THE SMALL WORLD PROBLEM

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The pleasing notion that we live in a "small world" where people are connected by "six degrees of separation" may be the academic equivalent of an urban myth. New evidence discovered in the Milgram papers in the Yale archives, together with a review of the research on the small world problem, reveals that this widely accepted idea rests on scanty empirical evidence.

The "small world problem" takes its name from an experience familiar to us all. As Stanley Milgram described it:

> Fred Jones of Peoria, sitting in a sidewalk cafe in Tunis, and needing a light for his cigarette, asks the man at the next table for a match. They fall into conversation; the stranger is an Englishman who, it turns out, spent several months in Detroit studying the operation of an interchangeable-bottlecap-factory. "I know it's a foolish question," says Jones, "but did you ever by any chance run into a fellow named Ben Arkadian? He's an old friend of mine, manages a chain of supermarkets in Detroit..."
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> "Arkadian, Arkadian," the Englishman mutters. "Why, upon my soul, I believe I do! Small chap, very energetic, raised merry hell with the factory over a shipment of defective bottlecaps"
>
> "No kidding!" Jones exclaims in amazement.
>
> *"Good lord, it's a small world, isn't it?"* (1967:61)

The question of how people are hooked up had long been an entertaining parlor game among mathematicians where it took such forms as: If you choose any two people in the world at random, how many acquaintances are needed to create a chain between them? Ithiel de Sola Pool at MIT and Manfred Kochen of IBM collaborated on mathematical models of the small world problem and circulated unpublished papers within an invisible college of colleagues for two decades. They were reluctant to publish, Kochen explains, because "we never felt we had 'broken the back of the problem'" (1989, viii).

The brilliant social psychologist Stanley Milgram believed he had solved the problem, or at least made substantial empirical progress, through an ingenious experiment. Milgram asked "starters," supposedly "randomly" chosen people from psychologically distant locations like Kansas or Nebraska, to send a folder through the mail to a target person in places like Cambridge, Massachusetts or Boston. The starters were given basic information about the target person and written instructions to send the folder through the mail to someone they knew on a first-name basis who would be more likely to know the target. That person was to send the folder on to someone closer to the target whom he or she knew on a first name basis. Returned tracer postcards tracked the progress of each chain. The idea was to see how many jumps were needed to reach someone, when the connections could only be through friends, relatives, or close personal acquaintances.

Would any folders reach the target person? Milgram's first target was the wife of a divinity student living in Cambridge. He was astonished at how fast she got the folder from Kansas. In a memorable example in his famous article in the first issue of *Psychology Today* in 1967, Milgram wrote: "Four days after the folders were sent to a group of starting persons in Kansas, an instructor at the Episcopal Theological Seminary approached our target person on the street. 'Alice,' he said, thrusting a brown folder toward her, 'this is for you.' At first she thought he was simply returning

a folder that had gone astray and had never gotten out of Cambridge, but when we looked at the roster, we found to our pleased surprise that the document had started with a wheat farmer in Kansas. He had passed it on to an Episcopalian minister in his hometown, who sent it to the minister who taught in Cambridge, who gave it to the target person. Altogether, the number of intermediate links between starting person and target amounted to *two*!" (pp. 64-65).

In a second study, using Nebraska starters and a target who lived in Sharon, Massachusetts and worked in Boston, Milgram reported that "chains varied from two to 10 intermediate acquaintances, with the median at five" (p. 65). Thus, any person appeared to be able to reach another person in just six jumps—the empirical basis for the famous phrase "six degrees of separation."

Milgram's fascinating findings have slipped away from their scientific moorings and sailed into the world of imagination. "Six Degrees of Separation" became the name of an acclaimed play by John Guare. "Six Degrees of Lois Weisberg" became the title of a famous article by Malcolm Gladwell (*The New Yorker*, January 11, 1999:52-63) explaining the value of social connectors, people who know people from different subcultures. "Six Degrees of Kevin Bacon" became the name of a parlor game for movie buffs. "Six Degrees of Separation" became the name of a web site, which explains that it was inspired by the idea of six degrees of separation to create a place which would connect millions of people from around the world. "It's a Small, Small World" sing dolls in their national costume at a heart-warming Disneyland exhibit.

The vast majority of chains in any small world study spanning more than one city were never completed. The memorable example of the Kansas wheat farmers who reached the wife of the divinity student in two jumps comes from an unpublished study I found in the Milgram archives. Only 5 percent of the letters actually reached their target. Milgram's other studies show completion rates of roughly 30 percent. Further, the astonishing degree of acceptance of the notion that people are connected by only six degrees of separation is in itself a phenomenon that needs to be explained.

An explosion of interest in the "small world problem" is occurring in mathematics and other fields ranging from disease transmission to neuroscience. What triggered this interest was an important article in 1998 in *Nature* by D.J. Watts and S.H. Strogatz, entitled "Collective Dynamics of 'Small-World' Networks" (393: 440-442). In it the authors propose a mathematical foundation for the notion that we live in a small world. Mathematical models, however, rely on non-empirical assumptions. Whether anyone has yet "broken the back" of the small world problem is still open to question.

Information in the Milgram Papers

I had always regarded Milgram's work on the small world problem as one of the great, counterintuitive studies in the social sciences. My interest in pursuing its details arose from a teaching problem. Social science research, some of my graduate students insisted, was nothing more than the systematic study of what you already know.

Thinking about how to show my skeptical students that social research could produce surprising results, I hit upon the idea of replicating Milgram's small world study in the Internet Age. We would run a postal version and an e-mail version of his great study. Surely those of us on the right side of the digital divide were far more connected to each other than Milgram had ever imagined. I fantasized about finding the original target people in Milgram's small world studies, such as the wife of the divinity student or the Boston stockbroker, and asking them to be the targets for this replication more than a quarter of a century later, a bit of showmanship worthy of Stanley Milgram himself.

To prepare for this research project, I needed to find Milgram's original research materials, available for public review in Boxes 48 and 49, Stanley Milgram Papers, Manuscripts and Archives, Yale Library (Kaplan, 1996). Key details of Milgram's study were unclear. What exactly had Milgram sent through the mail? Sometimes it was called a "chain-letter," sometimes a "passport," sometimes a "document in a folder." What this item actually looked like could make a big difference in whether people sent on the letters or tossed them out. People would find a chain-letter easy to throw out, I reasoned, but not a document that looked like a passport.

What I found in the Milgram papers in the Yale archives was disconcerting. Milgram published the arresting anecdote of the divinity student's wife who had gotten a letter in four days (quoted above) in the *Psychology Today* article without giving the statistical results of this study. An un-

dated paper, "Results of Communication Project," in the Stanley Milgram papers in the Yale archives reveals that 60 people had been recruited as starters from a newspaper advertisement in Kansas, and 50 chains had actually been started. Just 3 of the 60 documents (5%) reached the wife of the divinity student, and they passed through an average of 8 people (9 degrees of separation). The memorable anecdote in *Psychology Today* was at great variance from the actual, unreported results of the first study.

Subtle features of Milgram's second and published Nebraska study strongly favored chain completion. The document sent through the mail turned out to be impressive indeed: a passport of thick royal blue cardboard with the name "Harvard University" embossed in gold letters on the cover and a stylish gold logo. The roster of signatures was visually impressive as well—each person's name signed with the fountain pens commonly used in the period. An impressive passport is not a biasing factor. But it did support the idea that people would have tried to send on the document rather than not bother with it, the explanation usually offered for the low chain completion rates.

Other features of Milgram's small world studies might well have biased the results in favor of the conclusion that people live in a small world. Take the selection of the sample. I found in the archives the original advertisement recruiting subjects for the Wichita, Kansas study. This advertisement was worded so as to attract not *representative* people but particularly *sociable* people proud of their connections and confident of their powers to reach someone across class barriers. A second biasing factor was that Milgram recruited subjects for the Nebraska and Los Angeles studies by buying mailing lists, an item which appears in his proposal budget available in the Milgram papers. People with names worth selling are more likely to be high-income people, who are better connected. (See M. Beck and P. Cadamagnani, "The Extent of Intra- and Inter-Social Group Contact in the American Society. Unpublished manuscript, Stanley Milgram Papers, Manuscripts and Archives, Yale University, 1968.)

I found in the archives a variation of the small world study, probably sent to Milgram for review but to my knowledge unpublished. This study not only showed extremely low chain completion rates (below 18%) but also suggested that people are actually separated quite dramatically by social class. This study recruited 151 volunteers from Crestline, Ohio, divided into low-income, middle-income, and high-income groups. The starters were to try to reach a low-income, middle-income, or high-income person in Los Angeles. While the chain completion rate was too low to permit statistical comparisons of subgroups, the researchers make an important observation: "No low-income senders were able to complete chains to target Ss other than the low-income target" (p. 5). The middle-income and high-income people, on the other hand, did get messages through to some people in every other income group. These patterns suggest a world divided by social class, with low-income people more apt to be disconnected.

Other Research on the Small World Problem

I realized that Milgram's original experiment—sending a document from people in Nebraska to a stockbroker in Boston—did not in a scientific sense support the popular interpretation that people in the United States, or in some versions the world over, are connected by six degrees of separation. After all, this study was based on efforts to reach only one particular person and a socially prominent person at that. But surely there had been numerous replications of the small world problem all over the world, just as there had been of Milgram's famous study of obedience to authority. The small world study was easy to replicate and inexpensive. The Nebraska study, I learned in the Yale archives, had a budget of only $680.

I did an exhaustive search of the published literature, not only using computerized databases but also following up bibliographical leads that I found in the unpublished papers in the Milgram archives. Some of this research could not be found in today's computerized literature searches. I spent months tracking down obscure journals and triumphantly located the author (Eugene Garfield, "It's a Small World after All." *Current Contents*, 1973, 43:5-10) of a mysterious research review of the small world problem that had been sent to Milgram for his comments.

Using as my criterion for a "replication" of the small world study, that the study had to span at least two disconnected cities, I could find only *two* published replications, both conducted by Milgram himself. In the first study, the inescapable fact is that the great majority of the chains were never completed (Travers and Milgram, 1969). To put it another way, the vast majority of people did not reach the target person.

The inescapable fact is that the great majority of chains were never completed when a study spanned at least two disconnected cities. To put it another way, the vast majority of people did *not* reach the target person. Of the 296 possible chains in the technical research report, 217 chains were started, and 64 were completed—a success rate of only 29% of started chains.

A careful reading of the technical report also shows that the starters had social advantages; they were far from a random or representative group. The three starter groups were: (a) 100 blue chip stock owners from Nebraska recruited from a mailing list, (b) 96 people from Nebraska designated as the "Nebraska random" group [quotations in the original] but actually recruited from a mailing list, and (c) 100 people from Boston designated as the "Boston random" group [quotations in the original] but actually recruited from a newspaper advertisement. All would have had a leg up in making social connections to a Boston stockbroker.

Milgram's subsequent study with Korte of acquaintance networks between racial groups again reveals not only a low rate of chain completion but also suggests the importance of social barriers (see C. Korte and S. Milgram, "Acquaintance Links between White and Negro populations: Application of the Small World Method. *Journal of Personality and Social Psychology*, 1970, 15(2):101-108). White starters in Los Angeles, solicited through mailing lists, tried to reach both white and "Negro" targets in New York. Of the 270 chains started and directed toward "Negro" targets, only 13% got through compared to 33% of the 270 chains directed toward white targets.

I could find only one other replication of the small world study in the published literature which came close to meeting the criterion that a replication had to span at least two disconnected cities—Lin, Dayton, and Greenwald's investigation (cited below) of a single urbanized area in the Northeast. The research purpose was to examine social stratification, particularly barriers between whites and blacks. Of 596 packets sent to 298 volunteers, 375 packets were forwarded and 112 eventually reached the target—a success rate of 30%. But this study, too, underscores the racial divide. "Communication flows mainly within racial groups," the authors conclude. "Crossing the racial boundary is less likely to be attempted and less likely to be effective" (p. 118). Substantial research has indeed occurred on the small world phenomenon, but this industry of studies consisted mostly of adaptations of the method to such limited settings as a college campus (see R.L. Shotland, *University Communication Networks: The Small World Method* (New York: Wiley, 1976)); businesses (see C.C. Lundberg, "Patterns of Acquaintanceship in Society and Complex Organization: A Comparative Study of the Small World Problem, *Pacific Sociological Review*, 1975, 18:206-222); a high-rise apartment (S. Bochner, R. Duncan, E. Kennedy, and F. Orr, "Acquaintance Links between Residents of a High Rise Building: An Application of the 'Small World' Method, *Journal of Social Psychology* 1976, 100:277-284), or a single urban area (N. Lin, P. Dayton, and P. Greenwald, "The Urban Communication Network and Social Stratification: A 'small world experiment,'" in B. D. Ruben (Ed.), *Communication Yearbook: Volume 1* (New Brunswick: Transaction Books, 1978):107-119.

The One Exception

I located one study inconsistent with the pattern of low chain completion rates in small world studies over a large geographic area. This research did not meet my criterion for a replication, spanning at least two disconnected cities. Guiot's (1976) study of ethnic gate-keeping focuses on only one city, Montreal. Nonetheless, his completion rate of 85% is so unusual that this study warranted special attention.

Guiot had developed an interesting adaptation of the small world method. Instead of using the mail, he used the telephone. Each potential starter was called on the telephone and asked to participate, using telephone messages to move closer toward the target. If a person dropped out, the chain was reactivated by calling back the previous person and asking that person to select a new contact to restart the chain. Whether this novel procedure is consistent with the theoretical nature of the small world problem is questionable since people who did not telephone another contact, despite prodding from the researcher, may have been socially isolated individuals.

The starters were 52 French Canadian volunteers in Montreal who were instructed to reach a prominent Jewish target. The 85% chain completion rate may only demonstrate that Jews in Montreal live in a small social world: Once you find a Jew, you can get your message through. Still, future research on the small world problem should consider a telephone method, where re-

searchers can monitor the reasoning, networks, and progress of people trying to make connections.

Drawing Conclusions from the Studies

The research on the small world problem suggests not a counter-intuitive triumph of social research but an all-too-familiar pattern: We live in a world where social capital, the ability to make personal connections, is not widespread but more apt to be a possession of people of higher social status. Many small worlds do exist, such as scientists with worldwide connections or university administrators at a single campus. Rather than living in a "small, small world," we may live in a world that looks a lot like a bowl of lumpy oatmeal, with many small worlds loosely connected and perhaps some small worlds not connected at all. Milgram's "small world" theory could be viewed as the "strong" form of the small world phenomenon, for which we have little empirical evidence. The "lumpy oatmeal" theory, that we live in a world with many small worlds possibly but not necessarily connected, might be viewed as the "weak" form of the small world phenomenon, for which we do have evidence.

We Want To Believe a "Small, Small World"

The speed with which both researchers and the general public accepted Milgram's results raises an intriguing question: Why do we find it so easy to believe what appears to be a counter-intuitive notion, that we live in a small, small world? Psychological research on information processing suggests why people may be so willing to accept the notion of six degrees of separation. A small world experience is memorable. We judge vivid experiences that come to mind with ease to be more frequent than they in actuality are—the error of judgment that Kahneman and Tversky (1996) label the "availability heuristic."

As I questioned people about whether they believed in a "small world" and why, I was astonished to find how strong this belief was and how resistant it was to challenge. Three major reasons recurred:

1. Belief in a small world gave people a sense of security. "It's a scary world out there," one federal judge told me. "It's good to believe that we are all somehow holding hands."

2. Small world experiences supported religious faith. When you met someone from your past or someone who knew someone from your past, this was evidence of design.

3. People had little intuitive understanding of coincidence. Odd coincidences do occur. Here is one: The two great investigators of the small world problem, Stanley Milgram and Ithiel de Sola Pool, both died in the same year, 1984, Milgram of a heart attack and de Sola Pool of cancer (Kochen, 1989).

As I listened to people's descriptions of cherished small world experiences, I began to realize that a verbal confusion was taking place. What people labeled a "small world experience" had a different mathematical structure from the small world problem that Milgram and the mathematicians were investigating. The classic "small world problem" is expressed in such forms as: What are the chances that two people chosen at random from the population will have a friend in common?

But the small world experiences I was hearing about would be expressed mathematically in a quite different form: What is the probability that you will meet a friend from your past or a stranger who knows a friend from your past over the course of your lifetime? These probabilities are apt to be high. How likely would it be, particularly for educated people who travel in similar social networks, *never* to meet *anyone anywhere at any time* who knew someone from their past?

Interest in the "Small World Problem"

A mathematical breakthrough has occurred with the small world problem, which has created a renaissance of interest in many other fields, from disease transmission to corporate communication. What triggered this interest was the invention of a mathematical model explaining how the small world phenomenon might operate (Watts & Strogatz, 1998). A few random connectors in a mathematical network of connected points (analogous to the "Lois Weisbergs" who span subcultures) turn out to vastly decrease the distance between points. Following up the Watts & Strogatz findings, Kleinberg (2000) investigated the nature of connections in a mathematical network where everyone is connected to four points on each side but also has some long range, oddball connection. Short connections through the maze do exist, he demonstrates, but the maze would seem too bewildering, he believes, for people to find their way

through. These mathematical models thus make sense of Milgram's findings that most people could not get their letters through, even though they live in a small world.

Watts and his colleagues could be correct. We may indeed live in a world where everyone is connected by a short chain of personal acquaintances, but it is hard for most people to find these connections. On the other hand, their mathematical models may merely assume the conclusion. After all, the mathematical models already consist of connected points. We can imagine other mathematical models that represent the human world. Suppose the world had a population of 50 people, 25 A's and 25 B's. All the A's know each other and all the B's know each other. But no A knows a B and no B knows an A.

Empirical research is needed to investigate the small world question and other questions like these: What does it actually mean in practical terms to be linked to others on a first-name basis? A welfare mother in New York might be connected to the president of the United States by a chain of fewer than six degrees: Her caseworker might be on first-name terms with her department head, who may know the mayor of Chicago, who may know the president of the United States. But does this mean anything from the perspective of serving the needs of the welfare mother? As mathematicians put it: Is "six degrees of separation" a large or a small number? We are used to thinking of "six" as a small number, but in terms of practical connections, "six" may be a huge number indeed. Nothing is so useful as a good problem. How we are connected to each other remains an eternally fascinating mystery … and a researchable one.

SUGGESTED FURTHER READINGS

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