Exploring co-evolution of individuals' social networks and physical activities

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Abstract

The interplay between individuals' social networks and traits (including behaviors) has been studied extensively. One particular avenue studies how positions (centralities) of individuals in the social network are associated with their traits. Traditionally, due to limitations in collecting longitudinal social interaction and trait data, scholars studied the relationship between network positions and traits at a single time point, in a static fashion. More recently, longitudinal social interaction data collected from smartphones became accessible, which could be modeled as a dynamic network. Yet, trait data remained static. Here, scholars studied the interplay between individuals' evolving network positions and static traits. For example, we showed that clusters of individuals with similar evolving network centralities (e.g., according to phone call or Facebook interactions) correspond well to clusters of individuals with similar static traits (e.g., gender or agreeableness). At present, individuals' longitudinal trait data can be collected as well, e.g., via Fitbit devices. This is what we do in the NetHealth study[i], which monitors smartphone usage (e.g., SMS interactions) and health-related behaviors (e.g., physical activities, heart rates, or sleep habits) of _˜700 Notre Dame undergraduates over 2+ years. With such data, we are able to study the co-evolution of individuals' dynamic social network positions and dynamic behaviors. Our dataset is relatively small in terms of the number of individuals, but rich in terms of data volume, including their temporal and heterogeneous nature.
We use a general-purpose framework for studying complex systems on our NetHealth data to: 1) construct a high-quality dynamic network of social interactions between reliable/compliant users; 2) understand network evolution by comparing global properties of network snapshots and local properties of nodes at different time points; 3) examine static trait differences between users whose local properties evolve over time versus those whose properties remain stable; and 4) test the existence of a co-evolution relationship between individuals' local properties and their physical (Fitbit) activity behaviors.

In terms of network evolution, snapshots from consecutive time periods are more similar than non-consecutive snapshots, and holiday and non-holiday snapshots are different. Also, global properties of the network remain stable with time except during breaks. However, local properties of 69% of all nodes significantly change with time. Static traits such as anxiety and conscientiousness are significantly different between the significantly changing versus time-stable users. Moreover, evolving local properties of 25% of all nodes are significantly

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correlated (i.e., co-evolve) with their evolving physical activities. That is, only for some people, changes in network positions are related to changes in physical activity behaviors. Traits such as anxiety, depression, agreeableness, and extraversion are significantly different between the users with versus without the co-evolution relationship.

In follow-up work, we will test co-evolution relationships between social networks and other health-related traits, e.g., sleep habits and heart rates. Then, we will use our observations to develop a predictive model of social network structure from trait information and vice versa.

i

The NetHealth study was launched in August of 2015 and is being conducted by a research team consisting of seven Principal Investigators from the Departments of Sociology, Psychology, and Computer Science at the University of Notre Dame, and affiliated with two research centers at Notre Dame, the Interdisciplinary Center for Network Science and Applications (iCeNSA) and the Wireless Institute. The NetHealth project is funded by the National Heart, Lung, and Blood Institute at the National Institutes of Health (award number: NIH 1R01HL117757).