4.4 Games "In the Large" (48:35)

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Up till now in our discussions of Game Theory, we've focused on two-person games. Really we've actually focused on one particular example of a two-person nonzero-sum game, namely the Prisoner's Dilemma.

01:19

Now the Prisoner's Dilemma is an important and much-studied situation in Game Theory, but it's one of only hundreds of thousands or perhaps millions of interesting situations that come up under the umbrella of game theory. Remember what I said? Game theory is really the subject of how you make decisions in the presence of others making decisions, reasoning about what to do in the situation given that you know that others are also reasoning about that situation. So two-person games are an example of that where you're making a decision, and another person is making a decision, and your choice is going to be colored by what you think the other person is going to do.

01:49

What I'd like to focus on today, though, is a different kind of different genre of games, which are games in the large what happens when there are not two players or even three or four but a large number. Large here could be in the thousands or millions, or it could be perhaps 20 or 50 players. But regardless, the general notion here is

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the typical situation, the typical kind of thing that we'll be talking about will be - how do you make a decision are in the presence of a fairly large number of other people making a decision about the same situation. OK, so that's usually the way these things are cast. We're not going to try and analyze what each and every person is going to do. Rather, we're going to look at how one person think of it if you make the decision given that you're in a large crowd.

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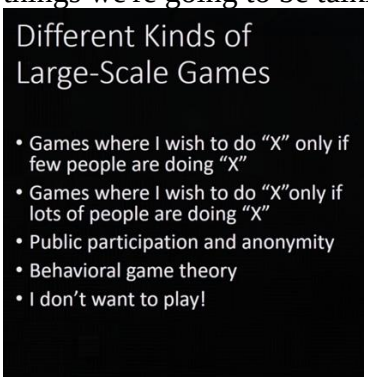
making similar decisions about the situation. So we're going to look at some prominent examples and themes about games in the large, and let me run through these, for these are the kinds of things we're going to be talking about today.



03:31

In certain kinds of games where you want to do X, you want to take some action only if you think that few people, few or no people, are also doing X. In other words, you want to run against the crowd; whatever you think the crowd is going to be doing, you'd like to do the opposite. That's one type of situation. Another type of situation is where you want to do X only if lots of other people are doing X - you want to follow the crowd in this case, so you want to make a decision based on what you found on following or imitating what you think a lot of other people are going to be doing.

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We'll take a look at the theme of anonymity. This is a kind of different thing than anything we've talked about before. It's really about the structure of the game, the rules under which the entire game is played, and how that might influence your decision when dealing with games in the large OK. We'll see an example where

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depending on whether your choice is anonymous or public might make a big difference as to how do you make your choice. We'll look at an example of a fairly recent branch of game theory called Behavioral Game Theory which really combines psychological and getting theoretical reasoning together. It isn't a pure game theory. It's game theory with a sort of overlay of your reasoning about not just other people's decisions but other people's psychological state.

05:17
And finally will look at us, you know certain kinds of games where in fact, there's no winners once you're in a game like this - it's bad news. So these are games where somehow you want to get out of the situation, you find that you're in the position you want to get out of the situation. These are games that you don't want to play, OK. So those are the themes it will be talked about. Of course, there are many, many more that we could talk about it such a rich subject, but I think these will give you a flavor for the kinds of

05:51
you know the the kinds of areas that people study when they're looking at game theory, particularly in these situations where there are large numbers of participants. So let's start with that first bullet game where you wish to do X only if a few people are doing X. I experience in a partial way something of the situation every day and going to work driving into work.

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There are two ways I could get into work one is to take the highway, and another is to take an alternate route that goes through the city. I'm not going to go into details because who cares - highway or alternate road. Now, generally speaking, all other things being equal on the highway is faster. I'll get to work faster if I take the highway, but if there are lots and lots of people driving on the highway, in other words, if traffic is congested on the highway, which happens at rush hour.

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then I'm better off taking the alternate road city road. This is a little bit of a decision where I want to do X only if I think few people are doing X. Namely; I want to take the highway only if I think few people are taking the highway right now. That's sort of a case like this here's a more clear case, I think.

07:24
I'm showing you a photo of Waikiki beach in Honolulu. Now, this is from a WebCam that is maintained by one of the hotels in Honolulu. In other words, the hotel has a WebCam, and it'll show you at any given moment out you know the beach and how many people are there and what the weather looks like, and so forth.

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I'm not the biggest fan of going to the beach or in any way, and I have a difficult time figuring out why it is that people want to go to the beach, but like I grew up in Manhattan. But I certainly wouldn't want to go to the beach if it's packed. I mean, what's the fun in that? To me, it's like going on the New York subway, you know, it's just like being in a huge crowd of people. I wouldn't find that fun; maybe if you're on an empty beach or if you know a near-empty beach, that could be fun. But if I were to look at these WebCam ads and see, oh

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there are thousands of people out there on the beach I would be less likely to go. So this is a case where I would want to do X, namely go to the beach only if I were aware of or thinking that very few people will also be on the beach,

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which is admittedly pretty rare in Honolulu. But anyway I would prefer to do something only if I thought a few people were going to do it. There are quite a few situations if you think about this in your own life - you could think about situations where with your analogous, that's where you want to make a decision you want to take some action only if you think you're going to be

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either alone or nearly alone in taking that decision. For whatever reason the situation is, it's preferable to you soon to be one of the very few people making that decision. So these are just simple examples of that. What about other the other extreme, where you want to make a decision

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only if lots of other people are making that decision. Well, here's you have to kind of bear with me for the next example because it takes a little bit of explaining but I think it's a really good example of game theoretical reasoning that took this into account and with great success. So what you're looking at here is a still

10:18
from probably the most famous TV commercial ever aired. This was the commercial for the Apple Macintosh. It was aired at the Super Bowl in 1984. The commercial had a kind of George Orwell's 1984 theme, and it cost a great deal for Apple to make. Remember, this is it.

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this is not the powerful sort of mega-corporation Apple of today. This is the fledgling Apple corporation of early 1984, and they basically spent a huge chunk of their budget. Maybe they're close to their entire advertising budget. For all I know on this one ad, the Super Bowl ad clearly getting time at the Super Bowl is expensive, and the ad itself.

11:18
was also expensive; they hired Ridley Scott, the heart the Hollywood Director, the Director of Blade Runner and Alien, to direct this ad. But let me explain to you what was going on here; let me set the scene for you because this is this really is a great example of game theoretical reasoning.

11:57
In early 1984 Apple had just come out with this new machine called a Macintosh, and they were very enthusiastic about it. And people who saw it were enthusiastic about it. The main competition at this point, the main, you know, sort of two competitors in the still rather young home computer market were Apple and IBM. Now IBM had as its competitor the IBM PC, that was their home computer.

12:04
And or do you know workplace computer desktop computer. IBM, of course, it was a well-established corporation. It had been the powerhouse of computing all through the 1950s and 60s

and, do some extent, the 70s as well, so IBM was an extremely powerful corporation and, you know, a venerable corporate one that had been around quite a while.

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Many people, I won't get into endless arguments about the merits of one PC over the other but many many people who saw the PC and the Macintosh preferred the Macintosh. They found it was easier to use; the interface was better, and so forth. But they didn't feel safe purchasing a Macintosh because, after all, Apple is a new, you know, relatively untried company, and IBM is an established famous company. I don't know if it was an official IBM slogan.

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and one of the things that were repeatedly said it became kind of a cliché to take to get people to buy the IBM PC was "no one ever got fired for buying IBM." In other words him, it's a safe choice - you could take a risk on buying the Macintosh, but if you buy the IBM PC, no one will ever get fired for doing that. It's a safe choice.

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Think about the situation you're in the market you're you yourself are in the market for a new home computer. You want to try one out; you have a choice between the IBM PC and the Macintosh. You've seen them both; you like the Macintosh better. It looks pretty cool but then again, what happens, you know, if it's realistic or what happens if you buy the Macintosh, an apple goes out of business. Then there's nobody to repair or maintain your machine anymore. What happens if you buy the Macintosh and

15:01
all the other people make the safe choice and buy IBM. Then you have a very small user community to help you out - you want when you buy a PC, a home computer, you want that home computer to be part of the largest community, right? You want other people to have it so that you can you know there will be magazines about how you know tips about how to use your computer there will be,

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Apple will be responsive to customer demands and complaints, all those kinds of things. You want to make the choice that other people are making. In this case, you don't want to get a Macintosh if you think nobody else is going to buy it, even if you think it's a better machine on its own merits. You don't want to get a Macintosh. If you think that only very few people are going to have it, you just never know what will happen. So here you are watching the Super Bowl in 1984, and in January 1984, and this brilliant commercial comes on - the Apple commercial comes on. And you, as a viewer, are supposed to think that Apple was anticipating that your thoughts would run something like this.

15:55
One, oh, this is an ad for that Macintosh computer. Yeah, I kind of like that Macintosh computer. It looks pretty interesting, fun interface. Maybe I should give that a try.

16:10
Two - but maybe I better not give it a try because, after all, um, lots of people are going to be buying the IBM PC, and so maybe the safe choice is not to buy a Macintosh. Three, and this is crucial. Hey, wait a minute, this is the Super Bowl. I'm watching this commercial. I know that tens of millions of people are also watching this commercial at the same time.

16:38
Maybe it's not so unsafe to buy a Macintosh because, after all, I'm watching this commercial in a vast audience. If others in the audience are making or seeing the same value that I'm seeing, it's not so unsafe to buy a Macintosh. There will be lots of customers. There will be lots of people in the user community for the Macintosh.

17:08
Now consider this reasoning on Apple's part. They could have gotten more viewers by using their advertising budget on zillions of late-night commercial slots- things at two in the morning in between the magical sunglasses in the kitchen magician or something. In other words, if they had aired a commercial, a cheaper commercial, or even this commercial thousands of times in

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you know, obscure timeslots. They might very well have overall gotten a larger viewership, but that wasn't the point. The point was to get a large viewership that knew that it was a large viewership - in other words, I'm watching the thing, and I'm saying, hey, it's Super Bowl. Everybody's watching this. I guess you know it's a pretty safe choice to buy the Macintosh that was brilliant game theoretical reasoning. They wanted to air the commercial in such a way that it would make people feel safer to get the Macintosh because they would intuitively believe that others would be making the same decision.

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That's an example of your wanting to make a decision based on imitating what other people are going to be doing, and again there are lots of similar cases about this, and there may be cases, for example, with

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certain kinds of software word processors. There are only about two or three prominent word processing software examples out there. There's only if I mean there maybe once and lots of you know word processing applications, but there's only two or three prominent ones and speaking for myself the one that I use I'm not going to go into it the one that I use I'm not especially fond of, but it's kind of the most well-used word processor out there.

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I might go and look for a better, you know, text processing application - but even if I find one, if it's a relatively unknown application, there's not much point in switching. It just won't be that many people using it if there are bugs, they may not get fixed right away, the company may go out of business, and so I may have a totally unsupported word processor. These are the kinds of decisions that often go in into, you know, these are the kind of thoughts that often go into your

decisions. You only want to do something if you think other people are also doing it, and this Apple commercial is a great example of them.

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Let's look at it and another thing - the idea, well, this is related to the idea that you want to reach a decision in a large crowd that knows it's a large crowd. This is actually an example of; what you're seeing here is a photo from the early 1900s of the coronation.

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ceremony for King George fifth of England thinks it was around 19 or thereabouts. And now there's an interesting book called Rational Ritual by a writer named Michael Suk-Young Chwe. And he talks about situations like this historically; let's take England as an example - in a monarchy over the centuries, historically, the most perilous time for a new king or queen for a new monarch is immediately after they take the throne. Things are still in the state of flux right they've taken the throne but

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that's a new decision people don't you know people may not be familiar with their new king and so forth. There may be competitors. This is when a king or queen is most vulnerable - is right at the point where they take the throne. Now historically, what a king or queen would do in this situation is they would go on a tour.

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of their, you know their country they would go on a tour of their domain. OK, now, why is the new king doing that? It's not in particular because he needs to see what England looks like. It's rather because he wants to go out.

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It is early stage, and it'll be a pageant. It'll be like a parade. People all throughout England will come out to see the new king, just they're coming out to see the new king in this photo of George the fifth. So importantly, people in England will now be seeing who the new king is, but even more important, just as in the Apple commercial - they'll be seeing the new king, and they'll be seeing each other seeing the new king. So it's not just that they themselves are aware that there is a new monarch. They're aware that everybody else knows it's a way of making sure that everybody in the community is on the same page.

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It's a way of ensuring a certain degree of order. This is again another example where can, theoretically, what you want is an audience, not just a large audience but a large audience that knows that it's a large audience. And one way to do that is to get them all outside, saying that they were in a crowd. This is different from having an ad in the Super Bowl, OK.

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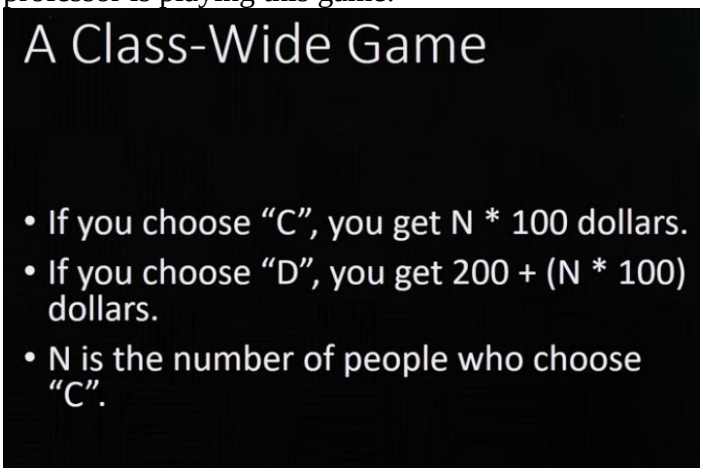
Let's talk about yet another subject here - so clear your minds of those earlier examples. Now imagine you're sitting in a room with, I don't know if this would be a classroom game, the professor is playing this game.



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It's sort of setting me the rules for the entire class, but let's say a class of 50 people, there are 50 students sitting in the class, OK. The professor gives all the students this offer. If you choose C and D, as in the prisoner's dilemma, have this notion of cooperating or defect; if you choose C, you will get N x $100; if you choose D, you will get 200 + N x $100.

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What's N? N is the number of people who choose C, OK? So again, 50 people if everybody chooses if all 50 choose to cooperate then all of them get $5000, not too bad.

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If all of them choose to defect each and every once used to defect, then N is zero, and everybody gets $200; OK, not so good. Now you have to choose C or D; notice that whatever the rest of the class does, you will make more money by choosing D. Suppose you're the only one choosing D, then.

25:46
N is 49, and everybody else in the class is going to get $4900; you will get $5100 if you do better. So regardless of it's a little bit like the prisoner's dilemma in the situation and that regardless of what the other players do, you do better by choosing to defect.

26:09
OK, now ponder the situation for a bit and think to yourself which you would choose C or D. Given this situation, you're sitting in the classroom, which would you choose C or D? Now, let me throw in a different consideration. Let's say that there are two ways that this game could be played - in scenario one, the professor says the following write your vote right what you want to do, see your D on a little slip of paper with your name, fold it up, hand it to me I won't make the results public.

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And then, I will tally the results later today, and I'll send you a check in them in the mail. So that situation number one scenario number one: You write the C or D on the slip of paper along with your name, and you do you know, put them in a stack, and I will send you your reward, whatever it is later on during the day OK.

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That's where the choice is made privately. In scenario number two, the professor just says to all those who chose C to raise your hands and all those who chose D to raise your hands. OK, and then he takes down the names and gives you your award. And think about those two scenarios. OK, in one scenario, your vote is from the game theory standpoint,

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the matrix hasn't changed, OK. Your particular choice hasn't changed and may not change that is the reasoning that you would employ whether you want to cooperate or defect. The reasoning that you employ may not change, however.

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they are very different situations. I mean, suppose that you were inclined to defect, that you were inclined to take the extra money whatever however the other people in the class behave. In scenario number one, nobody ever knows that you just put your name on a slip of paper in your hand it to the professor, and you get some money later in the day.

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In scenario number two, suppose you were the only person to vote D, so when the professor says raise your hands if you're voting C, everybody else in the class raises their hand, and then the professor says raise your hand if you're voting D and you raise your hand.

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That may not be the most comfortable situation. You can imagine that the other 49 people in the class would be looking at you with something less than affection in that situation, and so your choice might change not because the matrix in the game-theoretic situation has changed but because the information that other people will get about your vote.

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is different, and these are situations also that come up in gains prominently in gains in the large. If you make a decision that is in your self-interest, but everybody else knows about that, and it's

public, it can be very embarrassing. So partly what keeps people in line in situations like this is this - a scenario where you know decisions are public to everybody. If your decision has to be made public, you may have an inclination to if I can put it this way by behaving better or behave more cooperatively

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then you would otherwise OK. Totally another topic. This is an example from behavioral game theory, so I am again imagine a professor playing this game with 50 students in the room.

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and you have to you have to allow for you know some fanciful thinking here but what the professor says on a certain day, let's say a day this summer on you know June 15 this year

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all of you are going to the evening before all of you are going to be whisked off to Paris you're going to spend the day in Paris, each of the different hotels, so you're not going to be able to communicate with each other so you're going to wake up in Paris all in different places and you're going to spend the whole day in Paris. Now here's the game I'm offering you - I want you to choose on your own privately a time and a place in Paris that you will

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that you will guarantee to be - you know you choose the place in Paris, and you choose the time, and then you're guaranteed to be there in Paris at that time and place on June 15, OK. You will be rewarded in proportion to the number of people who make the same choice. So here's your situation I'm going to wake up in Paris and I want to choose a time and a place to be in Paris on that day.

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which I believe that many other people will choose because I get rewarded more if there are if all 50 of us show at the same time and place; the reward could be enormous if I'm the only one who shows up at this time and place then the reward would be paltry so basically what I'm trying to do is make a choice of a time and place that I think lots of other people are going to make

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So this has similarities to the game where you want to do X only if you think other people are going to do X but note this interesting factor.

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from the game-theoretical standpoint, you draw a matrix there's no; by the way, you might think for yourself what time and what place would you choose to meet in Paris on that particular day in the hopes that other people also making independent decisions would show up at that time and place a very common response I don't know if you made this response internally, but a very common response is

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the Eiffel Tower at noon. I will show up at the Eiffel tower at noon and hope that there will be a lot of other people from the class there at that same time. Now from the game-theoretical standpoint

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this is one of those games where there is an infinite number of choices. You could show up anywhere in Paris at any time. You could have made the choice to show up at the Louvre at 4 PM or the Arc de Triomphe at 8 AM.

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Any place at any time is equally good there's no reason to make one choice or another based on the matrix itself. You're just hoping that other people will make the same choice that you do, but that's your reasoning here is not game theoretical reasoning - it's psychological reasoning; a lot of people choose the Eiffel tower because it kind of seems like the most prominent place in Paris whenever in movies whenever they're showing Paris the show the Eiffel tower is in establishing shot it's sort of the same the architectural symbol of Paris by now so

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that's a reasonable choice of place to go, and you might think this is psychological reasoning you're thinking, well other people are going to find it prominent also similar - what about noon wine noon well just seems like a prominent time you're going to choose any all-time to me noon seems like

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who knows just seems like a prominent time as opposed to two in the afternoon or 3:30 or some like that, so that you may fail. I mean, maybe other people won't make this decision, but you're making a choice not based on reasoning from the matrix, the game-theoretic matrix, which is, in any event, huge you're making a choice based on your reading of other people's psychology and these are situation that falls under the heading of this newer area of what's called behavioral game theory.

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Finally, let me talk about a very interesting kind of game, a famous game where are you really don't wanna play you that there are no winners in a game like this. This game was first described by an ecologist, Garrett, who wrote a paper about it in a science magazine back in the 60s, and you might've heard the term before. It's called the Tragedy of the Commons.

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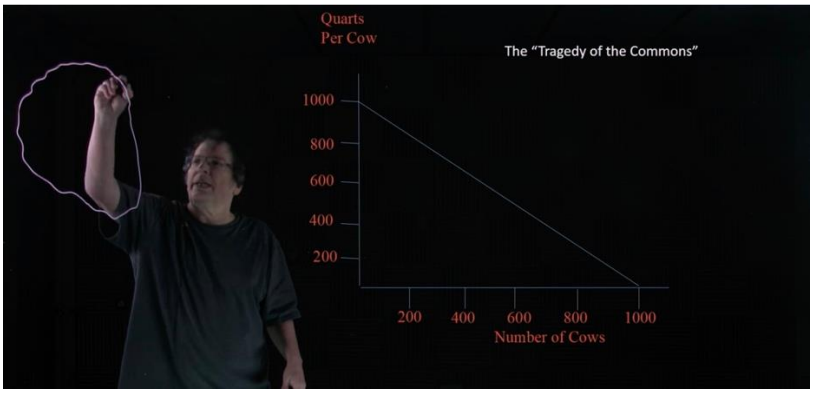
Here's the idea behind the tragedy of the commons. Imagine the following scenario - you are living in a village with 100, a total of 100 families, OK? So there are 100 households living in this village, and the village people keep cows, or they have cows in this village. I'm always a little vague talking about this because you do have to remember I'm from Manhattan. I really don't know about keeping cows or anything like that, but in the village, there is a common pasture what I'm sort of drawing here, so this is, you know.



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It's a map of a common pastor in the village. The houses are scattered around here. The common pasture is available to all, and it's available for people to graze their cows, OK? ow so you know there are people can send their cows out there

37:51
That's a cow

37:58
That's another cow. So people can send their cows out there to graze the productivity of the cows is given by this graph, and again, don't worry about the particular numbers. The point of the graph is just to show it look when there are zero cows - the very first cow out on the common pasture will produce 1000 quarts.

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I don't know a thousand quarts per something per year, whatever. So it will have a productivity of 1000, so the very first cow will have a productivity of 1000 those out on this pasture as there are more and more cows put out on the common land.

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then the productivity per cow goes down, so if you have 1000 cows out on the common land, then they produce nothing at all. The common pasture is so overcrowded that the cows can't produce any milk; now, if you have 500 cows out on the common land than

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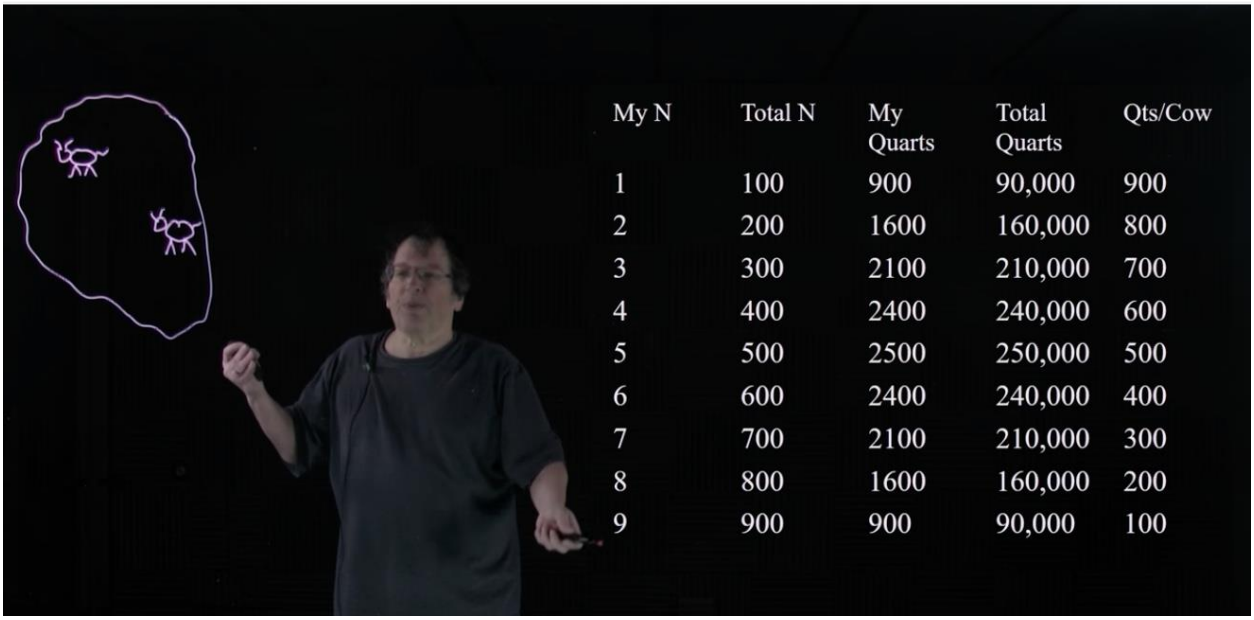
they'll produce 5 0 quarts per cow, so it is a straight linear graph here. The more cows that are out on the common pasture, the less productive each cow is, and we just Xpress that, in this case, is a straight line graph starting of 1000 and going down to zero on the Y-axis, and the limit of productivity is reached when there are 1000 cows out there on the pastor OK. So that's starting situation.

39:57
Now the key to analyzing this is in this graph; there's a lot of information in the graph; start with that first row, the first row across OK - I have a cow. Should I put my cow out in the pasture?

Well, if it's free, the pasture is free, and if I put my cow out on the pasture.



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I don't think there's a downside to putting my car while on the pasture it's free and the cow will produce some you know some milk if everybody on this first day - think of these these rows successive days if you like or successive weeks doesn't matter when

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but we move forward in time as we move down here. The first day or the first week, I put my cow out there, and so do all the other 99 inhabitants of the village, so there are 100 cows out on the common pastor, and if you look at the graph, you see that with 100 cows out on the pasture each cow is producing.

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milk at a rate of 900. That's their productivity level, so with 100 cows out on the pasture they're producing, each cow is producing 900 quarts of milk. The total number of quarts of milk is 90,000 for the whole village, and the quarts per cow is 900

41:36
Week two rolls around, and we all have to make a similar decision should I put a second cow out on the pastor? Well, why not? I mean, if I put a cow out there, it will produce milk, and if I don't put a cow out there and everybody else does, I don't gain anything, so there's really no point - holding off doesn't make any sense, and other people won't see any reason to hold off, so I put my second cow out there on the pastor asked you all the other 99 people there are now 200 cows out in the pasture I'm getting 1600 quarts because the cows are producing it at a

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rate of 8 00 the whole village is producing 160,000 quarts. Week three rolls around. Should I put a third cow out there? Well, it doesn't. Again doesn't benefit me not to do that if everybody else is going to do it. I'm just losing productivity. I'm losing milk by free milk by, you know, not putting a cow out there, so sure I put a cow out there now there are 300 cows out on the pastor there's 2100 I get 2100 quarts the village of producing 210, 000 total and each for each cow is producing 740 you can keep running down the road here.

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Really the decisions remain the same, but a really interesting choice occurs between weeks five and six. We get to week six. OK, I notice a couple of things about this first of all, if I put a cow out there in week six.

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and everybody else does. I'm going to have fewer quarts than I did the previous week, and in fact, the whole village is going to have fewer quarts than it did the previous week; however, my decision is still the same. What's the point in my holding off. The cow will produce milk if I put it on the common pasture, and if I don't, I'll just lose money.

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if everybody else puts their cows out there. So if we're all going to reason in the same way, it's like, well, I might as well put my sixth cow out there because if I don't, I'll just lose money when other people do that, so yes, I'll put the sixth cow out there, there are now 600 cows out on the pasture I get 2400 quarts fewer than I did last week. Still, if I didn't put that sixth cow out there, I would have even fewer, so what's the point the total quarts in the village has gone down? The village has become less productive.

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Same decision keeps getting made week after week until finally, the commons break down, so this is what Garrett Hardin called the tragedy of the commons. We are all making decisions independently that seem to be rational, and we were all making decisions that not only seem right.

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rational but pretty much forced. How could you choose otherwise, and yet when we all make these the same decisions, the system collapses. If you think this is unrealistic, this exact kind of scenario has been used to talk about things like the phenomenon of overfishing in the oceans where certain species have now become near-extinct, and yet it seems to be in no individual country's interest to stop catching this particular species of fish because if they stop, but nobody else does what is the benefit them, so the tragedy of the commons is not some obscure abstract situation much like the Schelling neighborhood problem, and in fact, it's a model of a situation in which

46:13
by all using a common resource, the system collapses and breaks down. What is the solution to this well? The solution is that you don't want to be in this game, and they were different ways of

analyzing it, you know, depending on one's political leanings. I'll paint with a very broad brush here, but the sort of the response from the political right would be something like that shouldn't be any common property. It is a bad idea he shouldn't have a common pasture.

46:50
People should have to pay for, you know, the particular piece of pasture that they use, and then you won't run into this problem. Then sort of, you know, the response from the political left would be something like you could have a common pastor but has to be regulated. There have to be regulations and rules about how to use the common pastor; otherwise, you may run into the situation regardless of what you find convincing in the response. The basic point is that this is a game you don't want to be in.

47:30
There is no best behavior in this situation. You just want to be out of the situation, so you want that in the sense you're looking at the game structure itself and saying, this is an unhealthy game structure. I want to get out of this, so those are a variety of different themes around games in the large, and I hope this is giving you some flavor for all the different ways in which these large-scale games can play out.

48:08
There are situations and types of situations that are now much discussed in feels like evolutionary biology, political science, economics, and so forth, where you're making decisions lots of other people are making decisions, and different kinds of reasoning can be employed depending on what everybody is doing.