(0.072)	(0.044)	(0.042)	(0.290)	(0.134)	(0.234)
Steps	-0.244***	-0.209***	-0.103***	-0.047**	-0.034***	-0.020***	-0.244***	-0.210***	-0.103***
	(0.039)	(0.023)	(0.027)	(0.021)	(0.007)	(0.007)	(0.039)	(0.023)	(0.027)
Sleep Relation Length	-0.098***	-0.070***	-0.087***	-0.018*	-0.007***	-0.004	-0.098***	-0.070***	-0.086***
	(0.013)	(0.009)	(0.015)	(0.011)	(0.002)	(0.003)	(0.013)	(0.009)	(0.015)
Trust	0.547	0.414	-3.021	-0.717	0.339	0.014	0.547	0.420	-3.017
	(1.565)	(1.043)	(2.400)	(1.081)	(0.571)	(0.723)	(1.564)	(1.044)	(2.402)
Close	-3.934	1.377	2.261	0.725	0.961	1.997	-3.940	1.334	2.272
	(5.082)	(2.885)	(4.749)	(1.707)	(1.461)	(1.270)	(5.074)	(2.886)	(4.750)
Contact Position	1.209***	0.222	0.362	-0.504***	-0.389***	-0.357***	1.212***	0.222	0.367
	(0.306)	(0.314)	(0.295)	(0.178)	(0.097)	(0.103)	(0.306)	(0.314)	(0.295)
Relation Length	0.416	0.414**	0.754***	0.059	-0.184**	0.205**	0.407	0.409**	0.747***
	(0.293)	(0.175)	(0.257)	(0.137)	(0.090)	(0.093)	(0.293)	(0.175)	(0.258)
In-Network Comm. Freq.	-0.035	0.011	-0.061**				0.116***	0.162***	0.089***
	(0.025)	(0.014)	(0.026)				(0.025)	(0.014)	(0.026)
Out-Network Comm. Freq.	-0.023	-0.001	-0.053				0.130***	0.151***	0.098
	(0.021)	(0.018)	(0.070)				(0.022)	(0.018)	(0.070)
Call Relation Length	-0.740***	-0.733***	-0.519***				0.255***	0.261***	0.474***
	(0.056)	(0.061)	(0.061)				(0.056)	(0.061)	(0.060)
Constant	241.620***	200.299***	193.561***	24.221***	18.405*	34.772	241.701***	200.319***	193.789***
	(42.252)	(36.533)	(55.615)	(6.050)	(10.254)	(23.456)	(42.385)	(36.525)	(55.636)
Observations	28,563	57,351	19,456	28,563	57,351	19,456	28,563	57,351	19,456
R-squared	0.089	0.066	0.078	0.060	0.152	0.189	0.059	0.064	0.086
Number of egoid	114	229	114	114	229	114	114	229	114
Physical Activity	Sedentary	Medium	Active	Sedentary	Medium	Active	Sedentary	Medium	Active
Unit F.E.	YES	YES	YES	YES	YES	YES	YES	YES	YES
Day F.E	YES	YES	YES	YES	YES	YES	YES	YES	YES

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Notes. The group of "Sedentary" refers to the participants whose average Steps are at the bottom 25%(mean <10283 steps); the "Medium" group refers to participants whose average steps are ranked from 25% to 75% (mean range from 10283 to 13544 steps); the "Active" group represents the rest of the top 25% participants (mean >=13544 steps)

Table 7 Moderating Effects of Network Size (1 Neighbor Borrowing)

VARIABLES	(1) NoComm.	(2) NoComm.	(3) NoComm.	(4) Comm.	(5) Comm.	(6) Comm.	(7) Screen Time	(8) Screen Time	(9) Screen Time
K-Core	-2.266**	-1.109*	-1.250*	-0.165	-0.076	0.127	-2.270**	-1.111*	-1.259*
	(0.951)	(0.662)	(0.668)	(0.221)	(0.100)	(0.155)	(0.953)	(0.662)	(0.669)
Activated Nodes	0.880	-0.612	0.205	3.079***	3.676***	2.872***	0.791	-0.669	0.153
	(1.466)	(0.481)	(0.474)	(0.360)	(0.275)	(0.199)	(1.466)	(0.481)	(0.475)
Out-Network Contacts Activated	-0.181	-0.262	-0.582**	1.526***	1.204***	1.134***	-0.196	-0.276	-0.582**
	(0.581)	(0.224)	(0.251)	(0.140)	(0.073)	(0.091)	(0.580)	(0.223)	(0.251)
Sleep Duration	-0.061***	-0.093***	-0.070***	-0.001	-0.005***	-0.008***	-0.061***	-0.093***	-0.070***
	(0.014)	(0.010)	(0.013)	(0.001)	(0.001)	(0.001)	(0.014)	(0.010)	(0.013)
Trust	-0.294	0.534	1.411	-0.467	0.150	-0.475	-0.295	0.539	1.408
	(2.076)	(1.050)	(1.239)	(0.461)	(0.230)	(0.346)	(2.075)	(1.049)	(1.239)
Close	-4.109	-1.065	-1.353	1.140*	0.231	1.466**	-4.097	-1.066	-1.315
	(4.977)	(2.557)	(3.509)	(0.652)	(0.584)	(0.609)	(4.975)	(2.556)	(3.511)
Contact Position	0.729	-0.003	0.438*	0.020	-0.276***	-0.194***	0.734	-0.003	0.441*
	(0.768)	(0.274)	(0.246)	(0.145)	(0.054)	(0.057)	(0.767)	(0.274)	(0.246)
Relation Length	1.514***	0.419**	0.262	-0.047	-0.284***	-0.204***	1.511***	0.411**	0.252
	(0.466)	(0.165)	(0.228)	(0.094)	(0.037)	(0.052)	(0.466)	(0.165)	(0.229)
Call Relation Length	-0.706***	-0.770***	-0.576***	1.015***	1.024***	1.006***	0.286***	0.225***	0.418***
	(0.092)	(0.044)	(0.045)	(0.016)	(0.008)	(0.009)	(0.092)	(0.044)	(0.045)
In-Network Comm. Freq.	-0.006	-0.006	0.005				0.144***	0.144***	0.155***
	(0.032)	(0.013)	(0.021)				(0.032)	(0.013)	(0.021)
Out-Network Comm. Freq.	0.027	-0.041*	-0.059**				0.178***	0.111***	0.092***
	(0.033)	(0.021)	(0.026)				(0.033)	(0.021)	(0.025)
Steps	-0.133***	-0.213***	-0.233***	-0.015**	-0.019***	-0.020***	-0.133***	-0.213***	-0.234***
	(0.038)	(0.023)	(0.034)	(0.006)	(0.004)	(0.004)	(0.038)	(0.023)	(0.034)
Constant	-87.144	238.214***	172.141***	4.537***	119.306***	63.042***	-81.060	240.495***	175.302***
	(68.065)	(40.976)	(41.467)	(1.663)	(10.443)	(13.050)	(67.980)	(40.931)	(41.464)
Observations	14,769	56,111	34,490	14,769	56,111	34,490	14,769	56,111	34,490
R-squared	0.101	0.114	0.096	0.736	0.848	0.795	0.107	0.092	0.102
Number of egoid	114	229	114	114	229	114	114	229	114
Network Size	Small	Medium	Large	Small	Medium	Large	Small	Medium	Large
Unit F.E.	YES	YES	YES	YES	YES	YES	YES	YES	YES
Day F.E	YES	YES	YES	YES	YES	YES	YES	YES	YES

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Notes. The group of "Small" refers to the participants whose average social networks are at the bottom 25%(mean <4.18 nodes); the "Medium" group refers to participants whose average nodes are ranked from 25% to 75% (mean range from 4.18 to 8.25 nodes); the "Large" group represents the rest of the top 25% participants (mean >=8.25 nodes)

Table 8 Moderating Effects of Steps (1 Neighbor Borrowing)

VARIABLES	(1) NoComm.	(2) NoComm.	(3) NoComm.	(4) Comm.	(5) Comm.	(6) Comm.	(7) Screen Time	(8) Screen Time	(9) Screen Time
K-Core	-0.415	-1.572***	-1.463**	-0.155	-0.221	-0.100	-0.412	-1.578***	-1.469**
	(1.070)	(0.526)	(0.616)	(0.255)	(0.136)	(0.175)	(1.070)	(0.526)	(0.615)
Activated Nodes	-0.540	-0.196	0.671	3.648***	3.324***	2.651***	-0.586	-0.255	0.617
	(0.744)	(0.450)	(0.761)	(0.309)	(0.236)	(0.230)	(0.743)	(0.450)	(0.761)
Out-Network Contacts Activated	-0.929**	-0.482***	0.175	1.298***	1.178***	1.097***	-0.944**	-0.489***	0.172
	(0.395)	(0.180)	(0.444)	(0.124)	(0.064)	(0.079)	(0.394)	(0.179)	(0.444)
Network Nodes	-0.247	-0.028	-0.782	-0.644*	-0.175	0.107	-0.234	-0.015	-0.772
	(1.521)	(0.923)	(1.520)	(0.334)	(0.183)	(0.280)	(1.518)	(0.923)	(1.520)
Network Edges	0.169	0.014	0.140	0.100**	0.049*	0.007	0.167	0.013	0.139
	(0.299)	(0.117)	(0.247)	(0.047)	(0.027)	(0.040)	(0.299)	(0.117)	(0.247)
Sleep Duration	-0.095***	-0.073***	-0.085***	-0.005***	-0.004***	-0.002	-0.095***	-0.073***	-0.085***
	(0.012)	(0.010)	(0.016)	(0.001)	(0.001)	(0.001)	(0.012)	(0.010)	(0.016)
Trust	-0.037	0.894	1.248	-0.249	0.012	-0.652**	-0.031	0.889	1.247
	(1.292)	(1.016)	(1.466)	(0.426)	(0.205)	(0.283)	(1.289)	(1.016)	(1.467)
Close	-1.260	-1.576	-5.051	1.218	0.765	1.617**	-1.272	-1.570	-5.048
	(4.145)	(2.624)	(3.774)	(0.881)	(0.537)	(0.646)	(4.136)	(2.625)	(3.776)
Contact Position	0.721**	0.079	-0.008	-0.230***	-0.287***	-0.166**	0.725**	0.078	-0.005
	(0.294)	(0.280)	(0.311)	(0.060)	(0.062)	(0.079)	(0.294)	(0.280)	(0.310)
Relation Length	0.542**	0.387**	0.700**	-0.203***	-0.292***	-0.069	0.532**	0.380**	0.694**
	(0.259)	(0.167)	(0.279)	(0.059)	(0.039)	(0.054)	(0.258)	(0.167)	(0.280)
Call Relation Length	-0.749***	-0.746***	-0.471***	1.034***	1.017***	0.996***	0.246***	0.248***	0.522***
	(0.056)	(0.056)	(0.061)	(0.011)	(0.008)	(0.012)	(0.055)	(0.056)	(0.060)
In-Network Comm. Freq.	-0.018	0.012	-0.038				0.133***	0.163***	0.112***
	(0.021)	(0.014)	(0.024)				(0.021)	(0.014)	(0.024)
Out-Network Comm. Freq.	-0.043**	-0.020	-0.043				0.109***	0.131***	0.108**
	(0.021)	(0.018)	(0.053)				(0.021)	(0.018)	(0.053)
Steps	-0.274***	-0.225***	-0.124***				-0.274***	-0.226***	-0.124***
	(0.039)	(0.024)	(0.025)				(0.039)	(0.024)	(0.025)
Constant	522.627***	-26.192	124.145*	4.798***	154.686***	134.543***	527.798***	-24.266	126.505*
	(57.745)	(58.895)	(67.217)	(1.151)	(11.607)	(14.365)	(57.667)	(58.876)	(67.229)
Observations	28,563	57,351	19,456	28,563	57,351	19,456	28,563	57,351	19,456
R-squared	0.119	0.100	0.105	0.860	0.803	0.773	0.090	0.098	0.113
Number of egoid	114	229	114	114	229	114	114	229	114
Steps	Low	Medium	High	Low	Medium	High	Low	Medium	High
Unit F.E.	YES	YES	YES	YES	YES	YES	YES	YES	YES
Day F.E	YES	YES	YES	YES	YES	YES	YES	YES	YES

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Notes. The group of "Sedentary" refers to the participants whose average Steps are at the bottom 25%(mean <10283 steps); the "Medium" group refers to participants whose average steps are ranked from 25% to 75% (mean range from 10283 to 13544 steps); the "Active" group represents the rest of the top 25% participants (mean >=13544 steps

Table 9 Moderating Effects of K-Core (1 Neighbor Borrowing)

VARIABLES	(1) NoComm.	(2) NoComm.	(3) NoComm.	(4) Comm.	(5) Comm.	(6) Comm.	(7) Screen Time	(8) Screen Time	(9) Screen Time
K-Core	-1.664*	-1.020	-1.352**	-0.408*	-0.105	-0.164	-1.671*	-1.025	-1.353**
	(0.996)	(0.706)	(0.595)	(0.223)	(0.118)	(0.176)	(0.998)	(0.706)	(0.596)
Activated Nodes	1.340	-0.090	0.078	3.241***	3.235***	3.241***	1.281	-0.147	0.029
	(1.173)	(0.492)	(0.572)	(0.325)	(0.224)	(0.244)	(1.173)	(0.492)	(0.572)
Out-Network Contacts Activated	-0.142	-0.717***	-0.175	1.395***	1.155***	1.091***	-0.163	-0.719***	-0.181
	(0.451)	(0.223)	(0.266)	(0.085)	(0.059)	(0.098)	(0.449)	(0.223)	(0.265)
Network Nodes	-0.722	-1.725*	1.157	-0.224	-0.396**	-0.240	-0.691	-1.716*	1.167
	(1.858)	(0.991)	(1.385)	(0.285)	(0.193)	(0.418)	(1.846)	(0.992)	(1.384)
Network Edges	0.137	0.373**	-0.167	0.177**	0.060**	0.057	0.132	0.372**	-0.168
	(0.518)	(0.188)	(0.150)	(0.071)	(0.029)	(0.043)	(0.516)	(0.188)	(0.150)
Sleep Duration	-0.085***	-0.090***	-0.058***	-0.002	-0.006***	-0.006***	-0.085***	-0.089***	-0.058***
	(0.017)	(0.010)	(0.013)	(0.002)	(0.001)	(0.001)	(0.017)	(0.010)	(0.013)
Trust	-2.137	0.715	2.536**	-0.688**	0.136	-0.431	-2.112	0.707	2.529**
	(1.783)	(1.027)	(1.211)	(0.339)	(0.258)	(0.332)	(1.779)	(1.027)	(1.212)
Close	1.474	-0.248	-7.189	2.643***	0.934*	1.115	1.419	-0.231	-7.170
	(4.871)	(2.650)	(4.779)	(0.886)	(0.557)	(1.076)	(4.857)	(2.647)	(4.785)
Contact Position	0.216	0.252	0.392	-0.151	-0.279***	-0.191***	0.214	0.254	0.393
	(0.455)	(0.266)	(0.288)	(0.096)	(0.050)	(0.058)	(0.454)	(0.266)	(0.288)
Relation Length	1.340***	0.345**	0.146	-0.207***	-0.281***	-0.207***	1.330***	0.338**	0.138
	(0.311)	(0.160)	(0.240)	(0.057)	(0.040)	(0.055)	(0.310)	(0.160)	(0.241)
Call Relation Length	-0.855***	-0.624***	-0.684***	1.022***	1.026***	1.012***	0.139**	0.370***	0.311***
	(0.070)	(0.043)	(0.073)	(0.012)	(0.012)	(0.010)	(0.069)	(0.043)	(0.072)
In-Network Comm. Freq.	-0.031	0.006	-0.011				0.119***	0.156***	0.140***
	(0.024)	(0.016)	(0.019)				(0.024)	(0.016)	(0.019)
Out-Network Comm. Freq.	0.057*	-0.016	-0.091***				0.209***	0.135***	0.060**
	(0.032)	(0.021)	(0.029)				(0.031)	(0.021)	(0.029)
Steps	-0.220***	-0.225***	-0.205***	-0.016***	-0.016***	-0.020***	-0.220***	-0.225***	-0.205***
	(0.034)	(0.027)	(0.033)	(0.006)	(0.004)	(0.005)	(0.034)	(0.027)	(0.033)
Constant	262.327***	306.585***	-187.537***	4.424***	124.432***	115.704***	263.576***	308.445***	-183.467***
	(69.099)	(45.136)	(62.564)	(1.448)	(9.511)	(14.342)	(69.124)	(45.093)	(62.523)
Observations	16,420	49,609	28,090	16,420	49,609	28,090	16,420	49,609	28,090
R-squared	0.121	0.093	0.122	0.886	0.805	0.808	0.089	0.102	0.104
Number of egoid	108	216	108	108	216	108	108	216	108
Communication	Low	Medium	High	Low	Medium	High	Low	Medium	High
Unit F.E.	YES	YES	YES	YES	YES	YES	YES	YES	YES
Day F.E	YES	YES	YES	YES	YES	YES	YES	YES	YES

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Notes. The group of "Small" refers to the participants whose average social networks are at the bottom 25%(mean <4.18 nodes); the "Medium" group refers to participants whose average nodes are ranked from 25% to 75% (mean range from 4.18 to 8.25 nodes); the "Large" group represents the rest of the top 25% participants (mean >=8.25 steps)

Table 10 Moderating Effects of Screen Time (Two-Way Activation)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
VARIABLES	NoComm.	NoComm.	NoComm.	Comm.	Comm.	Comm.	Screen Time	Screen Time	Screen Time
K-Core	-1.005**	-0.865*	-2.066*	-0.123	-0.098	-0.297	-1.012**	-0.870*	-2.062*
	(0.424)	(0.524)	(1.121)	(0.128)	(0.139)	(0.213)	(0.424)	(0.523)	(1.121)
Activated Nodes	0.139	-1.181**	-0.515	2.424***	3.345***	3.747***	0.087	-1.237**	-0.569
	(0.532)	(0.502)	(1.006)	(0.223)	(0.224)	(0.340)	(0.533)	(0.502)	(1.005)
Out-Network Contacts Activated	-0.516***	-0.412**	-0.064	1.108***	1.202***	1.402***	-0.522***	-0.416**	-0.088
	(0.188)	(0.206)	(0.391)	(0.074)	(0.070)	(0.126)	(0.188)	(0.206)	(0.391)
Network Nodes	-1.164*	0.745	-1.370	-0.240	-0.261	-0.201	-1.166*	0.756	-1.343
	(0.639)	(0.779)	(1.495)	(0.187)	(0.174)	(0.442)	(0.641)	(0.778)	(1.493)
Network Edges	0.179*	-0.089	0.225	0.030	0.057**	0.070	0.179*	-0.090	0.221
	(0.104)	(0.102)	(0.275)	(0.027)	(0.025)	(0.062)	(0.105)	(0.102)	(0.275)
Sleep Duration	-0.015	-0.041***	-0.094***	-0.001	-0.007***	-0.006***	-0.015	-0.041***	-0.094***
	(0.011)	(0.008)	(0.018)	(0.001)	(0.001)	(0.001)	(0.011)	(0.008)	(0.018)
Trust	-0.202	1.671*	1.033	0.128	0.035	-0.466	-0.200	1.668*	1.034
	(1.009)	(1.001)	(1.538)	(0.240)	(0.297)	(0.354)	(1.011)	(1.001)	(1.536)
Close	0.599	-4.672*	-2.281	1.165**	0.421	1.613*	0.613	-4.665*	-2.318
	(2.456)	(2.604)	(4.875)	(0.548)	(0.680)	(0.900)	(2.462)	(2.602)	(4.869)
Contact Position	0.194	0.205	0.569	-0.194***	-0.160***	-0.436***	0.195	0.206	0.569
	(0.208)	(0.186)	(0.504)	(0.067)	(0.047)	(0.090)	(0.208)	(0.186)	(0.505)
Relation Length	0.466***	0.565***	0.429	-0.230***	-0.245***	-0.291***	0.458***	0.558***	0.421
	(0.128)	(0.156)	(0.336)	(0.051)	(0.040)	(0.073)	(0.129)	(0.156)	(0.336)
Call Relation Length	-0.580***	-0.633***	-0.823***	1.016***	1.019***	1.019***	0.414***	0.360***	0.173***
	(0.053)	(0.044)	(0.051)	(0.011)	(0.010)	(0.009)	(0.053)	(0.043)	(0.051)
In-Network Comm. Freq.	-0.137***	-0.088***	-0.010				0.014	0.063***	0.140***
	(0.025)	(0.015)	(0.025)				(0.025)	(0.015)	(0.025)
Out-Network Comm. Freq.	-0.073***	-0.103***	-0.045*				0.078***	0.047**	0.107***
	(0.019)	(0.019)	(0.027)				(0.019)	(0.019)	(0.027)
Unlock	1.052***	0.971***	0.663***				1.051***	0.971***	0.662***
	(0.070)	(0.066)	(0.220)				(0.070)	(0.065)	(0.220)
Steps	-0.083***	-0.247***	-0.419***	-0.014***	-0.022***	-0.015***	-0.083***	-0.247***	-0.420***
	(0.017)	(0.021)	(0.046)	(0.004)	(0.004)	(0.004)	(0.017)	(0.021)	(0.046)
Constant	-161.328***	662.426***	488.350***	2.604**	168.510***	30.748	-159.871***	665.638***	491.373***
	(30.182)	(38.314)	(181.076)	(1.123)	(11.307)	(18.754)	(30.195)	(38.325)	(180.974)
Observations	24,341	55,531	25,498	24,341	55,531	25,498	24,341	55,531	25,498
R-squared	0.255	0.246	0.194	0.811	0.766	0.890	0.267	0.248	0.169
Number of egoid	114	229	114	114	229	114	114	229	114
Steps	Low	Medium	High	Low	Medium	High	Low	Medium	High
Unit F.E.	YES	YES	YES	YES	YES	YES	YES	YES	YES
Day F.E	YES	YES	YES	YES	YES	YES	YES	YES	YES

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Notes. The group of "Small" refers to the participants whose average screen time is at the bottom 25%(mean <149.99 minutes); the "Medium" group refers to participants whose average screen time is ranked from 25% to 75% (mean range from 149.99 to 204.03 minutes); the "Large" group represents the rest of the top 25% participants (mean >=204.03 minutes)

levels. In Table 6, we continue to estimate the equations 1 by stratifying participants into three groups (low, medium, and high) according to their personal average communication volume since our primary IVs, social network features, are facilitated by communication behaviors. By doing this, we investigate how the effects of social network features vary with communication level. Columns 1-3 represent, in order, the results of the estimation of specification 1 as the level of communication increases. First of all, since in-network nodes do not show consistent and significant impact on screen time, therefore, hypothesis **??** is not supported. We observe that degree centrality does not influence non-communication screen time regardless of communication level. Moreover, the reductive effect of core number only appears in the group of medium communication level but not the low nor top communication-level group. Specifically, increasing the core number by one standard deviation (SD=3.724) leads to a 5.81-minute decrease in non-communication screen time (Column 1).

Upon examining the impact of degree centrality on communication-driven smartphone use, we found no significant effect in low and high-communication-level groups. Nevertheless, we observed significant and opposite effects from the core number in all communication-level group. We observe that the core number, rather than increasing, shows a significant reductive effect on communication-driven smartphone use even if the activation of the core number relies on communication. For the sake of completion, we further investigate the impact of social network features on overall smartphone use with equation 1, which are represented in columns 7-9. The results indicate that the benefit of the core number persists and even strengthens in the low communication group, reflecting its cumulative impact on communication and non-communication smartphone use. In

Table 11 Moderating Effects of Screen Time (1 Neighbor Borrowing)

VARIABLES	(1) NoComm.	(2) NoComm.	(3) NoComm.	(4) Comm.	(5) Comm.	(6) Comm.	(7) Screen Time	(8) Screen Time	(9) Screen Time
K-Core	-1.178**	-0.902*	-1.750	-0.025	-0.129	-0.243	-1.184**	-0.907*	-1.747
	(0.465)	(0.524)	(1.109)	(0.115)	(0.138)	(0.213)	(0.466)	(0.524)	(1.109)
Activated Nodes	0.144	-1.189**	-0.396	2.420***	3.350***	3.760***	0.091	-1.245**	-0.450
	(0.531)	(0.501)	(1.011)	(0.223)	(0.224)	(0.342)	(0.531)	(0.502)	(1.009)
Out-Network Contacts Activated	-0.519***	-0.410**	-0.047	1.109***	1.203***	1.401***	-0.525***	-0.414**	-0.071
	(0.187)	(0.206)	(0.391)	(0.073)	(0.070)	(0.127)	(0.187)	(0.206)	(0.391)
Network Nodes	-1.204*	0.668	-1.390	-0.245	-0.247	-0.182	-1.206*	0.678	-1.363
	(0.641)	(0.767)	(1.489)	(0.190)	(0.174)	(0.442)	(0.643)	(0.766)	(1.486)
Network Edges	0.189*	-0.081	0.209	0.026	0.057**	0.066	0.190*	-0.082	0.206
	(0.104)	(0.101)	(0.270)	(0.027)	(0.026)	(0.062)	(0.105)	(0.101)	(0.270)
Sleep Duration	-0.015	-0.041***	-0.094***	-0.001	-0.007***	-0.006***	-0.015	-0.041***	-0.094***
	(0.011)	(0.008)	(0.018)	(0.001)	(0.001)	(0.001)	(0.011)	(0.008)	(0.018)
Trust	-0.409	1.977*	0.534	0.053	0.010	-0.414	-0.406	1.974*	0.532
	(1.009)	(1.015)	(1.609)	(0.226)	(0.293)	(0.356)	(1.011)	(1.014)	(1.607)
Close	1.004	-5.476**	-1.564	1.148**	0.570	1.345	1.015	-5.471**	-1.592
	(2.414)	(2.593)	(4.956)	(0.543)	(0.674)	(0.889)	(2.420)	(2.591)	(4.951)
Contact Position	0.219	0.254	0.276	-0.196***	-0.169***	-0.458***	0.220	0.255	0.277
	(0.209)	(0.188)	(0.550)	(0.067)	(0.046)	(0.095)	(0.209)	(0.188)	(0.550)
Relation Length	0.481***	0.555***	0.397	-0.229***	-0.242***	-0.283***	0.473***	0.548***	0.388
	(0.128)	(0.158)	(0.335)	(0.051)	(0.040)	(0.071)	(0.128)	(0.158)	(0.334)
Call Relation Length	-0.580***	-0.633***	-0.823***	1.017***	1.019***	1.019***	0.414***	0.360***	0.173***
	(0.053)	(0.044)	(0.051)	(0.011)	(0.010)	(0.009)	(0.053)	(0.043)	(0.051)
In-Network Comm. Freq.	-0.137***	-0.088***	-0.012				0.014	0.063***	0.139***
	(0.025)	(0.015)	(0.025)				(0.025)	(0.015)	(0.025)
Out-Network Comm. Freq.	-0.073***	-0.103***	-0.045				0.078***	0.047**	0.107***
	(0.019)	(0.019)	(0.027)				(0.019)	(0.019)	(0.027)
Unlock	1.052***	0.971***	0.662***				1.051***	0.971***	0.662***
	(0.070)	(0.066)	(0.220)				(0.070)	(0.065)	(0.220)
Steps	-0.083***	-0.247***	-0.420***	-0.014***	-0.022***	-0.015***	-0.083***	-0.247***	-0.420***
	(0.017)	(0.021)	(0.046)	(0.004)	(0.004)	(0.004)	(0.017)	(0.021)	(0.046)
Constant	-162.574***	662.770***	479.907***	2.586**	168.450***	26.415	-161.096***	665.991***	482.999***
	(30.072)	(38.484)	(180.694)	(1.127)	(11.319)	(18.991)	(30.086)	(38.497)	(180.591)
Observations	24,341	55,531	25,498	24,341	55,531	25,498	24,341	55,531	25,498
R-squared	0.256	0.246	0.194	0.811	0.766	0.890	0.267	0.248	0.169
Number of egoid	114	229	114	114	229	114	114	229	114
Steps	Low	Medium	High	Low	Medium	High	Low	Medium	High
Unit F.E.	YES	YES	YES	YES	YES	YES	YES	YES	YES
Day F.E	YES	YES	YES	YES	YES	YES	YES	YES	YES

Robust standard errors in parentheses
*** $p<0.01$, ** $p<0.05$, * $p<0.1$

Notes. The group of "Small" refers to the participants whose average social networks are at the bottom 25%(mean <4.18 nodes); the "Medium" group refers to participants whose average nodes are ranked from 25% to 75% (mean range from 4.18 to 8.25 nodes); the "Large" group represents the rest of the top 25% participants (mean >=8.25 steps)

contrast, the impact of degree centrality diminishes as it is not significant in any communication-level groups.

Overall, our results suggest that activating contacts with a higher-than-usual degree centrality does not contribute to curbing smartphone overuse. Thus, Hypothesis **??** is not supported. The finding implies that connecting with contacts with high connections but not engaging in social groups has limited effects in improving smartphone users' social engagement levels. In contrast, we find strong and consistent reduction effects from the core number on smartphone use. This finding verifies our previous conjecture about core number: contacts with higher-than-typical K-Core values reflect the contact's capacity to formalize and initiate group-level social activities. Therefore, Hypothesis **??** is supported. In addition, our results suggest that once a cluster of networks is activated, the impact of social network features does not change with communication volume although the activation action is built on communication events.

5.3. Logistic Model for Smartphone Addiction

Instead of estimating general smartphone use, we identify observations of users when they were addicted to smartphones on a certain day. By doing this, we investigate whether network features could benefit reducing the probability of being addicted to smartphones. Figure 4 (Appendix I) shows the distribution of average individual screen time for different purposes. Figure 5 (Appendix I)shows the distribution of individual smartphone addiction rates (addicted days/ total days) with varying addiction threshold value N in criteria 2. Table 14 shows the estimation for smartphone overuse. The first three columns represent the results for addiction to non-communication smartphone use; columns 4-5 represent the results for addiction to communication-driven smartphone

Table 12 Additional Control: Extraversion (1 Neighbor Borrowing)

VARIABLES	(1) Total	(2) Total	(3) Total
K-Core	-2.006***	-2.018***	-1.892***
	(0.772)	(0.735)	(0.727)
extraversion	-8.505	-5.943	-6.089
	(7.233)	(7.284)	(7.133)
Unlock	1.066***	1.072***	1.045***
	(0.085)	(0.086)	(0.086)
Activated Nodes	1.327*	1.197	-0.732
	(0.675)	(0.733)	(0.605)
Out Contacts	-0.041	0.096	-0.395
	(0.250)	(0.254)	(0.247)
Network Nodes	-0.492	-0.196	-0.144
	(0.950)	(1.180)	(1.125)
Network Edges	0.165	0.136	0.114
	(0.132)	(0.158)	(0.152)
Steps		-0.271***	-0.262***
		(0.023)	(0.023)
Sleep Duration		-0.038***	-0.036***
		(0.011)	(0.011)
Trust		-0.097	-0.213
		(1.348)	(1.334)
Close		-0.890	-1.025
		(3.358)	(3.330)
Contact Position		-0.092	0.105
		(0.297)	(0.295)
Relation Length		0.435**	0.587***
		(0.195)	(0.192)
Call Duration		0.322***	0.310***
		(0.052)	(0.051)
In-Network Comm. Freq.			0.091***
			(0.018)
Out-Network Comm. Freq.			0.054***
			(0.019)
Constant	154.542***	185.902***	184.863***
	(22.135)	(22.625)	(22.064)
Observations	33,567	33,567	33,567
R-squared	0.186	0.204	0.209
Number of egoid	369	369	369
Communication	Full	Full	Full
Unit F.E.	YES	YES	YES
Week F.E	YES	YES	YES

Robust standard errors in parentheses
*** $p<0.01$, ** $p<0.05$, * $p<0.1$

Notes. The group of "Small" refers to the participants whose average social networks are at the bottom 25%(mean <4.18 nodes); the "Medium" group refers to participants whose average nodes are ranked from 25% to 75% (mean range from 4.18 to 8.25 nodes); the "Large" group represents the rest of the top 25% participants (mean >=8.25 steps)

use; columns 6-9 show the results for overall smartphone overuse. We can find that K-core reduces the probability of smartphone overuse for all kinds of screen use.

The dependent variable refers to the probability of being addicted to a smartphone, where addiction identification is based on criteria 3: observations with top 10% individual screen time. We first estimate the model specified in 2 (column (1)) only with the variables about network features. We find that the core numbers can significantly reduce the likelihood of addiction for any purpose of smartphone use. Specifically, one standard deviation increase (SD=3.724) in core number reduces the probability of non-communicative addiction by 6.69%. We add control variables of physical activity (steps and sleep duration) and interpersonal relationships (Trust, social closeness, survey

Table 13 Moderating Effects of Overall Communication on Smartphone Screen Time

VARIABLES	(1) NonComm.	(2) NonComm.	(3) NonComm.	(4) Comm.	(5) Comm.	(6) Comm.	(7) Screen Time	(8) Screen Time	(9) Screen Time
Degree Centrality	5.021	2.405	3.132	4.731	5.831*	15.111	5.084	2.384	3.166
	(9.097)	(8.612)	(18.779)	(3.778)	(2.964)	(9.570)	(9.111)	(8.620)	(18.764)
Core Number	-1.559**	-1.199	-2.461	-0.575***	-0.635*	-1.483*	-1.569**	-1.204	-2.457
	(0.636)	(0.809)	(1.912)	(0.210)	(0.326)	(0.773)	(0.637)	(0.810)	(1.912)
In-Network Nodes	-0.348	0.387	-3.266*	3.316***	3.957***	4.510***	-0.405	0.346	-3.282*
	(1.200)	(1.207)	(1.848)	(0.287)	(0.376)	(0.732)	(1.201)	(1.207)	(1.846)
In-Network Inactive Nodes	-0.846	0.427	-1.205	-0.470*	-0.796***	-1.022	-0.849	0.439	-1.179
	(1.108)	(1.020)	(1.540)	(0.273)	(0.247)	(0.628)	(1.108)	(1.020)	(1.538)
Out-Network Contacts	-0.457	-0.493*	-0.612	1.172***	1.162***	1.271***	-0.464	-0.496*	-0.637
	(0.356)	(0.271)	(0.468)	(0.096)	(0.099)	(0.179)	(0.356)	(0.271)	(0.468)
Edges	0.284	-0.063	0.190	0.088**	0.095***	0.249**	0.285	-0.064	0.187
	(0.198)	(0.131)	(0.311)	(0.042)	(0.033)	(0.105)	(0.198)	(0.131)	(0.311)
Steps	-0.054***	-0.182***	-0.352***	-0.015*	-0.036***	-0.039***	-0.055***	-0.183***	-0.352***
	(0.018)	(0.021)	(0.042)	(0.008)	(0.008)	(0.015)	(0.018)	(0.021)	(0.042)
Sleep Length	-0.037***	-0.074***	-0.130***	-0.001	-0.006***	-0.022**	-0.037***	-0.073***	-0.130***
	(0.010)	(0.008)	(0.015)	(0.002)	(0.002)	(0.010)	(0.010)	(0.008)	(0.015)
Trust	-0.214	-0.432	0.592	0.532	0.615	-1.395	-0.210	-0.436	0.609
	(1.171)	(1.250)	(1.707)	(0.470)	(0.477)	(1.533)	(1.172)	(1.250)	(1.704)
Social Closeness	-0.583	2.626	-4.440	0.393	-0.136	3.709	-0.579	2.635	-4.543
	(2.820)	(3.151)	(5.692)	(0.936)	(1.229)	(2.710)	(2.825)	(3.151)	(5.684)
Survey Contact Position	0.372	0.267	1.391**	-0.278**	-0.431***	-0.435**	0.373	0.269	1.391**
	(0.294)	(0.216)	(0.625)	(0.107)	(0.101)	(0.171)	(0.295)	(0.216)	(0.625)
Relation Length	0.430**	0.457***	0.508	0.034	-0.021	-0.316*	0.423**	0.450**	0.503
	(0.174)	(0.173)	(0.407)	(0.095)	(0.087)	(0.163)	(0.174)	(0.173)	(0.406)
In-Network Comm.Freq.	-0.005	-0.028*	0.018				0.146***	0.122***	0.168***
	(0.017)	(0.016)	(0.022)				(0.017)	(0.016)	(0.022)
Out-Network Comm.Freq.	0.011	-0.021	-0.013				0.162***	0.129***	0.139***
	(0.035)	(0.025)	(0.030)				(0.035)	(0.025)	(0.030)
Call Relation Length	-0.559***	-0.634***	-0.806***				0.435***	0.359***	0.190***
	(0.062)	(0.048)	(0.055)				(0.062)	(0.047)	(0.054)
Constant	163.353***	183.062***	327.889***	5.371***	35.561***	22.101	163.712***	183.018***	327.929***
	(36.798)	(20.699)	(94.590)	(1.991)	(13.056)	(18.407)	(36.814)	(20.726)	(94.446)
Observations	24,341	55,531	25,498	24,341	55,531	25,498	24,341	55,531	25,498
R-squared	0.045	0.068	0.104	0.146	0.155	0.089	0.060	0.070	0.077
Number of egoid	114	229	114	114	229	114	114	229	114
Communication	Low	Medium	High	Low	Medium	High	Low	Medium	High
Unit F.E.	YES	YES	YES	YES	YES	YES	YES	YES	YES
Day F.E	YES	YES	YES	YES	YES	YES	YES	YES	YES

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Notes. The group of low communication refers to the participants whose average communication frequency is at the bottom 25% (mean<57.571); the medium group refers to participants whose average communication frequency ranked in the middle 50% (mean range from 57.571 to 188.279; the high group contains the rest of the top 25% participants(mean>188.279)

position, and relation duration) in column 2. In column 3, we further add control variables of smartphone communication. The results in columns 1–3 are consistent, while column 3 is our preferred model, as it encompasses the most control factors that might affect smartphone use. The results in column 3 suggest that one standard deviation increase (SD=3.724) in core number is associated with a 7.82% decrease in non-communicative addiction probability. Columns 4 and 5 depict the impact of network features on communication addiction. Column 5 additionally controls physical activity and interpersonal relationships. Even though the action of network activation is based on mobile communication, the core number shows a significant reductive effect on communication addiction probability: one standard deviation increase (SD=3.724) in the core number is associated with a 26.81% decrease in communication-driven addiction probability. The results suggest that activating contacts with a high core number motivates the focal persona's social engagement and reduces the time spent on the screen. In comparison, one standard deviation increase in the degree centrality (SD=0.329) is associated with a 8.12% increase in communication-driven addiction. The results imply that activating contacts with a high degree centrality increased the likelihood of communication addiction, which does not help improve a focal person's social engagement level. This supports our conjecture that contacts with a high degree centrality but a low core number can only motivate pairwise interaction but cannot facilitate group-level activity. Columns 6 – 9 show the impact of network features on overall smartphone addiction, of which model 9 considers most control variables. The results in column 9 suggest that degree centrality does not show significant impact on overall screen time, while one standard deviation increase in core number reduces addiction probability by 5.34%. Our findings reveal that the core number not only helps reduce the general

Table 14 Impact of Social Network Features on the Probability of Smartphone Addiction

VARIABLES	(1) NonCommAddic	(2) NonCommAddic	(3) NonCommAddic	(4) CommAddic	(5) CommAddic	(6) Addiction	(7) Addiction	(8) Addiction
Degree Centrality	0.072	0.122	0.125	0.650***	0.247***	0.141**	0.191**	0.117
	(0.060)	(0.086)	(0.086)	(0.060)	(0.091)	(0.060)	(0.087)	(0.087)
Core Number	-0.018**	-0.018**	-0.021***	-0.088***	-0.072***	-0.031***	-0.028***	-0.020***
	(0.008)	(0.008)	(0.008)	(0.008)	(0.008)	(0.008)	(0.008)	(0.008)
In-Network Nodes	-0.024***	-0.023***	-0.021***	0.201***	0.205***	0.024***	0.027***	-0.016**
	(0.007)	(0.007)	(0.008)	(0.006)	(0.007)	(0.007)	(0.007)	(0.008)
In-Network Inactive Nodes	-0.002	-0.002	-0.004	0.015***	0.009*	-0.003	-0.002	0.005
	(0.004)	(0.005)	(0.005)	(0.005)	(0.006)	(0.004)	(0.005)	(0.005)
Out-Network Contacts	-0.006***	-0.005**	-0.007**	0.036***	0.037***	0.004*	0.005**	-0.009***
	(0.002)	(0.002)	(0.003)	(0.002)	(0.002)	(0.002)	(0.002)	(0.003)
Edges	0.001**	0.001*	0.001**	-0.001*	-0.000	0.001	0.001	0.000
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Steps		-0.004***	-0.004***		-0.002***		-0.004***	-0.004***
		(0.000)	(0.000)		(0.000)		(0.000)	(0.000)
Sleep Relation Length		-0.002***	-0.002***		-0.001***		-0.002***	-0.002***
		(0.000)	(0.000)		(0.000)		(0.000)	(0.000)
Trust		0.016	0.017		0.001		0.012	0.013
		(0.013)	(0.013)		(0.013)		(0.013)	(0.013)
Social Closeness		-0.079**	-0.072**		0.101***		-0.067*	-0.088**
		(0.034)	(0.034)		(0.036)		(0.035)	(0.035)
Survey Contact Position		0.010***	0.009***		-0.031***		0.004	0.010***
		(0.003)	(0.003)		(0.004)		(0.003)	(0.003)
Relation Relation Length		0.011***	0.012***		0.006**		0.007***	0.011***
		(0.002)	(0.002)		(0.002)		(0.002)	(0.002)
In-Network Comm.Freq.			0.000					0.001***
			(0.000)					(0.000)
Out-Network Comm.Freq.			0.000					0.001***
			(0.000)					(0.000)
Call Relation Length			-0.005***					0.004***
			(0.000)					(0.000)
Constant	-1.964***	-0.687	-0.670	-2.253***	-1.688***	-1.874***	-0.475	-0.763
	(0.617)	(0.622)	(0.620)	(0.480)	(0.488)	(0.551)	(0.564)	(0.551)
Observations	105,298	105,298	105,298	105,256	105,256	105,298	105,298	105,298
Communication	Full	Full	Full	Full	Full	Full	Full	Full
Unit F.E.	YES	YES	YES	YES	YES	YES	YES	YES
Day F.E	YES	YES	YES	YES	YES	YES	YES	YES

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Notes. Columns 1-3 represent the results for non-communication smartphone use estimated in equation 1; Columns 4-5 represent the results for communication-driven smartphone use (communication variables In-COMM and Out-COMM are not included as they comprise DV: communication use time); Columns 6-9 represent the results for overall smartphone use .

use of smartphones, but also helps fix the behavior of those who are addicted to smartphones. The estimation results validate the effectiveness of core number in promoting social engagement.

6. Robustness Checks

In this section, we conduct multiple robustness checks to investigate the consistency of our explanation and address potential endogeneity.

6.1. Alternative Activation Threshold (Two-Way Communication)

In the main analysis of the manuscript, the activation threshold is a communication event > 0, which means a contact could be successfully activated with a single call or message. Nevertheless, there could be a situation in which the contacts did not respond to the information, which led to a failed activation. We adjust the activation threshold as follows: a contact is activated if any of the two conditions are met: First, the communication event type is a call; second, the communication event type is a message (SMS, MMS, or WhatsApp), and there are both "outgoing" and "incoming" messages (SMS, MMS, or WhatsApp). The above two conditions could ensure two-way communication (an effective activation) exists between two smartphone users. This eliminates the possibility of one-way communication: one only sends or receives communication information. Overall, the estimation results are mostly consistent with earlier results after the adjustment.

The estimation results in Table 15 based on the two-way activation threshold are consistent with our main results, which validates our findings.

Table 15 Impact of Social Network Features on Smartphone Use

Alternative Activation Threshold (Two-way communication)

VARIABLES	(1) NonComm.	(2) NonComm.	(3) NonComm.	(4) Comm.	(5) Comm.	(6) Screen Time	(7) Screen Time	(8) Screen Time
Degree Centrality	3.652	3.076	8.728	9.992***	11.394***	13.528**	14.465*	8.685
	(6.102)	(8.302)	(8.189)	(2.249)	(3.665)	(6.494)	(8.584)	(8.188)
Core Number	-1.765***	-1.881***	-2.315***	-1.153***	-0.993***	-2.906***	-2.857***	-2.315***
	(0.674)	(0.684)	(0.678)	(0.246)	(0.244)	(0.696)	(0.697)	(0.678)
In-Network Nodes	-1.107***	-1.132***	-0.699**	2.646***	2.712***	1.538***	1.584***	-0.707**
	(0.307)	(0.311)	(0.326)	(0.132)	(0.133)	(0.323)	(0.323)	(0.326)
Out-Network Contacts	-0.505**	-0.459**	-0.232	1.340***	1.350***	0.819***	0.875***	-0.252
	(0.223)	(0.223)	(0.255)	(0.093)	(0.092)	(0.218)	(0.217)	(0.255)
Edges	0.049	0.039	0.053	0.035**	0.040**	0.084	0.080	0.053
	(0.063)	(0.064)	(0.064)	(0.016)	(0.016)	(0.063)	(0.064)	(0.064)
Steps		-0.180***	-0.191***		-0.031***		-0.211***	-0.192***
		(0.017)	(0.017)		(0.006)		(0.018)	(0.017)
Sleep Relation Length		-0.076***	-0.080***		-0.010***		-0.087***	-0.080***
		(0.007)	(0.007)		(0.003)		(0.007)	(0.007)
Trust		1.113	1.048		-0.337		0.771	1.052
		(1.011)	(0.976)		(0.508)		(1.013)	(0.975)
Social Closeness		-3.090	-3.459		0.018		-3.158	-3.463
		(2.785)	(2.643)		(0.922)		(2.626)	(2.644)
Survey Contact Position		0.593**	0.483**		-0.355***		0.225	0.485**
		(0.237)	(0.229)		(0.081)		(0.234)	(0.229)
Relation Relation Length		0.424**	0.520***		-0.025		0.414**	0.513***
		(0.178)	(0.173)		(0.070)		(0.179)	(0.173)
In-Network Comm.Freq.		-0.014					0.137***	
			(0.022)					(0.022)
Out-Network Comm.Freq.		-0.016					0.137***	
			(0.045)					(0.045)
Call Relation Length			-0.707***					0.287***
			(0.041)					(0.041)
Constant	149.429***	208.671***	218.341***	6.227***	14.587***	162.020***	230.413***	218.369***
	(24.816)	(25.843)	(25.770)	(1.991)	(3.839)	(27.304)	(28.549)	(25.770)
Observations	105,370	105,370	105,370	109,693	109,693	105,370	105,370	105,370
R-squared	0.027	0.035	0.065	0.096	0.099	0.025	0.035	0.056
Number of egoid	457	457	457	487	487	457	457	457
Communication	Full	Full	Full	Full	Full	Full	Full	Full
Unit F.E.	YES	YES	YES	YES	YES	YES	YES	YES
Day F.E	YES	YES	YES	YES	YES	YES	YES	YES

Robust standard errors in parentheses
*** $p<0.01$, ** $p<0.05$, * $p<0.1$

Notes. Columns 1-3 represent the results for non-communication smartphone use estimated in equation 1; Columns 4-5 represent the results for communication-driven smartphone use (communication variables In-COMM and Out-COMM are not included as they comprise DV: communication use time); Columns 6-9 represent the results for overall smartphone use .

6.2. Neighbour Borrowing with Limitation to Closest 1 Survey

In the main analysis, we look up missing contact information from the closest neighbor thorough complete social network surveys. It is important to note that the process of finding missing contacts may lead to inaccurate feature information if the contact is found in a survey that is far from the current one. For instance, if a contact is missed in Survey 2 and it is only reported in Survey 8, the time interval between the two surveys is so long that the network feature in Survey 8 may have changed significantly compared to Survey 2. This means that the feature information may not be reliable due to the changes that have occurred in the network. In this section, we limit the look-up process to the closest 1 neighbor survey. For example, if an activated contact is missed in Survey 3, we will only look up the missed contact in Survey 2 or Survey 4 (the neighbor surveys of Survey 3). If the contact is not found in Survey 3 or Survey 4, we will consider it an out-of-network contact. The daily activated network contacts decreased from 2.93 to 2.31 with this approach. The estimation results based on look-up with limitations are consistent with those in our main results, which validate our findings.

7. Conclusion and Discussion

7.1. Implications

As an intrinsic nature of human beings, socializing plays a significant role in self-achievement, fulfilling the sense of belonging, and maintaining mental health. Activating social networks and mobilizing social capital provides a potential vehicle for improving individuals' health behaviors.

Table 16 Neighbour Borrowing with Limitation to Closest 1 Wave Survey

VARIABLES	(1) NoComm.	(2) NoComm.	(3) NoComm.	(4) Comm.	(5) Comm.	(6) Total	(7) Total	(8) Total
Degree Centrality	0.536	0.578	3.991	10.202***	7.724**	10.738	8.302	4.005
	(6.198)	(8.852)	(8.386)	(2.085)	(3.547)	(6.637)	(8.455)	(8.388)
Core Number	-1.450*	-1.421*	-1.762**	-1.070***	-0.939***	-2.520***	-2.361***	-1.766**
	(0.775)	(0.791)	(0.793)	(0.298)	(0.298)	(0.809)	(0.821)	(0.794)
Activated Network Nodes	-0.987	-1.201	-0.624	3.452***	3.630***	2.465***	2.428***	-0.655
	(0.788)	(0.899)	(0.896)	(0.318)	(0.299)	(0.732)	(0.856)	(0.896)
Inactive Network Nodes	0.335	0.198	-0.076	-0.778***	-0.723***	-0.443	-0.525	-0.064
	(0.657)	(0.759)	(0.742)	(0.210)	(0.201)	(0.640)	(0.741)	(0.742)
Out-Network Contacts	-0.692***	-0.659***	-0.383*	1.446***	1.455***	0.754***	0.797***	-0.393**
	(0.168)	(0.169)	(0.197)	(0.081)	(0.081)	(0.161)	(0.162)	(0.197)
Network Edges	0.024	0.026	0.066	0.120***	0.118***	0.144	0.144	0.065
	(0.107)	(0.111)	(0.112)	(0.032)	(0.031)	(0.107)	(0.113)	(0.112)
Steps		-0.179***	-0.190***		-0.032***		-0.211***	-0.190***
		(0.017)	(0.017)		(0.006)		(0.018)	(0.017)
Sleep Relation Length		-0.076***	-0.080***		-0.009***		-0.085***	-0.079***
		(0.007)	(0.007)		(0.003)		(0.007)	(0.007)
Trust		-0.112	-0.198		-0.262		-0.374	-0.195
		(0.976)	(0.920)		(0.424)		(0.931)	(0.920)
Social Closeness		-0.428	-0.346		1.167		0.739	-0.353
		(2.790)	(2.588)		(1.107)		(2.550)	(2.589)
Survey Contact Position		0.519**	0.441**		-0.377***		0.142	0.443**
		(0.206)	(0.197)		(0.071)		(0.203)	(0.197)
Relation Relation Length		0.293**	0.436***		-0.026		0.268*	0.429***
		(0.145)	(0.141)		(0.061)		(0.148)	(0.141)
In-Network Comm. Freq.			-0.004					0.146***
			(0.012)					(0.012)
Out-Network Comm. Freq.			-0.027*					0.124***
			(0.016)					(0.016)
Call Relation Length			-0.706***					0.288***
			(0.041)					(0.041)
Constant	145.301***	205.112***	214.971***	15.330	23.543**	160.631***	228.655***	214.995***
	(24.867)	(25.712)	(25.686)	(9.302)	(9.701)	(27.407)	(28.415)	(25.693)
Observations	105,271	105,271	105,271	105,271	105,271	105,271	105,271	105,271
R-squared	0.027	0.034	0.065	0.105	0.108	0.025	0.035	0.056
Number of egoid	454	454	454	454	454	454	454	454
Communication	Full	Full	Full	Full	Full	Full	Full	Full
Unit F.E.	YES	YES	YES	YES	YES	YES	YES	YES
Day F.E	YES	YES	YES	YES	YES	YES	YES	YES

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Notes. Columns 1-3 represent the results for non-communication smartphone use estimated in equation 1; Columns 4-5 represent the results for communication-driven smartphone use (communication variables In-COMM and Out-COMM are not included as they comprise DV: communication use time); Columns 6-9 represent the results for overall smartphone use .

As a primary approach of ICTs, smartphone has been playing a crucial role in facilitating interpersonal social interaction. Whether smartphone-facilitated social interaction has similar benefits as physical social interaction is poorly understood. With this in mind, our study investigates how smartphone-based social network activation affects individuals' behavior and wellness.

Our study contributes to the literature from multiple aspects. First, our study advances the understanding of the impact of social engagement on individual behavior and well-being from social interaction volume to the structure of social networks. Our results suggest that activating and mobilizing contacts who are embedded in one's social network can increase group-level social engagement and thus reduce excessive smartphone use. Moreover, we find that activating different segments of one's social network can have varying effects on an individual's health behavior, highlighting the heterogeneity of these impacts. In contrast to much of the previous research, which primarily measures social interaction based on its frequency or volume, we adopt a more comprehensive approach. Utilizing social network analysis, we delve into a deeper exploration of an individual's social engagement. This approach enables us to not only assess the overall level of social engagement but also dissect the intricate structure of one's social network.

The second key advancement our study offers is shedding light on the intricate mechanisms underlying the heterogeneous effects of activating different parts of an individual's social network Previous studies have established that mobilizing social capital can yield positive outcomes, such as effective career threat management (Smith et al. 2012). However, we acknowledge the darker side, wherein activating specific segments of one's social network may lead to detrimental consequences, including social isolation, mistrust, and a decline in self-esteem (Pescosolido et al. 2010, Wahl 2012). Our research seeks to bridge this knowledge gap by closely examining the characteristics of the activated clusters within one's social network. Furthermore, our study takes a dynamic perspective, a departure from the predominantly static analyses prevalent in current social network research. We recognize the inherent nature of social interactions as dynamic and evolving over time (Emirbayer 1997). Therefore, by tracking changes in an individual's social network throughout our study, we aim to uncover the intricate dynamics of social interactions and their impact on health behavior.

Current research about social engagement has several limitations in analyzing an individual's social behavior. First of all, prior research traditionally takes the volume of social interaction as a metric of social engagement level relying on self-reported data (Onnela et al. 2014). In addition, current research in this field probes social interaction heavily, focusing on local interpersonal social activities (we use the term "local interpersonal social activities" to refer to the social interaction that directly involves the focal individual), which may lead to some limitations in the understanding of one's overall social behavior.

In summary, our research advances the current understanding of the relationship between social networks and health behavior in three key ways: by providing a more comprehensive measurement of social engagement through social network analysis, by examining the mechanisms behind the heterogeneous effects of network activation, and by adopting a dynamic approach to the study of evolving social networks. These contributions collectively enhance the depth and breadth of knowledge in the field of social network analysis and its implications for health outcomes. Moreover, in future research endeavors, it becomes increasingly essential to conduct meticulous investigations into the nuanced ways in which both social disconnectedness and perceived isolation uniquely shape and influence an individual's utilization of smartphones.

7.2. Limitations

In the discussion of our findings, it is imperative to acknowledge the inherent limitations of our study. While our analysis offers valuable insights into the interplay between social network activation and smartphone utilization, it is crucial to recognize the following constraints: First, demographic homogeneity. Our study predominantly comprises students as participants. While this cohort provided us with valuable data, it may not be fully representative of the broader population. Different age groups and professional backgrounds may exhibit diverse smartphone usage patterns, potentially limiting the generalizability of our findings. Second, screen time is confounding. The method we employed to detect social network activation was based on mobile communication events, which inherently encompass screen time. This introduces an inherent challenge in isolating the precise influence of social network activation on smartphone usage independently, as these variables tend to overlap.In light of these limitations, it is advisable for future research to encompass a more diverse and inclusive participant pool spanning various age groups and professions. Additionally, refining our measurement techniques to disentangle the effects of screen time from social network activation could provide a more nuanced understanding of this intricate relationship."

Notes

[1] https://www.pewresearch.org/internet/fact-sheet/mobile/

[2] https://www.statista.com/statistics/1045353/mobile-device-daily-usage-time-in-the-us/

References

Ahuja, M. K., Galletta, D. F., & Carley, K. M. (2003, January). Individual Centrality and Performance in Virtual R&D Groups: An Empirical Study. *Management Science*, *49*(1), 21–38. Retrieved 2023-08-11, from https://pubsonline.informs.org/doi/10.1287/mnsc.49.1.21.12756 doi: 10.1287/mnsc.49.1.21.12756

Allcott, H., Gentzkow, M., & Song, L. (2022, July). Digital Addiction. *American Economic Review*, *112*(7), 2424–2463. Retrieved 2024-08-16, from https://pubs.aeaweb.org/doi/10.1257/aer.20210867 doi: 10.1257/aer.20210867

Allen-Perkins, A., Pastor, J. M., & Estrada, E. (2017, October). Two-walks degree assortativity in graphs and networks. *Applied Mathematics and Computation*, *311*, 262–271. Retrieved 2023-08-15, from https://linkinghub.elsevier.com/retrieve/pii/S0096300317303235 doi: 10.1016/j.amc.2017.05.025

Alotaibi, M. S., Fox, M., Coman, R., Ratan, Z. A., & Hosseinzadeh, H. (2022, April). Perspectives and Experiences of Smartphone Overuse among University Students in Umm Al-Qura University (UQU), Saudi Arabia: A Qualitative Analysis. *International Journal of Environmental Research and Public Health*, *19*(7). Retrieved 2024-09-10, from https://www.ncbi.nlm.nih.gov/pmc/articles/PMC8998548/ doi: 10.3390/ijerph19074397

Bapna, S., & Funk, R. (2021, June). Interventions for Improving Professional Networking for Women: Experimental Evidence from the IT Sector. *MIS Quarterly*, *45*(2), 593–636. Retrieved 2023-08-12, from https://misq.org/interventions-for-improving-professional-networking-for-women-experimental-evidence-from-the-it-sector.html doi: 10.25300/MISQ/2021/15620

Barrat, A., Barthélemy, M., Pastor-Satorras, R., & Vespignani, A. (2004, March). The architecture of complex weighted networks. *Proceedings of the National Academy of Sciences*, *101*(11), 3747–3752. Retrieved 2023-08-15, from https://pnas.org/doi/full/10.1073/pnas.0400087101 doi: 10.1073/pnas.0400087101

Boston College, Kane, G. C., Alavi, M., Emory University, Labianca, G. J., University of Kentucky, . . . University of Kentucky (2014, January). What's Different about Social Media Networks? A Framework and Research Agenda. *MIS Quarterly*, *38*(1), 274–304. Retrieved 2023-08-12, from https://misq.org/what-s-different-about-social-media-networks-a-framework-and-research-agenda.html doi: 10.25300/MISQ/2014/38.1.13

Braghieri, L., Levy, R., & Makarin, A. (2022, November). Social Media and Mental Health. *American Economic Review*, *112*(11), 3660–3693. Retrieved 2024-09-08, from https://pubs.aeaweb.org/doi/10.1257/aer.20211218 doi: 10.1257/aer.20211218

Brass, D. J., Butterfield, K. D., & Skaggs, B. C. (1998, January). Relationships and Unethical Behavior: A Social Network Perspective. *The Academy of Management Review*, *23*(1), 14. Retrieved 2023-08-12, from http://www.jstor.org/stable/259097?origin=crossref doi: 10.2307/259097

Burgess, T. F., Grimshaw, P., & Shaw, N. E. (2017, March). Research Commentary—Diversity of the Information Systems Research Field: A Journal Governance Perspective. *Information Systems Research*, *28*(1), 5–21. Retrieved 2023-08-13, from https://pubsonline.informs.org/doi/10.1287/isre.2016.0657 doi: 10.1287/isre.2016.0657

Carter, B., Rees, P., Hale, L., Bhattacharjee, D., & Paradkar, M. S. (2016). Association Between Portable Screen-Based Media Device Access or Use and Sleep Outcomes. *JAMA Pediatrics*, *170*(12), 1202–1202. Retrieved from http://archpedi.jamanetwork.com/article.aspx?doi=10.1001/jamapediatrics.2016.2341 doi: 10.1001/jamapediatrics.2016.2341

Chang, K., Li, X., Zhang, L., & Zhang, H. (2022, February). A Double-Edged Impact of Social Smartphone Use on Smartphone Addiction: A Parallel Mediation Model. *Frontiers in Psychology*, *13*, 808192. Retrieved 2025-02-27, from https://www.frontiersin.org/articles/10.3389/fpsyg.2022.808192/full doi: 10.3389/fpsyg.2022.808192

Choi, J. H., Li, Y., Kim, S. H., Jin, R., Kim, Y. H., Choi, W., . . . Yoon, K. C. (2018, October). The influences of smartphone use on the status of the tear film and ocular surface. *PLOS ONE*, *13*(10), e0206541. Retrieved 2025-03-03, from https://dx.plos.org/10.1371/journal.pone.0206541 doi: 10.1371/journal.pone.0206541

Emirbayer, M. (1997, September). Manifesto for a Relational Sociology. *American Journal of Sociology*, *103*(2), 281–317. Retrieved 2023-08-23, from https://www.journals.uchicago.edu/doi/10.1086/231209 doi: 10.1086/231209

Fang, X., Hu, P. J.-H., Li, Z. L., & Tsai, W. (2013, March). Predicting Adoption Probabilities in Social Networks. *Information Systems Research*, *24*(1), 128–145. Retrieved 2023-08-13, from https://pubsonline.informs.org/doi/10.1287/isre.1120.0461 doi: 10.1287/isre.1120.0461

Garnett F., M., & Curtin C., S. (2023, April). *Suicide Mortality in the United States, 2001–2021* (Tech. Rep.). National Center for Health Statistics (U.S.). Retrieved 2023-08-16, from https://stacks.cdc.gov/view/cdc/125705 doi: 10.15620/cdc:125705

Golbeck, J. (2013). *Analyzing the social web* (First edition ed.). Waltham, MA: Morgan Kaufmann is an imprint of Elsevier.

Golbeck, J., & Klavans, J. L. (2015). *Introduction to social media investigation: a hands-on approach*. Waltham, MA: Syngress, an imprint of Elsevier.

Gray, Parise, & Iyer. (2011). Innovation Impacts of Using Social Bookmarking Systems. *MIS Quarterly*, *35*(3), 629. Retrieved 2023-08-12, from https://www.jstor.org/stable/10.2307/23042800 doi: 10.2307/23042800

Hydari, M. Z., Adjerid, I., & Striegel, A. D. (2022). Health Wearables, Gamification, and Healthful Activity. *Management Science*.

Kane, & Borgatti. (2011). Centrality-Is Proficiency Alignment and Workgroup Performance. *MIS Quarterly*, *35*(4), 1063. Retrieved 2023-08-12, from https://www.jstor.org/stable/10.2307/41409973 doi: 10.2307/41409973

Kane, G. C., & Alavi, M. (2008, September). Casting the Net: A Multimodal Network Perspective on User-System Interactions. *Information Systems Research*, *19*(3), 253–272. Retrieved 2023-08-13, from https://pubsonline.informs.org/doi/10.1287/isre.1070.0158 doi: 10.1287/isre.1070.0158

Kane, G. C., & Ransbotham, S. (2016, June). Research Note—Content and Collaboration: An Affiliation Network Approach to Information Quality in Online Peer Production Communities. *Information Systems Research*, *27*(2), 424–439. Retrieved 2023-08-11, from https://pubsonline.informs.org/doi/10.1287/isre.2016.0622 doi: 10.1287/isre.2016.0622

Khan, A., McLeod, G., Hidajat, T., & Edwards, E. J. (2023, October). Excessive Smartphone Use is Associated with Depression, Anxiety, Stress, and Sleep Quality of Australian Adults. *Journal of Medical Systems*, *47*(1), 109. Retrieved 2025-03-03, from https://link.springer.com/10.1007/s10916-023-02005-3 doi: 10.1007/s10916-023-02005-3

Levina, N., & Arriaga, M. (2014, September). Distinction and Status Production on User-Generated Content Platforms: Using Bourdieu's Theory of Cultural Production to Understand Social Dynamics in Online Fields. *Information Systems Research*, *25*(3), 468–488. Retrieved 2023-08-13, from https://pubsonline.informs.org/doi/10.1287/isre.2014.0535 doi: 10.1287/isre.2014.0535

Lieber, S. B., Moxley, J., Mandl, L. A., Reid, M. C., & Czaja, S. J. (2024, June). Social support and physical activity: does general health matter? *European Review of Aging and Physical Activity*, *21*(1), 16. Retrieved 2025-03-04, from https://eurapa.biomedcentral.com/articles/10.1186/s11556-024-00347-6 doi: 10.1186/s11556-024-00347-6

Magni, M., Ahuja, M. K., & Trombini, C. (2023, March). Excessive Mobile Use and Family-Work Conflict: A Resource Drain Theory Approach to Examine Their Effects on Productivity and Well-Being. *Information Systems Research*, *34*(1), 253–274. Retrieved 2024-08-16, from https://pubsonline.informs.org/doi/10.1287/isre.2022.1121 doi: 10.1287/isre.2022.1121

Malliaros, F. D., Giatsidis, C., Papadopoulos, A. N., & Vazirgiannis, M. (2020, January). The core decomposition of networks: theory, algorithms and applications. *The VLDB Journal*, *29*(1), 61–92. Retrieved 2023-08-15, from http://link.springer.com/10.1007/s00778-019-00587-4 doi: 10.1007/s00778-019-00587-4

Negre, C. F. A., Morzan, U. N., Hendrickson, H. P., Pal, R., Lisi, G. P., Loria, J. P., ... Batista, V. S. (2018, December). Eigenvector centrality for characterization of protein allosteric pathways. *Proceedings of the National Academy of Sciences*, *115*(52). Retrieved 2023-08-14, from https://pnas.org/doi/full/10.1073/pnas.1810452115 doi: 10.1073/pnas.1810452115

Onnela, J.-P., Waber, B. N., Pentland, A., Schnorf, S., & Lazer, D. (2014, July). Using sociometers to quantify social interaction patterns. *Scientific Reports*, *4*(1), 5604. Retrieved 2023-08-25, from https://www.nature.com/articles/srep05604 doi: 10.1038/srep05604

Perry, B. L., & Pescosolido, B. A. (2015, January). Social network activation: The role of health discussion partners in recovery from mental illness. *Social Science & Medicine*, *125*, 116–128. Retrieved 2023-08-09, from https://linkinghub.elsevier.com/retrieve/pii/S027795361400029X doi: 10.1016/j.socscimed.2013.12.033

Pescosolido, B. A., Martin, J. K., Long, J. S., Medina, T. R., Phelan, J. C., & Link, B. G. (2010, November). "A Disease Like Any Other"? A Decade of Change in Public Reactions to Schizophrenia, Depression, and Alcohol Dependence. *American Journal of Psychiatry*, *167*(11), 1321–1330. Retrieved 2023-08-23, from http://psychiatryonline.org/doi/abs/10.1176/appi.ajp.2010.09121743 doi: 10.1176/appi.ajp.2010.09121743

Precht, L.-M., Mertens, F., Brickau, D. S., Kramm, R. J., Margraf, J., Stirnberg, J., & Brailovskaia, J. (2023, February). Engaging in physical activity instead of (over)using the smartphone: An experimental investigation of lifestyle interventions to prevent problematic smartphone use and to promote mental health. *Journal of Public Health*. Retrieved 2024-01-30, from https://link.springer.com/10.1007/s10389-023-01832-5 doi: 10.1007/s10389-023-01832-5

Robert, L. P., Dennis, A. R., & Ahuja, M. K. (2008, September). Social Capital and Knowledge Integration in Digitally Enabled Teams. *Information Systems Research*, *19*(3), 314–334. Retrieved 2023-08-13, from https://pubsonline.informs.org/doi/10.1287/isre.1080.0177 doi: 10.1287/isre.1080.0177

Sasidharan, S., Santhanam, R., Brass, D. J., & Sambamurthy, V. (2012, September). The Effects of Social Network Structure on Enterprise Systems Success: A Longitudinal Multilevel Analysis. *Information Systems Research*, *23*(3-part-1), 658–678. Retrieved 2023-08-13, from https://pubsonline.informs.org/doi/10.1287/isre.1110.0388 doi: 10.1287/isre.1110.0388

Schmuck, D. (2020, August). Does Digital Detox Work? Exploring the Role of Digital Detox Applications for Problematic Smartphone Use and Well-Being of Young Adults Using Multigroup Analysis. *Cyberpsychology, Behavior, and Social Networking*, *23*(8), 526–532. Retrieved 2025-03-03, from https://www.liebertpub.com/doi/10.1089/cyber.2019.0578 doi: 10.1089/cyber.2019.0578

Shea, C. T., & Fitzsimons, G. M. (2016, November). Personal goal pursuit as an antecedent to social network structure. *Organizational Behavior and Human Decision Processes*, *137*, 45–57. Retrieved 2023-08-13, from https://linkinghub.elsevier.com/retrieve/pii/S0749597816304290 doi: 10.1016/j.obhdp.2016.07.002

Shea, C. T., Menon, T., Smith, E. B., & Emich, K. (2015, October). The affective antecedents of cognitive social network activation. *Social Networks*, *43*, 91–99. Retrieved 2023-08-09, from https://linkinghub.elsevier.com/retrieve/pii/S0378873315000052 doi: 10.1016/j.socnet.2015.01.003

Smith, E. B., Menon, T., & Thompson, L. (2012, February). Status Differences in the Cognitive Activation of Social Networks. *Organization Science*, *23*(1), 67–82. Retrieved 2023-08-09, from https://pubsonline.informs.org/doi/10.1287/orsc.1100.0643 doi: 10.1287/orsc.1100.0643

Trier, M. (2008, September). **Research Note** —Towards Dynamic Visualization for Understanding Evolution of Digital Communication Networks. *Information Systems Research*, *19*(3), 335–350. Retrieved 2023-08-11, from https://pubsonline.informs.org/doi/10.1287/isre.1080.0191 doi: 10.1287/isre.1080.0191

Umberson, D., & Karas Montez, J. (2010, March). Social Relationships and Health: A Flashpoint for Health Policy. *Journal of Health and Social Behavior*, *51*(1_suppl), S54–S66. Retrieved 2023-08-09, from http://journals.sagepub.com/doi/10.1177/0022146510383501 doi: 10.1177/0022146510383501

University of Georgia, Schecter, A., Nohadani, O., Benefits Science Technology, Contractor, N., & Northwestern University. (2022, May). A Robust Inference Method for Decision-Making in Networks. *MIS Quarterly*, *46*(2), 713–738. Retrieved 2023-08-12, from https://misq.umn.edu/a-robust-inference-method-for-decision-making-in-networks.html doi: 10.25300/MISQ/2022/15992

Wahl, O. F. (2012, January). Stigma as a barrier to recovery from mental illness. *Trends in Cognitive Sciences*, *16*(1), 9–10. Retrieved 2023-08-23, from https://linkinghub.elsevier.com/retrieve/pii/S136466131100235X doi: 10.1016/j.tics.2011.11.002

Yan, L., & Tan, Y. (2014, December). Feeling Blue? Go Online: An Empirical Study of Social Support Among Patients. *Information Systems Research*, *25*(4), 690–709. Retrieved 2024-10-05, from https://pubsonline.informs.org/doi/10.1287/isre.2014.0538 doi: 10.1287/isre.2014.0538

Zhang, B., Pavlou, P. A., & Krishnan, R. (2018, June). On Direct vs. Indirect Peer Influence in Large Social Networks. *Information Systems Research*, *29*(2), 292–314. Retrieved 2023-08-13, from https://pubsonline.informs.org/doi/10.1287/isre.2017.0753 doi: 10.1287/isre.2017.0753

Zhu, B., & Watts, S. A. (2010, June). Visualization of Network Concepts: The Impact of Working Memory Capacity Differences. *Information Systems Research*, *21*(2), 327–344. Retrieved 2023-08-11, from https://pubsonline.informs.org/doi/10.1287/isre.1080.0215 doi: 10.1287/isre.1080.0215

Appendix A: Features of Social Network

In this section, we review the features of social networks as well as their applications, implications, and associated outcomes.

Table 17: Social Network Features and Their Implications

Feature	Definition	Implication	Formula
Degree Centrality	The number of edges a node has in a network. It can be normalized as the number of the node's edges over the maximum possible edges it could have in a network [3].	It measures a node's centrality degree in a network. A greater value may indicate greater connectivity to the rest of the network (Golbeck & Klavans 2015).	$C_D(v) = \deg(v)$
Betweenness Centrality	The number of the shortest paths connecting other nodes that pass through the current node.	The score captures the degree of a node that facilitates the paths that pass through it.	$g(v) = \sum_{s \neq v \neq t} \frac{\sigma_{st}(v)}{\sigma_{st}}$
Closeness Centrality	The average shortest distance from a node to the other nodes (Golbeck 2013).	The score measures how close a node is to the rest of the nodes(Golbeck 2013).	$C(x) = \frac{N-1}{\sum_y d(y,x)}$
Pagerank Centrality	The importance of a node that is built on the links between nodes. It is originally invented by Google for web page ranking.	The score measures how important a node is for the network.	$PR_v(G) = a \cdot \left(\sum_{u \in N_G(v)} \frac{PR_u(G)}{D_u(G)}\right) + b_v$
Eigenvector Centrality	All nodes in the network are given ratings based on the idea that links to high-scoring nodes add more to the node's score than do equivalent connections to low-scoring nodes.	A high eigenvector centrality indicates the node is connected to more nodes that themselves are important in the network (Negre et al. 2018).	$p(v) = \sum_u N^T(v,u) \cdot p(u)$
Pagerank Damping	The factor of PageRank damping is the probability that a path will continue in the path, it adds randomness to the network. It usually takes the constant value of 0.85	It prevents the PageRank scores of the network from converging to 0 or 1.	$W_i = (1-d) + d\sum_{i=1}^{N} 1_{ij} \frac{W_i}{n}$
Clustering Coefficient	Clustering Coefficient refer to the probability that two nodes are neighbors when they are independent neighbors of a third node.	The score tells the density of triangles in a network.	$C = \frac{\text{number of closed triplets}}{\text{number of all triplets (open and closed)}}$
Degree Assortativity	The degree assortativity is the propensity that two high-degree nodes in a network to connect with each other (Allen-Perkins et al. 2017).	The score measures the likelihood of a connection between similar (positive value) or dissimilar nodes (negative value).	$r = \frac{\sum_{(i,j) \epsilon E}\left(f(i)-\bar{f}_1\right)\left(f(j)-\bar{f}_2\right)}{\sqrt{\sum_{(i,j) \epsilon E}\left(f(j)-\bar{f}_2\right)}\sqrt{\sum_{(i,j) \epsilon E}\left(f(j)-\bar{f}_2\right)^2}}$
Average Neighbor Degree	For a certain node, the average neighbor degree refers to the mean of its neighbors' degree (Barrat et al. 2004), where the degree implies the total neighbors of a node.	A node with a higher average neighbor degree implies a higher influential power or centrality degree in the network.	$k_{nn,i} = \frac{1}{\|N(i)\|} \sum_{j \in N(i)} k_j$
Triangle	A triangle in a social network refers to the closure structure in which three nodes are connected.	The number of triangles in a social network can help probe the transitivity of the network.	
Squares	Similar to a triangle, a square is a closed loop structure in which four nodes are connected.		
Reciprocity	In directed networks, the reciprocity score measures the likelihood that two nodes have mutually directed connections.	The study extends the prior study on unethical behavior that focuses on individuals' characteristics by emphasizing the disregard perspective through analyzing the relationships and structure of social entities.	
K-Core	A K-Core is defined as the maximal number of nodes in a group in which all nodes have k connections with other nodes.	The indicator of core number suggests how well a node is connected with the nodes around it (Malliaros et al. 2020).	
Katz Centrality	By counting the number of immediate neighbors (first-degree nodes) and all other nodes in the network that connect to the node under consideration through these immediate neighbors, Katz centrality calculates the relative importance of a node within a network.	Katz Centrality is another way to measure the influence power of a node in a network	$C_{\mathrm{Katz}}(i) = \sum_{k=1}^{\infty}\sum_{j=1}^{n} \alpha^k \left(A^k\right)_{ji}$
Hubs Score	A hub is a node that has significantly more connections than the other nodes. The hub score is the sum of the scaled authority scores.	A hub is a node that connects many authorities.	
Authorities Score	A node that is connected to other nodes that are regarded as significant information hubs receives a high authority score.	An authority node is a node that many hubs link to.	
Community	A community in a social network is a portion of the network with more frequent interaction inside.	Community cluster the whole network based on the interactions and relations among nodes.	

Continued on next page

Figure 1 Publications of Social Network Analysis in Business Research(FT50+UTD24)

Table 17 – continued from previous page

Feature	Definition	Implication	Formula
Eigenvector Centrality	The value of eigenvector centrality measures the influence level of a node in the network.	Since connections can have a changing value thanks to eigenvector centrality, connecting to some vertices is more advantageous than connecting to others.	$p(v) = \sum_u N^T(v,u) \cdot p(u)$
Network Motif	Recurrent and statistically significant sub-graphs or patterns inside a larger graph are known as network motifs.	Sub-graphs known as network motifs are those that recur inside a particular network or even across other networks.	

Appendix B: Literature Review

Figure 2 Publications of Social Network Analysis in Business Research(FT50+UTD24)

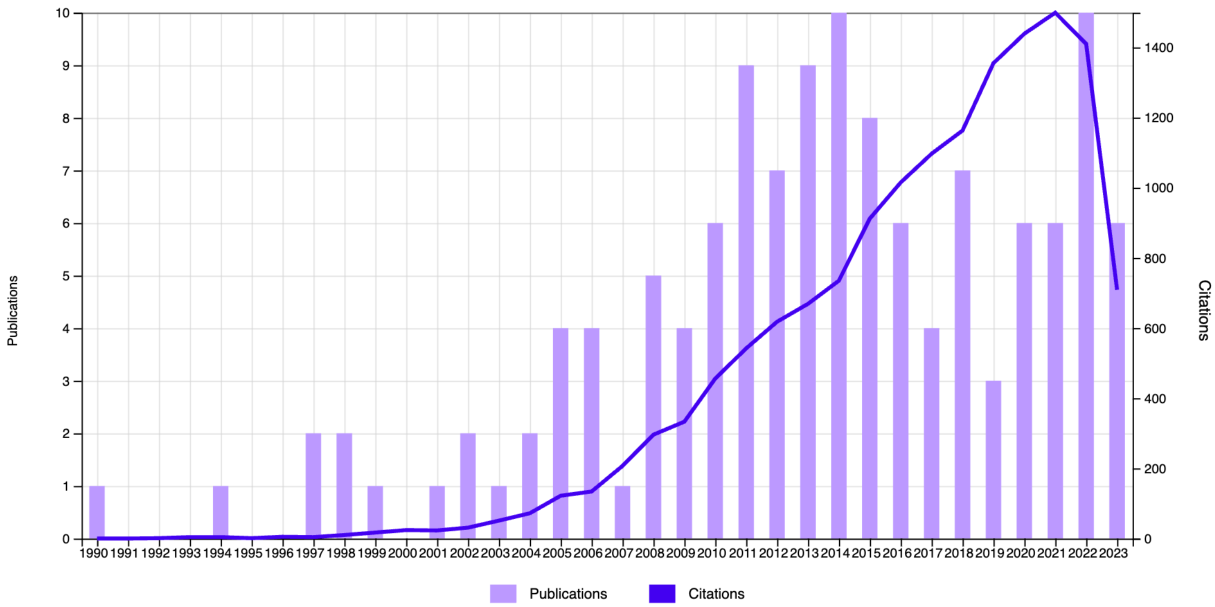


Table 18: Publications of Social Network Analysis in Business Research

Papers	Context	Status	Directionality	Features	Synthesis	Contribution
Status Differences in the Cognitive Activation of Social Networks (Smith et al. 2012) (Organization Science)	Labor Markets; Social Inequality	Dynamic	Undirected	Size; constraint	The study designs a cognitive model for the activation of social networks and applies it to explain how people of different socioeconomic statuses activate their social networks to solicit resources in order to respond to the career challenge.	The study integrates cognitive theories and network principles to analyze the employee's responses to job threats. It reveals that individuals with higher socioeconomic status can activate a larger and broader portion of their social network to manage career challenges, which accelerates social inequality.
The affective antecedents of cognitive social network activation (Shea et al. 2015) (Social Networks)	Social networks	Dynamic	Undirected	Size, density	The study examines how individuals' instant feelings affect the activation of social ties. The results show that positive experiences can activate broader and more sparse social networks while negative experiences can activate smaller, redundant social networks.	The study provides predictive insights for the activation of cognitive social networks. The findings contribute to the understanding of the activation of social networks due to human mental states.
Social network activation: The role of health discussion partners in recovery from mental illness (Perry & Pescosolido 2015) (Social Science & Medicine)	Mental Health	Dynamic	Undirected	social relationshipship	The article inspects the relationship between social network activation and the recovery of mental illness. It explores how the activation of the social network affects individuals' help-seeking behavior.	The study reveals that the activation strategy of social networks has a heterogeneous effect on the recovery from mental illness.
Towards Dynamic Visualization for Understanding Evolution of Digital Communication Networks (Trier 2008) (ISR)	Online Communication	Dynamic	Undirected	Size, density, and centralities.	The research note discusses the evolution from static social networks to social networks in the area of digital communication.	The study provides a novel framework for the visualization and analysis of event-based social networks which can overcome the limitations of static social networks.
Visualization of Network Concepts: The Impact of Working Memory Capacity Differences (Zhu & Watts 2010)(ISR)	Information Visualization	Static	Undirected	Visualization	Theories: Cognitive Fit Theory; Working Memory Capacity; Information Load	Social network visualizations can improve work performance when their design support the interaction of cognitive fit and working memory capacity (WMC)

Continued on next page

Table 18 – continued from previous page

Papers	Context	Status	Directionality	Features	Synthesis	Contribution
Individual Centrality and Performance in Virtual R&D Groups: An Empirical Study (Ahuja et al. 2003)(MS)	IS Project Teams	Static	Undirected	Centralities	The study inspects the impact of the features of social network (individual's centrality) on the group members' performance through a longitudinal field study.	The study reveals that individuals' social network features can work as stronger predictors for their contribution to teamwork than personal characteristics such as functional role, communication pattern, and organizational rank.
What's Different about Social Media Networks? A Framework and Research Agenda (Boston College et al. 2014)(MISQ)	Social Media	Staic	Undirected	Density, centralities.	The study probes the different processes of technology adoption for traditional offline social networks and online social networks. It points out the theoretical distinct point regarding the two types of research.	Demonstrates the boundary of the research between traditional offline social networks and virtual social media networks. Provides a framework for investigating the theoretical implications of social media.
Centrality-Is Proficiency Alignment and Workgroup Performance (Kane & Borgatti 2011)(MISQ)	Work Performance	Static	Undirected	Centralities	The study finds that work groups can have better performance if more proficient team members are located at the communication and workflow center of the group.	Provide a framework for the application of SNA at the group level. The method of the study organically integrates the structure and principles of SNA and provides a protocol for studying the group-level user-IT interactions in both IS and organizational literature.
Innovation Impacts of Using Social Bookmarking Systems (Gray et al. 2011) (MISQ)	Social tagging system	Static	Directed	Size, Out-degree centrality, effective size, effective reach	The paper applies the principal and theories of social networks to study the impact of using social bookmarking systems on innovation	The paper extends the literature on social networks and applies it to theorize the functionalities of social bookmarking systems. It contributes to the understanding of social technologies based on structural holes theory.
Interventions for Improving Professional Networking for Women: Experimental Evidence from the IT Sector (Bapna & Funk 2021)(MISQ)	IT workers, women in IT (Gender gap)	Static	Undirected	Centrality	The study applies randomized field experiments to investigate the networking factors that make women less representative in career development. Findings show that both search and social intervention can contribute to expanding women's professional networks and career development.	The paper identifies and theorizes two barriers to professional networking that cause gender gaps in occupational environments where women are underrepresented: search and social.
A Robust Inference Method for Decision Making in Networks (University of Georgia et al. 2022)(MISQ)	Robust Optimization	Static	Directed	Edges, Triangle	The study identifies the perception gap due to the data errors from the actual and perceived state of the network and its impact on statistical inference.	The study provides a method of robust optimization for remedying inaccurate statistical inferences due to the discrepancies between observable network structure and theoretical network mechanisms.
Relationships and unethical behavior: A social network perspective (Brass et al. 1998)(Acad Manage Rev)	Unethical Behavior	–	Undirected	Density, centrality,	From a perspective of social network analysis, the study probes how the structure and types of social relationships relate to unethical behavior and social contagion.	The study extends the prior study on unethical behavior that focuses on individuals' characteristics by emphasizing the disregard perspective through analyzing the relationships and structure of social entities.
Personal goal pursuit as an antecedent to social network structure (Shea & Fitzsimons 2016)(Organizational Behavior and Human Decision Processes)	Workplace advancement	Static	Undirected	Density, centrality	The study argues that individuals' career motivation and pursuit can work as strong predictors for the activation of their social network. It also demonstrates that personal advancement pursuit can trigger the instrumental attribution of social networks.	The study provides novel insights into how employees mobilize their social network to solicit social capital in order to achieve their career advancement.
Diversity of the Information Systems Research Field: A Journal Governance Perspective (Burgess et al. 2017) (ISR)	Research Commentary	Static	Undirected	Node centrality	The study applies the social network analysis to examine the diversity of demographic and social identity of IS researchers in the academic community.	The study reveals that the demographic diversity of IS researchers is relatively low and demographic diversity correlates with the diversity in other aspects such as communities: business core research and engineering-related research.

Continued on next page

Table 18 – continued from previous page

Papers	Context	Status	Directionality	Features	Synthesis	Contribution
The Effects of Social Network Structure on Enterprise Systems Success: A Longitudinal Multilevel Analysis (Sasidharan et al. 2012)(ISR)	Enterprise Systems	Static	Undirected	In-degree centrality	The study investigates the effect of employees' social network structure on the post-implementation success of enterprise systems using the data of a large organization. The techniques of SNA is used to estimate the features of employees' network, then the features are applied in regression analysis.	The study has significant implications for understanding the successful implementation of enterprise systems at both organizational and individual levels. From the perspective of SNA, it reveals how the structure of employees' social networks affects the adoption success of enterprise systems.
On Direct vs. Indirect Peer Influence in Large Social Networks (Zhang et al. 2018) (ISR)	Technology Diffusion; Peer Influence	Dynamic	Undirected	Degree centrality	The study looks into how individuals' technology adoption decision is directly or indirectly influenced by their peers' behavior in a large social network.	The study provides novel insights on technology diffusion: Companies should make customized business plans based on the group size of target customers.
Predicting Adoption Probabilities in Social Networks (Fang et al. 2013) (ISR)	Technology Adoption	Dynamic	Undirected	Entity similarity	The study leverages social network theories and measurements to predict the technology adoption probability under the influence of confounding factors that are unobservable.	Taking advantage of SNA techniques, the authors of the paper developed an effective method of weighting expectation-maximization for the Naïve Bayesian algorithm to estimate the probability of technology adoption of social entity.
Content and Collaboration: An Affiliation Network Approach to Information Quality in Online Peer Production Communities (Kane & Ransbotham 2016) (ISR)	Information Quality				DV: seven-point scale evaluation of Wiki article quality; IV: contributor collaboration; quality weighted degree centrality; eigenvector centrality	Using SNA, the study shows that the article quality in Wikipedia is associated with the position in the contributor community.
Social Capital and Knowledge Integration in digitally enabled teams (Robert et al. 2008)(ISR)	Social Capital, Knowledge Integration	Static	Directed	Degree centrality; eigenvector centrality	The study probes how the three types of social capital (structural, relational, and cognitive) influence the knowledge integration and performance of teamwork facilitated by digital communication.	The work reveals that structural and cognitive capital play more significant roles in knowledge integration when teamwork is conducted online compared to offline. There is no significant difference between the online and offline effect of relational capital on knowledge integration.
Distinction and Status Production on User-Generated Content Platforms: Using Bourdieu's Theory of Cultural Production to Understand Social Dynamics in Online Fields (Levina & Arriaga 2014)(ISR)	User-generated content (UGC)	Dynamic	Undirected	Centrality	Leveraging Bourdieu's theory about cultural production, the study looks into the relationship between the social status of users who generate online content and the social dynamic in the online UGC community.	The authors developed a theoretical framework to understand the social dynamics drawing on Bourdieu's theory of culture production.
Casting the net: A multimodal network perspective on user-system interactions (Kane & Alavi 2008)(ISR)	User-System Interaction	Staitc	Undirected	Node centrality	The study applies SNA to explore the user-system interaction from the perspective of a multimodal network.	The study extends the traditional user-system research by addressing the practical fact that multiple users can interact with multiple information systems. The finding reveals that the centrality of IT systems is associated with the efficiency and quality of systems' outcomes.

Appendix C: Data Collection Process and Variable Construction

The following process is a high-level view of how the data are collected and manipulated:

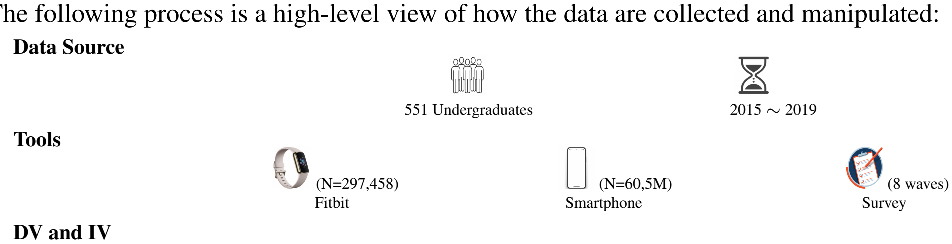
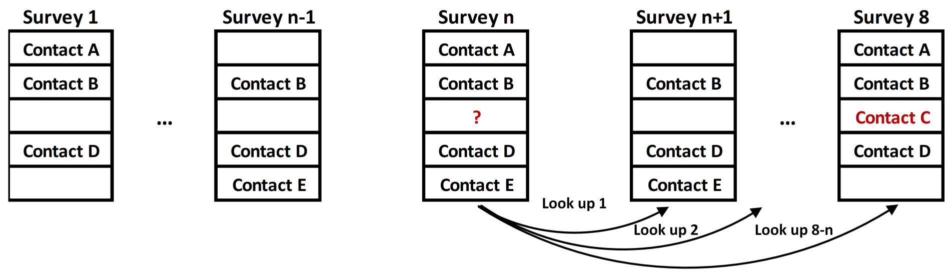
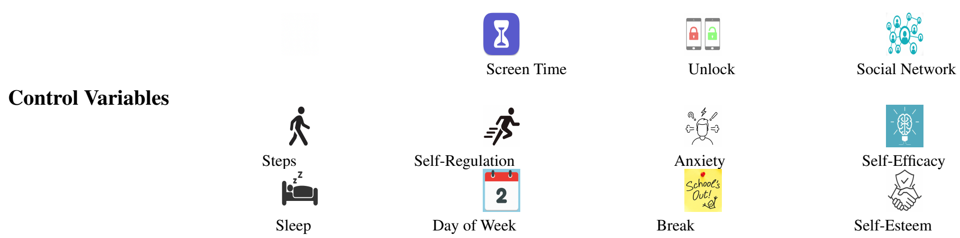


Figure 3 Alternative Lookup Iteration for Contacts Missed(Backward-Forward)



Notes. The figure suggests that contact C is not reported by the participant in survey n. The lookup iteration first looks up contact C in the backward direction and propagates from survey n+1 to survey n. Once C is found in the process, the missing cell in survey n is filled with the information found and the function stops. If Contact C is not found in the forward lookup, a forward lookup is initiated to search for Contact C in the previous surveys until it is found.



Appendix D: K-Core

This section introduces how the K-core value of a node is determined. Figure **??** shows the core number of nodes in a social network. The nodes in the outer layer of the network have one core. There are two situations: First, they only have one connection. Second, they have more than one connection, but the minimal connection the group members have is one. Either situation makes their core number equal to one. Next, we drop the nodes with one core when identifying the nodes with two cores. The nodes in the middle layer of the network have two cores, as the minimal number of connections one group member (including one member group) has is two. Similarly, we drop the nodes whose connection is less than three when identifying nodes with three cores. When the outer and middle layers are dropped, the minimal number of connections the node in the center layer has is three. Although the node at the center has four connections, the minimal number of connections its group member has is three. Thus, the core number for the nodes at the central layer is three.

Appendix E: Additional Robustness Checks

In this section, we conduct multiple robustness checks to investigate the consistency of our explanation and address potential endogeneity.

E.1. Alternative Lookup Iteration for Contacts Missed (Backward-Forward)

The objective of the approach is to search for the missing contacts' social network information from the closest neighbors' social network surveys. This approach starts from a forward lookup followed by a backward lookup for missed contacts in the current wave of social networks. We also conducted an alternative lookup approach by searching for the missing contacts backward first and then forward, which could work as robustness checks.

In both cases, we borrow the missed contacts' network features from the closest wave that the contact exists. By doing this, we could have a relatively complete social network. The estimation with an adjusted approach is mostly consistent with earlier estimations:

The results suggest that an increase in core number could lead to a decrease in screen time, which is consistent with the original estimation.

E.2. Neighbour Borrowing with Limitation to Closest 1 Wave

Table 19 Impact of Social Network Features on Smartphone Use

Alternative Lookup Iteration for Contacts Missed(Backward-Forward)

VARIABLES	(1) NonComm.	(2) NonComm.	(3) NonComm.	(4) Comm.	(5) Comm.	(6) Screen Time	(7) Screen Time	(8) Screen Time
Degree Centrality	-0.347	-0.934	3.405	11.681***	8.148***	11.334**	7.214	3.437
	(5.366)	(7.076)	(6.832)	(2.192)	(3.149)	(5.696)	(7.108)	(6.835)
Core Number	-1.313**	-1.422**	-1.808***	-0.977***	-0.819***	-2.290***	-2.241***	-1.813***
	(0.612)	(0.619)	(0.601)	(0.256)	(0.255)	(0.613)	(0.614)	(0.601)
In-Network Nodes	-1.322*	-1.651*	-0.718	3.911***	4.029***	2.589***	2.378***	-0.756
	(0.778)	(0.917)	(0.914)	(0.237)	(0.277)	(0.776)	(0.911)	(0.913)
In-Network Inactive Nodes	0.081	-0.169	-0.462	-0.700***	-0.678***	-0.619	-0.847	-0.449
	(0.663)	(0.797)	(0.790)	(0.173)	(0.191)	(0.666)	(0.795)	(0.789)
Out-Network Contacts	-0.629***	-0.595***	-0.498**	1.157***	1.167***	0.528***	0.573***	-0.506**
	(0.170)	(0.170)	(0.203)	(0.074)	(0.074)	(0.166)	(0.167)	(0.203)
Edges	0.036	0.052	0.099	0.114***	0.115***	0.150	0.167	0.098
	(0.108)	(0.116)	(0.117)	(0.028)	(0.029)	(0.111)	(0.119)	(0.117)
Steps		-0.180***	-0.191***		-0.032***		-0.212***	-0.192***
		(0.017)	(0.017)		(0.006)		(0.018)	(0.017)
Sleep Relation Length		-0.077***	-0.080***		-0.009***		-0.086***	-0.080***
		(0.007)	(0.007)		(0.003)		(0.007)	(0.007)
Trust		0.153	0.119		-0.160		-0.008	0.122
		(0.851)	(0.815)		(0.489)		(0.862)	(0.815)
Social Closeness		-0.590	-0.277		1.368		0.778	-0.300
		(2.380)	(2.281)		(0.994)		(2.306)	(2.280)
Survey Contact Position		0.636***	0.525***		-0.420***		0.216	0.527***
		(0.206)	(0.196)		(0.073)		(0.200)	(0.196)
Relation Relation Length		0.368***	0.485***		-0.062		0.306**	0.478***
		(0.139)	(0.136)		(0.064)		(0.141)	(0.136)
In-Network Comm.Freq.			-0.012					0.138***
			(0.012)					(0.012)
Out-Network Comm.Freq. 0.134***				-0.018				
			(0.018)					(0.018)
Call Relation Length			-0.709***					0.286***
			(0.041)					(0.041)
Constant	145.781***	204.945***	214.001***	13.396	21.597**	159.177***	226.543***	214.076***
	(24.890)	(25.742)	(25.636)	(9.351)	(9.739)	(27.471)	(28.501)	(25.640)
Observations	105,370	105,370	105,370	105,370	105,370	105,370	105,370	105,370
R-squared	0.027	0.035	0.065	0.115	0.119	0.026	0.036	0.056
Number of egoid	457	457	457	457	457	457	457	457
Communication	Full	Full	Full	Full	Full	Full	Full	Full
Unit F.E.	YES	YES	YES	YES	YES	YES	YES	YES
Day F.E	YES	YES	YES	YES	YES	YES	YES	YES

Robust standard errors in parentheses

*** $p<0.01$, ** $p<0.05$, * $p<0.1$

Notes. Columns 1-3 represent the results for non-communication smartphone use estimated in equation 1; Columns 4-5 represent the results for communication-driven smartphone use (communication variables In-COMM and Out-COMM are not included as they comprise DV: communication use time); Columns 6-9 represent the results for overall smartphone use .

Table 20: Summary statistics

Variable	Mean	Std. Dev.	Min.	Max.	N
Total Screen	209.72	130.977	0	1072.863	105271
Comm.Screen	29.242	39.036	0.009	1429.967	105271
NoComm.Screen	180.478	130.207	-1429.967	1056.663	105271
Unlock Freq.	81.921	58.123	0	4691	105271
Degree Centrality	0.509	0.348	0	1	105271
Core Number	5.021	3.787	0	23	105271
Steps	118.038	54.746	2.6	642.26	105271
Sleep Relation Length	416.721	101.309	1	1171	105271
Naps	0.122	0.352	0	7	105271
Nap Relation Length	13.436	42.545	0	879	105271
Activated Network Nodes	2.31	2.225	0	21	105271
Inactive Network Nodes	7.988	6.929	-5	25	105271
Out-Network Contacts	6.52	5.981	0	95	105271
contacts	8.829	6.823	1	99	105271
Network Edges	47.246	50.034	0	320	105271
Network Nodes	10.298	8.069	0	26	105271
Relation Relation Length	6.794	6.468	0	21	105271
Call Relation Length	10.723	29.482	0	1396.067	105271
In-Network Comm. Freq.	62.852	106.759	0	2121	105271
Out-Network Comm. Freq.	62.202	98.675	0	1764	105271
Call	2.882	4.32	0	117	105271
SMS	114.228	146.354	0	2640	105271
MMS	4.527	9.791	0	396	105271
WhatsApp	4.704	33.62	0	1231	105271

Continued on next page...

... table 20 continued

Variable	Mean	Std. Dev.	Min.	Max.	N
Trust	6.706	4.034	0	10	105271
Survey Contact Position	4.52	4.444	0	25	105271
Social Closeness	2.81	1.669	0	4	105271

E.3. Alternative Assumption of Communication Time

To separately estimate the impact of network features on total, non-communicative, and communication screen time, we rely on the assumption for measuring texting time. In the main estimation, we assume that communication time = daily message characters/ Z characters per minute + MMS * 0.15 minutes. In this section, we vary texting time by adjusting the value of Z. First, we assume that individuals can text 60 characters per minute, and we obtain the following results: The results show that core numbers have a similar impact on screen time under this assumption. Moreover, we adjust the texting speed by varying Z from 50 to 80. As shown above, the estimation results validate our findings in the main analysis.

E.4. Variation of the Smartphone Addiction Threshold

In this section, we conduct robustness checks for the logistic estimation of smartphone addiction by varying the threshold of addiction. Recall that we define smartphone addiction based on multiple criteria:

- Screen time is greater than a certain threshold. For example, 5 hours per day: observations with daily screen time that are greater than 5 hours (300 minutes).
- Observations with daily screen time that are ranked top N % among the population. We adjust the portion of smartphone addiction by varying N. For example, we define that a user is addicted to a smartphone on a given day when his/her screen time is ranked top 10%, 20%, 30% higher among the population.
- Top 10% screen time observations for each individual's total observations.

Table 21 Alternative Assumption of Communication Time

(60 characters per minutes)

VARIABLES	(1) NonComm.60	(2) NonComm.60	(3) NonComm.60	(4) Comm.60	(5) Comm.60	(6) Comm.60	(7) Screen Time	(8) Screen Time	(9) Screen Time
Degree Centrality	7.569	7.515	2.974	13.622**	13.524**	12.720*	9.431	9.349	5.730
	(7.021)	(7.093)	(9.126)	(5.595)	(5.562)	(6.634)	(6.314)	(6.382)	(8.166)
Core Number	-1.863**	-1.863**	-1.919**	-1.781***	-1.767***	-1.610**	-2.195***	-2.191***	-2.259***
	(0.735)	(0.742)	(0.756)	(0.612)	(0.605)	(0.623)	(0.668)	(0.672)	(0.678)
In-Network Nodes	-1.953**	-1.816**	-2.258**	7.488***	7.525***	7.757***	-1.276	-1.120	-1.520*
	(0.906)	(0.907)	(1.028)	(0.715)	(0.716)	(0.783)	(0.791)	(0.788)	(0.911)
In-Network Inactive Nodes	-0.126	-0.083	-0.486	-1.370**	-1.344**	-1.139*	-0.525	-0.477	-0.835
	(0.772)	(0.769)	(0.913)	(0.577)	(0.578)	(0.629)	(0.698)	(0.693)	(0.825)
Out-Network Contacts	-0.947***	-0.896***	-0.875***	4.596***	4.624***	4.609***	-0.344	-0.274	-0.255
	(0.281)	(0.281)	(0.280)	(0.234)	(0.236)	(0.237)	(0.255)	(0.255)	(0.254)
Edges	0.058	0.054	0.087	0.217**	0.212**	0.199**	0.123	0.117	0.146
	(0.121)	(0.121)	(0.132)	(0.097)	(0.097)	(0.100)	(0.111)	(0.111)	(0.120)
Call Relation Length	-0.693***	-0.700***	-0.701***	1.087***	1.084***	1.085***	0.295***	0.288***	0.287***
	(0.040)	(0.040)	(0.040)	(0.023)	(0.023)	(0.023)	(0.040)	(0.041)	(0.041)
In-Network Comm.Freq.	-0.371***	-0.375***	-0.376***				0.141***	0.138***	0.137***
	(0.027)	(0.027)	(0.027)				(0.022)	(0.022)	(0.021)
Out-Network Comm.Freq.	-0.393***	-0.394***	-0.399***				0.142***	0.141***	0.136***
	(0.058)	(0.058)	(0.058)				(0.045)	(0.045)	(0.044)
Steps		-0.168***	-0.167***		-0.073***	-0.074***		-0.192***	-0.192***
		(0.018)	(0.018)		(0.010)	(0.010)		(0.017)	(0.017)
Sleep Relation Length		-0.079***	-0.080***		-0.020***	-0.019***		-0.080***	-0.080***
		(0.007)	(0.007)		(0.004)	(0.004)		(0.007)	(0.007)
Trust			1.479			-0.971			1.224
			(1.146)			(0.869)			(0.994)
Social Closeness			-2.638			3.367			-2.283
			(2.991)			(2.149)			(2.702)
Survey Contact Position			0.537**			-0.721***			0.530**
			(0.233)			(0.181)			(0.222)
Relation Relation Length			0.529***			-0.593***			0.490***
			(0.186)			(0.117)			(0.176)
Constant	138.753***	198.073***	197.744***	-14.100***	2.640	8.118	157.101***	220.012***	219.756***
	(23.418)	(24.707)	(24.664)	(5.057)	(5.798)	(5.761)	(24.760)	(25.924)	(25.854)
Observations	105,370	105,370	105,370	109,693	109,693	109,693	105,370	105,370	105,370
R-squared	0.183	0.189	0.189	0.321	0.323	0.324	0.048	0.056	0.056
Number of egoid	457	457	457	487	487	487	457	457	457
Communication	Full	Full	Full	Full	Full	Full	Full	Full	Full
Unit F.E.	YES	YES	YES	YES	YES	YES	YES	YES	YES
Day F.E	YES	YES	YES	YES	YES	YES	YES	YES	YES

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Notes. Columns 1-3 represent the results for non-communication smartphone use estimated in equation 1; Columns 4-5 represent the results for communication-driven smartphone use (communication variables In-COMM and Out-COMM are not included as they comprise DV: communication use time); Columns 6-9 represent the results for overall smartphone use. The number at the end of the DV describes how many characters one can text in one minute.

Table 22 Impact of Social Network Features on Smartphone Use

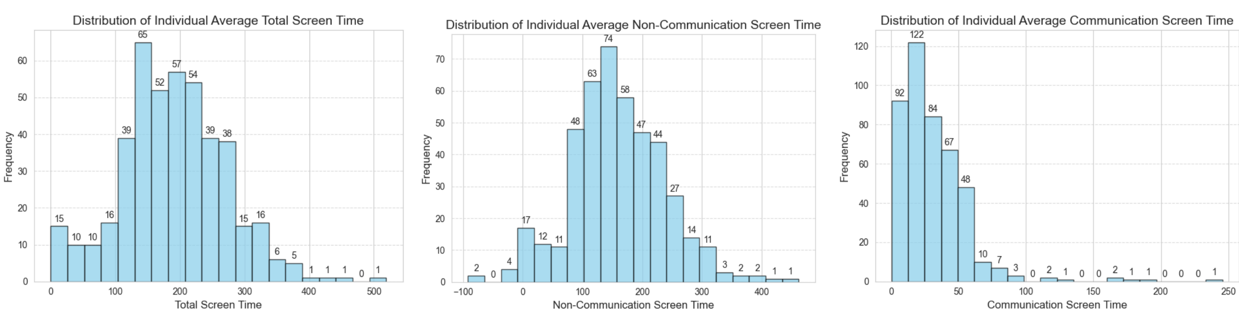
Moderating Impact of Texting Speed

VARIABLES	(1) NonComm.50	(2) NonComm.60	(3) NonComm.70	(4) NonComm.80	(5) Comm.50	(6) Comm.60	(7) Comm.70	(8) Comm.80	(9) Screen Time
Degree Centrality	2.356	2.808	3.130	3.372	17.697**	15.635**	14.162**	13.057**	5.067
	(8.221)	(7.844)	(7.610)	(7.456)	(8.549)	(7.315)	(6.451)	(5.817)	(6.981)
Core Number	-1.763**	-1.768**	-1.771***	-1.773***	-1.679**	-1.473**	-1.325**	-1.215**	-1.789***
	(0.728)	(0.693)	(0.671)	(0.657)	(0.794)	(0.675)	(0.591)	(0.529)	(0.611)
In-Network Nodes	-2.204*	-1.948*	-1.766*	-1.629	14.642***	12.355***	10.721***	9.495***	-0.672
	(1.180)	(1.101)	(1.052)	(1.019)	(1.117)	(0.934)	(0.804)	(0.707)	(0.919)
In-Network Inactive Nodes	-0.035	-0.089	-0.128	-0.157	-2.012***	-1.744***	-1.552***	-1.408***	-0.360
	(0.912)	(0.882)	(0.864)	(0.851)	(0.701)	(0.588)	(0.508)	(0.448)	(0.794)
Out-Network Contacts	-1.318***	-1.182***	-1.085***	-1.012***	5.635***	4.686***	4.008***	3.499***	-0.503**
	(0.260)	(0.244)	(0.234)	(0.227)	(0.231)	(0.194)	(0.168)	(0.149)	(0.203)
Edges	0.030	0.040	0.047	0.052	0.339***	0.292***	0.259***	0.234***	0.088
	(0.133)	(0.129)	(0.126)	(0.124)	(0.110)	(0.092)	(0.079)	(0.070)	(0.118)
Steps	-0.162***	-0.167***	-0.171***	-0.173***	-0.115***	-0.098***	-0.086***	-0.077***	-0.192***
	(0.018)	(0.018)	(0.018)	(0.017)	(0.014)	(0.012)	(0.011)	(0.010)	(0.017)
Sleep Relation Length	-0.081***	-0.081***	-0.081***	-0.081***	-0.024***	-0.021***	-0.019***	-0.017***	-0.080***
	(0.007)	(0.007)	(0.007)	(0.007)	(0.006)	(0.005)	(0.005)	(0.005)	(0.007)
Trust	0.991	0.867	0.779	0.713	-1.039	-0.862	-0.735	-0.640	0.251
	(1.074)	(1.009)	(0.967)	(0.940)	(1.171)	(1.010)	(0.898)	(0.817)	(0.844)
Social Closeness	-1.697	-1.587	-1.508	-1.449	4.386	3.688	3.190	2.816	-1.036
	(2.830)	(2.696)	(2.612)	(2.556)	(2.805)	(2.402)	(2.118)	(1.907)	(2.361)
Survey Contact Position	0.595***	0.585***	0.577***	0.572***	-1.313***	-1.116***	-0.975***	-0.869***	0.534***
	(0.216)	(0.209)	(0.206)	(0.203)	(0.219)	(0.185)	(0.161)	(0.143)	(0.204)
Relation Relation Length	0.518***	0.514***	0.512***	0.510***	-0.795***	-0.631***	-0.513***	-0.425***	0.497***
	(0.147)	(0.143)	(0.141)	(0.139)	(0.151)	(0.130)	(0.115)	(0.104)	(0.136)
In-Network Comm.Freq.	-0.452***	-0.353***	-0.283***	-0.230***					0.138***
	(0.021)	(0.018)	(0.017)	(0.016)					(0.012)
Out-Network Comm.Freq.		-0.466***	-0.366***	-0.295***	-0.241***				
0.134***									
	(0.025)	(0.023)	(0.022)	(0.021)					(0.018)
Call Relation Length	-0.697***	-0.700***	-0.702***	-0.704***					0.286***
	(0.040)	(0.040)	(0.040)	(0.040)					(0.041)
Constant	185.713***	190.443***	193.822***	196.356***	79.692**	68.314**	60.187**	54.091***	214.095***
	(24.471)	(24.313)	(24.287)	(24.317)	(31.428)	(26.664)	(23.287)	(20.775)	(25.645)
Observations	105,370	105,370	105,370	105,370	105,370	105,370	105,370	105,370	105,370
R-squared	0.239	0.189	0.154	0.130	0.238	0.231	0.224	0.216	0.056
Number of egoid	457	457	457	457	457	457	457	457	457
Texting Speed	50 char/min	60 char/min	70 char/min	80 char/min	50 char/min	60 char/min	70 char/min	80 char/min	60 char/min
Unit F.E.	YES	YES	YES	YES	YES	YES	YES	YES	YES
Day F.E	YES	YES	YES	YES	YES	YES	YES	YES	YES

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Notes. Columns 1-3 represent the results for non-communication smartphone use estimated in equation 1; Columns 4-5 represent the results for communication-driven smartphone use (communication variables In-COMM and Out-COMM are not included as they comprise DV: communication use time); Columns 6-9 represent the results for overall smartphone use.The number at the end of the DV describes how many characters one can text in one minute.

Figure 4 Distribution of Screen Time for Different Purposes



(a) Total Screen Time (b) Non-communication (c) Communication

Notes.

We first apply addiction criteria 1 and show the estimation based on screen time. An observation is labeled as smartphone addiction if its total screen time is ≥ 300 minutes. Similarly, it is labeled as non-communication addiction if its non-communication screen time is ≥ 240 minutes. Moreover, it is labeled as communication smartphone addiction if its communication screen time is ≥ 40 minutes;

Next, we apply addiction criteria 2 which observations with daily screen time that are ranked top N % among the population are labeled as addiction. We estimate the probability of addiction by varying the value N from 10, 15, to 20.

Table 23 Smartphone Addiction Estimation Based on the Threshold of Absolute Screen Time

	NoComm: $\geq$ 240 minutes; Comm: $\geq$ 40 minutes; Total: $\geq$ 300 minutes							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
VARIABLES	Addic-NoCOM	Addic-NoCOM	Addic-NoCOM	Addic-COM	Addic-COM	Addiction	Addiction	Addiction
Degree-Centrality	0.009	0.019	0.025	0.140***	0.089***	0.028	0.029	0.014
	(0.027)	(0.030)	(0.030)	(0.036)	(0.034)	(0.025)	(0.026)	(0.026)
K-Core	-0.005**	-0.005**	-0.005**	-0.010***	-0.008***	-0.007***	-0.007***	-0.006**
	(0.002)	(0.002)	(0.002)	(0.003)	(0.003)	(0.002)	(0.002)	(0.002)
In-Contact	-0.003***	-0.003**	-0.003***	0.031***	0.032***	0.003**	0.003**	-0.003***
	(0.001)	(0.001)	(0.001)	(0.002)	(0.002)	(0.001)	(0.001)	(0.001)
Out-Contact	-0.001*	-0.001*	-0.001*	0.016***	0.016***	0.000	0.001	-0.002***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Edges	0.000	0.000	0.000	0.001**	0.001**	0.000	0.000	0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Steps		-0.001***	-0.001***		-0.000***		-0.001***	-0.001***
		(0.000)	(0.000)		(0.000)		(0.000)	(0.000)
Sleep		-0.000***	-0.000***		-0.000***		-0.000***	-0.000***
		(0.000)	(0.000)		(0.000)		(0.000)	(0.000)
Trust		-0.000	-0.000		0.006		-0.001	-0.001
		(0.004)	(0.004)		(0.005)		(0.004)	(0.004)
Social Closeness		-0.008	-0.007		0.024**		-0.003	-0.006
		(0.011)	(0.011)		(0.012)		(0.010)	(0.010)
Survey Contact Position		0.001	0.001		-0.003***		0.000	0.001
		(0.001)	(0.001)		(0.001)		(0.001)	(0.001)
Relation-Length		0.002***	0.002***		-0.000		0.001**	0.002***
		(0.001)	(0.001)		(0.001)		(0.001)	(0.001)
In-COM			0.000					0.000***
			(0.000)					(0.000)
Out-Com			0.000					0.000***
			(0.000)					(0.000)
Call Time			-0.001***					0.001***
			(0.000)					(0.000)
Constant	-0.025	0.121**	0.108**	0.667***	0.614***	-0.045**	0.098**	-0.016
	(0.022)	(0.050)	(0.049)	(0.032)	(0.057)	(0.019)	(0.045)	(0.045)
Observations	95,413	95,413	95,413	95,413	95,413	95,413	95,413	95,413
R-squared	0.020	0.026	0.029	0.097	0.099	0.017	0.024	0.037
Number of egoid	441	441	441	441	441	441	441	441
Communication	Full	Full	Full	Full	Full	Full	Full	Full
Unit F.E.	YES	YES	YES	YES	YES	YES	YES	YES
Day F.E	YES	YES	YES	YES	YES	YES	YES	YES

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Notes. Addiction is defined as: Overall addiction: overall screen time > 300 min; Non-communication addiction: Non-communication screen time > 240 min; Communication addiction: Communication screen time > 40 min

Table 24 Estimation for smartphone addiction (Addiction threshold: Individual daily screen time ranked $\geq$ 10% of the population)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
VARIABLES	Addic-NoCOM90	Addic-NoCOM90	Addic-NoCOM90	Addic-COM90	Addic-COM90	Addiction90	Addiction90	Addiction90
Degree-Centrality	-0.001	0.009	0.012	0.072***	0.047**	0.020	0.024	0.015
	(0.017)	(0.019)	(0.019)	(0.022)	(0.021)	(0.017)	(0.019)	(0.018)
K-Core	-0.003**	-0.003**	-0.003**	-0.006***	-0.005**	-0.005***	-0.005***	-0.004***
	(0.001)	(0.001)	(0.001)	(0.002)	(0.002)	(0.001)	(0.001)	(0.001)
In-Contact	-0.002***	-0.002***	-0.002***	0.013***	0.014***	0.002**	0.002**	-0.002***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Out-Contact	-0.000	-0.000	-0.000	0.008***	0.008***	0.000	0.000	-0.001*
	(0.000)	(0.000)	(0.000)	(0.001)	(0.001)	(0.000)	(0.000)	(0.001)
Edges	-0.000	-0.000	-0.000	0.000*	0.000*	0.000	0.000	0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Steps		-0.000***	-0.000***		-0.000***		-0.000***	-0.000***
		(0.000)	(0.000)		(0.000)		(0.000)	(0.000)
Sleep		-0.000***	-0.000***		-0.000***		-0.000***	-0.000***
		(0.000)	(0.000)		(0.000)		(0.000)	(0.000)
Trust		-0.001	-0.001		0.002		0.001	0.001
		(0.003)	(0.003)		(0.004)		(0.003)	(0.003)
Social Closeness		-0.008	-0.007		0.015*		-0.006	-0.008
		(0.008)	(0.008)		(0.008)		(0.008)	(0.008)
Survey Contact Position		0.001*	0.001*		-0.002***		0.000	0.001
		(0.001)	(0.001)		(0.001)		(0.001)	(0.001)
Relation-Length		0.001*	0.001*		-0.000		0.000	0.001*
		(0.000)	(0.000)		(0.000)		(0.000)	(0.000)
In-COM			0.000					0.000***
			(0.000)					(0.000)
Out-Com			-0.000					0.000***
			(0.000)					(0.000)
Call Time			-0.000***					0.000***
			(0.000)					(0.000)
Constant	0.037**	0.146***	0.139***	0.919***	0.912***	0.016	0.126***	0.054
	(0.015)	(0.036)	(0.036)	(0.023)	(0.042)	(0.015)	(0.036)	(0.036)
Observations	95,413	95,413	95,413	95,413	95,413	95,413	95,413	95,413
R-squared	0.014	0.019	0.021	0.038	0.040	0.013	0.020	0.029
Number of egoid	441	441	441	441	441	441	441	441
Communication	Full	Full	Full	Full	Full	Full	Full	Full
Unit F.E.	YES	YES	YES	YES	YES	YES	YES	YES
Day F.E	YES	YES	YES	YES	YES	YES	YES	YES

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Notes. Non-COMM, COMM, and Total screen time are estimated by varying texting time from 6s, 9s, 18s to 30s

Table 25 Estimation for smartphone addiction (Addiction threshold: Individual daily screen time ranked $\geq$ 15% of the population)

VARIABLES	(1) Addic-NoCOM85	(2) Addic-NoCOM85	(3) Addic-NoCOM85	(4) Addic-COM85	(5) Addic-COM85	(6) Addiction85	(7) Addiction85	(8) Addiction85
Degree-Centrality	0.005	0.013	0.017	0.106***	0.070***	0.022	0.025	0.013
	(0.021)	(0.023)	(0.023)	(0.028)	(0.027)	(0.022)	(0.023)	(0.023)
K-Core	-0.005***	-0.005***	-0.005***	-0.008***	-0.006**	-0.006***	-0.006***	-0.005**
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
In-Contact	-0.002**	-0.002**	-0.002**	0.020***	0.021***	0.002**	0.002**	-0.003***
	(0.001)	(0.001)	(0.001)	(0.002)	(0.002)	(0.001)	(0.001)	(0.001)
Out-Contact	-0.001*	-0.001	-0.001	0.011***	0.011***	0.001	0.001	-0.001**
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Edges	0.000	0.000	0.000	0.000*	0.000*	0.000	0.000	0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Steps		-0.000***	-0.000***		-0.000***		-0.001***	-0.000***
		(0.000)	(0.000)		(0.000)		(0.000)	(0.000)
Sleep		-0.000***	-0.000***		-0.000***		-0.000***	-0.000***
		(0.000)	(0.000)		(0.000)		(0.000)	(0.000)
Trust		0.001	0.001		0.004		0.000	0.000
		(0.004)	(0.004)		(0.005)		(0.004)	(0.004)
Social Closeness		-0.013	-0.012		0.020**		-0.004	-0.007
		(0.009)	(0.009)		(0.010)		(0.009)	(0.009)
Survey Contact Position		0.001	0.001		-0.002***		0.001	0.001*
		(0.001)	(0.001)		(0.001)		(0.001)	(0.001)
Relation-Length		0.001**	0.001**		-0.000		0.001	0.001**
		(0.001)	(0.001)		(0.001)		(0.001)	(0.001)
In-COM			0.000					0.000***
			(0.000)					(0.000)
Out-Com			0.000					0.000***
			(0.000)					(0.000)
Call Time			-0.001***					0.001***
			(0.000)					(0.000)
Constant	0.030*	0.164***	0.157***	0.858***	0.833***	0.001	0.126***	0.032
	(0.017)	(0.041)	(0.041)	(0.029)	(0.050)	(0.019)	(0.041)	(0.041)
Observations	95,413	95,413	95,413	95,413	95,413	95,413	95,413	95,413
R-squared	0.017	0.023	0.025	0.058	0.060	0.016	0.023	0.034
Number of egoid	441	441	441	441	441	441	441	441
Communication	Full	Full	Full	Full	Full	Full	Full	Full
Unit F.E.	YES	YES	YES	YES	YES	YES	YES	YES
Day F.E	YES	YES	YES	YES	YES	YES	YES	YES

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Notes. Non-COMM, COMM, and Total screen time are estimated by varying texting time from 6s, 9s, 18s to 30s

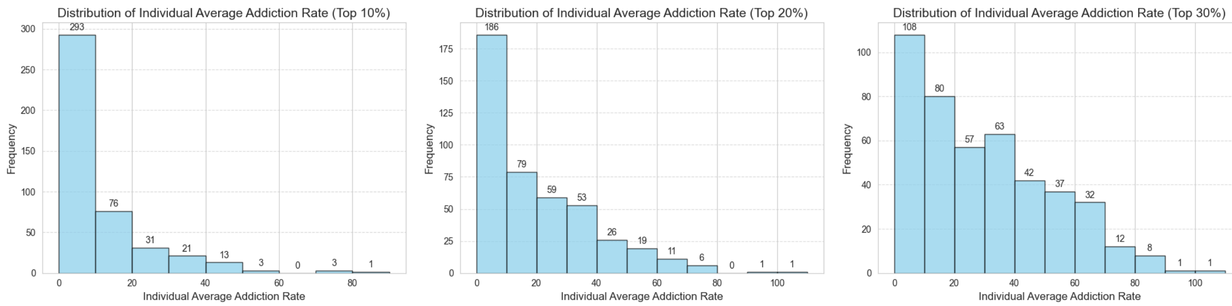
Table 26 Estimation for smartphone addiction (Addiction threshold: Individual daily screen time ranked $\geq$ 20% of the population)

VARIABLES	(1) Addic-NoCOM80	(2) Addic-NoCOM80	(3) Addic-NoCOM80	(4) Addic-COM80	(5) Addic-COM80	(6) Addiction80	(7) Addiction80	(8) Addiction80
Degree-Centrality	-0.003	0.008	0.013	0.122***	0.078**	0.028	0.029	0.015
	(0.025)	(0.027)	(0.027)	(0.032)	(0.030)	(0.025)	(0.027)	(0.026)
K-Core	-0.005**	-0.005**	-0.006**	-0.009***	-0.007**	-0.007***	-0.007***	-0.005**
	(0.002)	(0.002)	(0.002)	(0.003)	(0.003)	(0.002)	(0.002)	(0.002)
In-Contact	-0.003**	-0.003***	-0.003**	0.026***	0.027***	0.003**	0.003**	-0.003***
	(0.001)	(0.001)	(0.001)	(0.002)	(0.002)	(0.001)	(0.001)	(0.001)
Out-Contact	-0.002**	-0.001**	-0.002**	0.014***	0.014***	0.000	0.001	-0.002***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Edges	0.000	0.000	0.000	0.000*	0.000*	0.000	0.000	0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Steps		-0.001***	-0.001***		-0.000***		-0.001***	-0.001***
		(0.000)	(0.000)		(0.000)		(0.000)	(0.000)
Sleep		-0.000***	-0.000***		-0.000***		-0.000***	-0.000***
		(0.000)	(0.000)		(0.000)		(0.000)	(0.000)
Trust		-0.001	-0.001		0.005		-0.001	-0.001
		(0.004)	(0.004)		(0.005)		(0.004)	(0.004)
Social Closeness		-0.012	-0.011		0.022**		-0.003	-0.006
		(0.011)	(0.011)		(0.011)		(0.010)	(0.010)
Survey Contact Position		0.001	0.001		-0.003***		0.000	0.001
		(0.001)	(0.001)		(0.001)		(0.001)	(0.001)
Relation-Length		0.001**	0.002***		-0.001		0.001**	0.002***
		(0.001)	(0.001)		(0.001)		(0.001)	(0.001)
In-COM			0.000					0.000***
			(0.000)					(0.000)
Out-Com			0.000					0.000***
			(0.000)					(0.000)
Call Time			-0.001***					0.001***
			(0.000)					(0.000)
Constant	0.024	0.189***	0.183***	0.777***	0.734***	-0.046**	0.099**	-0.015
	(0.020)	(0.047)	(0.046)	(0.032)	(0.055)	(0.019)	(0.045)	(0.045)
Observations	95,413	95,413	95,413	95,413	95,413	95,413	95,413	95,413
R-squared	0.019	0.025	0.028	0.078	0.080	0.017	0.024	0.037
Number of egoid	441	441	441	441	441	441	441	441
Communication	Full	Full	Full	Full	Full	Full	Full	Full
Unit F.E.	YES	YES	YES	YES	YES	YES	YES	YES
Day F.E	YES	YES	YES	YES	YES	YES	YES	YES

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Notes. Non-COMM, COMM, and Total screen time are estimated by varying texting time from 6s, 9s, 18s to 30s

Figure 5 Distribution Addiction Rate



(a) Top 10% (b) Top 20% (c) Top 30%

The estimation results above based on different criteria show similar results: activating contacts with a high core number decreases the probability of smartphone addiction. The results confirm the main findings presented in the manuscript's main text.

Appendix F: Additional Analysis

F.1. Moderating Impact of Perceived Loneliness

It would be interesting to explore how the impact of network features varies with perceived loneliness (We group the observations into low, medium, and high groups based on individuals' average perceived social loneliness. Since participants did not always respond to social surveys, the total observations (59,563) are less than those utilized in our main estimation (105,370). It would be interesting to explore how the impact of network features vary with perceived loneliness (We group the observations into low, medium, and high groups based on individuals' average perceived social loneliness. Since participants did not always respond to social surveys, so the total observations (59,563) are less than those utilized in our main estimation (105,370). The results suggest that for individuals' with high perceived social lonelines, the core number is not effective in reducing smartphone use. It indicates that the effectiveness of core number is influenced by individuals' perceived loneliness. However, it should be noted that since participants' perceived loneliness is updated over survey, there is not much variability in perceived loneliness.

The results suggest that for individuals with high perceived social loneliness, the core number is not effective in reducing smartphone use. It indicates that the effectiveness of the core number is influenced by individuals' perceived loneliness. However, it should be noted that since participants' perceived loneliness is updated over the survey, there is not much variability in perceived loneliness. The data may not support us in the impact of social network features under the influence of perceived social loneliness. For now, we are just concentrating on the impact of network activations and features. We excluded the hypothesis about perceived loneliness for now.

Appendix G: Additional Analysis

Table 27 Moderating Impact of Perceived Social Loneliness

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
VARIABLES	NonComm.	NonComm.	NonComm.	Comm.	Comm.	Comm.	Screen Time	Screen Time	Screen Time
Degree Centrality	-21.492	14.991	0.553	12.457**	4.957	16.480	-21.598	15.017	0.602
	(17.737)	(10.582)	(15.315)	(5.139)	(4.405)	(11.921)	(17.726)	(10.592)	(15.305)
Core Number	-1.831	-1.957*	1.852	-1.180**	-0.686*	-1.305*	-1.842	-1.967*	1.855
	(1.379)	(1.102)	(1.280)	(0.477)	(0.414)	(0.675)	(1.378)	(1.103)	(1.280)
In-Network Nodes	-2.970*	-0.280	-3.727	3.890***	3.173***	4.678***	-2.998*	-0.312	-3.762
	(1.590)	(1.539)	(2.563)	(0.463)	(0.612)	(0.976)	(1.587)	(1.537)	(2.561)
In-Network Inactive Nodes	-1.650	0.284	-4.702**	-0.391	-1.367***	0.311	-1.630	0.296	-4.674**
	(1.298)	(1.447)	(2.220)	(0.368)	(0.484)	(0.750)	(1.297)	(1.446)	(2.217)
Out-Network Contacts	-0.368	-0.334	0.076	1.476***	0.999***	0.872***	-0.373	-0.340	0.072
	(0.446)	(0.270)	(0.613)	(0.173)	(0.087)	(0.328)	(0.445)	(0.269)	(0.615)
Edges	0.422***	0.006	0.560	0.078	0.210***	-0.108	0.420***	0.005	0.558
	(0.151)	(0.191)	(0.351)	(0.052)	(0.059)	(0.132)	(0.151)	(0.191)	(0.350)
Steps	-0.216***	-0.202***	-0.143***	-0.017	-0.019**	-0.069***	-0.217***	-0.202***	-0.143***
	(0.048)	(0.024)	(0.037)	(0.010)	(0.008)	(0.023)	(0.048)	(0.024)	(0.037)
Sleep Relation Length	-0.074***	-0.082***	-0.102***	-0.006	-0.011***	-0.020	-0.074***	-0.082***	-0.102***
	(0.014)	(0.011)	(0.016)	(0.004)	(0.002)	(0.016)	(0.014)	(0.011)	(0.016)
Trust	-0.171	-2.635*	1.774	-0.017	0.758	-3.303	-0.161	-2.628*	1.775
	(2.355)	(1.399)	(2.210)	(0.659)	(0.543)	(2.511)	(2.357)	(1.399)	(2.203)
Social Closeness	-0.997	4.999	-4.218	-0.025	-0.116	2.291	-0.995	5.026	-4.275
	(6.740)	(3.811)	(5.153)	(1.855)	(1.486)	(2.161)	(6.741)	(3.811)	(5.148)
Survey Contact Position	1.525***	0.385	-0.182	-0.236	-0.324***	-0.690***	1.523***	0.386	-0.183
	(0.573)	(0.334)	(0.428)	(0.164)	(0.119)	(0.242)	(0.572)	(0.334)	(0.429)
Relation Relation Length	0.439	0.605***	0.273	0.124	-0.040	-0.011	0.429	0.598***	0.263
	(0.298)	(0.167)	(0.452)	(0.106)	(0.091)	(0.153)	(0.298)	(0.167)	(0.451)
In-Network Comm.Freq.	0.026	0.004	-0.032				0.176***	0.154***	0.118***
	(0.030)	(0.015)	(0.023)				(0.030)	(0.015)	(0.023)
Out-Network Comm.Freq.	-0.047	-0.015	-0.111**				0.104**	0.136***	0.041
	(0.043)	(0.022)	(0.050)				(0.043)	(0.022)	(0.050)
Call Relation Length	-0.719***	-0.632***	-0.819***				0.275***	0.362***	0.176***
	(0.103)	(0.051)	(0.064)				(0.103)	(0.051)	(0.064)
Constant	282.348***	184.391***	252.237***	14.289***	29.115*	65.427*	282.167***	184.439***	252.258***
	(43.463)	(37.719)	(47.841)	(4.126)	(16.972)	(35.410)	(43.476)	(37.744)	(47.895)
Observations	12,398	34,788	12,377	12,398	34,788	12,377	12,398	34,788	12,377
R-squared	0.108	0.062	0.120	0.142	0.123	0.094	0.106	0.068	0.071
Number of egoid	102	205	102	102	205	102	102	205	102
Social Loneliness	Low	Medium	High	Low	Medium	High	Low	Medium	High
Unit F.E.	YES	YES	YES	YES	YES	YES	YES	YES	YES
Day F.E	YES	YES	YES	YES	YES	YES	YES	YES	YES

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Notes. Columns 1-3 represent the results for non-communication smartphone use estimated in equation 1; Columns 4-5 represent the results for communication-driven smartphone use (communication variables In-COMM and Out-COMM are not included as they comprise DV: communication use time); Columns 6-9 represent the results for overall smartphone use .

Table 28   Moderating Impact of Perceived Family Loneliness

VARIABLES	(1) NonComm.	(2) NonComm.	(3) NonComm.	(4) Comm.	(5) Comm.	(6) Comm.	(7) Screen Time	(8) Screen Time	(9) Screen Time
Degree Centrality	-29.343*	19.613*	19.987	9.589	7.094	10.970**	-29.410*	19.703*	19.865
	(15.158)	(11.521)	(15.098)	(14.377)	(4.423)	(4.826)	(15.178)	(11.529)	(15.069)
Core Number	1.265	-2.902***	-0.821	-0.082	-1.110**	-1.187**	1.263	-2.916***	-0.817
	(1.551)	(1.065)	(1.519)	(0.679)	(0.432)	(0.477)	(1.551)	(1.065)	(1.517)
In-Network Nodes	-1.311	-1.628	-2.306	4.715***	3.060***	4.291***	-1.360	-1.657	-2.339
	(2.338)	(1.594)	(2.019)	(0.894)	(0.561)	(0.537)	(2.337)	(1.593)	(2.014)
In-Network Inactive Nodes	-0.548	-1.390	-1.948	-0.239	-1.251***	-0.298	-0.538	-1.373	-1.935
	(1.963)	(1.482)	(1.792)	(0.815)	(0.474)	(0.405)	(1.962)	(1.481)	(1.793)
Out-Network Contacts	0.105	-0.334	-0.347	0.902***	1.118***	1.182***	0.102	-0.341	-0.353
	(0.585)	(0.295)	(0.417)	(0.165)	(0.117)	(0.166)	(0.585)	(0.294)	(0.418)
Edges	0.168	0.327*	0.017	0.095*	0.172***	0.134	0.168	0.325*	0.016
	(0.253)	(0.196)	(0.303)	(0.051)	(0.062)	(0.094)	(0.253)	(0.195)	(0.303)
Steps	-0.160***	-0.192***	-0.218***	-0.038*	-0.029***	-0.036***	-0.161***	-0.193***	-0.219***
	(0.037)	(0.026)	(0.042)	(0.019)	(0.010)	(0.013)	(0.037)	(0.026)	(0.042)
Sleep Relation Length	-0.095***	-0.079***	-0.096***	-0.027	-0.009***	-0.008**	-0.095***	-0.079***	-0.096***
	(0.018)	(0.011)	(0.015)	(0.019)	(0.002)	(0.004)	(0.018)	(0.011)	(0.015)
Trust	-4.052*	-1.488	0.680	-1.833	0.546	0.472	-4.055*	-1.476	0.675
	(2.190)	(1.529)	(1.911)	(2.050)	(0.555)	(0.718)	(2.189)	(1.529)	(1.909)
Social Closeness	9.646*	1.807	-2.990	-3.476	1.541	-1.129	9.684*	1.806	-3.015
	(5.422)	(4.166)	(4.739)	(4.385)	(1.289)	(2.278)	(5.430)	(4.166)	(4.736)
Survey Contact Position	0.174	0.370	1.517***	-0.594**	-0.310***	-0.537***	0.174	0.370	1.519***
	(0.638)	(0.307)	(0.545)	(0.232)	(0.112)	(0.181)	(0.638)	(0.307)	(0.545)
Relation Relation Length	0.800**	0.460**	0.512**	-0.053	0.075	-0.187	0.790**	0.450**	0.506**
	(0.362)	(0.227)	(0.253)	(0.157)	(0.073)	(0.131)	(0.361)	(0.227)	(0.252)
In-Network Comm.Freq.	-0.009	0.003	0.001				0.141***	0.153***	0.151***
	(0.021)	(0.018)	(0.026)				(0.021)	(0.018)	(0.026)
Out-Network Comm.Freq. 0.135***		-0.045	-0.055**	-0.016				0.107	0.096***
	(0.064)	(0.022)	(0.028)				(0.065)	(0.022)	(0.029)
Call Relation Length	-0.785***	-0.716***	-0.577***				0.210**	0.278***	0.416***
	(0.083)	(0.052)	(0.075)				(0.082)	(0.052)	(0.075)
Constant	210.473***	198.300***	268.861***	49.875*	14.961	34.308*	210.397***	198.206***	269.142***
	(39.073)	(46.164)	(36.989)	(25.704)	(9.262)	(18.155)	(39.054)	(46.223)	(36.937)
Observations	14,049	33,006	12,508	14,049	33,006	12,508	14,049	33,006	12,508
R-squared	0.106	0.078	0.068	0.097	0.108	0.137	0.081	0.067	0.086
Number of egoid	102	205	102	102	205	102	102	205	102
Family Loneliness	Low	Medium	High	Low	Medium	High	Low	Medium	High
Unit F.E.	YES	YES	YES	YES	YES	YES	YES	YES	YES
Day F.E	YES	YES	YES	YES	YES	YES	YES	YES	YES

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Notes. Columns 1-3 represent the results for non-communication smartphone use estimated in equation 1; Columns 4-5 represent the results for communication-driven smartphone use (communication variables In-COMM and Out-COMM are not included as they comprise DV: communication use time); Columns 6-9 represent the results for overall smartphone use .

Table 29 Moderating Impact of Perceived Romantic Loneliness

VARIABLES	(1) NonComm.	(2) NonComm.	(3) NonComm.	(4) Comm.	(5) Comm.	(6) Comm.	(7) Screen Time	(8) Screen Time	(9) Screen Time
Degree Centrality	-11.907	8.181	9.007	7.066	10.685	1.591	-11.917	8.187	9.031
	(18.878)	(11.009)	(15.408)	(8.541)	(7.035)	(3.018)	(18.898)	(11.007)	(15.415)
Core Number	0.649	-1.876	-1.280	-1.403*	-0.682	-0.299	0.638	-1.885	-1.285
	(1.755)	(1.180)	(1.327)	(0.737)	(0.495)	(0.217)	(1.757)	(1.180)	(1.328)
In-Network Nodes	-5.955***	-2.004	1.859	3.547**	3.562***	3.749***	-5.970***	-2.038	1.822
	(1.918)	(1.533)	(2.109)	(1.386)	(0.625)	(0.293)	(1.919)	(1.531)	(2.106)
In-Network Inactive Nodes	-2.754*	-2.747**	2.695	-1.527	-1.006**	-0.173	-2.721*	-2.731**	2.704
	(1.634)	(1.338)	(2.002)	(1.068)	(0.454)	(0.241)	(1.637)	(1.335)	(2.003)
Out-Network Contacts	-0.453	0.032	-0.442	0.813***	1.141***	1.101***	-0.452	0.024	-0.448
	(0.475)	(0.319)	(0.450)	(0.209)	(0.114)	(0.090)	(0.475)	(0.318)	(0.450)
Edges	0.319	0.365**	-0.149	0.185	0.179**	0.057*	0.316	0.363**	-0.150
	(0.324)	(0.172)	(0.269)	(0.122)	(0.072)	(0.030)	(0.324)	(0.171)	(0.269)
Steps	-0.280***	-0.162***	-0.145***	-0.058***	-0.023**	-0.016**	-0.281***	-0.162***	-0.146***
	(0.037)	(0.025)	(0.044)	(0.021)	(0.010)	(0.008)	(0.037)	(0.025)	(0.044)
Sleep Relation Length	-0.086***	-0.082***	-0.096***	-0.004	-0.019**	-0.006**	-0.086***	-0.082***	-0.096***
	(0.015)	(0.011)	(0.016)	(0.005)	(0.009)	(0.002)	(0.015)	(0.011)	(0.016)
Trust	-1.989	-1.402	-1.914	1.152	-0.300	-0.548	-1.977	-1.392	-1.924
	(2.635)	(1.353)	(2.477)	(1.190)	(1.063)	(0.373)	(2.639)	(1.352)	(2.481)
Social Closeness	7.476	3.573	-6.844	1.862	-1.847	0.491	7.507	3.563	-6.827
	(6.816)	(3.571)	(6.272)	(3.709)	(2.059)	(1.051)	(6.826)	(3.568)	(6.276)
Survey Contact Position	1.201*	0.462	0.072	-0.612*	-0.357***	-0.270***	1.203*	0.461	0.074
	(0.612)	(0.328)	(0.453)	(0.317)	(0.125)	(0.079)	(0.612)	(0.328)	(0.453)
Relation Relation Length	0.241	0.567***	0.513*	-0.279*	-0.058	0.295***	0.232	0.559***	0.506*
	(0.446)	(0.202)	(0.277)	(0.160)	(0.087)	(0.085)	(0.446)	(0.202)	(0.277)
In-Network Comm.Freq.	0.015	-0.030	0.052**				0.165***	0.120***	0.203***
	(0.018)	(0.019)	(0.026)				(0.018)	(0.019)	(0.026)
Out-Network Comm.Freq.	-0.046	-0.057**	-0.012				0.105***	0.094***	0.139***
	(0.040)	(0.026)	(0.049)				(0.040)	(0.026)	(0.049)
Call Relation Length	-0.701***	-0.769***	-0.554***				0.294***	0.226***	0.438***
	(0.061)	(0.061)	(0.081)				(0.061)	(0.060)	(0.081)
Constant	245.109***	251.957***	216.711***	35.719***	11.951	21.571**	244.761***	252.220***	216.595***
	(38.970)	(19.639)	(54.088)	(12.425)	(16.925)	(10.279)	(39.016)	(19.670)	(54.060)
Observations	14,004	30,983	14,576	14,004	30,983	14,576	14,004	30,983	14,576
R-squared	0.099	0.080	0.066	0.067	0.114	0.203	0.107	0.057	0.072
Number of egoid	102	205	102	102	205	102	102	205	102
Romantic Loneliness	Low	Medium	High	Low	Medium	High	Low	Medium	High
Unit F.E.	YES	YES	YES	YES	YES	YES	YES	YES	YES
Day F.E	YES	YES	YES	YES	YES	YES	YES	YES	YES

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Notes. Columns 1-3 represent the results for non-communication smartphone use estimated in equation 1; Columns 4-5 represent the results for communication-driven smartphone use (communication variables In-COMM and Out-COMM are not included as they comprise DV: communication use time); Columns 6-9 represent the results for overall smartphone use .