

# The connected age and the small world problem

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Social Networks (Soc 204)  
Princeton University

Wednesday, January 29, 2025  
Week 1, Lecture 2



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- ▶ No precept this week, precept times coming soon

Expectations about reading and lecture:

- ▶ I expect you to read the pre-read

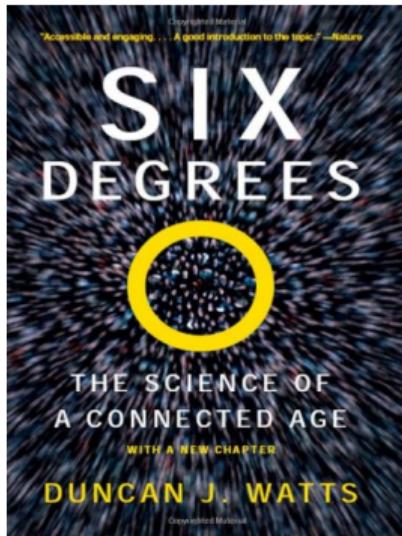
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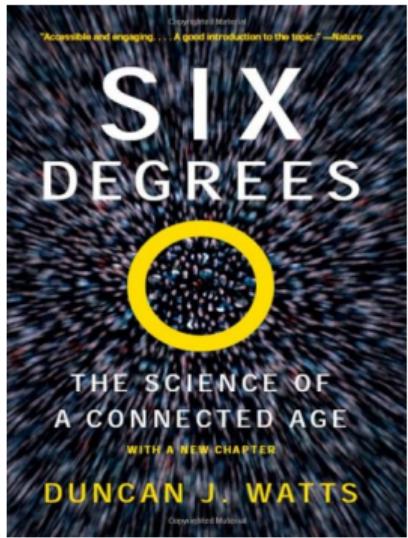
- ▶ I expect you to read the pre-read
- ▶ I expect you to read the materials

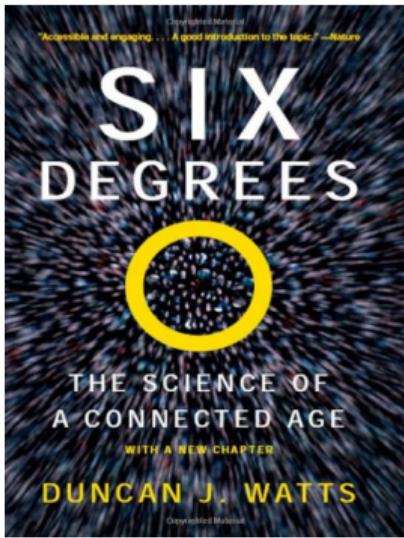
Expectations about reading and lecture:

- ▶ I expect you to read the pre-read
- ▶ I expect you to read the materials
- ▶ In the lecture, I will do a mix of reviewing the reading, providing context, and discussing extensions. The mix will evolve throughout the semester.

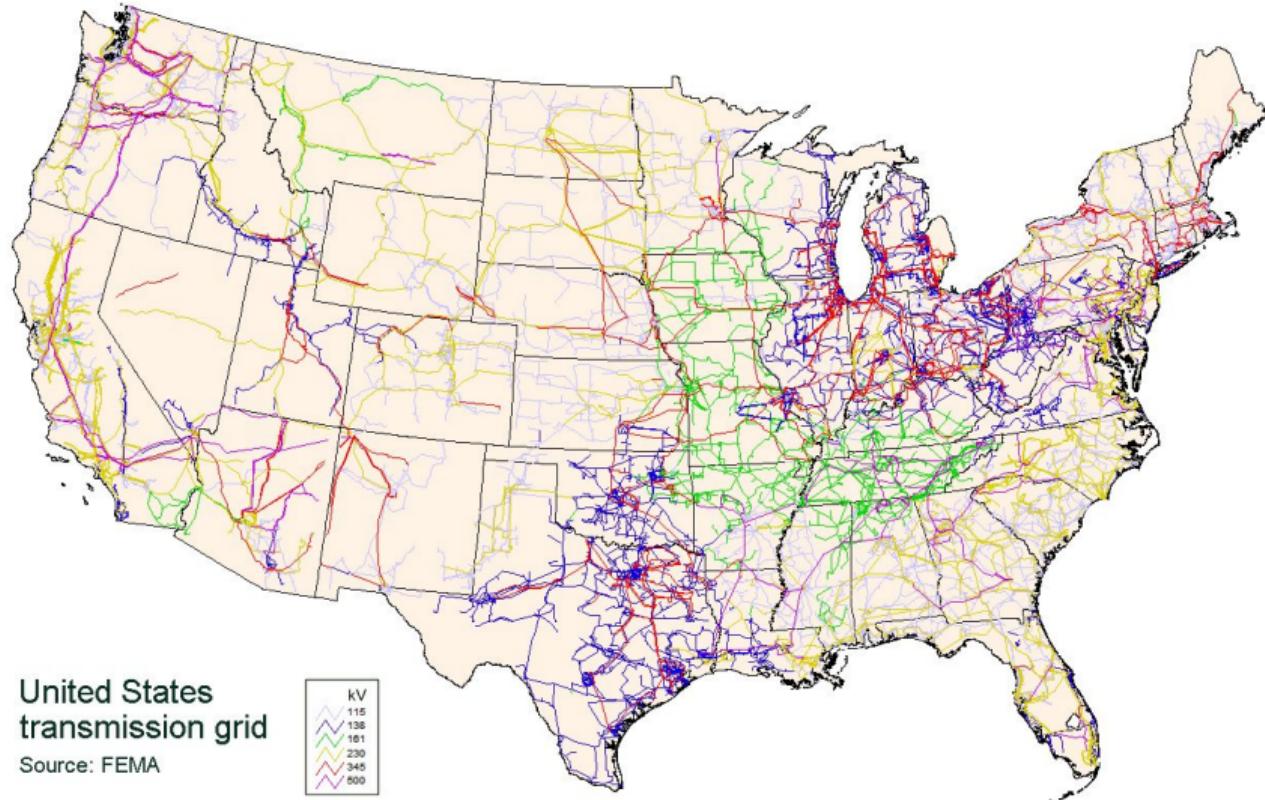
1. Watts, Preface and Chapter 1.
2. Milgram, S. (1967). The small world problem. *Psychology Today*.
3. Travers, J. and Milgram, S. (1969). An experimental study of the small world problem. *Sociometry*.
4. Kleinfeld, J.S. (2002). The small world problem. *Society*.







Science in action done by people like us



How does individual behavior aggregate  
to collective behavior?

## The small world problem

Notice: idea → formal question → empirical research → critique

“Oh my goodness. It’s a small world!”

When was the last time you said this? Think-pair-share

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Two times that people say this:

- ▶ See someone they know in an unexpected place

“Oh my goodness. It’s a small world!”

Two times that people say this:

- ▶ See someone they know in an unexpected place
- ▶ Meet someone and find out that they have an acquaintance in common

Let's think back to 1967 . . . .



[http://upload.wikimedia.org/wikipedia/commons/f/f5/1967\\_Ford\\_Fairlane\\_Ranchero.jpg](http://upload.wikimedia.org/wikipedia/commons/f/f5/1967_Ford_Fairlane_Ranchero.jpg)



[http://commons.wikimedia.org/wiki/File:Ericsson\\_Dialog\\_in\\_green.JPG](http://commons.wikimedia.org/wiki/File:Ericsson_Dialog_in_green.JPG)



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 fella named Ben Arkadian? He's an old friend of mine, manages a chain of supermarkets in Detroit . . . "

"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!"

Milgram (1967)

- ▶ What is the probability that two people chosen at random know each other?

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- ▶ What is the probability that two people chosen at random share a friend?
- ▶ Given two individuals selected randomly from the population, what is the probability that the minimum number of intermediaries required to link them is 0,1,2,...k?

Modeling approach (i.e., MIT approach)  
vs.  
Empirical approach (i.e., Harvard approach)



We need your help in an unusual scientific study carried out at Harvard University. We are studying the nature of social contact in American society. Could you, as an active American, connect another American citizen regardless of his work office? If the same or an American citizen were picked out at a bar, could you get to know that person using only your network of friends and acquaintances? Just how open is our "open society"? To answer these questions, which are very important to our research, we ask for your help.

You will notice that this letter has come to you from a friend. He has joined this study by sending this folder on to you. He hopes that you will aid the study by forwarding this folder to someone else. The name of the person who sent you this folder is listed on the Roster at the bottom of this sheet.

In the box below right you will find the name and address of an American citizen who has agreed to serve as the "target person" in this study. The idea of the study is to forward this folder to the target person using only a chain of friends and acquaintances.

**TARGET PERSON**  
Stanley Milgram  
32 Harvard Street  
Share, Massachusetts  
  
Occupation: Investment  
Broker at McConnell & Co.  
21 Congress Street  
Boston, Mass.  
  
Married. Lived in former  
home place of McConnel, Mass.  
Attended: Northeastern Univ.  
(from 1953-54; served in  
U.S. Air Force)

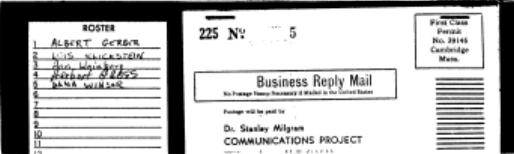
HOW TO TAKE PART IN THIS STUDY	
<b>1</b>	ADD YOUR NAME TO THE ROSTER AT THE BOTTOM OF THIS SHEET, so that the next person who receives this letter will know who it came from.
<b>2</b>	DETACH ONE POSTCARD, FILL IT OUT AND RETURN IT TO HARVARD UNIVERSITY. No stamp is needed. The card is very important. It allows us to keep track of the progress of the folder as it moves toward the target person.
<b>3</b>	IF YOU KNOW THE TARGET PERSON ON A PERSONAL BASIS, FORWARD THIS FOLDER DIRECTLY TO HIM HER. Do this only if you have previously met the target person and know each other on a first name basis.
<b>4</b>	IF YOU DO NOT KNOW THE TARGET PERSON ON A PERSONAL BASIS, DON'T HESITATE BUT TRY TO CONTACT HIM DIRECTLY. INSTEAD, MAIL THIS SAME POSTCARD AND ALL TO A PERSON IN A POSITION OF AUTHORITY WHO IS MORE LIKELY THAN YOU TO KNOW THE TARGET PERSON. You may not know the target person's friends or relatives or acquaintances, but it must be someone you know on a first name basis.

Remember, the aim is to forward this folder toward that target person using only a chain of friends and acquaintances. On first thought, this may seem like a difficult task. This is true. However, at least you can start it moving in the right direction! Who among your acquaintances might conceivably move in the same social circle as the target person? The real challenge is to identify among your friends and acquaintances or persons who can advance the folder toward the target person. You may take several steps beyond your friend to get to the target person, but the important thing is to start the folder on its way. The person who receives this folder will then repeat the process until the folder is received by the target person. May we ask you to begin?

Every person who participates in this study and returns the post card as well receives a certificate of appreciation from the Communications Project. All participants are entitled to a report describing the results of the study.

Please forward this folder within 24 hours. Your help is greatly appreciated.

Stanley Milgram  
Stanley Milgram, Ph.D.  
Director, Communications Project



This procedure is elegant.

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- ▶ provides a view of the big invisible social network of Americans

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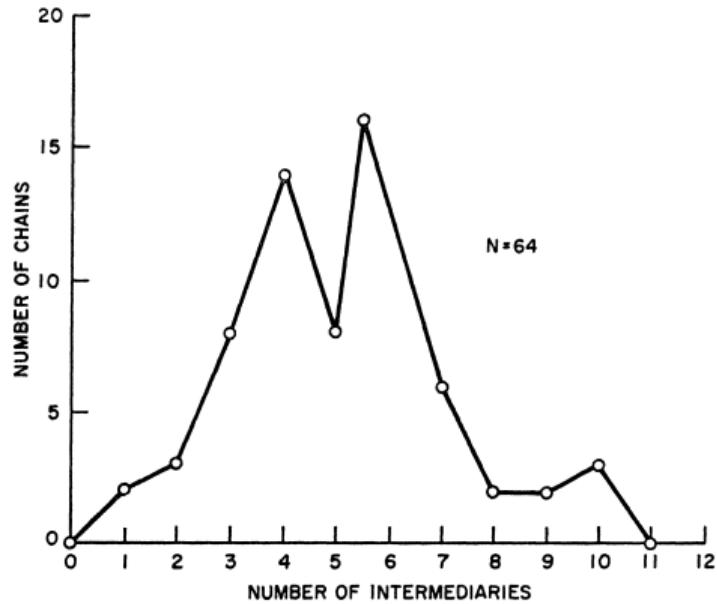
- ▶ provides a view of the big invisible social network of Americans
- ▶ flexible in choice of starters and targets

This procedure is elegant.

- ▶ provides a view of the big invisible social network of Americans
- ▶ flexible in choice of starters and targets
- ▶ tracer cards provide data on incomplete chains (and demographics of participants)

## Results

# Result 1



Mean number of intermediaries: 5.2

## Result 1

- ▶ 1 intermediary = 2 “degrees of separation”

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- ▶ 1 intermediary = 2 “degrees of separation”
- ▶ 5 intermediaries = 6 “degrees of separation”

## Result 2

- ▶ Travers and Milgram: 29% of chains reached target

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Be careful as you read.

- ▶ How should we interpret the distribution of chain lengths in the presence of chains that don't complete?

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- ▶ Chains that complete will tend to be shorter than chains that don't complete (you will see this again in reading for next class).

- ▶ How should we interpret the distribution of chain lengths in the presence of chains that don't complete?
- ▶ Demo of the effects of random attrition
- ▶ Chains that complete will tend to be shorter than chains that don't complete (you will see this again in reading for next class).
- ▶ General lesson: Think about the data you see and the data you don't see. If the data you don't see are systematically different from the data you see, be careful.

## Result 3

Means

Starting Population	Mean Chain Length
Nebraska Random	5.7
Nebraska Stockholders	5.4
All Nebraska	5.5
Boston Random	4.4
All	5.2

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What does this design reveal about Travers and Milgram?

## Result 4

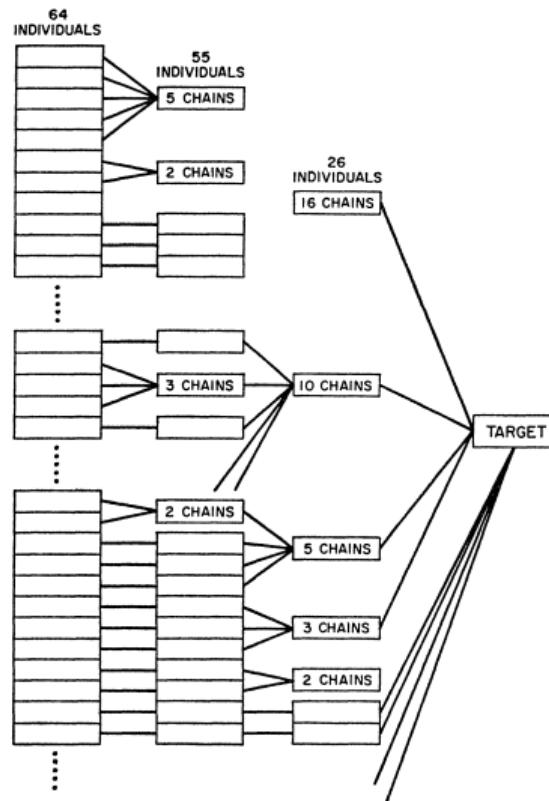


FIGURE 3

*Common Paths Appear as Chains Converge on the Target*

# Result 4

arch extends to an enormous number of persons.

we state there are only five acquaintances, this closeness between the position of son and the target person.

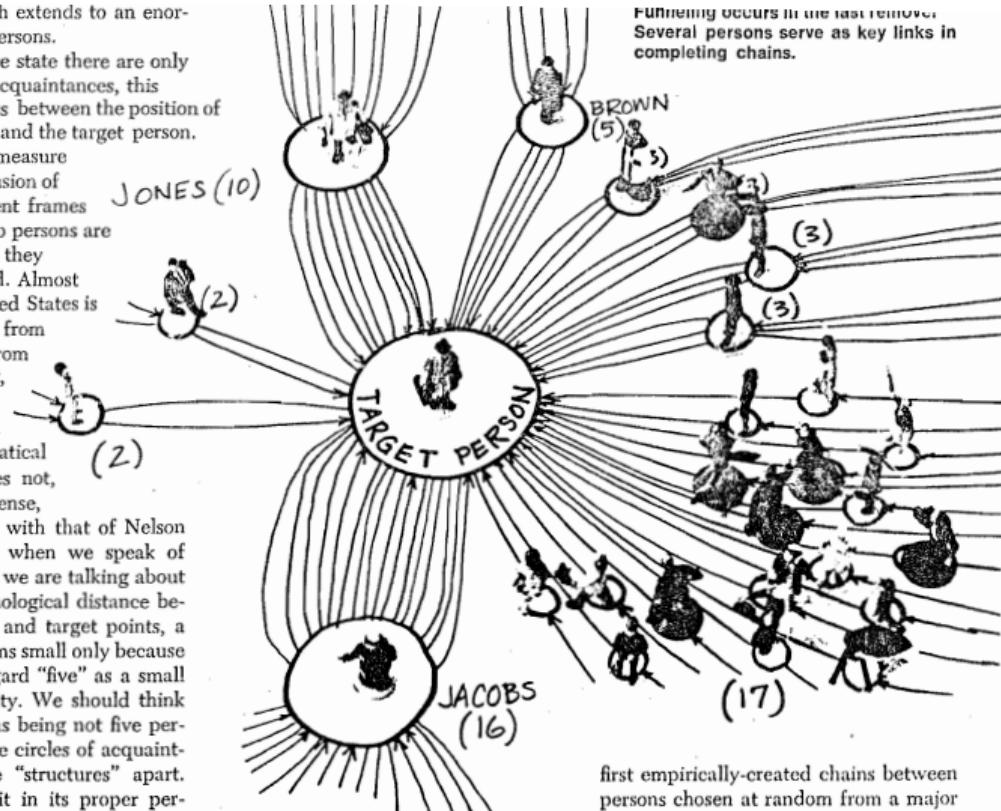
ge measure

infusion of different frames

two persons are near, they lead. Almost United States is miles from or from nearer,

if a mathematical does not,

il sense, agrees with that of Nelson us, when we speak of ties, we are talking about psychological distance between source and target points, it seems small only because we regard "five" as a small unit. We should think of ties as being not five persons but five "structures" apart. Let it in its proper per-



Funneling, will be the subject of future work

This is just one of many possible small world experiments. Milgram chose to do others.  
Let's see what he did. . .



[http://upload.wikimedia.org/wikipedia/commons/f/f5/1967\\_Ford\\_Fairlane\\_Ranchero.jpg](http://upload.wikimedia.org/wikipedia/commons/f/f5/1967_Ford_Fairlane_Ranchero.jpg)



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[http://content.time.com/time/covers/0\\_16641\\_19670804,00.html](http://content.time.com/time/covers/0_16641_19670804,00.html)

Detroit 12th street riots: more than 40 people died, more than 1,000 injured, and more than 2,000 buildings destroyed

## ACQUAINTANCE NETWORKS BETWEEN RACIAL GROUPS: APPLICATION OF THE SMALL WORLD METHOD<sup>1</sup>

CHARLES KORTE<sup>2</sup>

AND

STANLEY MILGRAM

*Harvard University*

*The City University of New York*

White "starter" persons in Los Angeles were asked to generate acquaintance chains to white and Negro target persons in New York, using the "small world method." The mean number of intermediaries between starters and target persons was similar to that found in earlier studies, approximately five to six, and this remained constant over differences in race of the target person. The number of completed chains was two and one-half times as great for white targets as for Negro targets. Explanations to account for the results are discussed.

540 white starters in LA

540 white starters in LA

18 targets:

TABLE 1  
TARGET DESCRIPTION

Target	Occupation	Age	Income
Negro			
1	Physician	36	\$6,400
2	Research technician	26	5,600
3	Policeman	38	8,400
4	Nursing assistant	39	6,000
5	Post office clerk	55	6,300
6	Funeral director	44	10,000
7	Post office clerk	45	6,400
8	Company president	44	25,000
9	Machinist	38	9,000
White			
1	Company director	31	25,000
2	Shipping manager	43	6,000
3	Opera stage director	29	11,500
4	Research technician	41	9,000
5	Bakery manager	51	10,000
6	Youth director	49	9,000
7	Campus policeman	58	4,300
8	Medical technician	54	6,800
9	Photo offset work	40	6,400

Race of target was not explicitly known to participants

## Result 1

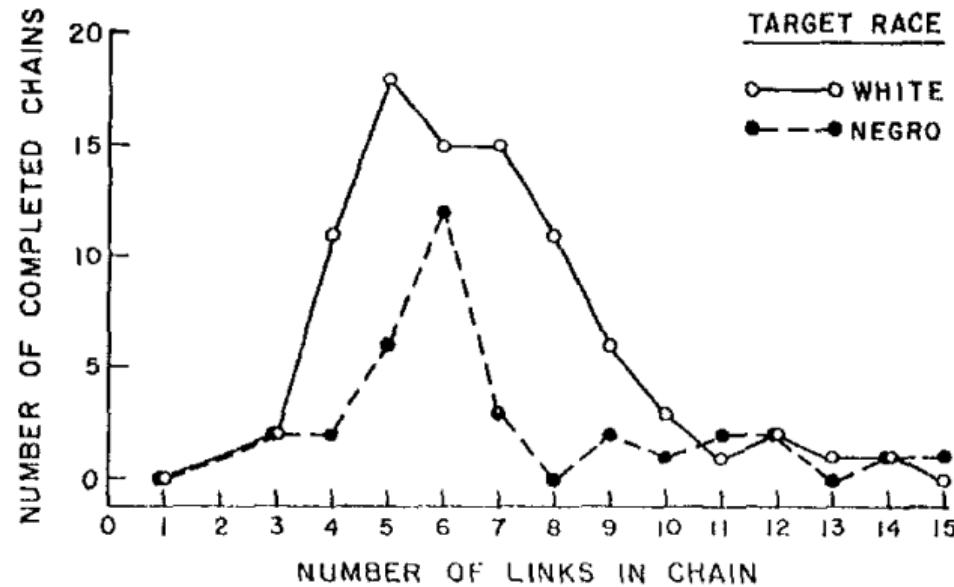


FIG. 1. Distribution of chain lengths for completed chains.

Mean intermediaries: 5.5 (white targets), 5.9 (Black targets)

## Result 2

TABLE 2  
COMPLETION VERSUS INCOMPLETION OF CHAINS AS A FUNCTION OF TARGET RACE

Chain success	White target chains		Negro target chains		All chains	
	No. chains	% chains	No. chains	% chains	No. chains	% chains
All chains <sup>a</sup>						
Complete	88	33	35	13	123	22
Incomplete	182	67	235	87	417	78
Starting chains <sup>b</sup>						
Complete	88	39	35	15	123	27
Incomplete	140	61	195	85	335	73

<sup>a</sup> Chi-square analysis of the Target-Race  $\times$  Chain-Success contingency table for all chains showed a significant association ( $\chi^2 = 29.58$ ,  $df = 1$ ,  $p < .001$ ).

<sup>b</sup> Excludes chains not begun by initial participants. Chi-square analysis of the Target-Race  $\times$  Chain-Success contingency table for starting chains only showed a significant association ( $\chi^2 = 31.82$ ,  $df = 1$ ,  $p < .001$ ).

Completion rate: about 30% (white targets), about 10% (Black targets)

## Result 3: Gate keepers

TABLE 3  
CHARACTERISTICS OF GATEKEEPERS

Characteristic	Complete chains	Incomplete chains	All chains
White senders <sup>a</sup>			
Sex			
Male	86%	78%	81%
Female	14%	22%	19%
Age: mean yr.	44.4	44.3	44.3
Status (head of family)			
Professional	65%	51%	57%
Managerial	6%	28%	19%
Sales, clerical	13%	16%	15%
Service workers	10%	2%	5%
Other	6%	2%	4%
Negro recipients <sup>b</sup>			
Sex			
Male	77%	80%	80%
Female	23%	20%	20%
Age: mean yr.	42.0	43.6	43.3
Status (head of family)			
Professional	55%	61%	60%
Managerial	18%	11%	13%
Sales, clerical	18%	19%	19%
Service workers	9%	6%	6%
Other	—	3%	2%

<sup>a</sup> White participants who send booklets on to Negroes in Negro-target chains.

<sup>b</sup> Negro participants who receive booklets from whites in Negro-target chains.

“Gatekeepers” of white to Black connections were predominately Male professionals  
 In 23 of the 35 successful cross-group chains, the first Black person was the target  
 Most failed chains (80%) never crossed the racial boundary

[https://bit.ly/soc204\\_s2025](https://bit.ly/soc204_s2025)

- ▶ Introduction to the connected age

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- ▶ Small world problem shows the scientific arc: idea → formal question → empirical research → critique

- ▶ Next class: More on the small world problem and some history
- ▶ You have until 11:59pm if you want to try the optional, ungraded quiz this week.  
Graded quizzes start next week.