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WHAT CAN THE ANIMALS TEACH US ABOUT SOCIAL RELATIONSHIPS?

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Having friends benefits us in many ways: we receive information and help, if needed, and we collaborate with our friends to solve complex problems. Wild animals also rely on social relationships. Have you ever thought about what we can learn from animals about our own social networks? The spotted hyena and the rock hyrax are two species that can teach us about the ecology and evolution of social relationships. Scientists have discovered that an individual's position in the social network affects their chances of survival, reproduction, and contracting diseases. So how do groups maintain their social structures over time? In this study, we describe a process called social inheritance that provides the first clue. In this process, offspring inherit their social connections from their parents. We found that social inheritance depends on parent's traits, and it may help to maintain the stability of social groups.

SOCIAL RELATIONSHIPS IN ANIMALS

Imagine a rock hyrax living in the Ein Gedi Nature Reserve in Israel (Figure 1)—let us call her Calliope. Rock hyraxes have evolved to be highly adapted to their habitat, so that they can survive and reproduce. Only in this way can they pass their genes on to the next generation. So, what does Calliope need to do to survive? Every day, a rock hyrax needs to find food. Fortunately for Calliope, Ein Gedi's springs allow many species of plants to grow in the area, and she loves to eat them all (a rock hyrax can eat even oleander—a very poisonous plant). She must also maintain her body temperature. In summer it gets very hot, and she must spend most of the day sheltering in the shade; and in winter it is cold and the nights are long. There are other dangers—various predators are active in the area, and the most dangerous of all is the wolf (in the past there were also leopards in the Judean Desert, but unfortunately, they are now extinct in this area). It is difficult to face these challenges and dangers alone. But she is not alone—our Calliope lives in a group with about 20 other hyraxes. They huddle together to keep warm in winter, warn each other of predators with warning calls, and lead each other to food sources. Their social connections help each of them survive, find mates, and raise offspring [1].

Figure 1

Figure 1

Left: A rock hyrax at Ein Gedi, Israel. Rock hyraxes live in groups that include several adult females, their offspring, and an unrelated adult male who has joined the group. Females usually stay in a group all their lives. Males leave the group in which they were born after reaching adulthood and are then referred to as "bachelors". Some bachelors join other groups later in life. **Right**: Spotted hyenas at Maasai Mara Reserve, Kenya. Spotted hyenas live in clans, dominated by females. Adult males also leave their clan and usually join another clan.

Although social connections are important to the hyrax, who live in groups, many species of animals are solitary—that is, each individual lives almost all its life alone. Leopards, for example, live alone except for two major events: when a male and a female meet to mate, and when a female raises a cub until it reaches adulthood. Thus, in the course of **evolution**, diverse social structures evolved, unique to each species. In some species, the social structure changes with the seasons. For example, in some birds, pairs nest together in spring and summer but join flocks in the winter.

EVOLUTION

The process by which species undergo genetic changes over generations, leading to adaptation, and diversity in life forms.

SOCIAL INHERITANCE AND HYRAXES

So how do you "get" friends? Everyone knows that it is not easy to find a good friend, and it is also difficult to be friends with many people at the same time. Calliope was born in a group of other hyraxes. She knew her mother from an early age, of course, as well as her mother's friends—adult group members, some of whom are related to Calliope. In addition, she was born with several other pups. Most of them did not survive (many dangers lurk for young pups) but some have been with her since birth. Thus, Calliope was born into a particular social environment. In fact, she "inherited" her social connections from her mother. If she had been born to a different mother in another group, she would have known other hyraxes.

We call the process described here **social inheritance**. Erol Akçay (University of Pennsylvania, USA) and I developed a **theoretical model** based on this idea [2]. The model lets us examine what certain situations would mean for the **social interactions** of the group. For example, if we assume that females form more social connections than males, we can examine how this would affect the overall structure of the **social network**. The model does not try to perfectly recreate reality, just as a model of a building does not try to show every little detail of the real building. Our model simplifies reality to test whether social inheritance can lead to social networks like those observed in wild animals (Figure 2).

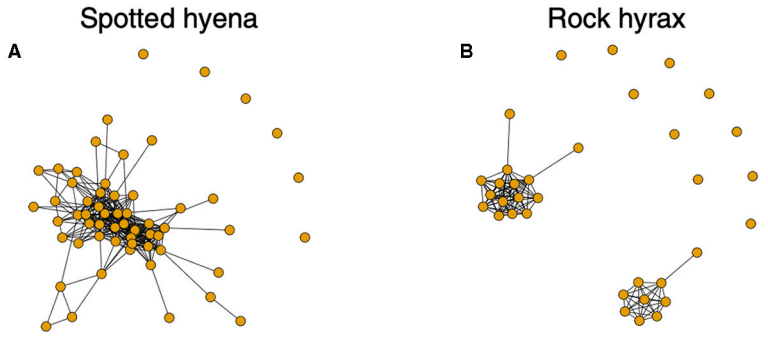

Figure 2

THE SOCIAL INHERITANCE MODEL

In our computer model, we define a **population** of individuals, for example rock hyraxes. At the beginning of the simulation, the animals are connected to each other randomly, with a 10% **probability** that any two individuals will be socially linked. Probability describes the chances of an event occurring: in the case of rolling a 10-sided dice, for example, there is a 10% probability (one in ten) of rolling any one number. At each stage of the simulation, we add an individual to the population and randomly select its mother. Through its

SOCIAL INHERITANCE

A process by which offspring passively or actively copy some of their parents' social relationships.

THEORETICAL MODEL

A simplified representation of how something works, using ideas and math to predict behavior or outcomes without direct testing or observation.

SOCIAL INTERACTION

A non-random social encounter between two or more individuals.

SOCIAL NETWORK

All of the social connections that exist in a particular population.

Figure 2

Examples of social networks of **(A)** spotted hyenas and **(B)** hyraxes. Each circle represents one animal. A line represents a strong social bond during the year in which the data were collected. The data are based on observations of individuals who were close by. A circle connected to many lines represents an animal with many social connections, and a circle connected only by one line represents an animal that has only one connection with another animal.

POPULATION

All the individuals of the same species that live in a specific area.

PROBABILITY

The chance that something will happen. It tells us how likely an event is, like flipping a coin and getting heads.

SOCIAL RELATIONSHIP

An ongoing relationship between individuals who know each other and summarizes their interactions.

mother, the individual "inherits" its **social relationships** with a certain probability. The higher this probability, the more similar the offspring's relationships will be to its mother's. With another probability (usually smaller), the offspring forms social relationships with other individuals not related to its mother. This represents the desire of the offspring to establish relationships that are not inherited from its mother—such as with its peers. At each stage of the simulation, we also randomly remove one individual (as if it died) to keep population size stable.

We run the simulation on a computer so that the steps are repeated many times, and then examine the resulting social networks.

SOCIAL INHERITANCE AND SPOTTED HYENAS

I studied social inheritance in-depth in spotted hyenas, a species that lives in groups in the savannas of Africa [3]. Each group of hyenas is called a clan, with a clear hierarchy: the clan is headed by a female, and her offspring receive a high social rank because of her. It became clear to us that offspring "inherit" from their mother not only social rank, but also social relationships. In other words, offspring form social bonds similar to those of their mothers (Figure 3). However, the degree of social inheritance is not uniform. The offspring of high-ranked mothers are more likely to replicate her social ties than those born to low-ranked mothers. This is an example of the "silver spoon" effect: someone born to successful parents benefits by copying their behaviors. On the other hand, someone born to less successful parents (such as hyenas of low social status, in our case) is better off changing its behaviors rather than copying those of its parents.

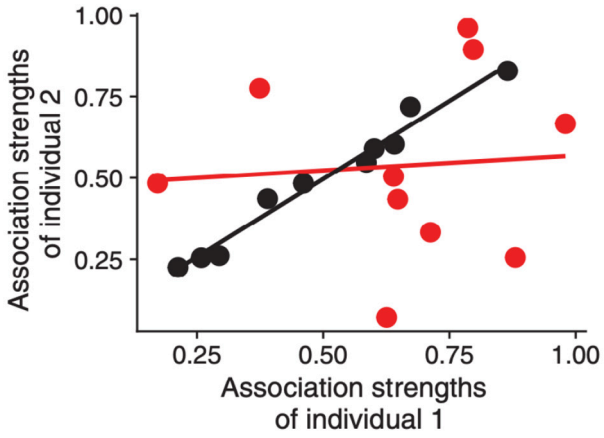

Figure 3

Figure 3

When social inheritance is strong there is a correlation between an offspring's relationships with other individuals and his mother's relationships with those same individuals (black dots). When there is no social inheritance, the relationships of mother with other individuals does not influence the relationships of its offspring with other individuals (red dots). In most cases, a high correlation was found between an offspring's relationships with other hyenas and its mother's relationships, indicating the existence of social inheritance.

QUESTIONS FOR THE FUTURE

Many questions remain unanswered. Today, we are trying to understand the rules by which animals maintain multiple social

relationships at the same time, and how they make social decisions on a day-to-day basis. Do individuals need a well-developed memory to meet "friends" they have not seen in a while, or are there simple rules of thumb for making short-term social decisions?

Another open question relates to the extent to which different traits influence the social character of individuals (for example, whether they tend to form many or few relationships, or strong or weak relationships), and to what extent each individual animal has a unique "social personality". Regarding social inheritance, we would like to know what influences an individual's decision to form relationships different from its mother's.

These and other questions lead us to search for and develop new research methods and technologies that will help answer them and which will certainly lead to additional questions.

WHY IS SOCIALITY RESEARCH IMPORTANT?

Most research on social relationships in wild animals is fundamental research, which means it aims to expand our knowledge in a particular field and not necessarily to solve a particular problem. The study of social relationships in animals contributes to the understanding of the evolution of social behavior in humans, and it is used by researchers in the fields of psychology and sociology to help people and communities with social interactions.

In another direction, our research serves as inspiration for the development of robots that collaborate with each other. Using the rules we discovered that govern social interactions in wild animals, robots can be programed to form connections and work together. This study also adds to the understanding of the spread of infectious diseases, which depends on social relationships between individuals. Overall, this research provides information on the range of social behaviors in nature, inspiring is to build better human societies.

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YOUNG REVIEWERS

ZALMAN ARAN, AGES: 13–14
We are curious 8th graders from Zalman Aran Middle School in Holon. This year, our entire class took part in the Frontiers for Young Minds program, in which we were challenged with interesting topics, learned how to read a scientific article and reviewed articles. The activity with Frontiers Science for Young Minds is part of our curriculum and appears on our end-of-year report card.

AUTHORS

AMIYAAL ILANY
Prof. Amiyaal Ilany grew up in Sapir in the Arava, Israel. His father was a zoologist who studied leopards in the Judean Desert. Amiyaal studied biology and computer science at Tel Aviv University, and although he thought about becoming a programmer or footballer, he eventually became a zoologist. Today, he studies the prey of leopards—rock hyraxes—in the same area. He was a postdoctoral fellow at the National Institute for Mathematical and Biological Synthesis at the University of Tennessee, Knoxville, and later at the University of Pennsylvania, both in the United States. In 2016, he returned to Israel where he joined Bar-Ilan University as a faculty member. Currently, he is a faculty member at Tel Aviv University. He thinks he was born at the wrong time, because 35 million years ago, hyraxes the size of rhinos lived in Africa. *amiyaal@gmail.com