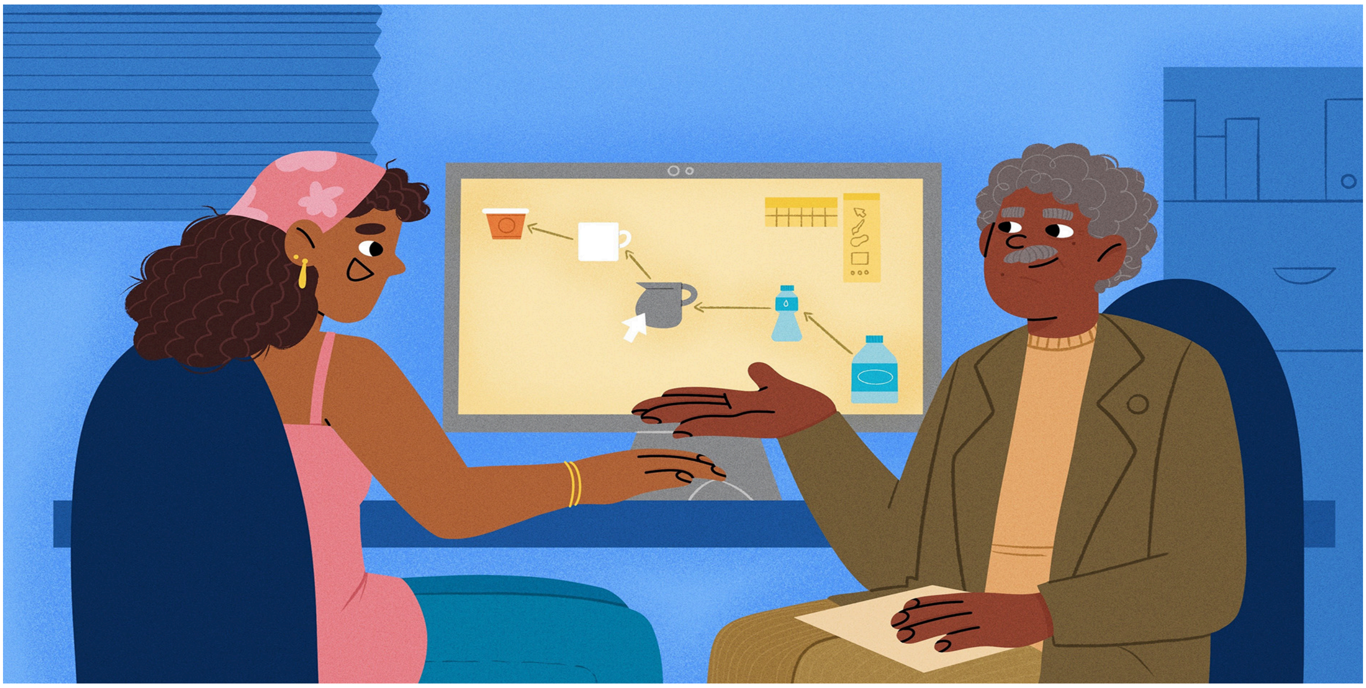
NEUROSCIENCE AND PSYCHOLOGY
Published: 08 April 2024
doi: 10.3389/frym.2024.1239117



WHAT IS SIMILARITY AND HOW CAN SCIENTISTS MEASURE IT?

Eben Daggett and Michael C. Hout *

Department of Psychology, New Mexico State University, Las Cruces, NM, United States

YOUNG REVIEWERS:


CARROT


SKY

Which is closer to a dog: a cat or a fish? Easy! The cat is closer. What you may not have noticed here, is that we asked which is *closer*, not *more similar*. It does not matter which term we use because people usually understand that the term *closer* means *more similar* when used in questions like this. People often talk about similarity between objects as if this idea could be thought of as a distance between two (or more) items. It feels very natural to use the language of distance (words like *closer*, *near*, or *far*) to describe similarity. The tendency to understand similarity as a distance is useful to scientists because, as you know, it is very easy to measure distances as numbers (like measuring the distance between two points using a ruler). In this article, we will tell you how psychologists measure similarity and use those numbers to explore how the mind works.

WHY DO SCIENTISTS CARE ABOUT THE CONCEPT OF SIMILARITY?

Most people do not often think about why two things are similar or dissimilar, but we all tend to automatically make decisions about similarity as we look at objects around us. For example, if you look at a bunch of objects that hold liquids—mugs, cups, pitchers, bottles—you would automatically (without even thinking about it) understand which of these were most similar to each other. Which property matters most in deciding similarity? The color of the object? Whether or not it has a handle? Whether it is tall or short, wide or narrow, big or small? All these decisions are made almost instantly in your brain, without you even realizing it.

In psychology experiments, it is often useful to assign a number to represent the similarity between objects. This allows scientists to understand the impact that similarity has on how people see the world, in way that is easy to understand. But how do scientists assign numbers to the similarity between objects used in experiments? For instance, in the example above, you probably agree that the mug and the cup are more similar than the mug and the pitcher, but *how much* more similar are they? If scientists assign numbers to the similarity between each pair of objects, they can more easily compare and contrast similarities. Because distances are easily measured as numbers (like inches, yards, feet), it also makes sense to measure similarity as a number. Unfortunately, there are no rulers or tape measures to quantify the similarity between objects. But scientists *do* have some tools to measure similarity, and we will introduce two of them in this article.

ASSIGNING A NUMBER TO SIMILARITY

One method used to gather similarity data is to have participants rate the similarity between pairs of objects with a number—for example, a higher number might mean that the two objects are more similar, and a lower number would therefore mean the objects are less similar (or vice versa). This is an example of a **pairwise method** because similarity is rated by comparing one pair of objects at a time. Imagine again the set of mugs, cups, pitchers, and bottles. In a pairwise method, you would only see two things at a time, like a mug and a bottle, and you would be asked to indicate how similar they are using a number between 1 and 7. You can imagine that this would get boring very quickly! Also, it can be difficult to give a good answer when you cannot see the full set of objects, which is called the **context** of the set, or the "bigger picture". In other words, it is easier to make a judgement about the similarity between two objects when you can see *all* the other objects at the same time. Knowing what other objects you will need to rate helps you adjust your ratings for any given pair. If you are trying to rate the similarity of a cat to a dog, for instance, it helps to know if the rest of the items in the set include other household pets, other animals more generally, or maybe an entirely different set of objects altogether. Knowing about the entire set allows you to figure out which features of the items are most important to think about when providing your ratings.

PAIRWISE METHOD

An experimental method for gathering information about how similar objects are by presenting them one pair at a time, and asking for participants to rate their similarity using some type of scale.

CONTEXT

Information that conveys the "big picture" of a situation or task.

One of the best tools scientists have for measuring the similarity between objects is called the **spatial arrangement method (SpAM)**. SpAM is an excellent tool because it uses our natural ability to think of similarity like a distance [1]. Imagine that we placed mugs, cups, pitchers, and bottles on a table in front of you (Figure 1). Now imagine that we asked you to arrange them on the table so that the more similar you feel they are, the closer you place them to each other. It might take some time, and you might have to make many adjustments, but you could definitely do it. This is exactly what SpAM is (Figure 2), except scientists usually use computers. Instead of arranging objects on a table with their hands, participants in psychology experiments drag and drop images of objects on a computer screen. Once they are done making their adjustments, the computer automatically measures the distance between each pair of objects by counting the number of **pixels** between them. By doing so, the similarity information is measured as a number. One of the biggest advantages of SpAM is that the participant can always see the full set of objects at the same time [2]. Participants often say that SpAM is fun and that they enjoy finding the best way to arrange the objects on the screen. Other methods of measuring similarity may not be as fun.

SPATIAL ARRANGEMENT METHOD (SPAM)

A fun and easily understandable experimental method for gathering information about how similar objects are, according to study participants. It involves moving items around on a screen (or some other surface) and arranging them according to perceived similarity.

Figure 1

Figure 1

In a typical pairwise task, the participant is only presented with one pair of objects at a time and is asked to rate the similarity between the objects on a number scale. For instance, you might first rate the similarity of a cup and a mug, and then a cup and a bottle, and so on. This requires many trials for each pair of stimuli to be rated. In the example above, it takes six trials to rate every combination of four different liquid containers.

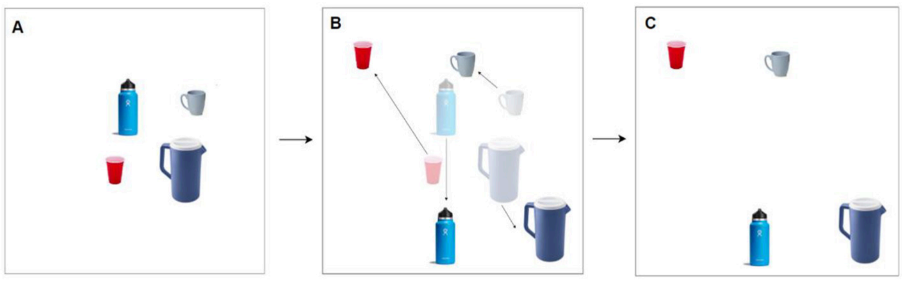


Figure 2

Figure 2

(A) In a typical SpAM experiment, the participant is presented with many objects on a screen. In this case, it is the cup, mug, bottle, and pitcher from the examples in the text. **(B, C)** During the experiment, the participant drags and drops the objects on the screen, so that the final position represents how similar the participant thinks the objects are to each other.

SpAM is not only fun, but it is also very fast because all the objects are right there on the computer screen. When using a pairwise method, the scientist must show the participant every possible pair of objects in the set. If there are five objects, that is 10 pairs. If there are 50 objects, that is 1,225 pairs of objects! Imagine being asked to rate the similarity of 1,225 pairs of objects—that might take all day! So, SpAM helps scientists to collect data much more quickly.

PIXELS

A small area of illumination on a computer screen that is used to create more complex images, and which can also be used as a small unit of measurement.

WHAT DO SCIENTISTS DO WITH SPAM DATA?

Why do scientists need data on similarity in the first place? Just like all science experiments, psychology experiments are all about **variables**—things that change across various scenarios, or that can differ between people or situations. By changing a variable during an experiment, scientists can measure how those changes impact the results. For example, scientists might do an experiment in which participants search for an object on a screen. This is called a visual search experiment, and these types of tasks are important because lots of people have important jobs in which they must look for things, such as medical screeners looking for cancer on chest x-rays, or airport security personnel looking for prohibited items in travelers' luggage. Imagine a simple version of a visual search task, in which one group of searchers looks for an object that is very similar to other objects on the screen, while the second group looks for an object that is very different from the other objects (Figure 3). In this experiment, the scientist tests how changing the variable of *similarity* affects participants' abilities to find the object. This can provide scientists with valuable information about how the mind (and eyes!) works.

VARIABLE

An element or feature that is subject to change.

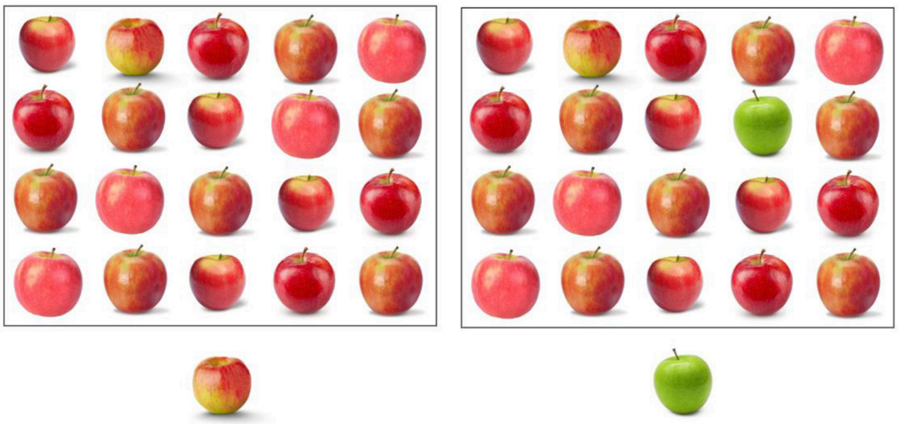


Figure 3

Figure 3

Is it easier to find the example apple in the box on the left or the right? You can probably find the green apple on the right a lot faster than the apple on the left, because it is less similar to the other apples and therefore easier to identify. This is an example of how similarity plays a role in in the direction of our visual attention.

SpAM is currently being used to help scientists study the role of similarity in learning, memory, attention, and lots of other mental processes. For instance, researchers have found that the ability to recognize paintings by an artist whose paintings we have already seen is dependent on the similarity between the new painting and familiar ones [3]. Additionally, the speed at which we categorize pictures is dependent on similarity. If you try to label pictures of dogs as either golden retrievers or yellow labs, you will do it much faster if all the yellow labs look similar to each other, compared to when they look different [4]. Each of these studies showed that similarity plays a key role in the ways we see and understand the world.

USING THESE TOOLS IN THE FUTURE

SpAM is an essential tool in scientists' efforts to better understand the mind. As you have learned, our brains are constantly measuring the similarity between the objects around us, without us even realizing it. Every day, scientists are learning more and more about how those similarity judgments shape the way people see the world around them and how they navigate through it. SpAM is, and will likely continue to be, one of the best tools scientists have to detect those similarity judgements and apply them to the experiments they use to explore the inner workings of the human mind.

REFERENCES

1. Goldstone, R. 1994. An efficient method for obtaining similarity data. *Behav. Res. Methods Inst. Comp.* 26, 381–6. doi: 10.3758/BF03204653
2. Hout, M. C., Goldinger, S. D., and Ferguson, R. W. 2013. The versatility of SpAM: a fast, efficient, spatial method of data collection for multidimensional scaling. *J. Exp. Psychol.* 142, 256–81. doi: 10.1037/a0028860
3. Yago, E., and Ishai, A. 2006. Recognition memory is modulated by visual similarity. *Neuroimage* 31:807–17. doi: 10.1016/j.neuroimage.2005.12.014
4. Snodgrass, J. G., and McCullough, B. 1986. The role of visual similarity in picture categorization. *J. Exp. Psychol.* 12:147. doi: 10.1037//0278-7393.12.1.147

SUBMITTED: 12 June 2023; **ACCEPTED:** 22 March 2024;
PUBLISHED ONLINE: 08 April 2024.

EDITOR: Xi-Nian Zuo, Beijing Normal University, China

SCIENCE MENTORS: Qiuyu Lu and Rui Su

CITATION: Daggett E and Hout MC (2024) What Is Similarity and How Can Scientists Measure It? Front. Young Minds 12:1239117. doi: 10.3389/frym.2024.1239117

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

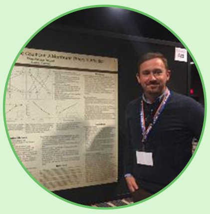
CARROT

Hi! My name is Carrot, from Hangzhou, China. I really enjoy the time when indulge myself reading psychology books, that is my pursuit of happyness, as I believe there is no whY in happiness but there is an I.

SKY

I enjoy different kinds of exercise activities. I also have an interest in Positive Psychology. Outside of school, I initiated "Shimmer", a public welfare project aimed at preventing depression and suicide among Chinese youth. As a Young Reviewer this time, I have a deeper understanding of the scientific research process of psychology. I will choose psychology as my major, when I attend college.

AUTHORS



EBEN DAGGETT

Eben attended Carroll University in southeast Wisconsin, where he earned a dual B.S. in biology and psychology with a minor in biochemistry. After college, he joined the Army where he served for 8 years. He eventually planted some loose roots in Boulder, Colorado, where he works as a data scientist and AI researcher in the medical technology field. His research interests are centered around the role of similarity in visual attention, computer models of the mind, visual search, and artificial intelligence. In his free time, he enjoys fly fishing, mountain biking, backpacking, and reading.

MICHAEL C. HOUT

Michael C. Hout is a professor in the Department of Psychology at New Mexico State University, and an associate editor at the journal *Attention, Perception, & Psychophysics*. His research focuses primarily on visual cognition (including search, attention, eye movements, and memory) and the development of new methods, tools, and stimuli to be used in experimental research. He has won several awards for research and teaching, including the *Rising Star* award from the *Association for Psychological Science*. In his limited free time, he enjoys walking his dog, running, hiking, playing hockey, and going on road trips with his wife. *mhout@nmsu.edu