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We're All in This Together: Modeling Interdependence in Collaborative Settings

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Abstract

When individuals collaborate their actions are not isolated. Instead, they respond to and build upon the actions of others, creating interdependent systems. This suggests that valid models of collaborative processes, which inform research, assessments, and education, should account for interdependence. However, many models treat the collaborative actions of individuals as independent from the context in which they occur. In this talk, I discuss an approach for determining the conditions under which models that account for interdependence are more appropriate. The approach estimates the difference between independent and interdependent models using information about the social and cognitive structure of the collaborative context. Using simulation studies, I show that the estimates are reliable under a variety of conditions. This work furthers our understanding of the social and cognitive interactions that characterize collaboration, and provides guidance for researchers as to which kind of model (independent vs interdependent) may be more appropriate for their data.

Simon:

Okay. All right. Welcome everybody to this November. November. November. It's not nearly, nearly, It's October.

Welcome to this webinar.

It's fantastic to have Zach Swiecki here with us today.

Zach is an education researcher he's focusing on collaboration analytics such huge interest in collaboration and teamwork, collaborative problem solving.

And so the challenge of how we're going to model. Collaboration is a very interesting one for us either either as a researchers studying collaborative problem solving, or as learning analytics people interested in actually trying to automate that process as well and get feedback. So it's great to have Zach with us Zach is currently in the US but about to move to Melbourne where he's taking up his new lectureship position at Monash University which is exciting to see. So he's bringing together learning sciences learning analytics and human computer interaction, which is a great mix. One close to my heart.

So Zack if you'd like to just share your screen so we can see it. Then we'll get going. That's going to talk for about half an hour, and then we'll throw it open for the usual q&a so Zach fantastic to have you with us.

Over to you.

To me one second here.

Zachari:

All right, let me get this working now for everybody. Yep, that's right. Awesome. Thank you, Simon for the introduction and thank you everybody for taking the time, whatever time it is and the worldview to listen to this talk and this webinar. So today I'm going to be talking a bit about my work on modeling interdependence and clutter, problem solving, and most of this work was done. As I was completing my dissertation at UW Madison in Wisconsin. But as Simon mentioned I'm going to be moving on to Melbourne and Monash University so update the title slide and also throw an extra l in there so I can fit in.

So as most of us know,

Clever problem solving is very important to society so decisions work together to perform surgeries or diagnose illnesses, illnesses engineers work together to design structurally sound buildings and other problems in team sports teams work together to win games and entertain crowds, with reference to learning and the learning sciences, there's a long history of

collaboration as a key mechanism for learning so this goes all the way back to regard skis work on the zone of proximal development forward to Shell's work on joint problem spaces. And this work and the host of others argues that negotiating meaning and developing shared understandings contribute to learning and that's a key process of collaboration and learning in general.

So given the importance of collaboration on problem solving, to learning it's no surprise that there are several assessments that have been are being developed of collaborative problem solving skills, both large and small scale, large scale example is the PISA assessment that's relatively recent. But regardless of the kind of assessment, they all require models are some representation of the phenomenon that's going on so that we can make predictions or test theories. And in general, there are kind of two ways to model collaboration and those have to do with the level of analysis which you're casting your, your focus so we can look at the team as a whole. Right treat that as a level of analysis and say what they do, irrespective of the particular individual, or we can focus on a given individual and kind of isolate their actions and then say what they did. But obviously this is not that simple because when people are on teams. They actually interact with one another. And this means that when they're interacting. They actually have to respond to and are influenced by others or in collaboration and that's generally what we mean by interdependence. And so, In my work for many years I've argued that this is a critical thing to to model and collaboration, but actually there aren't many techniques that can do this kind of modeling or account for this interdependence. So I'm going to talk a bit today about one model or one technique that can that percentage network analysis and I'll get into the details of that later.

But as some of you may have run into the issue with interdependent models are ones that can account for interdependence likey and a does compared to what I'm calling independent models are those that isolate the, the actions of individuals and collaborative contexts, is that interdependent models tend to be more complex both visually and computationally. So that's important because people actually use these models to do something research reviews and to get insights, teachers use them to find interventions teams use them as mirrors. And so what we found is that these independent models tend to be easier to to understand in real time.

Views compared to interdependent models which takes some training and some experience to get used to.

So, what would be useful then as if we had some criteria that could help us decide when it was absolutely necessary to use an interdependent model and introduce that complexity, or when we could use an independent model.

Other techniques like when your hierarchical linear models have such criteria but there aren't ones for for techniques like DNA or other interdependent models.

So to talk about these criteria. First, and to get a little bit more specific about what we mean by interdependence. And to do that, I'm going to use an example from Hudgins work on

distributed cognition. So, what Hutchins did is he studied the navigational practices of sailors and the Navy, the US Navy in the 90s and in particular, he looked at one task of the sailors that was called position fixing right so this is where sailors balkanization of a ship on the navigational chart, and they project the future position to the ship, and they do this so along with GPS calculations as a redundancy or a stopgap.

So what they do is they plot the position by taking the bearing measurements or angle measurements between the Ford line of motion of the ship and different landmarks in the vicinity. And the way that this works is there's someone on the team called the plotter who picks the landmarks that they're going to use for decking bearing measurements, and they relay those landmarks to the bearing recorder who's another person on the team, who then relays that information in situ others on outside of the on the outer wings of the ship called the force operators. And what they do is they actually take these angle measurements between the landmarks in the ship and they do that using a tool called the pleura sets where they get their name. So once they get this information they then relay that back to the bearing recorder records it, and then passes that to the plotter so that that person can actually fix the position of the ship.

And so we can see kind of how this unfolds when we looked at a record of one example talk on some of these teams a very brief one so here we have the bearing recorder. Introducing what the landmarks are that they're going to be taking bearing bearing measurements from the plotter, tell us which landmark to take first the Point Loma one in this example, bearing recorder repeats this information and then tell us the Loris operators to actually take the bearings so that's where market their applause operator takes this bearing measurement relays that back to the other members of the team, bearing recorder records that force operator does the other poorest operator does their bearing as well. So this brief example highlights several kinds of interdependence that we can talk about the first is task interdependence so when one component of the task requires other components to be completed. So here the plus operators can't actually get started until they know the landmarks for example or told by the bearing reporter when to start.

There's also this idea of discursive interdependence so this is when either both have information or behavior have to be coordinated between individuals on the in the collaborative settings so here we have information being coordinated in terms of bearings and landmarks, but we also have actions and behaviors such as taking physical measurements with the tool, making communicated backs.

And then we have this idea of temporal interdependence so this has to do with when one kind of action in the team context makes other times more likely in the near future. So when the bearing recorder says to take the mark it's very likely that the ports operator will then do that recorded.

More generally, for our purposes this highlight highlights, an important thing about interdependence that it's a micro genetic phenomenon so it's unfolding moment by moment in

the interactions between individuals in this context. There are also cognitive differences that we see so different people talk about different things at different times.

There's a level of social interaction or inter Spurgeon of the communication or discourse. Right. And then there's this level of communication to density so even small discourse moves can have semantically meaningful content, sometimes, different kinds of meaningful content in the same move.

So to relate those ideas to these criteria for deciding between models.

I conducted four studies to kind of get at this larger question and I'm going to go over today. Other relatively high level.

The first was what drives interdependence in real scenario so what are the factors that contribute to it, which we've talked a little bit about already. Then can we measure the impact of interdependence Can we see when it's going to have an effect.

Then say it has a we can measure it, but does it actually matter if it's there or not so in other words how sensitive our results to the impact of interdependence if we account for does it change the decisions or conclusions that we would draw, and then getting more directly to these criteria, can we predict or estimate the impact of interdependence under a variety of conditions.

So the first study I'm going to gloss over a bit because it's a qualitative study and in depth qualitative study of two real data sets, one data set was the sadness data set, which many of you have heard me speak about before. So in this data teams participated in training scenarios that simulated them being on worksheets, and they use radar to detect aircraft or other vessels in the vicinity, and decide whether they were friendly or hostile or whether they should be engaged in combat or just worn away. In this context, these were called tracks. You'll see that pop up a couple of times.

So in this data there were 16 teams and total 109 individuals eight of those teams were in a control condition and neighbor and experimental condition experimental condition had access to a more sophisticated radar system that helped them to manage their collaborative efforts, hopefully better than the control condition.

And the actual data were transcripts of their radio communications as they work together on these problems.

So to conduct my analysis I used a set of codes to investigate the transcripts and these captured salient concepts in the team decision making process so things like seeking information, passing information about track behavior, giving orders or to warn or attack tracks and broadly what my analysis found is that those individuals in the control condition tended to seek information about track behavior detection and assessment, while those individuals in the experimental

condition tended to respond to information about track behavior, detection with orders recommendations and status updates, and this will become important in our further studies.

More broadly, though. This analysis confirmed that interdependence was happening at this micro genetic level between the interactions of individuals as was evidenced by their communications. We saw cognitive differences between individuals certain people said things that other people didn't or are said less likely.

There's a high level of social interaction so people intersperse their communication, a lot in this context, and even small pieces of discourse can have semantically meaningful content.

So I conducted a similar analysis in a second real data set. This is the never text data set. And some of you might be familiar with that it's an educational simulation in which students play the role of interns at a biomedical engineering company. This takes place online and they use a tool to conduct their research and do their teamwork, they have a chat tool where they communicate with one another. And they also have a design tool where their main task is to design a chemo dialysis machine for for kidney patients to patients with kidney failure, and they do that by picking certain inputs and relating them to certain outputs like cost or patient health and use that to judge the performance of their, their designs.

So in this data we had 12 internships that I looked at, there were five teams per internship and a total of 300 individuals.

I also had a record of their individual engineering notebooks which recorded their design justifications and these were used to classify the individuals as higher low performers.

And I had the chat logs from their communications throughout the internship. These were coded for salient aspects of the design process for them so things like justifications or rationales in terms of customer requests or performance requirements and also particular design moves like experimental testing or holding things constant and these codes were developed by a former person the upstanding analytics lab goal who I don't think is here because she just had a baby but congratulations to her.

Overall my analysis of this data suggested two things, those are the low, low performance justified design choices in terms of customer consult requests, and those in the high performance, performing context facilitated decision making process via communication, asking questions, and they also made design choices in relation to experimental moves.

Again, we saw that there was a micro genetic thing going on here, there were cognitive differences between individuals there's a level of social interaction and a level of communication density. So this is all good It suggests that interdependence is driven by some differences in cognitive social and community structures.

But it's limited as a qualitative study what would be nice if we could get a quantitative grip on whether or not or how interdependence is happening here.

And so for that I turned to my second study where we measured, or I developed a measure of the impact of interdependence. And I did this by developing what I'm calling the interdependence index or the dti. So how this works is it compares independent and interdependent model results to see how different they are and determine whether there's an impact of interdependence on the data in the data Excuse me.

So I did this, in particular using DNA it's theoretically possible to use other methods, but I chose DNA for a variety of reasons which we can discuss later. First we have to do an independent model using DNA. And what that means is we're going to take a record of the discourse. This is from the naval context. And for a given individual we're going to pull out their lines. And because it's an independent model we're going to just look within their lines and see whether or not their connections in those lines by themselves not in relation to each other just within each line. So in this example, the only line with connections in this this one has these three codes here and would form those connections. So we can do this for all this individuals lines and all individuals in the data. And what we end up getting is a vector representation of a given individual that shows the relative frequency with which they had each of these connections. This is what actually ends up going in the DNA to make the network diagrams, but we're not at that point yet.

So, we can also do a slightly different process. By using an interdependent model.

And so this is different in the sense that we find the lines associated with a given individual, and instead of just looking at those lines we put a window around them. So that includes the lines and contributions both from the person themselves, and from other people on the team. And this window gets moved through the data. And as it does. We're able to identify connections that occur within the window so here we're seeing connections, and the individual of interest the last person in this window to their own talk prior and also to the talk or contributions of others on the team. So, and this is what we mean by accounting for independence among teammates within this temporal context using DNA.

So this also produces a vector representation like the one before except the process by what you did it was different. And it gives us an interdependent vector for a given individual and for the same individual we have their independent vector. And now we want to do is see how different these are right. So what we can do is calculate the correlation between them, or the cosine of the angle between them, same thing. And this is what I'm calling the IDI or the interdependence index.

So since it's a correlation measure if it equals one. This means that these models are very similar, but the farther it gets away from one It means they're very different.

And that there's an impact of interdependence there. So if we collect together all these measures for all the individuals on a given data set, say, we can do statistical tests to see if on average, there's a statistical or significant impact of interdependence in this data. And so we can do that using linear models in this case a mixed model.

What we're doing is we're predicting that idi value based on the intercept, which corresponds to the average idi controlling for Team effects.

And what we're interested in doing is comparing this to some threshold. Some ipi or correlation threshold say point nine are very high, meaning similar models. so if we calculate this this average here and we see that it's the upper bound of its confidence interval is below our threshold would say that interdependence, is to be as impactful as statistically significant. However, if it's above that virtually would say that it's not impactful.

So here are the results of a model like this for the admin data set. So we can see that it's significant predictor of the intercept is significant.

One caveat here is that in order because these are correlations in order to do these tests we have to transform them to transform them back to the correlation scale and put that on the right there so pay attention to that. So here we're seeing that the confidence at or around this, this, this value here this idi value is 0.51 to 0.64. And that's well below 0.9 suggesting that this was a significant result which typically impacted by interdependence, we see something similar for the net protects data though the, the value is higher so it's much closer to our threshold 0.74 to 0.87.

So from this I concluded that yes we can get a handle on the impact of interdependence in our data. We do that by operationalizing the it is correlations.

So now we want to see whether or not this matters right so how sensitive our results to this impact will we get different conclusions if we account for interdependence versus not, and this will help us decide whether or not we should use it right. To do this we have to kind of place our guard horse to place our bets on we have to find a gold standard model or decide on which ones are the gold standard model. And the way one way that that's done in the way that I did that in this study was I compared these models to qualitative grounding grounded story or understanding of the data and the phenomenon that was going on. So in other words I looked for the convergence of either of these models with the qualitative findings that I found before.

Once you've done that you can settle on your model and you can see say that there are differences between groups in your model and they have a certain effect size. If we were to change the model or go to an independent model interdependent model for example and see a different effect size we can see whether or not these are statistically different and see whether there were quantitative differences between these approaches.

So here I'll be referring to some more traditional DNA representations of networks in a scores that hopefully many of you have seen.

So if we go back to our tetanus qualitative results we saw that the control individuals sought information about tracking a protection and assessment, the experimental ones responded to that information with orders recommendations status updates.

So that would suggest that the control condition individuals would have stronger connections between these codes and the study, and the experimental condition would have stronger connections between these codes. When he can, we can actually compare this hypothesis this qualitative hypothesis to the quantitative models ignores the interdependent network for all the control condition versus the experimental condition for the test data. And we can see that this model aligns quite well with the story right particularly for the control group. We see stronger connections between seeking information protection track behavior assessment on the left. On the right we see stronger connections between status updates, different kinds of orders and detection track behavior.

We do the same thing for the independent model things move around a bit but pieces of the story are the same right so on the experimental side, we still see some of those connect those connections between orders recommendations track behavior and protection. But importantly, on the control condition side we're missing a piece of the story there right so we're not seeing stronger connections between seeking information, detection or track behavior for the control group. There's no line there actually which suggests that the model found no difference. So, this independent model is missing a key conclusion of our qualitative analysis that we found before.

In terms of the quantitative difference we can look at the statistical differences between the two conditions experimental control and look at the effect size of those differences that's Cohen's f column there. The interdependent model had a higher effect size than the independent model but the confidence intervals around those overlaps so that suggests that the effect is not actually statistically different.

We can do a similar thing for the vertex data. So remember the low performing students justify design choices in terms of consistent customer and insulting request, high performers looked at decision making in relation to asking questions and communication and also experimental testing.

So that would suggest that these are going to be the connections that are most prominent in the network.

So for the interdependent model. This aligns well again see on the left, the customer consulting request and making design choices. On the right we see those connections for the high performers in terms of design choices to mutation etc.

When we look at the independent model things shift a bit, but we look carefully things are largely the same on the left on the low side the, we have the for the low performers the cluster and cylinder crosses on the left.

Those are actually all red lines connected to that they're very faint. I didn't have time to inflate all of our values here so we could see that more easily but there are stronger connections between customer requests, and making design choices for the low group, and those connections on the high group also exist in this model.

So looking at the quantitative results. And we see that there's no statistical difference between the effect sizes of these two models, some conclusion neither of the results had effect sizes that changed significantly so the quantitative result was essentially the same but the interpretation that results are the Tad misstated change more between the interdependent and dependent models compared to the net protect result. So it was more sensitive in terms of its interpretation, and to kind of explain that we can think back to those ici, competence intervals that we calculated previously the timeous data had lower idi value suggesting and had a greater impact than the Knepper texting, which was very close to that threshold that we understand.

So in some there. We found that results may be more sensitive. When the impact of interdependence is greater.

So moving now directly to this idea of getting criteria for choosing between these models we want to know if we can predict or estimate the impact of interdependence under a variety of conditions. And so you might be wondering well Didn't we already do that we have this this idi measure which measures this impasse Can we just use that and we could of course but there's a drawback to it in the sense that it requires using running two VNA models, comparing them.

It would be much better if we had a more general approach that that accounted for this phenomena that didn't necessarily require DNA to be used. We want them in some way to estimate the independent vector and estimate the interdependent vector, and then compare those and get the estimated ici.

So first I'll walk through how I did that with the independent estimate.

First thing I want to do is calculate a co occurrence matrix for a given individual. So here we're counting the CO occurrences that occur in their data and dividing it by the number of lines for each individual. Then we're going to unwrap that into a vector and normalize it. So in a way, this is operationalizing this idea of communication density because it's counting for the fact that individuals can have multiple codes appearing in their minds.

For the interdependent estimate, we take the same thing that we had before, we'll save that for later. But now we also need to account for the rest of the team because we're thinking about interdependency or so we can get this team occurrence matrix. What this does is it counts up the number of code occurrences, just the by themselves. divided by the number of

lines for each individual. And this operationalizes this idea of cognitive differences, so it shows the different rates for different concepts on the team, across individuals.

We also need some information about the social structure of the team and that's where the social matrix comes in for this estimate. So here we find the number of times each individual is in a window of whichever size you want with another individual. And so this will show the social structure of the team or how intersperse their talk is within the windows.

So now to actually get this vector we have to do a little bit of math, which I'll gloss over but I can talk about more detail. So what we're going to do is for a given pair of codes multiply the code probabilities times the window probabilities of the individual that we're creating the vector for, and we'll do that for both of the codes and the paradigm we consider. Then we'll find the union of those probabilities. And this is going to give the probability of the individual having that connection from A to B, either in their own lines or in the lines that are in their windows. So then we can normalize that repeat that for all the pairs of codes that we have. And then we're done with this estimate. So what we can now do that we have now that we have an estimate of the independent vector and interdependent vector is correlate those just like we did before to get this estimated idi.

And for real data what we're interested in, interested in is how well does that predict the actual ITR How close are we getting. Are we getting a significant relationship. So for the test data, we can see that the estimate is a strong and significant positive predictor of the IDI, and the overall relationship is quite strong according to the R squared values for the vertex data. We also have a significant result and positive but the relationship is not quite as strong more of a low art lower r squared.

So this is nice we seem to have a impact estimate that we can use on real data to help potentially make some decisions between interdependent independent models. But these are only two data sets right so it wouldn't be more useful if we were able to try under a variety of conditions, the same process and relate those to the to what makes those conditions different as a way to generalize the results. And so to do that we need to simulate some team data.

So I'm going to talk briefly about how I simulated collaboration data and use it to test. That's it. I estimate.

So, overall, the The goal of the simulation process is to produce some data that's at least in structure, a lot like the data that we typically use in quantitative ethnographic analyses, it has units, it has groups, it has codes right. In order to do this, there going to be four steps that I'm going to go over, and I'll talk about these steps in terms of say one team stayed at one simulated teams data. Again, simulated people not real people. The first thing we want to do is line generation so what this is going to do is generate the sequence of lines and the data, and also the number of lines for each simulated individual. So the way that we do that is we we have one of these teams social interaction agencies again, we choose the diagonal values here which represent the probability for example that one unit one has a line. The next line in the

data will be from unit one. So that's what the point five is when Unit Two has a line the next line in the data has an 80% chance of being from from from Unit Two for example.

And I'll talk about why we choose these particular values in a moment.

Then we choose the off diagonal values so that the rows sum to one. Right. And so if you're, you may have caught on that this is basically just a state transition diagram, or like one Markov chain on sentences that we can actually run that and generate a sequence of lines for a simulated data. So say we want to do 3000 lines we can start with the first person, run the Marco train 1000 times and get an order of those lines, start with the second person now run it 1000 times. Start with the third person thousand times. And now we have the order that we want our data to be in and we also have a record of how many lines are associated with each individual simulated team.

So partway there. Now we need to distribute the codes amongst those lines.

In a principled way and don't put them randomly but that wouldn't be very helpful. So the to this we have a complete code occurrence vector that we're going to create it so it tells us how many, the rate at which all kinds of the possible core connections occur in a given individuals line, line Excuse me. So here we have a co occurrence matrix, again we pick the diagonal and the stag and what this matrix has to do with the. It's just the probability of them having that code in their data. I'll talk about why we pick these particular values in a moment.

Then we multiply to get the off diagonal values so for the AB co occurrences we multiply A and B, A and C, B and C etc. and we can unwrap that into a vector.

And then we're missing one piece we want to concatenate on the overall the overall probability of getting a, b, and c, and your data so that we can really fill out our lines with each of these categories. And then we take this vector and we multiply it by the number of lines from the Markov sequence that actually were assigned to this individual that we're looking at. So what that's going to produce is another vector essentially that says how many, how many lines have each of these combinations of codes so in this example line one for this, or sorry one line for this person has a, b and c 28 lines have a, b, 14 have a and c, etc.

So that gives us a simulated team dataset from one team.

That's nice, but we actually want to do this for multiple teams and capture some of the variants in these parameters that we're talking about right so that's where the parameter variation. Step comes in so that we can get multiple data sets. We're pretty for given set of parameters for different teams.

So to do that we have our social matrix. And we pick its diagonal and it's off diagonals as I said before, but now if we want to kind of mess with or alter the social structure of this team.

Example this this matrix is going to save for a unit one.

There's a 50% chance that the next line is from you don't want a 25% chance to 25% chances from three for example, say we altered that to have ones all along the diagonal, so this would mean a social difference of zero for this team, and that every line when a given individual has a line are only followed by their own lines, or they never have any interest version of communication or discourse, we can increase this number to a point five. So we get more interest version of discourse people's lines are occurring within other their other's windows, we can actually increase it all the way if we want it so that anytime someone had a line. The next line would always be from someone else in the simulated data. So this represents the highest level of interaction, and the simulated data.

We can do kind of a similar thing for the cognitive structure of the team. So if we take their co occurrence matrix choose a diagonal for one particular individual on the team and we have other individuals on that team. We want to set it up so that their co occurrence rates, on average, are not different from each other, or differ by a specific value which I'm calling the cognitive dissonance. So for a cognitive difference value of zero.

Everyone would have the same code occurrence rates on the team. And then they would get the same rates for the other, the other values as well. Then we can vary this cognitive difference value to make different organizations have cognitive structure on the team so people talking about different things on the same team.

So once we have that we can accumulate the data for a set of parameters, and then run this process as many times as we want to get large data sets that have different collections of social and cognitive difference values.

Once we do that, we can calculate the actual idi and I'm wrapping up here I'll get a couple of minutes left.

And then we can calculate the estimated ici, and compare those again using a linear model. s

So this time we're going to compare the IDI that we get from doing Na to the estimate, and also control for the social and cognitive differences and team effects. So here's what the run of the simulation would look like on the y axis we have the average idi value on the x axis we have the social difference values and Here I'm showing you one run or set of runs Excuse me for a cognitive differences zero meaning that all the individuals on the simulated team had the same rates for codes and co occurrences. So what this is showing is that when people have talked about the same things or have the same distribution of talk it doesn't matter how much you intersperse their talk with each other and their windows they stay relatively stable in terms of the impact of interdependence stays close to one. And that makes sense, because they're not taught, they might be talking to different people but different people aren't talking about different things so it's not going to show up as being impactful in the model. However, if we look at a cognitive difference level that's higher say point five. We can start to see some

differences or impact of interdependence. So this is suggesting that when you have cognitive differences and you increase your social difference so people say different things and talk to different people, the impact of interdependence is going to be high, and you should consider using an interdependent model. So the regression, that I showed previously supports that we can see that the ITA estimate is again significantly predictive of the actual idi, and also the cognitive and social differences are predicted over the IDI so as those, those. The ipi values decrease as you increase your cognitive differences and social difference values, meaning you get a higher impact of interdependence. Okay, so this suggests that we can predict the impact of interdependence for real and simulated data using an estimate that operationalizes social and cognitive differences or structures on the team. And to wrap up here we'll talk about some contributions of this work. First we found that there are differences in cognitive and social structures that can drive interdependence and we saw that both qualitatively, and the first study in quantitative leader with the last regression, that we saw. We can also measure the impact of interdependence via the IDI, which right now is dependent on DNA but could radically be implemented with other models. We saw the results may be sensitive to the impact of interdependence so it can matter. These decisions between interdependent and independent models can have significant decisions or impacts on your decisions about what you say about your data and the conclusions you draw, we can predict the impact of interdependence on real and simulated data without using DNA when using this estimation procedure. And perhaps most importantly we have a simulation procedure that can use to test a variety of hypotheses about collaboration. We could use the simulated data that our procedure that I have here to test how other models might be sensitive, other models and DNA might be sensitive to independence for example, or how sequence or the ordering sequential models might be sensitive to this team structure cognitive structure, are just a couple of examples, and also importantly this work, shows that they're these two important techniques that I think are, that should be more part of our toolkit in general, when we're studying the learning sciences and also learning analytics and those are sensitivity analyses and simulation studies, and hopefully this has shown an example of how those might be done, and also showing the kind of questions that they can be applied to. Okay, so that's all I have. I'm happy to take some questions and comments.

That's an applause from around the world Zach Thank you, thank you, thank you. I can start sharing. Just look at me.

Yeah, okay. Right. Well that was coming out as for at 8am for me here in Sydney. That was quite an avalanche as I as I as I get into my day. Sir, folks. We got some questions for clarification, or, you know, asking for some comments. Have you seen work like this before, where the things in there that you'd like some, some clarification on, you can you can unmute your mic and stick your hand up. Using the control panel on the participant with. So, anybody want to kick us off here.

And as a general comments.

I think it's it's it's fantastic to see, you know, a controlled comparison, you know, of coding and counting against modeling independence. And the way that you've done that, is seems very elegant. To do that, and operationalize the differences that you get when you introduce independence. That seems seems like a very nice, nice, nice framework toolkit to do that DNA is offering us. Yeah, I mean one thing I want to point out is that in my implementation of this use DNA but again it's theoretically possible to use other techniques to calculate this metric, and the simulation procedure doesn't actually use it as well so that's that's just a separate procedure that can be used to test things separate for me and so it has kind of a broader hopefully impact for lots of different models and studies. Right. Right. And for someone like myself I'm coming in, probably from a more qualitative kind of background, actually, the idea of simulating a data set is maybe quite a novel one for some people here. You know, if you're going to simulate a conversation. Dialogue right. But of course, you know you're doing it in a very particular way with that methodologically that's a new kind of thing. I'm working with a machine learning.

who is you know simulating reflective writing. I'm like, What do you mean simulating reflective writing. And of course he's not actually simulating writing is simulating certain features in the creative set that he wants to model. Right. But that's one of those things that's the folks who are not used to seeing this, you know are going to go what, how are we doing this. And that's one of those interesting transdisciplinary things, new, new for anyone coming from a call background. Yeah, definitely. I saw that David and Carl had a virtual unreal hand raised. Okay. I have a comment actually on what Simon just said so maybe I'll do that instead of asking my question and Carl can go.

So, you know, I think one of the nice, one of the things that this illustrates is the way in which,

you know, part of what quantitative ethnography does is it, it forms a link between a qualitative analysis and a quantitative analysis and kind of the pivot place where they connect is the code.

Right, and that the codes are sort of the means of translating between those two. So, what I'm trying to what you just said really illustrates that nicely in the sense that we can't actually simulate qualitative data. But if we accept that the qualitative data is coded in particular ways we can see like the pattern of codes, even if we don't have the precise data that go with it. And that's and that's sort of part of that

part of the the way in which these two techniques, meet at the, at the point of the codes. I would also add David to that, I think that in addition to the codes, thinking about these data generating aspects right so things that we hypothetically are from the literature from our grounded understanding generate these kinds of structures and the data. And in addition to the codes those actually get operationalized as well and are essentially what you're using to do the simulation and the test and I think that that meeting point is very important too. And probably, I think the hardest thing to think about and decide upon and implement when you're doing things like this. Okay.

I can see that z Chang Kai had a question. So, go for it.

Hi, Zach. Great presentation.

I ran out good such a wonderful one. I have just so wide open and I want to ask you about dependency and interdependency why you make this difference. Basically you're attracted individual utterances out of a data set for each individual ads, independent model. And then you if you use, I'm thinking if you use the same windows sides, say five addresses and the five authors for a single individual may cover a long period of time, or big part of a task. Say it could be pains of the past, but five occurrences from a group of people may cover just one 30th of a task. So that makes the information, different. So, based on that data. if we are say just say that task. One is you're talking about just one piece of the puzzle. The other is talking about one third of a task. So the information is much different. So I'm wondering.

Yeah, so there's one clarification that I would make and that in the in the way that I implemented the independent model, the window is actually, it's using a window model but it's only ever, a size of one, so it only ever looks at one contribution right and then through the NA process it will accumulate the connections, based on the ones that occurred in those in those individual lines, and in the independent model. There is a window say of five or say whatever you determine to use for your window and that will include other other information from the group and I think, in order to be sensitive to your comment that decision has to be made carefully about how to, how big to make that second that interdependent window. Does it is five enough, or do you need more unique less, but the independent one has to be one window. in order to just isolate that individuals connections. One thing I want to see if I could jump in here to exactly the, I think one of the pieces that I think you you and Carl would just discussion, discussing I think Simon David touched on, is the role that qualitative analyses can play or the ethnographic pieces can play in this type of work is that you can actually by operationalizing and defining things in the way that you have you can start to say these are the types of things that qualitative researcher should be attend attending do I think you touched on this we talked about bringing things from theory right. And I think the, what's beneficial about taking this approach to do both sensitivity analyses, but also the simulation studies more broadly, is that then we can see how much of an impact that could have right like it's expensive often to collect the data and do these analyses, but if we can do some of this work to try to say these are the features that I want to, to key in on. And a key, I think a key tenet of quantitative ethnography is being able to try to find ways to quantitatively quantify those yeah models based on that.

And I think, I think without taking that approach, we don't we don't avail ourselves of this toolkit of doing simulation studies or sensitivity analyses, it would take much longer to understand some of these phenomenon, or even designed tools like you've done with the IDI to try to get them to see does this matter or not. Is this worth attending to. So I just really highlighting a lot of those pieces. yeah I mean the BQE perspective, I think is essential to doing good simulation studies, because you want to have principled data generation mechanisms to use you don't want to just use anything and see what happens right so I picked ones like social and cognitive differences that are both from the theory, like, that's something that Dylan Berg

talked about is symmetry and asymmetry communication right. But also, I saw that, that was occurring in my data qualitatively I saw that people talked about different things, some cases they had roles. So that meant that they almost by definition talked about different things than others. And I saw that they actually interspersed or had different social structures, as well. And so then, you know, the idea comes well are these related to this idea of interdependence right. Sparks, a comment. I mean, so what what you are asking there Brendon was the simulate being able to run a simulation allows you to ask is this analysis, even worth doing. Perhaps manually qualitatively because that's going to be expensive. That's what I. That's what I heard you asking. Right. I mean we could spend a lot of valuable research of time doing this analysis to establish a gold standard. But is it even worth doing. That's what I think you're asking me that sparked the thought that maybe you would run a simulation. Before you do your real data gathering, because you want to know is it worth generating data of this sort, so that we could do this analysis, afterwards. Does that make sense. So supposedly it does Yeah, there really are design decisions to make about the learning environment, or about what you're going to capture.

Yeah, actually, I that's an interesting thought I hadn't thought about it that way. I was reading Brendan's comment as the other way around so that there could be it could take a lot of time to develop these quantitative mechanisms for the simulation. And so you'll save yourself time and actually effort in a different place. If you ground yourself in the data and the theory, in order to decide what to use to conduct a simulation. And I mean in my, in my view, a simulation is useful for kind of generalizability is the way that I think about it so it's a way to in a given context we saw these things. Now what happens if we find the important things in these contexts and then we we broaden the range of how they happen and how they interact and what does that going to tell us because we expect that those broader range of actions might actually occur out in the wild. I think the other way it can be interesting to particularly if you already had some simulation and you wanted to see if you should have should collect more data to see if you need something, you know, if something is aligning like oh well okay let's collect some more data and see this so I think it's kind of a. You need both. You shouldn't just do one or the other.

Yeah, I guess I intended both, I was kind of thinking about both so I'm glad that, oh guess I'm in, you'd given voice to that part, too. I think the. Anyway, I don't want to take too much more time but, yeah, those are kind of what I was thinking. Okay.

Anyone else want to chip in. David, I think you had a thought. Do you want to lob that one in?

Well I have two as usual, um, one is just a response to what what you were just saying, which is, you know I hadn't really thought about this before but in one of the things we talked about in my lab and I think is sort of part of the broader discourse of quantitative ethnography is this idea of a smoking gun right so when you're trying to when you're trying to think about how you want to collect data how you want to construct an argument, even sometimes how you want to code, you know I try and think about, well, what is the piece of data, or pieces of data, what's the situation that I could see in the world that we would take as being, you know, really strong evidence for the phenomenon that we're interested in. And it's, it strikes me that you could

actually think about either figuring out whether a smoking gun is really smoking or whether it's the weather where you might go to look for a smoking gun by running a simulation study, it is you're imagining a piece of data, right there. Now the question is Would that data be dispositive and you could actually answer that in a simulation, before you even went out and tried to gather that particular kind of data, or along the way or something like that.

The question I had was a lot simpler though, which was. So I'm assuming, first of all, I'm assuming that you're going to boil some of this down to practice so there'll be an R package or something where people will just be about to put their data in and get out their idi or something like that but.

But even before that. I'm assuming most of the folks in this conversation right are probably not going to run the simulations that are code for the simulation studies themselves. Like, is, are there some, like big take homes from all of this, I'm thinking along the lines of, not the kind of contributions, but like, do we know when we should start worrying about interdependence kind of as a general matter or, you know, what would you be your best advice to somebody if they didn't want to actually take on all this computational machinery. Yeah, it's, it's not I mean it's on the surface. It's a simple question but it's actually kind of a nuanced one. But in general, I would say that. First you can do the AGI approach, without conducting the full simulation, if you wanted to, you can you can calculate that metric and compare it to a correlation threshold that you are comfortable exceeding or not. And that's fine. In terms of where the simulation helps us in terms of these mechanisms that might be driving that. And so what that's telling me is that, as you, and you can calculate things that the simulation uses on your data set. Regardless, and suggest that as you as people talk more with other people in their data or interact more with other people don't have to be talking. And those individuals are talking about different things. The, the more that that's happening, the more you should be considering or worrying about independence. And the other thing I would say is that there's not really a high cost at least for the cost is relatively small for you to use. The interdependent model and not be independent model, what you're paying there is a complexity cost right there's a trade off there. It's harder to understand and maybe to explain. Right. But the other way around. I think is words you're potentially harming your validity if you use an independent model when should be using an entrepreneur. But that is a trade off it's made in lots of modeling cases their people decide to use hlm, instead of LMS, or not based on criteria, about their data and that's what I'm trying to get at. So, but the basic idea is that if you suspect that there's a lot of communicate a lot of interaction about and people say different things and other people. You want to be using your interdependent model.

In the sort of final five minutes or so. I was wondering whether you could reflect on what kind of response this this kind of work gets from related communities and you can define who those related community should be but obviously there was a lot there a whole community to study teamwork. And yeah, science of teamwork. There are whole communities who study collaborative problem solving. What kinds of responses does this kind of work get from from them, are they are they confused excited. Is this revolutionary. Did they say nothing new here. You got any thoughts about that. Yeah, I think about it a lot and I will say that a lot of this, this

work at least that I'm presenting here the simulation stuff is relatively new and I'm just getting some of these ideas out there so I'm interested to see how people are reacting but just in my general experience I think that with all QE endeavors. There's you're trying to cater to multiple audiences who aren't fluent in one or the other pieces of things that the audience cares about right. So a lot of what I run into and I suspect that this probably happened in this presentation as well as that, I'm using relatively sophisticated quantitative ideas, and also relatively sophisticated qualitative ideas, and people were paying attention to those differently and understanding them differently, and it kind of makes the whole package harder to grok on at the same time and so I think that's, that's a challenge. And so I think that really focusing on on I think this is something we can all do a good job of is really focusing on the links between what the real phenomenon is and what the operationalized version is right, and how that's happening and how that's getting played out. And that seems to be the best way to tow that line but to help people from both camps unders understand. So yeah, that's that's something that I think I think we're all struggling with a bit. Hmm. You yes you know it's very it's it's a fascinating challenge for me I think to about how communities can when they've come across something new and exciting like this, how they start to engage the different stakeholders who are sitting around from the outside, you know, certain bits of what you say will result will will resonate and make sense immediately to different, different groups in the audience. And then the rest of the going, what did he do that. And I guess you know you could say, well there's there's no alternative except to spend time talking, and in dialogue. And so people could check their assumptions and ask and ask for, patience, but as a community we have to learn how to tell those stories in ways to to different audiences, I guess. Yeah, just add one one thing on that and then I'll be done I think one thing that the community is doing a good job of anything can continue to do is to use these ideas to make actual tools that people can use right. So David mentioned about the skinning implemented as an art package. Right. And so that's a different kind of dialogue or different kind of interaction with folks who then see what this might be used before and then can try it out on their own and investigate it without necessarily that back and forth, it is very valuable but might not be able to happen all the time so to the extent that we can take these ideas and package them, you know, metaphorically and actually into tools that can be used by others who have different research questions or ideas. I think can help that that issue greatly. Right. Yeah, and I'm a huge fan of you know encapsulating, you know, ideas like this into practical tools. I guess the flip side of that is the risk that someone is pulling stuff off the shelf loading package like pulling machine learning algorithms often just throwing in that data and hoping something interesting is going to come out and not understanding what what they're doing as well. And then may know, maybe, maybe no shortcuts to this, but giving people the chance to play with data. Find something that looks interesting, and then go okay I really need to understand this because that's that's a different way of working with data but it's one that data science opens up for more exploratory mode.

A bit like exploratory visualization tools which which by just messing around sometimes with different thresholds and so forth suddenly something looks interesting and then you start to drill in. Okay. All right. Well, we should wrap up there let's just think that one more time for this work as a huge goal of you. It's great that his work is now getting out there and some great peer reviewed journals and so forth and conferences that will start to pick up momentum. So

thank you, Zack next month. We have Brian Wu from East China Normal University. Due to the time zones, changing that is going to be at a different time from usual it could be 3pm CST I think if we got our calendars right but still am here in Australia. So, we'll see you next month, but thanks very much everybody for coming along and thank you very much. Does that today's webinar.