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Social capital is often accumulated not only in ego-networks, but in larger communities. However, these communities, although seemingly visible through social media, are still under-researched. In this work, we examine an online friendship network spanning over an entire middle-size city amounting to 194,601 users of VK social network site. We find that the share of user's in-city friends contributes to his/her brokerage and information influence abilities. More importantly, the number of user's online groups - that is, user's access to diverse or disconnected communities - is positively related with his/her bridging capital, and negatively with the bonding capital. Finally, our research questions the validity of some of the existing social capital measures.

Highlights

- All-city network represents a mixture ofsmall-world and scale-free graph models
- Longer SNS use gives a cumulative advantage for making additional friendship ties
- Participation in more SNS groups increases a user's online bridging social capital
- The number of likes on a user's wall is positively associated with online bridging
- The share of local friends among all user's VK friends increases online bridging

JEL classification**:** Z19

Keywords: social capital, social network sites, VKontakte, friendship, online user behavior, online communities

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Introduction

Social network sites (SNSs) are playing an increasing role in human interpersonal relationships, including the processes of social capital formation. Social capital, broadly understood as a person's ability to mobilize his/her contacts to reach specific goals, is associated with a multitude of factors; knowledge of those factors can contribute to our understanding of individual successes and failures in social capital accumulation. Online social capital, as a fraction of social capital gained and / or maintained online, is the more important the more pervasive are the SNSs themselves. Early research on the factors associated with online social capital, usually employing general measures of SNS use intensity, demonstrated that the use of SNS, and particularly Facebook, is associated with the formation and maintenance of different types of ties and of social capital, respectively (Quan-Haase and Wellman, 2002; Ellison et al., 2007). More recent research (Burke et al., 2011; Johnston et al., 2013; Ellison et al., 2014a, 2014b; Brooks et al., 2014; Su and Chan, 2017; Ellison and Vitak, 2015) has employed more fine-grained metrics and identified specific user practices that have different impact on social capital.

However, all existing research has been examining samples of ego-networks, although measures of social capital derived from an entire network have been considered richer and more informative (Borgatti et al., 1998). Moreover, multiple classic (Warner et al., 1963; Jacobs, 1961) and recent (Hampton and Wellman, 2003; Ellison et al., 2007) studies show that communication, networking and social capital formation to a large extent take place in a geographic setting – a neighborhood, a village or a town. This is true not only for offline social capital formation, but for the online capital as well, because, although contacts may be mobilized entirely online, much of the actual transfer of aid and resources is still possible only offline. Thus, knowing the structure of the online network of a geographic setting as a whole, it is possible not only to examine an individual's closest relations, but to assess his/her position in the entire network which is crucial for evaluating such abilities as brokerage, bridging, information spread or accumulation, and influence at the scale of a community – abilities increasingly important in an information-rich society. In addition to the ego-network focus, the existing research has mostly employed self-reported data on social capital, which has its strengths, but also limitations. Some of the latter are subjectivity and poor scalability. Finally, most of the existing research has been devoted to only one SNS – Facebook.

This study aims to overcome the listed above limitations. By examining a full network of online friendship that presents a collective digital trace of an entire human settlement, this

research contributes to our knowledge about online social capital formation in an online space supported by an underlying communication structure of a "real" city. Specifically, we find that users with a larger share of local friends among all their friends have higher levels of in-city bridging social capital. We also show that online social capital is associated with a whole range of factors, the most notable being membership in multiple online groups – a factor whose influence on social capital has not been studied so far – but also with user's effort to visualize his/ her account's content, as well as with the amount of fiends' feedback. Finally, we find that most of the factors boosting bridging and information capital have a negative effect on closure as a measure of bonding capital.

To make these conclusions, we use the data from VK (VKontakte, http://vk.com) – the largest Russian-speaking social network site with up to 400 million registered users and with 97 million monthly audience as of April, 2017 (About VK, 2012). Since VK provides functionality similar to Facebook and grants open access to much more diverse data than Facebook, this gives us an opportunity to collect rich observational data consisting of 194,601 user accounts and 9,800,107 friendship ties from a typical middle-size Russian city of Vologda. While ethical considerations of such data collection are discussed further below, essentially we collect only the data made public by users since it is this information that may influence the gain of new friends and thus of social capital.

The rest of the paper is structured as follows. In Section 2 we provide the additional background on the approaches to defining and measuring social capital. We review in detail the relevant works on the relationship between online behavior and human social capital formation. In Section 3 we report the procedure of collecting online data of VK users from public API. We examine structural properties of the SNS-based friendship network of Vologda viewing it as a collective digital trace of a human settlement; we also investigate various features of online user activity on VK. Section 4 presents the empirical model predicting structural social capital of friendship network, and the discussion on the implications is presented in Section 5.

Social capital and online social networks

Defining and measuring social capital

The concept of social capital, largely elaborated by efforts of Bourdieu (1986), Coleman (1988), Burt (1995), Lin (1999) and Putnam (2000), is quite broad and metaphoric. However,

despite certain differences, all theories converge in that social ties are the source of social capital. For instance, Bourdieu (1986, p. 251) defined social capital as "the aggregate of the actual or potential resources which are linked to possession of a durable network of more or less institutionalized relationships of mutual acquaintance and recognition". Such resources may include novel information, expertise, emotional support, or small and large services, including financial aid (Haythornthwaite, 2009).

Among multiple classifications of social capital, the most known is the distinction between bridging and bonding capital developed by many scholars, but most notably by Putnam (2000). Most generally, bonding social capital is a resource accumulated via a person's links within a homogeneous group tightly connected by strong ties, such as family or a group of close friends. Bridging social capital is connectedness of a person across homogeneous groups, or within a loosely connected heterogeneous community that provides access to more diverse resources. Tie strength is usually operationalized through emotional involvement and/or intensity of communication. There is some evidence (Sørensen, 2016) that bonding social capital is less relevant for urban communities than bridging social capital, as compared to rural settings. However, as a city-level network still usually consists of strongly tied clusters (Pfliegerand& Rozenblat, 2010), this research uses both of them.

We can conventionally discern two main approaches to measuring social capital. The first is to measure individuals' perceptions of the benefits they have obtained or may obtain from their relationships with others. These perceptions are usually captured by survey scales, such as the well-known scale by Williams (2006). The other approach is to measure individuals' positions in the networks of their relations, based either on self-reported or observational data. These positions are usually captured with the metrics from social network analysis (SNA). Here, this type of capital is termed structural social capital and is opposed to perceived social capital, however, without reference to the well-known distinction between structural, cognitive and relational dimensions of social capital (Nahapiet &Ghosal, 1998).

Both perceived and structural approaches have their strong and weak points. Measurement of perceptions provides direct information about the types and the amount of received benefits, but is prone to subjectivity. Structural approach, especially based on observational data, measures objectified capital, but it may not be able to assess how useful existing ties and positions actually are. Nevertheless, only big observational data that are being accumulated by SNSs, telecommunications companies and the digital economy as a whole allow studying social capital at scale, in particular, at the scale of an entire human settlement. The

extent to which these data represent human social networks as a whole, is still a matter of investigation (González-Bailón et al., 2014; Tufekci, 2014; Mislove et al., 2007), however, as SNSs are now an integral part of everyday life, social capital accumulated through them deserves research per se. Here it is termed online social capital, as opposed to general social capital.

Further, structural social capital may be measured either locally or globally. Local metrics use the information from individuals' immediate environments, most often from their ego-networks, while global metrics define individuals' positions in an entire network – for instance, in an organization or a city. Global metrics have become computable only with spread of big and relatively complete datasets mostly derived from the Internet. The increasing role of the Internet has also determined development of Internet-specific approaches to and measures of social capital, going beyond traditional distinctions. In particular, since information is the main resource transmitted via the Internet, of special importance is the ability of a user to quickly reach a large number of other users and/or to get easily visible to or reached by a large number of individuals. Here, this type of social capital is termed information capital.

Online User Behaviors as Mechanisms Influencing Social Capital

Most existing studies investigate the effects of online user features and behaviors on general self-reported social capital not restricted to its online component. Much fewer are the studies of online self-reported capital (Ellison et al., 2014a; 2014b; Su and Chan, 2017) and online observation-based structural capital (Brooks et al., 2011; 2014; Bohn et al., 2014).

There are two approaches to conceptualize and measure online user behavior: to measure the use of specific SNS features and functionalities regardless of user's motivation (private messaging, liking, tagging, etc.) (Lee et al., 2014) or to measure meaningful intentions and practices regardless of the features employed to exercise them (information sharing, maintaining relationships) (Smock et al., 2011). Both approaches are capable of revealing important associations of online user behavior with social capital: the former allows identifying unanticipated effects of the use of certain online functionalities, while the latter allows differentiating between the effects produced by the use of the same functionality, but caused by different reasons to employ it. Below, we review the most relevant findings related to both approaches and to all aforementioned types of social capital.

The significance of overall user involvement into SNSs for various types of social capital

has been shown in many studies. Thus, *intensity of Facebook use index*, which includes time and perceived role of Facebook in a person's life, among other things, was found to be positively associated with general perceived social capital and especially with its bridging subtype (Ellison et al., 2007). Later these findings were partially confirmed in multiple studies across the globe (Johnston et al., 2013; Ahmad et al., 2016).

In more nuanced studies, specific practices of SNS use have been identified; they include information sharing (McLaughlin & Vitak, 2012), social information seeking (Ellison et al., 2011), Facebook relationship maintenance behavior (FRMB) (Ellison et al., 2014b), help requesting (Ellison et al., 2014a) and others. In particular, *social information seeking* has been defined as browsing profiles of those individuals with whom the user has an offline contact in order to learn more about them (Ellison et al., 2011). This practice enables conversion of latent ties (Haythornthwaite, 2005, p. 137) into socially activated relationships. Along with the number of self-reported *actual friends* (people known by an offline context), it demonstrated a positive and strong effect on general perceived social capital, while the total number of Facebook friends had no such effect.

Facebook Relationship Maintenance Behavior (FRMB) has been defined as a specific form of *social grooming*. It appears as a diverse attention-signaling activity and engagement with a user's friend network. FRMB was found to be positively and strongly related to both general and Facebook-specific bridging and bonding social capital (Ellison et al., 2014a; 2014b; Brooks et al., 2014; Weiqin et al., 2016). Additionally, it was found to fully mediate the positive effect of the number of clusters in user's ego-network on perceived online bridging social capital (Brooks et al. 2014).

It thus appears that conscious practices of SNS use are visibly associated with perceived social capital; however, research on the use of *specific SNS communication features and functionalities* has been producing mixed results. For instance, Burke et al. (2011) investigated the effects of three distinct types of SNS use: *directed communication* which consists of personal, one-on-one exchanges (messages, likes etc.), *broadcasting* (posting for an indefinite audience) and *passive consumption* of social news. The authors found that only the amount of *incoming directed communication* acts had an impact on general perceived bridging social capital. Lee et al (2014) showed that the *number of Facebook features* used by an individual for communication was positively associated with general perceived bonding social capital, thus supporting the idea that individuals tend to use multiple channels to maintain strong ties. But on a more nuanced level, bonding capital was found to be higher among those who used *Like*

feature more frequently and *Comment feature* less frequently, while bridging capital was associated with *posting on a friend's wall*. However, Su and Chan (2017) have demonstrated that *commenting*, along with *liking*, *sharing*, *subscribing* and *private messaging* were positively related to perceived online bonding and bridging social capital.

Although group membership should theoretically be important for social capital (Blanchard, Hora, 2000), as an SNS feature, it has been receiving modest attention of researchers. Lee et al. (2014) have established that self-reported *frequency of group feature use* was unrelated to general perceived social capital. Norris (2002), having used Pew Internet & American Life project survey data, found that reported membership in some *types of SNS groups* contributed to perceived bridging and bonding social capital more than in others, although all contributions were modest. Other research has not addressed group membership directly. Thus, Kobayashi et al. (2010) found that gaming group heterogeneity enhances tolerance and thus should affect bridging social capital, but the latter hypothesis was not tested in the study. Lee and Lee (2010) reported that factors of relational and cognitive social capital, such as self-reported trust and shared values, predicted *online community use* along with other factors. Thus, the impact of group membership on social capital stays under-researched.

Finally, user network parameters have also been studied to some extent. Brooks et al (2014) found that, paradoxically, friendship *ego-network transitivity* negatively correlated with perceived bonding social capital, although transitivity is often used to measure bonding social capital. At the same time, the *number of clusters in the ego-network* positively correlated with perceived bridging social capital which is in line with Kobayashi's findings. Bohn et al (2014) investigated friendship and communication ego-networks of Facebook users. Authors argue that actual online interactions are a more reliable and accurate indicator of a social relationship than friendship ties. They have found that the *number of communication partners* is positively associated with both bridging and bonding dimensions of online structural social capital, and *the number of personalized outgoing communication ties* has a positive effect only on bridging dimension. On the whole, outgoing communication seems to have received more attention than incoming communication.

Summarizing the review, we can conclude that the existing research is based on very different populations, methods and metrics, which is why, although quickly growing, it is still fragmentary and does not produce a coherent picture. Most of the studied user practices and types of social capital have been measured through surveys and represent self-reported data. Observational data have only been collected in the form of user ego-networks. To the best of our

knowledge, there have been no studies investigating structural social capital at the level of an entire SNS network representing an entire human settlement.

Hypotheses

In this study, we examine the impact of online user behaviors on structural social capital calculated based on within-city ties.

Bridging social capital is known to be dependent on the access to disconnected individuals or groups with different resources; still we do not find attempts to measure such access in the studies of social capital on SNS. Kobayashi et al. (2010) measure heterogeneity within a group to which a user belongs, Vitak (2012) deals with audience diversity understanding it as the number of types of connections represented in a user's ego-network. Group membership, as mentioned above, is not measured as membership in multiple groups, which is exactly what we propose to do in order to test the following hypotheses:

H1a: The number of online groups a user belongs to is positively related to the user's online local bridging social capital.

H1b: The number of online groups a user belongs to is positively related to the user's online global bridging social capital.

We have mentioned that incoming communication, with the exception of Burke et al. (2011), has not received much attention of researchers, although it might affect user social capital in several ways. First, we assume that the larger is engagement of others in communication on a user's wall, the higher is the likelihood of new friendships among user's friends and, thus, of formation of closed triads in the user's network. This means that such engagement should contribute to the user's bonding social capital. Second, since Burke et al (2011) have NOT found any effect of incoming communication on perceived bonding social capital, but instead have found the effect of the former on bridging social capital, this might also be the case for structural social capital. And third, large amount of feedback should reflect high visibility of the user's posts. This may indicate his/her ability to effectively transmit information through the network and suggests that this user may possess large information capital. From this follows our second hypothesis:

H2a: The engagement of others in communication on user's wall is positively related to online structural bonding social capital.

H2b: The engagement of others in communication on user's wall is positively related to online structural bridging social capital.

H2c: The engagement of others in communication on user's wall is positively related to online structural information social capital.

Our next hypothesis is based on findings about social information seeking, the behavior that helps activate dormant relations and increases social capital (Ellison et al., 2011). For social information seeking to be successful, such information should be available. As friendship ties are mutual, disclosure of such information should be able to increase social capital not only of the information seeker, but also of the information holder. Among many types of social information, identity information (such as hometown, key biography events or user interests) is the one that may provide missing social context cues and facilitate establishing common ground and further tie formation between the parties, thus serving as social lubricant. For instance, Lampe et al. (2007) found that filling profile fields on Facebook was positively associated with the number of Facebook friends. This lets us to formulate the following hypothesis:

H3a: The amount of identity information is positively related to online bridging social capital.

H3b: The amount of identity information is positively related to online bonding social capital.

Finally, as we study social capital within a virtual network as a digital footprint of communication structure in a human settlement, user's engagement with his/her city of residence should affect his/her within-city social capital. Dominance of local ties in a user's ego-network means that this user has chosen to invest in the given urban setting. Therefore we expect, that along with the absolute number of friends in the city, the share of local friends among all user's friends should facilitate his/her ability to bridge structural holes and transmit information across the city:

H4a: Share of local friends among all user's friends is positively related to the user's bridging social capital.

H4b: Share of local friends among all user's friends is positively related to the user's information social capital.

Data and Methods

In this study, we examine structural social capital using server-level - that is, observational – data from an SNS. The object of this study is the users of the largest Russian SNS VK (http://vk.com) from a Russian city of Vologda. It was selected because this is a typical middle-sized Russian city (population 313,012) with the average standard of living (38 out of 85 Russian regions by GRP).

Dataset: Vologda Friendship Network and Online User Behavior

VK provides functionality similar to Facebook. The data was collected automatically using application programming interface (API).The dataset includes the data from users' profiles, such as counts of communication activity from their pages, friend lists and metadata (gender, age, interests, education, etc). Our data collection procedure was informed with the recent debates on big data ethics (Metcalf and Crawford, 2016; Zwitter, 2014; Moreno et al.,2013) that acknowledges the contradiction between the inapplicability of traditional ethical norms, such as informed consent, to data-driven research, on the one hand, and the need to protect human subjects from potential harm, on the other. In our research we, first, used only open access data available from VK server - that is the data that a user chooses not to protect with privacy settings. Second, we anonymized the data after the download.

Our initial population was 286,994 users who declared Vologda city as their place of residence as of the date of data collection (04.09.2017). After filtering out banned users and those whose last visit to the VK was earlier than 01.06.2016, we constructed the Vologda graph of reciprocal friendship ties that included 196,684 users connected by 9,800,107 edges (graph metrics are shown in Table 1). Overall, the Vologda VK network has structural characteristics similar to other online social networks (Arnaboldi et al., 2015) and some random graph models. Particularly, it is similar to Watts-Strogatz Small-World network model in terms of transitivity and modularity computed with Louvain 'community detection' algorithm. At the same time our network is similar to Barabasi-Albert scale-free model in terms of degree centralization. Thus, we can say that this network consists of internally dense clusters and star-type nodes with a very high centrality. After additional filtering, the final sample comprised 194,601 users; it was used for regression analysis.

Tab.1.Graph metrics for Vologda friendship network and random graph models

Metrics	Vologda graph		Random graph models		
	Entire graph	**Giant Component**	**Erdos-Renyi**	**Scale-free**	**Small World (p=0.3)**
Nodes	196684	196630	196630	196630	196630
Edges	9800107	9800077	9800077	9830225	9831500
Density	0.000507	0.000507	0.000507	0.000508	0.000508
Average degree	99.653	99.680	99.680	100	99.987
Connected components	27	1	1	1	1
Nodes in giant connected component	196630 (99.97%)	-	-	-	-
Diameter		9	4	4	4
Average geodesic distance		3.15546	2.957603	2.889812	2.998528
Transitivity (global clustering coefficient)		0.080921	0.000508	0.003621	0.087468
Average clustering coefficient (Watts-Strogats)		0.130105	0.000508	0.003529	0.088209
Average aggregate constraint		0.065472	0.010144	0.013402	0.011962
Centralization degree		0.033852	0.000245	0.022046	0.000168
Centralization betweenness		0.011070	0.000012	0.006248	0.000009
Assortativity by degree		0.140230	0.000289	0.003023	0.000017
Modularity		0.362820	0.070148	0.084263	0.361638
Clusters		21	8	9	4

Measures

The list of measures is given in Table 2.

Social capital. SNS friendship can be considered a source of social capital because it indicates a sustainable social connection because it reflects mutual recognition and makes friend's updates visible in a user's newsfeed (Ellison and boyd, 2013). The latter is important for receiving social news, maintaining relationships and for responding to help requests (Ellison et al., 2011; 2014b). In this research, we use two local and two global metrics to capture different types of structural social capital. For bonding capital, which by its nature can only be local, we use transitivity (local clustering coefficient) (Watts, Strogatz, 1998) calculated as the share of closed triads among all the triads in an ego-network. It reflects the embeddedness of an individual in a tightly connected group and the degree of the group closure, which, according to Burt (2004), is a most important source of social capital. For bridging capital, which can be both local and global, we use two metrics. The first is Burt's constraint index (Burt, 2005): it defines the extent to which an individual's brokerage ability is constrained by the connectedness of his/her immediate network. It is thus a multiplicative inverse value of local bridging capital defined by Burt as the ability to bridge structural holes (Burt, 2004). The second metric for bridging capital is betweenness centrality (Freeman, 1977), a global metric calculating the number of the shortest paths passing through a node. It estimates an individual's ability to connect distant nodes or clusters at the scale of an entire network, in our case – a city. Finally, we use eigenvector centrality (Bonacich, 1972) as a global metric capturing information social capital introduced in section 2. As it takes into account the number of connections of all node's connections, it is well suited to reflect an individual's ability to transmit information and make it visible.

Communication activity. It has been measured by a number of simple metrics, such as the absolute number of posts, likes, comments and reposts on a user's wall, and by some relative metrics, such as the share of posts of other on a user's wall, to account for the engagement of others. Reposts were excluded from the final analysis due to multicollinearity. Also, an aggregate index of activity dropped out of the final models because it obviously had a smaller explanatory power than the variables that it had been constructed of.

Identity information. This group included all fields from the users' profiles that were reasonably well populated. As we were interested in the amount of identity information, not in its

content, we used simple counts for such variables as Photos, as well as the additive index of Interests and Beliefs.

Access to multiple communities has been measured with only one variable – the number of groups to which a user belongs.

Network metrics were computed using igraph R package. The natural log transformation was performed for all dependent variables and for a number of independent variables to correct for the skewedness in the data.

Tab.2.Variables

Variable	Description
	Dependent Variables
Aggregate constraint index	Extent to which the connections of an ego are to others who are interconnected, which constrains the ego's ability to bridge separated groups (Burt, 2004).Varies usually between 0 and 1 (but it can be greater than 1), where 0 is no constraint, all ego's neighbors are disconnected from each other. Indicator reciprocal to local bridging capital.
Transitivity (local clustering coefficient)	Ratio of all existing ties between alters in an ego-network to all possible ties between alters in this ego-network. Varies between 0 and 1, where 1 is the clique –fully connected ego-network (Watts, Strogatz, 1998).Indicator of bonding capital.
Betweenness centrality	Number of shortest paths going through the vertex. Indicator of global bridging capital (Freeman, 1977).
Eigenvector centrality	Relative score of a node's centrality that depends on centralities of the node's neighbors (Bonacich, 1972). Indicator of global information capital
	Independent Variables
Controlling variables	
Age	User age indicated in the profile
Gender	User gender indicated in the profile
Occupation type	Main occupational activity (school, university, work, none)
Duration	Number of days since the date of a user's registration in VK
User's engagement in the urban network	
Share of local friends	Share of user's fiends residing in Vologda among all user's friends in VK

Communication activity	
Activity index	Sum of all posts, comments and likes on a user's wall
Posts	Total number of posts on a user's wall
Likes	Total number of likes to posts on a user's wall
Comments	Total number of comments to posts on a user's wall
Reposts	Total number of reposts of posts from a user's wall
Share of others' posts	Share of posts written by other users on a user's wall among all posts on the wall
Identity information	
Photos	Total number of photos shared on a user's page
Audios	Total number of audio records shared on a user's page
Interests & beliefs	Number of fields filled in a user's profile reflecting interests, beliefs and values: «Attitude to alcohol», «Attitude to smoking», «Religion/World view», «Personal priority/the main thing in a life», «Important in others», «Political views», «Inspired by», «Activity», «About me», «Interests», «Favorite music», «Favorite movies», «Favorite TV shows», «Favorite games», «Favorite books», «Favorite quotes». Varies between 0 and 16.
School	Presence of information about user's school on the page (0 or 1)
University	Presence of information about a user's university on the page (0 or 1)
Relatives	Presence of links to pages indicated as relatives on a user's page (0 or 1)
Access to multiple communities	
Groups	Number of online groups in VK in which a user is a member

Results

Table 3 presents the final OLS linear regression models predicting aggregate constraint index, betweenness centrality, transitivity and eigenvector centrality in the network of Vologda. The models suggest positive relations between independent variables and all types of capital, except local bridging capital, as its measure - constraint index - is a multiplicative inverse of it. For convenience of interpretation, we indicate the correct direction of association in square brackets after standard errors values that are reported in parentheses.

The models' predictive power varies in the range between 0.325 and 0.559, thus being comparable to or a little higher than the existing research (Brooks et al., 2011; 2014; Ellison et al., 2011; Bohn et al., 2014; Lee et al., 2014). Two other general notes should be made.

First, nearly all effects are significant, but we should keep in mind that with our sample size much more attention should be paid to the effect size than to its significance. Most variables have small values of regression coefficients and tend to randomly flip their signs when model parameters are slightly changed. It means that these predictors have no stable relation to the dependent variables. However, five variables highlighted in Italic have demonstrated the strong and stable pattern of association across all models; models based on only those five variables explain 92-95% of the variance explained by the full models. These variables are discussed further below.

Second, bonding capital has consistently demonstrated the inverse direction of association with all stable and most unstable predictors, as compared to other types of social capital. This might indicate some trade-off between bridging and bonding capital, but it also echoes with the results of Brooks et al (2014) who found transitivity to be negatively related to perceived bonding social capital. So far as transitivity is negatively associated with the number of likes, photos, groups and the share of local friends, it might be not the optimal measure for bonding social capital. Instead, along with aggregate constraint index it might be an inverse predictor of local bridging capital or the predictor of network closure which should not be firmly associated with the growth of bonding social capital. This problem is a matter for future research.

Tab.3. OLS regression predicting structural social capital of friendship network within local urban community

	Bridging Local Aggregate constraint index	Bridging Global Betweenness centrality	Bonding Local Transitivity	Information Global Eigenvector centrality
Controlling variables				
Gender	-0.023*** (0.004) [+]	0.029*** (0.008)	0.064*** (0.003)	-0.068*** (0.008)
Age	0.092*** (0.0002) [-]	-0.088*** (0.0004)	-0.021*** (0.0001)	-0.003*** (0.0004)
Occupation:school	0.034*** (0.010) [-]	0.004 (0.020)	0.054*** (0.007)	-0.103*** (0.020)
Occupation:university	-0.048*** (0.006) [+]	0.030** (0.011)	-0.039*** (0.004)	0.061*** (0.011)
Occupation:work	-0.087*** (0.006) [+]	0.079*** (0.012)	-0.046*** (0.004)	0.089*** (0.012)
Duration	-0.267*** (0.000) [+]	*0.218*** (0.00)*	*-0.226*** (0.000)*	*0.215*** (0.000)*
Communication activity				
Posts (log)	0.149*** (0.002) [-]	-0.161*** (0.004)	0.158*** (0.001)	-0.027*** (0.004)
Likes (log)	*-0.362*** (0.002)* [+]	*0.370*** (0.004)*	*-0.322*** (0.001)*	*0.204*** (0.004)*
Comments (log)	-0.011*** (0.002) [+]	0.024*** (0.003)	-0.0001 (0.001)	-0.001 (0.003)
Share of others' posts	-0.028*** (0.008) [+]	0.018 (0.016)	0.027*** (0.006)	-0.039** (0.016)
Identity information				
Photos (log)	-0.158*** (0.001) [+]	*0.162*** (0.003)*	*-0.111*** (0.001)*	*0.123*** (0.003)*
Audios (log)	0.007*** (0.001) [-]	-0.010*** (0.002)	-0.017*** (0.001)	-0.003* (0.002)
Interests & believes (log)	-0.005 (0.003) [+]	-0.002 (0.007)	-0.013*** (0.002)	0.049*** (0.007)
School	0.031*** (0.006) [-]	-0.018 (0.013)	0.017*** (0.004)	-0.018* (0.013)
University	-0.0002 (0.008) [+]	-0.012 (0.016)	-0.006 (0.006)	0.022(0.016)
Relatives	-0.002 (0.001) [+]	0.011 (0.012)	0.032*** (0.004)	-0.053*** (0.012)
Access to multiple communities				
Groups (log)	-0.217*** (0.002) [+]	*0.241*** (0.003)*	*-0.176*** (0.001)*	*0.231*** (0.003)*
User's engagement with the urban network				
Share of local friends	-0.329*** (0.011) [+]	*0.284*** (0.022)*	*-0.157*** (0.008)*	*0.179*** (0.022)*

Constant	0.000 (0.014)	0.000 (0.028)	0.000 (0.010)	0.000 (0.027)
Observations	191,772	186,962	183,818	191,772
Adjusted R^2	0,559	0,487	0,326	0,407

Note: Standardized coefficients and standard errors in brackets are reported

$^{*}p<0.05$ $^{**}p<0.001$ $^{***}p<0.001$

Controlling variables

Of all controlling variables, only usage duration – the time passed since a user registered on VK – has a large and a stable effect on structural social capital. The longer is the time of a user's stay on VK, the higher is his/her brokerage and his/her ability to transmit information in the network of his/her place of residence. The association between duration and transitivity, if the latter is understood as an indicator of network closure, also appears interpretable: the longer an individual is a VK user, the lower is his/her embeddedness in a closed and tightly connected community.

Groups

The number of online groups in which a user is a member has a strong positive effect on bridging and information capitals and a strong negative effect on closure. These results clearly support H1 – the more online groups a user joins, the higher is the user's brokerage in the friendship network of his/her city of residence. Additionally, we find that access to different communities contributes to users' ability to transmit information and gain visibility. Finally, in this case, too, the connection between the independent variable and closure is interpretable: the larger is a user's access to different communities, the higher is the chance to make new friends within those disconnected communities, and the less interconnected the user's network is.

Communication activity

Engagement of others with a user's wall was measured as the number of posts written by others, the share of posts written by others among all posts, and as the number of likes and comments, since the latter are mostly produced by page visitors. Of all types of communication activity on a user's wall, only the number of likes has a strong effect: it is positively related to

bridging and information capital, and negatively – to closure. Thus, hypotheses H2b and H2c are partially supported, since not all types of engagement of others on a user's wall are found to be related to social capital. Additionally, the direction of causality between likes and information social capital may be inverse to what is suggested by our selection of the dependent variable: the larger the ability of a user to transmit information and gain visibility, the more likes he/she receives. Regarding hypothesis H2a, the situation is different: although the null hypothesis can be rejected, the direction of the found association is opposite to what was expected.

Identity Information

The overall contribution of identity information into social capital is lower than that of activity on a user's wall, including activity of others. The large and stable effect has been demonstrated only by the number of photos which is positively related to bridging and information capital, and negatively – to closure. Again, we partially confirm hypothesis H3a and find the effect opposite to what was expected in hypothesis H3b. Additionally, we find an association with information capital that was not anticipated. The fact that it is photos that have an effect on social capital might have a number of explanations. First, photos are the most heavily used feature among all identity information features. Second, photos is what visualizes users' identity by picturing events, scenes and people a user finds to be important and worthy of displaying.

User's engagement with the network of his/her place of residence

Share of friends located in Vologda among all user's friends is normally distributed – this means that the majority of people tend to have relatively even proportions of friends within and outside the city, while only minorities are embedded entirely either within or outside Vologda. We might expect that only the absolute number of friends within the city has an effect on the within-city social capital, but it turns out that the share of local contacts has its independent effect on both bridging and information capital. Thus, hypothesis 4 is fully supported.

Discussion

Online Groups as a Source of Bridging Social Capital

As participation in multiple online groups is found to enhance network brokerage and information social capital, a possible mechanism causing this effect needs to be discussed. In general, the more online groups a user belongs to, the more various and separated are social

clusters and milieus the user bridges. However, formally, being a member of an online group and making friendships with other members are two distinct types of online behavior. There is a substantial body of literature exploring network structures of different types of online communities including online forums (Cobb et al., 2010), social news sites (Hogan, 2008), twitter #hashtag communities (Gruzd and Haythornthwaite, 2013), Facebook groups (Rieder, 2013), and VK groups (Gruzd and Tsyganova, 2015; Rykov et al., 2016; 2017). These studies demonstrate that despite different network patterns (Himelboim et al., 2017), dense and tightly connected clusters of members are usually formed within communities. This means that group membership increases the chance to make new friends. Thus, group membership may provide an access to a whole bunch of new social contacts that are likely to be non-redundant in Burt's sense (Burt 1995: 17). This allows a user to both bridge more structural holes and to reach more diverse audiences when posting.

Visualized Identity Information and Social Lubricant Effect

Social lubricant effect appears when identity information in SNS is used for searching and establishing common ground between users (Ellison et al., 2011; Ellison and Vitak, 2015). While previous research (Lampe et al., 2007) found that the amount of identity information was slightly positively related to the number of friends on Facebook, we find the effect of most types of such information so weak that it cannot be treated as able to affect social capital. This, combined with the established effect of the number of photos on bridging social capital, needs interpretation. While a user providing no information might indeed have low chances to find many friends, once the information is provided, it might equally serve "right" friend acquisition and "wrong" friend filtering. That is why, after initial identity "saturation", friendship gain may stop. A more nuanced research is needed to find whether really common-ground information, such as school or interests coinciding between a friendship seeker and a friendship giver, could have a stronger effect on the probability of friendship tie formation than a mere amount of information. Meanwhile, the number of photos increases bridging social capital, regardless of their content. Among all other types of identity information, a photo is the most emotional and the most easy-to-consume way of self-disclosure. Posts with photos are known to generate much more likes than regular posts (Corliss, 2012). Therefore, a wall full of photos is more likely to quickly provide information sufficient for establishing common ground with a social information seeker, as compared to relevant, but non-visualized information. This might be a possible explanation of why specifically photos play the role of social lubricant on SNS.

Engagement of Other Users as an Attention Signaling Activity

The fact that engagement of others in the form of likes contributes to bridging, not bonding capital deserves special consideration. If explained with social information seeking behavior, engagement of others on a user's wall should increase bridging capital of others, not of the wall host. For it is those others who would use their friend's wall to establish a new tie and thus to – possibly – connect to a new social cluster. In this case, bridging capital of the wall host would decrease, while closure and bonding capital should increase, which is exactly the opposite to our finding. Burke et al. (2011) who also find that incoming (and not outgoing) communication increases a user's bridging capital offer the following explanation: it is the feedback that signals a user about the existence of a tie. Developing this claim, we may say that outgoing communication, especially broadcasting that a wall host is engaged in on his/her wall, is only an attempted relationship maintenance activity. The reciprocated act of communication is a confirmation of this activity being successful. And it is likes that allow such confirmation at the lowest cost.

Closure and transitivity as problematic indicators of bonding social capital

The fact that bonding social capital is inversely related to all predictors of other types of social capital calls for some immediate explanation and for further research. First of all, transitivity is a value normalized by the number of possible links in an ego-network, and thus is negatively correlated with the number of friends. On the contrary, betweenness and eigenvector centralities, as well as multiplicative inverse of constraint index, are positively correlated to degree. In fact, transitivity and constraint are similar in that their growth indicates the closure of possibilities for an individual to develop a larger or a more diverse network. But does loosening of closure and the decrease in transitivity of the entire user's network necessarily lead to the decrease of bonding social capital? Arnaboldi et al. (2012) show that this is not the case. They find that online users maintain ties grouped in four distinct layers of strength, the size of each weaker layer being three times larger than that of the previous stronger layer. In our research, we also see that the overall city network is a loose collection of tighter clusters. This means that presence of tighter subsets in users' ego-networks is obscured by much larger and much looser portions of weak ties. Consequently, the portion of a user's network responsible for bonding social capital is not detected by metrics calculated on the entire ego-network. Finally, it is not obvious that SNS-specific digital footprints are good to identify which of the befriended users are strong ties, as it is this type of ties that are most likely to be maintained via other channels, such as face-to-face communication, oral telephone communication or private messengers. New

approaches to measuring bonding social capital, in particular online bonding social capital, are needed.

Conclusion and further research

This paper, to the best of our knowledge, has been the first examination of an online network which represents a collective digital trace of a human settlement – in our case, a middle-sized city. This has allowed us to investigate social capital measured not only locally, based on ego-network data, but also globally, at the level of a city network as whole, and to get a first understanding of the structure of an online network of this city. We have found that it presents a small-world graph containing dense clusters and star-type nodes with outstanding centrality. This suggests presence of an hierarchical structure in the network: although this relatively big community breaks into small sub-communities, it is also tied by a small number of city-level leaders. Further, the city-level community has no clear boundaries since the majority of users invest some varying proportion of their friending effort outside their city of residence. The internal online friending investment, however, is directly related to users' in-city online social capital, especially to its bridging subtype. All this structure could not have been captured based on the study of ego-networks only. The availability of rich city-level and village-level network data on VK opens wide possibilities for further comparative analysis of urban and rural communities, and for testing various hypotheses such as dependence of online within-city social capital on the number of years spent in local schools.

Next, a major finding of our research is the positive effect of multiple group membership on bridging social capital within the user's city of residence, and negative – on a user's ego-network closure. This hypothesis, paradoxically, was not tested before, perhaps, because such data was hard to obtain. Groups naturally serve gateways to new communities where new friends may be acquired for whom a user becomes a bridge to her other subgraphs. This effect might be stronger for city-independent social capital, as well as if groups have fewer intersecting members, which are potential questions for further research.

We have also shown that some types of outgoing (photos) and incoming (likes) activity on users' walls are positively related to his/her within-city bridging and information social capital. While photos visualize user's identity and thus provide social information seekers with necessary context for linking with the page host, likes seem to work differently. They, first, indicate user's visibility and ability to transmit information, and, second, they serve as signals for page hosts that their ties are "alive" and usable. A limitation of our study is that we have not

used the data about a user's activity outside his wall, such as liking or commenting on a friend's page, which is an important part of social grooming behavior. This is one of the ways to develop this research.

Finally, we have found that all measures of social capital are related to each other (least of all – transitivity) and to degree, and that bonding capital measured with transitivity is inversely related to most predictors, as compared to other types of social capital. Combined with findings of Brooks et al. (2014), this calls for a deeper investigation into validity of social capital measures based on both observational and self-reported data. Ultimately, it calls for further clarification of the concept that is being measured.

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