LEBS
Vol. 13 No. 2 (2022) 50–56
Letters on Evolutionary Behavioral Science

Is Mentalizing Essential to Predict Human Network Size? Reexamining the Social Brain Hypothesis From a Social Network Perspective

Taro Hirashima[1, *], Tasuku Igarashi[2]

[1]Aichi Shukutoku University, 2-9, Katahira, Nagakute-city, 480-1197, Japan

[2] Nagoya University, Furo-cho, Chikusa-ku, Nagoya, 464-8601, Japan

[*]Corresponding Author (hirashima.taro@gmail.com)

One central question in social science and evolutionary anthropology is how humans can form and maintain large social networks. The social brain hypothesis argues that humans use their mentalizing ability to read others' minds for the development of dyadic relationships in layered social networks. However, previous empirical studies have not directly examined the association between mentalizing and the size of the active network located at the outermost layer. By introducing a social network perspective, we predicted that individuals use their mentalizing ability not only to form and maintain dyadic relationships but also to belong to multiple communities, which indirectly expands the active network size. We collected data from undergraduates in Japan (*N* = 175) to examine how mentalizing is linked to the size of online social networks. Mentalizing was positively associated with the number of dyads but not with the number of communities and the active network size. These findings suggest that the social brain hypothesis has limited validity, and there is a need for more careful explanations surrounding the psychological and structural underpinnings of large human social networks.

Keywords
the social brain hypothesis, social network size, mentalizing, community

Introduction

It is known that humans can maintain larger social networks of stable relationships than other primates. The maximum average social network size is claimed to be approximately 150 people, known as "Dunbar's number" (Dunbar, 2018). Resolving the question of how humans can maintain organic social relationships to form a large society is important in social science and evolutionary anthropology. This study aims to investigate the psychological basis of large-scale human social networks.

Mentalizing is the sociocognitive ability to understand others' mental states, such as emotions, beliefs, and intentions. Mentalizing is considered necessary to build and maintain large social networks. According to the social brain hypothesis (SBH; Dunbar, 1998; Dunbar & Shultz, 2017), functional, cohesive, and bonded social group formations afford evolutionary benefits to group members among primates. However, living in such groups requires individuals to process complex social information. To form a stable group, individuals must adjust their behavior based on their understanding of other individuals' beliefs, which is computationally demanding. The SBH argues that large and complex societies co-evolved with mentalizing inherent in larger brains. The SBH also assumes that brain size constrains mentalizing ability, which constrains the social network size and adopts neocortical volume as an indirect measure of mentalizing.

Intergeneric comparisons among primates empirically support this theoretical assumption—the larger the mean group size of the genus, the larger the neocortex ratio (i.e., the relative volume of the neocortex to the whole brain excluding the neocortex) (Dunbar, 1992; Kudo & Dunbar, 2001; Pasquaretta et al., 2014). However, the relationship between mentalizing and social network size has not been directly tested, mainly due to the absence of commonly available tasks to measure mentalizing in different primate genera. Consequently, this line of empirical research focuses solely on humans and investigates the individual differences in mentalizing and social networks (Powell et al., 2012).

The SBH assumes a social network that comprises concentric layers centered on individuals, depending on the closeness and frequency of contact with others (Zhou et al., 2005). The SBH refers to the following: the innermost layer as the *support clique*, including others closest to oneself with high contact frequency (size 5); the second inner layer as the *sympathy group*, including others close to oneself (size 15); and the outer layer as the *active network*, including others whose names and faces match each other and form organic social relationships, (size 150; corresponding to Dunbar's number). The layered network structure is even observed in mobile phone calls (Mac Carron et al., 2016) and social media communications, such as Twitter and Facebook (Dunbar et al., 2015).

Theoretically, mentalizing provides a basis for constructing close relationships. However, they require time to maintain, and information processing associated with mentalizing is highly cognitively demanding (Lewis et al., 2011). Intuitively, applying the sociocognitive ability to read the minds of all 150 individuals included in active networks is not efficient. There is no rigorous evidence that mentalizing directly functions as a psychological basis for active networks. Previous research (Launay et al., 2015; Stiller & Dunbar, 2007) reported the positive correlations

doi: 10.5178/lebs.2022.99
Received 09 October 2022.
Accepted 15 October 2022.
Published online 27 October 2022.

of mentalizing with *support clique* size but did not directly measure the *active network* size. Recently, Hirashima (2017) used the "Reading the Mind in the Eyes" Test (Baron-Cohen et al., 2001) as a measure of mentalizing ability and found that mentalizing was positively correlated with the size of the support clique but not with the size of the active network. These findings cast doubt on the SBH assumption that mentalizing underlies the emergence of large social networks.

Migliano et al. (2017) analyzed the social network structure of modern hunter-gatherer bands in the Philippines and Congo-Brazzaville. They revealed that the band members formed small but close dyadic relationships with non-relatives (friends) who connected to their households. Such ties function as 'shortcuts' to connect closely knit clusters, resulting in a small-world structure (Watts & Strogatz, 1998) within the band—the hunter-gatherers formed a network that allowed for efficient information exchange across households. Individuals effectively extend their networks by developing close dyadic relationships with a few others in other households.

This finding implies the need to shift away from the simple layered network perspective when we examine the association between psychological ability and active network size. Social network size in the SBH framework is often measured as the number of dyads comprising the individual's composition of each layer (e.g., Stiller & Dunbar, 2007). However, the concept of social networks is not the sum of dyads. In social networks, individuals are often affiliated with multiple communities (Martí et al., 2017; McCarty, 2002). Communities are determined by clusters, a substructure of networks comprising three or more individuals (triads), which can serve both formal groups (e.g., family and workplace) and informal groups (e.g., friendship circles) (Homans, 1950).

Networking across multiple communities occurs naturally in modern societies. A typical person belongs to different formal and informal groups, such as relatives, workplace, neighborhood, and a group of school friends. They are separated as a cluster in personal (egocentric) networks. The person would have close connections with a few people in each community but would also try to maintain casual contact with the rest of the community members surrounding the close relationships. It is reasonable to say that hunter-gatherer and modern societies share similar mechanisms of social network formation.

The structural anatomy of social networks allows us to consider the role of mentalizing in expanding the active network from a different point of view. The idea is simple: When individuals become members of a community, they use their mentalizing ability to create and maintain close dyadic relationships not with many, but with only a few community members. They then would connect with other community members as casual contacts through these close relationships. Expressly, the mentalizing ability increases the number of communities individuals belong to and results in large social networks. This idea is endorsed by research on self-monitoring. Self-monitoring is characterized by the ability to tailor one's behavior to the intentions and desires of others; its primary function overlaps with mentalizing (Schutte et al., 2001). High self-monitors are more likely to be positioned as brokers among different friendship communities in an organization (Sasovova et al., 2010).

In sum, this study aims to resolve the inconsistency between the theoretical assumptions of the SBH and empirical evidence on mentalizing and network size by making an auxiliary assumption of multiple communities in personal networks. The prediction is that the mentalizing ability at the individual level shows positive associations with the number of dyads and the number of communities. If this is supported, the active network size is predicted to indirectly relate to mentalizing via the number of communities to which individuals belong.

Methods

Participants

In 2016, a total of 186 undergraduates (120 men, 60 women, and six unanswered; M_{age} = 18.37 years, SD = 0.56) from the Department of Education or Engineering at a university in Japan volunteered to participate in a survey in a classroom setting. Of 186, 175 respondents (117 men, 58 women, and 114 engineering and 61 education students; M_{age} = 18.36 years, SD = 0.55) who completed all items were included in the analyses.

Measures

(a) Social network size

To reduce recall bias, we asked participants to report their use of LINE (a messaging app like WhatsApp and Facebook Messenger) by referring to its logs on their smartphones. LINE is the most popular messaging platform in Japan, used by 79.3% of teenagers and 96.3% of people in their 20s at the time of the survey (Ministry of Internal Affairs and Communications, 2017). All participants had a LINE account.

In LINE, users create a chat room (called "talk-room") and send one-to-one or group messages to others in the contact lists (called "friends" regardless of their relationships).[1] In the survey, participants listed chat rooms in which they had communicated within the week,[2] reported the number of people in each chat room and categorized their relationship into one of 10 choices (e.g., family/relatives and old friends/acquaintances; see below). Participants also reported the total number of "friends" in their LINE contact lists.

(b) Mentalizing ability

We used the EQ-8 (Loewen et al., 2010; eight items, see Table S1 in Supplementary Materials for item information) to measure self-reported mentalizing ability on a 4-point Likert scale ("strongly agree" to "strongly disagree").

(c) Big-Five personality

We measured personality traits as control variables by using the Japanese version of the Ten Item Personality Inventory (Oshio et al., 2014; 10 items) on a 7-point Likert

[1] LINE allows users to join a group chat even if not all group members are in their contact list, as long as one person invites all of them. Thus, individuals know at least one person in each chat room. The members of each chat room are all different. One can create separate chat rooms in which the lists of the members overlap.

[2] The term was set to one week based on the operational definition of the support clique that a person who personally contacts once a week (Dunbar & Spoors, 1995).

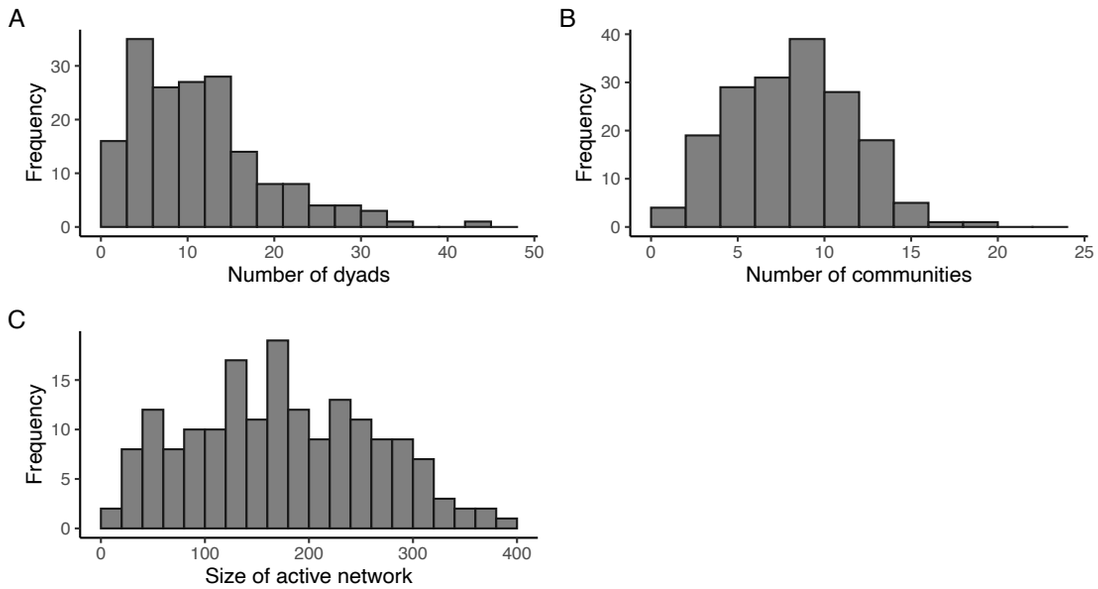

Figure 1. Histograms of the number of dyads (A), number of communities (B), and active network size (C) (N = 175).

scale ("strongly agree" to "strongly disagree").

We also measured social skills, generalized trust, self-esteem, and social networking motivations. These measures were not used in the following analyses.

Results

LINE chat rooms were classified as either dyad (including only two members: respondents and another person) or community (including respondents and two or more persons). The active network size was calculated as the number of "friends" in the LINE contact lists, excluding business accounts (e.g., brands and companies)[3]. Descriptive statistics are shown in Tables 1 and 2 and Figure 1.

The average number of chat rooms in which each participant communicated in the past week was 20.5 (175 participants communicated in 3582 chat rooms). The average number of dyads was approximately 12 ± 8 (1*SD*). The size was within the range of the support clique per the SBH. The average number of communities was approximately 9 ± 3 (1*SD*), and the average number of people in each community was approximately 35 ± 42 (1*SD*), of which 42.7% included fewer than 15 people (the size of the sympathy group). The average active network size (number of friends in the contact list) was approximately 96 ± 50 (1*SD*). The size was slightly smaller than Dunbar's number but similar to that of Roberts et al. (2009) (72 ± 33 [1*SD*]). The chat-room breakdown by relationship shown in Table 2 indicates that participants exchanged most messages with old and university friends/acquaintances and extracurricular activity group members.

As shown in Table 1, the number of communities and the active network size showed a significant positive correlation (r = .44, p < .001). Mentalizing showed a weak but significant positive correlation with the number of dyads (r = .15, p = .04) but was not significantly related to either the number of communities (r = −.07, p = .33) or active network size (r = .05, p = .31). Extraversion was significantly associated with mentalizing (r = .16, p = .03) and the numbers of dyads and communities (rs = .20–.39, ps < .01). Age showed significant negative correlation with the active network size (r = −.19, p = .01)[4].

Table 3 shows the results of multiple regression analysis on network size. Mentalizing showed a significant and positive association with the number of dyads when controlling for gender, age, and personality. However, mentalizing relates to neither the number of communities nor the active network size. These findings indicate no direct and indirect association between mentalizing and the active network size.[5]

Discussion

This study scrutinized the relationship between mentalizing and the structure of inner to outer personal networks. Consistent with the previous literature (Stiller & Dunbar, 2007), a positive association was found between mentalizing and the number of dyads. However, mentalizing was unrelated to the number of communities and the active network size. Therefore, the initial prediction on mentalizing and social network size was not fully supported.

The results imply that the high cognitive costs for

[3] Previous research (e.g., Kanai et al., 2012; Krol et al., 2018) used the number of Facebook contacts as a proxy for real-world social networks, therefore as a reflection of the Dunbar's number.

[4] The negative correlation between age and active network size is not predicted by the SBH and is difficult to interpret reasonably. This could be a pseudo-correlation caused by sample heterogeneity between the departments. We report the results of follow-up analyses including department as a dummy variable in Supplementary Materials.

[5] We also conducted a negative binomial regression on the number of dyads (that showed skewed distribution). The result shown in Table S4 in Supplementary Materials is consistent with the multiple regression analysis in Table 3. Mentalizing and extraversion were the only significant predictors of the number of dyads.

Table 1. Descriptive statistics and correlation coefficients ($N = 175$).

	M	*SD*	*Med.*	*Min*	*Max*	1	2	3	4	5	6	7	8	9	10
1. Gender (0:male, 1: female)						—									
2. Age	18	0.6	18	18	20	−.15 *	—								
3. Mentalizing	0.8	0.4	0.8	0	1.8	.11	.13	—							
Big-Five															
4. Extraversion	4.1	1.4	4	1	7	.21 **	−.01	.16 *	—						
5. Agreeableness	5	1.00	5	2	7	.09	.07	.41 ***	.02	—					
6. Conscientiousness	3.3	1.3	3	1	6.5	.08	.05	.23 **	.06	.15	—				
7. Neuroticism	4.4	1.2	4.5	1	7	06	.08	−.10	.07	−.18 *	−.29 ***	—			
8. Openness	4	1.2	4	1	7	−.01	.05	.07	.26 ***	.02	−.01	.12	—		
Social network size															
9. Dyad	12	7.7	10	0	43	.19 *	−.04	.15 *	.39 ***	−.07	−.01	.10	.09	—	
10. Communitiy	8.6	3.5	9	1	20	−.03	−.05	−.07	.20 **	−.04	−.12	.13	.14	.46 ***	—
11. Active network	174	88	166	9	390	.00	−.19 *	.05	.38 ***	−.06	−.02	.14	.11	.52 ***	.44 ***

*** $p < .001$. ** $p < .01$. * $p < .05$.

Note. Possible score range for Mentalizing score is 0–2 because "strongly agree" responses scored 2, "slightly agree" responses scored 1, "slightly disagree" and "strongly disagree" responses scored 0 (Baron-Cohen & Wheelwright, 2004). Possible score range for each Big Five personality trait score is 1–7.

Table 2. Chat-room breakdown by relationship ($N = 3582$).

	Dyads (two members)		Communities (three or more members)	
Family/relatives	200	(5.6%)	49	(1.4%)
Romantic partner	34	(0.9%)	1	(0.0%)
Old friends/acquaintances	563	(15.7%)	186	(5.2%)
Friends/acquaintances in the same department	661	(18.5%)	522	(14.6%)
Friends/acquaintances in another department	136	(3.8%)	64	(1.8%)
People taking the same classes	28	(0.8%)	79	(2.2%)
Extracurricular activity group members	343	(9.6%)	507	(14.2%)
Friends outside the university	49	(1.4%)	6	(0.2%)
Workmates at a part-time job	33	(0.9%)	35	(1.0%)
Other	24	(0.7%)	62	(1.7%)
Total	2071	(57.8%)	1511	(42.2%)

Table 3. Results of multiple regression analysis on social network size.

	Social network size								
	Dyad			Community			Active network		
	Beta		*SE*	Beta		*SE*	Beta		*SE*
Gender (ref.: male)	.11		.07	−.07		.08	−.13		.07
Age	−.04		.07	−.05		.08	−.22	**	.07
Mentalizing	.16	*	.08	−.08		.09	.06		.08
Extraversion	.35	***	.07	.20	*	.08	.38	***	.07
Agreeableness	−.13		.08	.03		.08	−.04		.08
Conscientiousness	−.04		.07	−.09		.08	.01		.07
Neuroticism	.06		.07	.08		.08	.14		.07
Openness	−.02		.07	.08		.08	.00		.07
Adj. R^2	.16***			.04			.17***		

*** $p < .001$. ** $p < .01$. * $p < .05$.

SE: Standard error. Coefficients (Betas) are standardized.

mentalizing may limit its coverage to a small number of dyadic relationships with frequent contacts requiring higher maintenance costs. The remaining outer-layer networks are not always available and accessible to individuals, so mentalizing may not be a prerequisite for their management. In sum, the current findings suggest the limited validity of the theoretical assumption of the SBH on the role of mentalizing in networking. It would be fair to say that mentalizing is a cognitive basis for maintaining a *small* number of close dyadic relationships, probably inside the support clique, as previously reported (Hirashima, 2017; Launay et al., 2015; Stiller & Dunbar, 2007). Future research should examine the validity of the SBH by focusing on psychological foundations other than mentalizing with due consideration to the structure of social networks, for which explicit assumptions were not given in the theory.

This study has one theoretical issue and two methodological limitations. First, the SBH was originally proposed to explain inter-generic differences between primates' brains and group size, and one might criticize a within-species approach for the leap to test the hypothesis. Although we should be careful about this point, Dunbar and colleagues (Dunbar, 2018; Powell et al., 2012) argue that the SBH is applicable to both between- and within-species contexts. The present study follows in the same vein.

Second, mentalizing was assessed only by cross-sectional, self-report measures. This remains a possibility of reverse causality: Individuals having greater number of dyads reported their own mentalizing abilities as high. Although the alternative interpretation is contradictory to the finding that mentalizing was not associated with active network size, future research should employ longitudinal research designs and use more objective, performance-based measures, such as the imposing memory task (Kinderman et al., 1998) for mentalizing ability assessments, to confirm the robustness of the current findings.

Third, the current community measure may not be a perfect index for estimating the relationship between network size and mentalizing. A possible overlap of "friends" across different chatrooms in LINE could bias the accuracy of the measure. More importantly, interaction patterns among individuals in a networked community would be more complicated than the initial assumption as they included some close ties with non-family members (a shortcut to joining other closely-knit clusters) and other casual contacts. One example is triadic closure, which is known as a networking process like "friends of a friend become friends." When individuals in a community reconnect to a person with emotional bonds, they also tend to have emotional connections to others via the person (Granovetter, 1973; Holland & Leinhardt, 1971). Triadic closure is likely to emerge when individuals have a chance of joint attendance at social events and occasions. Messaging platforms like LINE provide greater opportunities for collective interactions in group chat rooms. Communications involving triadic closure (i.e., dense subgroups) may be more cognitively demanding than in communities involving a shortcut and casual contacts. Such social environments would demand more than mentalizing, but we cannot test this possibility due to the lack of structural information about each community. Future research should calculate more detailed network metrics based on the entire structure of personal networks to clarify whether mentalizing predicts human social network size.

Acknowledgments

This work was supported by JSPS KAKENHI Grant Number JP25780371.

Author contributions

TH and TI developed the study concept and collected and analyzed the data. TH and TI wrote the manuscript. All authors read and approved the final manuscript.

Ethical statement

This research was approved by the Ethical Review Board of the Graduate School of Education and Human Development, Nagoya University (15-763). All participants gave informed consent prior to answering the questionnaire.

Data accessibility & program code

The raw data supporting the conclusion of this article will be made available by the authors without undue reservation.

Supplementary material

Electronic supplementary materials are available online.

References

Baron-Cohen, S., & Wheelwright, S. (2004). The empathy quotient: an investigation of adults with Asperger syndrome or high functioning autism, and normal sex differences. *Journal of Autism and Developmental Disorders*, *34*(2), 163–175. https://doi.org/10.1023/b:jadd.0000022607.19833.00

Baron-Cohen, S., Wheelwright, S., Hill, J., Raste, Y., & Plumb, I. (2001). The "Reading the Mind in the Eyes" test revised version: A study with normal adults, and adults with Asperger syndrome or high-functioning autism. *Journal of Child Psychology and Psychiatry, and Allied Disciplines*, *42*(2), 241–251. https://doi.org/10.1111/1469-7610.00715

Dunbar, R. I. M. (1992). Neocortex size as a constraint on group size in primates. *Journal of Human Evolution, 22*(6), 469–493. https://doi.org/10.1016/0047-2484(92)90081-J

Dunbar, R. I. M. (1998). The social brain hypothesis. *Evolutionary Anthropology*, *6*(5), 178–190. https://doi.org/10.1002/(sici)1520-6505(1998)6:5<178::aid-evan5>3.0.co;2-8

Dunbar, R. I. M. (2018). The anatomy of friendship. *Trends in Cognitive Sciences*, *22*(1), 32–51. https://doi.org/10.1016/j.tics.2017.10.004

Dunbar, R. I. M., Arnaboldi, V., Conti, M., & Passarella, A. (2015). The structure of online social networks mirrors those in the offline world. *Social Networks*, *43*, 39–47. https://doi.org/10.1016/j.socnet.2015.04.005

Dunbar, R. I. M., & Shultz, S. (2017). Why are there so many explanations for primate brain evolution? *Philosophical Transactions of the Royal Society B: Biological Sciences*, *372*(1727), 20160244. https://doi.org/10.1098/rstb.2016.0244

Dunbar, R. I. M., & Spoors, M. (1995). Social networks, support cliques, and kinship. *Human Nature*, *6*(3), 273–290. https://doi.org/10.1007/BF02734142

Granovetter, M. S. (1973). The strength of weak ties. *The American Journal of Sociology*, *78*(6), 1360–1380. https://www.journals.uchicago.edu/doi/abs/10.1086/225469

Hirashima, T. (2017). Tasha hyoujou kara no joudou ninchi to shakaiteki nettowa-ku saizu: Nihonjin daigakusei wo taishou to shita kentou [Does reading emotion from eyes expand social networks? A preliminary analysis on the relationships between social network size and social intelligence among Japanese undergraduates]. *Tokai Journal of Psychology*, *11*, 29–39. https://psych.educa.nagoya-u.ac.jp/toukaishinri/?page_id=53

Holland, P. W., & Leinhardt, S. (1971). Transitivity in structural models of small groups. *Comparative Group Studies*, *2*(2), 107–124. https://doi.org/10.1177/104649647100200201

Homans, G. C. (1950). *The human group*. Routledge.

Kanai, R., Bahrami, B., Roylance, R., & Rees, G. (2012). Online social network size is reflected in human brain structure. *Proceedings of the Royal Society B: Biological Sciences*, *279*(1732), 1327–1334. https://doi.org/10.1098/rspb.2011.1959

Kinderman, P., Dunbar, R. I. M., & Bentall, R. P. (1998). Theory-of-mind deficits and causal attributions. *British Journal of Psychology*, *89*(2), 191–204. https://doi.org/10.1111/j.2044-8295.1998.tb02680.x

Krol, S. A., Meyer, M. L., Lieberman, M. D., & Bartz, J. A. (2018). Social working memory predicts social network size in humans. *Adaptive Human Behavior and Physiology*, *4*(4), 387–399. https://doi.org/10.1007/s40750-018-0100-9

Kudo, H., & Dunbar, R. I. M. (2001). Neocortex size and social network size in primates. *Animal Behaviour*, *62*(4), 711–722. https://doi.org/10.1006/anbe.2001.1808

Launay, J., Pearce, E., Wlodarski, R., van Duijn, M., Carney, J., & Dunbar, R. I. M. (2015). Higher-order mentalising and executive functioning. *Personality and Individual Differences*, *86*, 6–14. https://doi.org/10.1016/j.paid.2015.05.021

Lewis, P. A., Rezaie, R., Brown, R., Roberts, N., & Dunbar, R. I. M. (2011). Ventromedial prefrontal volume predicts understanding of others and social network size. *NeuroImage*, *57*(4), 1624–1629. https://doi.org/10.1016/j.neuroimage.2011.05.030

Loewen, P. J., Lyle, G., & Nachshen, J. S. (2010). An eight-item form of the Empathy Quotient (EQ) and an application to charitable giving. Unpublished manuscript. Retrieved from https://www.researchgate.net/publication/254000149_An_eight-item_form_of_the_Empathy_Quotient_EQ_and_an_application_to_charitable_giving

Mac Carron, P., Kaski, K., & Dunbar, R. I. M. (2016). Calling Dunbar's numbers. *Social Networks*, *47*, 151–155. https://doi.org/10.1016/j.socnet.2016.06.003

Martí, J., Bolíbar, M., & Lozares, C. (2017). Network cohesion and social support. *Social Networks*, *48*, 192–201. https://doi.org/10.1016/j.socnet.2016.08.006

McCarty, C. (2002). Structure in personal networks. *Journal of Social Structure*, *3*(1), 20. https://www.cmu.edu/joss/content/articles/volume3/McCarty.html

Migliano, A. B., Page, A. E., Gómez-Gardeñes, J., Salali, G. D., Viguier, S., Dyble, M., Thompson, J., Chaudhary, N., Smith, D., Strods, J., Mace, R., Thomas, M. G., Latora, V., & Vinicius, L. (2017). Characterization of hunter-gatherer networks and implications for cumulative culture. *Nature Human Behaviour*, *1*, 0043. https://doi.org/10.1038/s41562-016-0043

Ministry of Internal Affairs and Communications (2017). *White paper: Information and communications in Japan 2017*. https://www.soumu.go.jp/main_sosiki/joho_tsusin/eng/whitepaper/2017/index.html

Oshio, A., Abe, S., Cutrone, P., & Gosling, S. D. (2014). Further Validity of the Japanese Version of the Ten Item Personality Inventory (TIPI-J). *Journal of Individual Differences*, *35*(4), 236–244. https://doi.org/10.1027/1614-0001/a000145

Pasquaretta, C., Levé, M., Claidière, N., van de Waal, E., Whiten, A., MacIntosh, A. J. J., Pelé, M., Bergstrom, M. L., Borgeaud, C., Brosnan, S. F., Crofoot, M. C., Fedigan, L. M., Fichtel, C., Hopper, L. M., Mareno, M. C., Petit, O., Schnoell, A. V., di Sorrentino, E. P., Thierry, B., … Sueur, C. (2014). Social networks in primates: smart and tolerant species have more efficient networks. *Scientific Reports*, *4*, 7600. https://doi.org/10.1038/srep07600

Powell, J., Lewis, P. A., Roberts, N., García-Fiñana, M., & Dunbar, R. I. M. (2012). Orbital prefrontal cortex volume predicts social network size: an imaging study of individual differences in humans. *Proceedings of the Royal Society B: Biological Sciences*, *279*(1736), 2157–2162. https://doi.org/10.1098/rspb.2011.2574

Roberts, S. G. B., Dunbar, R. I. M., Pollet, T. V., & Kuppens, T. (2009). Exploring variation in active

network size: Constraints and ego characteristics. *Social Networks*, *31*(2), 138–146. https://doi.org/10.1016/j.socnet.2008.12.002

Sasovova, Z., Mehra, A., Borgatti, S. P., & Schippers, M. C. (2010). Network churn: The effects of self-monitoring personality on brokerage dynamics. *Administrative Science Quarterly*, *55*(4), 639–670. https://doi.org/10.2189/asqu.2010.55.4.639

Schutte, N. S., Malouff, J. M., Bobik, C., Coston, T. D., Greeson, C., Jedlicka, C., Rhodes, E., & Wendorf, G. (2001). Emotional intelligence and interpersonal relations. *The Journal of Social Psychology*, *141*(4), 523–536. https://doi.org/10.1080/00224540109600569

Stiller, J., & Dunbar, R. I. M. (2007). Perspective-taking and memory capacity predict social network size. *Social Networks*, *29*(1), 93–104. https://doi.org/10.1016/j.socnet.2006.04.001

Watts, D. J., & Strogatz, S. H. (1998). Collective dynamics of "small-world" networks. *Nature*, *393*(6684), 440–442. https://doi.org/10.1038/30918

Zhou, W.-X., Sornette, D., Hill, R. A., & Dunbar, R. I. M. (2005). Discrete hierarchical organization of social group sizes. *Proceedings of the Royal Society B: Biological Sciences*, *272*(1561), 439–444. https://doi.org/10.1098/rspb.2004.2970