Title: How do our brains support our real-life friendships?

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Note: This article was written to introduce young audiences (teens and preteens) to an emerging area of research that combines tools and methods from neuroscience and mathematics.

Abstract

Have you ever wondered how your friends impact how you see the world? Or how you're able to keep track of the many different people in your life? To study these questions, scientists have begun to look at people's social networks and their brains at the same time. We give an introduction to this area of study and discuss how scientists use ideas from both neuroscience and mathematics to examine these questions. We also highlight some recent discoveries that reveal both how our brains support our ability to socialize with others and how our relationships with other people are related to how we use our brains.

Keywords: social networks, friendships, neuroscience

How do our brains support our real-life friendships?

Your Complex Social Life

Think about all of the people who you know. Who comes to mind? You might think first about your closest friends. You might also think about the people who are the most popular in your grade, such as the kids with the most friends or those who are well-known by everyone else in school. How are you able to keep track of all of these different people and their relationships with each other? Our brain has mechanisms to support our ability to keep track not only of all of the different people in our lives, but also of the complicated relationships between those people. Scientists have also begun to look at how the ways that we use our brains are related to features of our social world, like the number of friends that we have and whether we play an influential role in our social groups.

Studying Social Networks

How do scientists study the relationships between the features of people's social worlds and the ways that they use their brains? For many years, neuroscientists have studied people's brains without considering the social environment in which people live. Meanwhile, other scientists — including mathematicians, statisticians, and sociologists — have developed many tools to study networks. There are all sorts of networks around us. Some examples are networks of roads between locations in a city, flights between airports, power lines between houses, and the World Wide Web. However, people are particularly attuned to one specific type of network: our **social networks**. Recently, researchers have begun to combine the study of brains with the study of social networks to help us understand how our brains support our ability to socialize and connect with other people.

Scientists can study a social network in many ways. Most typically, a social network is a collection of people who know each other and the relationships between those people [1,2]. Suppose that a researcher seeks to characterize a social network of your school based on friendship. To do this, the researcher can map out the students in your school and which students are friends with each other. In network-science terms, the students are called **nodes** and each friendship between two students is called an **edge** (see Figure 1).

Figure 1 – An example social network of students.

In network-science terms, each student is a “node” and each friendship between two students is an “edge”. In this figure, we represent edges by drawing lines between students. We calculate the distance between two students by adding the number of edges between them. For example, the distance between Felicity and Marco is 2. [This figure was designed using resources from Adobe Stock File #221784609.]

What are we interested in learning about your school’s social network? Perhaps we seek to identify the most influential student in your school. Depending on the type of influence that interests us, we can try to do this in different ways. If we are interested in identifying the most popular student in the network, we can calculate what network scientists call **degree**. We calculate the degrees in your school’s social network by counting the number of friends of each student in the school. For instance, maybe the most popular student in the school has 54 friends, giving them a degree of 54. If we are instead interested in identifying the students who are good at connecting different groups of friends together, we can calculate a measure of social “bridges” called **brokerage**. Degree and brokerage are just two examples of the many different things that we can calculate to study a person’s role in a social network. We can also calculate degree and brokerage in networks other than social networks. For example, using airports as nodes and flights between them as edges, we can calculate brokerage to identify which airports serve as large hubs by connecting otherwise unconnected airports.

We can also use the information in a social network to calculate how close or far away people in the network are from each other. This is an abstract type of **distance** between them. Let’s think more about this type of distance using an example. Suppose that we pick two random students—Felicity and Marco—in a school’s social network. We can calculate the distance between Felicity and Marco by using the information about who their friends are. If Felicity and Marco are friends with each other, there is a distance of 1 between them. If they are not friends

with each other, but Felicity is friends with Amy who is friends with Marco, then Marco and Felicity are “friends of friends”, so there is a distance of 2 between them (see Figure 1).

Figure 2 - People think about and keep track of social connections.

When you see a friend, your brain automatically keeps track of their social-network characteristics. For example, Felicity’s brain calculates Marco’s degree. Because Marco is connected to two people, Marco’s degree is 2. Additionally, when Felicity sees Marco, her brain calculates the distance between them in the network of friendships of the people who they know. Marco is a friend of a friend of Felicity, so the distance between them is 2. [This figure was designed using resources from Adobe Stock File #221784609.]

Studying Brains

How can we relate the rich information in a social network to how the people in that network use their brains? One way that scientists have begun to study this question is by collecting and studying brain data of people in the same social network. In our example of a school friendship network, researchers may ask some of the students in the school to attend a **functional magnetic resonance imaging (fMRI)** study session to measure their brain activity

while they are doing a task. An MRI scanner is a powerful magnet that can take pictures of a person's brain while they are doing a task—like watching a movie, viewing pictures of people, or playing a game—that a researcher has asked them to do [3]. For more information on how an MRI scanner works, see [3].

Figure 3 – **How scientists study social networks and brains in combination.**

Scientists often use surveys to collect information about people's social networks. For example, scientists can ask people to list their friends. Scientists can then use these people's responses to characterize their social networks. Scientists can also obtain information about how people's brains respond to the world by measuring their brain activity in functional magnetic resonance imaging (fMRI) studies. Scientists can then combine the results from brain scans with information about people's social networks to study questions about how our brains and social worlds interact with each other. [This figure was designed using resources from Flaticon.com.]

Scientists can study many interesting questions by combining information about how different parts of a person's brain respond during a task with information about the person's social network (see Figure 3). Try thinking about a specific student at your school. What types of information about this student come to your mind? You might think about what this person looks like or if they are kind or funny. You might also think about what "role" this person plays in your social world; this is called their **social-network position**. Is this person popular? Is this person good at connecting people from different friendship groups? Scientists have shown that people's brains automatically process these different types of information when they see people who they know [1] (see Figure 2). Why would your brain automatically do this? One reason may be that keeping track of other people's social-network positions can help you navigate your social world. For example, you probably would only want to share a secret with your closest friends, and it could be risky to tell a secret to the most popular student at school because this person is well-connected to a lot of other people.

Scientists have discovered that people in certain social-network positions use their brains differently in different contexts. For example, remember how people's brains automatically track

how popular someone is? Recent research has revealed that the brains of people with a large degree (i.e., popular people) track the degrees of other people especially closely [4]. In other words, popular people may pay especially close attention to the popularity of their peers. Scientists have also studied if people with large brokerage use their brains differently in a particular context. In one study, researchers found that the brains of people with large brokerage were particularly sensitive to determining when other people's opinions were different from their own [4]. These people had especially elevated activity in parts of the brain that are involved in thinking about what other people are thinking about. This is a very important function for people with large brokerage, because these people provide social bridges to connect different groups of people who may have distinct beliefs or opinions.

Scientists have also compared how the brains of different people in the same social network process the world around them. In one study, researchers examined a social network of business-school students [5]. Some of these students participated in an fMRI study in which they watched a bunch of movie clips. Students who were closer together in the social network (such as friends) had more similar brain activity, and people who were farther apart had less similar brain activity. Friends had especially similar brain activity in brain regions that are involved in processing emotions and interpreting the movies. This study suggests that people who are closer to each other in their social network may think in similar ways when they watch movies and perhaps also when they experience other things. To evaluate whether this result is reasonable, consider the similarities between you and your friends. Do you and your friends laugh at the same jokes or feel similar emotions when you watch movies? This may reflect similarities in how you and your friends think about the world around you.

Even though scientists have found that people in different social-network positions have brains that operate in different ways, they haven't yet discovered (1) if differences in the brain lead to people occupying particular social-network positions or (2) if occupying particular social-network positions can cause changes in the brain [1]. These open issues are hard to resolve in humans because of both practical and ethical concerns. For instance, it would be very difficult to randomly assign people to occupy specific network positions (for example, to randomly assign one person to have many friends and a different person to have no friends). Even if it were possible in practice to randomly assign people to occupy different social-network positions, it would be unethical to do so. For example, forcing an individual to have a smaller number of friends may cause distress in that individual. (For more information on the role of ethics in studying brains, see [6].) Instead, scientists have studied other animals (such as macaque monkeys) to gain some insights into them. One group of researchers placed macaque monkeys in social networks of different sizes and then used an MRI scanner to measure the monkeys' brain structure and activity about one year later [7]. They found that monkeys in larger social networks developed differences in the structure and activity of brain regions that help them (and also help humans) make sense of what others are thinking. Although it is not yet known if things work

exactly the same way in humans, this study demonstrates the power of social networks to shape the brain in a closely-related species.

Conclusions

Scientists simultaneously study the brain and social networks to investigate how our brains shape and are shaped by the complex social world in which we live. Such research has helped us learn how our brains support our ability to keep track of people in our social networks and their relationships with other people. It can also help scientists understand how people in different social-network positions may use their brains differently and how people in a social network may be similar in how they process the world around them. Combining the study of brains and social networks is a new area of research, and interesting new studies in it are coming out all of the time. What questions would you be interested in answering if you could measure people's brain activity and study their social network?

Glossary

- **Brokerage:** A measure of how well a person in a social network connects (i.e., “bridges”) different groups of people in the network.
- **Degree:** The number of connections of a node in a network. For example, the degree of a person indicates how many friends they have in a social network.
- **Distance:** How far apart two nodes are from each other in a network. This is an abstract notion of distance. For example, there is a distance of 1 between you and your friends and a distance of 2 between you and a friend of one of your friends.
- **Edge:** A connection between two nodes in a network. An example is a friendship between two people in a social network.
- **Functional magnetic resonance imaging (fMRI):** A way of measuring what is going on in somebody’s brain. An MRI scanner is a powerful magnet that can very quickly take many pictures of a person’s brain. See [3] for more details.
- **Node:** An object in a network that is connected to other objects. An example is a person in a social network.
- **Social network:** A network in which, typically, each node represents a person and an edge represents some kind of connection (such as a friendship) between two people.
- **Social-network position:** Someone’s social-network position encompasses the roles that they play in their social network. These roles may relate to various questions. Some example questions include the following: Who are their friends? Do they have many friends? Do they “bridge” otherwise separated people?

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Conflict of interest statement

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Author Biographies

Elisa C. Baek is a postdoctoral fellow at UCLA. She spent many years in Philadelphia for college and graduate school, and while she loved the Northeast, she is excited to be back in her hometown of Los Angeles. Elisa studies what makes messages persuasive and likely to be widely shared with others. She also studies how our brains support our abilities to connect with others in our social networks. In her free time, Elisa loves to hike through the National Parks, challenge herself in the kitchen to cook and bake difficult recipes, and garden. She is also an avid fan of LA sports teams (Lakers/Dodgers/Rams) plus the Philadelphia Eagles!

Ryan Hyon is a Ph.D. student in the Department of Psychology at UCLA. He went to college on the east coast but returned to his hometown of Los Angeles to pursue a graduate education. He is interested in combining brain imaging and network analysis to study the factors that lead people to become friends. In addition to studying the nature of friendship, Ryan loves to spend time with his friends, cooking for his friends, going to live music shows with his friends (pre-COVID-19), and doing anything outside in the sun. Most of all, Ryan loves spending his free time with his 2-year-old dog Shiloh.

Mason A. Porter is a professor in the Department of Mathematics at UCLA. He was born in Los Angeles, California, and he is excited to be a professor in his hometown. In addition to studying networks and other topics in mathematics and its applications, Mason is a big fan of games of all kinds, fantasy, baseball (Go Dodgers!), the 1980s, and other delightful things. Mason used to be a professor at University of Oxford, where he did actually wear robes on occasion (like in the *Harry Potter* series). He likes to think of himself as playing a central role in several social networks, but first one has to define what one means by “central”.

Carolyn Parkinson is an assistant professor in the Department of Psychology and the Brain Research Institute at UCLA. She is originally from Ontario, Canada and moved to Los Angeles by way of Montreal, Beijing, and New England. She studies how our brains represent, shape, and are shaped by the social networks that surround us. In her free time, she enjoys cooking, reading, doing crossword puzzles, and exploring new places.