

The connected age and the small world problem

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Social Networks (Soc 204)
Princeton University

Wednesday, September 8, 2021
Week 2, Lecture 2



Expectations about reading and lecture:

- ▶ I expect you to watch the pre-read video

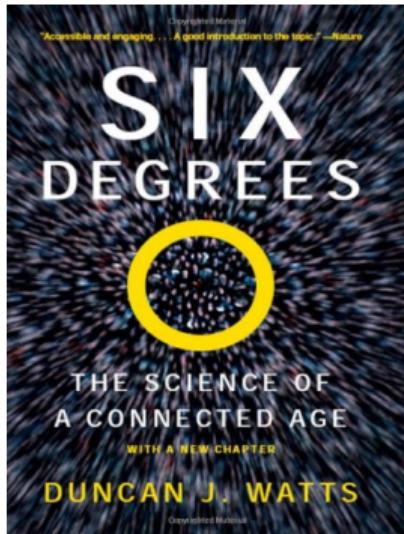
Expectations about reading and lecture:

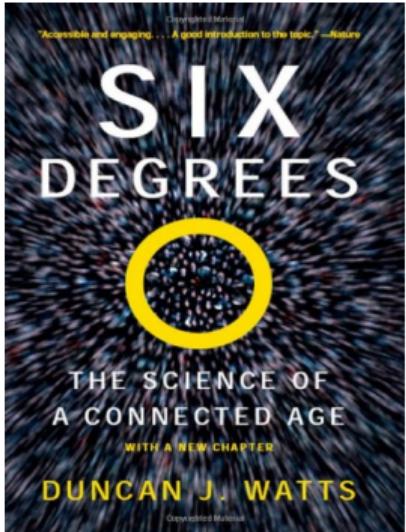
- ▶ I expect you to watch the pre-read video
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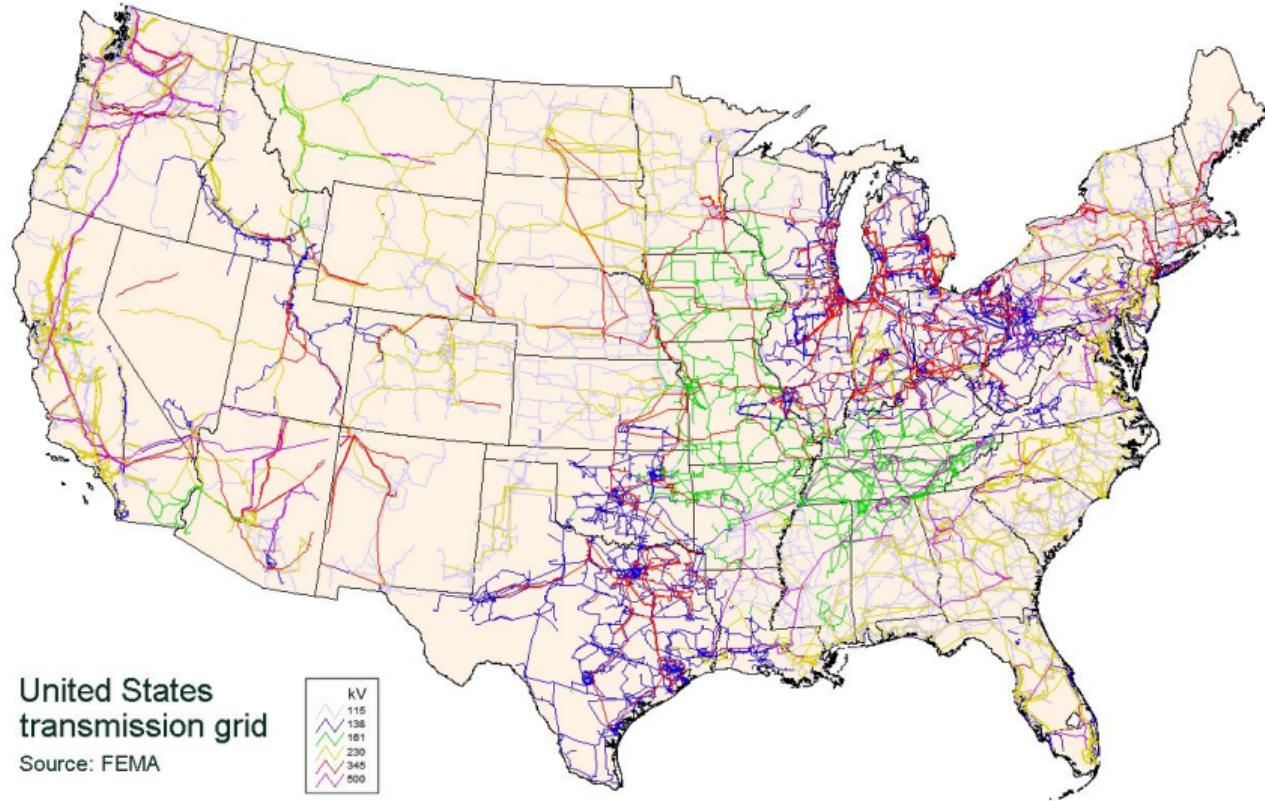
Expectations about reading and lecture:

- ▶ I expect you to watch the pre-read video
- ▶ I expect you to read the materials
- ▶ In the lecture, I will do a mix of reviewing the reading, providing context, and discussing extensions

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*.







How does individual behavior aggregate
to collective behavior?

The small world problem

“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://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?

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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, contact another American citizen regardless of his walkability? If the same or an American citizen were picked out at a bar, could you get to know their 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. Helped aided 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 to the 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 *move* this folder to the target person using only a chain of friends and acquaintances.

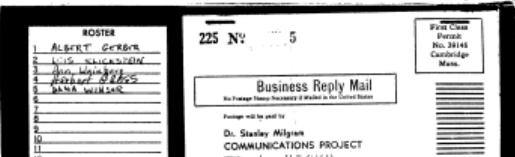
HOW TO TAKE PART IN THIS STUDY	
1	ADD YOUR NAME TO THE ROSTER AT THE BOTTOM OF THIS SHEET, so that the next person who receives this letter will know who it came from.
2	DETACH ONE POSTCARD, FILL IT OUT AND RETURN IT TO HARVARD UNIVERSITY. No stamp is needed. The post card is very important. It allows us to keep track of the progress of the folder as it moves toward the target person.
3	IF YOU KNOW THE TARGET PERSON ON A PERSONAL BASIS, MAIL THIS FOLDER DIRECTLY TO THAT PERSON. Do this only if you have previously met the target person and know each other on a first-name basis.
4	IF YOU DO NOT KNOW THE TARGET PERSON ON A PER- SONAL BASIS, DO NOT TRY TO CONTACT HIM DIRECTLY. INSTEAD, MAIL THIS FOLDER (POST CARD) TO A FRIEND OR ACQUAINTANCE WHO IS MORE LIKELY THAN YOU TO KNOW THE TARGET PERSON. You may ask this friend or acquaintance to forward the folder on to another friend or acquaintance, but in no case someone you know on a first name basis.

Remember, the aim is to move this folder toward the target person using only a chain of friends and acquaintances. On first thought you may feel you do not know anyone who would be willing to take part in this experiment. If so, test yourself on it and you will be surprised. Who among your acquaintances is more likely to be in the same social circle as the target person? The real challenge is to identify among your friends and acquaintances a person who can advance the folder toward the target person. It may take several steps before you find the target person, but what counts most is to let 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 help?

Every person who participates in this study and returns the post card to us will receive a certificate of appreciation from the Communications Project. All participants are invited to a party describing the results of the study.

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

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



This procedure is elegant.

This procedure is elegant.

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

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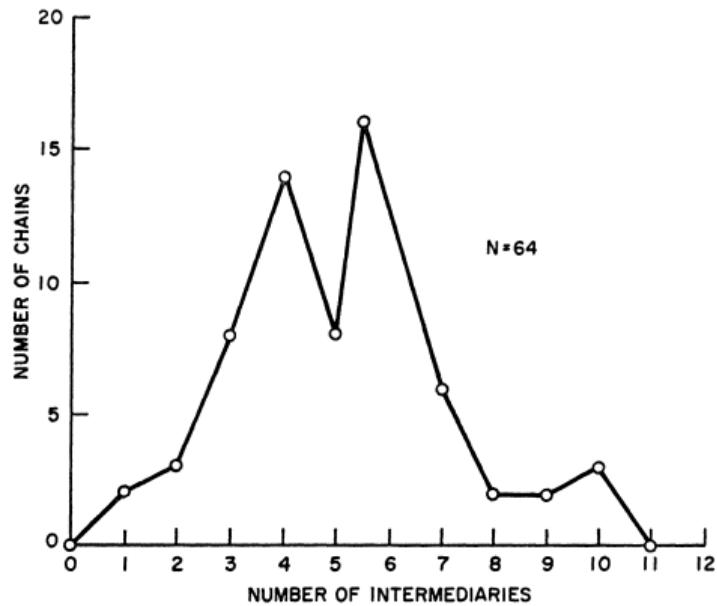
- ▶ provides a view of the big invisible social network of Americans
- ▶ flexible in choice of starters and targets

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”

Result 1

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- ▶ 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).

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- ▶ 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

Result 3

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What does this design reveal about Travers and Milgram?

Result 4

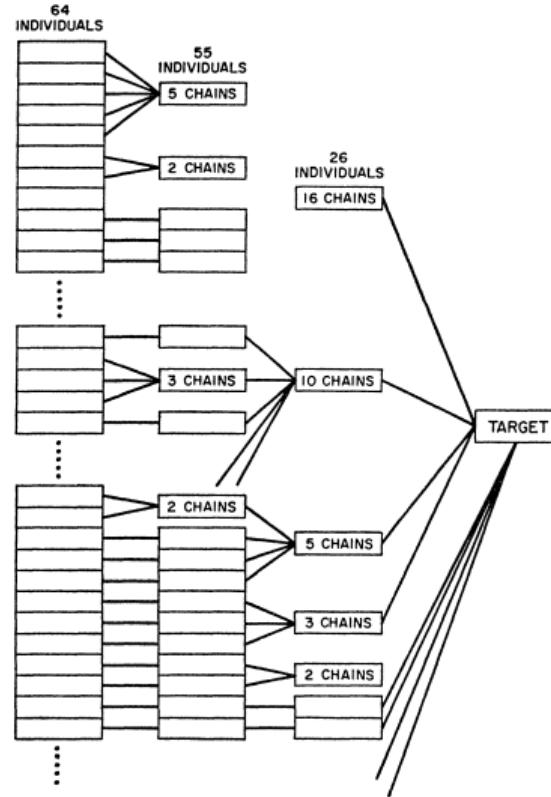


FIGURE 3

Common Paths Appear as Chains Converge on the Target

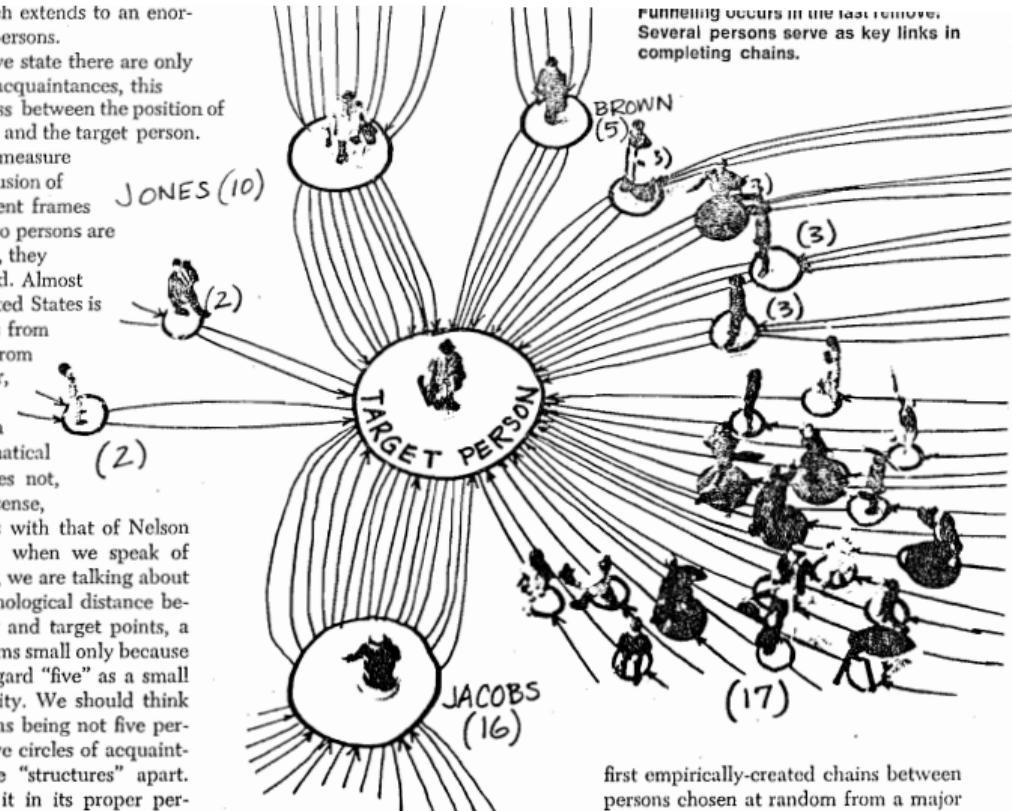
Result 4

arch extends to an enormous number of persons.

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

ge measure
infusion of
different frames
two persons are
near, they
need. Almost
United States is
comes from
r from
ller,

if a
mathematical
does not,
it sense,
ves with that of Nelson
us, when we speak of
ties, we are talking about
psychological distance be-
ing and target points, it
seems small only because
regard "five" as a small
entity. We should think
of ties as being not five per-
son "five circles of acquaint-
ance" "structures" apart.
set it in its proper per-



first empirically-created chains between
persons chosen at random from a major

Funneling, will be the subject of future work

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



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://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 METHOD¹

CHARLES KORTE²

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

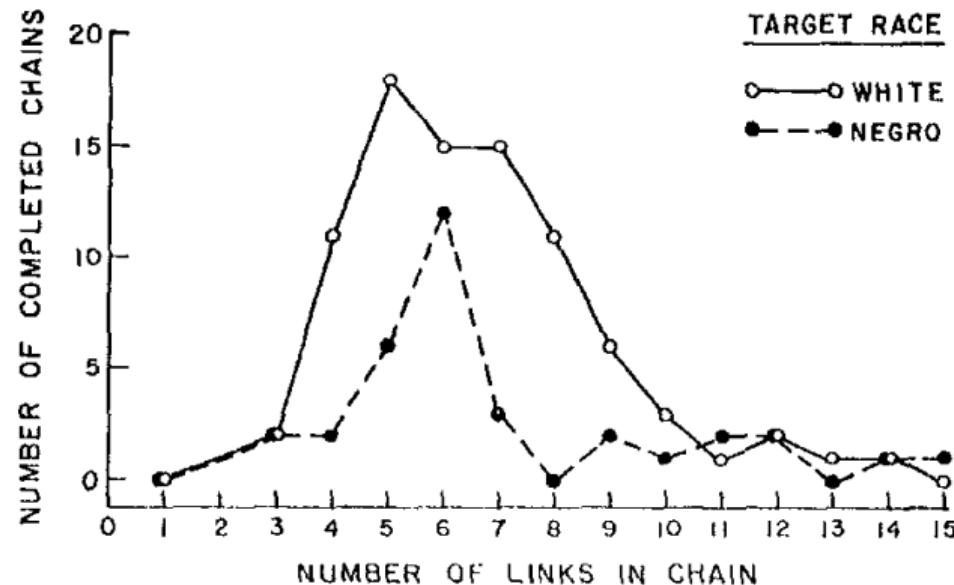


FIG. 1. Distribution of chain lengths for completed chains.

Mean intermediaries: 5.5 (white targets), 5.9 ("Negro" 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 ^a						
Complete	88	33	35	13	123	22
Incomplete	182	67	235	87	417	78
Starting chains ^b						
Complete	88	39	35	15	123	27
Incomplete	140	61	195	85	335	73

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

^b 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 ($\chi^2 \approx 31.82$, $df = 1$, $p < .001$).

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

Result 3: Gate keepers

TABLE 3
CHARACTERISTICS OF GATEKEEPERS

Characteristic	Complete chains	Incomplete chains	All chains
White senders ^a			
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 ^b			
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%

^a White participants who send booklets on to Negroes in Negro-target chains.

^b Negro participants who receive booklets from whites in Negro-target chains.

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

- ▶ 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

<http://bit.ly/soc204-2021>