A Network Science Approach to Modelling and Predicting Empathy

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Abstract — In this paper we adopt a network science approach to investigate empathy and its implications for online social networks. We demonstrate that empathy is closely linked to social capital - the findings suggest that individuals higher on cognitive empathic skill are overall likely to report both higher bridging and higher bonding social capital. On the other hand, attributes of network structure around the individual, quantified through networks analysis metrics, were related to cognitive empathy. Further, an examination of the interplay between network structure, social capital and empathy suggests that empathy facilitates the relation between network structure and social capital previously reported in literature. We discuss the implications of our findings for the understanding of empathy in the context of online social networks and for the design of these systems.

Keywords — *Empathy; social capital; ego networks; online communities*

I. INTRODUCTION

Individuals are increasingly establishing social capital by turning to online social networks for support - social, emotional, psychological (Eg [16]). An important research challenge in this context is to develop an operational understanding of how social capital can help foster online communities. In this paper we focus on one aspect of social capital, empathy, and its relationship with social capital and social network structure. This understanding can ultimately used to enhance and foster online communities.

Empathy is an important trait that enables us to "tune in" to others' feelings and thoughts. It can be described as the ability to feel or imagine another person's emotional experience [13]. Empathy allows us to understand the intentions of others, predict their behaviour, and experience an emotion triggered by their emotion [1]. Thus, the ability to empathise enables us to interact effectively with others,

both face to face and online, and is fundamental to successful human relationships.

One useful approach to understanding and drawing insights into social interactions is social networks analysis. While on the one hand the representation of relationship ties as links in a network is a simplification, it is this very simplification that makes it valuable for the population level analysis of personality traits. Given that empathy and social interactions are closely tied, can the "fingerprints" of empathy then be found in social network structure? If so, then networks analysis can be used as a lens with which to study empathy, to the extent to which empathic skill is tied to social interactions. Thus the answer to this question can have implications for understanding empathy and also for the design of systems that foster empathic relating between users.

Motivated by this basic question, in this work we adopt a network science perspective to investigate how online social network structure can help us understand and predict empathy. To achieve this we take advantage of the large-scale and granular availability of social network data on Facebook.

The following are the contributions of the paper : (1) We show that empathic ability and social capital are closely related. (2) Through sociometric analysis we find a link between an individual's social network structure and empathic ability. (3) We demonstrate through mediation analysis that this link facilitates the previously reported [19] link between network structure and social capital. (4) Finally, we draw insights from our findings on how design can foster communities, how to target advertising, and how to enhance affective computing applications.

II. BACKGROUND

Despite the strong link between social interaction and empathy shown in literature, just one prior study has considered social network analysis as a proxy for studying empathy. Specifically, Wölfer et al. [21] recently showed that empathy is mirrored in the structure of social ties

among adolescents in German schools, as recorded through face-to-face interactions.

Here we extend this prior work to examine how empathic ability is reflected in the social network structure around individuals. To do this, we take advantage of the availability of social network data from a cohort of participants on the Facebook social network site. Facebook is typically used as a means of building and maintaining relationships involving those with whom users share "some common offline element" [3]. However, Facebook enables users to "convert latent and weak ties" [7] and is therefore particularly useful for developing bridging social capital [18]. Thus network structure on Facebook, while closely related to and impacted by the offline network, has it's own role and impact on individuals.

While little previous work has examined empathy directly with online social network structure, a number of previous studies suggest that empathy may affect network structure. Interaction between individuals of diverse backgrounds, such as diverse ethnicity [2] can lead to increased empathy. Conversely, those with increased empathy are more comfortable with individuals of diverse background, and for example, reduce out-group stereotyping [9]. While prior work has not directly linked empathy to network structure, it does suggest that structural holes [5] indicate diversity. Therefore, one way to address our research question is to investigate whether individuals whose networks contain relatively more structural holes are more empathic.

Empathic individuals are, by definition, likely to better understand others' needs and distress, and are thus likely to provide social support [21]. As a consequence of social reciprocity [10], empathic individuals are thus more likely to receive help from others. Another way to address our research question, therefore, is to establish whether individuals with higher empathy have increased social capital.

Prior work has also directly linked social network structure to social capital [19]. Given this finding, if empathy is indeed reflected in social network structure, then one may expect that empathy helps individuals exploit their network structure for social capital. For example, more empathic people may better translate potential resources in their network structure into social capital. In other words, we can seek to address our research question by investigating whether empathy moderates the relationship between network structure and social capital.

Finally, should we find evidence to support our assertions (i.e. links between empathy & structural holes, and empathy & social capital), then one might expect that the influence of network structure on social capital happens partly through empathy: network structure affects empathic skills, which in turn lead to higher social capital. Hence, we can further address our research question by attempting to establish whether empathy mediates the relationship between network structure and social capital.

III. STUDY

93 participants (57 male; average age 28.2, sd 5.1) were recruited through online announcements and emails. Each participant gave us access to their list of friends, and the friendships between these friends, on Facebook, from which we were able to construct their social network and calculate a number of structural metrics regarding their position in the network. Participants had on average 315 friends (SD=172, max=875, min=50). In addition to providing us access to their Facebook social graph, each participant responded to standard questionnaires of empathy [15] and social capital [20].

A. Network Structure

We use measures of structural holes to capture the diversity each participant's social network. A typical feature of social networks is that they consist of dense clusters linked by occasional bridge connections between the clusters. The "holes" in the network between these dense clusters of individuals who are not interacting are referred to as structural holes [5]. Individuals within a cluster are likely to be of similar background due to homophily [5]. Therefore, structural holes is of interest to us as those who act as bridges between clusters are exposed to diverse ties. Structural holes are quantified through the network constraint and betweenness centrality metrics :

- Constraint is high in a small network of contacts who are close to one another, or strongly tied to one central contact. High constraint networks exhibit fewer structural holes while low constraint networks exhibit more structural holes [4].

- Betweenness centrality captures the relative importance of an ego in the quick transmission of information within the ego network [8].

We also recorded the number of friends and the number of isolated friends (friends with whom the individual has no common friends) since these are known to be related with social capital [19].

B. Empathy

Empathy was measured with the 8-item version [15] of the empathy quotient (EQ) scale [1]. A principal components analysis (varimax rotation, eigenvalue>1, loadings>0.6) on the items of the empathy scale revealed a three-factor structure, in agreement with Lawrence et al.'s [13]

validation of the original EQ scale. Following their labelling, these factors are: (1) Cognitive Empathy - the capacity to comprehend the emotions of others (items 2, 3 & 4 of the questionnaire from [15], example: "I am quick to spot when someone in a group is feeling awkward or uncomfortable"; eigenvalue=2.29, 28.65% explained variance, Cronbach α=0.679), (2) Social Skills - knowing of how to behave in different social situations and the understanding of social norms (items 5 & 6, example: "I find it hard to know what to do in a social situation"; eigenvalue=1.47, 18.39% explained variance, Cronbach α=0.52), and (3) Emotional reactivity - the extent to which individuals own emotional state is affected by other people's emotions (item 8 - "Other people often say that I am insensitive, though I don't always see why"; eigenvalue=1.07, explained variance 13.34%).

While it is not clear whether emotional reactivity is by itself a component of empathy, it is likely to tap into affective empathy (the capacity to experience others' emotions) [13]. The social skills factor shows a low reliability score, and emotional reactivity is measured by a single item. Therefore results following from these factors must be interpreted with care.

C. Social Capital

Social capital is generally described using the constructs of bridging and bonding social capital [18]. Bridging social capital refers to the social capital created from bonds across individuals of different backgrounds. While these ties may lack in depth, they provide individuals with a broader horizon and open opportunities for new resources and information. Conversely, bonding social capital is created in bonds within individuals of a closed group such as family and close friends. These ties provide substantial and strong emotional support.

Bridging and bonding social capital were measured with an adapted version of Williams' [20] Internet Social Capital scales, consisting of six items for bridging social capital (Cronbach α=0.581, example: "Interacting with people reminds me that everyone in the world is connected") and five items for bonding social capital (Cronbach α=0.654, example: "There are several people I trust to help solve my problems"). Detailed information about the items used for bridging and bonding can be found in [19].

Before proceeding further with analysis, all participants' scale ratings and network metrics were converted to normalised z-scores. Degree, betweenness and constraint had heavy-tailed distributions and hence were converted to logarithmic scale.
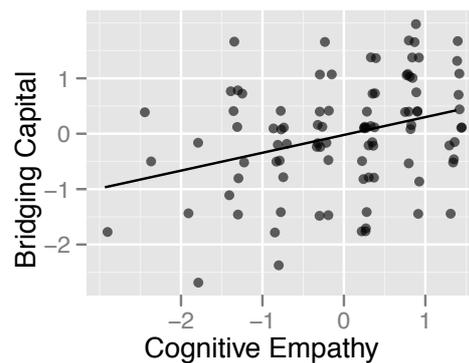

Fig 1. Cognitive empathy vs Bridging Social Capital (darker dots indicate overlapping points).
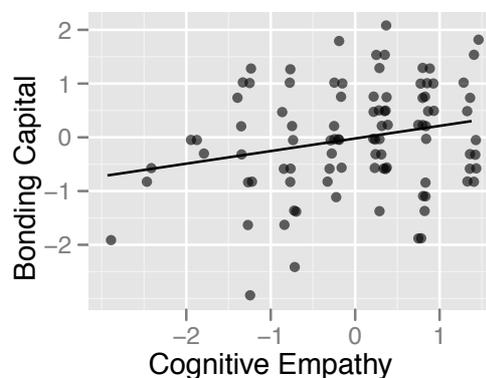

Fig 2. Cognitive empathy vs Bonding Social Capital

IV. RESULTS

Independent samples t-tests showed no significant gender differences in any of the empathy subscales ($p > 0.05$). However, overall females reported significantly higher bonding social capital than males ($t(91)$=-2.21, $p < 0.05$; Males: mean -0.18, sd=0.95; Females: 0.28, sd=1.02). There was no significant effect of gender on bridging social capital. While age was positively related to social skills (b=0.047, $t(91)$=2.37, $p < 0.05$, r-sq=0.048), it was not significantly related with cognitive empathy or emotional reactivity, nor bridging or bonding social capital ($p > 0.05$). However, since our participants largely comprised of young individuals, our results might not capture the true effect of age on these variables.

A. Social Capital and Empathy

Next, we examined the relationship between the 3 factors of the empathy scale and social capital. Regression analysis showed that cognitive empathy had a significant positive relationship with both bridging social capital (b=0.325, $t(91)$=3.275, $p < 0.01$, r-sq=0.106)) and bonding social
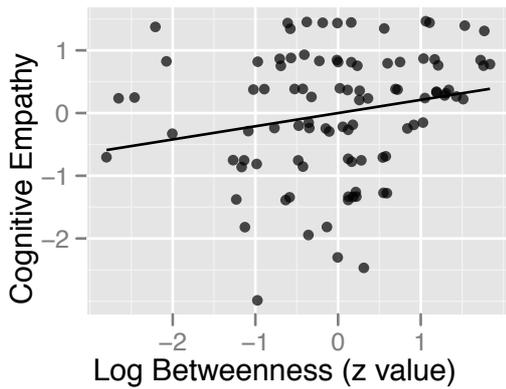
Fig 3. Betweenness (log scale) vs Cognitive Empathy
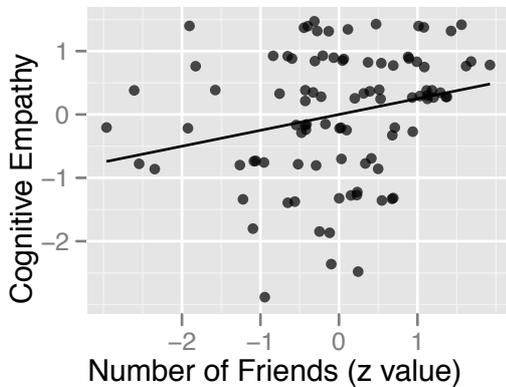

Fig 4. Number of Friends vs Cognitive Empathy

capital (b=0.223, t(91)=2.212, p<0.05, r-sq=0.051). These are shown in Figures 1 and 2. Social skills showed no significant relationship with either component of social capital.

Emotional reactivity showed a significant relationship with bonding social capital (b=0.377, t(91)=3.93, p<0.01, r-sq=0.145), but not with bridging social capital (p>0.05). Overall the results show that empathy is positively associated with both bridging social capital (cognitive empathy) and bonding social capital (cognitive empathy and emotional reactivity).

B. Network Structure and Empathy

Measures of structural holes (betweenness and constraint) showed a significant relationship with cognitive empathy (Figure 3). For betweenness (log scale z scores) : b=0.214, t (91)=2.092, p<0.05, r-sq=0.046. This confirms that individuals with networks containing larger structural holes are likely to have higher cognitive empathy. However, betweenness (and other measures of structural holes)

showed no significant relationship with either social skills or emotional reactivity (p>0.05).

The number of friends also showed a significant relationship with cognitive empathy (b=0.264, t(91)=2.393, p<0.05, r-sq=0.059) (Figure 4), but not with social skills or emotional reactivity (p>0.05). The number of isolated friends showed no significant relationship with either of the 3 factors (p>0.05).

Structural holes (measured by betweenness) also showed a significant relationship with bridging social capital (b=0.205, t(91) = 2.0, p<0.05, r-sq=0.042), and so did the number of isolated friends (b=0.283, t(91)=2.80, p<0.05, r-sq=0.08). We refer the reader to [19] for a complete discussion on the relationship between network structure and social capital. In this paper we focus on empathy and its relationship to these variables.

C. Role of Empathy in Social Capital – Network Structure Relationship

Multiple regression analyses showed no significant interaction between any empathy factor and any of the network metrics in predicting bridging or bonding social capital (p>0.05). Thus our results suggest that that empathy does not play a moderating role in the relationship between network structure and social capital.

Finally, we examined whether empathy played a mediating role in the relationship between structural holes and bridging social capital. As suggested by Preacher and Hayes [17], especially for small samples, we conducted a bootstrap analysis for indirect effects to test for mediation. Based on 5000 bootstrap samples, the analysis found empathy to be a significant mediator in the relationship between betweenness and bridging social capital (confidence interval [0.0108, 0.1566], p<0.05, Data=0.0614, boot=0.0613, bias=-0.0002, SE=0.0353). This suggests that empathy is, in part, an intermediate variable in the translation of network structure to bridging social capital.

V. DISCUSSION

Our study set out to understand the relationship of empathy to social capital and social network structure. The ultimate goal of such work is towards drawing insights on fostering online communities. We find that empathy is related to social capital, and show how social network structure can be used to understand empathy. Below we discuss how these findings enhance our understanding of empathy, and how these insights can be ultimately lead to design for fostering online communities.

A. Understanding Empathy

Our work shows meaningful trends in the relationship between online network structure and empathy. Thus a network science approach can provide a novel lens with which to study empathy. In particular, we find a consistent relationship between structural holes and empathy. While Wölfer et al. [21] report that in face to face networks between adolescents in classrooms those who are more central show higher empathy, we find similarly that the extent of structural holes is significantly related to empathy in more general online social networks of adults. The large-scale automated analysis available with online social networks make this an important opportunity for population-level analysis of this trait.

In addition, the relationship between empathy and bridging and bonding social capital suggest that it is an important ability that facilitates individuals to support and draw support from each other. There are two possible ways this can happen. First empathic individuals, by nature of inclination towards prosocial activities [21], increase the overall social capital of the community of ties around them, thus indirectly affecting their own social capital. Second, such individuals are likely to receive direct reciprocity [10] for their support, and thus experience higher social capital. By either mechanism, empathic individuals increase the social capital of the community, due to which this skill can facilitate community fostering.

The evidence for a mediation role of empathy in the relationship between network structure and social capital further reiterate the importance of this skill in communities. This result suggests that part of the translation of network structure to social capital is able to take place due to the effect of structural holes on empathic skill. While careful confirmation of the exact direction of causality will require longitudinal assessment, our findings suggest that these factors, to an extent, vary together.

B. Informing Design

Empathy is known to be consistently related with prosocial activities [21]. Thus individuals with higher empathy are more disposed to help others in the network, and participate in overall community building. Our findings show that it is feasible to predict empathic ability through automated analysis of social network structure. If we can predict empathy using sociometric analysis, then we can identify those particular manifestations of human behaviour in a large network. Facebook is uniquely able to see a "macro" view of empathy across the network, and therefore can propose "interventions" that will influence social networks and communities in a number of ways.

One way in which the ability to predict empathy can be exploited is in the fostering of online communities. Individuals who are likely to possess aspects of empathic skill such as cognitive empathy, which are traceable in network structure, can be identified, and the support of these individuals can be leveraged. For example, in online support communities such as those for quitting smoking or for coping with depression, it can often happen that certain individuals are unable to get draw the support they require from the community, be it due to a difficulty to communicate on their part or a difficulty on the part of members in the community to understand their support needs. Such users might have better chances of response from members who are likely to have high cognitive empathic skills, and thus such members can be highlighted for these users to draw support from.

Predicting empathy can also be used to improve audience targeting for organisations such as those working on social causes. Particularly, being able to identity the different kinds of empathy in an individual can inform the design of targeted calls for support. For example, individuals with higher affective empathy might be likely to better identify with videos showing the people in distress, while for those higher on cognitive empathy it might be more important to highlight the background situation that is causing the distress for which the cause attempts to help.

Finally, there is a body of work on affective computing which attempts to identify the emotional states of the user, such as frustration, and thereby provide appropriate responses to reduce this frustration [12]. However, there has been skepticism about the "canned" response of affective computers [13]. One way to overcome the drawback of "canned" interventions in a social networking setting is to highlight the presence of empathic members who are experts in the network. Those with high cognitive empathy are likely to be more effective at communicating with other users, and therefore such a member is likely to better assist an individual who is identified to be stressed by the use of the application.

While the ideas presented above are of a speculative nature and concrete design requirements will require further maturation of this area of work, we have attempted to provide a glimpse into possibilities that can result from understanding empathy in a social network setting.

VI. LIMITATIONS AND CONCLUSION

This paper set out to study the relationship between empathy and network structure and social capital. We find that empathy is related to both the structure of individuals' networks and the social capital they report. A limitation of the study is the modest sample size drawn largely from a young population. In addition, it is important to recognise that techniques to gather data on individuals' empathy have

inherent limitations. Particularly, there are limitations in self report as it involves subjective assessment. We could alternatively use more objective tests such as the ability to recognise facial expressions [11] or even brain activity [6]. However, such tests do not directly measure empathy itself, but rather certain underlying mechanisms related to empathy. While the approach we adopted was most appropriate and feasible for this work, future work can consider different or multiple approaches to measuring empathy.

It is important to stress that empathy is not purely determined by network structure, but rather that the way the network structure evolves reflects and affects certain aspects of empathy. These traces of empathy can be detected in network structure over a macro view of the population. Clearly, other factors such as the nature of close and intimate relationships also affect empathy, which network structure might not capture. What our work shows is that network structure sufficiently reflects empathy to be detectable, and to that extent can be understood through social networks analysis. While we drew a number of findings from the current analysis, these have implications both for the understanding of this fundamental human trait and for the fostering of communities in online social networking for future work to explore.

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