frontiers FOR YOUNG MINDS

NEUROSCIENCE AND PSYCHOLOGY
Published: 20 May 2022
doi: 10.3389/frym.2022.640262

HOW DO OUR BRAINS SUPPORT OUR FRIENDSHIPS?

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YOUNG REVIEWERS:

ADVAITH
AGE: 15

HANA
AGE: 14

MAYUKHA
AGE: 12

Have you ever wondered how your friends impact how you see the world? Or how you are 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. In this article, we introduce 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.

YOUR COMPLEX SOCIAL LIFE

Think about the people 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? The human brain has mechanisms to support the 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 begun to look at how the ways that we use our brains are related to features of our social worlds, like the number of friends that we have and whether we play an influential role in our social groups.

STUDYING SOCIAL NETWORKS

SOCIAL NETWORK

A network in which, typically, each node represents a person and each edge represents some type of connection (such as a friendship) between two people.

NODE

An object in a network. It is connected to other objects through edges. An example is a person in a social network.

EDGE

A connection between two nodes in a network. An example is a friendship between two people in a social 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.

BROKERAGE

A measure of how well a person in a social network connects ("bridges") different groups of people in the network.

How do scientists study the relationships between people's social worlds and the ways that they use their brains? For many years, neuroscientists (that is, scientists who study the brain) 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 many different types of networks. 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**. Most typically, a social network is a collection of people who know each other and the relationships between those people [1, 2]. Recently, scientists 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. Suppose that a researcher seeks to characterize the social network of students at your school based on friendships. To do this, the researcher can study 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).

Perhaps we seek to identify the most influential student in your school. Depending on the type of influence that interests us, we can do this in various ways. If we are interested in identifying the most popular student, we can calculate what network scientists call **degree**. We calculate the degree of each student 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; that student has a degree of 54. If we are instead interested in identifying the students who are good at connecting different groups of friends, 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 roles in a social network.

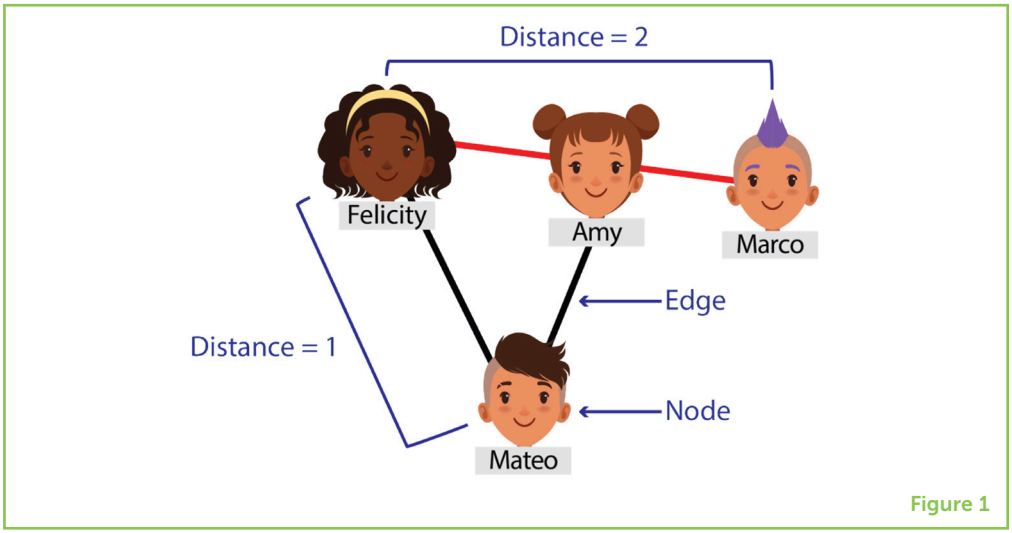

Figure 1

A 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 counting the number of edges that are needed to connect them. For example, the distance between Felicity and Marco is 2. (Image credit: Adobe Stock File #221784609)

DISTANCE

How far apart two nodes are from each other in a network. (This is an abstract type of distance.)

FUNCTIONAL MAGNETIC RESONANCE IMAGING (FMRI)

A way of measuring what is going on in a person's brain as the person performs a task. To learn how an MRI scanner works, see [3].

SOCIAL-NETWORK POSITION

The set of roles that an individual plays in a social network. These roles can relate to various things, including who their friends are, whether or not they have many friends, or whether or not they "bridge" people who otherwise might not be connected to each other.

We can also use the information in a social network to calculate how close people in the network are to each other. This is an abstract type of **distance**. 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 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).

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 examining brain data from people in the same social network. Scientists often collect brain data using a technique called **functional magnetic resonance imaging (fMRI)**. A magnetic resonance imaging (MRI) scanner uses powerful magnets to take pictures that capture a person's brain activity while they are doing a task that a researcher has asked them to do. Examples of such tasks are watching a movie, viewing pictures of people, or playing a game. For more information about how an MRI scanner works, see [3].

By combining fMRI data with information about people's social networks, scientists can study many interesting questions (see Figure 2). Try thinking about a specific student at your school. What types of information come to your mind? You might think about what this person looks like or if they are funny or kind. You might also think about what role this person plays in your social world. Is this person popular? Is this person good at connecting people from different friendship groups? Such features characterize the person's **social-network position**. Scientists have shown that our brains automatically process

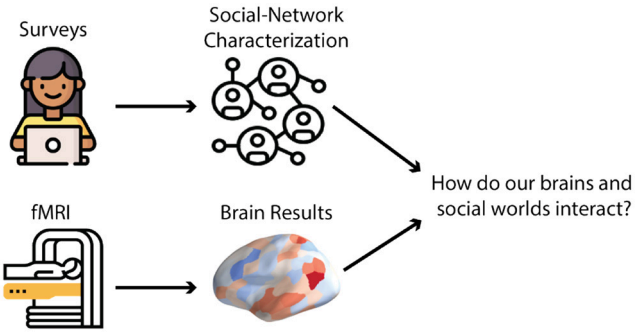

Figure 2

How scientists study social networks and brains together. Scientists often use surveys to collect information about people's social networks. For example, scientists can ask people to list their friends, and they can then use the responses to their questions to characterize those people's social networks. Scientists can also obtain information about how people's brains respond to the world by measuring their brain activity using fMRI. Scientists can then combine the information from brain scans with information about people's social networks to study how our brains and social worlds interact with each other. (Image credit: Flaticon.com)

information about other people's social-network positions when we see people who we know (see Figure 3) [1]. Why would our brains automatically do this? One reason may be that keeping track of other people's social-network positions can help us navigate our social worlds. For example, perhaps you only want to share a secret with your closest friends. Additionally, it could be risky to tell a secret to the most popular student at school because this person is connected to a lot of other people.

Scientists have discovered that people in certain social-network positions use their brains differently in specific situations. For example, recent research has revealed that the brains of people with a large degree (that is, popular people) track the degrees of other people especially closely [4]. In other words, popular people may pay particularly close attention to the popularity of their peers. Scientists have also studied whether or not people with large brokerage use their brains differently. 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 theirs [4]. These people had especially elevated activity in brain areas that are involved in thinking about what other people are thinking about. This is a very important function for people with large brokerage because they provide social bridges to connect groups of people who may have different beliefs or opinions.

Scientists have also compared how the brains of 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 investigation in which they watched a bunch of movie clips. Students who were closer together in the social network (for example, students who were friends) had more similar brain activity, and students 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 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.

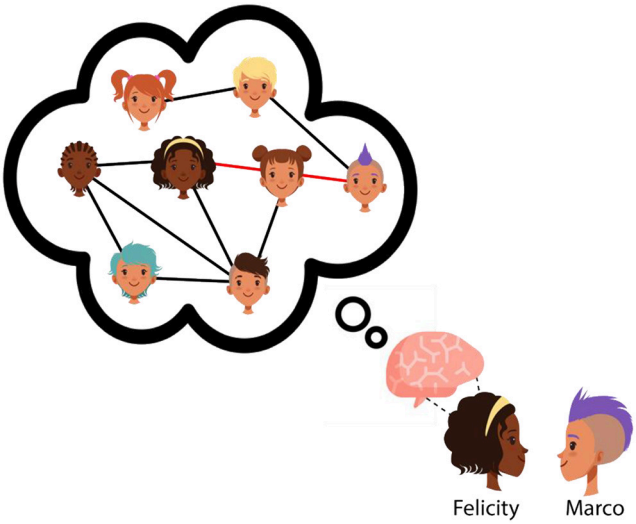

Figure 3

People 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. When Felicity sees Marco, her brain calculates the distance between them in their social network. Marco is a friend of a friend of Felicity, so the distance between them is 2. (Image credit: Adobe Stock File #221784609)

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 differently, they have not yet discovered if differences in the brain lead to people occupying particular social-network positions or if occupying particular social-network positions causes changes in the brain [1]. This is hard to resolve in humans. For instance, it would be very difficult to randomly assign many friends to one person and no friends to some other person. Even if it were possible to randomly assign people to 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 that person to feel distressed. (For information about the role of ethics in studying brains, see [6].) Scientists have also studied other animals (such as macaque monkeys) to gain insights into the relationship between brain differences and social-network positions. One group of researchers studied macaques who had been placed in social networks of different sizes and used an MRI scanner to measure the monkeys' brain structure and activity after about 1 year [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 such relationships work the same way in humans, this study demonstrates the potential power of social networks to influence the brain.

CONCLUSIONS

Scientists simultaneously study the brain and social networks to investigate how our brains influence and are influenced 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 monitor other people's relationships with each other. Such research can also help scientists understand how and why people in different social-network positions may process the world around them in different ways. Combining the study of brains and social networks is a new area of research, and interesting new studies in this area 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 networks?

ACKNOWLEDGMENTS

We are grateful to our young readers—Nia Chiou, Taryn Chiou, Zoe Chiou, Leia Chung, Valerie K. Eng, Maple Leung, and Meredith Ooi—for their many helpful comments. We also thank their parents, teachers, and friends (especially Lyndie Chiou and Christina Chow) for putting us in touch with them and soliciting their feedback. We are also grateful to our paper's young reviewers and their mentors for their many helpful comments. We acknowledge support from the National Science Foundation SBE Postdoctoral Research Fellowship [Grant No. 1911783] and the National Science Foundation [Grant No. SBE-1835239 and Grant No. SBE-2048212].

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SUBMITTED: 11 December 2020; **ACCEPTED:** 11 March 2022;
PUBLISHED ONLINE: 20 May 2022.

EDITOR: Caroline A. Niziolek, University of Wisconsin-Madison, United States

SCIENCE MENTORS: Farhad Maleki and Deepa Cherukunnath

CITATION: Baek EC, Hyon R, Porter MA and Parkinson C (2022) How Do Our Brains Support Our Friendships? Front. Young Minds 10:640262. doi: 10.3389/frym.2022.640262

CONFLICT OF INTEREST: 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.

YOUNG REVIEWERS

ADVAITH, AGE: 15
A prolific reader boasting to become a scientist! I enjoy doing physics experiments, composing tunes with the flute and penning my thoughts through essays.

HANA, AGE: 14
My name is Hana. I am interested in astronomy and space travel and enjoy watching science fiction movies. I hope to discover and invent new things. I also like nature including animals, landscapes, and enjoy looking at the sky. In my spare time I like to play volleyball, sketch, and paint.

MAYUKHA, AGE: 12
Aspiring to join national administrative services and become a classical dancer! Spreading happiness is my motto.

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Elisa C. Baek is a postdoctoral fellow at UCLA, and will be an assistant professor in the Department of Psychology at the University of Southern California starting in January 2023. She spent many years in Philadelphia for college and graduate school, and while she loved living in Philadelphia, she is excited to be back in her hometown of Los Angeles. Elisa studies what makes messages persuasive and likely to be shared widely with others. She also studies how our brains support our ability to connect with others in our social networks. In her free time, Elisa loves to hike through 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) and the Philadelphia Eagles! *elisabaek@ucla.edu

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Ryan Hyon is a Ph.D. student in the Department of Psychology at UCLA. He went to college in New England 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 spending 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.

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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, influence, and are influenced by the social networks that surround us. In her free time, she enjoys cooking, reading, doing crossword puzzles, and exploring new places. *cparkinson@ucla.edu